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Edited by

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PREFACE

The division of Volume 5 into two parts is a new venture in this series. It has become evident that these volumes are continually growing. Perhaps correctly, criticism has been made that certain topics are out-weighting the balance of the volumes. This is especially true with such topics as ^{19}F resonance.

Certainly had this chapter, which constitutes Volume 5B, been published with Volume 5A as one volume the number of pages would have been in excess of one thousand.

Therefore this Volume 5B is in some way an experiment which is reasonable as many would be interested in the ^{31}P data without necessarily wishing to have Volume 5A. This will become especially evident on inspection of the Compound Indices which are exhaustive and basically forming a catalogue of some hundred and ninety pages giving data on various phosphorus compounds. Comments on this new move would be most welcome and it may be more convenient in future years to run the second part of each volume on some special topic such as ^{19}F or ^{31}P resonance studies which, by virtue of the nature of the investigations, tends to become a vast catalogue.

Volume 6, which is now in preparation, is again a single volume work.

I must finally express my gratitude to Professor Mavel for his patience with my editing and for his efforts in preparing the manuscript and producing a very valuable contribution to this series.

ERIC F. MOONEY

*Anacon (Instruments) Ltd,
Buckinghamshire,
October, 1973*

THE CHEMICAL SHIFT SCALES

Readers are reminded of the convention for the presentation of chemical shift data introduced into Volume Three of this series. This self-consistent convention has now been used for some two years in various places and is gradually being universally accepted.

Convention adopted for Chemical Shift Scales

1. All shifts will be denoted by the delta scale, low-field shifts being shown as positive and high-field shifts as negative values. In all cases the standard will take the reference shift of δ 0.0.
2. No other symbols to denote shifts at infinite dilution will be used.

NMR Studies of Phosphorus Compounds (1965–1969)

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I. INTRODUCTION

THE IMPORTANCE of NMR in phosphorus chemistry is today not a matter for dispute—this was already clearly evident at the time of writing my earlier review on this topic.^(1966, 1) This earlier review was concerned with nearly four hundred and fifty publications from the early days of NMR (about 1950) until the end of 1965. Papers specifically restricted to ^{31}P data were not included but these were, however, reviewed by Van Wazer *et al.*^(1967, 1) who at approximately the same time presented results for about three thousand compounds.

The years 1966 to 1969† have seen a continuous increase in the interest of NMR studies of phosphorus compounds both from the practical, for the solution of structural and conformational problems, and the theoretical aspects, for a better understanding of the nature of the bonding in phosphorus compounds. About one thousand five hundred papers appeared during those four years and it was clear that the moment was ripe for an up-dated account of the NMR achievements in this field. In this review it will be found that this formidable volume of literature has answered many of the questions raised in the earlier review,^(1966, 1) especially those dealing with phosphorus coupling constants and the relationship of these J values to the hybridisation of phosphorus and molecular geometry. Meanwhile, a number of new puzzling points have been revealed, challenging for theoreticians and intriguing for chemists attracted to a better understanding of structure and reactivity in phosphorus compounds. This essentially arises from the richness of phosphorus as a central atom, with its flexible hybridisation, and as a major element in inorganic, organic and biological chemistry.

† The present literature survey was concluded at the end of December 1969.

This review is intended to cover most of the aspects of NMR in phosphorus chemistry, especially stressing those aspects directly related to electronic and structural factors. Some subjects will only be briefly reviewed, e.g. resonances in solid compounds, in metal complexes [this subject has been treated in a previous article in this series^(1969, 1)] and biological applications. All the compounds reviewed are tabulated in either Formula Index I (inorganics) or Formula Index II (organics), the whole comprising of more than four thousand five hundred entries. These indices† list all available chemical shifts for phosphorus and fluorine; those for other nuclei (except protons) are reported in the text of this review.

II. CHEMICAL SHIFTS IN PHOSPHORUS COMPOUNDS‡

A. Phosphorus chemical shifts

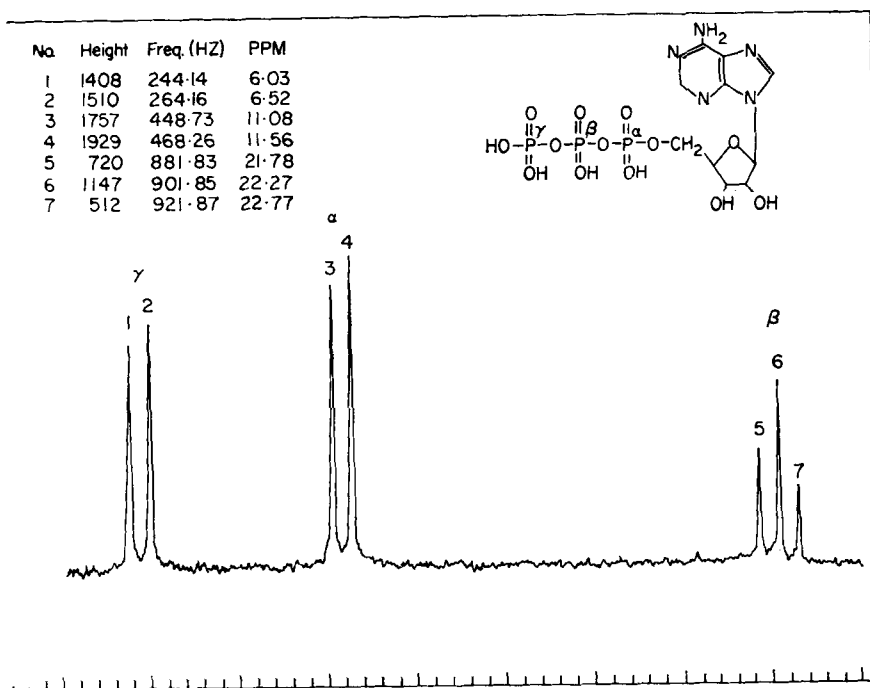
1. *Experimental determination of phosphorus chemical shifts*

As the phosphorus-31 nucleus represents 100% of natural phosphorus, has a spin of $\frac{1}{2}$ and not too low a magnetic moment the direct observation of ^{31}P resonance is straightforward, as adequately reviewed by Van Wazer *et al.*^(1967, 1) The use of newer techniques is nevertheless interesting and, as initiated by Pudovik and other Russian authors,^(1967, 2 to 4) the INDOR technique of Baker may be especially fruitful. In addition to its increased sensitivity it gives a convenient method for the determination of the signs of coupling constants [for a review see McFarlane^(1968, 1)]. Advantage of this technique has been taken over the past two years for investigating various typical compounds^(1968, 2, 3; 1969, 2 to 4) as discussed later in Section III. Another method of obtaining spectra is the use of FOURIER Transform Spectroscopy as described by Klein and Phelps;^(1967, 5) the sample under observation being submitted to pulse sequences, the FOURIER transform of its response-function is the absorption function (see vol. 5A, p. 557). Fig. 1 provides a typical FT spectrum of A.T.P.

Obviously, all this refers to observations on liquid samples; some work is nevertheless done on solid samples. With great care, one may obtain additional data using solid samples, especially *chemical shift anisotropy*. Such work has very recently been performed on anhydrous sodium and potassium pyrophosphates, for which $\sigma_{\parallel}-\sigma_{\perp}$ was measured as 200 ± 10

† The signs given in the indices strictly follow the conventions adopted in these volumes (see the General Foreword). In the text itself, however, the original conventions have been used for the sake of comparison with the reviewed literature.

‡ Throughout this section all chemical shifts will be discussed as given in the literature (i.e. with positive sign for *upfield* shifts), except where noted.

FIG. 1 ^{31}P FT spectrum of A.T.P. (Courtesy of Jeol. Co.)

ppm for phosphorus^(1969, 5) and for polycrystalline BaFPO₃, for which a value of -145 ± 20 ppm for phosphorus and 182 ± 22 ppm for fluorine^(1969, 6, 7) were obtained. A full discussion has been presented for P(CN)₃, P₄O₁₀ and P₄S₁₀; for these Lucken and Williams^(1969, 8) analysed the anisotropies of the different phosphorus types in terms of orbital populations.

Another interesting point is to be presented in relation to chemical shift evaluations. From the directly-measured *spin-rotation* constant of POF₃, diamagnetic and paramagnetic contributions to phosphorus chemical shifts were estimated (*ca.* + 1000 and - 640 p.p.m.). Extended to H₃PO₄, which is the commonly accepted reference compound, this gives *about 320 p.p.m. for the absolute ³¹P chemical shift.*^(1969, 9)

2. Theoretical investigation of phosphorus chemical shifts

The outstanding variation of the hybridisation of phosphorus, which may involve mixed *s*, *p* and *d* orbital participations, makes the interpretation of ³¹P chemical shifts a very difficult task. As mentioned above (§ 1), the separation of dia- and para- magnetic terms is obtained from spin-rotation constants, in those compounds for which such observations are possible but this is far from being generally applicable. Another type of experimental data which may be found relevant, when discussing diamagnetic contributions, is to be expected from "chemical shifts" observed in ESCA spectroscopy;^(1967, 6) these chemical shifts being of electrostatic origin. In any case, the paramagnetic term which is the dominating one (except, possibly, for tetrahedrally surrounded atoms) integrates the influence of too many factors to be described by a few gross parameters even for the simplest cases, such as attempted for PX₃ or YPX₃ compounds for which a relation of X-P-X bond angles and "magnetic configurations" was derived on the basis of an empirical modification of the Lamb formula.^{(1965, 1)†} The same applies to attempted correlation of ³¹P chemical shifts with theoretically calculated changes.^(1969, 10)

Letcher and Van Wazer^(1966, 2, 3; 1967, 1) have proposed to deal with *s* and *p* contributions, and especially their π -terms, as being by far the most important in relation to sizeable parameters, e.g. substituent electronegativities and bond angles, of phosphorus. As the latter are known in but a few compounds the use of derived formulae can only be qualitative as for phosphonate anions.^(1967, 7) Of course, the consideration of only *s* and *p* orbitals is better when dealing with di- or tri- valent

† A clarification of this notation of "magnetic configurations" has been presented more recently by this author^(1968, 4) as the first step for elucidating the ³¹P chemical shifts on a firmer theoretical basis.

phosphorus compounds;† in these cases, however, the role of lone-pair electrons is so important that their contribution cannot be really properly appreciated.^(1965, 2)

For phosphorus involving tetra-, penta- or hexa- coordination the importance of *d* electrons (even if quantitatively small) must not be underestimated;^(1968, 5) it is especially easy to detect as it strongly decreases the paramagnetic shift from which a net high-field shift arises. To consider these *d*-contributions on a theoretical basis is rather complex^(1964, 1) and is at present limited to qualitative conclusions.^(1968, 5) The case of the assumed PBr_4^- ion, for which a shift of -150 p.p.m. is observed (compared with -225 for PBr_3) is rather interesting in this respect.^(1969, 11)

3. Empirical correlations of phosphorus chemical shifts

The above facts explain the difficulties encountered when trying to set up *empirical correlations* for observed chemical shifts. First attempts were unsuccessful,^(1956, 1) but Grim and co-workers have succeeded in establishing such a relation for P^{III} and $\text{P}^{\text{IV}+}$ compounds. In defining additive constants σ^{P} for various groups these authors^(1965, 3; 1967, 8; 1968, 6) established fair correlation for tertiary phosphines:

$$\delta = 62 - \sum_1^3 \sigma^{\text{P}}$$

and for secondary phosphines:

$$\delta = 99 - 1.5 \sum_1^2 \sigma^{\text{P}}$$

For primary phosphines, Maier^(1966, 4) similarly obtained the relation: $\delta = 163.5 - 2.5\sigma^{\text{P}}$. Typical values of σ^{P} are shown in Table I.

TABLE I
Some typical additive constants σ^{P} for phosphorus-31 chemical shifts

R	σ^{P}	R	σ^{P}
CH_3	0	C_6H_5	+18
C_2H_5	+14	$\text{C}_6\text{H}_5\text{CH}_2$	+17
<i>iso</i> C_3H_7	+27	CN	-24.5
cyclo- C_6H_{11}	+23		

† Also applies to phosphonium compounds, although diamagnetic term is now more important and chemical shifts are essentially controlled by small changes in hybridisation arising from substituent electro-negativities.

As stated in the footnote on p. 5, phosphonium compounds afford a better example of chemical shifts which are essentially governed by inductive factors thus giving better correlations.

The following relations, having the same σ^P values, have been given:^(1968, 7)

$$R_3PH^{\oplus}: \delta = 3 - 0.5 \sum_1^3 \sigma^P$$

$$R_2(C_6H_5)PH^{\oplus}: \delta = -1 - 0.57 \sum_1^2 \sigma^P$$

$$R(C_6H_5)_2PH^{\oplus}: \delta = -1.4 - 0.57 \sigma^P$$

More generally, in phosphonium ions the relationship:

$$\delta = -22.0 - 0.8n - 0.26 \sum \sigma^P$$

where n = the number of attached alkyl groups, is found to be valid.^(1966, 5) It is seen that the contribution from phenyl groups is entirely different when dealing with P^{III} and $P^{IV\oplus}$ compounds. In the former case the phenyl groups accept electrons from the phosphorus lone-pair while this is not so in the latter case in which there is π -electron donation from the phenyl groups to the phosphorus d orbitals.^(1968, 7)

Lastly, Olah^(1969, 12) has proposed the following relationship for tertiary phosphonium ions:

$$\delta = 3.2 - 0.56 \sum_1^3 \sigma^P$$

It must be noted that all these σ^P values have no significant correlation with the corresponding Taft or Hammett constants;† the precise interpretation of these σ^P values remains open to doubt.

4. Relation of observed chemical shifts to the nature of phosphorus bonds

As previously stated, the analysis of ^{31}P chemical shifts for the elucidation of the nature of bonds is not straightforward, but qualitative relationships are possible. For example, in the recently described azaphosphatriptycene (1)^(1969, 13) for which the δ_P of +80 is especially high for a P^{III} nucleus linked to three carbon atoms, the authors suggested that this indicated a high percentage s character for the lone pair. For the phosphonium homolog (2) the δ_P of +4.8 indicated a $P-CH_3$ bond with a high σ character, i.e. an electron density greater than sp^3 on phosphorus and less than s on methyl group. Similarly, in phosphiran (3)

† Correlations have, however, been described for phosphorus chemical shifts in $(C_6H_5)_2P(O)X$, $(C_6H_5)_2P^{\oplus}X_2$ etc. with the X substituent parameters.^(1967, 9; 1968, 8)

the ^{31}P shift appears at an astonishingly high position of +341,^(1967, 10) it should be noted that the PH group is neither mobile nor exchangeable.

These unusual shifts may be an indication of a significant d orbital participation, especially in phosphiran which probably has a nearly planar geometry and may possess some "aromatic" character as in the parent cyclopropanes [the P-H coupling in 3 of 155 Hz is between that found in $\text{PH}_2^\ominus$ (138 Hz) and PH_3 (182 Hz)]. The same conclusions would to some extent apply to organogermyl-, organostannyl- and organosilyl-phosphines recently discussed by Schumann.^(1969, 14)

Lastly, relevant routine discussions for the elucidation of electronegativity or conjugation effects from ^{31}P chemical data are fairly numerous;^(1965, 4; 1966, 6 to 9; 1967, 3, 11 to 14; 1968, 9 to 12; 1969, 15) cyano-, phenyl and perfluorophenyl groups have all been considered from this point of view as have halogeno groups [for which ^{31}P data compares with direct observation as for instance obtained from ^{35}Cl NQR data^(1967, 15)].

B. Proton and fluorine chemical shifts

Most of the applications of NMR to phosphorus compounds imply a discussion of the relevant proton or fluorine spectra. These deserve no special comment as they generally are not typical; mention will be made of some discussions of the *electronic structure* of molecules (stereochemical aspects will be considered in Section IV). Consideration of organic derivatives[†] is often based upon a Taft-type interpretation of resonance data, thus permitting a separation of σ - and π - electron distributions in substituent-phosphorus bonds (often through p_π - d_π conjugation; see 1967, 16 for a general discussion). Such investigations often make use of ^{19}F data involving either monofluoro- or perfluoro- substituents.^(1965, 5; 1966, 10; 1967, 17; 1968, 13, 14; 1969, 16 to 19) PMR may give gratifying results, e.g. in *p*-tolyl compounds^(1968, 15, 16) and appears to be useful for discussing group electronegativities^(1967, 18; 1968, 17, 18) or for estimating pK values.^(1967, 19)

C. Carbon-13 chemical shifts

Because of the low natural abundance, the low sensitivity of the resonance signal and the very long relaxation times associated with the nucleus, carbon-13 resonance has not been really investigated prior to 1965. The first spectra were observed using fast passage conditions;^(1957, 1; 1965, 6)

[†] Inorganic compounds present similar problems, e.g. for mixed halides of the type SPFXX ^(1968, 19) in which the fluorine resonance gives an indication of π -bonding present in systems when considered in conjunction with phosphorus-resonances.

TABLE II

Carbon-13 chemical shifts for typical organo-phosphorus compounds

Type	Compound	Chemical shift ^a	Reference
Tricoordinated phosphorus	(CH ₃) ₃ P	-116.8	1968, 3
		-111.4	1968, 22
	(CH ₃) ₂ PH	-121.6	1968, 22
	CH ₃ PH ₂	-133.1	1968, 22
	CH ₃ PCl ₂	-113.5	1968, 20
	(CH ₃ CH ₂) ₃ P	-104.0	1968, 3
	(CH ₃ CH ₂) ₂ P*	-113.6	1968, 3
	(CH ₃ O) ₃ P	-75	1968, 3
		-79.8	1968, 22
	(CH ₃ CH ₂ O) ₃ P*	-65.6	1968, 3
		-70.7	1968, 22
	(CH ₃ CH ₂ O) ₃ P*	-106.3	1968, 3
		-111.3	1968, 22
		-111.9	1968, 3
Phosphonium ions	(CH ₃) ₄ P [⊕]	-111.9	1968, 3
	(CH ₃ CH ₂) ₄ P [⊕] *	-111.3	1968, 3
Tetracoordinated phosphorus	(CH ₃ CH ₂) ₄ P [⊕] *	-117.3	1968, 3
	(CH ₃) ₃ PS	-100.4	1968, 3
	(CH ₃) ₃ PSe	-100	1968, 3
	CH ₃ P(O)Cl ₂	-97.0	1968, 20
	CH ₃ P(O)F ₂	-107.0	1968, 20
	CH ₂ P(S)Cl ₂	-87.5	1968, 20
	HP(O)(OCH ₃) ₂	-71.3	1968, 3
	(CH ₃ O) ₃ PO	-69.0	1968, 3
			1965, 7
	(CH ₃ CH ₂ O) ₃ PO*	-59.8	1968, 3
	(CH ₃ CH ₂ O) ₃ PO*	-107.3	1968, 3
	(CH ₃ O) ₃ PS	-68.5	1968, 3
	(CH ₃ CH ₂ O) ₃ PS*	-62.3	1968, 3
	(CH ₃ CH ₂ O) ₃ PS*	-107.4	1968, 3
	(CH ₃ S) ₃ PS	-110.4	1969, 20
	[(CH ₃) ₂ N] ₃ P	-90.7	1969, 20
	[(CH ₃) ₂ N] ₃ PO	-91.5	1969, 20
	[(CH ₃) ₂ N] ₃ PS	-90	1969, 20
	[(CH ₂) ₄ N] ₃ P	-84.3; -104.5	1969, 20

^a In ppm downfield respect to C₆H₆.

the results (especially regarding resolution) were latter improved either by spectral accumulation^(1968, 20, 21; 1969, 20) or by noise decoupling which washes out all structure arising by coupling to neighbouring protons.^(1968, 22; 1969, 21) Another method is using the INDOR technique, as mentioned for ^{31}P resonance, which involves selective irradiation of the carbon-13 peaks while observing the proton spectrum.^(1968, 3; 1969, 2 to 4)

Some typical carbon-13 shifts of phosphorus compounds are shown in Table II. As is well known (see 1969, 22), one of the interests in carbon-13 data is the sensitivity to charge distributions in molecules since these shifts are less susceptible to spurious effects than found for proton shifts (e.g. solvent effects, diamagnetic anisotropy of neighbours, etc.). For instance, comparison of carbon-13 shifts of methyl phosphines and methyl substituted methanes (Table III) at first sight exclude any hyperconjugation as a major factor in the $\text{P}-\text{CH}_3$ bond. A systematic study of phosphines and phosphonium compounds by Bucci,^(1968, 17) which took into account the lone-pair contribution, revealed only a slight change in phosphorus electronegativity, from 2.4 to 2.2, in going from $(\text{CH}_3)_3\text{P}$ to $(\text{CH}_3)_4\text{P}^{\oplus}$ despite the presence of the positive charge on the phosphonium ion; a charge of similar magnitude but in the reverse direction was expected.[†] Thus some minor interaction in the $\text{P}-\text{CH}_3$ bond seems to be very likely.

This effect is better illustrated when considering conjugated and hetero-atomic systems. For instance, a carbon-13 shift of 85.5 p.p.m. is observed^(1968, 20) in $(\text{EtO})_2\text{P}(\text{O})\text{CH}_2\text{COCH}_3$ compared to 104 in $(\text{CH}_3)_2\text{CO}$ and 57.0 and 28.0 ppm in $(\text{EtO})_2\text{P}(\text{O})\text{C}\equiv\text{C}\cdot\text{CH}_3$ compared to 46 in $\text{Et}\cdot\text{C}\equiv\text{C}\cdot\text{Et}$. In both these cases the observed changes support the presence of conjugation of the phosphoryl group with either the carbonyl or acetylenic group^(1969, 23) as was suggested from consideration of proton and phosphorus resonance.^(1967, 20 to 22) Similar trends are found in hetero-atomic molecules as shown in Table IV.^(1968, 3; 1969, 20) These relations are especially neat for nitrogen in which, as discussed later (see III.B.5), $\text{P}-\text{N}$ conjugation occurs. Conversely, it is noted that the observed changes are relatively insensitive to the nature of the element attached to phosphorus in the $\text{>P}=\text{X}$ group. This was attributed to the anisotropic effect of the phosphoryl or thiophosphoryl groups as these are highly polarisable.^(1968, 3) This interpretation is questionable as it ignores the possible rehybridisation of phosphorus and, in consequence, of the neighbouring atoms.

[†] A similar effect is found in the comparison of tetramethylammonium ion and trimethylamine.^(1961, 1)

TABLE III

Comparison of carbon-13 shifts of methyl phosphines and methyl substituted methanes

CH_3PH_2	134.3	$(\text{CH}_3)_2\text{PH}$	122.9	$(\text{CH}_3)_3\text{P}$	112.5
CH_3CH_3	122.8	$(\text{CH}_3)_2\text{CH}_2$	113.1	$(\text{CH}_3)_3\text{CH}$	104.3

TABLE IV

Comparison of carbon-13 shifts of some phosphorus compounds and some closely related ethers, sulphides and amines

$(\text{CH}_3\text{O})_3\text{P}$	75 to 80	CH_3OH	81
$(\text{CH}_3\text{O})_3\text{P}=\text{O}$	69 to 75	$(\text{CH}_3)_2\text{O}$	69.3
$(\text{CH}_3\text{O})_3\text{P}=\text{S}$	68 to 73		
$[(\text{CH}_3)_2\text{N}]_3\text{P}$	90.7	$(\text{CH}_3)_3\text{N}$	81.2
$[(\text{CH}_3)_2\text{N}]_3\text{P}=\text{O}$	91.5		
$(\text{CH}_3\text{S})_3\text{P}=\text{S}$	110.4	$(\text{CH}_3)_2\text{S}$	109

D. Boron-11 chemical shifts

Boron-11 resonance has been rather frequently investigated in boron containing phosphorus compounds which, in most instances, were borane- or boron halide-adducts (see Section IV). Some data are nevertheless available for typical boron-phosphorus compounds which may be discussed in relation to available ^{11}B literature (for a general review see 1969, 24).

Cage-like structures containing phosphorus have been assigned on the basis of NMR spectra. For instance, in $\text{B}_{10}\text{H}_{10}\text{CHP}$, identified as a 1,2- or 1,7- isomer, the shifts of the main resonance peaks for the isomers differ +14.7 and -9.6 in the former and +13.6 and -3.9 in the latter isomer,^(1969, 25) or in $\text{RR}'\text{PB}_5\text{H}_8$, in which the phosphorus links B-2 and B-3 when $\text{R}=\text{CH}_3$, $\text{R}'=\text{CH}_3$ or CF_3 but resides on B-1 if $\text{R}=\text{R}'=\text{CF}_3$.^(1968, 23)

Other interesting problems solved by ^{11}B resonance include monomer-dimer equilibria in molecules of the type $\text{Cl}_2\text{BNRP}(\text{CF}_3)_2$,^(1968, 24) the structure of $(\text{Me}_3\text{PBH}_2\text{NMe}_3)^{\oplus}$ ($\delta^{11}\text{B} = +8.7$, ref. BF_3 -etherate) which is written $\text{Me}_3\text{PBH}_2^{\oplus}\text{NMe}_3^{\ominus}$ ^(1969, 26) and lastly the nature of the bonding in the compounds shown in Table V compared to corresponding simple boron esters.^(1969, 27)

TABLE V

Comparison of boron-11 shifts of phosphorus containing boron esters
with simple boron esters

	$\delta^{11}\text{B}$		$\delta^{11}\text{B}$
$\text{B}[\text{OP}(\text{CF}_3)_2]_3$	-17.2	$\text{B}(\text{OCH}_3)_3$	-18.3
$\text{CH}_3\text{B}[\text{OP}(\text{CF}_3)_2]_2$	-33.6	$\text{CH}_3\text{B}(\text{OCH}_3)_2$	-29.5
$(\text{CH}_3)_2\text{BOP}(\text{CF}_3)_2$	-60.3	$(\text{CH}_3)_2\text{BOCH}_3$	-53.0

E. Other nuclei

Obtaining resonance data on elements other than those mentioned above is not very easy and available data are therefore rather scarce. The other nuclei will be reviewed according to the method used for observing the resonance.

1. Direct observation of other nuclei

(a) *Nitrogen-14*. The ^{14}N resonance has been investigated in $[(\text{CH}_3)_2\text{N}]_3\text{PO}$ (1964, 2) and in $\text{Et}_2\text{P}(\text{O})\text{NH}\text{Et}$ (1968, 25) but only the chemical shift of the former compound was reported (351 ± 8 p.p.m., ref. NO_3^-). For comparison, one may note that the shifts in $(\text{CH}_3)_2\text{NH}$ and Et_2NCHO are 353 ± 1 and 259 respectively which, at first sight, might imply a negligible delocalisation of the nitrogen lone-pair to phosphorus in structures such as $\text{>N}^+=\text{P}(\text{O}^-)$ (for a general review see 1969, 26). This implication is in contradiction with indirect conclusions drawn from estimation of Lewis basicity (see Section IV) and from dipole moment analysis. (1970, 1) A more profound analysis is certainly required in order to elucidate this problem.

(b) *Oxygen-17*. Christ and Diehl (1963, 1) collected data on a rather large number of compounds (Table VI) some years ago and, on this account, no detailed discussion is possible at present.

(c) *Aluminium-27*. This resonance has only been observed in adducts such as $(\text{CH}_3)_3\text{P} \cdot \text{AlCl}_3$ and $(\text{CH}_3)_3\text{P} \cdot \text{AlBr}_3$ (-108.2 and -100.8 respectively vs AlCl_3) in which ^{27}Al - ^{31}P coupling appears. (1967, 23) This resonance has also been useful for following halogen exchange in Al_2X_6 - POCl_3 mixtures (1969, 28) (see Vol. 5A, p. 465).

2. Indirect observations of other nuclei

The technical difficulties of observing the resonance of other nuclei are often deterring and an elegant solution may be found in the INDOR

TABLE VI
Oxygen-17 data on typical phosphorus compounds
[After Christ and Diehl ^(1963, 1)]

Compounds	Chemical Shifts ^a	Compounds	Chemical Shifts ^a
H ₃ PO ₂	84	(CH ₃ O) ₂ PO	68, 19
H ₃ PO ₃	102	(C ₂ H ₅ O) ₃ PO	66
H ₃ PO ₄	79	(CH ₂ O) ₂ P(O)H	101, 38
(CH ₃ O) ₃ P	45	(C ₄ H ₉ O) ₂ P(O)H	84
(C ₂ H ₅ O) ₃ P	80	Cl ₃ PO	216

^a In p.p.m. downfield vs. H₂O.

technique, previously mentioned for observing ¹³C and ³¹P shifts. The first, perhaps typical applications, have recently been reported for *silicon* and *tin* in (CH₃)₃SiP(C₆H₅)₂ and (CH₃)₃SnP(C₆H₅)₂ ^(1969, 2) and for *selenium* in CH₃SeP(CH₃)₂ and CH₃SeP(S)(CH₃)₂. ^(1969, 4) As a common reference standard has not yet been defined (reference frequency being ¹H resonance of TMS or dioxane according to the authors), the measured shifts are not reported here; the technique certainly appears to be promising for future investigations.

III. SPIN-SPIN COUPLINGS IN PHOSPHORUS COMPOUNDS

A. General considerations and theoretical approach

1. Main features and phenomenological description

The spin-spin couplings observed in phosphorus compounds offer a number of interesting features many of which being particularly challenging for theoreticians. These will be detailed hereafter but to pinpoint the most important we may list:

- (i) relation to the hybridisation of phosphorus
- (ii) marked stereospecificity in many two- and more bond situations.
- (iii) sign reversal appearing especially in typical one-bond couplings for which a positive (or at least, a stable) sign was previously taken as a rule.

The first two points permit the invoking of lone-pair contributions to explain the unusual behaviour in P^{III} compounds as previously proposed for ¹⁵N couplings ^(1969, 28) and was satisfactorily accounted for in this case on the basis of the theoretical treatment of Yonezawa *et al.* ^(1967, 24; 1969, 29)

It is noticeable that lone-pair contributions may intervene in coupling not directly involving but passing *through* the heteroatom; this has been reported in pyrazolines.^(1967, 25) Similarly, the stereospecificity of $H\cdots H$ couplings in **4** for which $J(\text{trans})$ is *ca.* 12 Hz and $J(\text{gauche})$ *ca.* 2 Hz.^{(1968, 27)†} We shall find a similar behaviour later when discussing $H\cdots H$ couplings in trioxaphosphabicyclooctane (see Section III.B.8); a clearer example is afforded by $F\cdots F$ couplings in P_2F_4 —the fluorine atoms are inequivalent and the $FP-PF$ and $FP-PF'$ couplings are opposite in sign.^(1969, 31)

Obviously, phosphorus lone-pair contribution cannot be invoked for explaining the stereospecificity observed in couplings involving P^V atoms, but some evidence has been presented supporting “through-space” contributions [“through-space” meaning via another route other than formal bonds and not arising from direct dipole-dipole coupling which involves a “direct coupling” contribution as discussed by Barfield and Karplus^(1969, 32)]. This is especially clear when fluorine nuclei are involved; for instance, $P\cdots CF_3$ couplings in $(CF_3C_6H_4)_3P$ only appear when the trifluoromethyl group is *ortho*, i.e. sterically very close to the phosphorus atom.^(1969, 33) Many examples of stereospecific proton-phosphorus couplings will be presented to support such “through-space” long-range mechanisms. Just to quote some striking cases, methyl groups in $(CH_3)_2NP(O)F(t-C_4H_9)$ are inequivalent, one with a $P\cdots CH_3$ coupling of 8.2 Hz, the other with a zero coupling (simultaneously, the $F\cdots CH_3$ couplings are 2.0 and 0.0 Hz);^(1965, 8) methylene protons in $HP(C_2H_5)C_6H_5$ present two different couplings (+5.5 and 1.0 Hz) to phosphorus^(1968, 28; 1969, 34) and R' groups have different couplings in $(RO)_2P(O)C(O)NR'_2$.^(1967, 26; 1968, 29) Similarly, “through-space” couplings have been suggested in metal complexes.^(1967, 27) In all cases, observed trends cannot agree with the simple description of Fermi contact terms by a “Hund” coupling mechanism.^(1964, 3)

The same appears to be the case when couplings do not decrease with increasing bond separation as in $\searrow P(O)C(O)CH_2CH_3$, in which $^3J(P-CH_2)$ is less than 0.5 Hz while $^4J(P-CH_3)$ is about 1 Hz. Similarly, the absence of sign reversal when comparing the couplings in a compound and the methyl homologue is an indication of anomalous behaviour. This behaviour has been observed in oximes (**5** and **6**) in which the absolute signs of coupling are known^(1969, 35) for which the coupling involving the *cis* (H) is normal but not so for *trans* (H'); this is in agreement with the possible influence of the nitrogen lone-pair. A similar behaviour will be found in unsaturated phosphorus systems (see Section III.B.7).

† See also^(1969, 30) for a Karplus-like relationship in secondary cyclic alcohols.

2. Theoretical descriptions

The preceeding approach is purely qualitative and the proposed mechanism is only phenomenological. Despite the difficulty of the description of phosphorus orbitals the problem is nevertheless an appealing one for theoreticians and to date two different approaches have been made to a non-empirical description.

(a) *Theoretical approach of Cowley and White.* This method starts from the Pople-Santry formalism^(1964, 4; 1965, 9) of the general Ramsey formula for spin-spin coupling, thus avoiding the "mean excitation energy" approximation which is especially misleading as it necessarily predicts a stable sign for a given type of coupling. As a first step, Cowley, White and Manatt performed calculations for one bond couplings, using extended Huckel and CNDO-SCF molecular orbitals, thus obtaining some qualitative agreement with experimental data as shown in Table VII.^(1967, 28)

TABLE VII
Comparison of some calculated and experimental phosphorus
coupling constants

	EHMO	CNDO-SCF	Experimental
$J(\text{P-H})$ in PH_3	+189.4	+66.6	+182
$\text{PH}_4^{\oplus}$	+213.7	+192.6	+547
$J(\text{P-F})$ in PF_3	-736.2	-424.4	-1441
$J(\text{P-P})$ in " P_2 "	-129.0	-30.5	-180 (in P_2Me_4)

Evidently, this approach did not take into account orbital overlap. These rather gratifying results and the puzzling question of the stereospecificity of coupling and sign reversal prompted the authors to refine their approach by including overlap and bond-geometry in one-bond and higher couplings; again use was made of semi-empirical LCAO-SCF orbitals after the Pople-Santry formalism.^(1969, 36 to 38) They succeeded in reproducing changes in sign of ^{31}P - ^{31}P and ^{31}P - ^{13}C one-bond coupling and of ^{31}P - ^1H two-bond couplings; the general predicted trends qualitatively agreed with experimental finds as shown in Table VIII. One shortcoming has nevertheless been found for P_2F_4 in which $J(^{31}\text{P}$ - $^{31}\text{P})$ is definitely negative;^(1969, 31) further improvements therefore are necessary.

(b) *Theoretical approach of Jameson.* Jameson and Gutowsky^(1969, 39) have been able to account for the reversal of sign of various one-bond

TABLE VIII

Typical couplings calculated by Cowley and White^(1969, 37)

Molecules	Couplings	Calculated value	Experm. value
<i>One-bond couplings</i>			
$\text{PH}_2^\oplus$	P-H	+130.6	139
PH_3	,,	+146.3	+182
$\text{PH}_4^\oplus$	,,	+297.0	+547
P_2H_4 <i>gauche</i>	,,	+169.0	+186 ₅
<i>trans</i>	,,	+160.0	—
<i>cis</i>	,,	+167.6	—
CH_3PH_2	,,	+179.4	+186 ₃
$\text{CH}_3\text{PH}_3^\oplus$	,,	+246.3	—
CF_3PH_2	,,	+122.1	+199 ₈
PF_3	P-F	-1407.3	-1441
P_2F_4 <i>gauche</i>	,,	-1189.5	-1125
<i>trans</i>	,,	-1160.8	—
<i>cis</i>	,,	-1250.7	—
P_2H_4 <i>gauche</i>	P-P	-53.5	-108 ₂
<i>trans</i>	,,	+169.0	—
<i>cis</i>	,,	-84.6	—
P_2F_4 <i>gauche</i>	,,	+219.8	-227.4 ^a
<i>trans</i>	,,	+707.4	—
<i>cis</i>	,,	+212.2	—
CH_3PH_2	P-C	-20.9	9 ₃ ^b
CF_3PH_2	,,	+42.4	—
$\text{CH}_3\text{PH}_3^\oplus$	,,	+7.5	°
<i>Two-bond couplings</i>			
PH_3	H-P-H	-18.8	-13 ₄
CH_3PH_2	,,	-14.1	-12 ₅
CF_3PH_2	,,	-4.0	-13 ₄
HPF_2	H-P-F	+34.4	+41 ₇
CF_3PH_2	P-C-F	+47.9	+48 ₃
CH_3PH_2	P-C-H	+2.9 ₅	+3.9 ₉
$\text{CH}_3\text{PH}_3^\oplus$	,,	-7.7	—

^a (1969, 31).^b (1968, 22) probably negative.° +55₅, +56₅ in $(\text{CH}_3)_4\text{P}^\oplus$ (1968, 3; 1969, 2).

(reduced) couplings $K_{N-N'}$ by separating the contact terms of N and N' , a_N and $a_{N'}$, each of which may be written:

$$a_N = a_N(s) + a_N(\text{core pol})$$

This introduces, besides $a_N(s)$ (the direct Fermi contact term from the

s electrons in an open shell or in accessible configurations with open s shells), an indirect Fermi contact interaction from the polarisation of s electrons in the core. The latter could be the most important if the ground figuration of N is not an open s shell or if no low-lying configurations with open s shells are available. This is the case for Group VI and VII nuclei, such as ^{19}F , but not for Groups I to IV (e.g. ^1H , ^{11}B , ^{13}C); Group V appears to be on the borderline and, according to the state of hybridisation, a_N could be positive or negative.

This model at least provides a rationalisation of the observed trends throughout the table of elements. It has been extended by Jameson to account for two-bond couplings, especially those involving phosphorus. Using localized VB orbitals (s and p orbitals only with perfect pairing), she considered^(1969, 40) reduced geminal couplings $^2K_{XYZ}$ as arising from a_X , a_Y and γ_{XYZ} , a transfer factor for "electron spin information" from the X bonding to the Z bonding orbitals.† The latter term is a function of exchange integrals so it is sensitive to the hybridisation of the Y atom, the bond angles, the substituents etc. The factor, γ , may be positive or negative—its average over all dihedral angles being probably negative (in agreement with "Hund coupling").

This phenomenological model has been used by Jameson^(1969, 40) to explain some typical results which will be discussed in detail later. The first one is the great charge from P^{III} compounds (with a nearly p_3 hybridisation) to $\text{P}^{\text{IV}\oplus}$ and P^{V} compounds (nearly sp_3 , with more p contribution in $\text{P}=\text{X}$ bonds from $\text{X}=\text{Se}$, S to O). For the former, $a_P(s)$ is small and in bonds involving carbon a_P (core pol) becomes predominant, thus giving small positive $\text{P}-\text{C}$ couplings; $\text{P}-\text{H}$ couplings, governed by $a_P(s)$, are also small and positive. If substituents attached to phosphorus have an increasing electronegativity, the s character of the $\text{P}-\text{C}$ bond is increased and the $\text{P}-\text{C}$ coupling becomes positive and $\text{P}-\text{C}-\text{H}$ coupling negative; similarly $\text{P}-\text{H}$ coupling becomes increasingly positive. This whole picture agrees with the rationalisation of experimental data on the basis of the Walsh rule (see ref. 1966, 1, p. 265 *seq.*). For $\text{P}^{\text{IV}\oplus}$ and P^{V} compounds, $a_P(s)$ is greater towards C or H (increasing for $\text{P}^\oplus$, PSe , PS , PO); $\text{P}-\text{H}$ coupling becomes more and more positive, $\text{P}-\text{C}$ coupling positive and $\text{P}-\text{C}-\text{H}$ coupling negative. As both $\text{P}-\text{C}$ and $\text{P}-\text{C}-\text{H}$ couplings have a_P as the dominant term, the close relationship between these two types (see Section III.D.1) is clear enough.

The Jameson model would similarly apply to $\text{H}-\text{P}-\text{H}$ couplings which were investigated by Manatt *et al.*^(1969, 41) In P^{III} compounds (PH_3 ,

† The importance of separating the effects of intervening atoms in the transmission of spin-spin couplings had similarly been stressed for couplings through carbon atoms in saturated chains.^(1962, 1)

CH_3PH_2 , etc.) $^2J(\text{H-P-H})$ are negative and decrease when substituents on phosphorus have an increased electronegativity (e.g. $\text{C}_6\text{H}_5\text{PH}_2$, CF_3PH_2). In $\text{P}^{\text{IV}}\oplus$ compounds [$\text{PH}_4^\oplus$, $(\text{CH}_3)_2\text{PH}_2^\oplus$], $^2J(\text{H-P-H})$ are small and positive; in $\text{H}_2\text{PO}_2^\ominus$, which has a tetrahedral hybridisation with strongly electronegative substituents on phosphorus, the H-P-H coupling is large and positive (despite the rather small H-P-H angle, *ca.* 92°). This latter example caused Manatt *et al.* some puzzlement, but now fits in fairly well with the Jameson approach.

Somewhat similar arguments may be used to discuss P-F (or other) couplings in penta-coordinated compounds which were discussed at some length in ref. 1966, 1, p. 281 *seq.* For the direct P-F couplings, $a_P(s)$ would be the dominating term and $J(\text{P-F}_{\text{ax}})/J(\text{P-F}_{\text{eq}})$ may be directly related to the *s* character of these two orbitals. For couplings through phosphorus (proton-proton, proton-fluorine or fluorine-fluorine), one would have $J(\text{ax-ax})$, $J(\text{eq-ax})$ and $J(\text{eq-eq})$ in a ratio determined by $\gamma(\text{ax-ax})$, $\gamma(\text{eq-ax})$ and $\gamma(\text{eq-eq})$. A closer examination of these transfer factors may be of interest for discussing this type of experimental data.

The various types of couplings encountered involving phosphorus in the order of practical importance, i.e. P-H, P-F, P-P, P-C and others, will now be considered.

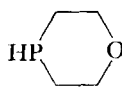
B. Phosphorus coupling to proton and fluorine

1. One-bond P-H and P-F couplings

(a) *P-H couplings.* P-H couplings have been investigated in a large variety of compounds and cover a range from *ca.* 120 to 1180 Hz [in H_2PSiH_3 ^(1963, 2)]. Typical data are given in Table IX for the various types of phosphorus hybridisation. In all cases, where the signs of coupling were determined, these were found to be positive, ^(1966, 13; 1967, 31 and 40; 1968, 28 and 30; 1969, 47 and 48) in clear contradiction with the reasoning of Paolillo and Feretti. ^(1966, 54) It should be emphasised that such determinations were generally made on P^{III} compounds but no obvious reason exists for reversal of sign as no value around zero has yet been reported. Some theoretical considerations regarding these couplings have already been mentioned which agree with the stability of the sign of the coupling, variation in magnitude with the phosphorus hybridisation and substituent electronegativity. Vinogradov and Nicolaiev ^(1969, 49) have recently calculated the P-H coupling in PH_3 and $\text{PH}_4^\oplus$ using the Pople-Santry formalism and the function of the angle ϕ between the P-H bond and the symmetry axis of the molecule. These authors found that the effect of ϕ was marked for the tetrahedral conformation of $(\text{P}^{\text{IV}})^\oplus$ but was relatively of less importance for P^{III} conformations.

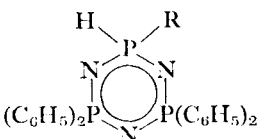
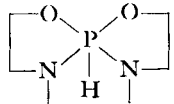
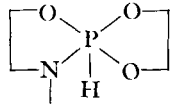
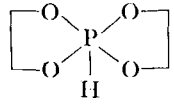
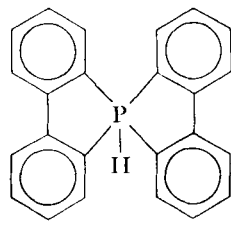
TABLE IX

Typical one-bond phosphorus-proton coupling constants

Compound	Coupling	References
(P^{II})[⊖]		
PH ₂ [⊖]	137 to 140	1965, 10; 1966, 11 and 12
(BH ₃) ₂ ·PH ₂ [⊖]	ca. 320	1969, 42
P^{III}		
PH ₃	182 to 189	1966, 11; 1969, 42
H ₂ PPH ₂	+ 186·5	^a
H ₂ PPF ₂	191	1968, 31
H ₂ PCH ₃	186·4	^a
H ₂ PGeH ₃ ; H ₂ PSiH ₃	180 to 181	1967, 29; 1968, 32
H ₂ PCF ₃	± 187·8	1966, 13
H ₂ PR (R = C ₂ H ₅ to C ₁₂ H ₂₅)	185 to 192	1965, 11; 1966, 14 and 15
H ₂ PCH ₂ PH ₂	190 to 202	1966, 15 and 16
H ₂ P(CH ₂) _n PH ₂ (n = 2 to 41)	190 to 193	1966, 16
H ₂ PC ₆ H ₅	195 to 201	1965, 11; 1966, 17 and 18
		1967, 30
H ₂ PC ₆ F ₅	205·5	1966, 19
HPF ₂	+ 181·7; 182·4	1966, 20; 1967, 31 and 32
HP(CH ₃) ₂	+ 191·6	^a
HP(GeH ₃) ₂ ; HP(SiH ₃) ₂	171 to 187	1967, 29; 1968, 32
HP(CF ₃) ₂	217 to 218	1969, 43
	155	1967, 10
	185	1969, 44
HP(C ₆ H ₅) ₂	214 to 218 (239)	1966, 21; 1967, 30; 1968, 33
HP(C ₆ F ₅) ₂	219	1966, 19
HP(CH ₃)C ₆ H ₅	+ 204·2	1968, 33; 1969, 34
HP(C ₂ H ₅)C ₆ H ₅	+ 205	1965, 11; 1968, 28; 1969, 34
(P^{IV})[⊕]		
PH ₄ [⊕]	547·5 to 548·3	^a ; 1969, 42
(CH ₃) ₃ PH [⊕]	+ 505·5	1966, 22
(CH ₃) ₂ PH ₂ [⊕]	516·6	1966, 22
CH ₃ PH ₃ [⊕]	527·1	1966, 22
(i-C ₃ H ₇) ₃ PH [⊕]	455	1968, 7
P^V		
HP(O)F ₂	844 to 878	1967, 33; 1968, 34
HP(O)F(OH)	1030	1968, 34
HP(O)(CH ₃)C ₆ H ₅	+ 467·8	1968, 33; 1969, 34

^a Quoted in 1968, 30.

TABLE IX (*continued*)

Compound	Coupling	References
$\text{HP(O)(C}_6\text{H}_5\text{)CH}_2\text{C}_6\text{H}_5$	+ 474	1968, 35; 1969, 34
$\text{HP(O)(C}_6\text{H}_5\text{)}_2$	481 to 486	1968, 35 and 36
$\text{HP(O)(OC}_2\text{H}_5\text{)}_2$	688	1967, 34
$\text{HP(O)[N(CH}_3\text{)}_2\text{]}_2$	570	1966, 18
$[\text{HP(O)(O}^\ominus\text{)}]_2\text{O}$	+ 667.5	1968, 37
$\text{HPO}_3^{2\ominus}$	577	1967, 35
$\text{HPO}_2\text{S}^{2\ominus}$	548	1967, 35
HP(S)F_2	725.4	1967, 33
$\text{HP(Se)(i-C}_4\text{H}_9\text{)}_2$	420	1966, 23
$\text{HP(Se)(C}_6\text{H}_5\text{)}_2$	450	1966, 23
HPF_4 (-16°)	1075	1966, 24; 1967, 36
H_2PF_3 (0°)	841	1966, 24; 1967, 36
$\text{H(CH}_3\text{)PF}_3$	850	1968, 38 and 39
$\text{HPF}_2(\text{CH}_3)(\text{OC}_2\text{H}_5)$	850	1967, 37 and 38
$\text{H[(CH}_3\text{)}_2\text{N]}_2\text{P=NR}$	560 to 590	1969, 15
R = CH_3	509	1968, 40
	$\text{R = OC}_6\text{H}_5$ 676	1968, 40
	730 to 810	1967, 39; 1969, 45
	780	1967, 39
	830	1967, 39
	480 to 500	1966, 25; 1969, 46
$(\text{P}^{\text{VI}})^\ominus$		
$[\text{HPF}_4(\text{CF}_3)]^\ominus$	943	1967, 39
$[\text{HPF}_3(\text{CF}_3)_2]^\ominus$	622	1968, 41

Previously Issleib *et al.*^(1966, 27) had found a clear relationship of $J(\text{P-H})$ with the s character, calculated from LCAO-MO orbitals, for $\text{PH}_2^\ominus$ (*ca.* 140 Hz; 17% s), PH_3 (185 Hz; 18% s) and $\text{PH}_4^\oplus$ (550 Hz; 36% s).† Other factors, however, may contribute to these couplings, some arguments have been recently proposed^(1969, 50) to prove the importance of the phosphorus *effective* charge, similar to that found for the effect of the carbon charge on $^{13}\text{C-H}$ coupling.^(1965, 11)

Related to these "electronic" factors, some examples of stereospecific coupling are known. In **7** the geminal protons on phosphorus are non-equivalent and exhibit slightly different couplings to phosphorus, both of which are temperature and solvent dependent.^(1969, 51) A clearer example is given by the recent work of Mikołajczyk^(1969, 52) on the two isomers **8** and **9**.

Isotope effects have also been investigated for the case of hydrogen-deuterium substitution in $(\text{C}_6\text{H}_5)_2\text{PH}$, $\text{C}_6\text{H}_5\text{PH}_2$,^(1967, 30) HPO_3^{2-} , $\text{HP}(\text{O})(\text{OCH}_3)_2$ and other examples.^(1967, 42) Lastly, temperature and solvent effects have also been considered for a variety of cases.^(1967, 43 to 47; 1969, 51 and 53)

(b) *P-F couplings.* P-F couplings vary from *ca.* 750 to 1500 Hz which is a much smaller range than for P-H couplings by nearly $\frac{1}{10}$ (see Table X). Relative signs have been established in P^{III} ^(1967, 28, 31, 40, 55 and 57) and in P^{V} compounds;^(1967, 57; 1969, 31) all are *negative*, the same as for P-F coupling in phosphonitriles (see ref. 1967, 55 and 1969, 68). This has been definitely confirmed by analysing the line-shape of the ^{19}F resonance in solid BaFPO_3 .^(1969, 6 and 7) It was seen in Section III.A, that both the Cowley-White and Jameson theoretical approaches properly account for this observation.

Tri- and tetra- coordinated phosphorus compounds will first be considered. On account of the extreme electronegativity of fluorine, substituent changes in P^{III} compounds do not alter the phosphorus hybridisation too markedly as far as inductive effects are concerned. This is reflected in the rather small range of variation (50%), and in the restricted influence on complexation, of the coupling constants; the latter effect is seen in the case of $(\text{F}_2\text{P})_2\text{O} \cdot \text{BH}_3$ [1328 Hz compared to 1354 Hz in the free ligand^(1968, 34)]. This also accounts for the good correlation of the additivity of group contributions with $J(\text{P-F})$ in compounds of the form XYPF .^(1968, 12) Similarly, the relation of $J(\text{P-F})$

† Such an argument may be used for elucidating the nature of the phosphorus bonding in phosphirane $\text{HP}(\text{CH}_2)_2$ ($J = 155$ Hz).^(1967, 10) On the other hand, it explains changes between P^{III} compounds and their adducts, for instance PH_3 : *ca.* 180 Hz and $\text{PH}_3 \cdot \text{BH}_2\text{Br}$: 405 Hz.^(1967, 41)

TABLE X
Some typical one-bond phosphorus-fluorine couplings

Compound	Coupling	References
P^{III}		
PF ₃	1400 to 1440	1967, 32 and 48
P ₂ F ₄	-1194, -1199	1967, 49; 1969, 31
P(PF ₂) ₃	1225	1968, 42
H ₂ PPF ₂	1134	1968, 31
F ₂ PCl	1380 to 1390	1967, 31
F ₂ PBr	1388	1967, 50
F ₂ PCH ₃	1131 to 1157	1967, 37, 38 and 51; 1968, 42
F ₂ PCCl ₃	1285	1967, 48
F ₂ PCF ₃	1245	1967, 48
F ₂ PCF=CF ₂	-1202	1969, 54, 55
F ₂ PC ₆ H ₅	1110 to 1170	1967, 51 and 52
F ₂ PC ₆ F ₅	1222	1966, 19
F ₂ POCH ₃	1280	1963, 3
F ₂ PN(CH ₃) ₂	1190 to 1197	1965, 12; 1968, 43
F ₂ PCN	1267 to 1273	1966, 28
F ₂ PNCO	1361	1969, 56
F ₂ PNCS	1336	1967, 53
F ₂ POPF ₂	1354 to 1358	1966, 28, 1968, 34
* F ₂ POP(O)F ₂	1032.5	1969, 57 and 58
* F ₂ PSP(S)F ₂	1321.5	1969, 59
F ₂ PSPF ₂	-1306	1969, 31
F ₂ P(NCH ₃)PF ₂	-1261; 1264	1969, 31, 60 and 61
F ₂ P(NC ₆ H ₅)PF ₂	-1252	1969, 61
FPCL ₂	1320	1967, 50
FPBr ₂	1301	1967, 50
FP(CH ₃) ₂	820 to 830	1967, 54; 1968, 12 and 42
FP(CF ₃) ₂	-1013	1967, 48 and 55
FP(OC ₂ H ₅) ₂	1225	1969, 61
FP[N(CH ₃) ₂] ₂	1023 to 1043	^a
FP(NCS) ₂	1252	1967, 53
P^V		
F ₃ PO	1055 to 1080	1966, 29; 1969, 62
F ₂ P(O)H	1114 to 1122	1967, 33; 1968, 34
F ₂ P(O)Br	1203	1967, 56
F ₂ P(O)(<i>t</i> -C ₄ H ₉)	1169	1965, 8; 1966, 30
F ₂ P(O)CF ₃	1215	1968, 44
F ₂ P(O)C ₆ H ₅	1105	1968, 45

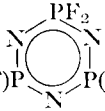
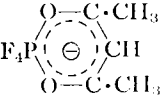
^a Quoted in 1968, 30.

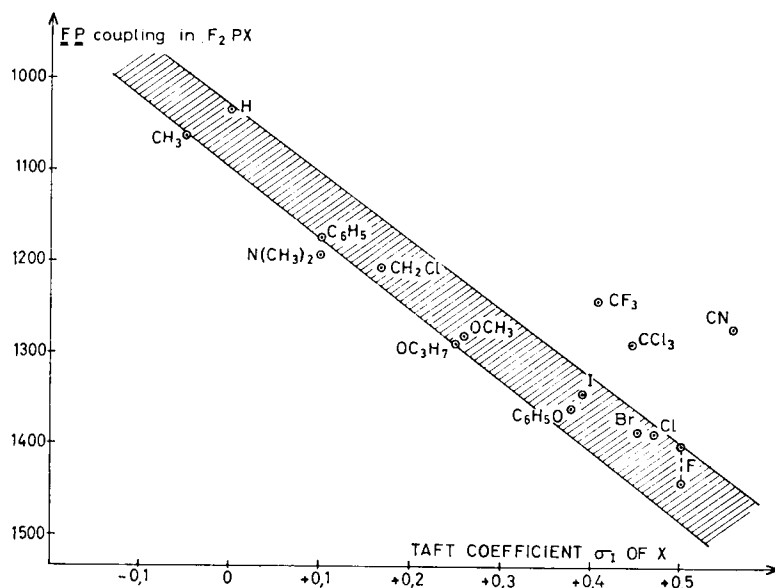
TABLE X (continued)

Compound	Coupling	References
P^v		
F ₂ P(O)N(CF ₃) ₂	1065	1966, 31
F ₂ P(O)OC ₂ H ₅	1012	1967, 53
F ₂ P*(O)OPF ₂	1412	1969, 58
F ₂ P(O)OP(O)F ₂	-1062.9	1969, 62
FP(O)(OC ₃ H ₇ - <i>i</i>)	-955	1967, 57
FP(O)H(OH)	1030	1968, 34
FP(O)Br ₂	1263	1967, 56
F ₃ P(S)	1170 to 1184	1965, 13; 1966, 8
F ₂ P(S)H	1153	1966, 32; 1967, 33
F ₂ P(S)Cl	1220	1966, 8
F ₂ P(S)OCH ₃	1126	1968, 45
F ₂ P(S)SCH ₃	1207	1968, 45
F ₂ P(S)N(CH ₃) ₂	1079 to 1082	1966, 30; 1968, 46
F ₂ P(S)OP(S)F ₂	-1168.2	1969, 17
FP(S)(CF ₃) ₂	1174.6	1968, 47
FP(S)Cl ₂	1240	1967, 58
FP(S)[N(CH ₃) ₂] ₂	1016	1968, 46
P^v pentacoordinate		
PF ₅	938 ^b	1969, 63
PF ₄ H	944 to 980	1966, 24; 1967, 36
PF ₄ (CF ₃)	802 (F _a)	1968, 48
PF ₄ (SCH ₃)	1032	1969, 62
PF ₄ [N(CH ₃) ₂]	836	1967, 59; 1969, 64
PF ₄ Cl	1085	1968, 49
PF ₃ H ₂	860 to 877	1966, 24; 1967, 36
PF ₃ H(CH ₃)	795 (F _a); 965 (F _e)	1968, 38, 39
	805 (F _a); 968 (F _e)	1968, 42
PF ₃ (CF ₃) ₂	968 (F _a)	1968, 48
PF ₃ Cl[N(CF ₃) ₂]	930 (F _a); 1030 (F _e)	1966, 31
PF ₃ (CH ₃)[N(CH ₃) ₂]	804 (F _a); 957 (F _e)	1965, 12
$ \begin{array}{c} \text{N(CH}_3\text{)} \\ \diagup \quad \diagdown \\ \text{F}_3\text{P} \quad \quad \text{PF}_3 \\ \diagdown \quad \diagup \\ \text{N(CH}_3\text{)} \end{array} $	894	1969, 65
PF ₂ H(CH ₃) ₂	535	1968, 42
PF ₂ (CH ₃) ₃	541	1967, 60
PF ₂ (C ₆ H ₅) ₃	659 to 664	1967, 61; 1968, 303
PF ₂ (CF ₃) ₃	881	1968, 48
PF ₂ (OC ₆ H ₅) ₃	721	1967, 61
PF ₂ [N(CH ₃) ₂] ₃	707	1967, 61
PF ₂ Cl ₂ (CF ₃)	1085	1969, 66

^b Previously reported as 1080 from oxidised PF₅(POF₃).

TABLE X (continued)

Compound	Coupling	Reference
P^V pentacoordinate		
PFCl ₃ (CF ₃)	1000	1967, 62
	PF ₂ : 879 to 898	1968, 50
C ₆ H ₅ (F)P  P(F)C ₆ H ₅	P(F)C ₆ H ₅ 939 to 965	
PF ₂ (C ₆ H ₅)=NCN	1132 to 1140	1967, 63
(P^{VI})[⊖]		
PF ₆ [⊖]	706	1969, 67
PF ₅ S ^{2⊖} (?)	718 (F _a); 909 (F _e)	1968, 46
PF ₅ CF ₃	810	1969, 67
PF ₄ H(CF ₃)	858	1969, 67
	725 to 834 (F _e)	1968, 41
PF ₄ (CF ₃) ₂	884	1969, 67
	714, 824	1966, 33

FIG. 2(a). P-F couplings as a function of the inductive effect of the X substituents for F_2PX .

to substituent constants is generally good (Figs. 2a and 2b); Walsh's rule was found to be generally applicable except for very bulky groups such as CF_3 , CCl_3 ^(1968, 30) and CN . Another cause of discrepancy may be the conjugation of substituents to phosphorus ^(1966, 34) which may be sufficient to stabilize conformers. In 10 two isomers were identified

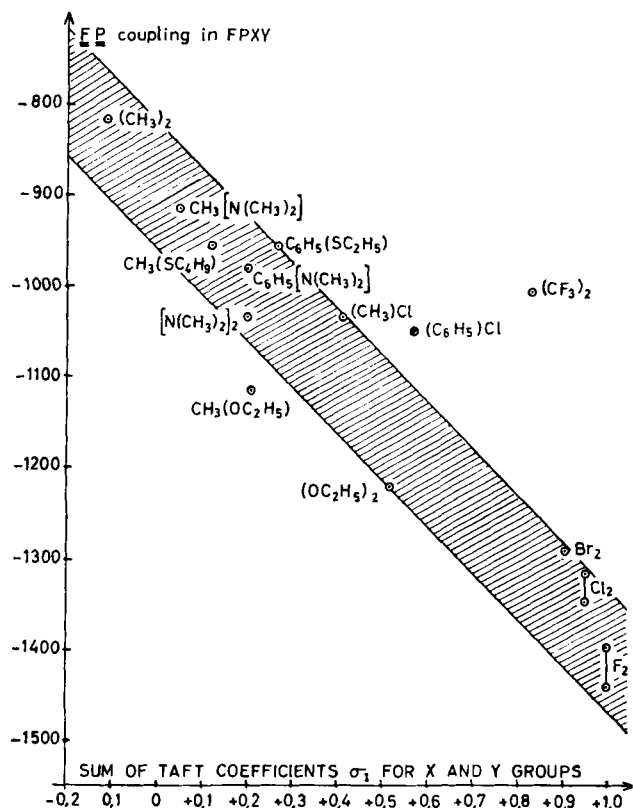


FIG. 2(b). P-F couplings as a function of the X and Y substituents for FPXY compounds.

which have different P-F couplings namely 1071 and 1011 Hz. ^(1965, 8) Related to this has been some solvent and variable temperature studies. ^(1968, 51; 1969, 31)

When considering P^{V} compounds, trends are not so clear as any change is accompanied by a complete rehybridisation of phosphorus, especially in phosphorylated series. Nevertheless, additivity rules are approximately obeyed in compounds of type $\text{XYP}(\text{Z})\text{F}$, ^(1969, 69) for

which Fluck determined the following increments (1200 Hz being taken as the reference value):

=O	0	-SR	-70
=S	+110	-OR	-90
-Br	+20	-NR ₂ and -NCS	-130
-Cl	0	-NCO	-140
-F	-60	-NH ₂	-160

Penta-coordinated fluorophosphoranes have been extensively considered by Schmutzler^(1965, 12 and 14) and discussed in detail in ref. 1966, 1, p. 281 *seq.* The special interest was in the existence of two well-defined types of fluorine substituents, as well as for the hexa-coordinated (P^{VI})[⊖] compounds. Fluorine exchange generally occurs by pseudorotation† but steric hindrance, substituent conjugation and low temperatures may stabilize fluorine atoms in their respective position. As a rule (see Section IV.B.3), the fluorine atoms first occupy the two axial positions—which may not be equivalent^(1967, 64) as in F₂P(C₆H₅)₂SCH₃ in which the P-F couplings are 694 and 823 Hz^(1969, 62)—then one or more of the three [four for (P^{VI})[⊖]] equatorial positions are occupied.

As was discussed in the earlier review,^(1966, 1, p. 282 *seq.*) P-F_a bonds are larger than P-F_e^(1965, 15 and 16; 1966, 35; 1969, 70) and, having a lower *s* character, have smaller coupling constants which become even smaller when the electronegativity of the other substituents decreases. In addition to the data reported in 1966, 1, this point may be further illustrated by considering the P-F_{ax} coupling in F₂PXYZ compounds (Fig. 3); the only major exceptions to the relationship of these couplings with substituent electronegativity arise from the presence of bulky substituents, such as OC₆H₅ or, to a lesser extent, OCH₃, or CF₃; the latter groups may occupy axial positions (see later Section IV.B.3) as in (P^{VI})[⊖] compounds, for instance in **11**.^(1968, 41)

2. P-H and P-F couplings through carbon atoms

When discussed in the earlier review^(1966, 1, p. 266 *seq.*) P-C-H, P-C-C-H and higher couplings presented a number of interesting features in relation to the nature of the bonds in the relevant molecules; some gross trends were explained on the basis of hybridisation (and especially *s* character) changes induced by substituents. Similar arguments were used by Manatt and co-workers when considering newer data with signs of couplings.^(1966, 13; see also 1968, 30) Ignoring the signs of couplings does not present any understandable correlations;^(1965, 17; 1966, 36) as we shall see

† Line width measurements at variable temperature^(1969, 64) agree with the mechanism proposed by Berry.^(1960, 1)

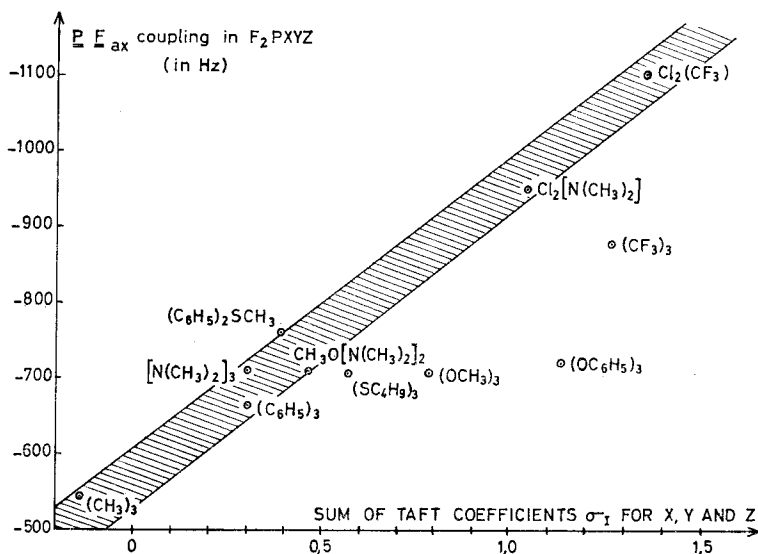


FIG. 3. P-F couplings in F_2PXYZ compounds as a function of the inductive effects of the X, Y and Z groups.

later this point is now better appreciated. Another point which has in the meantime been clarified is the strong stereospecific dependence of these couplings. In all cases, where some conformational preference exists, observed couplings reflect this aspect in addition to the dependence upon bond nature [and possibly on the net charge on phosphorus (see 1969, 50)]. This makes the discussion of P-H couplings through carbon atoms more interesting although naturally more difficult; the same applies to P-F couplings in similar situations. The various aspects of relevant couplings will each be considered in turn.

(a) *P-C-H couplings.* These couplings are known in a wide variety of compounds and some typical data are given in Table XI. Their dependence upon substituents has been discussed for various representative acyclic compounds by Gallagher^(1968, 56) but, as earlier pointed out, the relevant hybridisation change cannot clearly be the only governing criteria.^(1965, 19; 1966, 36)

This is especially true for trivalent compounds for which no clear correlation pattern could be found. When the signs are considered (these changes being more sensitive in P^{III} compounds as suggested in 1966, 1) it is then possible to highlight the importance of geometrical factors as will now be exemplified.

TABLE XI
Some typical values of P-C-H couplings

Compound	Coupling, Hz	References
p^{III}		
P(CH ₃) ₃	+2.7	1969, 2
P(C ₂ H ₅) ₃	-0.5	^a
P(CH ₂ OH) ₃	6.6	1968, 52
P(CH ₂ O) ₃ P	+9.3	1966, 37; 1969, 3
P(CH ₂ O) ₃ CR	7.8 to 8.5	1966, 37; 1968, 53; 1969, 71
HP(CH ₃) ₂	+3.6	^a
FP(CH ₃) ₂	5.9 to 6.0	1967, 65 and 66
ClP(CH ₃) ₂	8.3 to 8.7	^a
C ₆ H ₅ P(CH ₃) ₂	+3.0; 2.7 to 3.6	1968, 7 and 54
C ₆ F ₅ P(CH ₃) ₂	5.4	1966, 19
(CH ₃) ₂ NP(CH ₃) ₂	5.5 to 5.7	1965, 18; 1966, 38; 1969, 72
CH ₃ SeP(CH ₃) ₂	+7.0	1969, 4
(CH ₃) ₂ PP(CH ₃) ₂	+6.9	^a
(CH ₃) ₂ P(S)P(CH ₃) ₂ [*]	+4.1	^a
(CF ₃) ₂ P·P(CH ₃) ₂	6.2	1968, 55
H ₂ PCH ₃	+4.1	^a
F ₂ PCH ₃	10.2 to 10.4	^a
Cl ₂ PCH ₃	17.5 to 17.7	1966, 36
(CF ₃) ₂ PCH ₃	4.8	^a
H(H ₃ Si)PCH ₃	+3.7	1969, 73
(C ₆ H ₅) ₂ PCH ₃	4.0 to 5.0	1967, 65; 1968, 7 and 54
Cl ₂ PCH ₂ CH ₃	15.0	^a
(p^{IV})[⊕]		
P [⊕] (CH ₃) ₄	-14.6; 15.1	1966, 39; 1968, 54; 1969, 2
P [⊕] (C ₂ H ₅) ₄	-12.6	1966, 22
HP [⊕] (CH ₃) ₃	-15.7	1966, 22
HP [⊕] (C ₂ H ₅) ₃	-12.7	1966, 22
(CH ₃) ₂ NP [⊕] (CH ₃) ₃	13.4	1965, 18
H ₂ P [⊕] (CH ₃) ₂	-17.0	1966, 22
[(CH ₃) ₂ N] ₂ P [⊕] (CH ₃) ₂	13.5 to 13.8	1965, 18; 1967, 67
H ₃ P [⊕] CH ₃	-17.6	1966, 22
(<i>t</i> -C ₄ H ₉) ₃ P [⊕] CH ₃	13	1967, 68
(CH ₃ O) ₃ P [⊕] CH ₃	17.2	1967, 69
[(CH ₃) ₂ N] ₃ P [⊕] CH ₃	14.1 to 14.5	1965, 18; 1967, 67 and 70
p^V tetracoordinate		
OP(CH ₃) ₃	-12.8 and -13.4	1967, 71
OP(CH ₂ O) ₃ PO	7.8	1966, 37
OP(CH ₂ O) ₃ CR	5.6 to 7.4	1966, 37; 1968, 53
OP(CH ₃)F ₂	19 to 19.9	1969, 20 and 74
OP(CH ₃)Cl ₂	16.2 to 17	1969, 20 and 74

TABLE XI (*continued*)

Compounds	Coupling, Hz	References
P^V		
OP(CH ₃)(OCH ₃) ₂	17.4	1969, 20
OP(CH ₃)(SCH ₃) ₂	13.9	1969, 20
OP(CH ₃)(C ₆ H ₅)H	-13.8	1969, 34
SP(CH ₃) ₃	-13.0	^a
SP(CH ₃) ₂ H	14.4	1966, 40
SP(CH ₃) ₂ SeCH ₃	-12.7	1969, 4
SP(CH ₂ O) ₃ CR	5.3 to 7.3	1968, 53
SP(CH ₃)(<i>t</i> -C ₄ H ₉)H	13.4	1968, 2
SP(CH ₃)(<i>t</i> -C ₄ H ₉)OH	12.3	1968, 2
SP(CH ₃)(OH)(OR)	15.8 to 16.0	1967, 72
P^V pentacoordinate		
(CH ₃) ₃ PF ₂	17.2	1967, 60
(CH ₃) ₃ PCl[N(CH ₃) ₂]	14.0	1968, 54
(CH ₃) ₃ P=NSi···	12.4 to 12.5	1967, 73
(C ₂ H ₅) ₃ P=NSi···	10.2 to 10.5	1967, 73
(CH ₃) ₂ PF ₂ H	18.3	1968, 42
CH ₃ PF ₃ H	17.6 to 18	1968, 38, 39 and 42
C ₂ H ₅ PF ₃ H	18.5	1968, 38 and 39

^a Quoted in reference 1968, 30.

(i) *Signs* have been determined for various P^{III} compounds. ²*J*(P-C-H) are positive in all cases involving methyl groups such as in (CH₃)₃P, (CH₃)₂PH, CH₃PH₂, (CH₃)₂P·P(CH₃)₂, etc.; (1966, 13; 1968, 28, 33 and 57; 1969, 2, 4, 34 and 73) this is also true for ethyl groups. The two methylene protons of C₂H₅PH(C₆H₅) or of ClCH₂PH₂ are non-equivalent and both have positive coupling constants. (1968, 28 and 58; 1969, 34) In both the cases of ClCH₂PCl(NR₂) and C₆H₅CH₂PH(C₆H₅), the two non-equivalent methylene protons have, besides one largely positive, one slightly negative coupling; (1968, 59; 1969, 34) both couplings, however, remain positive in P(CH₂O)₃P. (1969, 3)

For (P^{IV})⁺ ions, the only determination, carried out on P(CH₃)₄⁺, gave a negative sign for the coupling (1969, 2) in agreement with the suggestions of Allen *et al.* (1968, 60) Likewise, all known signs in P^V compounds, either with phosphoryl [CH₃P(O)H(C₆H₅), etc.] or with thiophosphoryl groups [(CH₃)₂P(S)SeCH₃], are negative. (1968, 33; 1969, 4 and 34)

Thus, it clearly appears that sign reversal occurs in this coupling system. As will be seen later, this is partly dependent upon molecular geometry and upon nature of substituents, but the main factor is the

hybridisation of the phosphorus. This is illustrated by the change of sign observed in $P(CH_3)_3$ when complexed with some Lewis acid, e.g. $AlEt_3$; the phosphorus hybridisation changes from nearly p_3 to sp_3 and the $^2J(P-C-H)$ coupling changes from positive to negative when the $AlEt_3$ concentration is increased. ^(1966, 41; see also 1968, 53) This was taken as an indication of the existence of two competing mechanisms involving opposite signs, one at least being highly dependent upon the molecular geometry. ^(1968, 30) The absence of the reversal of sign from $P-C-H$ to the relevant $P-C(CH_3)$ coupling (both being positive for P^{III} compounds) and the rather general anomaly $-|J(P-C-C-H)| > |J(P-C-H)|$ - point to the same conclusion as discussed earlier (Section III.A.1), especially for trivalent phosphorus. This, however, would be valid in addition for other hybridisations as observed in such compounds as **12** in which $^3J(P-C-CH_3)$ is 13 Hz while in **13** the $^2J(P-CH)$ coupling is zero. ^(1967, 74)

Apart from this phenomenological description and that of Jameson, we have seen that the theoretical approach of Cowley and White was capable of reproducing this behaviour (Section III.A.2). It would therefore be interesting to similarly investigate the geometrical dependence which will now be considered.

(ii) The *stereospecificity* of $^2J(P-C-H)$ is clearly revealed by observations on various compounds having some degree of asymmetry such as in $ClCH_2PH_2$ and especially in $ClCH_2P(Cl)N(CH_3)_2$ in which hindered rotation affords different $P-C-H$ couplings at room temperature ($+19.4$, $+7.6$ and $+26$, -3 Hz respectively). ^(1968, 58, 59) Similarly, the $P-C-H$ couplings involving the axial and equatorial methyl groups 1-methyl in phosphorinanes also differ; ^(1967, 75) the same is found in $(P^{IV})^\oplus$, e.g. **14** and **15**, P^V , e.g. **16** and **17** ^(1968, 61) and pentacoordinated compounds (**18** and **19**) ^(1969, 75); in **20** the two $P-C-H$ couplings have been reported to be different. ^(1967, 76)

All this data has prompted various authors to present a discussion of $P-C-H$ couplings as a function of the molecular geometry and more especially of the dihedral angle $H-C-P$: or $H-C-P=X$. ^(1967, 77; 1968, 30) A more complete analysis has been presented by Albrand *et al.* ^(1968, 62; 1969, 76) (Fig. 4) to improve the Karplus-like description of $^2J(P-C-H)$ values for trivalent phosphorus. As is seen zero coupling is possible with a dihedral angle of about 45° ; the CH and CH_3 resonances appear as singlets in **21** ^(1966, 42) and **22** ^(1967, 78; 1969, 77) respectively.†

The same stereospecificity is probably the origin of the marked

† The extension of this curve for $(P^{IV})^\oplus$ and P^V compounds has not actually been considered. It would be necessary to take into account such unusual couplings as observed in **23** and **24**. ^(1968, 63)

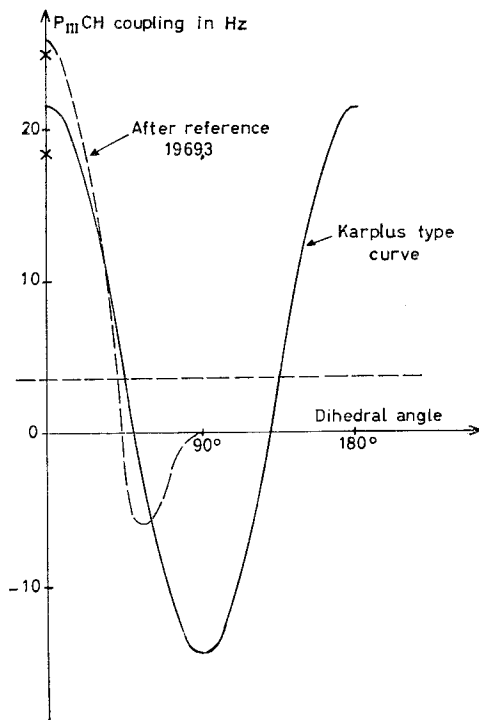


FIG. 4. Geometrical dependence of P-C-H couplings in derivatives of trivalent phosphorus.

changes observed when the conformation of the PCH group is perturbed, for instance by increasing chain length. This effect is especially sensitive in P^{III} compounds, for example in $CH_3P(C_6H_5)_2$, $^2J(P-CH)$ is 5.0 Hz while in $CH_3 \cdot CH_2 \cdot P(C_6H_5)_2$ the same coupling is only 1.5 Hz; ^(1967, 79) from Fig. 4 this would indicate the importance of a preferred conformation (25 and 26). (In agreement with this, an increase is expected for $P-C-C-H$ couplings with increasing chain length; see below.) Similar effects are found in penta-coordinated phosphorus compounds, e.g. compare 27 and 28, while in the homolog acyclics the difference in J value is by no means as great (29 and 30).

(b) $P-C-C-H$ couplings. Typical values for this coupling are given in Table XII and have been found to be positive, in all cases where sign determination has been performed, in both P^{III} [e.g. $t-C_4H_9P(C_6H_5)_2$ and $C_2H_5P(C_6H_5)H$] and P^V compounds [e.g. $C_2H_5P(O)(OC_2H_5)C_6H_5$ and $ClCH_2CH_2P(S)Cl_2$]. ^(1968, 28; 1969, 2, 34 and 79)

TABLE XII
Some typical values of $^3J(\text{P-C-CH})$

Compound	Coupling	References
p^{III}		
$\text{P}(\text{C}_2\text{H}_5)_3$	+13.7	^a
$\text{P}(i\text{-C}_3\text{H}_7)_3$	11.5	1968, 7
$\text{P}(t\text{-C}_4\text{H}_9)_3$	9.8	1969, 78
$\text{C}_6\text{H}_5(\text{C}_2\text{H}_5)_2$	ca. 14	1968, 7
$\text{C}_6\text{H}_5\text{P}(i\text{-C}_3\text{H}_7)_2$	15.2	1968, 7
$\text{C}_6\text{H}_5\text{P}(t\text{-C}_4\text{H}_9)_2$	+12.3	1969, 2
$\text{H}_2\text{N}\cdot\text{P}(t\text{-C}_4\text{H}_9)_2$	11.0	1968, 64
$(\text{C}_6\text{H}_5)_2\text{PC}_2\text{H}_5$	16.5	1967, 79
$(\text{C}_6\text{H}_5)_2\text{PC}_4\text{H}_9\text{-}t$	12.3	1967, 79
$(\text{H}_2\text{N})_2\text{PC}_4\text{H}_9\text{-}t$	12.5	1968, 65
(P^{IV})[⊕]		
$\text{P}^\oplus(\text{C}_2\text{H}_5)_4$	+18.1	1966, 22
$\text{HP}^\oplus(\text{C}_2\text{H}_5)_3$	+20.0	1966, 22
$\text{HP}^\oplus(i\text{-C}_3\text{H}_7)_3$	18.0	1968, 7
$\text{CH}_3\text{P}^\oplus(t\text{-C}_4\text{H}_9)_3$	15	1967, 68
$\text{HP}^\oplus(\text{C}_6\text{H}_5)(\text{C}_2\text{H}_5)_2$	21.5	1968, 7
$\text{HP}^\oplus(\text{C}_6\text{H}_5)(i\text{-C}_3\text{H}_7)_2$	20.6	1968, 7
P^V		
$\text{P}(\text{O})(\text{C}_2\text{H}_5)_3$	+18	^a
$\text{CH}_3\text{OP}(\text{O})(i\text{-C}_3\text{H}_7)_2$	15.7	1968, 65
$\text{ClP}(\text{O})(t\text{-C}_4\text{H}_9)_2$	16.2	1965, 8
$\text{F}_2\text{P}(\text{O})\text{C}_4\text{H}_9\text{-}t$	19.0	1965, 8; 1966, 30
$\text{Cl}_2\text{P}(\text{O})\text{C}_4\text{H}_9\text{-}t$	25.0	1965, 8
$\text{P}(\text{S})(t\text{-C}_4\text{H}_9)_3$	14	1967, 68
$\text{HP}(\text{S})(\text{CH}_3)\text{C}_4\text{H}_9\text{-}t$	18.5	1968, 2
P pentacoordinate		
$\text{C}_2\text{H}_5\text{PF}_3\text{H}$	26.4	1968, 39
$t\text{-C}_4\text{H}_9\text{PCl}(\text{NHSi}\cdots) = \text{N}\cdots$	20.4	1968, 65

^a Quoted in reference 1966, 1.

Despite the smaller effects, compared with $P\text{-C-}H$ couplings, stereospecificity of vicinal $P\text{-C-C-}H$ couplings is well documented, in agreement with earlier proposals of Ben Ezra when studying phosphonates. ⁽¹⁹⁶⁶⁾
⁴³⁾ Typical examples may be found in acyclic compounds with discernible rotamers as in $i\text{-C}_3\text{H}_7\text{P}(\text{C}_6\text{H}_5)\text{N}(\text{CH}_3)_2$ in which $P\text{-C-CH}_3$ couplings are 17.9 and 13.4 Hz for the two non-equivalent methyls of the isopropyl group ^(1967, 80) or in $(i\text{-C}_3\text{H}_7)_2\text{PC}_6\text{H}_5$ where the corresponding

couplings are 14.7 and 11.0 Hz.^(1968, 66) Likewise, significant differences have been observed in the isomers of *t*-C₄H₉P(O)(F)N(CH₃)₂ [16.9 and 15.6 Hz]^(1965, 8) or for the geminal methyl groups in (C₆H₅)₂P(O)-C(CH₃)₂CH(C₆H₅)NHC₆H₅ [16 and 14 Hz],^(1967, 76) in (CH₃)(C₆H₅)-P(O)C(CH₃)₂CH(CH₃)C(CH₃)C₆H₅ [19.5 and 17.0 Hz]^(1968, 67) or in CH₃P(O)(C₆H₅)C(CH₃)₂*i*-C₃H₇ [16 and 15 Hz].^(1968, 68) The effect involving the methylene groups is much larger in (C₆H₅)₂P(S)CH-(CO₂H)CH₂·C₄H₉-*t* [19.0 and 2.5 Hz].^(1966, 44)

Phosphorus ring systems also present the same stereospecificity and, once more, facilitate the assignment of the relevant geometry. Such examples were first described by Churi^(1967, 81) while studying epoxy-alkylphosphonates (**31** and **32**) and by Cremer and Chorvat^(1967, 82) in phosphetanes in which the non-equivalent ³J(P-C-CH) couplings involving the methyl and methylene groups are shown in **33** and **34** respectively. This similar effect has been found in phosphonium ions (e.g. **35**), in the isomeric phosphorus(V) compounds (**36** and **37**)^(1968, 61) and for the non-equivalent methyl groups in **38**^(1968, 67) and in various dimethyl bicyclo[2.2.1]heptyl phosphonates.^(1969, 80) These results permitted Benézra to propose a Karplus-like dependence for the relevant *P-C-C-H* couplings. Further data were obtained by Cox and Adelman^(1969, 81) on various compounds of the form (CH₃O)₂P(O)CH₂CH₂X and by Bothner-By and Cox^(1969, 79) while analysing the rotamers in Cl₂P(S)-CH₂CH₂Cl during a detailed variable-temperature investigation. These authors concluded in proposing the dihedral dependence of *P-C-C-H* couplings shown in Fig. 5.

Such an angular dependence may be the origin of the trends observed when systematically comparing homologous couplings in *n*-alkyl groups; when these are larger such conformations as shown in **39** are probably stabilised, thus resulting in larger couplings following the upper curve. This is found, for instance, in C₂H₅(*t*-C₄H₉)P(O)Cl in which the ³J(P-H) is 23 Hz for the ethyl group and 26 Hz for the *t*-butyl group;^(1966, 45) in agreement with this picture, the opposite change is expected (and observed) for the relevant *P-C-H* couplings as discussed earlier.

This behaviour is not restricted to triply- or quadruply- connected compounds as is seen in the pentacoordinated compound (**40**)^(1967, 76) but experimental data on this latter type of compound are rather scarce.

(c) *Higher PC...CH couplings.* These are far less well documented but in general appear to present similar features.^(1969, 82, 83) The stereospecificity of ⁴J(P-C-C-C-H) has been clearly indicated from the observations of Churi^(1967, 81) on **41**. Cremer and Chorvat have reported other examples in the phosphetane derivatives;^(1967, 82) this, together

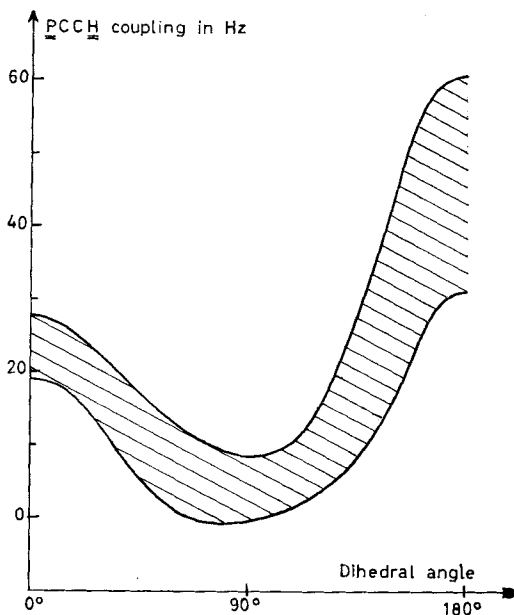


FIG. 5. Geometrical dependence of P-C-C-H couplings [From Bothner-By and Cox, (1969, 79)]

with the rigid systems such as bicyclo[2.2.1]heptyl derivatives investigated by Benezra,^(1969, 80) are characteristic W-type couplings. Use of this stereospecificity has been made by Ross and Martz for the assignment of the conformation of cholestanyl phosphonate and related compounds.^(1969, 83)

(d) *P-C-F couplings*. Typical values for these couplings are shown in Table XIII; it will be noted that no value is less than 40 Hz. In all cases, where the sign has been determined, the couplings were found to be positive as, for example, in $(\text{CF}_3)_2\text{PF}$ of +89.6 and $(\text{CF}_3)_2\text{PSCF}_3$ of +83.8 Hz^(1967, 40, 55 and 57) based upon the negative sign for the P-F coupling which had been established earlier. Thus, in contrast to the corresponding P-C-H couplings, the P-C-F couplings undergo no reversal in sign. As discussed in Section III.A, the observed sign of coupling agrees with the theoretical conclusions of Cowley and White and of Jameson.

Relatively few examples of the stereospecificity of P-C-F couplings exist in the literature but the general features are similar to that found for P-C-H couplings. It is observed for instance, that in the neat sample of

TABLE XIII

Some typical values of P-C-F couplings

Compounds	Coupling	References
p ⁱⁱⁱ		
(CF ₃) ₃ P	85.5	^a
(CF ₃) ₂ PH	68.6 to 70.0	1969, 43
(CF ₃) ₂ PF	+ 89.6	1967, 48 and 55
(CF ₃) ₂ PCl	85.1	^a
(CF ₃) ₂ PBr	80.6	^a
(CF ₃) ₂ PCN	73.2	^a
(CF ₃) ₂ PCH ₃	76.7	^a
(CF ₃) ₂ PN(CH ₃) ₂	85.6	^a
(CF ₃) ₂ PN(CF ₃) ₂	149.4	1968, 68
(CF ₃) ₂ P•P(CH ₃) ₂	64.1 to 64.2	1967, 83; 1968, 55
(CF ₃) ₂ POC ₂ H ₅	86.6	^a
(CF ₃) ₂ PSCH ₃	77.8	^a
(CF ₃) ₂ PSCF ₃	+ 83.8	1967, 48
(CF ₃) ₂ P•S•P(S)(CF ₃) ₂	82.5	1969, 57
(CF ₃) ₂ PSeCF ₃	77.2	^a
(CF ₃) ₂ P•P(CH ₃) ₂	64.1	1967, 83
CF ₃ PF ₂	87.2	1967, 48
CF ₃ PCl ₂	79.9	^a
CF ₃ PBr ₂	69.6	^a
CF ₃ PI ₂	52.1	^a
CF ₃ PH ₂	48.5	^a
CF ₃ P[N(CH ₃) ₂] ₂	87.4	^a
CF ₃ P[N(CF ₃) ₂] ₂	113.7	1968, 69
CF ₃ P[P(CH ₃) ₂] ₂	40.2	1967, 83
(CF ₃ CF ₂ CF ₂) ₂ PF	62.1	^a
CF ₃ CF ₂ CF ₂ PF ₂	90.5	^a
p ^v		
(CF ₃) ₃ PO	113.4	^a
(CF ₃) ₂ P(O)CH ₃	99	1969, 84
(CF ₃) ₂ P(O)OCH ₃	120	1969, 84
CF ₃ P(O)F ₂	162	1968, 44
CF ₃ P(O)Cl ₂	151	1968, 70
(CF ₃) ₃ PS	108.7	^a
(CF ₃) ₂ P(S)F	128.6	1968, 47
(CF ₃) ₂ P(S)Cl	123.1	1968, 47
(CF ₃) ₂ P(S)Br	119.7	1968, 47
(CF ₃) ₂ P(S)I	111.4	1968, 47
(CF ₃) ₂ P(S)N(CH ₃) ₂	102.9	1968, 47
(CF ₃) ₂ P(S)SH	110.0	1968, 47
(CF ₃) ₂ P(S)•S•P(CF ₃) ₂	111.7	1969, 57

^a Quoted in reference 1968, 30.

TABLE XIII (*continued*)

Compounds	Coupling	References
P^v pentacoordinate		
(CF ₃) ₂ PCl ₂ [N(CF ₃) ₂]	187.3	1969, 85
(CF ₃) ₂ PCl ₃	193 (CF ₃ axial)	1967, 62
(CF ₃ CF ₂ CF ₂) ₂ PF ₃	125	1969, 66
CF ₃ PF ₂ Cl ₂	165	1969, 66
CF ₃ PFCl ₃	149	1967, 62
CF ₃ PCl ₄	154	1967, 62
CF ₃ CF ₂ CF ₂ PF ₄	124	1969, 66
CF ₃ CF ₂ CF ₂ PF ₂ Cl ₂	128	1969, 66
(P^{VI})[⊖]		
(CF ₃) ₂ PF ₃ H [⊖]	132	1968, 41
CF ₃ PF ₄ H [⊖]	156	1969, 67
CF ₃ PF ₅ [⊖]	145	1969, 67
(CF ₃) ₂ PF ₄ [⊖]	145	1969, 67

CH₂ClCF₂P(Cl)N(CH₃)₂ the geminal fluorine atoms of the CF₂ group are non-equivalent and have different couplings, but of the same sign, ± 93 and ± 53 Hz at room temperature; if the sample is, however, dissolved then both couplings merge and have a common value of *ca.* 70 Hz. Similarly, if the neat sample is heated to $+150^\circ$ the couplings become more similar (80 and 60 Hz); conversely these are more dissimilar at low temperature (116 and 40 Hz at -60°). The relation of these changes of coupling constant values to molecular geometry thus seems well established.^(1968, 71) The same undoubtedly occurs in cyclic compounds, for which one example is known (42)^(1962, 2) in which the two non-equivalent fluorine atoms have couplings of 128 and 54 Hz.

These data are not sufficient to build up a complete curve relating *P-C-F* couplings and dihedral angles but such a relation has been sketched in Fig. 6 for P^{III} compounds by similarity with the corresponding behaviour of *P-C-H* couplings. For this system one may postulate that preferred conformations such as 43 may explain the reduction in the value of the coupling constant generally observed between *P-CF₃* to the analogous *P-CF₂-R* groups. Similar perturbations of conformational equilibria presumably result in the observed solvent dependence of *P-C-F* couplings^(1969, 43) which, in this case, involves hydrogen bonding with the solvent.

Considering the influence of substituents on the observed couplings it is found that for the best documented cases (Fig. 7) that increasing electronegativity results in increased *J* values; some discrepancies occur

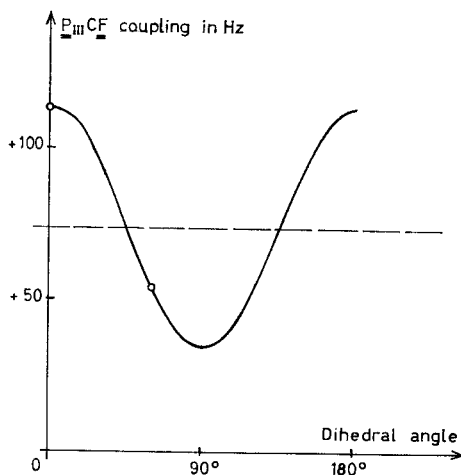


FIG. 6. Assumed geometrical dependence of P-C-F couplings in derivatives of trivalent phosphorus.

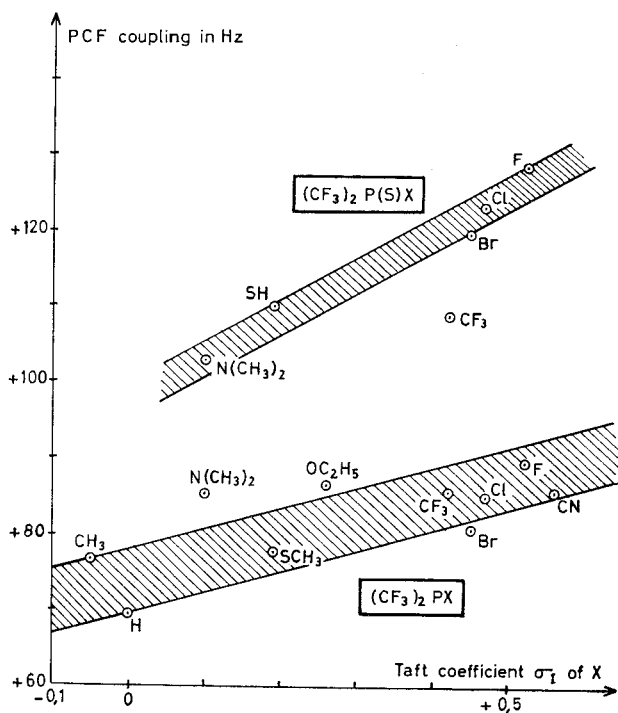


FIG. 7. P-C-F couplings in $(\text{CF}_3)_2\text{PX}$ and $(\text{CF}_3)_2\text{P(S)X}$ compounds as a function of the inductive effect of the substituent X.

for P^{III} compounds when mesomeric effects are operative, e.g. for $-OR$ or $-NR_2$ groups.

The interpretation of observations on penta- or hexa- coordinated compounds is not so clear as CF_3 groups may occupy *axial* positions, even when competing with fluorine substituents as in (44).^(1968, 41)

(e) $P-C-C-F$ couplings. These couplings have not been so extensively studied as for the corresponding proton couplings. The sign of $^3J(P-C-C-F)$ in $C_2F_5PCl_2$ and $C_3F_7PCl_2$ has been established by Manatt *et al.*^(1967, 40) and was found to be positive, i.e. the same as the corresponding $P-C-F$ coupling. Thus, there is no reversal of sign between 2J and 3J but, as previously noted,^(1966, 1, p. 286) long-range anomalies are not so frequent, e.g. in most cases, but not all, $^3J(P-C-C-F) < ^2J(P-C-F)$.

3. Couplings through oxygen atoms

A large number of POCH couplings[†] have been reported and typical examples are given in Table XIV. It is clearly seen that these couplings are not too sensitive to the nature of substitution. Four bond couplings are generally rather small (< 1 Hz) and the sign of the coupling constant affords the greatest interest. Exceptionally high values[‡] have been found in $P(OC_2H_5)_4$, of ca. 2 Hz,^(1969, 86) in 45 to 49^(1966, 37, 46) and a similar value for the six bond coupling in 50.^(1969, 343) No similar data are available for the fluorine homologs and thus the following discussion is of necessity restricted to POCH couplings.

(i) Relative signs have first been established in P^V compounds. Using triple resonance, McFarlane assigned a *positive* value to $^3J(P-O-CH)$ in $HP(O)(OCH_3)_2$ (+12.0) in contrast to $P-H$ and $^{13}C-H$ values. The same sign was proposed by Miyazima *et al.* for $^3J(P-O-CH)$ and $^4J(P-O-C-CH)$ in $Cl_2P(O)OC_2H_5$,^(1967, 84) in agreement with previous determinations of relative signs by Duval and co-workers^(1966, 47; 1967, 85) for the same couplings in:

	$OP(OCH_2CH_3)_3$	same sign	(8.40; 0.84)
	$SP(OCH_2CH_3)_3$	" "	(9.85; 0.73)
	$P(OCH_2CH_2CH_3)_3$	" "	(7.65; 0.80)
but	$P(OCH_2CH_3)_3$	opposite sign	(7.9 ; 0.55).

[†] $P-O-H$ and $P-C(OH)$ couplings have rarely been considered; one example of the latter has been reported in $(C_2H_5O)_2P(O)CH(OH)CH_2OC_2H_5$ of 10.0 Hz.^(1969, 82)

[‡] Values of 14 to 15 Hz have been reported for $P(O)OCH_2CH_3$ couplings;^(1968, 72) this, however, requires confirmation.

TABLE XIV
Typical *P-O-CH* couplings

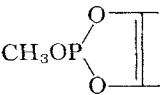
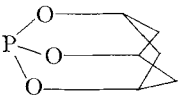
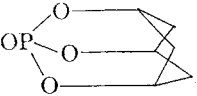
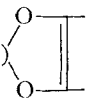
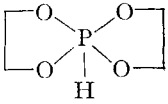
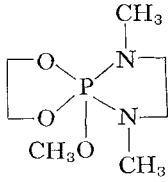
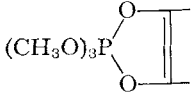
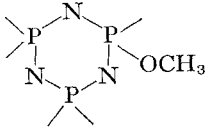
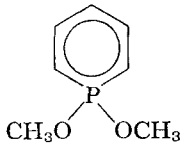
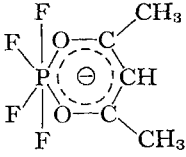
Compound	Couplings	References
P^{III}		
(CH ₃ O) ₃ P	10.8 to 11.8	1969, 86, 87
(C ₂ H ₅ O) ₃ P	7.3 to 8.0	1967, 86; 1969, 86
(R·CH ₂ O) ₃ P (R > CH ₃)	6.1 to 7.5	^a
(C ₆ H ₅ CH ₂ O) ₃ P	7.9	1968, 73
(CH ₃ O) ₂ PCl	11	1965, 20
(CH ₃ O) ₂ PC ₆ H ₅	10.5 to 11.5	1969, 74, 87
(C ₂ H ₅ O) ₂ PC ₆ H ₅	8.3	1969, 34
CH ₃ OP(CF ₃) ₂	13.0	1969, 84
CH ₃ OP(C ₆ H ₅) ₂	13.7	1969, 87
	13	^a
P(OCH ₂) ₃ CR	1.8 to 2.0	1966, 37, 48
	6.3	1966, 37
(P^{IV})[⊕]		
(CH ₃ O) ₄ P [⊕]	11.2	1967, 69
(CH ₃ O) ₃ P [⊕] CH ₃	11.5	1967, 69
(C ₂ H ₅ O) ₃ P [⊕] C ₂ H ₅	7.5	^a
P^V		
(CH ₃ O)PO	10.2 to 11.4	^a , 1969, 87
(C ₂ H ₅ O) ₃ PO	6.8 to 8.4	^a
(CH ₃ O) ₂ P(O)H	12	1969, 74
(CH ₃ O) ₂ P(O)CH ₃	11.0	^a
(CH ₃ O) ₂ P(O)C ₆ H ₅	11	1969, 87
CH ₃ OP(O)H ₂	13	^a
CH ₃ OP(O)(C ₆ H ₅) ₂	11.0	1969, 87
CH ₃ OP(O)(CF ₃) ₂	11.1	1969, 84
OP(OCH ₂) ₃ CR	6.5	1966, 37, 48
	18.0	1966, 37
(CH ₃ O) ₃ PS	13.4	1969, 87
(C ₂ H ₅ O) ₃ PS	10.2	^a
(CH ₃ O) ₂ P(S)Cl	11.0	^a
(CH ₃ O) ₂ P(S)CH ₃	10.2 to 10.7	^a
(CH ₃ O) ₂ P(S)C ₆ H ₅	13.8	1969, 87

TABLE XIV (*continued*)

Compound	Couplings	References
$\text{CH}_3\text{OP}(\text{S})(\text{C}_6\text{H}_5)_2$	13.5 to 14	1967, 87; 1969, 87
$\text{CH}_3\text{OP}(\text{S})\text{F}_2$	14.1	1968, 45
$\text{CH}_3\text{OP}(\text{S})(\text{OCH}_2)\text{CR}_2$	13.8	1968, 74
	11.5	1967, 86
P^{v} pentacoordinate		
$(\text{CH}_3\text{O})_5\text{P}$	12	^a
$(\text{CH}_3\text{O})_3\text{PF}_2$	15.2	1967, 61
	12.5	1967, 39
	$\text{POCH}_3: 14.5$	1967, 163
	13.5	1965, 21
	16.5	1966, 49
	13.5	1968, 75
$(\text{P}^{\text{v}})^{\ominus}$		
	$\text{POCCH}_3: 2$ $\text{POCCH}: < 2$	1966, 33

^a Quoted in reference 1967, 297.

A positive sign has also been found for $P-O-CH$ involving a pentacoordinated phosphorus (in phosphonitrilics).^(1969, 68) As no $J(P-O-CH)$ values are in the vicinity of zero it is unlikely that this coupling experiences sign reversal; it may be taken as positive in all cases. As a consequence, this is not so for $J(P-O-C-CH)$, especially for the above mentioned phosphites.

Sign determinations have also been made on the stereospecific couplings to be discussed in section (ii) below. The O -methylene protons in $C_6H_5P(O)C_2H_5(OC_2H_5)$ are not equivalent but the two $J(P-O-CH)$ values are of the same sign.^(1969, 34) Considering cyclic P^{III} compounds the $J(P-O-CH)$, $J(P-O-C-CH_A)$ and $J(P-O-C-CH_3)$ in the phosphorinanes (**51**), and $J(P-O-CH_A)$ and $J(P-O-CH_B)$ in phospholanes (**52**) are all of the same sign.^(1969, 88) This is also true for P^V oxazaphospholanes (**53**) in which the $P-O-CH$ couplings are distinct and positive (+11.15 and +8.05).^(1968, 76)

(ii) The stereospecificity of $P-O-CH$ couplings have been previously mentioned while discussing sign determination. Various other examples are known, for instance in acyclic compounds in which rotamers exist, such as $C_6H_5P(OC_2H_5)_2$ or $C_6H_5P(O)C_2H_5(OC_2H_5)$,^(1969, 34) thus supporting the early suggestions of Verkade,^(1964, 5; 1965, 22) Benezra^(1966, 43) and Haake *et al.*^(1968, 77) The relevant conformations are, however, not easily identified as the $P-O-C$ bonds are rather flexible.^(1969, 89) For the interpretation of the data it is perhaps better to consider the numerous examples of dioxaphospholanes (**54**) and phosphorinanes (**55**) which have been investigated despite the possible controversy concerning the conformation at the phosphorus atom in **55**^(1966, 50; 1968, 78, 79; 1969, 90) or in **54**.^(1968, 77)

This topic has been discussed in detail by Gagnaire and co-workers^(1967, 88; 1968, 80; 1969, 91) for P^{III} compounds; the stereo-specificity was attributed to the influence of the phosphorus lone-pair.[†] This parallels the explanation proposed to account for similar effects involving ^{15}N in oximes.^(1967, 89) Additional data have been obtained in ethylene phosphites^(1966, 50, 51; 1968, 77; 1969, 92 to 94) but, for the purposes of discussion, a clearer example have recently been investigated in great detail by Kainosho and Nakamura,^(1969, 90) namely **56**. Complete assignment, based upon spin-decoupling gave the following values for the $P-H$ couplings:

$P-H_x$	A	B	C	D	E	F	G
J	4.4	1.7	9.6	3.8	1.7	2.5	9.3

[†] The influence of the heteroatom lone-pairs on couplings through phosphorus, as proposed by Kainosho *et al.*^(1969, 90) for explaining the $H_A \cdots H_F$ long-range couplings in the trioxaphosphabicyclo-octane (**56**), cannot be excluded.

and, by estimating dihedral angles using Dreiding models, these authors succeeded in establishing a Karplus-like curve for the angular dependence of $J(\text{POCH})$ (Fig. 8).

In relation to the consideration of the stereospecificity of coupling in P^{III} compounds, an observation of Kainosho^(1969,95) seems especially important. Complexing the phosphorus atom by addition of a paramagnetic ion removes any stereospecific phosphorus couplings. In the phosphorinane **55a**, $^3J(\text{POCH}_\text{A}) = 2.2$ and $^3J(\text{POCH}_\text{B}) = 10.5$ Hz but on increasing the concentration of nickel acetylacetonate in solution first

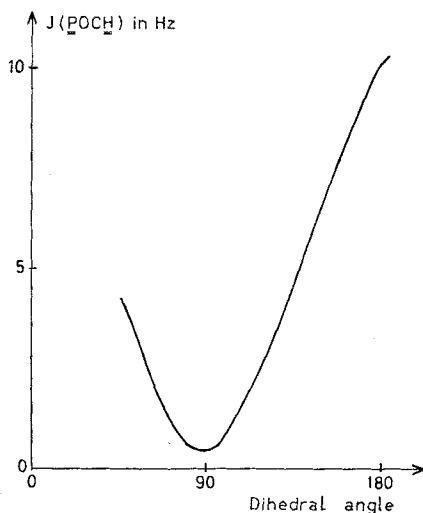


FIG. 8. Geometrical dependence of P–O–C–H couplings in derivatives of trivalent phosphorus [From Kainosho and Nakamura.^(1969,90)]

results in decoupling of P-H_A then P-H_B . All these observations clearly indicate that *factors other than conventional “through-bond” mechanisms are important when considering such couplings.*^(1969,94)

Considering now P^{V} compounds, various examples of stereospecific coupling have been reported. Following a complete study of conformational equilibria in phosphoric acid esters Tsuboi and co-workers^(1967,90;1968,81;1969,95,96) were able to assign changes of coupling in dioxaphosphorinanes (**57**) as shown. Similar values were assigned (19 to 26 and 2 to 6 Hz) in various substituted trioxaphosphorinanes (**58**)^(1967,91;1968,82;1969,92,97). This also appears to be applicable to more complicated systems such as cytidine phosphate (**59**)^(1969,98) and other “biological” structures.^(1969,96)

The same features exist at a reduced level for *POCCH* couplings in phosphorinanes and these are about 2.6 Hz for an equatorial proton at C-5, while it is less than 1 Hz for an axial proton. Similarly, coupling of phosphorus to an equatorial methyl at C-4 is 2 to 3 Hz while that to axial methyl is less than 1 Hz; ^(1968, 83) similar trends have been found in the corresponding phosphonates. ^(1969, 52)

When comparing such values with the relevant data on ethyl (or higher) phosphates, it is clear that, in all acyclic compounds, the observed values for *J(POCCH)* are averaged over a range of 4 or 5 Hz (going down to negative values in P^{III} compounds) as rotation is completely free. This is not necessarily so when comparing *POCH* couplings in phosphites and phosphates of increasing chain length or, moreover, phosphites and phosphates with cage-like structures. ^(1966, 37) In the case of $P(OR)_3$ or $OP(OR)_3$ the coupling is *ca.* 11 Hz when $R = CH_3$, 6 to 8 Hz for higher alkyl group but in $OP(OR)_3$ with $R = CH_2C(CH_3)_3$ is 4.8 Hz. This strongly suggests that for higher alkyl groups the methylene groups are in a *gauche* conformation (60). ^(1969, 94) Such phenomena are certainly solvent and temperature dependent. ^(1967, 44)

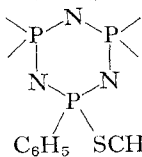
Lastly, the pentacoordinated phosphorus compounds, in which Ramirez succeeded in observing isomers by freezing the pseudorotation at -100° , will be considered. Once again, the same stereospecific trends appear for the *POCH*₃ and *POCH* coupling in 61a and b; the *POC*₍₅₎*H* couplings are 2.0 and 3.5 Hz respectively while the *PC*₍₃₎*H* couplings are 17.0 and 6.0 Hz. The three methoxyl groups are also clearly identified and the couplings to phosphorus different, namely 10.8 Hz for the apical and 12.2 and 12.9 Hz for the non-equivalent equatorial methoxyl groups. The differences are greater in 62 in which the apical methoxyl has a coupling of 10.6 Hz compared to 12.7 and 14.0 for the equatorial methoxyl groups. ^(1968, 84)

4. Couplings through sulphur atoms

Coupling in *P-SH* groups has not yet been reported but may be present in the low temperature spectrum of $F_2P(S)SH$. ^(1969, 99) The *P-S-CH* couplings are better known (Table XV) but the range of information is by no means as complete as for the oxygen homologs; no sign determinations have been carried out,† but it is likely that all *P-S-CH* couplings have the same sign and probably the same as for *P-O-CH* (see 1966, 1, p. 270). The stereospecificity of these couplings has only been recognised

† The sign of *P-S-CF* in $CF_3SP(CF_3)_2$ has been determined and found to be positive. ^(1967, 55) As no further data on *PSCF* couplings are available this subject will not be further discussed.

TABLE XV
Some typical *P-S-CH* couplings

Compound	Coupling	References
P^{III}		
(CH ₃ S) ₃ P	9.8	1966, 1
RC(CH ₂ S) ₃ P	2.1	1968, 85; 1969, 71
CH ₃ SP(OCH ₃)Cl	19	1965, 20
(P^{IV})[⊕]		
CH ₃ SP [⊕] (NH ₂) ₃	16.2	1968, 86
P^V		
(CH ₃ S) ₃ PO	15.1	1966, 1
RC(CH ₂ S) ₃ PO	11.0	1968, 85
C ₂ H ₅ SP(O)(OC ₂ H ₅) ₂	15	1966, 52
CH ₃ SP(O)(NH ₂) ₂	14.8	1968, 86
(CH ₃ S) ₃ PS	17.5	1966, 1
RC(CH ₂ S) ₃ PS	10.0	1968, 85
CH ₃ SP(S)F ₂	20.3	1968, 45
CH ₃ SP(S)(OCH ₃) ₂	16	1965, 20
P^V pentacoordinate		
CH ₃ SPF ₄	25.2	1969, 62
CH ₃ S(C ₆ H ₅) ₂ P = NP(O)-(C ₆ H ₅) ₂	13.2	1967, 92
	18.0	1969, 100

in the *S*-methylene group of CH₃P(O)(OR)SCH₂SR' (1969, 101) but it may be suspected in other cases as discussed earlier for *P-O-CH* couplings (Section 3.B.3(ii)). For instance this effect is seen when comparing free rotating groups and those of cage compounds. (1968, 85)

Comparison of *P-S-CH* couplings (Hz) in freely rotating groups and in related fixed conformations

(CH ₃ S) ₃ P	9.8	(CH ₃ S) ₃ PO	15.1	(CH ₃ S) ₃ PS	17.5
CH ₃ C(CH ₂ S) ₃ P	2.1	CH ₃ C(CH ₂ S) ₃ PO	11.0	CH ₃ C(CH ₂ S) ₃ PS	10.0

It should be noted that the range of $P-S-CH$ couplings is much larger than for $P-O-CH$ or $P-N-CH$; likewise these are found to be more sensitive to complex formation, e.g. the $P-S-CH$ coupling in $CH_3SP(O)(OCH_3)_2$ and the corresponding BF_3 adduct differ by 1 Hz while the corresponding $P-O-CH$ coupling only differs by 0.2 Hz. (1969, 102) This appears to arise from the decreased polarity in the $P-X-CH$ chain on going from $X=O$ to S (or Se) which facilitates the coupling transmission;† additionally this feature favours the transmission of long-range coupling effects such as found in **63**. (1966, 53)

5. Couplings through nitrogen atoms

(i) Two-bond $P-NH$ couplings have only been observed in a few P^V compounds, such as $F_2P(O)NH_2$, (1967, 93) $(C_2H_5O)_2P(O)NHCH_3$, (1969, 20) $(C_6H_5)_2P(O)NHC(CH_2C_6H_5)=C(CN)C_6H_5$, (1968, 88) $FCIP(S)-NHSi(CH_3)_3$, (1969, 69) and $(P^{IV})^{\oplus}$ compounds, such as $C_6H_5P^{\oplus}(NH_2)-[NCH_3N(CH_3)_2]_2$. (1967, 94) No examples involving P^{III} have been reported; the doublet nature of the NH resonance in $C_6H_5P(NHC_3H_7-i)_2$ has been proved to arise from coupling with the neighbouring CH group. (1967, 95) Longer-range couplings between phosphorus and NH groups are not observed, as for instance might be possible in $RP'P(O)C(O)NH\cdots$ compounds. (1968, 29)

(ii) Three-bond $PNCH$ couplings will now be considered and some typical values are shown in Table XVI.‡ A distinctive feature of the $PNCH$ system (for which a positive sign is likely§) is the possibility of $d_{\pi}-p_{\pi}$ conjugation between phosphorus and nitrogen; this shortens the $P-N$ bond and facilitates the stabilisation of rotamers. These are readily observed in P^{III} compounds when steric hindrance is present or at sufficiently low temperatures. The interpretation of experimental data may, however, be obscured by various factors: repulsion of phosphorus and nitrogen lone-pairs seems a secondary factor in these P^{III} compounds, (1969, 105, 107) but the possible inversions at phosphorus and nitrogen have to be discussed further. Inversion at the phosphorus atom requires a much higher energy than that at nitrogen; moreover, when $P-N$ conjugation occurs, the configuration about nitrogen which is normally pyramidal becomes planar (1969, 108) thus facilitating the N -inversion. Phosphorus, however, retains the pyramidal configuration as the d -

† Similarly, much larger couplings through sulphur than through oxygen are observed in 1,3-thioxanes. (1968, 87)

‡ $PNCF$ couplings are known in too few compounds to warrant discussion here. (1966, 31)

§ Such a sign was suggested by Manatt *et al.* (1966, 13) as for $POCH$ coupling; this has been established by Haigh (1969, 68) in phosphonitrilics.

TABLE XVI

Some typical values of *P-N-CH* couplings

Compound	Coupling	References
P^{III}		
$[(CH_3)_2N]_3P$	8.8 to 9.0	1965, 18; 1967, 65; 1969, 87
$[(CH_3)_2N(CH_3)N]_3P$	4.5	1967, 94
$[(C_2H_5)_2N]_3P$	8.3	1965, 18
$[(CH_3)_2N]_2PCl$	12.3	1965, 18; 1967, 65
$[(CH_3)_2N(CH_3)N]_2PCl$	7.3	1969, 103 and 104
$[(C_2H_5)_2N]_2PCl$	11.2	1965, 18
$[(CH_3)_2N]_2PCH_3$	8.7	1965, 18
$[(CH_3)_2N]_2PC_6H_5$	9.5	1969, 87
$(CH_3)_2NPCl_2$	12.9 to 13.0	1965, 18; 1966, 34; 1967, 65
$(CH_3)_2N(CH_3)NPCl_2$	7.2	1969, 103
$(C_2H_5)_2NPCl_2$	13.3	1965, 18
$(CH_3)_2NP(CH_3)_2$	9.8	1965, 18; 1969, 72
$(CH_3)_2NP(C_6H_5)_2$	9.5	1969, 87
$(CH_3)_2NP(OC_2H_5)_2$	9.4	1969, 20
$(CH_3)_2NP(C_6F_5)_2$	10.9	1966, 19
$CH_3N(PCl_2)_2$	3.0	1967, 96; 1968, 89
$[(CH_2)_2N]_3PO$	14	1964, 6
(P^{IV})[⊕]		
$[(CH_3)_2N]_3P^{\oplus}Cl$	13.0	1967, 65
$[(CH_3)_2N]_3P^{\oplus}CH_3$	10.0 to 10.1	1965, 18; 1967, 65
$[(CH_3)_2N]_3P^{\oplus}SCH_3$	11.2	1969, 105
$[(CH_3)_2N]_2P^{\oplus}(CH_3)_2$	10.3 to 10.5	1965, 54; 1967, 65
$(CH_3)_2NP^{\oplus}(CH_3)_3$	11.3 to 11.5	1965, 18; 1968, 54
$[(C_2H_5)_2N]_3P^{\oplus}Cl$	14	1968, 90
P^V		
$[(CH_3)_2N]_3PO$	9.4 to 9.5	1965, 18, 23; 1967, 65; 1968, 91; 1969, 87
$[(C_2H_5)_2N]_3PO$	9.9 to 14	1965, 18; 1968, 90
$[(CH_3)_2N]_2P(O)Cl$	12.9 to 13.0	1965, 18, 23; 1967, 65; 1968, 91
$[(C_2H_5)_2N]_2P(O)Cl$	13.4	1965, 18
$[(CH_3)_2N]_2P(O)C_6H_5$	9.8 to 9.9	1965, 23; 1969, 87
$(CH_3)_2NP(O)Cl_2$	15.8 to 15.9	1965, 18, 23; 1967, 65; 1968, 91
$(C_2H_5)_2NP(O)Cl_2$	17.2	1965, 18
$(CH_3)_2NP(O)(C_6H_5)_2$	10.0 to 10.2	1965, 23; 1968, 91; 1969, 87
$[(CH_3)_2N]_3PS$	11.0 to 11.3	1965, 18, 23; 1967, 65; 1968, 91; 1969, 87, 105

TABLE XVI (*continued*)

Compound	Coupling	References
P^v		
$[(C_2H_5)_2N]_3PS$	11.4	1965, 18
$[(CH_3)_2N]_2P(S)Cl$	15.3 to 15.4	1965, 18, 23; 1967, 65; 1968, 91
$[(CH_3)_2N]_2P(S)C_6H_5$	12.0 to 12.1	1968, 91; 1969, 87
$[(C_2H_5)_2N]_2P(S)Cl$	14.8	1965, 18
$(CH_3)_2NP(S)Cl_2$	17.2 to 17.7	1965, 18, 23; 1967, 65; 1968, 91
$(C_2H_5)_2NP(S)Cl_2$	18.9	1965, 18
$(CH_3)_2NP(S)(C_6H_5)_2$	14.3 to 14.6	1968, 91; 1969, 87
$[(CH_3)_2N]_3PSe$	11.6	1969, 87
$[(CH_3)_2N]_2P(Se)C_6H_5$	12.5	1969, 87
$(CH_3)_2NP(Se)(C_6H_5)_2$	15.0	1969, 87
P^v pentacoordinate		
$[(CH_3)_2N]_3PF_2$	10.6	1967, 61
$(CH_3)_2NPF_4$	2.1	1967, 59
$(CH_3)_2NPF_2Cl_2$	13.2	1968, 43
$[CH_3NPF_3]_2$	14.5	1967, 59
$ \begin{array}{ccc} CH_3N & \text{---} & PCl_3 \\ & & \\ Cl_3P & \text{---} & NCH_3 \end{array} $	20.0	1966, 53
$ \begin{array}{c} \text{---} C \text{---} \\ / \quad \backslash \\ N \quad N \\ \quad \\ N \quad N \\ \backslash \quad / \\ P \quad P \\ \quad \\ N \quad N \end{array} $	11.1	1969, 106

orbitals are involved when it participates in the P–N conjugation. An extensive variable temperature PMR study by Imbery and Friebohn (1968, 92) confirmed these views. In compounds which are asymmetric at the nitrogen but not at the phosphorus atom, e.g. $(R^1CH_2)R^2NPX_2$, no non-equivalence of the methylene group was observed, even at the lowest temperatures attained, on account of the rapid inversion at nitrogen. For the corresponding compounds $(R^1CH_2)R^2NPXX^1$ ($X \neq X^1$) which are asymmetric at phosphorus, non-equivalence appears at some temperature; thus inversion at phosphorus is clearly slower than that at nitrogen. It is especially noticeable that this is accompanied by different couplings of the methylene protons to the phosphorus, e.g. 13.8 and 4.8 Hz in $C_6H_5CH_2(CH_3)NP(Cl)(C_6H_5)$. Similar conclusions hold for a

compound symmetrically substituted at nitrogen but asymmetric at phosphorus, e.g. in $(\text{CH}_3)_2\text{NPCl}(\text{C}_6\text{H}_5)$ in which the two $^3J(\text{PNCH})$ values involving the methyl groups are 19.0 and 7.0 Hz, ^(1968, 92) or even if the phosphorus is symmetrically substituted but the temperature sufficiently low as, for example in $(\text{CH}_3)_2\text{NPCl}_2$ at -80° , the couplings are 19.3 and 6.6 Hz. ^(1967, 80) This clearly rules out the *anti*-isomer as predominating at these temperatures but favours the *gauche* isomer (**64**). Evidently, this remains true for cases in which the substituents on nitrogen are different, when lowering the temperature separates the conformers, e.g. in $\text{CH}_3(\text{C}_6\text{H}_5)\text{NPF}_2$; in one conformer the methyl is coupled to phosphorus by 4.2 Hz, while in the second conformer the coupling is 11.0 Hz. ^(1966, 34)

Such observations are naturally simpler in cyclic compounds, such as in ephedrine derivatives (**65**) when $^3J(\text{PNCH})$ are 2.3 and 1.0 Hz depending upon the isomer. ^(1969, 109) This effect is even more pronounced in cyclic P^{V} compounds ^(1968, 76) such as **66** in which the two $^3J(\text{PNCH})$ values are clearly distinguished and have opposite signs (+11.5 and -0.31 Hz).

Similar observations are possible with acyclic P^{V} compounds if the substituents of phosphorus are different and also rather bulky (and more especially if chelation can occur to stabilise the conformers). ^(1969, 110) In $(\text{CH}_3)_2\text{NP}(\text{O})\text{F}(\text{C}_4\text{H}_9-t)$, the methyl groups are non-equivalent with $^3J(\text{P-N-CH}_3)$ of 8.2 and 0.0 Hz. ^(1965, 8) The phosphorus inversion remains the dominating phenomenon here. ^(1969, 111)

Nevertheless, although the stereospecificity is well documented in these *PNCH* systems, the underlying phenomena are probably more complicated than previously discussed for *PCH*, *PCCCH* and *POCH* couplings, because of the role played by the π -electrons. ^(1968, 29)

(iii) On account of the stabilisation of the P-N bonds by the hybridisation features discussed above, the changes in *J* values accompanying modification of substituent groups, or changes in phosphorus coordination are rather regular; it is observed that, in a given series, the coupling modulus (as well as proton chemical shift) increases for the sequence P, PO, PS and $\text{P}^{\oplus}$. Anomalies are certainly linked to some perturbation of the conjugation scheme. In this respect, multiple bonding is especially important and enhances couplings as, for example, in $(\text{RO})_2\text{P}(\text{O})\text{N}=\text{CHOR}^1$ (15 to 17.5 Hz) ^(1966, 55) or in $(\text{RO})_2\text{P}(\text{S})\text{N}=\text{CHNR}^1_2$ (22 to 25 Hz). ^(1966, 43)

(iv) Longer-range couplings are known in non-conjugated systems such as in $(\text{CH}_3)_3\text{CNHPCl}_2$ (2.2 Hz) ^(1969, 112) or in $[(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})]_2\text{-CHN}(\text{CH}_3)_2$ (1.5 Hz); ^(1968, 93) this is also true when other heteroatoms are present, for instance $(t\text{-C}_4\text{H}_9)_2\text{PNHX}(\text{CH}_3)_3$ ($\text{X}=\text{Si}$, $J=0.6$; $\text{X}=\text{Ge}$, $J=0.3$ Hz). ^(1968, 64)

This long-range coupling becomes more predominant in compounds in which multiple bonding is present, e.g. as in **67** ^(1966, 56) or in **68** and **69** ^(1968, 88) and even more so when conjugation is present as in phosphonitrilics, where ¹⁴N decoupling proves that *PNPNCH* coupling exists ^(1965, 24) or in **70**, which when compared to **71** clearly shows the importance of conjugation; ^(1967, 97; 1968, 94) going further one has an example of five-bond coupling **72**. ^(1968, 94)

6. Couplings through other nuclei

Besides couplings through metal atoms observed in such compounds as **73** in which $^3J(\text{PSnCH}_3) = 4.4 \text{ Hz}$, ^(1968, 95) the most interesting data come from the germyl and silyl homologs of the P^{III} compounds discussed earlier.

Relative signs have only been determined for *P-Si-H* coupling; this was found to be positive in $\text{CH}_3\text{PH}(\text{SiH}_3)$. ^(1969, 73) It is likely, contrary to expectation for these two bond couplings, that all couplings are similarly positive in derivatives of methylphosphines; ^(1967, 98; 1968, 32, 96; 1969, 113) these couplings are shown in Table XVII.

TABLE XVII

Some examples of two-bond *P-X-H* couplings (Hz), X = C, Ge and Si, in methyl phosphine derivatives

$\text{P}(\text{CH}_3)_3$	+2.8	$\text{P}(\text{GeH}_3)_3$	15.2 to 15.9	$\text{P}(\text{SiH}_3)_3$	17.0
$\text{HP}(\text{CH}_3)_2$	+3.6	$\text{HP}(\text{GeH}_3)_2$	15.7	$\text{HP}(\text{SiH}_3)_2$	15.7
H_2PCH_3	+4.1	H_2PGeH_3	15.3	H_2PSiH_3	15.3

In addition to the identical signs it is also noticed that, in the carbon derivatives, the *P...H* coupling increases with decreasing number of methyl groups while for the germanium and silicon derivatives the coupling basically decreases. This arises from the relative electronegativity of Si and Ge (1.8) compared to that of C (2.5) and P and H (2.1); replacing a methyl group by a proton decreases the *s* character of the remaining methyl groups while replacing a SiH_3 or GeH_3 groups by a proton increases the *s* character of the remaining groups. The same general rules apply for mixed groups, for instance it is observed ^(1969, 73) that *H-Si-P* coupling decreases in the series $\text{H}_3\text{SiP}(\text{CH}_3)(\text{SiH}_3)$; $\text{H}_3\text{SiP}(\text{H})\text{CH}_3$, $\text{H}_3\text{SiP}(\text{CH}_3)_2$ with increasing *s* character.

The only recorded data for homologs of ethylphosphines ^(1969, 113) are shown in Table XVIII in which the data are compared to those of the triethylphosphine.

TABLE XVIII

Coupling constant data (Hz) for silicon derivatives of triethylphosphines

	$^2J(\text{P-XH}_2)$	$^3J(\text{P-X-XH}_3)$
$\text{P}(\text{SiH}_2\text{SiH}_3)_3$	17.5	?
$\text{H}_2\text{PSiH}_2\text{SiH}_3$	18.5	2.0
$\text{P}(\text{CH}_2\text{CH}_3)_3$	-0.5	+13.7

Lastly, comparison is possible between $\text{P}[\text{C}(\text{CH}_3)_3]_3$ for which $^3J(\text{PCCH}) = 9.8$, $\text{P}[\text{Si}(\text{CH}_3)_3]_3$ with $^3J(\text{PSiCH}) = 4.5$ and $\text{P}[\text{Ge}(\text{CH}_3)]_3$ with $^3J(\text{PGeCH}) = 3.7$ Hz. (1966, 57; 1967, 29)

Having taken into account the change in electronegativity and size of the central atoms, it appears that the couplings are intrinsically larger for the carbon compounds. This helps clarify the anomalous behaviour which existed for coupling to α -CH groups which was discussed earlier (Section III.B.2.a).

7. Couplings through unsaturated systems

It has been realised for sometime that the presence of π -electrons in hydrocarbon chains enhances all the J values and this is also true for phosphorus compounds. In addition, the existence of isomers provides data on geometrically well-defined conformations and finally the participation of phosphorus in conjugated systems will give some unusual behaviours.

(a) Vinylic systems will be considered first; the P-H couplings somewhat parallel those of the corresponding H-H couplings. The double quantum analysis of Lancaster (1967, 99) has established that all the couplings have the same sign; these couplings constant values are shown in Table XIX. The data for **74** has been confirmed by Williamson *et al.* (1968, 97)

TABLE XIX

P-H couplings in vinyl phosphorus derivatives

	<i>cis</i>	<i>trans</i>	<i>gem</i>
$\text{P}(\text{CH}=\text{CH}_2)_3$	± 13.6	± 30.2	± 11.8
$\text{C}_6\text{H}_5(\text{CH}_3)_2\overset{\oplus}{\text{P}}-\text{CH}=\text{CH}_2$	± 25.3	± 48.5	± 24.0
$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}=\text{CH}_2$ (74)	± 25.1	± 50.5	± 11.8

using double resonance; they have carried out a detailed analysis of $(C_2H_5O)_2P(O)CX=CYZ$, where X, Y, Z = H or Cl. The observed trends are similar for all types of phosphorus hybridisation but once again it should be noted that there is a big variation in changing from P^{III} to $(P^{IV})^{\oplus}$ and P^V . It is also noticeable that in all cases the proton closer to phosphorus (i.e. *gem*) exhibits the smaller coupling and of the two β -protons that closer to phosphorus (i.e. *cis*) again has the smaller value.

Geometrical factors are also important as shown by Benezra *et al.* for the *cis* couplings in hindered compounds. (1966, 43, 58; 1967, 100) They proposed a Karplus-like behaviour for these couplings in compounds of the type 75.

Considering now the corresponding methylated compounds it is found that for phosphines and phosphonates the *gem* $PC(CH_3)$ couplings are of similar importance to the corresponding *gem* $P-C-H$ couplings (the relative sign is not known) as in *cis* and *trans* positions replacing CH by $C\cdot CH_3$ gives a lower coupling (in modulus) with opposite sign as predicted by "Hund coupling" (1967, 101). Thus, in methylated vinyl phosphines, the *gem*, *cis* and *trans* $J(P\cdots CH_3)$ values are respectively 12, 3 and 2.5 Hz while the corresponding values for $J(P\cdots CH)$ in the parent vinyl phosphines are 10, 12 and 30 Hz.

Similarly the variation in P^V compounds with α - and β - methyl substituents are shown in 76 and 77 (1966, 59) and 78 to 80 (1963, 4; 1966, 60).

The behaviour for substitution in the α -position is clearly contrary to predicted trends and supports the idea of two superimposed mechanisms acting in different directions when the expected coupling should be negative (*gem*) and in the same direction when expected to be positive.

Similar behaviour is found in the variously substituted vinylic systems. In P^{III} fluorinated vinyl compounds, for which Cowley and Taylor have obtained the relative signs, (1969, 54, 55) it is found that sign reversal may occur in *gem* couplings and that the *trans* couplings generally have the lowest values (Table XX).

TABLE XX
P-F couplings in fluorovinyl phosphines

	<i>gem</i>	<i>cis</i>	<i>trans</i>
$Cl_2PCF=CF_2$	-17.2	+85.7	+7.3
$F_2PCF=CF_2^a$	+20.9	+69.6	+4.8
$ClP(CF=CF_2)_2$	0	70	?
$P(CF=CF_2)_3$	24	53	8

^a Stereospecificity is also found in the $^4J(F-P-C-CF)$ values: 2.8 Hz for *cis* and 13.2 Hz for *trans*. (1969, 55)

In P^V compounds results are only available for the *gem* positions (1968, 98) and these values cover a wide range:

$(CH_3O)_2P(O)CF=CClCF_3$	<i>cis</i> $^2J(P-CF)$	91.9
	<i>trans</i> $^2J(P-CF)$	90.0
$(C_6H_5)_2P(O)CF=CClCF_3$	<i>cis</i> $^2J(P-CF)$	14.2
	<i>trans</i> $^2J(P-CF)$	24.0

the same situation exists for the perfluoromethyl analogs: (1967, 102, 103; 1968, 98)

$(C_2H_5)_2PC(CF_3)=CHCF_3$	$^3J(PCCCF_3)$	<i>ca.</i> 0 Hz
	$^4J(PCCCCF_3)$	53 Hz
$(C_6H_5)_2PC(CF_3)=C(CF_3)P(C_6H_5)_2$	$^3J(PCCCF_3)$	313 Hz
$(CH_3O)_2P(O)CF=CClCF_3$	<i>cis</i> $^4J(PCCCCF_3)$	3.2 Hz
	<i>trans</i> $^4J(PCCCCF_3)$	1.0 Hz
$(C_6H_5)_2P(O)CF=CClCF_3$	<i>cis</i> $^4J(PCCCCF_3)$	63.7 Hz
	<i>trans</i> $^4J(PCCCCF_3)$	5.5 Hz

and finally in phosphonium compounds:

$(C_6H_5)_3P^{\oplus}CH=C(CF_3)_2$	$^4J(PCCCCF_3)$	1.5 to 5 Hz
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This variability may be related to the sensitivity of fluorine to "through-space" coupling as mentioned in Section III.A.1.

Lastly, couplings have been reported for penta-coordinated phosphorus compounds having perfluorovinyl substituents **81**; (1969, 114) it will be observed that the stereospecificity of the couplings is retained.

(b) Allenic systems have received considerable attention from Simonin and co-workers who established the following relative signs (1966, 61; 1967, 104; 1968, 99; 1969, 115)†

For allenic phosphines:

	$RR^1PCH=C=CH_2$	$^2J(P-CH)$	+
or	$RR^1PC(CH_3)=C=CH_2$	$^3J(P-C-CH_3)$	+
		$^4J(P-CC-CH)$	±

the last sign varies according to the nature of the substituents on phosphorus and their ability to conjugate.

In allenic phosphine oxides:

	$RR^1P(O)CR^2=C=CR^3$	$^2J(P-CH)$	+
		$^3J(P-C-CH_3)$	+
	R^2 and $R^3 = H$ or CH_3	$^4J(PCCCH)$	-
		$^5J(PCCCCCH_3)$	+

† Apart from cumulenes, non-conjugated polyenes have received far less attention but seem to have somewhat similar behaviour as regards long-range coupling. (1965, 25)

The change from P^{III} to P^V has rather smaller effects when compared to the effects of conjugation of phosphorus; this is especially true with amino substituents with which $p_\pi-d_\pi$ interaction is likely to occur.

The consideration of allenic molecules and of the methylated homologs show anomalies similar to those discussed in the preceding paragraph. Substituting a methyl for a proton it would be expected that there would be a reduction in the modulus, and a change in sign, of the relevant $P\cdots H$ coupling based on the simple "Hund coupling mechanism" of the Fermi contact term.^(1964, 7) Actually, for the α -position to phosphorus, $P-C-H$ and $P-C-CH_3$ couplings have the same sign and comparable magnitude, for instance in:

$Cl_2PCH=C=CH_2$	$^2J(P-C-H)$	± 9.5 Hz
$Cl_2PC(CH_3)=C=CH_2$	$^3J(P-C-CH_3)$	± 3.4 Hz
$Cl_2P(O)CH=C=CH_2$	$^2J(P-C-H)$	± 16.4 Hz
$Cl_2P(O)C(CH_3)=C=CH_2$	$^3J(P-C-CH_3)$	± 20.2 Hz

while, for the γ -position, the expected changes are observed, for instance in:

$Cl_2P(O)CH=C=CH_2$	$^4J(PCCCCH)$	∓ 18.2
$Cl_2P(O)CH=C=C(CH_3)_2$	$^5J(PCCCCCH_3)$	± 12.1

The possibility of a "through-space" mechanism, which would be especially sensitive for the α -position for blocked systems such as these, cannot be ruled out.

(c) Acetylenic systems will be considered next for these may exist as a tautomeric form of the allenic compounds; allenic-acetylenic isomerisation readily occurs in various compounds as has been discussed by Russian authors (see ref. 1967, 21 for a brief review). On account of the non-existence of substituents α to phosphorus, sign determinations are not so easy and the only known result has been provided by Ionin *et al.* (1967, 105) in $F_2P(O)C\equiv CCH_3$, in which the $P-F$ and $P-H$ couplings were of opposite sign, which means the latter is positive.

It should be pointed out that sign reversals are likely to occur when the hybridisation of phosphorus, or the nature of the substituents, change in systems such as:^(1966, 62)

$(C_6H_5)_2PC\equiv CH$	$J < 0.5$ Hz	$(C_6H_5)_2P(C\equiv C)_2H$	1.45 Hz
$(C_6H_5)_2P(O)C\equiv CH$	9.7		
$(C_6H_5)_2PC\equiv CCH_3$	1.7	$(C_6H_5)_2P(C\equiv C)_2CH_3$	1.3
$(C_6H_5)_2P(O)C\equiv CCH_3$	3.8	$(C_6H_5)_2P(C\equiv C)_3CH_3$	0.7
$(C_6H_5)_2P(S)C\equiv CCH_3$	4.1		
$(C_6H_5)_3P^+C\equiv CCH_3$	4.6		

or, moreover when amino substituents are attached to the phosphorus atom as in: ^(1967, 106)

$(\text{CH}_3)_2\text{NP}(\text{C}\equiv\text{CH})_2$	1.2 Hz	$(\text{CH}_3)_2\text{NP}(\text{O})(\text{C}\equiv\text{CH})_2$	11.8
$[(\text{CH}_3)_2\text{N}]_2\text{PC}\equiv\text{CH}$	1.5	$[(\text{CH}_3)_2\text{N}]_2\text{P}(\text{O})\text{C}\equiv\text{CH}$	11.3
$(\text{CH}_3)_2\text{NP}(\text{C}\equiv\text{CCH}_3)_2$	2.7	$(\text{CH}_3)_2\text{NP}(\text{O})(\text{C}\equiv\text{CCH}_3)_2$	4.2
$[(\text{CH}_3)_2\text{N}]_2\text{PC}\equiv\text{CCH}_3$	3.0	$[(\text{CH}_3)_2\text{N}]_2\text{P}(\text{O})\text{C}\equiv\text{CCH}_3$	4.2

In the latter cases it might be anticipated that rehybridisation of the phosphorus occurs as there is possibility of conjugation between the phosphorus and neighbouring triple bond as discussed earlier (Section III.B.3).

(d) Allylic systems afford some interest on account of the well defined stereochemistry of the *cisoid-transoid* type. ^(1967, 107, 108) Assuming a negative sign for the phosphorus-methylene coupling, it is possible to establish the following signs: ^(1967, 101)

$-\text{P}(\text{O})\text{CH}_2\text{CH}_\beta=\text{CH}_\gamma-$	$\text{P}-\text{H}_\beta$	+
	$\text{P}-\text{H}_\gamma$	-
$-\text{P}(\text{O})\text{CH}_2\text{C}(\text{CH}_3)_\beta=\text{C}(\text{CH}_3)_\gamma-$	$\text{P}-(\text{CH}_3)_\beta$	-
	$\text{P}-(\text{CH}_3)_\gamma$	+

The regular behaviour previously sought for in vinylic and allenic systems is observed; couplings are reduced in magnitude and change sign in going from the proton to the methyl homolog. A similar comparison would be of interest in propargylic compounds but only the magnitude of the couplings are known in these compounds. ^(1966, 63)

(e) Phospholenic compounds are interesting homologs of the preceeding vinylic and allenic compounds, namely 2-phospholenes (**82**) and 3-phospholenes (**83**), and have received considerable attention.

(i) 2-Phospholenes have coupling constants rather similar to those observed in vinyl compounds. For P^{V} compounds typical data are shown in **84** and **85**. ^(1964, 8; 1966, 64, 65; 1967, 108; 1968, 100; 1969, 20) For the case of P^{III} and $(\text{P}^{\text{IV}})^{\oplus}$ compounds some $^2J(\text{P}-\text{H})$ values are shown in **86** and **87** ^(1968, 100) and **88**. ^(1967, 108)

(ii) 3-Phospholenes are far better known. Relative signs of coupling in P^{V} compounds agree with results on the parent allyl compounds; being opposite in sign for $^2J(\text{PCH})$ and $^3J(\text{PCCH})$. ^(1967, 101) Typical values for P^{V} compounds are shown in **89**, ^(1964, 8; 1966, 64 to 66; 1967, 108 to 110; 1968, 61, 100 and 101; 1969, 20) couplings in related oxaphospholenes appear to be rather similar. ^(1969, 116) The corresponding data for $(\text{P}^{\text{IV}})^+$ and P^{III} compounds are shown in **90** and **91**.

There is an interesting example for comparison purposes in the pair of conformers, described by Katz *et al.*, ^(1966, 67) for which the data are shown in **92** and **93**; the data for the corresponding phosphoryl com-

pounds are given in parenthesis. These data clearly show the marked stereospecificity, not only for the α -protons but also for those in the β -positions, and the influence of the phosphorus lone-pair.

For the α -protons an additional point is found when comparing the $P\cdots CH_3$ coupling in methyl phospholenes with the relevant $P\cdots H$ coupling. For example, the data shown in **94** to **97** have been observed and demonstrates this point for the α -couplings, while for the β -position the $PCCCH_3$ couplings are between 1 and 2 Hz while the $PCCH$ couplings are in a similar range to that shown in **94** to **97**.

Going one stage further phospholes present distinctive features on account of the aromatic character;^(1967, 78; 1969, 77) this property is clearly reflected in the values of the coupling constants. The relevant data for 1-methyl phospholes have been published^(1969, 77) and are shown in **98**; these are obviously contrary to the trends previously reported for 2-phospholenes in which $|^2J(P-CH)| < |^3J(PCCH)|$. However, these are in agreement with observations on 1-phenyl-2,5-dimethylphosphole (**99**)^(1967, 70) and on 1-phenyl-3,4-dimethylphosphole (**100**);^(1969, 20) in the latter compound both couplings mentioned have been found to be of the same sign.

The corresponding $(P^{IV})^\oplus$ and P^V compounds exhibit the same general features and same representative data are shown in **101**, **102**^(1968, 101) and **103**.^(1969, 20) In **103** the signs of coupling are now opposite and, on account of the relative magnitude of both the couplings, it is likely that the long-range coupling has undergone a reversal in sign.

Analogues to these five-membered rings the six-membered ring compounds are also known. The family of phosphabenzenes are now well known and some typical values of coupling constants are shown in **104** to **107**;^(1966, 68; 1967, 111; 1968, 101) the data for a corresponding penta-coordinated homolog is shown in **108**.^(1968, 75)† The transmission of coupling interactions appears to be particularly facile and long-range values are especially high (unfortunately no sign determinations have been reported). The former point is especially clarified when comparing the conjugated species with the dihydrophosphazenes (**109**).^(1967, 112) The value of $^2J(P-CH)$ is 13 Hz for $R = C_6H_5$ and 8 Hz for $R = C_4H_9$ but no three-bond $P-C-CH$ coupling is observed; the couplings in the corresponding P^V compound are shown in **110**. The importance of conjugation for the transmission of couplings is also apparent when comparing the two values of $^3J(PCCH)$ in **111**, the larger value is that involving the double bond, 36.5 as against 22 Hz.^(1968, 102)

† The conjugation in such compounds is confirmed by bond lengths determined by X-ray structural analysis.^(1969, 117)

(f) A number of interesting coupling constants are found when aromatic groups are attached to phosphorus atoms. In the case of unsubstituted rings double resonance and solvent effects have been used for clarifying spectra and obtaining values of $J(\text{P}-\text{H}_{\text{ortho}})$ when *ortho* and *meta-para* patterns are complex; ^(1968, 103) these signals are more widely separated when substituents on P^{V} are more electronegative thus permitting sub-spectral analysis. ^(1967, 113) From these and other investigations ^(1966, 21; 1967, 113, 114) values for the $\text{P}-\text{H}_{\text{ortho}}$ couplings obtained are shown in Table XXI. In all cases, except triphenylphosphine, free rotation of the

TABLE XXI
Same values of $\text{P}-\text{H}$ (*ortho*) coupling constants

Compound	Hz	Compound	Hz
$\text{H}_2\text{PC}_6\text{H}_5$	6.0	$\text{OP}(\text{C}_6\text{H}_5)_3$	11.8
$\text{P}(\text{C}_6\text{H}_5)_3$	7.1	$\text{OP}(\text{C}_6\text{H}_5)_2\text{OCH}_3$	12.0
$\text{ClP}(\text{C}_6\text{H}_5)_2$	7.8	$\text{OP}(\text{C}_6\text{H}_5)_2\text{SCH}_3$	12.7
$\text{HP}(\text{C}_6\text{H}_5)_2$	7.9	$\text{OP}(\text{C}_6\text{H}_5)(\text{OCH}_3)_2$	13.3
$\text{Cl}_2\text{PC}_6\text{H}_5$	8.5 to 8.7	$\text{OP}(\text{C}_6\text{H}_5)\text{Cl}_2$	17.0

aromatic ring occurs under normal conditions and this has been taken as evidence for σ coupling. ^(1966, 69) In triphenylphosphine $\text{p}_\pi\text{-p}_\pi$ bonding seems predominant owing to steric hindrance and this makes the spectrum very complex as the signals from *ortho*, *meta* and *para* protons all overlap.

The spectra are clearer in substituted compounds, especially in *para*- and poly-substituted aromatic systems. In the former case sign determination is feasible and McFarlane has obtained the values for some typical compounds as shown in Table XXII; the data (without signs) for the tris(4-fluorophenyl)phosphine oxide are also included.

Changes in values of coupling constants appear to be essentially dependent upon changes in hybridisation of phosphorus, especially for the capability of phosphorus to participate in $\text{p}_\pi\text{-p}_\pi$ bonding and this effect is lessened from P^{III} to $(\text{P}^{\text{IV}})^{\oplus}$ or P^{V} compounds as the hybridisation changes from p_3 to sp_3 . Other factors, such as the nature of the substituents on the ring, seem to be rather unimportant, for instance P^{V} compounds with tolyl, nitrophenyl or chlorophenyl groups give essentially the same couplings as given above. ^(1966, 70; 1967, 116; 1969, 119)

In the case of the tolyl derivatives it should be noted that coupling of the phosphorus occurs only with the *ortho*-methyl group, for instance in $\text{o-CH}_3\text{C}_6\text{H}_4\text{P}(\text{O})(\text{OCH}_3)_2$ $^4J(\text{P-}o\text{CH}_3) = 1.7 \text{ Hz}$. ^(1966, 70; 1967, 117) As

TABLE XXII

Some values of P-H (*ortho*) and P-H (*meta*) in *para*-substituted phenylphosphine compounds

Compound	P-H (<i>ortho</i>)	P-H (<i>meta</i>)	Reference
(<i>p</i> -CH ₃ OC ₆ H ₄) ₃ P	+6.5	+1.1	1969, 118
(<i>p</i> -CH ₃ OC ₆ H ₄) ₃ PS	+12.5	+2.3	1969, 118
(<i>p</i> -CH ₃ OC ₆ H ₄) ₃ P [⊕] CH ₃ ,I [⊖]	+12.7	+2.6	1969, 118
(<i>p</i> -FC ₆ H ₄) ₃ P	+6.7	+1.3	1969, 118
(<i>p</i> -FC ₆ H ₄) ₃ PS	+12.4	+2.2	1969, 118
(<i>p</i> -FC ₆ H ₄) ₃ P [⊕] CH ₃ ,I [⊖]	+12.1	+2.5	1969, 118
(<i>p</i> -FC ₆ H ₄) ₃ PO	12.4	3.2	{1966, 70; 1967, 115}

noted in Section III.A, for the relevant CF₃ compounds, this may be indicative of a "through-space" mechanism; a number of related observations on *p*-tolyl derivatives points to the same conclusion^(1966, 71; 1967, 117, 118) and ⁷J(P-CH₃) values of 2.3 and 3.0 Hz have been observed in *p*-CH₃C₆H₄CH₂P(O)(OCH₃)₂ and *p*-CH₃C₆H₄CH₂P[⊕]-(C₆H₅)₃ respectively; likewise in *p*-tolyl phosphates a value for ⁷J(P-CH₃) of 0.6 Hz is observed in *p*-CH₃C₆H₄OP(O)(OCH₃)₂. Overlap hyperconjugation has been invoked in this respect, which is another way of depicting "through-space" contribution.

The case of higher conjugated systems is clearly different, for which a π -electron explanation seems well-suited; the relevant couplings are observed in similar ranges, for instance in **112**^(1966, 72) and also retain the stereospecificity as in **113**.^(1968, 104)

Fluoro- or perfluoro- aromatic compounds offer examples of coupling constants with higher moduli but the signs of which are only known in the *para*-fluorophenyl compounds; the results as obtained by McFarlane^(1969, 118) are shown below:

(<i>p</i> -FC ₆ H ₄) ₃ P	⁵ J(P-F) = -4.5 Hz
(<i>p</i> -FC ₆ H ₄) ₃ PS	⁵ J(P-F) = +2.4 Hz
(<i>p</i> -FC ₆ H ₄) ₃ P [⊕] CH ₃	⁵ J(P-F) = +1.3 Hz

Similarly, the ⁵J(P-F) values are also known in:

(<i>p</i> -FC ₆ H ₄) ₃ P=O	1.5 Hz (1967, 115)
(<i>p</i> -FC ₆ H ₄) ₂ PCl	5.2 Hz (1969, 120)
<i>p</i> -FC ₆ H ₄ PCl ₂	5.4 Hz (1969, 120)

On the basis of McFarlane's results the sign of the phosphine oxide would be positive while those of the chlorides would be negative. This

change in the sign of coupling is especially noticeable—it would be interesting to investigate the P-F couplings in relevant perfluoromethyl derivatives but, as previously stated (Section III.A), no coupling is observed between the phosphorus and *meta*- and *para*-CF₃ groups; only the *ortho* compounds show this coupling as in (*o*-CF₃C₆H₄)₃P $^4J(\text{P-CF}_3) = 55.0$ Hz,^(1969, 33) the marked positive temperature dependence of this coupling supports the proposed “through-space” mechanism.

Regarding other fluorine positions on the phenyl ring it is observed that *ortho*-fluorine atoms give the largest and most sensitive values; some reported values^(1966, 19) are shown in Table XXIII. For the purposes of comparison the data of Nichols^(1969, 121) shown in Table XXIV is of interest.

TABLE XXIII
Some typical values of *ortho*-fluorine coupling constants

Compound	$^3J(\text{P-F})$, Hz	Compound	$^3J(\text{P-F})$, Hz
C ₆ F ₅ PF ₂	63.2	(C ₆ F ₅) ₂ PN(CH ₃) ₂	40.1
C ₆ F ₅ PCl ₂	43.6	(C ₆ F ₅) ₂ PH	29
C ₆ F ₅ P(CH ₃) ₂	30.1	(C ₆ F ₅) ₃ P	12.3 ^a
C ₆ F ₅ PH ₂	3.9		

^a See footnote below.

TABLE XXIV
Comparison of P-F couplings in pentafluoroaromatic phosphine derivatives†

Compound	$^3J(\text{P-F}_o)$	$^4J(\text{P-F}_m)$	$^5J(\text{P-F}_p)$
(C ₆ F ₅) ₃ P	36.5	<0.1	<0.1
(C ₆ F ₅) ₃ PO	37.4	<1.0	<1.0
(C ₆ F ₅) ₂ PC ₆ H ₅	38.0	<0.5	<0.5
(C ₆ F ₅) ₂ P(O)C ₆ H ₅	6.5	3.6	2.3

Parent heteroaromatic structures have recently been described and typical couplings in the pyridine series, as reported by Thomas *et al.*^(1969, 122, 123) are shown in 114. Data for five-membered ring heterocyclics

† The value for (C₆F₅)₃P does not agree with the figure given above by Barlow *et al.* in Table XXIII, but is supported by other measurements (39.4 Hz).^(1966, 73)

have also been reported by Thomas *et al.* and also by Jakobsen *et al.*^(1969, 124 to 126) and are shown in **115** to **122**. For both **121** and **122** Jakobsen and Nielson have established signs from the analysis of double-quantum transitions and all couplings were found to be of the same sign.

Lastly, reference will be made to the investigation of Elguero and Wolf^(1967, 119) concerning phosphorus attached heteroaromatic systems by the heteroatom, in which couplings such as P-H₅ in pyrazoles (**123**) and P-H₃ in indazoles (**124**) are found.

(g) Unsaturated systems when attached to phosphorus through an heteroatom retain some of the previously described behaviours, for instance stereospecificity of the coupling in *O*-vinyl derivatives† as shown in Table XXV.^(1967, 120; 1969, 127)

TABLE XXV
Stereospecificity of P-H couplings in *O*-vinyl derivatives

Compound	"gem" ³ J(P-H)	<i>cis</i> ⁴ J(P-H)	<i>trans</i> ⁴ J(P-H)
(C ₂ H ₅ O) ₂ P(O)OCH=CH ₂	6.8	1.2	2.7
(CH ₃ O) ₂ P(O)OCH=CH ₂	6.8	4.1	2.8
(CH ₃ O) ₂ P(O)OCH=CHCH ₃	5.6	(7.0) ^a	7.0
(CH ₃ O) ₂ P(O)OC(CH ₃)=CH ₂	(0.0) ^a	0.2	0.3

^a Couplings involving CH₃ group.

The long-range coupling of phosphorus to methyl substituents are especially noticeable in these and similar compounds^(1967, 121). Chelation of the P=O group and of the γ -*cis* substituent has been invoked to explain this fact which would imply some "through-bond" mechanism. A further interesting point is the change of sign likely to occur for *cis* and *trans* P-H couplings.

Observations on *O*-phenyl compounds have been mentioned previously (Section III.B.7(f)); in these compounds the phosphorus coupling to the *para* protons is as great as that to the *ortho* protons^(1966, 75; 1967, 117) which leads to similar conclusions regarding the geometry of such derivatives and the coupling mechanism.

(h) The last unsaturated systems to be discussed, methylene phosphoranes, present some interesting features.† In these compounds the coupling transmission is easier as seen in **125** for which the couplings

† *S*-vinyl compounds are not well known but it appears that the general behaviour differs from that of *O*-vinyl compounds.^(1966, 74)

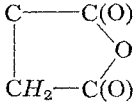
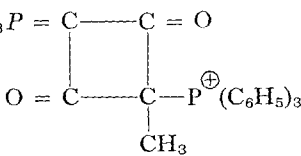
† One fluorine homolog [(CH₃)₂N]₃P=CF₂^(1964, 9) has been identified as [(CH₃)₂N]PF₂ by Ramirez *et al.*^(1966, 76)

are as shown. The relative signs in **126** have also been determined (see 1968, 105 to 107) and are opposite in sign for P-CH₃ and P-CH₂. The former coupling is probably negative as for other pentacoordinated phosphorus compounds (see Section III.B.2) while that of the P=CH₂ group would be positive. Similarly the couplings in **127** have been investigated and the P=CH and P...CHO couplings have the same sign. ^(1968, 20)

As is known, ^(1968, 108) there is some evidence for the overlap of the empty *d* orbital of phosphorus with the methylene *p* orbital; this stabilizes the molecule as a partly ionic species. It would be worthwhile investigating the magnitude and signs of couplings in various ylides having a range of stabilisation.

Another typical aspect in this type of compound is the long-range couplings which are readily observed; some typical examples are shown in Table XXVI.

TABLE XXVI
Some examples of long-range couplings in ylides

Compound	<i>J</i> , Hz	Reference
(C ₆ H ₅) ₃ P=C(COR)CH ₂ CO ₂ R	³ <i>J</i> (P-H), 28	1967, 122
(C ₆ H ₅) ₃ P=C(CO ₂ R)CH ₂ C(O)...	³ <i>J</i> (P-H), 15 to 17	1964, 10
(C ₆ H ₅) ₃ P=CH-CH=C(CH ₃)COCH ₃	⁵ <i>J</i> (P-H), 5	1968, 109
(C ₆ H ₅) ₃ P = 	³ <i>J</i> (P-H), 0.8	1964, 10
(C ₆ H ₅) ₃ P = 	⁵ <i>J</i> (P-H), 1.0	1967, 102 and 123 1968, 110
(C ₆ H ₅) ₃ P=C=C(CF ₃) ₂	⁴ <i>J</i> (P-F), 3.5	1967, 102

8. Long-range couplings

Finally, some typical phosphorus-proton or fluorine couplings through phosphorus or heteroatoms will be discussed.

(a) Some proton-phosphorus couplings of this type are given in Table XXVII. The sign of coupling in the P-N-P-CH group as found in (CH₃)₂P(S)NP(S)(C₆H₅)₂ is opposite to that of P-CH, ^(1968, 111) i.e. is probably positive.

TABLE XXVII

P-H couplings through phosphorus or other heteroatoms

Compound	J , Hz	Reference
H_2PPF_2	$^2J(H-P-P)$ 17	1968, 31
H_2PPH_2	$^2J(H-P-P)$ 11.9	1968, 31
$(CH_3)_2P-P(CH_3)_2$	$^3J(P-P-CH_3)$ +11.25	1967, 124 and 125
$(CH_3)P-P(CF_3)_2$	$^3J(P-P-CH_3)$ 12.7	1968, 55
$(CH_3)_3P=CH-P(CH_3)_2$	$^4J(P-C-P-CH_3)$ 0.7 ^a	1968, 107
$H-P(O)-O-P(O)H$	$^3J(P-O-PH)$ +1.5	1968, 37
$\begin{array}{c} O^- \\ \\ [(CH_3)_2N](C_2H_5)_2C-P(O)(OC_2H_5)_2 \\ \\ O^- \end{array}$	$^4J(CH_3N-C-P)$ 2.7	1969, 20
$CH_3SCH_2-P^+(CH_3)_3$	$^4J(CH_3SC-P)$ 1	1969, 128
$(CH_3)_3\overset{\oplus}{N}-CH_2-P^+(CH_3)_3$	$^4J(CH_3NC-P)$ 1	1969, 128
$(CH_3)_2N-CH_2-P^+(CH_3)_3$	$^4J(CH_3NC-P)$ 0	1969, 128

^a The $P=CH-P(CH_3)_2$ coupling is zero.

(b) Couplings involving fluorine have caused some interest. A series of compounds have been investigated by Rudolph, Newmark *et al.*^(1967, 40, 49; 1968, 42; 1969, 31, 60 and 61) and these are compared to data for other compounds in Table XXVIII, in which is included the data on $P-N=P$ compounds reported by Fluck and Heckman.^(1969, 69) From a study of $Cl_3P=NP(O)F_2$ and $Cl_3P=NP(O)FCl$, Glemser *et al.*^(1969, 129) found that the relative sign of $^3J(P-F)$ was opposite to that of $^1J(P-F)$, i.e. positive.

C. Phosphorus-phosphorus couplings

1. Direct $^{31}P-^{31}P$ couplings

The interest in considering such couplings in relation to the nature of P-P bonds has been discussed by Cowley in an earlier review.^(1965, 26) Since then a considerable amount of experimental data has been obtained and sign determination on typical compounds has revealed another interesting fact, namely that sign reversal occurs in this one-bond coupling depending upon the hybridisation of phosphorus and possibly upon the substituents. As mentioned earlier (Section III.A) this has prompted some theoreticians to consider this problem in detail.

(a) *Determination of $^{31}P-^{31}P$ couplings.* Symmetrical compounds, such as $(CH_3)_2PP(CH_3)_2$, will be considered first. Harris has shown that

TABLE XXVIII

P-F couplings through phosphorus and other heteroatoms

F_2P-PF_2	$^2J(F-P), +65^i$	F_2P-PH_2	$^2(F-P), 82^a$
$P(PF_2)_3$	$^2J(F-P), 61^i$	$F_2P(O)OP(O)O_2^{2-}$	$^3J(FP-O-P), -8^b$
$F_2P-S-PF_2$	$^3J(FP-S-P), +32^i$	$F_2P(O)OP(O)F_2$	$^3J(FP-O-P), -2.9^c$
$F_2P-(NCH_3)PF_2$	$^3J(FP-N-P), +41, -52^i$	$F_2PSP(S)F_2$	$^3J(FP-S-P), 22.0^{d,e}$
$F_2P-(NC_6H_5)PF_2$	$^3J(FP-N-P), 40^i$	$F_2P(S)-S-PF_2$	$^3J(FP-S-P), 15.0^{d,e}$
$CF_3P[P(CH_3)_2]_2$	$^3J(FCP-P), 6.4^f$	$(CF_3)_2P-P(CH_3)_2$	$^3J(FCP-P), 7.8^g$
$(CF_3)_2PSP(S)(CF_3)_2$	$^4J(FCPSP), 0^d$	$(CF_3)_2P(S)SP(CF_3)_2$	$^4J(FCPSP), 5.0^d$
$SPCl_2N=PClF_2$	$^3J(PN=PF), 5^h$	$SPClFN=PF_3$	$^3J(PN=PF), 2.8^h$
$SPClFN=PF_3$	$^3J(FP-N=P), 27^h$	$SPF_2N=PF_3$	$^3J(PN=PF), 3^h$
$SPF_2N=PF_3$	$^3J(FPN=P), 30^h$	$SPClFN=PCl_2(C_6H_5)$	$^3J(FPN=P), 19.5^h$
$SPClFN=PCl(C_6H_5)_2$	$^3J(FPN=P), 13.7^h$		

^a 1968, 31. ^b 1968, 112. ^c 1969, 62. ^d 1969, 57. ^e 1969, 59. ^f 1967, 83. ^g 1968, 55. ^h 1969, 69.

ⁱ 1967, 40, 49; 1968, 42; 1969, 31, 60 and 61.

analysis of the relevant $X_nAA'Z_n$ -type spectra (where A and A' = ^{31}P) gives $^1J(\text{P-P})$, in most cases from the proton or fluorine spectra, e.g. Harris and Finer have obtained $^1J(\text{P-P})$ of -179.7 for $(\text{CH}_3)_2\text{PP}(\text{CH}_3)_2$; additionally $^2J(\text{P-CH}_3) = +2.9$ and $^3J(\text{PPCH}_3) = +11.25$; ^(1967, 124, 125; 1968, 57) the negative sign of this one-bond P-P coupling should immediately be noticed. This has been recently confirmed by direct tickling experiments ^(1969, 31) and it would appear that all $\text{P}^{\text{III}}\text{-P}^{\text{III}}$ coupling constants have the same sign, but positive values are found when P^{V} atoms are involved.

Data for unsymmetrical compounds are obtained by directly observing the phosphorus AB spectra but the signs of coupling are obtained by spin-tickling or by analysis of higher order spectra.

(b) *Factors effecting $^{31}\text{P}\text{-}^{31}\text{P}$ one-bond couplings.* Typical data shown in Table XXIX clearly shows the dependence of the sign of coupling on the valency of phosphorus and the nature of substituents on phosphorus (see 1968, 57 and 113; 1969, 47). The importance of molecular geometry has been considered in recent variable temperature investigations of Rudolph and Newmark ^(1969, 31) on F_2PPF_2 (in parallel to F_2PSPF_2 and $\text{MeN}(\text{PF}_2)_2$ which will be discussed later). Despite the proximity of phosphorus lone-pairs no significant change is observed from -230.3 Hz at -101° to -228.6 Hz at -1° for the pure compound and -226.5 Hz at the same temperature for a 5% solution in CFCl_3 .

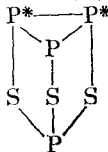
(c) *Theoretical approach to $^{31}\text{P}\text{-}^{31}\text{P}$ one bond couplings.* The previously mentioned points are sufficiently intriguing to arouse the interest of theoreticians. Harris and Finer ^(1968, 113) were the first to discuss this matter and, from the available signs found in P_2H_4 , P_2Me_4 , $\text{Me}_2\text{PP}(\text{S})\text{Me}_2$ (negative) and $\text{HP}_2\text{O}_5^{3-}$ (positive), rationalised the dependence of J upon the substituent electronegativity on the assumption that the sign was positive in P_2F_4 .

To account for this behaviour these authors proposed an extension of the theory, given by Pople and Santry, which predicted that the coupling constant depends upon the energies of the s relative to those of the p , d , etc. electrons of the coupled nuclei and additionally upon the resonance integral between the outer-shell s electrons of the two atoms. It was considered that the first factor remained fairly constant for the P-P bonds and the observed variation was qualitatively explained by the dependence of the second factor upon the electronegativity and the bulkiness of the substituent.

As discussed earlier (III.A.2(a)), Cowley, White and Manatt ^(1967, 28) had previously undertaken a quantitative determination of P-P coupling

TABLE XXIX

One-bond phosphorus-phosphorus couplings^a

P^{III}-P^{III} compounds		
H ₂ PPH ₂	-108	1961, 2
H ₂ PPF ₂	211	1968, 31
F ₂ PPF ₂	-227.4	1968, 31; 1969, 31
(CH ₃) ₂ PP(CH ₃) ₂	-179.7	1967, 124 and 125
(CH ₃) ₂ PP(CF ₃) ₂	-256, 252	1967, 40; 1968, 55
(C ₂ H ₅) ₂ PP(C ₆ H ₁₁) ₂	282	1965, 11
(C ₆ H ₅) ₂ PP(C ₆ H ₁₁) ₂	224	1965, 11
(C ₂ H ₅) ₂ PP(C ₂ H ₅)Li	396	1965, 27
C ₂ H ₅ P[P(C ₂ H ₅)K] ₂	306	1965, 27
[C ₆ H ₅ PP(C ₆ H ₅)Li] ₂	216	1965, 27
P(PF ₂) ₃	323	1968, 42
[CH ₃ P-C(CF ₃) ₂] ₂	55	1964, 11
(CH ₃ P) ₃ (CCF ₃) ₂	220	1964, 11
	157	1969, 130
P^{III}-P^V compounds		
(CH ₃) ₂ PP(S)(CH ₃) ₂	-220	1964, 12
(P^{IV})⁺-P^V compounds		
(C ₄ H ₉) ₃ P ⁺ P(S)(S ⁻)C ₆ H ₅	118	1966, 77; 1967, 126
(C ₄ H ₉) ₃ P ⁺ P(S)(S ⁻)C ₁₀ H ₉	96	1966, 77; 1967, 126
P^V-P^V compounds		
(CH ₃) ₂ P(S)P(S)(CH ₃) ₂	18.7	1965, 28
(C ₂ H ₅) ₂ P(S)P(S)(C ₆ H ₁₁) ₂	69	1965, 11 and 29
(C ₂ H ₅) ₂ P(O)P(O)(C ₂ H ₅) ₂	583	1967, 127
(C ₂ H ₅) ₂ P(O)P(S)(C ₂ H ₅) ₂	590	1967, 127
HP(O)(O ⁻)PO ₃ ²⁻	+465.5	1968, 113

^a Coupling in Hz for the starred atoms, sign given where directly established.

in the P₂ fragment on the basis of extended Hückel and CNDO-SCF molecular orbitals within the framework of the Pople-Santry approach. These authors obtained -128.95 and -30.54 respectively for the two modes of calculation; figures which were approximately in agreement with the data for P₂Me₄ and P₂H₄. Cowley and White later proposed (1969, 36, 37) an improvement by using semi-empirical LCAO-SCF but including overlap integrals for the whole molecule again within the

Pople-Santry formalism. In this manner the molecular geometry could be taken into more detailed account and the following parameters were obtained:

P_2H_4	<i>gauche</i>	- 53.50	P_2F_4	<i>gauche</i>	+ 219.75
	<i>trans</i>	+ 169.03		<i>trans</i>	+ 707.36
	<i>cis</i>	- 84.63		<i>cis</i>	+ 212.16

The predicted reversal of the sign for the different stereorelationships of P_2H_4 should be noted as should the positive sign obtained for the coupling in P_2F_4 as was previously assumed by Finer and Harris.

All this therefore appears gratifying—unfortunately heteronuclear tickling experiments definitely established a negative sign for $^1J(P-P)$ in P_2F_4 .^(1969, 31) This therefore re-opens the question of a sound theoretical approach to such couplings and this problem remains exceptionally attractive.

No application of the Jameson-Gutowsky approach (see III.A.2(b)) to the study of P-P coupling has been considered to date.

2. Two-bond $^{31}P-^{31}P$ couplings

Such couplings have been reported occurring across both carbon- and hetero- atoms; two-bond $P-P-P$ couplings are also known as in $P(PF_2)_3$ [36 Hz]^(1968, 42) and may also be present in **128** [75 Hz].^(1966, 78)

When considering symmetrical compounds these couplings are obtained by analysis of the relevant $X_nAA'X_n$ spectra as previously discussed for direct couplings (see III.C.1(a)), e.g. in aminophosphines^(1966, 79) or in various metal complexes.^(1968, 57; 1969, 131) In the latter case these couplings were found to be especially useful in assigning the geometry of the complex and in the discussion of the phosphorus-metal hybridisation;^(1969, 60, 132 to 134) this aspect will not be further discussed here.

In asymmetrical compounds direct observation gives the modulus of the coupling—sign determination being obtained from heteronuclear tickling experiments or analysis of higher-order spectra. As no general theory is applicable to the existing data each of the systems will be discussed separately.

(a) $J(P-C-P)$ have only been reported in **129** with a value of 47 ± 7 Hz^(1967, 123) but as a related system, however, we may also quote **130** with a value of 37.2 Hz.^(1967, 128)

(b) $J(P-O-P)$ are much better known. The relative sign of the coupling in the dianion **131** has been determined by McFarlane^(1968, 37) and found to be negative (-10.7 Hz) but, as a number of values around zero have been found, a reversal of sign cannot be dismissed. As no further signs are known only the moduli of the couplings will be dis-

cussed. Following the early study of the trianion **132** ^(1957, 2) the tripolyphosphate **133** with $^2J(\text{POP})$ of 21.5 Hz ^(1965, 28) and the ATP homolog (**134**), for which $J(\text{P}_\alpha\text{--O--P}_\beta) = 20.6$ and $J(\text{P}_\beta\text{--O--P}_\gamma) = 21.3$ (see 1967, 1, pp. 12 to 13), have been studied. This small difference in the value of $^2J(\text{P--P})$ may arise from differences in the hybridisation of the phosphorus atoms (two bearing one $\text{O}^\ominus$ group and the third having two $\text{O}^\ominus$ substituents). A similar situation arises in **135** for which $^2J(\text{P}_\alpha\text{--O--P}_\beta)$ [12.1 Hz] is lower than $^2J(\text{P}_\beta\text{--O--P}_\gamma)$ [14.5 Hz]. ^(1966, 79)

Molecular conformation may additionally be of considerable importance and the effect of pH is another factor as is the nature of the counterions as was found in an earlier study of tripolyphosphate. ^(1965, 30) A clear relationship of the mean $^2J(\text{POP})$ in ATP with pH has recently been found (Fig. 9) and is similar to that observed in ADP. Other examples have also been considered, the values of which are shown in Table XXX. No coupling has been found in $(\text{C}_6\text{H}_5)_3\text{P}^\oplus\text{--O--P}^\ominus\text{Cl}_5$. ^(1969, 135)

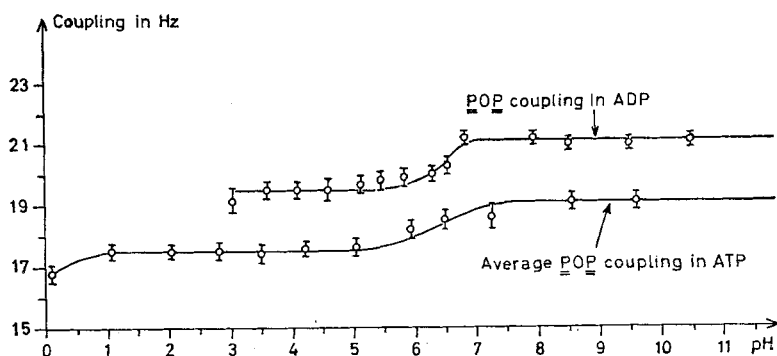
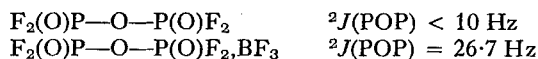


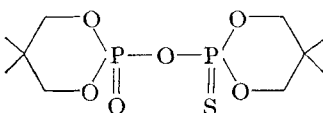
FIG. 9. pH Dependence of P–O–P couplings in ADP and ATP [From Ellenberger *et al.* ^(1970, 2)]

The sensitivity of $^2J(\text{POP})$ to changes in the hybridisation and electronegativity has been demonstrated for ATP. This effect is also noticeable when comparing ligands and related adducts, for example: ^(1968, 34)



(c) $J(\text{P--S--P})$ —although the number of known examples are fewer the general magnitude of the modulus of coupling appears to be greater. The sign of coupling (positive) is only known in F_2PSPF_2 ; this compound exhibits an astonishing temperature behaviour as $^2J(\text{PSP})$ increases from +274 at 39° to +392 at –120°. ^(1969, 31, 136) This is a

TABLE XXX
Additional examples of $^2J(\text{POP})$ couplings

	J (Hz)	Reference
$\text{HO}(\text{O})\text{P}-\text{O}-\text{P}(\text{O})\text{OH}$	17.7	1967, 29
$\begin{array}{c} \text{H} \quad \text{OH} \\ \quad \\ \text{H}(\text{O})\text{P}-\text{O}-\text{P}(\text{O})\text{H} \\ \quad \\ \text{O}^\ominus \quad \text{O}^\ominus \end{array}$	-10.7	1968, 37
$\text{F}_2(\text{O})\text{P}-\text{O}-\text{P}(\text{O})\text{F}_2$	4	1966, 28
	0	1969, 62
	<10	1969, 31
$^\ominus\text{O}(\text{O})\text{P}-\text{O}-\text{P}(\text{O})\text{F}_2$	2.5	1968, 112
	ca. 28	1967, 91
$\begin{array}{c} \text{F}_2\text{P}-\text{O}-\text{PF}_2 \\ \quad \\ \text{S} \quad \text{S} \end{array}$	7.1	1969, 62

clear indication of a rotational equilibrium as sulphur affords a rather loose link between the two phosphorus atoms with $3p_\pi-3d_\pi$ bonding and additionally this conformational dependence may depend upon the overlap of phosphorus lone-pairs.

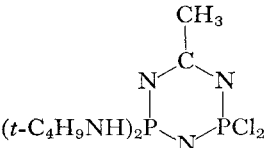
Other interesting examples are shown in **136**.^(1969, 130) The increase of the mean value from P-O-P to P-S-P and P-Se-P coupling reflects the decreased electronegativity of the bridging atom; this reduces the polarity of the intervening bonds thus facilitating the "coupling transmission".^(1966, 1, p. 217)

(d) $J(\text{P}-\text{N}-\text{P})$ couplings are known in many phosphonitrilic compounds and the relative sign has been found to be positive.^(1967, 57; 1969, 68) Some typical values are shown in Table XXXI.

The available data and sensitivity to molecular environment prompted Finer and Harris to investigate these couplings further;^(1967, 130; 1968, 57) they succeeded in accounting for the values, at least within a few percent, in compounds of the general type **137** by the following relationship:

$$J = (\lambda_A + \lambda_B)(\lambda_C + \lambda_D)$$

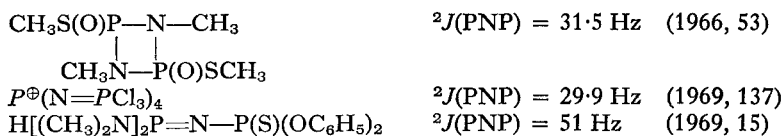
TABLE XXXI
Some typical values of $^2J(\text{P-N-P})$

Compound	J , Hz	Reference
$\text{N}_3\text{P}_3\text{Cl}_4(\text{NH}_2)[\text{N}=\text{P}(\text{C}_6\text{H}_5)_3]$	28	1968, 114
$\text{N}_3\text{P}_3\text{Cl}_{6-n}(\text{NCH}_3)_n$	34 to 48	1965, 24
$\text{N}_3\text{P}_3(\text{OCH}_2\text{CF}_3)_4(\text{NHC}_6\text{H}_5)_2$	72	1966, 80
$\text{N}_3\text{P}_3\text{F}_4(\text{C}_6\text{H}_5)_2$	<i>cis</i> 58 <i>trans</i> 65	1968, 67
	27	1969, 106

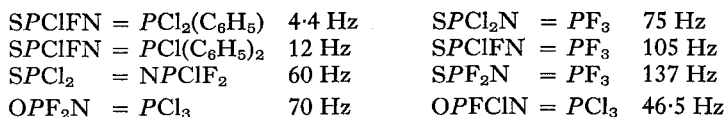
with typical λ contributions such as:

$$\begin{array}{ll}
 \lambda(\text{F}) = 7.0 & \lambda[\text{N}(\text{CH}_3)_2] = 3.2 \\
 \lambda(\text{OCH}_3) = 5.3 & \lambda(\text{SC}_2\text{H}_5) = 0.3 \\
 \lambda(\text{Cl}) = 3.6 &
 \end{array}$$

P-N-P couplings are, however, also known in systems other than phosphonitriles, for example:



and in the following series in which the electronegativity effects appear to be especially pronounced: (1969, 69, 129)



The most extensively investigated case is that of $\text{F}_2\text{P-N}(\text{CH}_3)\text{-PF}_2$ which, as for F_2PSPF_2 (see III.B.4), has been studied over a range of temperatures. In the latter compound the P(X)P coupling varied very considerably while for the case of $\text{F}_2\text{P-N}(\text{CH}_3)\text{-PF}_2$ the coupling is much more constant varying only from +432 to +442 Hz for temperature +30 to -70°C . (1969, 31) This was attributed to the rigidity of the

$2p_{\pi}-3p_{\pi}$ bonding which means there is restricted rotation around the P-N bonds and hence the absence of rotamers. For the phenyl homologue, $F_2P-N(C_6H_5)-PF_2$, the value of $^2J(PNP)$ is substantially lower, 371 Hz.^(1969, 61) It is worth noting that the P-N-P couplings are positive for this $P^{III}-P^{III}$ system as is the case for the P^V-P^V system of phosphonitrilics.

3. Higher $^{31}P-^{31}P$ couplings

These have only been observed for the P-O-C-P system in the following series of compounds:^(1969, 3 and 138)

$P(OCH_2)_3P$	-37.2; -38.1
$SP(OCH_2)_3P$	+48.4
$OP(OCH_2)_3PO$	+139.2
$SP(OCH_2)_3PO$	+151.3

The observed trend may be interpreted on the basis of changes of s character but again sign reversal is present.

D. Carbon-phosphorus couplings

Such couplings may be determined from carbon-13 spectra using heteronuclear "tickling"^(1967, 66; 1969, 2, 21 and 47) or by complete analysis of higher-order proton spectra.^(1967, 125) Carbon-13 satellites in phosphorus resonance are used if sensitivity is sufficiently good or after signal enhancement, for instance using the nuclear Overhauser effect.^(1967, 131) Of these methods "tickling" is the more useful as the relative signs are also obtained.

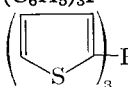
1. Direct $^{13}C-^{31}P$ couplings

The most significant results for $^{31}P-^{13}C$ couplings are presented in Table XXXII. It is evident that these couplings are very sensitive to: (i) the hybridisation of phosphorus (P^{III} , $P^{IV\oplus}$ or P^V), (ii) hybridisation of carbon (the largest $|J|$ being found in $(C_2H_5O)_2(O)P-C\equiv CH_3$ in which $^1J(^{13}C-^{31}P) = 304$ Hz), and (iii) the substituents attached to both atoms.

In particular, it is to be noted that in the case of P^{III} compounds a reversal of sign occurs for the direct coupling; a similar behaviour has also been found for direct phosphorus-phosphorus coupling (see III.C.1). Another feature which is also of significance is that, whenever it is possible to compare the corresponding $^{13}C-^{31}P$ and $^1H-C-^{31}P$ couplings, there is a fairly good correlation and that there is correspondence of sign reversal—from positive to negative for P-C when it is negative to positive for P-CH;^(1968, 20; 1969, 47) this point is clearly indicated in

TABLE XXXII

Direct phosphorus-carbon couplings in typical organo-phosphorus compounds^a

Compound	$J(^{31}\text{P}-^{13}\text{C})$	Reference
Tricoordinated phosphorus		
$(\text{CH}_3)_3\text{P}$	-13.5; -14.0	1968, 3; 1969, 2
$(\text{CH}_3)_2\text{PH}$	11.6	1968, 22
* $(\text{CH}_3)_2\text{PC}_6\text{H}_5$	-14	1967, 66
$(\text{CH}_3)_2\text{PSeCH}_3$	-25	1969, 4
CH_3PH_2	9.3	1968, 22
CH_3PCl_2	45	1968, 20
* $(\text{CH}_3\text{CH}_2)_3\text{P}$	0 ± 4	1968, 3
($\text{C}_3\text{H}_7\text{CH}_2$) ₃ P*	-10.9	1969, 21
$(\text{C}_6\text{H}_5)_3\text{P}$	12.4	1969, 21
	14.2	1969, 124
* $\text{P}(\text{CH}_2\text{O})_3$	-24	1969, 3
Phosphonium compounds		
$(\text{CH}_3)_4\text{P}^\oplus$	+55.5; +56.5	1968, 3; 1969, 2
* $(\text{CH}_3)_2\text{PH}(\text{C}_6\text{H}_5)$	+56	1967, 66
$(\text{CH}_3\text{CH}_2)_4\text{P}^\oplus$	+48.5	1968, 3
$(\text{C}_3\text{H}_7\text{CH}_2)_4\text{P}^\oplus$	+47.6	1969, 21
$(\text{C}_6\text{H}_5)_4\text{P}^\oplus$	88.4	1969, 21
Tetracoordinated phosphorus		
$(\text{CH}_3)_3\text{PS}$	+56.1	1968, 3
$(\text{CH}_3)_3\text{PSe}$	+48.5	1968, 3
$(\text{CH}_3)_2\text{P}(\text{S})\text{SeCH}_3$	+50	1969, 4
$\text{CH}_3\text{P}(\text{O})\text{Cl}_2$	104	1968, 20
$\text{CH}_3\text{P}(\text{O})\text{F}_2$	147	1968, 20
$\text{CH}_3\text{P}(\text{S})\text{Cl}_2$	81	1968, 20
$\text{CH}_3\text{C}\equiv\text{CP}(\text{O})(\text{OC}_2\text{H}_5)_2$	304	1968, 20
$\text{CH}_3\text{C}(\text{O})\text{CH}_2\text{P}(\text{O})(\text{OC}_2\text{H}_5)_2$	127	1968, 20

^a Coupling in Hz. Where there is possible ambiguity the carbon or phosphorus nucleus involved in the coupling is indicated by an asterisk.

Fig. 10. This feature undoubtedly reflects that there are similar factors effecting these couplings. Another observation which warrants mention is that geminal HPH couplings which have recently been investigated also demonstrate the same sign reversal, without any clear correlation with the H-P-H bond angle, but are very dependent upon the hybridisation of the phosphorus. ^(1969, 41)

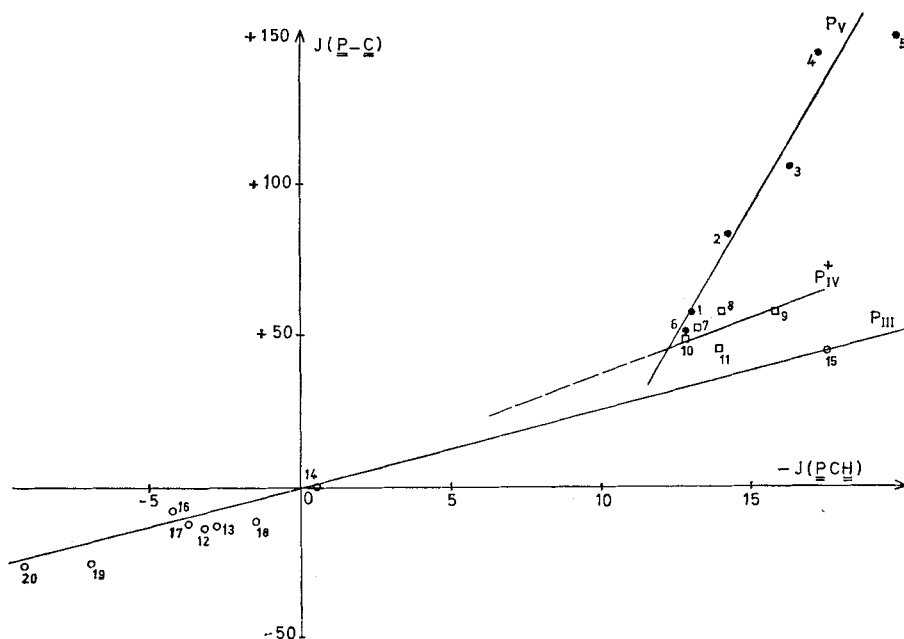


FIG. 10. Correlation of P-C and P-C-H couplings in typical derivatives of P^{III} , P^{IV} and P^V derivatives.

If the general trend in all these couplings may be qualitatively explained on the basis of the Walsh rule (i.e., the s character of the phosphorus atom being concentrated in bonds with the most electropositive substituents) the explanation of the reversal of sign is more complex. As proposed by Finer and Harris, ^(1968, 113) for the ^{31}P - ^{31}P direct couplings (see III.C.1(c)), the reversal may be reconciliated with the Pople-Santry theory, the dominating term in the coupling depending on the s level energies (approximately constant) and on the resonance integral between these s electrons which in turn depends upon the molecular hybridisation and geometry. Weigert and Roberts recently proposed ^(1969, 21) a similar explanation by noting that a negative one-bond coupling may occur when the energy difference between the valence s and p electrons

become large, this being especially important for p^3 hybridised while $P^{IV\oplus}$ and P^{IV} are more nearly sp^3 .

The most systematic approaches are these presented by Cowley and White and by Jameson (see above III.A.2). It was seen that predictions presented by the former authors (Table VIII) are in approximate agreement with observed values but far more data are required to establish the validity of the correlation. On the other hand, the Jameson model only qualitatively accounts for the observed trends.

2. Two-bond and higher ^{13}C - ^{31}P couplings

Two-bond P–C couplings have been reported through both carbon and heteroatoms and in one case a P–P–C coupling has been identified. The relevant values are shown in Table XXXIII. Wherever comparisons are possible it is seen that reversal of sign again occurs; all couplings involving $P^{IV\oplus}$ and P^V are negative, as expected, while the P^{III} compounds without exception involve positive couplings either through carbon and phosphorus or through heteroatoms.

No theoretical approach has been proposed to explain these couplings. It is, however, interesting to note that the same conclusions do not apply to higher couplings, at least for the only well established series:

$P(OCH_2CH_3)_3$	$+4.9$	(1968, 3 and 22)
$OP(OCH_2CH_3)_3$	$+6.8$	(1968, 3)
$SP(OCH_2CH_3)_3$	$+6.4$	(1968, 3)

No clear relation between the related $P\cdots C$ and $P\cdots H$ couplings (the signs of which have been estimated to be negative—see III.B.3(a)) in these compounds:

	$^2J(P-O-C)$	$^3J(POCH)$	$^3J(POCC)$	$^4J(POCCH)$
$P(OCH_2CH_3)_3$	$+11.3$	$+7.9$	$+4.9$	-0.5_5
$OP(OCH_2CH_3)_3$	-5.8	$+8.4$	$+6.8$	$+0.8_4$
$SP(OCH_2CH_3)_3$	-5.2	$+9.85$	$+6.4$	$+0.7_3$

Other higher couplings, but of unknown signs, have been observed by Weigert and Roberts, ^(1969, 21) e.g.:

$^3J(PCCC)$ in $P(C_4H_9)_3$	12.5 Hz	$^4J(PCCCC)$ in $P(C_6H_5)_3$	0 Hz
$P^\oplus(C_4H_9)_4$	15.4 Hz	$P^\oplus(C_6H_5)_4$	2.9 Hz
$P(C_6H_5)_3$	6.7 Hz		
$P^\oplus(C_6H_5)_4$	12.8 Hz		

E. Phosphorus coupling to other nuclei

Coupling of phosphorus to other nuclei have been reported in a variety of molecules but these examples have usually remained as curiosities rather than of practical use.

TABLE XXXIII

Two-bond phosphorus-carbon couplings in typical organo-phosphorus compounds^a

Compound	$^2J(^{31}\text{P}-^{13}\text{C})$	Reference
<i>Coupling through carbon</i>		
$^*(\text{CH}_3\text{CH}_2)_3\text{P}$	+14.1	1968, 3
$(\text{C}_2\text{H}_5\text{CH}_2\text{CH}_2)_3\text{P}^*$	+11.7	1969, 21
$^*(\text{CH}_3)_3\text{CP}(\text{C}_6\text{H}_5)_2$	+18	1969, 2
$\text{P}(\text{C}_6\text{H}_5)_3$	19.6	1969, 21
$^*(\text{CH}_3\text{CH}_2)_4\text{P}^\oplus$	-4.3	1968, 3
$(\text{C}_2\text{H}_5\text{CH}_2\text{CH}_2)_4\text{P}^\oplus$	-4.3	1969, 21
$(\text{C}_6\text{H}_5)_4\text{P}^\oplus$	10.9	1969, 21
$^*\text{CH}_3\text{C}\equiv\text{CP}(\text{O})(\text{OC}_2\text{H}_5)_2$	54	1968, 20
<i>Coupling through phosphorus</i>		
$^*(\text{CH}_3)_2\text{P}-\text{P}^*(\text{CH}_3)_2$	+7 (estimated)	1968, 57
<i>Coupling through heteroatoms</i>		
<i>Oxygen</i>		
$(\text{CH}_3\text{O})_3\text{P}$	+10	1968, 3 and 22
$^*(\text{CH}_3\text{CH}_2\text{O})_3\text{P}$	+11.3	1968, 3 and 22
$\text{P}(\text{CH}_2\text{O})_3$	≤ 10	1969, 3
$(\text{CH}_3\text{O})_3\text{PO}$	-5.8	1968, 3
$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{H}$	-6.0	1967, 132; 1968, 3
$^*(\text{CH}_3\text{CH}_2\text{O})_3\text{PO}$	-5.8	1968, 3
$(\text{CH}_3\text{O})_3\text{PS}$	-5.6	1968, 3
$^*(\text{CH}_3\text{CH}_2\text{O})_3\text{PS}$	-5.2	1968, 3
<i>Sulphur</i>		
$(\text{CH}_3\text{S})_3\text{PS}$	<10	1969, 20
<i>Selenium</i>		
$^*\text{CH}_3\text{SeP}(\text{CH}_3)_2$	+19.5	1969, 4
$^*\text{CH}_3\text{SeP}(\text{S})(\text{CH}_3)_2$	-5	1969, 4
<i>Nitrogen</i>		
$[(\text{CH}_3)_2\text{N}]_3\text{P}$	17	1969, 20
$[(\text{CH}_3)_2\text{N}]_3\text{PO}$	<10	1969, 20
$[(\text{CH}_3)_2\text{N}]_3\text{PS}$	<10	1969, 20
$[(\text{CH}_2)_4\text{N}]_4\text{P}$	<10	1969, 20
<i>Other atoms</i>		
$(\text{CH}_3)_3\text{SiP}(\text{C}_6\text{H}_5)_2$	-13	1969, 2
$(\text{CH}_3)_3\text{SnP}(\text{C}_6\text{H}_5)_2$	+7.5	1969, 2

^a Coupling in Hz. Where there is possible ambiguity the carbon or phosphorus nucleus involved in the coupling is indicated by an asterisk.

(a) *With N-14*. A value of 60 Hz has been reported for $^2J(^{14}\text{N}-^{31}\text{P})$ in F_2PCNS ^(1967, 53) and the value of $^1J(^{14}\text{N}-^{31}\text{P})$ in $(\text{EtO})_2\text{P}(\text{O})\text{NH}\text{Et}$ has been reported to be "great" from a consideration of ^{14}N spectra but no further details are available.

(b) *With O-17*. Some typical values have been obtained by Christ and Diehl ^(1963, 1) but the data cannot be interpreted too deeply as the various oxygen sites were not always distinguished in this study. Some values are shown below:

H_3PO_2	115 Hz	$\text{P}(\text{OCH}_3)_3$	154 Hz
H_3PO_3	106 Hz	$\text{P}(\text{OCH}_2\text{CH}_3)_3$	150 Hz
$\text{OP}(\text{OCH}_3)_3$	$\left\{ \begin{array}{l} 90 \text{ Hz} \\ 165 \text{ Hz} \end{array} \right.$	OPCl_3	203 Hz

In P-O-C and P-O-H groups the values of the P-O couplings appear in the ranges 150 to 160 and 100 to 120 Hz respectively. For phosphoryl compounds the value is more variable from 90 to 200 Hz. Clearly more data are required for a deeper understanding of the underlying effects.

(c) *With Si-29*. Data have been obtained for $(\text{C}_6\text{H}_5)_2\text{PSi}(\text{CH}_3)_3$ [21.5 Hz] ^(1969, 4) and for $\text{P}(\text{SiH}_3)_3$ [212 Hz?]. ^(1968, 96)

(d) *With Cl-35*. The coupling has been estimated by Winter ^(1959, 1) from relaxation studies in PCl_3 and in agreement with the recent estimation of Strange. ^(1969, 139)

(e) *With Se-77*. Reported in $(\text{CH}_3)_2\text{PSeCH}_3$ [-205 Hz] and $(\text{CH}_3)_2\text{P}(\text{S})\text{SeCH}_3$ [-341 Hz]. ^(1969, 4)

(f) *With Br-79 and Br-81*. Couplings have been obtained for PBr_3 by analysis of relaxation mechanisms at variable temperature ^(1968, 115) and were 350 and 380 Hz for Br-79 and Br-81 respectively. These results do not agree with an earlier estimate by Winter ^(1959, 1) of 690 Hz.

(g) *With Sn-119*. Dreskamp *et al.* ^(1969, 2) have found a value of 598 ± 4 Hz for $^1J(\text{P}-\text{Sn})$ in $(\text{C}_6\text{H}_5)_2\text{PSn}(\text{CH}_3)_3$ using the INDOR method. The P-Sn couplings have also been observed in the P-O-Sn system ^(1969, 140) such as:

$(\text{CH}_3)_2\text{P}(\text{O})\text{OSn}(\text{CH}_3)_3$	102 Hz
$\text{CH}_3\text{P}(\text{O})[\text{OSn}(\text{C}_4\text{H}_9)_3]_2$	83 and 110 Hz
$\text{[OP}(\text{O})(\text{C}_8\text{H}_{17})[\text{OSn}(\text{C}_4\text{H}_9)_2]_n$	144 and 172 Hz

For both of the last two compounds two different couplings were clearly identified corresponding to interaction between different sites in the first and to slow exchange of POSn bonds in the second as depicted by **138**.

(h) *With other metallic and non-metallic atoms.* Coupling of phosphorus to metal atoms has been observed in complexes, e.g. $P-^{63}Cu$, $P-^{65}Cu$, $P-^{183}W$ and $P-^{199}Hg$,^(1965, 31; 1967, 79; 1968, 116) in other systems to be discussed later (see IV.E.3), and boron and aluminium in appropriate adducts.^(1966, 81; 1967, 23, 32, 133 and 134; 1968, 34; 1969, 26 and 141)

F. Couplings through phosphorus

The influence of a phosphorus atom on coupling constants is often apparent when the phosphorus atom is situated between the two coupling nuclei. Some typical cases where the effect is found will be discussed here.

1. Proton-proton coupling through phosphorus

(a) The case of *HPH* couplings has been recently well documented by Manatt *et al.*^(1969, 41) This coupling has been mentioned earlier (III.A.2(b)) and especially for its sensitivity to the hybridisation of the phosphorus atom; the couplings being anomalously negative for P^{III} and positive for $P^{IV\oplus}$ and P^V compounds.

(b) Three bond *HPCH*† couplings do not appear to undergo change of sign and have been found to be positive, as expected, in all the cases in which sign determination has been made^(1968, 28; 1969, 34). Fortunately, however, the values for tri- and tetra- coordinated phosphorus are different and have the following values: +6.5 to 8 Hz for P^{III} , +5.5 Hz for $P^{IV\oplus}$ and +3 to 3.5 Hz for P^V .^(1966, 14; 1967, 135; 1968, 28 and 35; 1969, 34 and 73) This behaviour‡ is contrary to the hybridisation changes predicted for the P-H and P-C bonds and cannot fit into the Jameson formalism (see III.A.2(b)). Additionally, some stereospecificity is observed in these couplings—the methylene protons of $HP(CH_2CH_3)C_6H_5$ are not equivalent and are coupled differently to the P-H proton [+6.56 and +7.10 Hz].^(1968, 28) Likewise, it is possible to identify the conformation in cyclic compounds, e.g. in **139** the value of $^3J(HPCH)$ is 12 Hz for the *cis* proton but 2.5 Hz for the *trans*.^(1969, 142) In a few instances couplings in pentacoordinated compounds have been reported, e.g. in CH_3PF_3H [1.2 Hz] and $(CH_3)_2PF_2H$ [2.7 Hz].^(1968, 42)

(c) Four bond couplings have only been reported for $^4J(HCPCH)$ in

† Some *HPSiH* couplings have similarly been described.^(1969, 73)

‡ The same as for the relevant *CPCH* couplings, for which the value is +4.8 Hz in $P(CH_3)_3$ and +2.4 Hz in $P^\oplus(CH_3)_4$.^(1969, 2)

$P(CH_3)_3$ [$+0.15$ Hz] and in $P^\oplus(CH_3)_4$ [$+0.3$ Hz]^(1969, 2) and for $^4J(HCPSiH)$ in $CH_3P(SiH_3)_2$ and CH_3PHSiH_3 [0.4 and 0.3 Hz respectively];^(1969, 73) as for the case of $HCPH$ couplings the signs and magnitude were not as expected. In both cases "through-space" mechanism cannot be excluded which would involve some contribution from the lone-pair on P^{III} .

A longer-range coupling has been detected in **140**, between the ringed hydrogen atoms, and the stereospecificity used to assign the conformation.^(1968, 117)

2. Proton-fluorine coupling through phosphorus

(a) Two-bond HPF couplings. These were first recognised in simple tri- and tetra-coordinated compounds— HPF_2 $+41.7$ Hz, $HP(O)F_2$ 116 Hz and $HP(S)F_2$ 98.9 Hz.^(1966, 32; 1967, 31 and 33; 1968, 118) The signs are not known in the latter two compounds but, for HPF_2 , the sign is coherent with that (negative) of the relevant PF coupling. Numerous data are available for penta-coordinated compounds; two examples in simple compounds are:

HPF_4	(ca. $-20^\circ C$)	$90, 92$ Hz	^{1966, 24; 1967, 36}
H_2PF_3	(ca. $0^\circ C$)	80 Hz	

In both cases it is not possible to distinguish between axial and equatorial fluorine atoms; this is only possible in those cases in which the phosphorus has heavier substituent groups^(1968, 38, 39 and 42) as for:

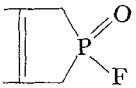
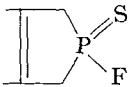
$$\begin{aligned}
 HPF_3(CH_3) \quad J(H-F_{ax}) &= 117 \text{ Hz} \\
 &J(H-F_{eq}) = 29.9 \text{ Hz}
 \end{aligned}$$

When three substituents are present then the two fluorine atoms are both axial as in $HPF_2(CH_3)_2$ with $J(H-F_{ax}) = 98.4$ Hz.^(1968, 42) Despite the greater polarity of the $P-F_{ax}$ bonds it clearly appears that $H-F_{ax}$ couplings are of greater magnitude than those of the $H-F_{eq}$. This may arise from the fact of the closer proximity of the atoms in the $H-F_{ax}$ case; this has been interpreted fairly well on the basis of the Jameson-Gutowsky formalism (III.A.2(b)) by estimating the relevant exchange integral.

Lastly, for $P^{VI\ominus}$ compounds it has been observed^(1968, 41) that the HPF couplings for the two non-equivalent equatorial positions were quite distinct as shown in **141**. The *trans* $H-F$ coupling in $[PF_5H]^\ominus$ is in fact a function of the $H-P-F$ angle.^(1969, 143)

(b) The best documented three-bond coupling is that involving the $FP-CH$ group.[†] Some typical values taken from the literature^(1966, 36; 1967, 60 and 110; 1968, 38, 39 and 42; 1969, 20, 62 and 74) are shown below:

[†] $HP-CF$ coupling has only been reported for $HP(CF_3)_2$ and was 9.9 Hz.^(1969, 43)

$(\text{CH}_3)_2\text{PF}$	18.5 Hz	CH_3PF_4	7.2 Hz (average)
CH_3PF_2	20.0 Hz	$\text{CH}_3\text{PF}_3\text{H}$	F_{ax} 12.6, F_{eq} 4.2 Hz
$\text{CH}_3\text{P}(\text{O})\text{F}_2$	6.0 to 6.2 Hz	$\text{CH}_3\text{PF}_2(\text{OC}_6\text{H}_5)_2$	F_{ax} 12.0 Hz
	13 Hz	$(\text{CH}_3)_2\text{PF}_2\text{H}$	F_{ax} 12.1 Hz
	12 Hz	$(\text{CH}_3)_2\text{PF}_3$	F_{ax} 12.9, F_{eq} 3.3 Hz
		$(\text{CH}_3)_3\text{PF}_2$	F_{ax} 12.0 Hz

A number of interacting factors precludes any generalisations to be made but it should be noted that the clear distinction of the proton couplings to axial and equatorial fluorine atoms in pentavalent compounds is again obtained. The same order is found as for $^2J(\text{H}-\text{P}-\text{F})$ namely $|^3J(\text{H}-F_{\text{ax}})| \gg |^3J(\text{H}-F_{\text{eq}})|$.

Some unusual three-bond couplings have been found in the following compounds: $F_2\text{PNHCH}_3$ [10.2 Hz], ^(1968, 119) $\text{FCIP}(\text{S})\text{NHSi}(\text{CH}_3)_3$ [2 Hz] ^(1969, 69) and in $F_2\text{P}(\text{S})\text{SH}$ [1.2 Hz]. ^(1969, 99)

(c) The majority of interesting four-bond couplings are $^4J(\text{H}-\text{F})$ found in $\text{FP}-\text{N}-\text{CH}$ groups ^(1965, 8; 1966, 30; 1967, 59; 1968, 43 and 46; 1969, 31, 56, 61 and 103) for example:

$(\text{CH}_3)_2\text{NPF}_2$	3.6 Hz	$(\text{CH}_3)_2\text{NP}(\text{O})\text{F}_2$	8.2 or 0.0† Hz
$(\text{CH}_3)_2\text{NP}(\text{CF}=\text{CF}_2)_2$	0.6 Hz	$(\text{CH}_3)_2\text{NP}(\text{S})\text{F}_2$	2.1 Hz
$\text{CH}_3\text{N}(\text{PF}_2)_2$	1.5 Hz	$[(\text{CH}_3)_2\text{N}]_2\text{P}(\text{S})\text{F}$	1.7 Hz
$(\text{CH}_3)_2\text{N}(\text{CH}_3)\text{NPF}_2$	3.1 Hz	$(\text{CH}_3)_2\text{NPF}_4$	2.1 Hz
$\text{CH}_3\text{O}(\text{CH}_3)\text{NPF}_2$	3.6 Hz	$(\text{CH}_3)_2\text{NPF}_2\text{Cl}_2$	2.7 Hz

The $^4J(\text{H}-\text{F})$ values are usually lower when atoms other than nitrogen separate the two nuclei ^(1965, 8; 1966, 30; 1968, 45; 1969, 62 and 84) as for example in:

$\text{CH}_3\text{P}(\text{O})(\text{CF}_3)_2$	0.78 Hz	$(\text{CH}_3)_3\text{CP}(\text{O})\text{F}_2$	<i>ca.</i> 1 Hz
$\text{CH}_3\text{OP}(\text{S})\text{F}_2$	0.7 Hz	$\text{CH}_3\text{SP}(\text{S})\text{F}_2$	1.3 Hz
$\text{CH}_3\text{SP}(\text{C}_6\text{H}_5)\text{F}_3$	2.0 Hz	CH_3SPF_4 (-100°C)	F_{ax} 3.0 Hz

Examples of longer-range H-F coupling have been found as follows:

$^5J(\text{H}-\text{F})$ in $(\text{CH}_3)_2\text{NP}(\text{CF}_3)_2$ [0.5 to 0.7 Hz], ^(1968, 47 and 55) in $(\text{CH}_3)_2\text{NP}(\text{CF}=\text{CF}_2)_2$ [0.6 Hz] and in $[(\text{CH}_3)_2\text{N}]_2\text{PCF}=\text{CF}_2$ [0.8 Hz], ^(1969, 55) in $\text{CH}_3\text{OP}(\text{CF}_3)_2$ [0.46 Hz] and $\text{CH}_3\text{OP}(\text{O})(\text{CF}_3)_2$ [0.37 Hz] ^(1969, 84) and in $(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{CF}=\text{CClCF}_3$ [0.45 Hz in *cis* and 0.40 in *trans* isomer]. ^(1968, 98)

$^6J(\text{H}-\text{F})$ in $(\text{CH}_3)_2\text{NP}(\text{C}_6\text{F}_5)_2$ and $[(\text{CH}_3)_2\text{N}]_2\text{PC}_6\text{F}_5$ [0.7 Hz]. ^(1966, 19)

† Depends upon isomer.

3. Fluorine-fluorine coupling through phosphorus

(a) The only observed two-bond couplings are found in penta- or hexa-coordinated fluorophosphoranes. The axial and equatorial positions, which differ appreciably when exchange is slowed down, are readily identified. For instance the following values have been obtained at low temperature: (1966, 31 and 82; 1968, 38, 39 and 42; 1969, 62 and 114)

$F_3PH(CH_3)$	19 to 20 Hz	$F_3P(CH_3)_2$	26.2 Hz
$F_3P(CF=CF_2)_2$	52 Hz	$F_3P(C_6H_5)SC_6H_5$	60.0 Hz
$F_3PCl[N(CF_3)_2]$	95 Hz		

The same appears to be true for $P^{VI\ominus}$ hexa-coordinated compounds such as $PF_5S^\ominus$ for which $^2J(F_{ax}-F_{eq})$ is 48 Hz^(1968, 46) and in $(CF_3)_2PF_3H^\ominus$ in which all the fluorine atoms are equatorial but can be differentiated as shown in **142**^(1968, 41) and finally **143**.^(1966, 33)

In some instances the axial positions are not equivalent and it is possible to distinguish three different sites at -100° in CH_3SPF_4 in which the couplings are $^2J(F_{ax}-F'_{ax})=19$, $^2J(F_{ax}-F_{eq})=104$ and $^2J(F'_{ax}-F_{eq})=91$ Hz, or two different sites at -80° as in $CH_3SPF_2(C_6H_5)_2$ in which $^2J(F_{ax}-F'_{ax})=28$ Hz.^(1969, 15)

(b) Higher F-F couplings through phosphorus have only been found in the following cases.

(i) Three-bond coupling. In P_2F_4 the fluorine atoms are not equivalent and it is found that the FPPF and FPPF' couplings have opposite signs.^(1969, 31) Other three-bond couplings for which the sign is known are in the compounds: $FP(CF_3)_2$ [-3.5 Hz],^(1967, 55) $F_2P(O)CF_3$ [11 Hz],^(1968, 44) $FPCl_3(CF_3)$ [8.4 Hz]^(1967, 62) and $F_2PCF=CF_2$.^(1967, 55)

(ii) Four-bond coupling. The values have been compared^(1966, 31) in the following series of compounds: $F_2P(O)N(CF_3)_2$ [8.6 Hz], $F_2Cl_2PN(CF_3)_2$ [14.1 Hz] and $F_3ClPN(CF_3)_2$ [10.8 Hz]—this last value is an average of the axial and equatorial couplings and suggests that the value of $J(F-F_{ax})$ is longer than $J(F-F_{eq})$, as was previously observed for couplings involving protons (III.F.2(a)). The sign of $^4J(F-F)$ in the P^{III} compound, $(CF_3)_2PSCF_3$ has also been established [$+1.1$ Hz].^(1967, 55)

In fluorovinyl compounds a similar stereospecificity is observed for F-F coupling as for P-F coupling (III.B.7(a)) and in $F_2PCF=CF_2$ the *cis* and *trans* $^4J(F-F)$ are 2.8 and 13.2 Hz respectively.^(1969, 55) Finally other example of four-bond couplings are found in $F_2P(O)OP(O)F_2$ and $F_2P(S)OP(S)F_2$ [2.4 and 3.7 Hz respectively]^(1969, 62) and in $F_2P(O)N=SF_2$ [4.5 Hz].^(1967, 136)

(iii) Five-bond couplings have only been reported in $CF_3P[N(CF_3)_2]_2$ and $(CF_3)_2PN(CF_3)_2$ [5.5 and 4.7 Hz respectively].^(1968, 69)

IV. APPLICATIONS OF NMR IN PHOSPHORUS CHEMISTRY

A. Applications to structural problems

NMR is so widely used for structural assignments that it would be inappropriate to give a general review of these applications and the discussion will be confined to considering some aspects associated with cyclic compounds which are by far the most interesting. Apart from the cases of rings composed entirely of phosphorus atoms and organo-metallic structures such as **144** ^(1967, 76) the following systems will be considered.

1. Carbon-phosphorus heterocyclics

These have recently been reviewed, including NMR data, up to 1967 by Berlin and Hellwege ^(1969, 144) and some new examples, not included in the above review, are:

Phosphabenzene P^{III} (**145**) and P^V (**146**) derivatives, ^(1968, 75 and 101; 1969, 145) or the higher homologs such as **147** ^(1968, 120) which may be compared with the non-conjugated counterparts such as **148** and **149**. ^(1968, 75 and 102)

Phosphazolidines (**150**) have been investigated by Issleib and co-workers. ^(1967, 137)

Phosphetanes have previously been discussed with respect to the stereo-specific coupling found in these compounds (III.B.2). ^(1967, 82; 1968, 67, 121 and 122)

Bicyclic compounds, such as **151**, have recently been synthesised. ^(1969, 146)

2. Heterocyclics containing phosphorus atom in ring

This type of compound (**152** to **155**) containing one P^{III} , or tetra- and penta-coordinated P^V atom have been described. ^(1967, 138 and 139; 1968, 123; 1969, 116) Heterocycles with two P-heteroatom bonds in the ring have been more commonly reported. In addition to the numerous P^V oxyphosphoranes and homologs, synthesised by Ramirez and co-workers (see 1968, 124 for a review of these compounds) and by others, ^(1967, 121, 140 and 141; 1969, 147) parent tri-, tetra- and penta-coordinated phosphorus heterocyclics with various structures (**156** to **162**) are known. ^(1965, 32; 1966, 83; 1967, 142 and 143; 1968, 76, 125 and 126; 1969, 65, 109 and 148) A somewhat related compound **163** has also been described. ^(1969, 149)

3. Phosphonitricls

The greatest attention has been devoted to these conjugated systems (certainly as far as the pentamers). The understanding of the nature of

the bonding and the molecular geometry is a very challenging problem as it presents an atypical case of aromaticity;† π -character of phosphorus has been considered in relation to chain mobility,^(1966, 6) to electron withdrawal by substituents^(1968, 127) and to chain planarity and lastly to substituent electronegativity.^(1966, 49)

Numerous data have been reported by Shaw and co-workers,^(1965, 24 and 33; 1966, 84 to 88; 1968, 91, 128 and 129; 1969, 150) by Moeller and co-workers^(1966, 89; 1967, 144 and 145; 1968, 50, 130 to 133) and numerous other workers.^(1965, 34 and 35; 1966, 6, 49, 80, 90 to 97; 1967, 130, 146 to 148; 1968, 114, 134 and 135; 1969, 151 to 153)

In all these cases the identification of the isomers could be readily established by using:

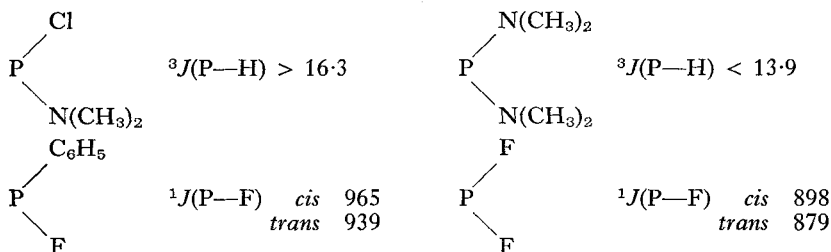
i) ^{31}P chemical shifts, e.g. in $\text{N}_3\text{P}_3\text{F}_5\text{X}$ it is possible to distinguish PF_2 and PFX groups:

PF_2	70.9	PF_2	71.2	PF_2	70.8
$\text{PF}[\text{N}(\text{CH}_3)_2]$	63.0	PFCI	32.0	PFBBr	20.5

It was also possible to distinguish between the *cis* and *trans* isomers, e.g. in $\text{N}_3\text{P}_3\text{F}_4(\text{C}_6\text{H}_5)_2$:

PFC_6H_5	$\left\{ \begin{array}{l} \text{cis} \\ \text{trans} \end{array} \right.$	^{31}P	$\begin{array}{l} -38.4 \\ -38.3 \end{array}$	^{19}F	$\begin{array}{l} 49.3 \\ 51.5 \end{array}$
PF_2	$\left\{ \begin{array}{l} \text{cis} \\ \text{trans} \end{array} \right.$		$\begin{array}{l} -12.4 \\ -10.8 \end{array}$		$\begin{array}{l} 65.2 \text{ to } 69.3 \\ 67.7 \end{array}$

ii) Coupling constants as in:



It should also be remembered, as discussed earlier (III.C.2(d)), that the P–N–P two bond couplings are also sensitive to nature of substituents.

Finally, it should be noted that various parent structures such as **164** and **165** have been reported.^(1966, 98; 1967, 149 and 150; 1968, 136 and 137)

B. Applications to stereochemical problems

The importance of NMR in stereochemical studies of phosphorus compounds is now firmly established; this aspect was discussed at length

† For instance see ref. 1958, 1; 1960, 2; 1962, 3.

for organic phosphorus compounds in a review by Gallagher and Jenkins; ^(1968, 138) this is also true for the elucidation of various biological mechanisms such as pseudorotation in the hydrolysis of phosphate esters. ^(1968, 139) Once again, the topic is far too extensive to be considered in great detail—only typical examples will be presented neglecting studies of optically active compounds such as menthyl phosphinates, e.g. ^(1967, 151; 1968, 140; 1969, 154)

1. Stereochemistry of saturated aliphatic compounds

NMR is an especially sensitive tool for detecting non-equivalence and for studying the underlying phenomena (steric hindrance, solvent effects, etc.) and a number of examples were cited in the previous section. Thus, it was noted from work of Rudolph and Newmark ^(1969, 31) that conformational equilibrium exists in F_2PSPF_2 (in which sulphur acts as a rather loose link) but not in F_2PPF_2 or $F_2P(NCH_3)PF_2$ (see Sections III.C.1.(b), III.C.2(c) and III.C.2(e)). Similarly, Lambert *et al.* have investigated rotational isomerism in diphosphines and obtain the relevant activation parameters. ^(1966, 99; 1968, 141)

Mono-phosphorus compounds will now be considered and discussed in order of the bridging atom (non-equivalent group are underlined).

(a) *Carbon*. Steric hindrance effects the protons as in $ClCH_2PH_2$ ^(1968, 58) and $ClCH_2PCl[N(CH_3)_2]$. ^(1968, 59) This feature is more pronounced in compounds as **166**. ^(1969, 155) This effect is also found in $P^{IV\oplus}$ and P^V derivatives. ^(1968, 68; 1969, 156 to 158)

(b) *Oxygen*. Non-equivalence from steric factors exists in various P^{III} and P^V compounds such as $C_6H_5P(OCH_2CH_3)_2$, $C_6H_5P(OCH_2CH_3)(CH_2CH_3)$. ^(1969, 34) The effect has been investigated as a function of temperature and solvent in **167**. ^(1969, 159) The effect can also arise from blocking by complexing in adducts; ^(1969, 160) other examples are to be found. ^(1965, 35 and 36; 1967, 152; 1968, 25, 142 and 143; 1969, 101, 161 and 162)

(c) *Sulphur*. The only detailed study, as a function of temperature and solvent, has been carried out on $CH_3P(O)(OR)SCH_2R'$. ^(1969, 101)

(d) *Nitrogen*. As discussed earlier (III.B.5(b)) the phosphorus-nitrogen bond is very sensitive to $d_\pi-p_\pi$ conjugation and this factor dominates the effects of inversion at nitrogen (always rapid) and at phosphorus (generally too slow). Trivalent phosphorus is very favourable for obtaining isomers at some accessible temperature such as in $RNHP(CF_3)_2$, ^(1968, 144) $R^1R^2PCl(C_6H_5)$, $CH_3(R^1)PR^2R^4$ ^(1968, 92) and other compounds. ^{(1965, 8;}

1967, 80; 1968, 145) With P^V compounds, in which conjugation with nitrogen is balanced by the formation of a $P=X$ bond, it appears that steric effects are predominant and initiate conformational stability which may arise from asymmetry of phosphorus^(1969, 111) as observed in $C_6H_5P(X)-(NHP^i)_2$ [$X = S$ or Se] and $(C_6H_5)_2P(S)NHP^i$; the non-equivalence of the methyl groups of these compounds has been investigated at various temperatures in different solvents.^(1968, 145) Internal hydrogen bonding may also add a stabilising effect when appropriate groups are present as in $Pr^iNHP(O)(OR)(OAr)$, in which $H \rightarrow O$ chelation occurring in the $NHP(O)$ group is likely to occur.^(1969, 110)

2. Stereochemistry of unsaturated aliphatic compounds

Stereochemical problems in these compounds are not specific to phosphorus compounds; the only additional feature is the existence of phosphorus couplings, the stereospecificity of which has been previously mentioned (III.B.7). It should be noted that phosphorus-bearing groups, and most especially phosphoryl groups, present on vinylic bonds create very important neighbouring effects on account of the magnetic anisotropy. These effects have recently been calculated, using the method of ApSimon, by Timofeeva *et al.*^(1969, 163) for the β -proton or methyl in **168** and **169**.

Likewise, a systematic use of such anisotropy effects has been used to establish the conformation of small rings from the proton shielding in the corresponding allenic phosphine oxides,^(1967, 153 to 156; 1968, 46; 1969, 164 to 166) for example in **170**.

3. Stereochemistry of acyclic penta-coordinated compounds

This question has been previously discussed in some detail (see ref. 1966, 1, p. 281) and is especially well-documented for fluorophosphoranes which have been extensively investigated by Schmutzler *et al.*^(1965, 12) (see III.B.1). Actually, in many cases, the first problem to overcome is the observation of distinct isomers as fluorine exchange occurs rapidly when bulky substituents are absent.

The nature of this exchange is now better understood following the extensive variable temperature investigations of both proton and fluorine resonances.^(1967, 157) For PF_5 it was concluded, from line width analysis, that intermolecular exchange occurred in solution;^(1969, 167) for intramolecular exchange pseudorotation has been invoked^(1967, 158) and the behaviour found to agree with the model of Berry.^(1960, 1) It may be added that this pseudorotation has been systematically analysed, from a topological point of view, in trigonal bipyramids.^(1968, 147; 1969, 168)

A last point is that the systematic assignment of fluorine atoms to the

axial positions may not always be true despite the theoretical predictions of the extended Hückel calculation.^(1966, 100) It has recently been concluded, from study of microwave spectra, that the molecular symmetry of CF_3PF_4 was C_{3v} ; this being only compatible with the presence of an axial CF_3 group.^(1968, 148)

4. Stereochemistry of one-ring compounds

This topic has been reviewed, for the period up to 1967, in some detail by Berlin and Hellwege.^(1969, 144) Various interesting examples will be considered later but many aspects have been discussed in Section III together with stereochemical aspects of spin-spin couplings. Additional instances will now be considered.

(a) Three membered rings have recently been described by Goldwhite *et al.*^(1969, 169) and in these, **171** to **174**, the isomers are distinguishable on account of the slow inversion at phosphorus.

(b) Four membered rings have been investigated by Cremer *et al.*,^(1968, 121; 1969, 170) e.g. **175** and **176**; both inversion at phosphorus and *cis-trans* equilibrium have been characterised for various substituents.

(c) Five membered rings with incorporated heteroatoms are generally much better known.† With a P^{III} atom these compounds show a slow inversion at phosphorus as evidenced by the non-equivalence of methyl groups in **177**^(1966, 51) and the non-equivalence of protons in **178**.^(1968, 77) These and other data^(1966, 50) suggests that the different positions arise from a planar ring in which the lone-pair on phosphorus is *cis* to two substituents and *trans* to the other two. In fact a more detailed discussion by Cox *et al.* using the parent ethylene, propylene and butylene phosphites^(1969, 93) proves that the NMR data are only consistent with a twist-envelope conformation **179**, as proposed earlier by Haake *et al.*^(1968, 77) According to this work, the twist angle would be *ca.* 30° for the ethylene phosphite (from vicinal H-H couplings); in the isobutylene homologue this angle would be somewhat larger.

Other substituted phosphites have been considered^(1967, 115; 1969, 85) as well as other heterocycles, for instance the oxaza analogues.^(1969, 171) Some P^{V} homologues have been investigated^(1967, 140; 1969, 171) as well as the corresponding penta-coordinated compounds, e.g. **180** and **181**,^(1967, 140 and 160; 1968, 76 and 123) in which the stereoisomerism may be washed out by pseudorotation.

(d) Six membered ring compounds—only dioxaphosphorinanes‡ have been investigated but present *syn-anti* isomerism with P^{III} ^{(1966, 46;}

† The compound $(\text{PCF}_3)_5$ has been described in which scrambling occurs at high temperature by torsional vibration.^(1967, 159)

‡ The chair conformation has been definitely established by X-ray study.^(1969, 172)

1967, 161 and 162; 1968, 78 and 79; 1969, 92 and 172) or P^V . (1966, 46; 1967, 90; 1968, 79, 83, 149 and 150; 1969, 92, 95, 97, 173 to 177)

In all these compounds the dihedral dependence of both *POCH* and *POCCH* couplings are clearly seen; this is of some importance in applications, especially for biological compounds^(1969, 96)—the only difficulty arises on account of the number of superimposed stereochemical factors as observed in the low temperature data of **182a** and **b**.^(1969, 173) This means that the ring conformation is the major but not the only important factor.

5. Stereochemistry of spiro-compounds

(a) Spirophosphorus compounds, in which the phosphorus is attached to carbon atoms only, have been investigated by Hellwinkel^(1965, 37) and the relevant stereochemistry was later discussed by the same author.^(1966, 26 and 101) The underlying pseudorotation mechanism has been investigated by a variable-temperature study, a trigonal bipyramidal conformation being stable.^(1968, 151)

(b) A large number of heteroatomic spirophosphoranes have been described and reviewed by Ramirez.^(1967, 163; 1968, 152 and 153) Various other systems **183** to **185** have been reported by Burgada *et al.*;^(1967, 39, 164 and 165; 1968, 154; 1969, 109 and 178) in **185** when $R = H$ a $P^V \leftrightarrow P^{III}$ tautomerism exists involving structure **186**. Many of these compounds exhibit a double diastereomerism (*cis-trans* and *quadrant* isomerism) which is detectable from the proton resonance of the R group; in this respect groups with $R = H$ and $CH(OH)R^1$ appear to very sensitive to molecular environment. Lastly, structural rearrangements have been elucidated for various *H*-spirophosphoranes **183**, $R = H$.^(1969, 179)

6. Stereochemistry of other cyclic compounds

Various polycyclic or juxtacyclic compounds have been considered^(1966, 102; 1967, 166; 1968, 117; 1969, 90 and 146) and **187** may be considered as a typical example in which the $^4J(POCH)$ and $^5J(HPOCH)$ values were used to assign the configuration shown. Some attention has been given to this aspect in steroid derivatives^(1965, 38; 1966, 103 and 104; 1967, 100, 167 and 168) and the stereospecificity of long-range *P-C-C-CH* couplings have been used, in addition to Zürcher rules, for conformational assignment of **188** in which $^4J(P-H)$ was 0.8 Hz.^(1969, 83)

C. Applications to intermolecular studies

1. Solvent and temperature effects have been especially studied in simple compounds—white phosphorus,^(1969, 180) PH_3 ,^(1967, 43) PF_3 ,^(1968, 51) phosphorus acid, phosphines, phosphonium compounds etc.^(1965, 39; 1967, 169; 1968, 155; 1969, 53) Phosphorus chemical shifts or line-widths,

proton or fluorine chemical shifts or coupling constants were in turn used for the measurements.

2. Hydrogen bonding has been considered in hydrofluoric or hydrochloric acid solutions of phosphates and other esters. ^(1967, 170; 1968, 156; 1969, 181 to 183) Less acidic media, such as alcohols, water and chloroform, have been used by Li *et al.* ^(1967, 171; 1968, 157 and 158) Comparison between the infrared and phosphorus resonance shifts have been found to be fruitful for understanding the interaction in the case of hydrogen phosphonates. ^(1967, 172) Thermodynamical parameters of the interaction were obtained using a variable temperature investigation. ^(1969, 184) To quote more "chemical" interactions, β -diketone-neutral ester systems have been considered, ^(1966, 105) as were mixtures of amines and acidic phosphates and pyrophosphates by Russian authors. ^(1969, 185)

3. Adduct formation results in well-defined species. Generally speaking, phosphorus compounds act as Lewis bases [exceptions being pentavalent phosphorus halides as reviewed by Webster ^(1966, 106)]; for other examples in which the relevant Lewis acids are metalloid derivatives see references 1966, 107 and 1969, 186. Adducts involving boron have recently been reviewed elsewhere ^(1969, 94 and 102) and are by far the most numerous and use has been made of phosphorus, boron, proton and fluorine resonances, in some cases at varying temperature. ^(1965, 40; 1966, 20, 36, 81, 108 to 110; 1967, 32, 41, 133, 134, 173 and 174; 1968, 79, 158 to 160; 1969, 42, 72, 86, 102, 113, 141, 187 to 196) As previously mentioned (III.E), the most striking feature is the appearance in P^{III} ligands of boron-phosphorus coupling through the dative bond [*ca.* 30 Hz in $PH_3 \cdot BH_3$ to *ca.* 100 Hz in $(CH_3O)_3P \cdot BH_3$]. Simultaneously, phosphorus is coupled to some protons or fluorine atoms through the $P \rightarrow B$ bond as in $(CH_3)_3P \cdot BH_3$ in which $^2J(P-BH)$ is 26.8 Hz or in $(CH_3)_3P \cdot BF_3$ in which $^2J(P-BF)$ is 229 Hz. Additionally for both P^{III} and P^V derivatives, the specific chemical shifts and coupling constants of the ligand are modified. Boron resonances shift about 10 ppm upfield for BF_3 and about 40 ppm for BH_3 , irrespective of the ligand and do not appear to be too sensitive to the "bond strength"; fluorine shifts give a better estimate of this, thus it is about 20 ppm upfield for the BF_3 complex which is far less than found in amine and ester complexes. For the phosphorus ligand nearly all shifts appear downfield on complex formation, in agreement with a σ -bonded type of adduct.† For protons the deshielding effect is nearly the same for all types of ligands (0.2 to 0.4 ppm), suggesting that this arises from the

† Assuming that no structural changes occur within the molecule. Halogen exchange is detected in some cases; ^(1968, 45; 1969, 28 and 102) similarly the influence of adduct formation on the thiono-thiolo isomerisation of thio- and seleno-phosphates has been noted. ^(1969, 189)

magnetic anisotropy of the boron ligand. Another interesting feature of the changes induced by adduct formation is afforded by the various phosphorus couplings. As noted earlier (III.B.1), phosphorus-fluorine couplings are rather insensitive on account of the high polarity of the bond while phosphorus-proton couplings are extremely sensitive. For example, P-H coupling is about 320 Hz in $\text{PH}_2^\ominus(\text{BH}_3)_2$ compared to about 140 Hz in the free ligand. As a rule the change is in the direction expected for an increase of the substituent electronegativity.

In molecules which can act as polydentates, one point of interest is the relative basic strength of the different basic sites. For $[(\text{CH}_3)_2\text{N}]_3\text{P}$ and other amino-phosphines, it was concluded that complexing to phosphorus was the major mechanism; ^(1969, 72 and 192) in $[(\text{CH}_3)_2\text{N}]_3\text{PO}$ there is competition between the phosphoryl group and nitrogen atoms for complex formation ^(1969, 94, 102 and 188) in agreement with previous hydrogen bonding studies (see 1966, 1, p. 295).

Adducts involving aluminium, gallium or indium derivatives as Lewis acids have also been described. ^(1965, 41; 1966, 111; 1967, 175 and 176; 1968, 161 and 162; 1969, 28, 197 to 199)

Here again, in P^{III} ligands, phosphorus-aluminium coupling is found or phosphorus-proton coupling through aluminium or gallium. The formation of complexes actually affords a means of detecting changes, and especially in the signs, of coupling constants. This was used by Pidcock *et al.* to obtain evidence for reversal of sign in $\text{P}\cdots\text{H}$ couplings in aluminium complexes of $\text{P}(\text{CH}_3)_3$ by varying the concentration (adduct exchange is sufficiently fast at room temperature to give an average spectrum); no similar variation appears for the $\text{P}\cdots\text{H}$ coupling of $\text{P}(\text{OCH}_3)_3$. ^(1966, 41) This observation supported the early assumption that the $\text{P}-\text{C}-\text{H}$ couplings depended upon two competing terms of opposite signs (see III.B.1).

Some attention has been given to the ligand exchange mechanism ^(1969, 198) and similarly bond-exchange has been detected in interhalogen mixtures, e.g. in $\text{Al}_2\text{F}_6-\text{POCl}_3$ from ^{27}Al resonance ^(1969, 28) or in $\text{BF}_3-\text{POF}_2(\text{CH}_3)$ from both fluorine and phosphorus resonances. ^(1969, 102)

In a few cases adducts other than these obtained with boron, aluminium gallium and indium have been described. ^(1962, 4; 1966, 112; 1968, 163 and 164; 1969, 200)

D. Applications to reaction studies

Brief consideration will be given to NMR investigation of intermediates, products and kinetics of reactions. Alkylation, arylation, metalation, reaction with organometallics, thermolysis and thermal rearrangements, isomerisation and many other reactions such as the Wittig, Michaelis and Arbuzov reactions, which are typical of organophosphorus

chemistry, have been considered. (1963, 5; 1965, 42 to 45; 1966, 60, 62, 71, 109, 113 to 137; 1967, 121, 139, 141, 177 to 185; 1968, 126, 145, 165; 1969, 116, 146, 201 and 202) NMR has also been used for polymerisation studies and polymer characterisation; (1965, 42, 46, and 47; 1966, 138; 1967, 186 to 188; 1968, 166; 1969, 203) this has been systematically exploited by South African authors (1968, 167; 1969, 203 and 204) for investigating mixed polymers in various systems such as methyl polyphosphate + methyl orthosilicate, arsenite or phosphite. It now appears that NMR data for inorganic systems is in general rather sparse. (1967, 129, 189 and 190)

Typical examples of such researches on reaction studies are:

(i) Valence rearrangements of phosphorus: $P^{III} \leftrightarrow P^V$ interconversion as in the "phenylphosphinidene" (1965, 48) and in spirophosphoranes (1967, 165) or $P^{IV} \leftrightarrow P^V$ interconversions as in R_3PX_2 compounds (1967, 191; 1968, 168) to which may also be added metathetical reactions. (1966, 139)

(ii) pH Dependence of molecular species as observed at pH values above 2.0 with methyl and dimethyl phosphates; (1969, 205) the former exhibits abrupt changes in proton chemical shifts and coupling constants when going through the upper pK (6.4) and the second which has only one low pK (1.3) presents a pH-independent spectrum in the range investigated.

(iii) Reactions and rearrangements of methylene phosphorane compounds in which an acid-catalysed exchange has been detected (1968, 169 to 171) which creates an anomalous temperature-dependence of the $P=CH$ coupling, first attributed to hindered rotation. (1966, 140; 1967, 192) The relevant stereochemistry has been further investigated by Snyder *et al.* (1969, 206 and 207)

(iv) Ligand exchange, a field pioneered by Van Wazer *et al.*, has received some attention, (1965, 49 and 50; 1967, 193; 1969, 140) for instance in adducts with fast interconverting ligands as in **189**. (1966, 36) Most examples, however, deal with halogen exchange either through an intramolecular process (if any) in PF_5 (1967, 194; 1968, 172) or intermolecularly in adducts (1968, 45 and 173; 1969, 28 and 102) for which the lifetime may be calculated.

Regarding lifetime studies, the interest in exchange observations cannot be over estimated. Thus, Grim and McFarlane could not observe phosphorus chemical shifts or coupling constants in mixtures of $HBr + (C_6H_5)_3P$, or $(C_6H_5)_2PH$ or $C_6H_5PH_2$, which gave an upper limit for the phosphonium ion lifetime of $3 \cdot 10^{-3}$ sec. In contrast to this $H-P-CH$ couplings are sometimes observed, depending upon the experimental conditions, for mixtures of HBr with $CH_3P(C_6H_5)_2$ or $(CH_3)_2PC_6H_5$; as these couplings were *ca.* 6 Hz the observation of these couplings implies a

lifetime greater than 0.2 sec. and absence a lifetime lower than this value. (1968, 7) Studies on the protonation of phosphines have recently been extended by Olah and co-workers to similar systems. (1969, 12)

E. Miscellaneous applications

Various fields in which NMR appears to be of considerable value will briefly be considered.

1. Relaxation studies have been rather scarce despite the early investigations of Winter (1959, 1) on ^{31}P relaxation in PCl_3 and PBr_3 .

Variable temperature measurement of T_1 in PCl_3 , POCl_3 and POF_3 (including use of fluorine resonance in the latter compound) (1968, 174), † of T_1 and $T_{1\rho}$ (in the rotating frame) for PBr_3 (1968, 115) and PCl_3 (1969, 139) permitted a better understanding of relaxation mechanisms and a separation of contributions from scalar, spin-rotational and direct dipolar interactions ($T_{1\rho}$ depends only on the first term). From these, it may be concluded that the major mechanism (for diamagnetic liquids) arises from the spin-rotation interaction, especially at high temperature; at lower temperatures scalar interactions become of some importance. Similar studies have been performed on liquid and solid P_4O_6 . (1968, 175; 1969, 208) Conversely, phosphorus relaxation rates have been used as a probe for following solvent effects on tributyl phosphate and complex formation with uranyl nitrate (1968, 109, and also see 1968, 176 and 1969, 209) and also for investigating ligand exchange in metal complexes, (1968, 177) ferroelectric changes in KH_2PO_4 ‡ (1968, 178) and electronic structures of phosphides. (1969, 211 and 212)

As a related topic, attempts to improve the signal to noise ratio in ^{31}P spectra using dynamic polarisation will be briefly described (for a review of the Overhauser effect see (1969, 213)). This was first used in high fields, using some radical probe such as tri-*t*-butylphenoxy, and the enhancement was found to be positive for P^{III} compounds but not so for P^{V} homologues. (1966, 141; 1967, 198; 1969, 130) Observations at low fields are more numerous but the results more complex (1968, 8; 1969, 214 and 215) being positive for phosphites and triphenyl phosphine but negative for diphenyl phosphine (all having trivalent phosphorus) and being negative for phosphates and thiophosphates but positive for dimethyl phosphonate, thiophosphoryl chloride and phenyl thiophosphoryl dichloride (all with

† Further analysis of T_1 for phosphorus (and fluorine) in POF_3 gives an estimate of *para*- and *dia*-magnetic terms in the relevant chemical shifts, thus permitting an appreciation of the *absolute* ^{31}P chemical shift (1969, 9) as discussed earlier (II.A.1).

‡ Proton or deuteron relaxation is also useful in this respect as shown for $\text{NH}_4\text{PO}_4\text{H}_2$ (1967, 195 and 196) and for the determination of rotational barriers in solid phosphonium halides. (1967, 197; 1968, 179 and 180; 1969, 210)

pentavalent phosphorus). It is suspected that, in addition to direct coupling by s electrons, there exists some indirect mechanism. When considering phosphonitrilics^(1969, 216) a specificity of the radical probe has been found, bis-diphenylene phenyl allyl being especially satisfactory and DPPH being the least effective of the species investigated. The enhancement attained appeared to be directly dependent upon the ring delocalisation.

2. Investigations on solid samples have been reported for a rather large variety of compounds generally using phosphorus resonance but in some cases proton, fluorine, boron and even ^{23}Na resonances^(1969, 217) and relaxation time measurements have been used. Phosphides, and especially simple or mixed paramagnetic phosphides, have often been considered,^(1961, 3; 1966, 142 to 145; 1967, 199 to 205; 1968, 181 to 185; 1969, 212, 218 and 219) sometimes using the resonance of the metal atom (Y, La, Mn, Al, etc.). Phosphates also present a large number of interesting cases—mineral and meteoritic, paramagnetic and paraelectric, ferroelectric and antiferroelectric phosphates have been studied, special attention being paid to the phase changes.^(1966, 146; 1967, 188, 195, 206 to 211; 1968, 178, 186 to 191; 1969, 27, 61, 220 to 224) Data are available for various other solids or glasses.^(1966, 147 and 148; 1967, 212; 1969, 225 to 227)

To cite the most interesting general features:

(i) Fine structure determination, pioneered by Andrew, has been extended to polycrystalline samples.^(1966, 149; 1967, 204) This has been found to be especially valuable when investigating solid-state adducts such as $\text{PCl}_5 \cdot \text{TiCl}_4$, which is formulated $\text{PCl}_4^+ \text{TiCl}_5^-$.^(1966, 150; 1967, 213 to 216; 1968, 192) Similarly, double resonance has been performed on solid samples of CaHPO_4 ^(1968, 193) and of $\text{NH}_4\text{PO}_4 \cdot \text{H}_2\text{O}$.^(1969, 228)

(ii) Line shape analysis has been possible in some cases, thus affording chemical shift anisotropy for phosphates^(1969, 5 and 221) and for BaFPO_4 .^(1969, 6 and 7) In the latter case the absolute sign of the P-F coupling could be unambiguously assigned on these grounds.

(iii) Variable temperature measurements were very useful for following phase transitions and molecular rearrangements as in hydroxyapatite^(1969, 224) as well as the identification of various hydroxyl and water species in solid phosphates.^(1969, 226)

3. *Metal complexes*

The importance of metal complexes of organo-phosphorus in homogeneous catalysis, or the role played by NMR in the structural assignment, needs no stressing. In ref. 1966, 1, a formulae index was presented for all these species studied using resonance other than that of phosphorus and more recently the ^{31}P resonances of these complexes has been fully

discussed in an earlier review in this series by Nixon and Pidcock.^(1969, 229) To keep abreast with this rapidly growing field of interest a summary is given in Table XXXIV according to the central atom and the resonance investigated and only a few outstanding points will be discussed.

(i) Phosphorus-phosphorus couplings—When more than one phosphorus ligand is present these couplings greatly assist in the stereochemical assignment, for instance being -40.5 and $+162$ Hz respectively in *cis*- and *trans*- $(\text{CO})_4\text{Mo}\{\text{P}(\text{OMe})_3\}_2$.^(1969, 132) These important variations may be considered in terms of changes in the *s*-character.^(1969, 133)

(ii) Ligand-exchange mechanisms are clarified using variable-temperature studies^(1967, 34; 1968, 235 and 243) or relaxation rate measurements^(1968, 177) and have been considered in relation to ion-pairing mechanisms.^(1965, 54 to 56) Stereochemical conversions^(1969, 279) have also been discussed in relation to intramolecular^(1967, 262) and σ - π rearrangements.^(1969, 309)

(iii) Chemical exchange spin decoupling in metal complexes, which removes couplings of phosphorus (i.e. to neighbouring protons) owing to its preferential relaxation by unpaired electrons,^(1965, 63 and 64; 1968, 217; 1969, 237) has been investigated using temperature and solvent dependence by Frankel^(1969, 237, 238 and 310) and the relevant theory established by Fackler and co-workers^(1969, 291) using the density-matrix technique of Kaplan and Alexander. It is especially noteworthy that this effect (which only exists in P^{III} compounds) is selective^(1969, 93) as non-equivalent couplings are not removed simultaneously, as previously discussed see III.B.3(b); thus, for H_A and H_B in **190** which have different coupling constants to phosphorus (2.2 and 10.5 Hz) are decoupled at different concentrations of added nickel acetylacetonate.

4. Biological problems

A detailed discussion of this topic is once again beyond the scope of this review. The field is particularly broad and includes the investigation of biological structures and configurations using various resonances, generally proton and phosphorus, but also ^{15}N ^(1966, 196), of the reactivities through complexing [especially by metal cations which may be used as resonance probes, such as ^{43}Ca ^(1969, 311) but also using other ions such as ^{35}Cl] or the interaction with other substrates [e.g. procaine-thiamine pyrophosphate interactions^(1969, 312)]. To briefly mention the relevant references according to the phosphorus compounds data may be listed for:

(i) AMP, ADP and ATP.^(1965, 72 to 74; 1966, 196 to 198; 1967, 263 and 264; 1968, 270 and 271; 1969, 311, 313 and 314)

TABLE XXXIV
NMR studies of metal complexes of phosphorus compounds^a

Metal atom	Proton resonance	Fluorine resonance	Phosphorus resonance	Other resonance
Ag	1966, 41; 1967, 102; 1968, 162, 194 and 195	1966, 41	1966, 110; 1967, 217 and 218	
Al	1969, 199, 230 to 232		1967, 23; 1969, 199 and 230	²⁷ Al-1967, 23
As			1968, 196	
Au	1966, 151; 1967, 219; 1969, 233			
Ca			1965, 30	
Cd	1966, 171		1966, 171; 1967, 221	
Co	1965, 51 to 57; 1966, 152 to 157; 1967, 27, 220 to 224; 1968, 197 to 205; 1969, 14, 78, 132, 234 to 243	1965, 57 and 58; 1967, 225; 1968, 57 and 206; 1969, 235, 240, 241, 244 and 245	1965, 53; 1967, 217 and 218; 1968, 203; 1969, 237 and 238	⁵⁹ Co—1969, 246
Cr	1966, 72 and 158; 1967, 79, 226 and 227; 1968, 202, 207 to 209; 1969, 14, 78, 247 and 248	1969, 60 and 133	1967, 79, 227 and 228; 1968, 207, 210 and 211; 1969, 60, 249 to 251	

^a This index follows in a more condensed form the Formulae Index V of ref. 1966, 1.

Cu	1967, 229; 1968, 43 and 194; 1969, 252 and 253	1968, 43	1965, 31; 1966, 110; 1967, 217 and 218	
Fe	1962, 5; 1965, 59; 1966, 158 to 161; 1967, 227; 1968, 53, 98, 201 to 204, 209, 212 to 215; 1969, 78, 237, 239 to 241, 254 to 260	1968, 98; 1969, 133, 134, 240, 241, 254 and 258	1967, 227; 1968, 203 and 216; 1969, 237	
Hg	1968, 202		1966, 110; 1967, 221	
Ir	1965, 52, 59 to 64; 1966, 162 to 164; 1967, 230 and 231; 1968, 217 to 224; 1969, 14, 236, 261 to 268	1969, 167	1969, 263	
Li			1965, 30	
Mg			1965, 30	
Mn	1962, 5; 1965, 65; 1966, 165 and 166; 1967, 232; 1968, 201, 212, 225 to 228; 1969, 14, 78, 237, 240, 241, 269 to 271	1969, 240 and 241	1969, 237	¹¹ B—1966, 1672 ⁵⁵ Mn—1969, 27
Mo	1965, 51; 1966, 72 and 158; 1967, 79, 226, 227, 233 to 235; 1968, 202, 207 to 209, 212, 229 to 232; 1969, 78, 104, 131, 239, 247, 273 to 275	1964, 13; 1966, 168; 1967, 235; 1968, 119; 1969, 60, 131, 133, 134 and 276	1967, 79, 227, 228 and 235; 1968, 119, 207, 210, 211, 230; 1969, 60, 249 to 251 and 276	

TABLE XXXIV (continued)

Metal atom	Proton resonance	Fluorine resonance	Phosphorus resonance	Other resonance
Ni	1965, 54 to 56 and 66; 1966, 152 and 169 to 173; 1967, 211, 220, 221, 224, 235 to 242; 1968, 53, 199, 204, 205 and 233; 1969, 34, 78, 141, 153, 159, 234, 277 to 282	1966, 168 and 174 and 175; 1967, 48 and 235; 1968, 234; 1969, 133, 283 and 284	1965, 66 and 67; 1966, 110, 169, 171, 176 to 178; 1967, 48, 174, 217, 218, 235, 236, 240, 243 to 245; 1968, 211, 234 and 235; 1969, 282 to 286	
Os	1965, 59; 1968, 217 and 236; 1969, 195, 263, 287 to 289		1969, 263	
Pb	1966, 171		1966, 171	
Pd	1965, 68; 1966, 179; 1967, 246; 1968, 237 to 243; 1969, 155, 233, 280, 290 to 293	1967, 247 and 248; 1968, 245 and 246	1968, 244; 1969, 291	
Pt	1965, 59, 68 and 69; 1966, 179 to 182; 1967, 220, 249 to 254; 1968, 218, 219, 247 to 254; 1969, 26, 233, 236, 263, 277, 280, 290, 292, 294 to 297	1965, 69; 1966, 181, 183 and 184; 1967, 247 and 248; 1968, 219, 246, 253 and 255; 1969, 121, 298 and 299	1966, 185; 1967, 228, 253 and 255; 1968, 145, 247, 249 and 256; 1969, 263	¹⁹⁵ Pt—1968, 251 and 257
Re	1965, 63 and 64; 1966, 186; 1968, 217; 1969, 263, 289 and 300		1969, 263	

Rh	1965, 52, 63, 64 and 70; 1966, 155, 163, 182, 187 to 191; 1967, 254, 256 to 259; 1968, 224, 258 to 262; 1969, 263, 301 to 305	1967, 248; 1968, 263; 1969, 121	1966, 192; 1969, 263	¹⁰³ Rh high-resolu- tion resonance 1969, 306
Ru	1965, 59 and 64; 1966, 193; 1967, 260; 1968, 217, 236, 259, 264 and 265; 1969, 263 and 307	1969, 307	1969, 263	
Sb			1968, 196	
Sn	1967, 211; 1969, 53			
Ti			1966, 194	
U	1965, 71; 1969, 74	1967, 261	1968, 109 (relaxation)	
V	1968, 212			
W	1962, 5; 1966, 72, 158 and 160; 1967, 79, 226 and 227; 1968, 207 to 209, 212, 230, 231, 266 and 267; 1969, 14, 71, 78 and 247	1968, 268; 1969, 60 and 133	1966, 195; 1967, 79, 227 and 228; 1968, 207, 210, 211, 230 and 269; 1969, 60, 71, 138, 249 to 251 and 308	
Zn	1968, 269		1967, 221	

(ii) Nucleotide and nucleoside phosphates, ^(1965, 75 and 76; 1966, 199; 1967, 265 to 267; 1968, 172, 272 to 276; 1969, 96, 98, 315 to 318) for which an extensive survey has been recently presented by Hollis and co-workers. ^(1969, 319)

(iii) Phospholipids. ^(1966, 200 and 201; 1967, 268 and 269; 1968, 277 to 279)

(iv) Phosphoproteins. ^(1966, 202; 1969, 320 and 321)

(v) Phosphorylated steroids and hormones, ^(1965, 38; 1966, 103 and 104; 1967, 167, 168 and 270) sugars and carbohydrates ^(1966, 203; 1967, 271 and 272; 1968, 280; 1969, 320 and 321) and enzymes. ^(1967, 257; 1968, 281)

(vi) Others include radioprotectors, ^(1966, 204) thiamine phosphate, ^(1966, 205; 1967, 273; 1969, 312) vitamin B6 ^(1967, 274) etc.—see also 1967, 275.

(vii) Lastly, phosphorus pesticides have received considerable attention ^(1961, 4; 1968, 282 and 283) and monographs have been recently published on these, one using 100 MHz spectra; ^(1968, 284 and 285; 1969, 322) see also review on the NMR of pesticides in Volume 4 of this series. ^(1971, 1)

5. *Miscellaneous applications*

Finally, the following miscellaneous applications will be briefly mentioned:

(i) Analytical uses. ^(1967, 189; 1968, 286 and 287)

(ii) Extraction studies ^(1969, 74, 323 and 324) on transition metal ions and in relation to flotation reagents. ^(1969, 325) It appears that the interest in such investigations has now decreased (see ref. 1966, 1, pp. 295–296), in clear contrast with all of the other fields reviewed herein.

V. FORMULA INDICES

The following indices list by formulae all available investigations on inorganic and organic phosphorus compounds† (except biological and metal complexes) with the corresponding references. Observed resonances are given with the relevant chemical shifts for phosphorus and fluorine; most of the published chemical shifts for other nuclei (except proton) are in the text of the review. Phosphorus chemical shifts are referred to 85% H_3PO_4 and for fluorine to CCl_3F ;‡ all are *positive* with increasing *frequencies* (i.e. for decreasing fields) according to the rules detailed in the General Foreword. When more than one nucleus of a given species exists in the reported molecule, chemical shifts are reported when available from left to right; when more than one nucleus exists on a phenyl ring these are reported in the sequence *ortho*, *meta* and *para*.

† No distinction has been made between deuterated compounds and the corresponding hydrogenated homologues.

‡ ^{31}P Chemical shifts referred to P_4O_6 have been corrected by +112.5 ppm; ^{19}F chemical shifts referred to $\text{CF}_3\text{CO}_2\text{H}$, $\text{CF}_3\text{C}_6\text{H}_5$ or F_2 have been corrected by -79.9, -63.8 and 427 ppm respectively.

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FORMULAE INDEX I NMR DATA ON INORGANIC COMPOUNDS^a

Formula	Compound	Resonance	Reference
PAICl ₃	PCl ₄ [⊕] AlCl ₄ [⊖]	P (+86.5)	1967, 276
PAI ₂ H ₂ O ₂	Al ₂ (PO ₂ H ₂)	H	1968, 162
PBBrH ₅	PH ₃ ·BH ₂ Br	H	1967, 41
PBGeH ₈	GeH ₃ ·PH ₂ ·BH ₃ (and deuterated derivative)	H	1968, 158
PBH ₆ Si	SiH ₃ ·PH ₂ ·BH ₃	H	1967, 173; 1968, 158
PBH ₁₀ Si ₂	Si ₂ H ₅ ·PH ₂ ·BH ₃	H	1969, 113
PBO ₄	BPO ₄	¹¹ B	1961, 3
PB ₂ H ₈ Na	H ₂ P(BH ₃) ₂ Na	¹¹ B, H	1969, 194
PB ₄ F ₂ H ₉	PF ₂ H·B ₄ H ₈	¹¹ B, H, P (<i>ca.</i> 118), F(−121.7)	1969, 141
PB ₄ F ₃ H ₈	B ₄ H ₈ ·PF ₃	¹¹ B	1966, 109
PBaFO ₃	BaFPO ₃	F, P	1969, 7
PBrFH ₂ NS	FBrP(S)NH ₂	H, F (−2.6)	1969, 325
PBrCl ₂ O	OPCl ₂ Br	P (−29.6)	1966, 9
PBrF ₂	PF ₂ Br	P (+218), F (−40.1)	1967, 50; 1968, 19
PBrF ₂ O	OPF ₂ Br	P (−28), F (−32.5)	1967, 56; 1968, 19
PBrF ₂ S	SPF ₂ Br	P (28.6), F (−2.3)	1966, 8; 1968, 19
PBrF ₄	PF ₄ Br	P (−72.6) F (−9.6)	1968, 49
PBr ₂ ClO	OPBr ₂ Cl	P (−64.8)	1966, 9
PBr ₂ F	PBr ₂ F	P (225), F (−70.4)	1967, 50; 1968, 19
PBr ₂ FO	OPBr ₂ F	P (−48.3), F (16.1)	1967, 56; ^b 1968, 19
PBr ₂ FS	SPBr ₂ F	P (−17.2), F (31.3)	1967, 58; 1968, 19
PBr ₂ F ₃	PBr ₂ F ₃	F (<i>ca.</i> +55)	1965, 77
PBr ₃	PBr ₃	P (relaxation; 227 to 229)	1959, 1; 1965, 1 and 2; 1967, 277; 1968, 19 and 115
PBr ₃ O	OPBr ₃	P (−102, −103.4)	1965, 1; 1966, 9 and 206; 1967, 277; 1968, 19
PBr ₃ S	SPBr ₃	P (−111.8, −112)	1965, 1 and 4; 1967, 277; 1968, 19
PCaHO ₄	CaHPO ₄	P (solid)	1968, 193
PClF ₂	PF ₂ Cl	P (176), F (−38.6)	1966, 105; 1968, 19
PClF ₂ O	OPF ₂ Cl	P (−14.8), F (−48.1)	1966, 278; 1967, 14; 1968, 19

^a Formulae have symbols arranged alphabetically except for phosphorus which is always placed first.

^b Misprint in ³¹P chemical shift originally quoted.

Formula	Compound	Resonance	Reference
PClF ₂ S	SPF ₂ Cl	P (50·0), F (–15·9)	1966, 8; 1968, 19
PClF ₃ NO ₂ S	F ₃ P=NSO ₂ Cl	F (–84·6)	1969, 326
PClF ₄	PF ₄ Cl	F (–24·3)	1968, 49
PCl ₂ F	PFCl ₂	P (224), F (–55·9 – 57·8)	1967, 50; 1968, 19
PCl ₂ FO	OPFCl ₂	P (0·0), F (–9·5)	1966, 9; 1967, 14; 1968, 19
PCl ₂ FS	SPFCl ₂	P (43·0), F (15·6)	1967, 58; 1968, 19
PCl ₂ F ₂ NO ₂ S	ClF ₂ P=NSO ₂ Cl	F (–50·4)	1969, 326
PCl ₂ F ₃	PCl ₂ F ₃	P (–27·8), F (<i>ca.</i> 32)	1965, 77; 1968, 288
PCl ₃	PCl ₃	P (relaxation, 219 to 220)	1959, 1; 1965, 1 and 2; 1967, 235 and 277; 1968, 19, 42 and 174
PCl ₃ FNO ₂ S	Cl ₂ P=NSO ₂ F	F (59·6)	1967, 279
PCl ₃ O	OPCl ₃	¹⁷ O, P (relaxation; 2·2 to 3·0)	1963, 1; 1965, 1 and 4; 1966, 9; 1967, 277; 1968, 19, 136 and 174
PCl ₃ S	SPCl ₃	P (28·8, 30·8)	1965, 1; 1966, 111; 1967, 277; 1968, 19
PCl ₅	PCl ₅	P (–80, –80·9)	1968, 124 and 288
PCl ₅ O ₄	PCl ₄ ⁺ ClO ₄ [–]	P (87·1)	1967, 276
PCl ₆	PCl ₆ [–]	P (–295)	1968, 288
PCl ₁₀ Sb	PCl ₄ ⁺ SbCl ₆ [–]	P (87·9)	1967, 276
PCsH ₂	CsPH ₂	H, P	1969, 327
PFH ₂ O ₂	FP(O)H(OH)	H, P (2·74), F (–64·3)	1968, 34
PFH ₂ O ₃	FP(O)(OH) ₂	P (–8), F (–77)	1967, 14
PFH ₃ N ₂ O ₂ S	(NH ₄) ₂ PO ₂ SF	P (43·9)	1967, 280
PFO ₃	PO ₃ F ^{2–}	P (0·75)	1966, 79
PF ₂ HO	OPF ₂ H, OPF ₂ D	H, P (–1), F (–61·9, –66·4)	1967, 33; 1968, 34
PF ₂ HO ₂	F ₂ P(O)OH	H, P (–20·1), F (–85·6, –87·5)	1967, 14, 281 and 282
PF ₂ HS	SPF ₂ H, SPF ₂ D	H, F (–46·1)	1966, 32; 1967, 33
PF ₂ HS ₂	F ₂ P(S)SH	H, F (–15·8)	1969, 99
PF ₂ H ₂ NO	F ₂ P(O)NH ₂	H, P (–1·2, –6), F (–73·5)	1967, 93, 282; 1969, 129
PF ₂ H ₂ NS	F ₂ P(S)NH ₂	H, P (66·2), F (–42·7)	1969, 328
PF ₂ H ₄ NOS	NH ₄ POSF ₂	P (47·1)	1967, 280
PF ₂ I	PF ₂ I	P (242·2), F (–48)	1966, 59
PF ₂ IS	SPF ₂ I	P (–71), F (–11·2)	1968, 45

Formula	Compound	Resonance	Reference
PF ₃	PF ₃	P [97, 105(?)], F (-33.7, -37.6)	1965, 1 and 2; 1966, 28; 1967, 28, 48, 51 and 235; 1968, 19, 42 and 51
PF ₃ H ₂	PF ₃ H ₂	H, P (<i>ca.</i> -39), F (-50)	1966, 24; 1967, 157
	PF ₃ H ₂ , PF ₃ D ₂	H, P (-24.1), F (-52.5)	1967, 36
PF ₃ O	OPF ₃	P (relaxation; -92.3, -94.3)	1966, 9 and 29; 1967, 14;
		F (relaxation; -35.5)	1968, 19 and 174; 1969, 63
PF ₃ O ₄ S	F ₂ P(O)OSO ₂ F	F (46.1; -81.7)	1966, 29
PF ₃ O ₇ S ₂	FP(O)(OSO ₂ F) ₂	F (47.1, -72.3)	1966, 29
PF ₃ O ₁₀ S ₃	OP(OSO ₂ F) ₃	P (165), F (50.1)	1966, 29, 1967, 283
PF ₃ S	SPF ₃	P (32.4), F (-51.3)	1965, 13; 1966, 8; 1968, 19
PF ₄ H	PF ₄ H, PF ₄ D	H, P (-50, -53.6) F [-49.6, -52, 7.5(?)]	1966, 24; 1967, 36; 1968, 42
PF ₄ NOS	F ₂ P(O)N=SF ₂	F (-69.9, 57.1)	1967, 136
PF ₄ NO ₂ S	F ₃ P=NSO ₂ F	F (-86.7, -60.9)	1969, 328
PF ₅	PF ₅	P ^a (-80.3), F (-71.4)	1966, 207; 1968, 42; 1969, 63 and 167
PF ₅ HK	PF ₅ H [⊖] K [⊕]	H, F	1969, 143
PF ₅ S	PF ₅ S ^{2⊖}	F (-22.0, -71.0)	1968, 46
PF ₆	PF ₆ [⊖]	P (-145), F	1966, 207; 1968, 288
PGeH ₅	GeH ₃ , PH ₂ ; GeD ₃ , PH ₂ GeH ₃ , PD ₂	H, P	1967, 284; 1968, 32 and 158
PGe ₂ H ₇	(GeH ₃) ₂ PH	H	1968, 32
PGe ₃ H ₉	(GeH ₃) ₃ P	H, P (-332.5)	1965, 120; 1967, 98; 1968, 32
PHO ₃	HPO ₃ ^{2⊖} , DPO ₃ ^{2⊖}	P (+7.1, +6.9)	1967, 42
PH ₂	PH ₂ [⊖]	H	1966, 11
PH ₂ K	PH ₂ K	H, P (-255.3)	1965, 10; 1966, 12; 1969, 203
PH ₂ Li	PH ₂ Li		1969, 327
PH ₂ Na	PH ₂ Na	H	1967, 46; 1969, 327
PH ₂ O ₂	PH ₂ O ₂ [⊖]	H	1968, 162; 1969, 41
PH ₂ O ₃	PH ₂ O ₃ [⊖]	H, P	1966, 131
PH ₂ Rb	PH ₂ Rb		1969, 203
PH ₃	PH ₃	H, P (-240, -241)	1965, 1 and 2; 1966, 11 and 13; 1967, 28, 43 and 47; 1968, 96 and 158; 1969, 41

^a Incorrectly reported as δP -35 from observations on oxidized PF₅ (see 1969, 63).

Formula	Compound	Resonance	Reference
PH_3O_2	PH_3O_2	^{17}O , H, P (10.5)	1963, 1; 1967, 45, 47 and 189
PH_3O_3	PH_3O_3	^{17}O , H, P (3.5)	1963, 1; 1966, 208; 1967, 45, 47 and 189; 1968, 155
PH_3O_4	H_3PO_4 H_3PO_4 (117%)	^{17}O , P (0) P (-1.7)	1963, 1; 1965, 1 1966, 117
PH_4	$\text{PH}_4^\oplus$	H, P	1966, 22; 1967, 28; 1969, 41
PH_5Si	SiH_3PH_2	H	1968, 158; 1969, 113
$\text{PH}_6\text{N}_3\text{O}$	$\text{OP}(\text{NH}_2)_3$	H	1968, 86
PH_7Si_2	$\text{Si}_2\text{H}_5\text{PH}_2$, $(\text{SiH}_3)_2\text{PH}$	H	1969, 113
PH_8IN_4	$\text{IP}(\text{NH}_2)_4$	P (31.6)	1969, 137
$\text{PH}_9\text{N}_2\text{O}_2\text{S}$	$(\text{NH}_4)_2\text{PHO}_2\text{S}$	P (34)	1967, 35
PH_9Si_3	$(\text{SiH}_3)_3\text{P}$	P (-378)	1968, 96
$\text{PH}_{15}\text{Si}_6$	$(\text{Si}_2\text{H}_5)_3\text{P}$	H	1969, 113
PI_3	PI_3	P (178)	1965, 1 and 2; 1967, 190
PO_4	$\text{PO}_4^{\ominus}$	P (6.0)	1965, 78
P_2	P_2	P	1967, 28
$\text{P}_2\text{ClF}_4\text{NS}$	$\text{F}_3\text{P}=\text{NP}(\text{S})\text{FCl}$	P (-39.0, 44.3) F (-4.8)	1969, 69 and 325
$\text{P}_2\text{ClH}_{12}\text{N}_7$	$[\text{P}(\text{NH}_2)_3]_2^\oplus\text{N}, \text{Cl}^\ominus$	P (15.6)	1967, 285; 1969, 137
$\text{P}_2\text{Cl}_2\text{F}_3\text{NS}$	$\text{F}_3\text{P}=\text{NP}(\text{S})\text{Cl}_2$	P (-40.8, 29.7), F (-3.7)	1969, 69
$\text{P}_2\text{Cl}_3\text{F}_2\text{NO}$	$\text{Cl}_3\text{P}=\text{NP}(\text{O})\text{F}_2$	P (6.5, -2.5), F (-70.3)	1969, 129
$\text{P}_2\text{Cl}_3\text{F}_2\text{NS}$	$\text{F}_2\text{ClP}=\text{NP}(\text{S})\text{Cl}_2$	P (-16.7, 29.4), F (33.5)	1969, 69
$\text{P}_2\text{Cl}_4\text{FNO}$	$\text{Cl}_3\text{P}=\text{NP}(\text{O})\text{FCl}$	P (3.9, -14.5), F (-30.2)	1969, 129
$\text{P}_2\text{Cl}_5\text{NO}$	$\text{Cl}_3\text{P}=\text{NP}(\text{O})\text{Cl}_2$	P (-0.1, -14.2)	1967, 286; 1969, 129
$\text{P}_2\text{F}_2\text{H}_2$	H_2PPF_2	H, P (293.7, -137.6), F (-91.2)	1968, 31
$\text{P}_2\text{F}_2\text{K}_2\text{O}_5$	$\text{K}_2(\text{P}_2\text{O}_5\text{F}_2)$	P (-17.8), F (-72.6)	1968, 112
P_2F_4	P_2F_4	P (226), F (-115.2, -117.5)	1966, 28 and 209; 1967, 49; 1968, 113; 1969, 31
$\text{P}_2\text{F}_4\text{O}$	$\text{O}(\text{PF}_2)_2$	P (111), F (39.9)	1966, 28; 1968, 34; 1969, 31
$\text{P}_2\text{F}_4\text{OS}_2$	$\text{P}_2\text{S}_2\text{OF}_4$	P, F (-40.2)	1969, 62
$\text{P}_2\text{F}_4\text{O}_2$	$\text{F}_2\text{P}(\text{O})\text{OPF}_2$	P (-9.8, -149.7), F (-80, -38.3)	1969, 57 to 58

Formula	Compound	Resonance	Reference
P ₂ F ₄ O ₃	O[P(O)F ₂] ₂	P (−39·3), F (−80)	1967, 287; 1969, 62
P ₂ F ₄ S	S(PF ₂) ₂	F (−65)	1969, 31 and 136
P ₂ F ₄ S ₂	F ₂ P(S)SPF ₂	P (−40·7, 75·5), F (13·7, 60·5)	1969, 57 and 59
P ₂ F ₅ NS	F ₃ P=NP(S)F ₂	F (−85·2, −38·0)	1969, 325 and 328
P ₂ Ge ₃ H ₁₄	[(GeH ₃) ₂ P] ₂ GeH ₂	H, P (−36·4, 42·0), F (−5·5, 41·5)	1967, 98; 1969, 69
P ₂ HO ₅	HP ₂ O ₅ ^{3⊖}	H, P	1967, 28; 1968, 113
P ₂ HO ₆	HP ₂ O ₆ ^{2⊖}	P	1967, 129
P ₂ H ₂ Na ₂ O ₇	P ₂ O ₇ H ₂ Na ₂	P (−7·9)	1969, 321
P ₂ H ₂ O ₅	H ₂ P ₂ O ₅ ^{2⊖}	H, P	1966, 131; 1968, 37
P ₂ H ₂ O ₆	H ₂ P ₂ O ₆ [⊖]	P	1967, 129
P ₂ H ₃ O ₆	H ₃ P ₂ O ₆	P	1967, 129
P ₂ H ₄	P ₂ H ₄	H, P	1967, 28; 1968, 113
P ₂ H ₄ O ₅	O[P(OH) ₂] ₂	H, P	1966, 208; 1967, 189
P ₂ H ₄ O ₆	H ₄ P ₂ O ₆	P	1967, 129
P ₂ I ₄	P ₂ I ₄	P	1967, 190
P ₂ K ₄ O ₇	K ₄ P ₂ O ₇	P	1969, 5
P ₂ N ₂ O ₆	[NP(O)O ₂ [⊖]] ₂	P (3·3)	1965, 78
P ₂ Na ₄ O ₇	Na ₄ P ₂ O ₇	P	1969, 5
P ₂ Zn ₃	Zn ₃ P ₂	P	1969, 329
P ₃ BrCl ₅ N ₃	P ₃ N ₃ BrCl ₅	P (17·7; −7·8)	1966, 94
P ₃ BrF ₅ N ₃	P ₃ N ₃ F ₅ Br	F (−20; −71)	1969, 151 and 152
P ₃ Br ₂ Cl ₄ N ₃	P ₃ N ₃ Br ₂ Cl ₄	P (16·1; −8·7; −38·6)	1966, 94
P ₃ Br ₃ Cl ₃ N ₃	P ₃ N ₃ Br ₃ Cl ₃	P (14·0; −10·0; −39·8)	1966, 94
P ₃ Br ₄ Cl ₂ N ₃	P ₃ N ₃ Br ₄ Cl ₂	P (13·9; −12·1; −41·3)	1966, 94
P ₃ Br ₅ ClN ₃	P ₃ N ₃ Br ₅ Cl	P (−14·0; −42·5)	1966, 94
P ₃ Br ₆ N ₃	P ₃ N ₃ Br ₆	P (−45·4)	1966, 93
P ₃ ClF ₅ N ₃	P ₃ N ₃ F ₅ Cl	F (−32; −71)	1969, 151 and 152
P ₃ Cl ₄ F ₂ N ₃	P ₃ N ₃ Cl ₄ F ₂	P	1966, 79; 1967, 130
P ₃ Cl ₄ H ₄ N ₅	P ₃ N ₃ Cl ₄ (NH ₂) ₂	P (18; 9)	1967, 145 and 147; 1968, 114
P ₃ Cl ₅ FN ₃	P ₃ N ₃ Cl ₅ F	P (14·4; 23); F	1966, 49; 1967, 130
P ₃ Cl ₅ H ₂ N ₄	P ₃ N ₃ Cl ₅ (NH ₂) ₂	P (20·4; 19·0)	1967, 145
P ₃ Cl ₆ N ₃	P ₃ N ₃ Cl ₆	P (19)	1966, 6 and 49; 1967, 147; 1968, 136 and 144; 1969, 216
P ₃ FO ₇	P ₃ O ₇ F ^{4⊖}	P (−5; −16·8; −20·4)	1966, 79
P ₃ F ₆ N ₃	P ₃ N ₃ F ₆	P (13·9); F (−7·3)	1968, 130
P ₃ H ₁₂ N ₉	P ₃ N ₃ (NH ₂) ₆	P (18·8)	1968, 114
P ₃ O ₁₀	P ₃ O ₁₀ ^{5⊖}	P (−6·8; −22·4)	1965, 30

Formula	Compound	Resonance	Reference
P_4	P_4	$P (-450; -462)$	1965, 1; 1968, 96
$P_4AlCl_{14}N_3$	$Cl(Cl_2P=N)_3PCl_3^{\oplus}, AlCl_4^{\ominus}$	P	1968, 166
$P_4BCl_{14}N_3$	$Cl(Cl_2P=N)_3PCl_3^{\oplus}, BCl_4^{\ominus}$	$B; P$	1968, 166
$P_4BrF_7N_4$	$P_4N_4F_7Br$	$F (-30.6)$	1969, 151
$P_4ClF_7N_4$	$P_4N_4F_7Cl$	$F (-38.9)$	1969, 151
$P_4Cl_8N_4$	$P_3N_3Cl_5(N=PCl_3)$	$P (20.5; -2.2; -3.3)$	1967, 145
	$(PNCl_2)_4$	P	1969, 216

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Formula	Compound	Resonance	Reference
PCBr ₂ NS ₂	SPBr ₂ (NCS)	P (−62·8)	1965, 4
PCCl ₂ F ₃ O	CF ₃ P(O)Cl ₂	F (−77·5)	1968, 70
PCCl ₂ F ₅	CF ₃ PF ₂ Cl ₂	P (−22·7); F (−77·0; −0·5)	1969, 66
PCCl ₂ NOS	OPCl ₂ (NCS)	P (−21)	1965, 4
PCCl ₃ F ₂	CCl ₃ PF ₂	F (−88); P (130·9)	1967, 48 and 51
PCCl ₃ F ₄	CF ₃ PCl ₃ F	F (−79·8; 126·1)	1967, 62
PCCl ₃ O ₃	CCl ₃ PO ₃ ^{2−}	P (8·1)	1967, 7
PCCl ₄ F ₃	CF ₃ PCl ₄	F (−81)	1967, 62
PCCsF ₈	CF ₃ PF ₅ , Cs	F (−71·3; −75·5)	1968, 48
PCF ₂ N	F ₂ PCN	P (140·8); F (−91·6)	1966, 28
PCF ₂ NO	F ₂ PNCO	F (−39·2)	1969, 56
PCF ₂ NOS	OPF ₂ (NCS)	P (−36·4); F (−71·6)	1967, 53 and 287
PCF ₂ NO ₂	OPF ₂ (NCO)	P (−29·5; −30); F (−72)	1967, 287 and 288
PCF ₂ NS	F ₂ P(NCS)	P (132); F (−54·2)	1967, 53; 1968, 289
PCF ₂ NS ₂	SPF ₂ (NCS)	P (−28·6); F (−36·6)	1967, 53 and 289
PCF ₅	CF ₃ PF ₂	P (153·3); F (−87·7; −104·1)	1967, 48 and 51
PCF ₅ O	CF ₃ P(O)F ₂	F (−73·9; −80·7)	1968, 44
PCHCl ₂ O ₃	CHCl ₂ PO ₃ ^{2−}	P (8·2)	1967, 7
PCH ₂ ClF ₂	CH ₂ ClPF ₂	H; P (201); F (−99)	1966, 36; 1967, 51
PCH ₂ ClF ₂ O	CH ₂ ClP(O)F ₂	H; P (12)	1966, 36; 1967, 14
PCH ₂ ClF ₂ S	CH ₂ ClP(S)F ₂	H	1966, 36
PCH ₂ ClF ₄	CH ₂ ClPF ₄	H	1966, 36

^a Formulae have symbols arranged alphabetically except for phosphorus which is always placed first followed immediately by carbon and hydrogen.

Formula	Compound	Resonance	Reference
PCH ₂ ClO ₃	CH ₂ ClPO ₃ ²⁻	P (11·3)	1967, 7
PCH ₂ Cl ₂ FO	CH ₂ ClP(O)FCl	P (32·0); F (−63)	1967, 14
PCH ₂ Cl ₃	CH ₂ ClPCl ₂	H	1966, 36
PCH ₂ Cl ₃ O	CH ₂ ClP(O)Cl ₂	H	1966, 36
PCH ₂ Cl ₃ S	CH ₂ ClP(S)Cl ₂	H	1966, 36
PCH ₂ F ₃	CF ₃ PH ₂	H; P; F	1967, 40 and 83
PCH ₃ ClF	CH ₃ PFCI	P (240)	1968, 12
PCH ₃ ClFO ₂	CH ₃ OP(O)FCl	P (−5·4); F (−50)	1967, 14
PCH ₃ Cl ₂	CH ₃ PCl ₂	¹³ C; H; P (192)	1966, 36; 1968, 20, 42 and 290
PCH ₃ Cl ₂ O	CH ₃ P(O)Cl ₂	¹³ C; H; P	1966, 36; 1967, 186; 1969, 74
	CH ₃ OPCl ₂	H; P (180·8)	1966, 36; 1967, 236
PCH ₃ Cl ₂ O ₂	CH ₃ OP(O)Cl ₂	¹³ C; P	1968, 3
PCH ₃ Cl ₂ S	CH ₃ P(S)Cl ₂	¹³ C; H; P (79·4)	1966, 36 and 114; 1968, 20
PCH ₃ F ₂	CH ₃ PF ₂	H; P (244·2, 245, 250·7); F (−92·7, −92·9, −98·8?)	1966, 36 and 210; 1967, 38, 51, 235 and 290; 1968, 42 and 81
PCH ₃ F ₂ O	CH ₃ P(O)F ₂	¹³ C; H; P (26·8, 27·4); F (−59·5)	1965, 12; 1966, 36; 1967, 14; 1968, 20; 1969, 24
	CHF ₂ P(O)H ₂	H; F	1967, 103
PCH ₃ F ₂ OS	CH ₃ OP(S)F ₂	H; F (−48·0)	1968, 45
PCH ₃ F ₂ S	CH ₃ P(S)F ₂	H	1966, 36
PCH ₃ F ₂ S ₂	CH ₃ SP(S)F ₂	H; F (−26·7)	1968, 45
PCH ₃ F ₄	CH ₃ PF ₄	H; P (−29·9); F (−45·6)	1966, 36; 1968, 42
PCH ₃ F ₄ S	CH ₃ SPF ₄	H; P (−34); F (−14·1, −19·8, −66·1)	1968, 291; 1969, 62
PCH ₃ F ₅	CH ₃ PF ₅ ⁺	P (−126·4); F (−45·8, −57·6)	1965, 12
PCH ₃ Na ₂ O ₄	CH ₃ OPO ₃ Na ₂	H	1967, 90
PCH ₃ O ₃	CH ₃ PO ₃ ²⁻	P (20·1)	1967, 7
PCH ₃ O ₄	CH ₂ OHPO ₃ ²⁻	P (15·5)	1967, 7

PCH ₄ Cl	CH ₂ ClPH ₂	H	1966, 211; 1968, 58
PCH ₄ ClO ₃	CH ₂ ClPO ₃ H ₂	H; P (18.5)	1965, 79; 1966, 212
PCH ₄ FN	CH ₃ NHPF	H; P (140.5); F (-70.6)	1968, 119
PCH ₄ FO ₂	CH ₃ P(O)(OH)F	P (32.2); F (-63)	1967, 14
PCH ₄ F ₃	CH ₃ PF ₃ H (?)	H; F (-175.8, -94.3)	1967, 157; 1968, 38
	CH ₃ PF ₃ H (?)	H; P (-7.7); F (-15.1, -96.5)	1968, 42
PCH ₅	CH ₃ PH ₂	¹³ C; H; P	1966, 4 and 13; 1967, 11; 1968, 22 and 33; 1969, 41 and 330
PCH ₅ O ₂	CH ₃ PO ₂ H ₂	H	1966, 211; 1968, 72
PCH ₅ O ₃	CH ₃ PO ₃ H ₂	H	1966, 36
	CH ₃ OPO ₂ H ₂	H	1966, 213
PCH ₅ O ₄	CH ₂ OHPO ₃ H ₂	H; P (23.5)	1965, 79; 1966, 212; 1967, 291
PCH ₆	CH ₃ PH ₃ ⁺	H	1966, 22
PCH ₆ NO ₂ S	CH ₃ SP(O)(OH)NH ₂	H	1968, 86
PCH ₆ NO ₃	NH ₃ CH ₂ P(O)(OH)O ⁺	H	1966, 214
PCH ₆ N ₂ NaO ₃ S	(NH ₂) ₂ CCH ₂ SPO ₃ Na	H	1968, 292
PCH ₇ N ₂ OS	CH ₃ SP(O)(NH ₂) ₂	H	1968, 86
PCH ₇ Si	CH ₃ P(SiH ₃)H	H	1969, 73
PCH ₈ B ₁₀ Br ₃	B ₁₀ H ₇ Br ₃ CHP	H	1969, 25
PCH ₉ B ₁₀ Br ₂	B ₁₀ H ₈ Br ₂ CHP	¹¹ B	1969, 25
PCH ₉ IN ₃ S	CH ₃ SP(NH ₂) ₃ I ⁺	H	1968, 86
PCH ₉ Si ₂	CH ₃ P(SiH ₃) ₂	H	1969, 73
PCHB ₁₀ Br	B ₁₀ H ₉ BrCHP	H	1969, 25
PCH ₁₁ B ₉	B ₉ H ₁₀ CHP ⁺	¹¹ B; H	1969, 25
PCH ₁₁ B ₁₀	B ₁₀ H ₁₀ CHP (isom.)	¹¹ B; H; P	1967, 292; 1969, 25
PCH ₁₂ B ₉	B ₉ H ₁₀ CHPH	¹¹ B; H	1969, 25
PC ₂ BrF ₆ S	(CF ₃) ₂ P(S)Br	F (-70.1)	1968, 47
PC ₂ BrN ₂ S ₃	BrP(S)(NCS) ₂	P (-28.4)	1965, 4

Formula	Compound	Resonance	Reference
PC_2ClF_6	$(\text{CF}_3)_2\text{PCl}$	F (−61·4)	1962, 6; 1963, 6 and 7; 1968, 293
$\text{PC}_2\text{ClF}_6\text{S}$	$(\text{CF}_3)_2\text{P(S)Cl}$	F (−70·5)	1968, 47
$\text{PC}_2\text{ClN}_2\text{OS}_2$	ClP(O)(NCS)_2	P (−41·5)	1965, 4
$\text{PC}_2\text{ClF}_9\text{N}$	$(\text{CF}_3)_2\text{NPF}_3\text{Cl}$	F (−55·3; −5·5)	1966, 31
$\text{PC}_2\text{Cl}_2\text{F}_3$	$\text{CF}_2=\text{CFPCl}_2$	F (−82·5, −103·6, −186·4)	1969, 54 and 55
$\text{PC}_2\text{Cl}_2\text{F}_5$	$\text{C}_2\text{F}_5\text{PCl}_2$	P; F	1967, 40
$\text{PC}_2\text{Cl}_2\text{F}_8\text{N}$	$(\text{CF}_3)_2\text{NPF}_2\text{Cl}_2$	F (−52·9, 64·0)	1966, 31
$\text{PC}_2\text{Cl}_3\text{F}_6$	$(\text{CF}_3)_2\text{PCl}_3$	F (−79·8)	1967, 62
$\text{PC}_2\text{Cl}_4\text{F}_3$	$\text{CF}_2\text{ClCFClPCl}_2$	F (−60·3, −130·8)	1969, 55
$\text{PC}_2\text{CsF}_{10}$	$(\text{CF}_3)_2\text{PF}_4\text{Cs}$	F (−71·9, −78·5)	1968, 48
$\text{PC}_2\text{FN}_2\text{OS}_2$	FP(O)(NCS)_2	P (−47·7); F (−55)	1967, 287
$\text{PC}_2\text{FN}_2\text{S}_2$	FP(NCS)_2	P (126·5); F (−80·3)	1967, 53; 1968, 289
$\text{PC}_2\text{FN}_2\text{S}_3$	FP(S)(NCS)_2	P (12·2); F (−27·4)	1967, 53 and 289
PC_2F_5	$\text{CF}_2=\text{CFPF}_2$	F (−79·9, −112·0, −199·1, −103·6)	1969, 54 and 55
$\text{PC}_2\text{F}_5\text{O}_2$	$\text{CF}_3\text{C(O)OPF}_2$	F (−76·5, −49·9)	1969, 56
$\text{PC}_2\text{F}_6\text{IS}$	$\text{IP(S)(CF}_3)_2$	F (−70·1)	1968, 47
PC_2F_7	$(\text{CF}_3)_2\text{PF}$	P; F (−66·5, −219)	1967, 40, 48 and 55
	$\text{CF}_2=\text{CFPF}_4$	F (−64·7, −79·4, −177·8, −54·9)	1969, 114
$\text{PC}_2\text{F}_7\text{S}$	$(\text{CF}_3)_2\text{P(S)F}$	F (−72·3, −94·5)	1968, 47
$\text{PC}_2\text{F}_8\text{NO}$	$(\text{CF}_3)_2\text{NP(O)F}_2$	F (−54·8, −70·5)	1966, 31
$\text{PC}_2\text{HCl}_3\text{F}_3$	$\text{CF}_2\text{ClCFHPCl}_2$	H; F (−59·2, −196·2)	1969, 55
PC_2HF_6	$(\text{CF}_3)_2\text{PH}$	H; F; P (49·8)	1967, 40; 1969, 43
$\text{PC}_2\text{HF}_6\text{S}_2$	$(\text{CF}_3)_2\text{P(S)SH}$	H; F (−71·0)	1968, 47 and 294
PC_2HF_9	$(\text{CF}_3)_2\text{PF}_3\text{H}^\ominus$	H; F (−72·7, −94·3, −58·5)	1968, 41
$\text{PC}_2\text{H}_2\text{Cl}_2\text{F}_3$	$\text{CHF}_2\text{CHFPCl}_2$		1966, 26

PC ₂ H ₂ F ₆ NS	(CF ₃) ₂ P(S)NH ₂	F (−73·5)	1968, 47
PC ₂ H ₂ NO ₃	N≡CCH ₂ PO ₃ ^{2−}	P (13·1)	1967, 7
PC ₂ H ₂ O ₅	[−] O ₂ C·CH ₂ PO ₃ ^{2−}	P (13·3)	1967, 7
PC ₂ H ₃ ClF ₃	CHClFCF ₂ PH ₂	H; F; P (−140·3)	1966, 215
PC ₂ H ₃ Cl ₂ F ₂	CHF ₂ CH ₂ PCl ₂	F	1965, 80
PC ₂ H ₃ F ₂ O ₂	CH ₃ C(O)OPF ₂	F (−54·4)	1969, 56
PC ₂ H ₃ F ₄	CHF ₂ CH ₂ PF ₂	F	1965, 80
PC ₂ H ₄ ClO ₂	(CH ₂ O) ₂ PCl	H; P (167)	1966, 50; 1968, 77; 1969, 45
PC ₂ H ₄ Cl ₃	CH ₂ ClCH ₂ PCl ₂	H; P (185·0)	1969, 331
	CH ₃ CHClPCl ₂	H; P (161·6)	1969, 331
PC ₂ H ₄ Cl ₃ O	CH ₂ ClCH ₂ P(O)Cl ₂	H; P (42·9)	1966, 220; 1969, 331
	CH ₃ CHClP(O)Cl ₂	H; P (45·5)	1969, 331
	(CH ₂ Cl) ₂ P(O)Cl	H; P (−49·3)	1969, 332
PC ₂ H ₄ Cl ₃ O ₂	CH ₂ ClCH ₂ OPCl ₂	H; P (179·0)	1969, 331
PC ₂ H ₄ Cl ₃ S	CH ₂ ClCH ₂ OP(O)Cl ₂	H; P (5·9)	1969, 331
	Cl ₂ P(S)CH ₂ CH ₂ Cl	H; P (78·8)	1969, 79 and 331
	Cl ₂ P(S)CHClCH ₃	H; P (86·9)	1969, 331
PC ₂ H ₄ FO ₂	(CH ₂ O) ₂ PF	H; F (−41·3)	1963, 3; 1966, 50
PC ₂ H ₄ F ₃	CHF ₂ CHFPH ₂	H; F (−128·2, −195·6)	1966, 86
	CH ₂ FCF ₂ PH ₂	H; F (−228·7, −96·3)	1966, 86
P ₂ C ₂ H ₅	(CH ₂) ₂ PH	P (−341)	1969, 169
P ₂ C ₂ H ₅ ClFO ₂	C ₂ H ₅ OP(O)FCI	F (−47); P (−5·2)	1967, 14
PC ₂ H ₅ Cl ₂ O	C ₂ H ₅ P(O)Cl ₂	P (53·0)	1966, 111
	C ₂ H ₅ OPCl ₂	H; P (178)	1966, 216; 1967, 84 and 236; 1968, 25
PC ₂ H ₅ Cl ₂ OS	C ₂ H ₅ OP(S)Cl ₂	H	1966, 216; 1967, 84; 1968, 25
PC ₂ H ₅ Cl ₂ O ₂	C ₂ H ₅ OP(O)Cl ₂	¹³ C; H; P	1966, 216; 1967, 84; 1968, 3
PC ₂ H ₅ Cl ₂ S	C ₂ H ₅ P(S)Cl ₂	P (95·4)	1966, 114
PC ₂ H ₅ F ₂	C ₂ H ₅ PF ₂	F (−106·5); P (234, 245)	1967, 38, 51 and 290; 1968, 12
PC ₂ H ₅ F ₂ O	C ₂ H ₅ P(O)F ₂	P (29·2)	1967, 14
PC ₂ H ₅ F ₂ O ₂	C ₂ H ₅ OP(O)F ₂	H; F (−85·6); P (−20·9)	1967, 14 and 282

Formula	Compound	Resonance	Reference
PC ₂ H ₅ F ₄ S	C ₂ H ₅ SPF ₄	F (−13·4, −21·4, −70·5); P (−34)	1968, 291; 1969, 62
PC ₂ H ₅ Na ₂ O ₄	C ₂ H ₅ OPO ₃ Na ₂	H	1967, 90
PC ₂ H ₅ O ₂	HO ₂ C·CH ₂ PH ₂	H; P (−142·6)	1967, 135
PC ₂ H ₅ O ₃	C ₂ H ₅ PO ₃ ^{2−}	P (24·1)	1967, 7
PC ₂ H ₆ BrO ₃	(CH ₃ O) ₂ P(O)Br	H	1969, 95
PC ₂ H ₆ BrS	(CH ₃) ₂ P(S)Br	H	1966, 36
PC ₂ H ₆ Cl	(CH ₃) ₂ PCl	H; P (96·5)	1966, 36; 1968, 42 and 290
PC ₂ H ₆ ClFN	(CH ₃) ₂ NPFCI (?)	H; F (−70·1)	1969, 55
PC ₂ H ₆ ClO	(CH ₃) ₂ P(O)Cl	H	1966, 36
PC ₂ H ₆ ClO ₂	(CH ₃ O) ₂ PCl	H; P (169)	1965, 20; 1968, 211
	CH ₂ Cl(CH ₃ O)P(O)H	H	1966, 124
	CH ₃ (CH ₃ O)P(O)Cl	H; P	1967, 186
PC ₂ H ₆ ClO ₂ S	(CH ₃ O) ₂ P(S)Cl	H	1966, 36; 1969, 95
	(CH ₃ O)(CH ₃ S)P(O)Cl	H; P (37·1)	1965, 20
PC ₂ H ₆ ClO ₃	(CH ₃ O) ₂ P(O)Cl	H; P (8)	1967, 69; 1969, 95
PC ₂ H ₆ ClS	(CH ₃) ₂ P(S)Cl	H	1966, 36
PC ₂ H ₆ Cl ₂ F ₂ N	(CH ₃) ₂ NPF ₂ Cl ₂	H; F (54·3)	1968, 43
PC ₂ H ₆ Cl ₂ N	(CH ₃) ₂ NPCl ₂	H	1965, 18; 1966, 36
PC ₂ H ₆ Cl ₂ NO	(CH ₃) ₂ NP(O)Cl ₂	H; P (16)	1962, 7; 1965, 18 and 23; 1966, 36; 1968, 91 and 136
	CH ₃ O(CH ₃)NPCl ₂	H	1969, 103
PC ₂ H ₆ Cl ₂ NS	(CH ₃) ₂ NP(S)Cl ₂	H	1965, 18 and 23; 1968, 91
PC ₂ H ₆ F	(CH ₃) ₂ PF	H; F (−195·5); P (185, 187)	1967, 54; 1968, 12, 42 and 290
PC ₂ H ₆ FO	(CH ₃) ₂ P(O)F	H; F (−68·5); P (66·7)	1966, 36; 1967, 14
PC ₂ H ₆ FO ₂	CH ₃ (CH ₃ O)P(O)F	F (−63·4; 2·2)	1967, 13 and 14; 1968, 295
PC ₂ H ₆ FO ₂ S	(CH ₃ O) ₂ P(S)F	H	1966, 36
PC ₂ H ₆ FO ₃	(CH ₃ O) ₂ P(O)F	F (−87; 26)	1967, 13 and 14; 1968, 295
	C ₂ H ₅ OP(O)(OH)F	F (−84); P (−11)	1967, 14

PC ₂ H ₆ FS	(CH ₃) ₂ P(S)F	H	1966, 36
PC ₂ H ₆ F ₂ N	(CH ₃) ₂ NPF ₂	H; F (−65·3); P (143)	1966, 30 and 36
PC ₂ H ₆ F ₂ NO	(CH ₃) ₂ NP(O)F ₂	H; F (−82)	1966, 36; 1967, 54
	CH ₃ O(CH ₃)NPF ₂	H	1969, 103
PC ₂ H ₆ F ₂ NS	(CH ₃) ₂ NP(S)F ₂	H; F (−52); P (75·7)	1966, 30; 1968, 46
PC ₂ H ₆ F ₃	(CH ₃) ₂ PF ₃	H; F (−2·6, −86·4); P (8·0)	1966, 36; 1967, 54; 1968, 42
	C ₂ H ₅ PF ₃ H	H; F (−178·8, −105·2)	1968, 38 and 39
PC ₂ H ₆ F ₃ N ₂ O ₂ S	F ₃ P(NCH ₃) ₂ SO ₂	H; F (−77·8); P (−76·8)	1968, 125; 1969, 65
PC ₂ H ₆ F ₃ S	CH ₃ (CH ₃ S)PF ₃	F (−75·2, 1·2); P (2·0)	1969, 62
PC ₂ H ₆ F ₄ N	(CH ₃) ₂ NPF ₄	H; F (−69); P	1966, 217; 1967, 59; 1969, 64
PC ₂ H ₆ F ₅ O	(CH ₃) ₂ OPF ₅	H	1966, 139
PC ₂ H ₆ F ₅ S	(CH ₃) ₂ SPF ₅	H	1966, 139
PC ₂ H ₆ NaO ₃ S	(CH ₃ O) ₂ POSNa	H	1969, 325
PC ₂ H ₆ O ₂	(CH ₃) ₂ P(O)O [⊖]	P (37·5)	1967, 9
PC ₂ H ₇	(CH ₃) ₂ PH	¹³ C; H; P	1965, 3; 1966, 13; 1967, 11; 1968, 22 and 33; 1969, 330
	C ₂ H ₅ PH ₂	P (−128)	1966, 4
PC ₂ H ₇ F ₂	(CH ₃) ₂ PHF ₂	H; F (−26·6); P (−31·7)	1968, 42
PC ₂ H ₇ F ₃ N	CH ₃ (CH ₃ NH)PF ₃	F (−50, −75)	1967, 64
PC ₂ H ₇ F ₅ N	(CH ₃) ₂ NHPF ₅	F (−70·8)	1966, 217
PC ₂ H ₇ O ₂	(CH ₃) ₂ PO ₂ H	H	1967, 19; 1968, 65
	CH ₃ (CH ₃ O)P(O)H	P (32)	1967, 172
PC ₂ H ₇ O ₂ S	(CH ₃ O) ₂ P(S)H	P (74·9)	1966, 218
	CH ₃ (CH ₃ O)P(S)OH	H	1967, 72
PC ₂ H ₇ O ₃	(CH ₃ O) ₂ P(O)H	¹³ C; ¹⁷ O; H; P (9·5, 11·2)	1963, 1; 1964, 14; 1965, 81; 1966, 36; 1967, 42, 44, 198, 277 and 293; 1968, 3; 1969, 74
	(CH ₃ O) ₂ P(O)D		
PC ₂ H ₇ O ₄	(CH ₂ OH) ₂ P(O)OH	H; P (48·7)	1965, 79; 1967, 291
	(CH ₃ O) ₂ P(O)OH	H; P	1966, 138
PC ₂ H ₇ S	(CH ₃) ₂ P(S)H	P (5)	1966, 40

Formula	Compound	Resonance	Reference
$\text{PC}_2\text{H}_7\text{S}_2$	$(\text{CH}_3)_2\text{PS}_2\text{H}$	H	1967, 19
PC_2H_8	$(\text{CH}_3)_2\text{PH}_2^\oplus$	H	1966, 22; 1969, 41
$\text{PC}_2\text{H}_8\text{B}_5\text{F}_6$	$(\text{CF}_3)_2\text{PB}_5\text{H}_8$	^{11}B ; F (−49.9); P (−25.1)	1968, 23
$\text{PC}_2\text{H}_8\text{Ga}$	$(\text{CH}_3)_2\text{PGaH}$	H	1966, 125
$\text{PC}_2\text{H}_8\text{NO}_3$	$\text{CH}_3\text{CH}(\text{NH}_2)\text{PO}_3\text{H}_2$	P (17.6)	1968, 296
$\text{PC}_2\text{H}_8\text{NS}$	$(\text{CH}_3)_2\text{PSNH}_2$	H	1968, 281
$\text{PC}_2\text{H}_8\text{N}_2\text{NaO}_3\text{S}$	$(\text{CH}_3\text{NH})(\text{NH}_2)\text{CH}_2\text{SPO}_3\text{Na}$	H	1968, 292
$\text{PC}_2\text{H}_9\text{Si}$	$(\text{CH}_3)_2\text{PSiH}_3$	H	1969, 73
$\text{PC}_2\text{H}_{10}\text{ClN}_2$	$(\text{CH}_3)_2\text{P}(\text{NH}_2)_2\text{Cl}$	H; P (42.3)	1967, 65
$\text{PC}_2\text{H}_{11}\text{B}_5\text{F}_3$	$\text{CH}_3(\text{CF}_3)\text{PB}_5\text{H}_8$ (isom.)	^{11}B ; H; F (−59.7); P (−33.5)	1968, 23
$\text{PC}_2\text{H}_{14}\text{B}_4\text{F}_2\text{N}$	$(\text{CH}_3)_2\text{NPF}_2\text{B}_4\text{H}_8$	^{11}B ; H; F (−72)	1969, 141
$\text{PC}_2\text{H}_{14}\text{B}_5$	$(\text{CH}_3)_2\text{PB}_5\text{H}_8$	^{11}B ; H; P (−85)	1968, 23
$\text{PC}_2\text{H}_{14}\text{B}_9$	$\text{B}_9\text{H}_{10}\text{CHPCH}_3$ (isom.)	^{11}B ; H; P	1969, 25
$\text{PC}_3\text{BrF}_8\text{O}$	$(\text{CF}_3)_2\text{CBrOPF}_2$	F (−77.8, −45.9)	1967, 294
$\text{PC}_3\text{Cl}_2\text{F}_7$	$\text{C}_3\text{F}_7\text{PCl}_2$	H; F; P	1967, 40
$\text{PC}_3\text{Cl}_2\text{F}_9$	$\text{C}_3\text{F}_7\text{PF}_2\text{Cl}_2$	F (−82.3; −124.0, −122.4, 40.2); P (−14.3)	1969, 66
$\text{PC}_3\text{Cl}_3\text{F}_4\text{O}$	$\text{CF}_2=\text{CClCF}_2\text{P}(\text{O})\text{Cl}_2$	F (−69.3, −72.1, −104.7)	1967, 295
$\text{PC}_3\text{CsF}_{12}$	$(\text{CF}_3)_3\text{PF}_3\text{Cs}$	F (−68.9, −63.3)	1968, 48
$\text{PC}_3\text{F}_7\text{O}_2$	$\text{CF}_3\text{CF}_2\text{C}(\text{O})\text{OPF}_2$	F (−83.8, −122.1, −49.7)	1969, 56
$\text{PC}_3\text{F}_8\text{IO}$	$(\text{CF}_3)_2\text{ClOPF}_2$	F (−74.5, −46.9)	1967, 294
$\text{PC}_3\text{F}_9\text{S}$	$(\text{CF}_3)_2\text{P}(\text{SCF}_3)$	F; P	1967, 55
$\text{PC}_3\text{F}_9\text{Se}$	$(\text{CF}_3)_2\text{P}(\text{SeCF}_3)$	F	1968, 293
PC_3F_{11}	$\text{C}_3\text{F}_7\text{PF}_4$	F (−80.2, −123.0, −114.0, −56.7)	1969, 66
$\text{PC}_3\text{N}_3\text{OS}_3$	$\text{OP}(\text{NCS})_3$	P (−61)	1967, 277
$\text{PC}_3\text{N}_3\text{O}_3$	$\text{P}(\text{NCO})_3$	P (97.0)	1967, 277
$\text{PC}_3\text{N}_3\text{O}_3\text{S}$	$\text{SP}(\text{NCO})_3$	P (12.4)	1967, 277

PC ₃ N ₃ O ₄	OP(NCO) ₃	P (−40·9)	1967, 277
PC ₃ N ₃ S ₃	P(NCS) ₃	P (86·6)	1967, 277
PC ₃ N ₃ S ₄	SP(NCS) ₃	P (−9·3)	1967, 277
PC ₃ HF ₈ O	(CF ₃) ₂ CHOPF ₂	H; F (−75·5, −50·5); P	1967, 294
PC ₃ H ₃ BCl ₂ F ₆ N	(CF ₃) ₂ PN(CH ₃)BCl ₂	¹¹ B; H; P (50·5)	1968, 24
PC ₃ H ₃ Cl ₂	CH ₂ =C=CHPCl ₂	H	1968, 99; 1969, 115
PC ₃ H ₃ Cl ₂ O	CH ₂ =C=CHP(O)Cl ₂	H	1966, 127; 1967, 104 and 296; 1969, 115
PC ₃ H ₃ F ₂ O	CH ₂ =C=CHP(O)F ₂	H; F (−70·7 or −66·4)	1966, 127; 1967, 296
PC ₃ H ₃ F ₆	CH ₃ C≡CP(O)F ₂	H; F; P	1967, 105
PC ₃ H ₃ F ₆ O	CH ₃ P(CF ₃) ₂	H; F (−66·9); P (−5·8)	1969, 84
	CH ₃ P(O)(CF ₃) ₂	H; F (−72·4)	1969, 84
PC ₃ H ₃ F ₆ O ₂	CH ₃ OP(CF ₃) ₂	H; F (−66·2); P (94·8)	1969, 84
PC ₃ H ₃ N ₂	CH ₃ OP(O)(CF ₃) ₂	H; F (−73·3); P (2·5)	1969, 84
PC ₃ H ₄ Cl ₃ O ₂	CH ₃ P(CN) ₂	P (−81·4)	1966, 4
PC ₃ H ₄ F ₅ O	Cl ₂ P(O)CH ₂ C(O)Cl	H	1966, 219 and 220
PC ₃ H ₄ F ₆ N	CF ₃ P(OCH ₃)CHF ₂	H	1965, 11
PC ₃ H ₅ Cl ₂ O ₂	(CF ₃) ₂ PNHCH ₃	H	1968, 144
PC ₃ H ₅ Cl ₂ S	Cl ₂ PCH ₂ CO ₂ CH ₃	H	1968, 297
PC ₃ H ₅ F ₂ O	CH ₂ =CHCH ₂ P(S)Cl ₂	P (86·4)	1966, 114
PC ₃ H ₅ O ₃	CH ₂ =CHCH ₂ OPF ₂	F (−48·8)	1963, 3
	CH ₂ =CHCH ₂ PO ₃ ^{2−}	P (18·6)	1967, 7
	CH(CH ₂ O) ₂ PO	H	1966, 221
PC ₃ H ₅ O ₄	CH(CH ₂ O) ₂ P(O)O	H	1966, 221
	CH ₃ C(O)CH ₂ PO ₃ ^{2−}	P (9·6)	1967, 7
PC ₃ H ₆ Br ₃	CH ₃ CHBrCH ₂ PBr ₂	H; P (183)	1966, 222
	CH ₃ CH(PBr ₂)CH ₂ Br	H; P (189)	1966, 222
PC ₃ H ₆ Br ₃ O	(CH ₂ Br) ₃ PO	H	1967, 7
PC ₃ H ₆ Cl ₃ N ₂ O	OC(NCH ₃) ₂ PCl ₃	H	1965, 6

Formula	Compound	Resonance	Reference
$\text{PC}_3\text{H}_6\text{Cl}_3\text{O}$	$(\text{CH}_2\text{Cl})_3\text{PO}$	H; P (39.3)	1968, 298; 1969, 333
$\text{PC}_3\text{H}_6\text{F}_4\text{NS}$	$\text{CF}_3\text{P}(\text{S})(\text{F})\text{N}(\text{CH}_3)_2$	F (−72.3, −76.8)	1968, 47
$\text{PC}_3\text{H}_6\text{N}$	$\text{H}_2\text{PCH}_2\text{CH}_2\text{CN}$	P (−135)	1966, 4
PC_3H_7	$\text{CH}_2=\text{CH}\cdot\text{CH}_2\text{PH}_2$	H	1969, 169
	$(\text{CH}_2)_2\text{PCH}_3$	H; P (−251)	1969, 169
	$\text{CH}_2\text{CH}(\text{CH}_3)\text{PH}$	H	1969, 169
$\text{PC}_3\text{H}_7\text{ClFO}$	$i\text{-C}_3\text{H}_7\text{P}(\text{O})\text{ClF}$	F (−53); P (49.5)	1967, 14
$\text{PC}_3\text{H}_7\text{ClFOS}$	$\text{CH}_3(\text{ClCH}_2\text{CH}_2\text{S})\text{P}(\text{O})\text{F}$	F (−43); P (63)	1967, 14
$\text{PC}_3\text{H}_7\text{Cl}_2$	$i\text{-C}_3\text{H}_7\text{PCl}_2$	P (−198.6)	1968, 6
$\text{PC}_3\text{H}_7\text{Cl}_2\text{O}$	$\text{C}_3\text{H}_7\text{OPCl}_2$	H; P (179.5)	1967, 236
	$i\text{-C}_3\text{H}_7\text{OPCl}_2$	H	1969, 94
	$\text{CH}_3(\text{CH}_2\text{Cl})_2\text{PO}$	H; P (41.6)	1967, 297; 1968, 299; 1969, 334
$\text{PC}_3\text{H}_7\text{Cl}_2\text{O}_2$	$(\text{CH}_3\text{O})(\text{CH}_2\text{Cl})_2\text{PO}$	H; P (40.9)	1968, 300; 1969, 332
	$i\text{-C}_3\text{H}_7\text{OP}(\text{O})\text{Cl}_2$	H	1969, 74
$\text{PC}_3\text{H}_7\text{Cl}_2\text{S}$	$\text{C}_3\text{H}_7\text{P}(\text{S})\text{Cl}_2$	P (90.1)	1966, 114
	$i\text{-C}_3\text{H}_7\text{P}(\text{S})\text{Cl}_2$	P (107.0)	1966, 114
$\text{PC}_3\text{H}_7\text{Cl}_3\text{NO}_2$	$(\text{CH}_3)_2\text{N}^{\oplus}\text{CHOP}(\text{O})\text{Cl}_2\text{Cl}^{\ominus}$	H	1966, 223
$\text{PC}_3\text{H}_7\text{F}_2\text{O}$	$\text{C}_3\text{H}_7\text{OPF}_2$	F (−50); P (111.5)	1963, 3; 1967, 235; 1969, 381
	$i\text{-C}_3\text{H}_7\text{P}(\text{O})\text{F}_2$	F (−79); P (29.5)	1967, 14
$\text{PC}_3\text{H}_7\text{I}_2\text{O}$	$\text{CH}_3(\text{CH}_2\text{I})_2\text{PO}$	H	1967, 297; 1968, 60
$\text{PC}_3\text{H}_7\text{O}_2$	$\text{H}_2\text{P}(\text{CH}_2)_2\text{CO}_2\text{H}$	P (−136.9)	1967, 135
$\text{PC}_3\text{H}_7\text{O}_3$	$\text{CH}_3\text{OP}(\text{OCH}_2)_2$	H; P (131.6)	1966, 50 and 224; 1968, 77 and 301
	$\text{CH}_3\text{P}(\text{O})(\text{OCH}_2)_2$	P (53)	1967, 69
$\text{PC}_3\text{H}_8\text{ClFNO}$	$\text{CH}_2\text{ClP}(\text{O})[\text{N}(\text{CH}_3)_2]\text{F}$	H; P	1967, 77
$\text{PC}_3\text{H}_8\text{ClFNS}$	$\text{CH}_2\text{ClP}(\text{S})[\text{N}(\text{CH}_3)_2]\text{F}$	H; P	1967, 77

PC ₃ H ₈ ClOS	CH ₃ P(S)(OC ₂ H ₅)Cl	H	1967, 72
PC ₃ H ₈ ClO ₂	CH ₃ P(O)(OC ₂ H ₅)Cl	H	1969, 74
PC ₃ H ₈ ClO ₃	CH ₂ ClP(O)(OCH ₃) ₂	P (28)	1967, 69
PC ₃ H ₈ ClS	CH ₃ P(SC ₂ H ₅)Cl	P (151)	1969, 335
PC ₃ H ₈ Cl ₂ N	CH ₂ ClP[N(CH ₃) ₂]Cl	H; P (123·0)	1965, 12; 1968, 59; 1969, 107
PC ₃ H ₈ Cl ₂ NO	CH ₂ ClP(O)[N(CH ₃) ₂]Cl	H(T){P}	1967, 77
PC ₃ H ₈ Cl ₂ NS	CH ₂ ClP(S)[N(CH ₃) ₂]Cl	H{P}	1967, 77
PC ₃ H ₈ F	CH ₃ (C ₂ H ₅)PF	P (182)	1968, 12
PC ₃ H ₈ FO	CH ₃ (C ₂ H ₅ O)PF	F (−101); P (218)	1968, 12
PC ₃ H ₈ FOS	C ₂ H ₅ (CH ₃ S)P(O)F	F (−57); P (67)	1967, 13 and 14; 1968, 295
	CH ₃ (C ₂ H ₅ S)P(O)F	F (−45); P (61·5)	1967, 14
PC ₃ H ₈ FO ₂	C ₂ H ₅ (CH ₃ O)P(O)F	F (−74); P (32·9)	1967, 13 and 14; 1968, 295
	CH ₃ (C ₂ H ₅ O)P(O)F	F (−63)	1967, 13 and 14; 1968, 295
PC ₃ H ₈ F ₃ S	CH ₃ (C ₂ H ₅ S)PF ₃	F (−72·7, 1·2); P (1·0)	1969, 62
PC ₃ H ₈ NO ₄	O(CH ₂) ₂ NCH ₂ PO ₃ H ₂	P (5·9)	1967, 291
PC ₃ H ₈ NO ₄ S	H ₂ NCH ₂ CHOHCH ₂ SPO ₃ ^{2−}	H	1966, 204
PC ₃ H ₉	(CH ₃) ₃ P	¹³ C; H; P (−62 to −66)	1965, 1, 2 and 3; 1966, 13, 36 and 41; 1967, 244; 1968, 3, 7, 17, 22, 42, 54, 211, 290, 302 and 303; 1969, 2
	CH ₃ (C ₂ H ₅)PH	P (−77)	1965, 3
PC ₃ H ₉ AlBr ₃	(CH ₃) ₃ P, AlBr ₃	²⁷ Al; P	1967, 23
PC ₂ H ₉ AlCl ₃	(CH ₃) ₃ P, AlCl ₃	²⁷ Al; P	1967, 23
PC ₃ H ₉ ClN	CH ₃ P[N(CH ₃) ₂]Cl	H; P (150·2)	1965, 12; 1966, 36
PC ₃ H ₉ ClNO	CH ₃ P(O)[N(CH ₃) ₂]Cl	H	1965, 82
PC ₃ H ₉ Cl ₂ N ₂	Cl ₂ PN(CH ₃)N(CH ₃) ₂	H	1969, 103
PC ₃ H ₉ FN	CH ₃ P[N(CH ₃) ₂]F	H; F (−117); P (170)	1965, 12; 1966, 36
PC ₃ H ₉ FNO	CH ₃ P(O)[N(CH ₃) ₂]F	F (−60); P (38·4)	1965, 12; 1966, 36; 1967, 13 and 14; 1968, 295
PC ₃ H ₉ F ₂	(CH ₃) ₃ PF ₂	H; F (−4·8); P (−158)	1967, 60; 1968, 356
PC ₃ H ₉ F ₂ N ₂	F ₂ PN(CH ₃)N(CH ₃) ₂	H	1969, 103

Formula	Compound	Resonance	Reference
PC ₃ H ₉ F ₂ O	CH ₃ (C ₂ H ₅ O)PF ₂ H	P (−20·5)	1967, 38
PC ₃ H ₉ F ₂ O ₃	(CH ₃ O) ₃ PF ₂	H; F (−72·8)	1967, 61
PC ₃ H ₉ F ₂ S	(CH ₃) ₂ PF ₂ (SCH ₃)	F (0·2)	1969, 62
PC ₃ H ₉ F ₂ SiO ₂	(CH ₃) ₃ SiOP(O)F ₂	H; F (−82·8); P (−28·7)	1967, 282
PC ₃ H ₉ F ₃ N	CH ₃ [(CH ₃) ₂ N]PF ₃	H; F (−68·5, −27·5); P (−37·5)	1965, 12; 1968, 304
PC ₃ H ₉ O	(CH ₃) ₃ PO	H; P (48·3)	1965, 78 and 83; 1967, 175
PC ₃ H ₉ O ₂	CH ₃ (C ₂ H ₅ O)P(O)H	H; P (32·6)	1967, 172; 1968, 72; 1969, 162
	(CH ₃) ₂ (CH ₃ O)PO	H	1968, 65
	CH ₃ (CH ₃ O) ₂ P	H	1968, 290
PC ₃ H ₉ O ₂ S	CH ₃ (C ₂ H ₅ O)P(S)OH	H	1967, 72
PC ₃ H ₉ O ₂ S ₂	(CH ₃ O) ₂ (CH ₃ S)PS	H; P (99·6)	1965, 20; 1966, 218
PC ₃ H ₉ O ₃	(CH ₃ O) ₃ P	¹³ C; H; ¹⁷ O; P (140)	1963, 1; 1965, 7, 21 and 84; 1966, 36, 141, 169, 206, 224 and 225; 1967, 198, 218, 277, 293, 298 and 299; 1968, 3, 22 and 211; 1969, 336
	CH ₃ (CH ₃ O) ₂ PO	¹³ C; H; P (35)	1966, 126, 133 and 226; 1967, 19, 120, 186 and 300; 1968, 3
PC ₃ H ₉ O ₃ S	(CH ₃ O) ₃ PS	H; P (73·4)	1966, 36, 133, 206 and 208; 1967, 277
	(CH ₃ O) ₂ (CH ₃ S)PO	¹³ C; H; P	1966, 133 and 226; 1968, 3
PC ₃ H ₉ O ₃ Se	(CH ₃ Se)(CH ₃ O) ₂ PO	H	1966, 226
PC ₃ H ₉ O ₄	(CH ₃ O) ₃ PO	¹³ C; H; ¹⁷ O; P (2·4)	1963, 1; 1965, 21, 84 and 85; 1966, 36, 133 and 226; 1967, 69, 86, 198 and 277; 1968, 3 and 73; 1969, 86, 127 and 336

$\text{PC}_3\text{H}_9\text{O}_5$	$\text{CH}_3\text{CHOHCH}_2\text{OPO}_3\text{H}_2$	P (4.04)	1966, 227
	$\text{CH}_3\text{CH}(\text{OPO}_3\text{H}_2)\text{CH}_2\text{OH}$	P (5.05)	1966, 227
$\text{PC}_3\text{H}_9\text{S}$	$(\text{CH}_3)_3\text{PS}$	^{13}C ; H; P	1966, 36; 1968, 3
$\text{PC}_3\text{H}_9\text{SSe}$	$(\text{CH}_3)_2\text{P}(\text{S})\text{SeCH}_3$	H{C; P; Se}	1969, 4
$\text{PC}_3\text{H}_9\text{S}_3$	$(\text{CH}_3\text{S})_3\text{P}$	P (124.5)	1966, 208
$\text{PC}_3\text{H}_9\text{Se}$	$(\text{CH}_3)_3\text{PSe}$	^{13}C ; H{C; P; Se}	1968, 3; 1969, 4
PC_3H_{10}	$(\text{CH}_3)_3\text{PH}^\oplus$	H	1966, 22
$\text{PC}_3\text{H}_{10}\text{Br}$	$(\text{CH}_3)_3\text{PHBr}$	H; P (-2.9)	1968, 7
$\text{PC}_3\text{H}_{10}\text{F}_2\text{NOSi}$	$\text{F}_2\text{P}(\text{O})\text{NHSi}(\text{CH}_3)_3$	H; F (-69.7); P (-3)	1969, 129
$\text{PC}_3\text{H}_{10}\text{NO}_2$	$\text{CH}_3(\text{CH}_3\text{O})\text{P}(\text{O})\text{NHCH}_3$	H	1966, 124
	$(\text{CH}_3)_2\text{NCH}_2\text{PO}_2\text{H}_2$	P (9.6)	1967, 301
$\text{PC}_3\text{H}_{10}\text{NO}_3$	$(\text{CH}_3)_2\text{NCH}_2\text{PO}_3\text{H}_2$	H; P (8.8)	1966, 212; 1967, 291
$\text{PC}_3\text{H}_{11}\text{ClN}$	$(\text{CH}_3)_3\text{PNH}_2\cdot\text{Cl}$	H; P (49.6)	1967, 65; 1968, 54
$\text{PC}_3\text{H}_{11}\text{F}_5\text{N}$	$\text{CH}_3\text{PF}_5, (\text{CH}_3)_2\text{NH}_2$	H; F (-57.4, -46.8); P (-124.9)	1966, 228
$\text{PC}_3\text{H}_{11}\text{N}_2\text{O}_3\text{S}$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{C}(\text{NH}_2)_2\text{SH}$	H	1967, 302
$\text{PC}_3\text{H}_{11}\text{O}_7\text{S}$	$(\text{CH}_3\text{O})_3\text{P}^\oplus\text{H}, \text{HSO}_4^\ominus$	P (26)	1969, 50
$\text{PC}_3\text{H}_{11}\text{Si}$	$(\text{CH}_3)_3\text{SiPH}_2$	H; P (-239.0)	1967, 29
$\text{PC}_3\text{H}_{15}\text{B}_2\text{Be}$	$(\text{CH}_3)_3\text{PBeB}_2\text{H}_6(?)$	^{11}B	1966, 45
$\text{PC}_3\text{H}_{17}\text{B}_2\text{Be}$	$(\text{CH}_3)_3\text{BeB}_2\text{H}_8$	^{11}B	1966, 45
PC_3N_3	$\text{P}(\text{CN})_3$	P (-135.7)	1966, 4; 1969, 8
$\text{PC}_3\text{N}_3\text{OS}_3$	$\text{OP}(\text{NCS})_3$	P (97.0)	1965, 50
$\text{PC}_3\text{N}_3\text{O}_3$	$\text{P}(\text{NCO})_3$	P (67.0)	1965, 4
$\text{PC}_3\text{N}_3\text{S}_3$	$\text{P}(\text{NCS})_3$	P (85.2)	1965, 50
$\text{PC}_3\text{N}_3\text{S}_4$	$\text{SP}(\text{NCS})_3$	P (-9.5)	1965, 4 and 50; 1967, 289
$\text{PC}_4\text{AsF}_{12}$	$(\text{CF}_3)_2\text{PAs}(\text{CF}_3)_2$	F (-44.9; -42)	1968, 55
PC_4ClF_6	$(\text{CF}_2=\text{CF})_2\text{PCl}$	F (-81.9; -103.9; -190.0)	1969, 55
$\text{PC}_4\text{F}_8\text{I}$	$(\text{CF}_2)_4\text{PI}$	F	1962, 2
PC_4F_9	$(\text{CF}_2=\text{CF})_2\text{PF}_3$	F (-66.8; -83.0; -180.7; -41.3; -76.8)	1969, 55, 114

Formula	Compound	Resonance	Reference
PC ₄ F ₉ O ₂	C ₃ F ₇ C(O)OPF ₂	F (−81·4; −127·2; −119·7; −49·7)	1969, 56
PC ₄ F ₁₂ N	(CF ₃) ₂ PN(CF ₃) ₂	F (−55·8; −51·7)	1968, 69
PC ₄ F ₁₉ Cl ₂ N	(CF ₃) ₂ NP(CF ₃) ₂ Cl ₂	F (−48·2; −77·7)	1969, 85
PC ₄ H ₃ Cl ₂ O	CH ₂ =CHC≡CP(O)Cl ₂	H	1965, 86
PC ₄ H ₃ F ₈ O ₃	CHF ₂ (CF ₂) ₃ PO ₃ H ₂	F	1962, 2
PC ₄ H ₄ ClF ₄	CF ₂ =CClCF ₂ PHCH ₃	H; F (<i>ca.</i> −80; −91·6)	1967, 295
PC ₄ H ₅ ClFO	FP(O)CH ₂ CH=CClCH ₂	H	1967, 110
PC ₄ H ₅ ClFS	FP(S)CH ₂ C(Cl)=CHCH ₂	H	1967, 110
PC ₄ H ₅ ClO ₂	ClP(O)OCH(=CH ₂)CH=CH	H; P (15·4)	1966, 229
PC ₄ H ₅ Cl ₂	Cl ₂ PC(CH ₃)=C=CH ₂	H	1968, 99
PC ₄ H ₅ Cl ₂ O	Cl ₂ P(O)CH=CHCH=CH ₂	H	1965, 86
	Cl ₂ P(O)C(CH ₃)=C=CH ₂	H	1969, 115
	Cl ₂ P(O)C≡CC ₂ H ₅	H	1965, 86
	ClP(O)CH ₂ CH=C(Cl)CH ₂	H	1967, 110
PC ₄ H ₆ AsF ₆	(CF ₃) ₂ PAs(CH ₃) ₂	H; P (10·2); F (−42·9)	1968, 55
	(CH ₃) ₂ PAs(CF ₃) ₂	H; P (−44·0); F (−43·8)	1968, 55
PC ₄ H ₆ BF ₆ O	(CH ₃) ₂ BOP(CF ₃) ₂	¹¹ B; H; P (31·2); F (−67)	1969, 27
PC ₄ H ₆ BrO	BrP(O)CH ₂ CH=CHCH ₂	H	1964, 8
PC ₄ H ₆ ClO	ClP(O)CH ₂ CH=CHCH ₂	H	1967, 109
PC ₄ H ₆ ClO ₂	ClP(O)OC(CH ₃)=CHCH ₂	H	1967, 110

$\text{PC}_4\text{H}_6\text{Cl}_3\text{N}_4\text{O}_3\text{S}$	$\text{Cl}_2\text{P}^\oplus\text{NC}(\text{O})\text{N}(\text{CH}_3)\text{C}^\oplus(\text{N}^\ominus\text{SO}_2)\text{NCH}_3, \text{Cl}^\ominus$	H; P (44.5)	1969, 380
$\text{PC}_4\text{H}_6\text{Cl}_3\text{O}_2$	$\text{Cl}_2\text{P}(\text{O})\text{CH}(\text{CH}_3)\text{CH}_2\text{C}(\text{O})\text{Cl}$ $\text{Cl}_2\text{P}(\text{O})\text{CH}_2\text{CH}(\text{CH}_3)\text{C}(\text{O})\text{Cl}$	H H	1966, 219 1966, 219
$\text{PC}_4\text{H}_6\text{FO}$	$\text{FP}(\text{O})(\text{CH}_2\text{CH})_2$	H	1967, 110, 303
$\text{PC}_4\text{H}_6\text{F}_4\text{N}$	$\text{CF}_2=\text{CFPF}[\text{N}(\text{CH}_3)_2]$	H; F (-90.1; -113.0; -190.0; -126.3)	1969, 55
$\text{PC}_4\text{H}_6\text{F}_6\text{N}$	$(\text{CF}_3)_2\text{PNCH}_2\text{H}_5$	H (T)	1968, 144
$\text{PC}_4\text{H}_6\text{F}_6\text{NS}$	$(\text{CF}_3)_2\text{P}(\text{S})\text{N}(\text{CH}_3)_2$	F (-68.3)	1968, 47
$\text{PC}_4\text{H}_7\text{Br}_2\text{Cl}_2\text{O}_4$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{OCHBrCBrCl}_2$	H	1968, 284, 285; 1969, 322
$\text{PC}_4\text{H}_7\text{ClF}_3$	$(\text{CH}_3)_2\text{PCF}_2\text{CHFCCl}$	H; P (-26.8); F	1966, 215
$\text{PC}_4\text{H}_7\text{ClF}_4\text{N}$	$\text{CHF}_2\text{CF}_2\text{PCl}[\text{N}(\text{CH}_3)_2]$	H; F (-134.9; -121.6)	1968, 71
$\text{PC}_4\text{H}_7\text{Cl}_2$	$\text{Cl}_2\text{PCH}=\text{C}(\text{CH}_3)_2$	H	1966, 94
	$\text{Cl}_2\text{PCH}_2\text{C}(\text{CH}_3)=\text{CH}_2$	H	1966, 94
$\text{PC}_4\text{H}_7\text{Cl}_2\text{F}_3\text{N}$	$\text{CHCl}_2\text{CF}_2\text{PF}[\text{N}(\text{CH}_3)_2]$	H; F (-115.6; -135.4)	1968, 71
$\text{PC}_4\text{H}_7\text{Cl}_2\text{O}_2$	$\text{Cl}_2\text{P}(\text{O})\text{CH}=\text{CHOC}_2\text{H}_5$	H	1969, 288
$\text{PC}_4\text{H}_7\text{Cl}_2\text{O}_3$	$\text{Cl}_2\text{P}(\text{O})(\text{CH}_2)_2\text{COOCH}_3$	H	1967, 313
$\text{PC}_4\text{H}_7\text{Cl}_2\text{O}_4$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{OCH}=\text{CCl}_2$	H	1968, 284
$\text{PC}_4\text{H}_7\text{Cl}_3\text{F}_2\text{N}$	$\text{CHCl}_2\text{CF}_2\text{PCl}[\text{N}(\text{CH}_3)_2]$	H; F (-112.6)	1968, 71; 1969, 107
$\text{PC}_4\text{H}_7\text{F}_5\text{N}$	$\text{CHF}_2\text{CF}_2\text{PF}[\text{N}(\text{CH}_3)_2]$	H; F (-134.7; -126.1; -136.5)	1968, 284
$\text{PC}_4\text{H}_7\text{F}_6\text{N}_2$	$(\text{CH}_3)_2\text{NNHP}(\text{CF}_3)_2$	H; F (-63.5)	1968, 145
$\text{PC}_4\text{H}_7\text{O}_3$	$\text{P}(\text{OCH}_2)_3\text{CH}$	H	1966, 37
	$\text{P}(\text{CH}_2\text{O})_3\text{CH}$	H	1966, 37; 1968, 53
	$\text{CH}_2\text{OPOCH}(\text{CH}_2)_2\text{O}$	H	1966, 121; 1969, 90
$\text{PC}_4\text{H}_7\text{O}_3\text{S}$	$\text{SP}(\text{CH}_2\text{O})_3\text{CH}$	H	1968, 53
$\text{PC}_4\text{H}_7\text{O}_4$	$\text{OP}(\text{CH}_2\text{O})_3\text{CH}$	H	1966, 37; 1968, 53
	$\text{OP}(\text{OCH}_2)_3\text{CH}$	H	1966, 37

Formula	Compound	Resonance	Reference
$\text{PC}_4\text{H}_9\text{ClO}_2$	$(\text{CH}_2\text{O})_2\text{POC}(\text{O})\text{CH}_3$	H	1966, 50
	$\text{ClPO}(\text{CH}_2)_2\text{CH}(\text{CH}_3)\text{O}$	H (T)	1966, 46; 1969, 92
$\text{PC}_4\text{H}_8\text{Cl}_2\text{N}$	$\text{ClP}[\text{OCH}(\text{CH}_3)]_2$	H	1966, 50
$\text{PC}_4\text{H}_8\text{Cl}_3$	$\text{C}_4\text{H}_8\text{NPCl}_2$	H; P (164.5)	1966, 230
$\text{PC}_4\text{H}_8\text{Cl}_3\text{O}_4$	$\text{Cl}_2\text{PCH}_2\text{CCl}(\text{CH}_3)_2$	H	1966, 60
	$\text{Cl}_2\text{PC}(\text{CH}_2\text{Cl})\text{C}(\text{CH}_3)_2$	H	1966, 60
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{CH}(\text{OH})\text{CCl}_3$	H	1968, 283, 284, 285; 1969, 322
$\text{PC}_4\text{H}_8\text{Cl}_5$	$(\text{CH}_2\text{Cl})_4\text{PCl}$	H; P (44.7)	1969, 63
$\text{PC}_4\text{H}_8\text{F}_2\text{N}$	$\text{C}_4\text{H}_8\text{NPF}_2$	H; P (146.2); F (−67.9)	1966, 230
$\text{PC}_4\text{H}_8\text{F}_2\text{NS}$	$\text{C}_4\text{H}_8\text{NP}(\text{S})\text{F}_2$	P (65.0); F (−48.4)	1966, 30
$\text{PC}_4\text{H}_8\text{NaO}_3\text{S}$	$\text{O}(\text{CH}_2)_2\text{CH}(\text{CH}_3)\text{OP}(\text{S})\text{ONa}$ (steroids.)	H; P (112.9; 120)	1969, 177
PC_4H_9	$\text{HPCH}_2\text{CHC}_2\text{H}_5$ (isom.)	H; P (−271, −788)	1969, 169
$\text{PC}_4\text{H}_9\text{Cl}_2$	<i>i</i> - $\text{C}_4\text{H}_9\text{PCl}_2$	H	1967, 393
$\text{PC}_4\text{H}_9\text{Cl}_2\text{O}$	<i>t</i> - $\text{C}_4\text{H}_9\text{PCl}_2$	P (197.5)	1968, 28
	<i>t</i> - $\text{C}_4\text{H}_9\text{P}(\text{O})\text{Cl}_2$	H; P (65.6)	1965, 8; 1966, 36
	$\text{C}_4\text{H}_9\text{OPCl}_2$	P (180.0)	1967, 236
	$\text{C}_2\text{H}_5\text{P}(\text{O})(\text{CH}_2\text{Cl})_2$	H; P (45.7)	1968, 299; 1969, 334
	$\text{C}_2\text{H}_5\text{OP}(\text{O})(\text{CH}_2\text{Cl})_2$	H; P (39.7)	1968, 300; 1969, 332
$\text{PC}_4\text{H}_9\text{Cl}_2\text{O}_2$	$\text{HP}(\text{O})(\text{OCH}_2\text{CH}_2\text{Cl})_2$	P (8.8)	1967, 277
$\text{PC}_4\text{H}_9\text{Cl}_2\text{O}_3$	$\text{C}_4\text{H}_9\text{P}(\text{S})\text{Cl}_2$	P (90.6)	1966, 114
$\text{PC}_4\text{H}_9\text{Cl}_2\text{S}$	<i>i</i> - $\text{C}_4\text{H}_9\text{P}(\text{S})\text{Cl}_2$	P (89.0)	1966, 114
$\text{PC}_4\text{H}_9\text{Cl}_3\text{N}$	<i>s</i> - $\text{C}_4\text{H}_9\text{N}=\text{PCl}_3$	P (−38.7)	1966, 288
$\text{PC}_4\text{H}_9\text{F}_2\text{O}$	<i>t</i> - $\text{C}_4\text{H}_9\text{P}(\text{O})\text{F}_2$	H; P (31.3); F (−81.6)	1965, 8; 1966, 36
	$\text{C}_4\text{H}_9\text{P}(\text{O})\text{F}_2$	P (29.3)	1967, 14
	$\text{C}_4\text{H}_9\text{OPF}_2$	F (−50.8)	1969, 61

PC ₄ H ₉ F ₃ N	CHF ₂ CH ₂ PF[N(CH ₃) ₂]	F (−110.2; −119.5)	1965, 80
PC ₄ H ₉ Li ₂ O ₄	F ₃ P(CH ₃)NH(CH ₂ CH=CH ₂)	P (−36.4); F (−75; −48)	1967, 64
PC ₄ H ₉ O	<i>t</i> -C ₄ H ₉ OP(O)(OLi) ₂	H	1965, 88
	(CH ₃) ₂ PC(O)CH ₃	H; P (−22.2)	1967, 346; 1968, 307
	HP(CH ₂ CH ₂) ₂ O	H; P (−79)	1969, 44
PC ₄ H ₉ O ₂	H ₂ PCH(C ₂ H ₅)COOH	P (−120.8)	1967, 135
	H ₂ P(CH ₂) ₃ COOH	P (−138.0)	1967, 135
	(CH ₃) ₂ P(O)C(O)CH ₃	H	1968, 307
PC ₄ H ₉ O ₂	(CH ₂) ₄ P(O)OH	¹³ C	1968, 22
PC ₄ H ₉ O ₃	C ₂ H ₅ P(O)(OCH ₂) ₂	H{P}, P (53)	1964, 14; 1967, 69
	(CH ₃) ₂ P(O)CH ₂ COOH	H	1965, 87
	CH ₃ OPOCH ₂ CH(CH ₃)O (isom.)	H; P (139; 142)	1966, 46; 1969, 94
	(CH ₃ O) ₂ P(O)CH=CH ₂	H	1969, 82
	HP(O)O(CH ₂) ₂ CH(CH ₃)O	H	1969, 52
PC ₄ H ₉ O ₄	(CH ₂ O) ₄ PH	H; P (−26)	1967, 39; 1968, 154, 304; 1969, 45
	(CH ₂ O) ₂ P(O)OC ₂ H ₅	P (17)	1967, 69
	(CH ₃ O) ₂ P(O)OCH=CH ₂	H	1967, 120; 1969, 127
	CH ₃ OP(O)OCH ₂ CH(CH ₃)O	H; P (16)	1969, 94
PC ₄ H ₉ O ₅	(CH ₃ O) ₂ P(O)OCH ₂ C(O)H	H; P (1.2)	1969, 337
PC ₄ H ₁₀ Ba _{1/2}	CH ₃ CH(OH)CH ₂ OP(O)(O [−])(OCH ₃)Ba _{1/2} [⊕]	H	1965, 88
PC ₄ H ₁₀ BrO ₃	(CH ₃ O) ₂ P(O)(CH ₂) ₂ Br	H; P (28.3)	1969, 145
PC ₄ H ₁₀ Br ₂ N	Br ₂ PN(C ₂ H ₅) ₂	H	1965, 18
PC ₄ H ₁₀ ClN ₂	ClP[N(CH ₃)CH ₂] ₂	H; P (167.3)	1966, 224; 1967, 305
PC ₄ H ₁₀ ClO ₂	(C ₂ H ₅ O) ₂ PCl	H; P (165)	1965, 20; 1966, 216; 1967, 198; 1968, 25
	(C ₂ H ₅)(C ₂ H ₅ O)P(O)Cl	P (45)	1966, 111

Formula	Compound	Resonance	Reference
PC ₄ H ₁₀ ClO ₂ S	(C ₂ H ₅ O)(C ₂ H ₅ S)P(O)Cl (C ₂ H ₅ O) ₂ P(S)Cl	H; P (34.1) H	1965, 20 1966, 216; 1967, 84; 1968, 25
PC ₄ H ₁₀ ClO ₃	(C ₂ H ₅ O) ₂ P(O)Cl	¹³ C; H; P (4)	1966, 216; 1967, 69, 84, 198; 1968, 3, 25; 1969, 74
PC ₄ H ₁₀ ClO ₃ S	(CH ₃ O) ₂ P(O)CH ₂ CH ₂ Cl (CH ₃ O) ₂ P(O)SCH ₂ CH ₂ Cl	H; P (28.5) H	1969, 81 1966, 74
PC ₄ H ₁₀ Cl ₂ N	Cl ₂ PN(C ₂ H ₅) ₂ Cl ₂ PNHC(CH ₃) ₃	H H	1965, 18 1969, 112
PC ₄ H ₁₀ Cl ₂ NO	Cl ₂ P(O)N(C ₂ H ₅) ₂	H	1965, 30
PC ₄ H ₁₀ Cl ₂ NS	Cl ₂ P(S)N(C ₂ H ₅) ₂	H	1965, 30
PC ₄ H ₁₀ FO	(C ₂ H ₅) ₂ P(O)F CH ₃ PF(OC ₃ H ₇)	P (71.8); F (-83.6) P (214); F (-101)	1967, 13, 14; 1968, 295 1968, 12
PC ₄ H ₁₀ FO ₂	C ₂ H ₅ (C ₂ H ₅ O)P(O)F CH ₃ PF(Oi-C ₃ H ₇) CH ₃ PF(OC ₃ H ₇) (C ₂ H ₅ O) ₂ PF	P (33.1); F (-68.5) H; P (27.5); F (-58.4) P (26.0); F (-63) F (-60.4)	1967, 13, 14; 1968, 295 1967, 13, 14; 1969, 74 1967, 14 1969, 61
PC ₄ H ₁₀ FO ₂ S	(C ₂ H ₅ O)(C ₂ H ₅ S)P(O)F	P (26.6)	1967, 14
PC ₄ H ₁₀ FO ₃	(C ₂ H ₅ O) ₂ P(O)F	P (-9.2); F (-82.3)	1967, 13, 14; 1968, 295
PC ₄ H ₁₀ F ₂ N	(C ₂ H ₅) ₂ NPF ₂	H; P (147; 144); F (-64.8)	1966, 230; 1967, 48, 235
PC ₄ H ₁₀ F ₂ NO	(C ₂ H ₅) ₂ NP(O)F ₂	P (-3.6)	1967, 13
PC ₄ H ₁₀ F ₂ NS	(C ₂ H ₅) ₂ NP(S)F ₂	H; P (71.3); F (-48.9)	1966, 30
PC ₄ H ₁₀ F ₄ N	(C ₂ H ₅) ₂ NPF ₄	F (-68)	1966, 217
PC ₄ H ₁₀ KO ₂ S ₂	(C ₂ H ₅ O) ₂ PS ₂ K	H	1969, 325
PC ₄ H ₁₀ KO ₃ S	(C ₂ H ₅ O) ₂ POSK	H	1969, 325
PC ₄ H ₁₀ Li	(CH ₃) ₂ (LiCH ₂)P=CH ₂	H	1968, 106, 107
PC ₄ H ₁₀ NO ₂	(CH ₂ O) ₂ PN(CH ₃) ₂	P (140)	1968, 301; 1969, 45

	$\text{CH}_3\text{OPO}(\text{CH}_2)_2\text{NCH}$	H	1969, 171
$\text{PC}_4\text{H}_{10}\text{NO}_3$	$\text{HP}[\text{O}(\text{CH}_2)_2\text{O}][\text{O}(\text{CH}_2)_2\text{NH}]$	H; P (-36.4)	1968, 304; 1969, 45
$\text{PC}_4\text{H}_{10}\text{NaO}_2\text{S}_2$	$(\text{C}_2\text{H}_5\text{O})_2\text{PS}_2\text{Na}$	H	1969, 325
PC_4H_{11}	$\text{CH}_3(\text{C}_3\text{H}_7)\text{PH}$	P (-84)	1965, 3
	$(\text{C}_2\text{H}_5)_2\text{PH}$	P (-57)	1965, 3
	$(\text{CH}_3)_2\text{PC}_2\text{H}_5$	P (-48)	1965, 3
	$(\text{CH}_3)_3\text{P}=\text{CH}_2$	H (T)	1967, 306; 1968, 105, 107, 305
$\text{PC}_4\text{H}_{11}\text{Cl}_2\text{OSi}$	$(\text{CH}_3)_3\text{SiCH}_2\text{P}(\text{O})\text{Cl}_2$	H	1966, 231
$\text{PC}_4\text{H}_{11}\text{F}_5\text{N}$	$\text{PF}_5 \cdot \text{NH}(\text{C}_2\text{H}_5)_2$	F (-80.5; -68)	1966, 217
$\text{PC}_4\text{H}_{11}\text{N}_2\text{O}_2$	$\text{HP}[\text{O}(\text{CH}_2)_2\text{NH}]_2$	P (-54)	1969, 45
$\text{PC}_4\text{H}_{11}\text{O}_2$	$(\text{CH}_3)_2\text{P}(\text{O})\text{OC}_2\text{H}_5$	H; P (50.3)	1966, 232; 1968, 65
	$(\text{C}_2\text{H}_5)_2\text{PO}_2\text{H}$	H	1968, 65
$\text{PC}_4\text{H}_{11}\text{O}_2\text{S}$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{S})\text{H}$	P (68.4)	1966, 218; 1968, 25
	$\text{CH}_3(\text{C}_3\text{H}_7\text{O})\text{POSH}$	H	1967, 72
$\text{PC}_4\text{H}_{11}\text{O}_2\text{S}_2$	$(\text{C}_2\text{H}_5\text{O})_2\text{PS}_2\text{H}$	H	1967, 84
$\text{PC}_4\text{H}_{11}\text{O}_3$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{H}$	^{13}C ; H; P (7.5)	1965, 81; 1966, 126; 1967, 42, 198, 277, 254, 293; 1968, 3, 25, 165, 306
	$t\text{-C}_4\text{H}_9\text{PO}_3\text{H}_2$	H; P (37.0)	1965, 8
$\text{PC}_4\text{H}_{11}\text{O}_3\text{S}$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{SC}_2\text{H}_5$	H	1966, 133
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{SH}$	H	1967, 307
$\text{PC}_4\text{H}_{11}\text{O}_4$	$\text{C}_4\text{H}_9\text{OPO}_3\text{H}_2$	P	1966, 117
	$(\text{C}_2\text{H}_5\text{O})_2\text{PO}_2\text{H}$	P (0.6)	1969, 321
$\text{PC}_4\text{H}_{11}\text{S}$	$(\text{C}_2\text{H}_5)_2\text{P}(\text{S})\text{H}$	P (31)	1966, 40
	$(\text{CH}_3)_2\text{PCH}_2\text{SCH}_3$	H	1969, 128
PC_4H_{12}	$\text{P}(\text{CH}_3)_4^{\oplus}$	H	1966, 22

Formula	Compound	Resonance	Reference
$\text{PC}_4\text{H}_{12}\text{BF}_4\text{O}_4$	$(\text{CH}_3\text{O})_4\text{P}^\oplus\text{BF}_4^\ominus$	H; P (1·9)	1969, 86
$\text{PC}_4\text{H}_{12}\text{Br}$	$(\text{CH}_3)_4\text{PBr}$	P (25·2)	1966, 5
$\text{PC}_4\text{H}_{12}\text{Cl}$	$(\text{CH}_3)_4\text{PCl}$	H; P (24·4)	1966, 39; 1968, 54, 107
$\text{PC}_4\text{H}_{12}\text{ClN}_2$	$[(\text{CH}_3)_2\text{N}]_2\text{PCl}$	H; P (158·7)	1965, 12, 18; 1966, 36; 1967, 80
$\text{PC}_4\text{H}_{12}\text{ClN}_2\text{O}$	$[(\text{CH}_3)_2\text{N}]_2\text{P(O)Cl}$	H; P (30)	1965, 18, 23; 1966, 36; 1968, 91, 136
$\text{PC}_4\text{H}_{12}\text{ClN}_2\text{O}_2$	$\text{ClP}[\text{N}(\text{CH}_3)\text{OCH}_3]_2$	H	1969, 103
$\text{PC}_4\text{H}_{12}\text{ClN}_2\text{S}$	$[(\text{CH}_3)_2\text{N}]_2\text{P(S)Cl}$	H	1965, 18, 23; 1966, 36; 1968, 91
$\text{PC}_4\text{H}_{12}\text{Cl}_6\text{O}_3\text{SSb}$	$(\text{CH}_3\text{S})(\text{CH}_3\text{O})_3\text{P}, \text{SbCl}_6$	H; P (53·2)	1969, 87
$\text{PC}_4\text{H}_{12}\text{Cl}_6\text{O}_3\text{Sb}$	$\text{CH}_3(\text{CH}_3\text{O})_3\text{P}, \text{SbCl}_6$	H; P (56)	1967, 69
$\text{PC}_4\text{H}_{12}\text{Cl}_6\text{O}_4\text{Sb}$	$(\text{CH}_3\text{O})_4\text{P}, \text{SbCl}_6$	H; P (51·5)	1967, 69, 308
$\text{PC}_4\text{H}_{12}\text{FN}_2$	$[(\text{CH}_3)_2\text{N}]_2\text{PF}$	H; P (150·8); F (−99·6)	1965, 12; 1966, 36
$\text{PC}_4\text{H}_{12}\text{FN}_2\text{O}$	$[(\text{CH}_3)_2\text{N}]_2\text{P(O)F}$	H; P (23·9); F (−83·6)	1966, 36; 1967, 14, 309
$\text{PC}_4\text{H}_{12}\text{FN}_2\text{O}_2$	$\text{FP}[\text{N}(\text{CH}_3)\text{OCH}_3]_2$	H	1969, 103
$\text{PC}_4\text{H}_{12}\text{FN}_2\text{S}$	$\text{FP(S)}[\text{N}(\text{CH}_3)_2]_2$	H; F (−62·3)	1968, 46
$\text{PC}_4\text{H}_{12}\text{FN}_4\text{O}_4\text{S}_2$	$\text{FP}[\text{N}(\text{CH}_3)_2\text{SO}_2]_2$	H; P (−85·0); F (−88·5)	1968, 125; 1969, 65
$\text{PC}_4\text{H}_{12}\text{F}_3\text{N}_2$	$\text{F}_3\text{P}[\text{N}(\text{CH}_3)_2]_2$	H; F (−55·3; −74·0)	1966, 217
$\text{PC}_4\text{H}_{12}\text{I}$	$(\text{CH}_3)_4\text{PI}$	^{13}C ; P (25·3)	1967, 244; 1968, 3; 1969, 2
$\text{PC}_4\text{H}_{12}\text{N}$	$(\text{CH}_3)_2\text{NP}(\text{CH}_3)_2$	H; P (39)	1965, 14; 1966, 38; 1968, 290; 1969, 72
$\text{PC}_4\text{H}_{12}\text{NO}_2$	$\text{CH}_3(\text{CH}_3\text{O})\text{P(O)N}(\text{CH}_3)_2$	H	1966, 124
$\text{PC}_4\text{H}_{12}\text{NO}_3$	<i>i</i> -C ₃ H ₇ CH(NH ₂)PO ₃ H ₂	P (16·4)	1968, 296
$\text{PC}_4\text{H}_{12}\text{NS}$	$(\text{CH}_3)_2\text{NP(S)}(\text{CH}_3)_2$	H	1966, 36
$\text{PC}_4\text{H}_{12}\text{N}_3\text{O}$	$(\text{CH}_3)_2\text{NP}(\text{NCH}_3)_2\text{CO}$	H; P (93·6)	1968, 126
$\text{PC}_4\text{H}_{13}\text{N}_2$	$(\text{CH}_3)_3\text{CP}(\text{NH}_2)_2$	H	1968, 65
$\text{PC}_4\text{H}_{13}\text{N}_2\text{O}$	$[(\text{CH}_3)_2\text{N}]_2\text{P(O)H}$	H; P (20·5)	1966, 82; 1967, 172

PC ₄ H ₁₄ ClN ₂	(CH ₃) ₂ P[N(CH ₃) ₂]NH ₂ Cl	H; P (54·0)	1967, 65
PC ₄ H ₁₄ N ₃ O	[(CH ₃) ₂ N]P(O)NH ₂	H	1965, 23; 1968, 91
PC ₅ F ₁₅ N ₂	[(CF ₃) ₂ N] ₂ PCF ₃	F (−58·6; −51·5)	1968, 69
PC ₅ H ₆ ClF ₄	CF ₂ =CClCF ₂ PH(C ₂ H ₅)	H; F (−80·0; −89·4)	1967, 295
PC ₅ H ₆ ClF ₄ O ₃	CF ₂ =CClCF ₂ P(O)(OCH ₃) ₂	H; F (−74·8; −77·0; −108·0)	1967, 295
	CF ₃ CCl=CFP(O)(OCH ₃) ₂	H; F (<i>cis</i> −62·0; −98·2 <i>trans</i> −64·0; −106·8)	1968, 98
PC ₅ H ₆ Cl ₃ OS	CH ₃ SCH=CHCCl=CHP(O)Cl ₂	H	1965, 25
PC ₅ H ₆ Cl ₃ O ₂	CH ₃ OCH=CHCCl=CHP(O)Cl ₂	H	1965, 25
PC ₅ H ₇	CH ₃ P(CH=CH) ₂	H; P (−8·6)	1967, 78
PC ₅ H ₇ Cl ₂ O	(CH ₃) ₂ C=C=CHP(O)Cl ₂	H	1966, 127; 1967, 104; 1969, 135
	CH ₂ =CHC(CH ₃)=CHP(O)Cl ₂	H	1965, 86; 1967, 310
	CH ₃ CH=CHCH=CHP(O)Cl ₂	H	1965, 86
PC ₅ H ₇ Cl ₂ S	CH ₂ =CHC(CH ₃)=CHP(S)Cl ₂	H	1965, 86
PC ₅ H ₇ F ₄ O ₂	F ₄ POC(CH ₃)CHC(CH ₃)O	H; F (−53·9; −73·8)	1966, 33
PC ₅ H ₇ F ₆ O ₂	(CH ₃) ₂ POCH(CF ₃) ₂	H; P (62·0)	1968, 302
PC ₅ H ₈ BrO	BrP(O)CH=C(CH ₃)(CH ₂) ₂	H	1964, 8
PC ₅ H ₈ ClO	ClP(O)CH=C(CH ₃)(CH ₂) ₂	H	1964, 8
PC ₅ H ₈ ClO ₂	ClP(O)OC(CH ₃)=C(CH ₃)CH ₂	H	1967, 311
	CH ₃ P(O)OC(CH ₃)=C(Cl)CH ₂	H	1967, 312
PC ₅ H ₈ ClO ₆	(CH ₃ O) ₂ P(O)OCH(COCl)C(O)H	H; P (−2·9)	1969, 337
PC ₅ H ₈ FO	FP(O)CH ₂ CHCH=CHCH ₃	H	1967, 110

Formula	Compound	Resonance	Reference
PC ₅ H ₈ FO	FP(O)CH ₂ CH=C(CH ₃)CH ₂ └──────────┘	H	1967, 110, 303
PC ₅ H ₈ FS	FP(S)CH ₂ CH=C(CH ₃)CH ₂ └──────────┘	H	1967, 110
PC ₅ H ₉	CH ₃ P(CH=CH ₂) ₂	H; P (-41.8)	1967, 78; 1968, 100; 1969, 77
PC ₅ H ₉ Br ₂	CH ₃ P(CH ₂ CHBr) ₂	H; P (-41.5)	1967, 78; 1969, 77
PC ₅ H ₉ ClN ₃ OS	CH ₃ N[C(O)NCH ₃] ₂ P(O)Cl	P (36)	1966, 233
PC ₅ H ₉ ClO ₂ S	Cl ₂ P(O)(CH ₂) ₂ COSC ₂ H ₅	H	1967, 313
PC ₅ H ₉ Cl ₂	CH ₃ P [⊕] Cl(CH=CH ₂) ₂ Cl [⊖]	H; P (112)	1968, 100
PC ₅ H ₉ Cl ₂ O ₃	Cl ₂ P(O)(CH ₂) ₂ COOC ₂ H ₅	H	1967, 313
	ClP(O)(OCH ₂) ₂ C(CH ₃)CH ₂ Cl	H	1968, 149
PC ₅ H ₉ Cl ₃ N ₃ O ₂	CH ₃ N[C(O)NCH ₃] ₂ P [⊕] Cl ₂ , Cl [⊖]	P (50)	1966, 233
PC ₅ H ₉ N ₂ O ₃ S	(CH ₂ O) ₂ P(S)O [⊖] C ₃ H ₅ N ₂ [⊕]	P (154.3)	1969, 177
PC ₅ H ₉ O	CH ₃ P(O)(CH=CH ₂) ₂	H	1968, 100
	CH ₃ P(O)(CH ₂) ₂ CH=CH └──────────┘	H	1968, 100
PC ₅ H ₉ OS ₃	(CH ₃ S) ₂ P(O)SCH ₂ C≡CH	H; P (62.5)	1967, 21
	OP(SCH ₂) ₃ CCH ₃	H	1968, 231
PC ₅ H ₉ O ₂	CH ₃ OP(O)(CH=CH ₂) ₂	H	1964, 8, 15; 1966, 133; 1967, 109
	(CH ₂) ₂ C(CH ₃)=CHPO ₂ H └──────────┘	H	1964, 8
	(CH ₃ O) ₂ P(O)C≡CCH ₃	H	1966, 63
	(CH ₃ O) ₂ P(O)CH ₂ C≡CH	H	1966, 63
	(CH ₃ O) ₂ P(O)CH=C=CH ₂	H	1967, 296
	CH ₃ OP(O)OC(CH ₃)CH ₂ └──────────┘	H	1967, 311

PC ₅ H ₁₀ O ₃	P(OCH ₂) ₃ CCH ₃	H	1966, 37; 1968, 85, 209
PC ₅ H ₉ O ₃ S	P(CH ₂ O) ₃ C(CH ₃)	H	1968, 53
	(CH ₃ O) ₂ P(O)SCH ₂ C≡CH	H; P (27·6)	1967, 21
	SP(CH ₂ O) ₃ CCH ₃	H	1968, 53
	SP(OCH ₂) ₃ CCH ₃	H	1968, 85
PC ₅ H ₉ O ₄	OP(OCH ₂) ₃ CCH ₃	H	1966, 37
	OP(CH ₂ O) ₃ CCH ₃	H	1968, 53
	CH ₃ OP(O)O(CCH ₃) ₂ O	H; P (11·5)	1967, 86; 1968, 73, 85
PC ₅ H ₉ S	(CH ₃) ₂ P(S)C≡CCH ₃	H	1965, 89
PC ₅ H ₉ S ₃	P(SCH ₂) ₃ CCH ₃	H	1968, 85
PC ₅ H ₉ S ₄	SP(SCH ₂) ₃ CCH ₃	H	1968, 85
	(CH ₃ S) ₂ P(S)SCH ₂ C≡CH	H; P (95)	1967, 21
PC ₅ H ₁₀ Ba _{1/2} O ₄	CH ₃ OP(O)(OBa _{1/2})OCH(CH ₃)COCH ₃	H	1967, 181
PC ₅ H ₁₀ BrO ₂ S	(CH ₃) ₂ C(CH ₂ O) ₂ P(O)Br	H	1969, 95
PC ₅ H ₁₀ BrO ₄	(CH ₃ O) ₂ P(O)OC(CH ₂ Br)=CH ₂	H	1969, 127
	(CH ₃ O) ₂ P(O)OC(CH ₃)=CHBr	H	1969, 127
PC ₅ H ₁₀ ClO ₂	(CH ₃) ₂ C(CH ₂ O) ₂ PCl	H; P (146·5)	1968, 80
	CH ₂ (CH ₃ CHO) ₂ PCl	H	1969, 88
PC ₅ H ₁₀ ClO ₂ S	(CH ₃) ₂ C(CH ₂ O) ₂ P(S)Cl	H	1967, 91; 1968, 74; 1969, 95
PC ₅ H ₁₀ ClO ₃	(CH ₃) ₂ C(CH ₂ O) ₂ P(O)Cl	H	1967, 91; 1968, 74; 1969, 95
	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH=CHCl	H; P (24)	1967, 108
PC ₅ H ₁₀ ClO ₃ S	(CH ₃ O) ₂ P(O)SC(CH ₃)=CHCl	H	1966, 74
	(CH ₃ O) ₂ P(O)SC(CH ₂ Cl)=CH ₂	H	1966, 74
PC ₅ H ₁₀ ClO ₄	Cl(CH ₃ O)P(O)(CH ₂) ₂ COOCH ₃	H	1967, 313
PC ₅ H ₁₀ Cl ₃ N ₂ O	CCl ₃ P(O)[N(CH ₃)CH ₂] ₂	H	1967, 314
PC ₅ H ₁₀ Cl ₃ O ₃	CCl ₃ P(O)(OC ₂ H ₅) ₂	P (6·5)	1966, 234
PC ₅ H ₁₀ FO ₂	(CH ₃) ₂ C(CH ₂ O) ₂ PF	H; P (132·9)	1968, 80
PC ₅ H ₁₀ F ₂ N	C ₅ H ₁₀ NPF ₂	H; P (140·5); F (-66·4)	1966, 230; 1967, 48

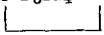
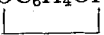
Formula	Compound	Resonance	Reference
PC ₅ H ₁₀ NO ₃	(CH ₃ O) ₂ P(O)(CH ₂) ₂ CN	H; P (29·1)	1969, 81
PC ₅ H ₁₀ N ₃ O ₄	CH ₃ N[C(O)NCH ₃] ₂ P(O)OH	P(0)	1966, 233
PC ₅ H ₁₁	C ₅ H ₁₀ PH	H	1969, 142
PC ₅ H ₁₁ Cl ₂ O	<i>t</i> -C ₅ H ₁₁ P(O)Cl ₂	H	1966, 231
PC ₅ H ₁₁ Cl ₂ O ₂	<i>i</i> -C ₅ H ₇ OP(O)(CH ₂ Cl) ₂	H; P (37·3)	1969, 332
PC ₅ H ₁₁ F ₂ O	C ₅ H ₁₁ OPF ₂	F (−50·4)	1969, 61
PC ₅ H ₁₁ NNaO ₄	(C ₂ H ₅ O) ₂ P(O)N [−] CHO, Na ⁺	H	1966, 235
PC ₅ H ₁₁ O	(CH ₃) ₂ P(O)C(CH ₃)=CH ₂	H	1966, 119
PC ₅ H ₁₁ O ₂	CH ₃ (CH ₃ O)P(O)CH ₂ CH=CH ₂	P (31·5)	1967, 21
	CH ₃ OPOCH ₂ C(CH ₃) ₂ O	H	1969, 93
	C ₅ H ₁₀ PO ₂ H	H	1969, 142
PC ₅ H ₁₁ O ₂ S	(CH ₃) ₂ C(CH ₂ O) ₂ P(S)H	H	1967, 91
PC ₅ H ₁₁ O ₂ S ₂	(CH ₃) ₂ C(CH ₂ O) ₂ P(S)SH	H	1967, 91
PC ₅ H ₁₁ O ₃	CH ₃ OPO(CH ₂) ₂ CH(CH ₃)O	H, {P}; P (301·4; 292·8) (stereois.)	1964, 14; 1969, 176
	CH ₃ OP(OCH ₂) ₂ CHCH ₃	H	1966, 46
	(CH ₃) ₂ C(CH ₂ O) ₂ P(O)H	H	1967, 91
	(CH ₃ O) ₂ P(O)CH ₂ CH=CH ₂	H; P (27·5)	1967, 21, 108
	CH ₃ (CH ₃ O)P(O)OCH ₂ CH=CH ₂	H	1967, 21
	CH ₃ OP[OCH(CH ₃)] ₂	H; P (<i>meso</i> : 135; 150; <i>dl</i> : 140)	1969, 94
PC ₅ H ₁₁ O ₃ S	CH ₃ OP(S)O(CH ₂) ₂ (CH ₃)O	H; P	1969, 176
PC ₅ H ₁₁ O ₄	CH ₃ OP(O)(OCH ₂) ₂ CHCH ₃	H	1966, 46
	C ₂ H ₅ O(H)P(O)CH ₂ COOCH ₃	H	1968, 297
	(CH ₃) ₂ C(CH ₂ O) ₂ PO ₂ H	H	1969, 95
	(CH ₃ O) ₂ P(O)OCH=CHCH ₃	H	1969, 127
	(CH ₃ O) ₂ P(O)OC(CH ₃)=CH ₂	H	1969, 127
	CH ₃ OP(O)[OCH(CH ₃)] ₂	H; P (<i>meso</i> : 15; 17; <i>dl</i> : 141)	1969, 94

PC ₅ H ₁₁ O ₅	(CH ₃ O) ₂ P(O)CH ₂ COOCH ₃ (CH ₃ O) ₃ P(OCH) ₂	H {P} H; P (-44.2)	1966, 236 1969, 337
PC ₅ H ₁₂ Ba _{1/2} O ₅	CH ₃ CH(OH)CH ₂ OP(O)(O [⊖])(OC ₂ H ₅), Ba _{1/2} [⊕]	H	1965, 88
PC ₅ H ₁₂ Ba _{1/2} O ₂	CH ₃ CH(OH)CH ₂ OP(O)(O [⊖])(O(CH ₂) ₂ OH), Ba _{1/2} [⊕]	H	1965, 88
PC ₅ H ₁₂ BrS	CH ₃ (<i>t</i> -C ₄ H ₉)P(S)Br	H; P (103.1)	1968, 2
PC ₅ H ₁₂ ClN ₂ O	CH ₂ ClP(O)N(CH ₃)(CH ₂) ₂ NCH ₃	H	1967, 314
PC ₅ H ₁₂ ClO ₃	(C ₂ H ₅ O) ₂ P(O)CH ₂ Cl	H; P (21)	1966, 234; 1967, 69; 1968, 56
PC ₅ H ₁₂ ClO ₃ S	(CH ₃ O) ₂ P(O)SCH(CH ₃)CH ₂ Cl (CH ₃ O) ₂ P(O)SCH ₂ CH(Cl)CH ₃	H H	1966, 74 1966, 74
PC ₅ H ₁₂ ClS	CH ₃ P(S)(C ₄ H ₉)Cl	P (153)	1969, 335
PC ₅ H ₁₂ Cl ₂ N	CH ₂ ClP(Cl)[N(C ₂ H ₅) ₂]	H	1968, 59
PC ₅ H ₁₂ Cl ₂ NO	CH ₂ ClP(O)Cl[N(C ₂ H ₅) ₂]	H {P}	1967, 77
PC ₅ H ₁₂ FN ₄ O ₃ S	FP[(NCH ₃) ₂ SO ₂][(NCH ₃) ₂ CO]	H; P (-67); F (-102.8)	1968, 125; 1969, 65
PC ₅ H ₁₂ FO	CH ₃ (C ₄ H ₉)P(O)F CH ₃ (<i>i</i> -C ₄ H ₉ O)PF	P (65.2); F (-75) P (216); F (-103)	1967, 14 1968, 12
PC ₅ H ₁₂ FOS	C ₂ H ₅ (<i>i</i> -C ₃ H ₇ S)P(O)F C ₂ H ₅ (C ₃ H ₇ S)P(O)F <i>i</i> -C ₃ H ₇ (C ₂ H ₅ S)P(O)F	P (65.3); F (-49.5) P (67.4); F (-54) P (74.0)	1967, 13, 14; 1968, 295 1967, 14 1967, 14
PC ₅ H ₁₂ FO ₂	<i>t</i> -C ₄ H ₉ P(O)F(OCH ₃) C ₂ H ₅ (C ₃ H ₇ O)P(O)F C ₂ H ₅ (<i>i</i> -C ₃ H ₇ O)P(O)F	H; P (36.6); F (-82.0) F (-68.6) P (32.2); F (-66.4)	1965, 8; 1966, 36 1967, 13 1967, 13, 14; 1968, 295
PC ₅ H ₁₂ FS	CH ₃ (C ₄ H ₉ S)PF	P (214); F (-151)	1968, 12
PC ₅ H ₁₂ IO ₃	CH ₂ IP(O)(OC ₂ H ₅) ₂	H	1968, 56
PC ₅ H ₁₂ Li	(C ₂ H ₅) ₂ (LiCH ₂)P=CH ₂	H	1968, 106
PC ₅ H ₁₂ NO ₂	(CH ₃) ₂ NP(OCH ₂) ₂ CH ₂	P (143.4)	1968, 301
PC ₅ H ₁₂ NO ₃	(CH ₂ O) ₂ P[NHCH ₂ CH(CH ₃)O]H	H; P (-39.5)	1967, 164; 1969, 45
	O(CH ₂) ₄ NCH ₂ PO ₂ H ₂	P (8.7)	1967, 301

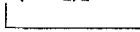
Formula	Compound	Resonance	Reference
PC ₅ H ₁₂ NO ₃	(CH ₂ O) ₂ PO(CH ₂) ₂ NHCH ₃ (CH ₂ O) ₂ P[N(CH ₃)(CH ₂) ₂ O]H	P (135) H; P (-44)	1967, 165 1967, 165
PC ₅ H ₁₂ NO ₃ S ₂	(CH ₃ O) ₂ P(S)SCH ₂ C(O)NHCH ₃	H	1968, 283 to 285
PC ₅ H ₁₂ NO ₄	(C ₂ H ₅ O) ₂ P(O)NHCHO (CH ₃ O) ₂ P(O)C(O)NHC ₂ H ₅	H H	1966, 235 1967, 26
PC ₅ H ₁₂ NO ₄ S	(CH ₃ O) ₂ P(O)SCH ₂ C(O)NHCH ₃	H	1968, 285
PC ₅ H ₁₂ N ₃ O	(CH ₃) ₂ NP(NCH ₃) ₂ CO	H; P (93.6)	1969, 109
PC ₅ H ₁₂ O	(CH ₃) ₃ P ⁺ C(O)CH ₃	H	1968, 307
PC ₅ H ₁₃	CH ₃ P(C ₂ H ₅) ₂ CH ₃ P(C ₄ H ₉)H (CH ₃) ₂ (C ₂ H ₅)P=CH ₂	P (-34) P (-86) H(T)	1965, 3 1965, 3 1968, 105 to 107, 305
PC ₅ H ₁₃ ClLi	(CH ₃) ₂ (C ₂ H ₅)P=CH ₂ , LiCl	H	1968, 106, 107
PC ₅ H ₁₃ ClN	<i>i</i> -C ₃ H ₇ PCl[N(CH ₃) ₂] <i>t</i> -C ₄ H ₉ NHP(CH ₃)Cl	H H	1969, 107 1969, 112
PC ₅ H ₁₃ ClNO	<i>i</i> -C ₃ H ₇ P(O)[N(CH ₃) ₂]Cl	H{P}, (T)	1967, 77
PC ₅ H ₁₃ CINS	<i>i</i> -C ₃ H ₇ P(S)[N(CH ₃) ₂]Cl	H{P}	1967, 77
PC ₅ H ₁₃ FN	CH ₃ P[N(C ₂ H ₅) ₂]F	P (165); F (-101 or -112)	1967, 37; 1968, 12
PC ₅ H ₁₃ FNO	CH ₃ P(O)[N(C ₂ H ₅) ₂]F <i>i</i> -C ₃ H ₇ P(O)[N(CH ₃) ₂]F	P (37.2); F (-55) H{P}	1967, 13, 14; 1968, 295 1967, 77
PC ₅ H ₁₃ F ₂ O	CH ₃ P(O <i>i</i> -C ₄ H ₉)HF ₂	P (-22.5)	1967, 38
PC ₅ H ₁₃ F ₃ N	(C ₂ H ₅) ₂ N(CH ₃)PF ₃ <i>i</i> -C ₄ H ₉ NH(CH ₃)PF ₃ C ₄ H ₉ NH(CH ₃)PF ₃	F (-72; -39) F (-75; -42; -30) F (-73; -42; -30)	1967, 64 1967, 64 1967, 64
PC ₅ H ₁₃ N ₂ O	CH ₃ OP[N(CH ₃)CH ₂] ₂	P (123.2)	1966, 224; 1968, 153
PC ₅ H ₁₃ OS	(CH ₃) ₂ P(O)SC ₃ H ₇ CH ₃ (<i>t</i> -C ₄ H ₉)P(S)OH	P (52.7) H	1967, 9 1968, 2
PC ₅ H ₁₃ O ₂	(C ₂ H ₅) ₂ P(O)OCH ₃ CH ₃ P(O)(O <i>s</i> -C ₄ H ₉)H	H P	1968, 65 1969, 162

PC ₅ H ₁₃ O ₂ S	CH ₃ P(S)(OC ₄ H ₉)OH	H	1967, 72
PC ₅ H ₁₃ O ₃	(CH ₃ O)(<i>t</i> -C ₄ H ₉ O)P(O)H	P (3·2)	1967, 293
	(C ₂ H ₅ O) ₂ PCH ₃	H	1968, 72
PC ₅ H ₁₃ O ₃ S	(C ₂ H ₅ O) ₂ P(O)SCH ₃	H	1966, 133
PC ₅ H ₁₃ O ₄	(CH ₃ O) ₂ P(O)(CH ₂) ₂ OCH ₃	H; P (32·9)	1969, 81
PC ₅ H ₁₃ S	CH ₃ (<i>t</i> -C ₄ H ₉)P(S)H	H; P (36·2)	1968, 2
PC ₅ H ₁₃ S ₂	CH ₃ (<i>t</i> -C ₄ H ₉)P(S)SH	H; P (79·0)	1968, 2
PC ₅ H ₁₄ Br	(CH ₃) ₃ (C ₂ H ₅)PBr	P (28·0)	1966, 5; 1968, 6
PC ₅ H ₁₄ Cl	(CH ₃) ₃ (C ₂ H ₅)PCl	H	1968, 107
PC ₅ H ₁₄ Cl ₆ OSb	(CH ₃) ₂ (CH ₃ O)(C ₂ H ₅ O)P, SbCl ₆	H; P	1967, 308
PC ₅ H ₁₄ I ₅	(CH ₃) ₃ P [⊕] CH ₂ SCH ₃ I [⊖]	H	1969, 128
PC ₅ H ₁₄ Li ₂ NO ₄	CO(CHCH) ₂ NPO ₃ Li ₂	H	1969, 338
PC ₅ H ₁₄ NO ₂	(C ₂ H ₅) ₂ NCH ₂ PO ₂ H ₂	P (16·6)	1967, 301
PC ₅ H ₁₄ NO ₃	(C ₂ H ₅) ₂ NCH ₂ PO ₃ H ₂	H; P (6·1)	1967, 291, 301, 315
	<i>s</i> -C ₄ H ₉ CH(NH ₂)PO ₃ H ₂	P (18·1)	1968, 296
PC ₅ H ₁₄ N ₃	CH ₃ NHP[N(CH ₃)CH ₂] ₂	H	1967, 305
PC ₅ H ₁₅ ClN	(CH ₃) ₃ P [⊕] N(CH ₃) ₂ , Cl [⊖]	H	1968, 54
PC ₅ H ₁₅ FN ₂	CH ₃ P [⊕] (N(CH ₃) ₂) ₂ F [⊖]	P (71·4); F (−82·3)	1965, 12
PC ₅ H ₁₅ F ₂ N ₂ O	[(CH ₃) ₂ N] ₂ P(OCH ₃)F ₂	F (−55·5)	1967, 61
PC ₅ H ₁₅ IN	(CH ₃) ₂ NP [⊕] (CH ₃) ₃ , I [⊖]	H	1965, 18
PC ₅ H ₁₅ N ₂	[(CH ₃) ₂ N] ₂ PCH ₃	H	1965, 18; 1968, 290
PC ₅ H ₁₅ O ₂ Sn	(CH ₃) ₂ P(O)OSn(CH ₃) ₃	P(H)	1969, 140
PC ₅ H ₁₅ N ₄ Si	(CH ₃) ₃ PNSi(CH ₃) ₂ N ₃	H	1967, 316
PC ₅ H ₁₇ ClN ₃	(CH ₃)P[N(CH ₃) ₂] ₂ NH ₂ Cl	H; P (53·0)	1967, 65
PC ₆ Br ₂ F ₅	C ₆ F ₅ PBr ₂	P (113·5)	1966, 7
PC ₆ Cl ₂ F ₅	C ₆ F ₅ PCl ₂	P (−137); F (−130; −160; −145)	1969, 17
PC ₆ F ₇	C ₆ F ₅ PF ₂	F (−140·1; −163·5; −148·8)	1966, 19
PC ₆ F ₇ O	C ₆ F ₅ P(O)F ₂	F (−128·7; −157·6; −140·2)	1969, 17
PC ₆ F ₉	(CF ₂ =CF) ₃ P	F (−82·6; −106·3; −175·9)	1969, 55

Formula	Compound	Resonance	Reference
PC_6F_{17}	$(\text{C}_3\text{F}_7)_2\text{PF}_3$	F (−80·7; −122·6; −122·8; −51·0)	1969, 66
$\text{PC}_6\text{F}_{18}\text{N}_3$	$[(\text{CF}_3)_2\text{N}]_3\text{P}$	F (−49·6)	1968, 69
$\text{PC}_6\text{H}_2\text{Cl}_5\text{OS}$	$\text{C}_6\text{Cl}_3\text{H}_2\text{OP}(\text{S})\text{Cl}_2$	H	1967, 116
$\text{PC}_6\text{H}_2\text{F}_5$	$\text{C}_6\text{F}_5\text{PH}_2$	H; P (−183·1); F (−130·1; −163·0; −155·1)	1966, 7, 19; 1967, 11
$\text{PC}_6\text{H}_2\text{F}_5\text{O}_2$	$\text{C}_6\text{F}_5\text{PO}_2\text{H}_2$	H	1966, 237
$\text{PC}_6\text{H}_4\text{BrCl}_2\text{O}_2$	$\text{OC}_6\text{H}_7\text{OPBrCl}_2$ []	P (−75·8)	1966, 238
$\text{PC}_6\text{H}_4\text{BrO}_2$	$\text{OC}_6\text{H}_4\text{OPBr}$ []	P (195·6)	1966, 238; 1967, 277
$\text{PC}_6\text{H}_4\text{BrO}_2\text{S}$	$\text{OC}_6\text{H}_4\text{OP}(\text{S})\text{Br}$ []	P (55·1)	1966, 238; 1967, 277
$\text{PC}_6\text{H}_4\text{BrO}_3$	$\text{OC}_6\text{H}_4\text{OP}(\text{O})\text{Br}$ []	P (3·6)	1966, 238; 1967, 277
$\text{PC}_6\text{H}_4\text{Br}_2\text{ClO}_2$	$\text{C}_6\text{H}_4\text{BrPO}^{2\ominus}$ $\text{OC}_6\text{H}_4\text{OPBrCl}$ []	P (8·8) P (−131)	1967, 7 1966, 238; 1969, 45
$\text{PC}_6\text{H}_4\text{Br}_3$	$\text{C}_6\text{H}_4\text{BrPBr}_2$	P (147)	1968, 100
$\text{PC}_6\text{H}_4\text{Br}_3\text{O}_2$	$\text{OC}_6\text{H}_4\text{OPBr}_3$ []	P (−189·0)	1966, 238; 1969, 45
$\text{PC}_6\text{H}_4\text{ClF}_2$	$\text{C}_6\text{H}_4\text{ClPF}_2$	P (196·8)	1967, 51, 52, 290
$\text{PC}_6\text{H}_4\text{ClO}_2$	$\text{OC}_6\text{H}_4\text{OPCl}$ []	P (173)	1967, 235, 277, 290; 1969, 45
$\text{PC}_6\text{H}_4\text{ClO}_2\text{S}$	$\text{OC}_6\text{H}_4\text{OP}(\text{S})\text{Cl}$ []	P (76·5)	1966, 238; 1967, 277
$\text{PC}_6\text{H}_4\text{ClO}_3$	$\text{OC}_6\text{H}_4\text{OP}(\text{O})\text{Cl}$ []	P (18·0)	1966, 238; 1967, 277
$\text{PC}_6\text{H}_4\text{ClO}_3$	$\text{C}_6\text{H}_4\text{ClPO}_3^{2\ominus}$	P (9·9)	1967, 7

PC ₆ H ₄ ClO ₃ S	(CH ₃ O) ₂ P(O)SCH ₂ C(CH ₃) ₂ Cl	H	1966, 74
PC ₆ H ₄ Cl ₂ F	(CH ₃ O) ₂ P(O)SC(CH ₃) ₂ CH ₂ Cl	H	1966, 74
	<i>p</i> -FC ₆ H ₄ PCl ₂	H; P (159); F (−106·3)	1967, 17; 1968, 14; 1969, 18, 120
	<i>m</i> -FC ₆ H ₄ PCl ₂	P (152); F (−120·3)	1969, 19, 120
PC ₆ H ₄ Cl ₂ FO	<i>m</i> - and <i>p</i> -FC ₆ H ₄ P(O)Cl ₂	F	1967, 17; 1969, 18, 19
PC ₆ H ₄ Cl ₂ FS	<i>m</i> - and <i>p</i> -FC ₆ H ₄ P(S)Cl ₂	F	1967, 17; 1969, 18, 19
PC ₆ H ₄ Cl ₃	<i>m</i> - and <i>p</i> -ClC ₆ H ₄ PCl	P (158·4)	1967, 114
	<i>o</i> -ClC ₆ H ₄ PCl ₂	P (151·9)	1967, 114
PC ₆ H ₄ Cl ₃ O ₂	OC ₆ H ₄ OPCl ₃	P (−26)	1965, 45; 1966, 238, 239
			
PC ₆ H ₄ Cl ₃ S	<i>p</i> -ClC ₆ H ₄ P(S)Cl ₂	P (71·4)	1966, 114
PC ₆ H ₄ FO ₂	OC ₆ H ₄ OPF	P (123·1)	1967, 235
			
PC ₆ H ₄ F ₃	FC ₆ H ₄ PF ₂	F	1968, 14
PC ₆ H ₄ F ₅	FC ₆ H ₄ PF ₄	F	1968, 14
PC ₆ H ₄ IO ₃	IC ₆ H ₄ PO ₃ ^{2−}	P (10·1)	1967, 7
PC ₆ H ₅ Br ₂	C ₆ H ₅ PBr ₂	P (151·8)	1968, 100
PC ₆ H ₅ ClF	C ₆ H ₅ PClF	F (−74)	1967, 37
PC ₆ H ₅ ClFO	C ₆ H ₅ P(O)ClF	P; F	1968, 45
PC ₆ H ₅ ClFOS	C ₆ H ₅ SP(O)ClF	H; P (84·8); F (−2·2)	1968, 308
PC ₆ H ₅ Cl ₂	C ₆ H ₅ PCl ₂	¹³ C; H; P (166 or 161)	1965, 7; 1966, 21, 240; 1967, 198, 235, 277; 1968, 103; 1969, 50, 120
PC ₆ H ₅ Cl ₂ O	C ₆ H ₅ P(O)Cl ₂	¹³ C; H; P (34)	1965, 7; 1966, 240; 1967, 186, 198, 277; 1968, 45, 103
PC ₆ H ₅ Cl ₂ O ₂	C ₆ H ₅ OP(O)Cl ₂	P (1·5)	1965, 45; 1966, 239
PC ₆ H ₅ Cl ₂ S	C ₆ H ₅ P(S)Cl ₂	¹³ C; P (74·6)	1965, 7; 1966, 111, 114, 240; 1967, 256
PC ₆ H ₅ Cl ₄	C ₆ H ₅ PCl ₄	P (−39·3)	1968, 168, 288

Formula	Compound	Resonance	Reference
PC ₆ H ₅ Cl ₄ O ₄	C ₆ H ₅ P [⊕] Cl ₃ , ClO ₄ [⊖]	P (103·0)	1967, 276
PC ₆ H ₅ Cl ₉ Sb	C ₆ H ₅ P [⊕] Cl ₃ , SbCl ₆ [⊖]	P (102·9)	1967, 276
PC ₆ H ₅ F ₂	C ₆ H ₅ PF ₂	P (205–208); F (–92–97)	1967, 51, 52, 235, 290
PC ₆ H ₅ F ₂ O	C ₆ H ₅ P(O)F ₂	P (11·4); F (–65·3)	1965, 12; 1967, 14; 1968, 45
	C ₆ H ₅ OPF ₂	F (–44·5)	1963, 3
PC ₆ H ₅ F ₂ OS	C ₆ H ₅ SP(O)F ₂	H; P (11·9); F (–49·2)	1968, 308
PC ₆ H ₅ F ₂ O ₂	C ₆ H ₅ OP(O)F ₂	P (–27·1)	1967, 14
PC ₆ H ₅ F ₄ S	C ₆ H ₅ SPF ₄	P (–38·3); F (–13·9; –16·9; –65·0)	1968, 291; 1969, 62
PC ₆ H ₅ F ₅	C ₆ H ₅ PF ₅ [⊖]	P (–136·0)	1965, 12
PC ₆ H ₅ O ₃	C ₆ H ₅ PO ₃ ^{2⊖}	P (10·9)	1967, 7
PC ₆ H ₆ Cl ₂ NO ₃ S	C ₆ H ₅ SO ₂ NHP(O)Cl ₂	P	1967, 286
PC ₆ H ₆ F	<i>m</i> - and <i>p</i> -FC ₆ H ₄ PH ₂	F	1967, 17; 1968, 14; 1969, 18, 87
PC ₆ H ₆ F ₆ N	(CF ₂ =CF) ₂ PN(CH ₃) ₂	H; F (–89·0; –110·0; –179·3)	1969, 55
PC ₆ H ₆ NO ₃	<i>p</i> -NH ₂ C ₆ H ₄ PO ₃ ^{2⊖}	P (11·8)	1967, 7; 1969, 119
PC ₆ H ₇	C ₆ H ₅ PH ₂	H; P (–119 or –124)	1966, 4, 18, 21; 1967, 11, 30; 1969, 41
PC ₆ H ₇ Cl ₂ O ₄ S	C ₆ H ₅ P [⊕] HCl ₂ , HSO ₄ [⊖]	P (41)	1969, 50
PC ₆ H ₇ F ₂ N ₂ S	C ₆ H ₅ (NH) ₂ P(S)F ₂	P (65·3); F (–54·3)	1967, 317
PC ₆ H ₇ OS ₂	C ₆ H ₅ P(O)(SH) ₂	P (40·2)	1967, 277
PC ₆ H ₇ O ₂	C ₆ H ₅ PO ₂ H ₂	H	1966, 18
PC ₆ H ₇ O ₂ S	C ₆ H ₅ P(S)(OH) ₂	P (14·6)	1967, 277
PC ₆ H ₇ O ₃	C ₆ H ₅ P(O)(OH) ₂	H; P	1965, 79; 1967, 186
PC ₆ H ₇ S ₃	C ₆ H ₅ P(S)(SH) ₂	P (60·2)	1967, 277
PC ₆ H ₈ FS ₂	CH ₃ (C ₂ H ₅ S)P(S)F	H	1966, 36

PC ₆ H ₈ F ₃ O ₆	(CH ₃ O) ₂ P(O)OCH(COCF ₃)C(O)H	H; P (-3.2)	1969, 337
PC ₆ H ₈ N	(CH ₃) ₂ NP(C≡CH) ₂	H	1967, 106
PC ₆ H ₈ NO	(CH ₃) ₂ NP(O)(C≡CH) ₂	H	1967, 106
PC ₆ H ₉	P(CH=CH ₂) ₃	H; P (-20.7)	1966, 241; 1967, 99; 1969, 172
PC ₆ H ₉ BCl ₂ F ₆ N	(CF ₃) ₂ PN(<i>t</i> -C ₄ H ₉)BCl ₂	¹¹ B; H; P	1968, 24
PC ₆ H ₉ N ₂	HP[(CH ₂) ₃ CN] ₂	P (-75)	1966, 4
PC ₆ H ₉ N ₂ O ₇	(CH ₃ O) ₂ P(O)OCH[C(O)NH] ₂ CO	H; P (1.3)	1966, 242
PC ₆ H ₉ N ₂ S	C ₆ H ₅ P(S)(NH ₂) ₂	H	1967, 318
PC ₆ H ₉ O ₂ S	C ₂ H ₅ P(O)(H)- 	H	1969, 74
PC ₆ H ₉ O ₃	(CH ₃ O) ₂ P(O)C≡CCH=CH ₂ P(OCH) ₃ (CH ₂) ₃ C ₆ H ₅ PO ₃ ²⁻ (CH ₂ O) ₂ POC ₂ H ₅	H H; P (137) P (17.6) P (135)	1965, 86 1966, 37; 1967, 218 1967, 7 1969, 109
PC ₆ H ₉ O ₃ S	(CH ₃ O) ₂ P(O)- 	H	1966, 130; 1969, 123
PC ₆ H ₉ O ₄	OP(OCH) ₃ (CH ₂) ₃ (CH ₃ O) ₂ P(O)- 	H H	1966, 37 1969, 123
PC ₆ H ₉ S	(CH ₃) ₂ P(S)C≡CCH=CH ₂	H	1965, 89
PC ₆ H ₁₀ BrO	BrP(O)[CH ₂ C(CH ₃) ₂] ₂	H	1964, 16
PC ₆ H ₁₀ BrO ₃	(C ₂ H ₅ O) ₂ P(O)C≡CBr	H	1967, 319
PC ₆ H ₁₀ Br ₃	C ₆ H ₁₀ BrPBr ₂ (isom.)	P (185; 202)	1966, 222
PC ₆ H ₁₀ ClN ₄ O ₃	ClP(O)[N(CH ₂) ₂ NHCO] ₂ 	H	1961, 32

Formula	Compound	Resonance	Reference
PC ₆ H ₁₀ ClO	CIP(O)CH=C(CH ₃)CH(CH ₃)CH ₂ └──────────────────┘	H	1964, 8, 16; 1969, 339
PC ₆ H ₁₀ ClO ₂	CIP(O)OC(CH ₃)=CHC(CH ₃) ₂ └──────────┘	H	1967, 311
PC ₆ H ₁₀ ClO ₃	(C ₂ H ₅ O) ₂ P(O)C≡CCl	H	1965, 90
	CIP(O)[OC(CH ₃)=CH ₂] ₂	H	1968, 297
PC ₆ H ₁₀ Cl ₃	C ₆ H ₁₀ ClPCL ₂ (isom.)	P (187; 199)	1966, 222
PC ₆ H ₁₀ Cl ₃ O ₃	(CH ₃) ₂ C(CH ₂ O) ₂ P(O)CCl ₃	H	1967, 91; 1968, 74
PC ₆ H ₁₀ Cl ₃ O ₅	(CH ₃ O) ₂ P(O)CH(CCl ₃)OC(O)CH ₃	H; P (11·4)	1967, 3
	(CH ₂ O) ₄ PCH(OH)CCl ₃	H; P (-18)	1968, 154
PC ₆ H ₁₀ FO	FP(O)[CH ₂ C(CH ₃)] ₂	H	1967, 110
PC ₆ H ₁₀ F ₆ N	(CF ₃) ₂ PNH- <i>t</i> -C ₄ H ₉	H(T)	1968, 144
PC ₆ H ₁₀ NaO ₂	NaOP(O)[CH ₂ C(CH ₃)] ₂	H	1966, 66
PC ₆ H ₁₁	(C ₂ H ₅) ₂ PC≡CH	H	1966, 243; 1967, 20
	CH ₃ PCH ₂ CH=C(CH ₃)CH ₂ └──────────┘	H	1968, 100
	C ₂ H ₅ P(CH=CH ₂) ₂	P (-20·8)	1969, 77
PC ₆ H ₁₁ CIN ₃	C ₆ H ₅ P(NH ₂) ₃ Cl	H; P (29·4)	1967, 65
PC ₆ H ₁₁ Cl ₂ S	C ₆ H ₁₁ P(S)Cl ₂	P (101·8)	1966, 114
PC ₆ H ₁₁ FNO ₃	CH ₂ FP(O)(OH)O [⊖] C ₆ H ₅ NH ₅ [⊕]	H; F	1967, 320
PC ₆ H ₁₁ N ₂ O ₃ S	OCH ₂ CH(CH ₃)OP(S)O [⊖] , C ₃ H ₅ N ₂ [⊕] └──────────┘	H; P (160)	1969, 177
PC ₆ H ₁₁ O	(C ₂ H ₅) ₂ P(O)C≡CH	H	1967, 20
	CH ₃ P[(CH ₂) ₂] ₂ CO	H	1967, 75
	CH ₃ P(O)CH ₂ CH=C(CH ₃)CH ₂ └──────────┘	H	1968, 100
	CH ₃ P(O)(CH ₂) ₂ C(CH ₃)=CH └──────────┘	H	1968, 100

$\text{PC}_6\text{H}_{11}\text{O}_2$	$\text{CH}_3\text{OP}(\text{O})\text{CH}_2\text{C}(\text{CH}_3)=\text{CHCH}_2$	H	1964, 8, 15; 1968, 100
	$\text{C}_2\text{H}_5\text{OP}(\text{O})(\text{CH}_2\text{CH}_2)$	H; P (68)	1964, 8, 15; 1966, 133, 241; 1969, 146
	$\text{HOP}(\text{O})\text{CH}_2\text{CH}(\text{CH}_3)\text{C}(\text{CH}_3)=\text{CH}$	H	1964, 8, 16
	$\text{HOP}(\text{O})[\text{CH}_2\text{C}(\text{CH}_3)]_2$	H	1964, 16; 1966, 66; 1969, 339
	$\text{CH}_3\text{OP}(\text{O})(\text{CH}_2)_2\text{C}(\text{CH}_3)=\text{CH}$	H	1968, 100
$\text{PC}_6\text{H}_{11}\text{O}_3$	$\text{C}_2\text{H}_5\text{OP}(\text{O})(\text{CH}_2)_2\text{CH}=\text{CH}$	P (69)	1969, 146
	$(\text{CH}_2)_4\text{CH}=\text{CPO}_3\text{H}_2$	H; P (12-3)	1966, 241
	$\text{P}(\text{OCH}_2)_3\text{CC}_2\text{H}_5$	P (92)	1967, 218; 1968, 209
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{C}\equiv\text{CH}$	H; P (-10)	1967, 21, 319
	$\text{CH}_3\text{OP}(\text{O})\text{O}[\text{C}(\text{CH}_3)]_2\text{CH}_2$	H	1967, 311
$\text{PC}_6\text{H}_{11}\text{O}_4$	$\text{C}_6\text{H}_{11}\text{PO}_3^{2-}$	P (24-8)	1967, 7
	$\text{HP}(\text{O})\text{OCHCH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}(\text{O})\text{CH}_2$	H	1966, 102; 1968, 117
$\text{PC}_6\text{H}_{11}\text{O}_6$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{OCH}(\text{COCH}_3)\text{C}(\text{O})\text{H}$	H; P (-2-6)	1969, 337
$\text{PC}_6\text{H}_{12}\text{BrO}_5$	$(\text{CH}_3\text{O})_2\text{PCBr}(\text{CH}_3)\text{COCH}_3$	H; P (-5-5)	1968, 309
$\text{PC}_6\text{H}_{12}\text{Cl}$	$(\text{CH}_3)_2\text{P}^+(\text{CH}_2\text{CH})_2, \text{Cl}^-$	H	1968, 61
$\text{PC}_6\text{H}_{12}\text{ClN}_2\text{O}_2$	$[\text{NCH}(\text{CH}_3)]_2\text{P}(\text{O})\text{O}(\text{CH}_2)_2\text{Cl}$	H	1966, 220
$\text{PC}_6\text{H}_{12}\text{ClO}_2$	$[(\text{CH}_3)_2\text{CO}]_2\text{PCl}$	H(T)	1966, 51
$\text{PC}_6\text{H}_{12}\text{ClO}_3$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CCl}=\text{CH}_2$	H	1966, 244; 1968, 25, 97
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}=\text{CHCl}$	H	1966, 244; 1968, 25, 97
	$\text{CH}_3\text{P}(\text{O})(\text{OCH}_3)\text{CH}_2\text{CHClC}(\text{O})\text{CH}_3$	H	1967, 312

Formula	Compound	Resonance	Reference
$\text{PC}_6\text{H}_{12}\text{ClO}_3$	$\text{CH}_3\text{POCH}_2\text{C}(\text{CH}_3)(\text{CH}_2\text{Cl})\text{CH}_2\text{O}$	H	1968, 85
$\text{PC}_6\text{H}_{12}\text{ClO}_3\text{S}$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{SCH}_2\text{CHClCH}=\text{CH}_2$	H	1966, 74
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{SCH}(\text{CH}_2\text{Cl})\text{CH}=\text{CH}_2$	H	1966, 74
$\text{PC}_6\text{H}_{12}\text{Cl}_3\text{O}_3$	$\text{P}(\text{OCH}_2\text{CH}_2\text{Cl})_3$	P (128.7)	1967, 277
$\text{PC}_6\text{H}_{12}\text{Cl}_3\text{O}_3\text{S}$	$\text{SP}(\text{OCH}_2\text{CH}_2\text{Cl})_3$	P (53.0)	1967, 277
$\text{PC}_6\text{H}_{12}\text{Cl}_3\text{O}_4$	$\text{OP}(\text{OCH}_2\text{CH}_2\text{Cl})_3$	P (2.0)	1967, 277
$\text{PC}_6\text{H}_{12}\text{FO}_2$	$\text{CH}_2=\text{CH}(i\text{-C}_4\text{H}_9\text{O})\text{P}(\text{O})\text{F}$	P (15.5); F (-70)	1967, 14
$\text{PC}_6\text{H}_{12}\text{F}_3\text{N}_2$	$\text{CF}_2=\text{CFP}[\text{N}(\text{CH}_3)_2]_2$	H; F (-89.4; -107.8; -181.3)	1969, 55
$\text{PC}_6\text{H}_{12}\text{NO}_2\text{S}$	$\text{CH}_3\text{P}(\text{O})(\text{OC}_2\text{H}_5)(\text{SCH}_2\text{CH}_2\text{CN})$	H	1969, 74
$\text{PC}_6\text{H}_{12}\text{NO}_3$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CN}$	H	1965, 90
	$\text{C}_2\text{H}_5\text{OP}(\text{O})(\text{H})\text{OC}(\text{CH}_3)_2(\text{CN})$	P (3.9)	1967, 293
	$(\text{CH}_2\text{O})_2\text{PN}(\text{CH}_2\text{CH}_2)_2\text{O}$	P (140)	1969, 340
$\text{PC}_6\text{H}_{12}\text{N}_3\text{O}_9$	$(\text{CH}_3\text{O})_2\text{PO}(\text{CH}_2)_3\text{C}(\text{NO}_2)_3$	H{P}	1964, 14
$\text{PC}_6\text{H}_{13}\text{Cl}_2\text{O}_2$	$\text{C}_4\text{H}_9\text{OP}(\text{O})(\text{CH}_2\text{Cl})_2$	H; P (37.8)	1968, 300; 1969, 332
$\text{PC}_6\text{H}_{13}\text{Cl}_2\text{O}_3$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CH}_2\text{Cl}$	H	1966, 244
$\text{PC}_6\text{H}_{13}\text{FN}$	$\text{CH}_3\text{PF}(\text{NC}_5\text{H}_{10})$	P (165); F (-115)	1968, 12
$\text{PC}_6\text{H}_{13}\text{F}_2\text{NS}$	$\text{C}_6\text{H}_{11}(\text{NH})_2\text{P}(\text{S})\text{F}_2$	P (65.3); F (-54.3)	1966, 30
$\text{PC}_6\text{H}_{13}\text{F}_3\text{N}$	$\text{F}_3\text{P}(\text{CH}_3)[\text{N}(\text{CH}_2)_5]$	F (-69; -47)	1967, 64
$\text{PC}_6\text{H}_{13}\text{N}_2$	$[(\text{CH}_3)_2\text{N}]_2\text{PC}\equiv\text{CH}$	H	1967, 106
$\text{PC}_6\text{H}_{13}\text{N}_2\text{O}$	$[(\text{CH}_3)_2\text{N}]_2\text{P}(\text{O})\text{C}\equiv\text{CH}$	H	1967, 106
$\text{PC}_6\text{H}_{13}\text{N}_2\text{O}_2$	$\text{HP}[\text{OCH}(\text{CH}_3)\text{CH}_2\text{NH}]_2$	H	1967, 165
$\text{PC}_6\text{H}_{13}\text{N}_2\text{O}_4$	$[\text{O}(\text{CH}_2)_2\text{NCH}_2]_2\text{PO}_2\text{H}$	P (26.8)	1967, 291
$\text{PC}_6\text{H}_{13}\text{O}$	$\text{CH}_3\text{P}[(\text{CH}_2)_2]_2\text{CH}(\text{OH})$	H	1967, 75
	$\text{CH}_3\text{C}(\text{O})\text{P}(\text{C}_2\text{H}_5)_2$	H	1969, 341
$\text{PC}_6\text{H}_{13}\text{O}_2$	$\text{C}_2\text{H}_5(\text{CH}_2=\text{CH})\text{P}(\text{O})\text{OC}_2\text{H}_5$	H	1966, 120
	$\text{CH}_3\text{OPOCH}(\text{CH}_3)\text{C}(\text{CH}_3)_2\text{O}$	H; P (137; 150)	1969, 94

PC ₆ H ₁₃ O ₃	CH ₃ OP(OCH ₂) ₂ C(CH ₃) ₂	H; P (122.7)	1966, 46; 1967, 88; 1968, 78, 80
	CH ₃ OP[OCH(CH ₃)] ₂ CH ₂	H	1966, 46; 1969, 88
	CH ₃ P(O)(OCH ₂) ₂ C(CH ₃) ₂	H	1967, 91; 1968, 74
	(C ₂ H ₅ O) ₂ P(O)CH=CH ₂	H	1967, 99; 1968, 25, 97
	C ₂ H ₅ OPOCH(CH ₃)(CH ₂) ₂ O	H(T)	1969, 92
PC ₆ H ₁₃ O ₃ S	$\begin{array}{c} \text{---} \\ \\ i\text{-C}_3\text{H}_7\text{OPOCH}_2\text{CH}(\text{CH}_3)\text{O} \end{array}$	H; P (139; 142)	1969, 94
	(CH ₃ O) ₂ P(O)SCH ₂ C(CH ₃)CH ₂	H	1966, 74
	CH ₃ OP(S)(OCH ₂) ₂ C(CH ₃) ₂	H; P (63)	1967, 91; 1968, 74
PC ₆ H ₁₃ O ₄	C ₂ H ₅ OP(S)OCH(CH ₃)(CH ₂) ₂ O	H(T)	1969, 92
	$\begin{array}{c} \text{---} \\ \\ (\text{CH}_3\text{O}_2\text{P}(\text{O}))\text{CHC}(\text{CH}_3)_2\text{O} \end{array}$	H	1966, 245; 1967, 81
	(CH ₃ O) ₂ P(O)C(CH ₃) ₂ C(O)H	H	1966, 245; 1967, 81
	CH ₃ OP(O)(OCH ₂) ₂ C(CH ₃) ₂	H; P (-6.8)	1966, 46; 1967, 91; 1968, 74
	CH ₃ OP(O)[OCH(CH ₃)] ₂ CH ₂	H	1966, 46
	(CH ₃ O) ₂ P(O)C ₄ H ₉ (OH)	H	1967, 100
	(C ₂ H ₅ O) ₂ P(O)OCH=CH ₂	H	1967, 120
	CH ₃ (CH ₃ O)P(O)OCH(CH ₃)COCH ₃	H	1967, 181
	(C ₂ H ₅ O) ₂ P(O)C(O)CH ₃	H	1967, 166; 1969, 82
	(CH ₃ O) ₂ P(O)(CH ₂) ₂ COCH ₃	H; P (34.3)	1967, 311; 1969, 81
	C ₂ H ₅ OP(O)(H)CH ₂ COOC ₂ H ₅	H	1968, 297
	CH ₃ (C ₂ H ₅ O)P(O)CH ₂ COOCH ₃	H	1968, 297
	(C ₂ H ₅ O) ₂ P(O)CH ₂ C(O)H	H	1969, 82
	(C ₂ H ₅ O) ₂ P(O)CHCH ₂ O	H{P}	1969, 82
	$\begin{array}{c} \text{---} \\ \\ (\text{CH}_3\text{O})_2\text{P}(\text{O})\text{CH}=\text{CHOC}_2\text{H}_5 \end{array}$	H	1969, 342

Formula	Compound	Resonance	Reference
$\text{PC}_6\text{H}_{13}\text{O}_4$	$i\text{-C}_3\text{H}_7\text{OP}(\text{O})\text{OCH}_2\text{CH}(\text{CH}_3)\text{O}$	H; P (14)	1969, 94
$\text{PC}_6\text{H}_{13}\text{O}_5$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{COOH}$ $(\text{CH}_3\text{O})_2\text{P}(\text{O})(\text{CH}_2)_2\text{COOCH}_3$	H H; P (32.6)	1965, 87 1966, 220; 1967, 313; 1969, 81
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{OCH}(\text{CH}_3)\text{C}(\text{O})\text{CH}_3$	P (−0.3)	1967, 86; 1968, 73
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{OC}(\text{CH}_3)=\text{C}(\text{OH})\text{CH}_3$	P (−2.5)	1968, 73
$\text{PC}_6\text{H}_{13}\text{O}_9$	1-glucose phosphate	P (−2.4)	1969, 321
$\text{PC}_6\text{H}_{14}\text{Ba}_{1/2}\text{O}_6$	$\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{OP}(\text{O})(\text{O}^\ominus)[\text{O}(\text{CH}_2)_2\text{OCH}_3], \text{Ba}_{1/2}^\oplus$	H	1965, 88
$\text{PC}_6\text{H}_{14}\text{BrS}$	$\text{C}_2\text{H}_5\text{P}(\text{SC}_4\text{H}_9)\text{Br}$	P (163)	1969, 335
$\text{PC}_6\text{H}_{14}\text{ClS}$	$\text{C}_2\text{H}_5\text{P}(\text{SC}_4\text{H}_9)\text{Cl}$	P (163)	1969, 335
$\text{PC}_6\text{H}_{14}\text{Cl}_3\text{N}_2\text{O}_2$	$[(\text{CH}_3)_2\text{N}^\oplus\text{CHO}]_2\text{PCl}, 2\text{Cl}^\ominus$	H	1966, 223
$\text{PC}_6\text{H}_{14}\text{FO}$	$(i\text{-C}_3\text{H}_7)_2\text{P}(\text{O})\text{F}$	P (78.2); F (−102)	1967, 14
$\text{PC}_6\text{H}_{14}\text{FOS}$	$\text{C}_3\text{H}_7(\text{C}_3\text{H}_7\text{S})\text{P}(\text{O})\text{F}$ $s\text{-C}_4\text{H}_9(\text{C}_2\text{H}_5\text{S})\text{P}(\text{O})\text{F}$	P (65.5); F (−51) P (71.0)	1967, 14 1967, 14
$\text{PC}_6\text{H}_{14}\text{FO}_2$	$\text{C}_3\text{H}_7(\text{C}_3\text{H}_7\text{O})\text{P}(\text{O})\text{F}$ $\text{C}_3\text{H}_7(i\text{-C}_3\text{H}_7\text{O})\text{P}(\text{O})\text{F}$ $i\text{-C}_3\text{H}_7(i\text{-C}_3\text{H}_7\text{O})\text{P}(\text{O})\text{F}$ $\text{C}_2\text{H}_5(\text{C}_4\text{H}_9\text{O})\text{P}(\text{O})\text{F}$ $\text{C}_2\text{H}_5(i\text{-C}_4\text{H}_9\text{O})\text{P}(\text{O})\text{F}$ $(\text{C}_3\text{H}_7\text{O})_2\text{PF}$	P (30); F (−65.4) P (26); F (−65.4) P (31.7); F (−75) P (32.3) P (32.4); F (−72) F (−60.3)	1967, 13, 14 1967, 14; 1968, 295 1967, 14 1967, 14 1967, 14 1969, 61
$\text{PC}_6\text{H}_{14}\text{FO}_3$	$(i\text{-C}_3\text{H}_7\text{O})_2\text{P}(\text{O})\text{F}$	H {P, F}; P (−4.5);	1967, 13, 14, 51, 185; 1968, 295; 1969, 74
	$(\text{C}_3\text{H}_7\text{O})_2\text{P}(\text{O})\text{F}$	P (−8.5); F (−86)	1967, 14
$\text{PC}_6\text{H}_{14}\text{F}_2\text{NS}$	$(\text{C}_3\text{H}_7)_2\text{NP}(\text{S})\text{F}_2$	H; P (70.0); F (−48.9)	1966, 30
$\text{PC}_6\text{H}_{14}\text{F}_4\text{N}$	$\text{F}_4\text{PN}(\text{C}_3\text{H}_7)_2$	F (−67.5)	1966, 217
$\text{PC}_6\text{H}_{14}\text{LiO}_5$	$\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{OP}(\text{O})(\text{O}^\ominus)(\text{O}i\text{-C}_3\text{H}_7)\text{Li}^\oplus$	H	1965, 88
$\text{PC}_6\text{H}_{14}\text{NO}$	$(\text{C}_2\text{H}_5)_2\text{NC}(\text{O})\text{CH}_2\text{PH}_2$	P (−150.2)	1967, 135
$\text{PC}_6\text{H}_{14}\text{NO}_2$	$\text{C}_5\text{H}_{10}\text{NCH}_2\text{PO}_2\text{H}_2$	P (9.2)	1967, 301

PC ₆ H ₁₄ NO ₃	(CH ₃) ₂ NP[OCH(CH ₃) ₂] ₂ (isom.) (CH ₃) ₂ NP(O)[OCH(CH ₃) ₂](?) (CH ₂ O) ₂ P(H)OCH ₂ C(CH ₃) ₂ NH	P (144.4; 147.8; 140.0) P (14.8) P (37-41)	1967, 321; 1968, 304 1969, 343 1969, 45, 178
PC ₆ H ₁₄ NO ₄	(C ₂ H ₅ O) ₂ P(O)CH ₂ C(O)NH ₂ (C ₂ H ₅ O) ₂ P(O)CH(OH)CH ₂ NH ₂ (CH ₃ O) ₂ P(O)C(O)NH <i>i</i> -C ₃ H ₇	H H H	1967, 22 1969, 82 1967, 26; 1968, 29
PC ₆ H ₁₄ N ₃	[(CH ₃) ₂ N] ₂ PN(CH ₂) ₂	H	1967, 305
PC ₆ H ₁₅	P(C ₂ H ₅) ₃	¹³ C; H; P (-20; -19)	1965, 3, 39; 1967, 20, 244; 1968, 3, 7, 17, 302, 303
PC ₆ H ₁₅ AlBr ₃	CH ₃ (C ₂ H ₅) ₂ P=CH ₂	H	1968, 106, 107
PC ₆ H ₁₅ AlCl ₃	(C ₂ H ₅) ₃ PAlBr ₃	²⁷ Al; P	1967, 23
PC ₆ H ₁₅ AlCl ₃	(C ₂ H ₅) ₃ PAlCl ₃	²⁷ Al; P	1967, 23
PC ₆ H ₁₅ ClLi	CH ₃ (C ₂ H ₅) ₂ P=CH ₂ , LiCl	H	1968, 106, 107
PC ₆ H ₁₅ Cl ₂	(C ₂ H ₅) ₃ PCl ₂	H; P	1969, 344
PC ₆ H ₁₅ FNO	<i>t</i> -C ₄ H ₉ P(O)F[N(CH ₃) ₂] (isom.)	H; P (42.5; 29.6); F (-88.4; -77.8)	1965, 8; 1968, 80
PC ₆ H ₁₅ F ₂ N ₂	CHF ₂ CH ₂ P[N(CH ₃) ₂] ₂	F	1965, 80
PC ₆ H ₁₅ F ₃ N	F ₃ P(C ₂ H ₅)[N(C ₂ H ₅) ₂] F ₃ P(CH ₃)NH <i>i</i> -C ₅ H ₁₁	P (-35.5); F (-74; -45) F (-73; 42; 30)	1967, 64 1967, 64
PC ₆ H ₁₅ N ₂ O	C ₂ H ₅ P(O)[N(CH ₃)CH ₂] ₂	H	1967, 314
PC ₆ H ₁₅ N ₂ O ₂	HP[OCH ₂ CH(CH ₃)NH] ₂	H; P (-56)	1967, 164
	C ₂ H ₅ OP(O)[N(CH ₃)CH ₂] ₂	H	1967, 314
	HP(OCH ₂ CH ₂ NCH ₃) ₂	H; P (-63)	1968, 304
	CH ₃ NH(CH ₂) ₂ OPN(CH ₃)CH ₂ OH ₂ O	H; P (137.2)	1968, 304
	HP[OCH(CH ₃)CH ₂ NH] ₂	P (-54.6)	1969, 45

Formula	Compound	Resonance	Reference
PC ₆ H ₁₅ O	(C ₂ H ₅) ₃ PO	H	1965, 83; 1967, 20
	(C ₂ H ₅) ₂ P(O)OC ₂ H ₅	H	1966, 120; 1968, 65
	(<i>i</i> -C ₃ H ₇) ₂ PO ₂ H	H	1968, 65
PC ₆ H ₁₅ O ₂ S ₂	C ₂ H ₅ SP(S)(OC ₂ H ₅) ₂	H; P (94·1)	1965, 20; 1966, 218
	CH ₃ P(O)(OCH ₃)SCH ₂ Si-C ₃ H ₇	H	1969, 101
PC ₆ H ₁₅ O ₃	P(OC ₂ H ₅) ₃	¹³ C; ¹⁷ O; H; (137–139)	1963, 1; 1964, 9; 1966, 47, 141, 216, 225; 1967, 34, 85, 198, 277, 293; 1968, 3, 22, 25, 303, 306; 1969, 50, 336
	C ₂ H ₅ P(O)(OC ₂ H ₅) ₂	H; P (32·8)	1966, 51, 105, 133
	HP(O)(<i>Oi</i> -C ₃ H ₇) ₂	P (3)	1967, 277, 293; 1969, 101, 162
	HP(O)(OC ₂ H ₅)(<i>Ot</i> -C ₄ H ₉)	P (1·4)	1967, 293
	SP(OC ₂ H ₅) ₃	¹³ C; H; P (68)	1966, 47, 133, 216; 1967, 84, 85, 198, 277, 293; 1968, 3, 25
PC ₆ H ₁₅ O ₃ S	C ₂ H ₅ SP(O)(OC ₂ H ₅) ₂	H	1966, 52, 133; 1967, 307
	HSP(O)(<i>Oi</i> -C ₃ H ₇) ₂	H	1967, 307
PC ₆ H ₁₅ O ₃ S ₂	(CH ₃ O) ₂ P(O)SC ₂ H ₄ SC ₂ H ₅	H	1968, 284, 285; 1969, 322
PC ₆ H ₁₅ O ₃ Se	(C ₂ H ₅ O) ₃ PSe	H; P (72·1)	1967, 84, 293; 1968, 25
	(C ₂ H ₅ O) ₃ PO	¹³ C; ¹⁷ O; H; P (–1·5)	1963, 1; 1966, 47, 133, 138, 216; 1967, 69, 84, 85, 198, 277, 293; 1968, 3, 25, 306; 1969, 74, 86, 336

	$(C_2H_5O)_2P(O)CH(OH)CH_3$	H	1969, 82
PC ₆ H ₁₆	HP(C ₂ H ₅) ₃ [⊕]	H	1966, 22
PC ₆ H ₁₆ As	(CH ₃) ₃ P=CHAs(CH ₃) ₂	H	1968, 287
PC ₆ H ₁₆ B ₁₁	B ₁₁ H ₁₁ PC ₆ H ₅	¹¹ B; H	1967, 292
PC ₆ H ₁₆ Br	HP(C ₂ H ₅) ₃ Br	H; P (19·7)	1968, 7
PC ₆ H ₁₆ Cl	(CH ₃) ₂ P(C ₂ H ₅) ₂ Cl	H	1968, 287
PC ₆ H ₁₆ Cl ₆ O ₂ Sb	(CH ₃) ₂ (C ₂ H ₅ O) ₂ P [⊖] , SbCl ₆ [⊖]	H	1967, 308
PC ₆ H ₁₆ I	(CH ₃) ₂ P(C ₂ H ₅) ₂ I	H	1967, 169
PC ₆ H ₁₆ N	(C ₂ H ₅) ₂ PN(CH ₃) ₂	P (43·5)	1967, 277
PC ₆ H ₁₆ NO	(C ₂ H ₅) ₂ P(O)N(CH ₃) ₂	P (85·1)	1967, 277
PC ₆ H ₁₆ NO ₂	(C ₂ H ₅ O) ₂ PN(CH ₃) ₂	P (143·4)	1964, 9
PC ₆ H ₁₆ NO ₃	(C ₂ H ₅ O) ₂ P(O)NHC ₂ H ₅	H	1968, 25; 1969, 110
	CH ₃ (<i>i</i> -C ₃ H ₇ O)P(O)O(CH ₂) ₂ NH ₂	H; P (33·1)	1967, 185
	CH ₃ (<i>i</i> -C ₃ H ₇ O)P(O)NH(CH ₂) ₂ OH	H; P (32·8)	1967, 276
PC ₆ H ₁₆ NO ₄	(C ₂ H ₅ O) ₂ P(O)NH(CH ₂) ₂ OH	H; P (11·5)	1967, 185
PC ₆ H ₁₆ NS	(C ₂ H ₅) ₂ P(S)N(CH ₃) ₂	P (61·3)	1967, 277
PC ₆ H ₁₆ N ₃	(CH ₃) ₂ NP[N(CH ₃)CH ₂] ₂	P (114·2)	1966, 224; 1968, 303
PC ₆ H ₁₆ N ₃ O	[(CH ₃) ₂ N] ₂ P(O)N(CH ₂) ₂	H	1966, 246
	(CH ₃) ₂ NP(O)[N(CH ₃)CH ₂] ₂	H; P (26·4)	1967, 314; 1968, 153
	(CH ₃) ₂ NP(NC ₂ H ₅) ₂ CO	P (87)	1968, 126
PC ₆ H ₁₆ Sb	(CH ₃) ₃ P=CHSb(CH ₃) ₂	H	1968, 107
PC ₆ H ₁₇ ClN	(CH ₃) ₃ P [⊕] CH ₂ N(CH ₃) ₂ , Cl [⊖]	H	1969, 128
PC ₆ H ₁₇ ClN ₃ O	[(CH ₃) ₃ N] ₂ P(O)NH(CH ₂) ₂ Cl	H	1966, 246
PC ₆ H ₁₇ IN ₃	CH ₃ (CH ₃ NH)P [⊕] [N(CH ₃)CH ₂] ₂ , I [⊖]	H	1967, 305
PC ₆ H ₁₇ NO ₂	C ₂ H ₅ OP[N(CH ₃) ₂] ₂	P (135·2)	1964, 9
PC ₆ H ₁₇ N ₂ O ₂	[(CH ₃) ₂ NCH ₂] ₂ PO ₂ H	P (22·7)	1967, 291
PC ₆ H ₁₇ N ₂ O ₃	C ₂ H ₅ [(CH ₃) ₂ N]P(O)(CH ₂) ₂ NH ₂	H; P (20·1)	1967, 185
	C ₂ H ₅ O[(CH ₃) ₂ N]P(O)NH(CH ₂) ₂ OH	H; P (12·1)	1967, 185
PC ₆ H ₁₇ N ₄	(CH ₃) ₂ NNHP[N(CH ₃)CH ₂] ₂	H	1967, 305
PC ₆ H ₁₇ O ₇ S	(C ₂ H ₅ O) ₃ P [⊕] H, HSO ₃ [⊖]	P (18)	1969, 50
PC ₆ H ₁₈ AlBr ₃ NSi	(CH ₃) ₃ SiN(AlBr ₃)P(CH ₃) ₃	H	1967, 176

Formula	Compound	Resonance	Reference
$\text{PC}_6\text{H}_{18}\text{AlCl}_3\text{NSi}$	$(\text{CH}_3)_3\text{SiN}(\text{AlCl}_3)\text{P}(\text{CH}_3)_3$	H	1967, 176
$\text{PC}_6\text{H}_{18}\text{AlI}_3\text{NSi}$	$(\text{CH}_3)_3\text{SiN}(\text{AlI}_3)\text{P}(\text{CH}_3)_3$	H	1967, 176
$\text{PC}_6\text{H}_{18}\text{AlO}$	$(\text{CH}_3)_3\text{POAl}(\text{CH}_3)$	H	1965, 83
$\text{PC}_6\text{H}_{18}\text{BF}_6\text{N}_2$	$[(\text{CH}_3)_2\text{NCH}_2]_2\text{BH}_2, \text{PF}_6$	H	1969, 26
$\text{PC}_6\text{H}_{18}\text{Br}_2\text{N}_3$	$[(\text{CH}_3)_2\text{N}]_3\text{P}^\oplus\text{Br}, \text{Br}^\ominus$	H	1965, 91; 1967, 67
$\text{PC}_6\text{H}_{18}\text{Br}_3\text{InSi}$	$(\text{CH}_3)_3\text{SiN}(\text{InBr}_3)\text{P}(\text{CH}_3)_3$	H	1967, 176
$\text{PC}_6\text{H}_{18}\text{ClN}_2$	$(\text{CH}_3)_2\text{P}[\text{N}(\text{CH}_3)_2]\text{Cl}$	H; P (68.4)	1967, 67
$\text{PC}_6\text{H}_{18}\text{ClN}_4$	$[(\text{CH}_3)_2\text{N}(\text{CH}_3)\text{N}]_2\text{PCl}$	H	1969, 103
$\text{PC}_6\text{H}_{18}\text{Cl}_2\text{N}_3$	$[(\text{CH}_3)_2\text{N}]_3\text{P}^\oplus\text{Cl}, \text{Cl}^\ominus$	H; P (50–53)	1967, 67; 1969, 59, 345
$\text{PC}_6\text{H}_{18}\text{Cl}_3\text{GaNSi}$	$(\text{CH}_3)_3\text{SiN}(\text{GaCl}_3)\text{P}(\text{CH}_3)_3$	H	1967, 176
$\text{PC}_6\text{H}_{18}\text{Cl}_3\text{InNSi}$	$(\text{CH}_3)_3\text{SiN}(\text{InCl}_3)\text{P}(\text{CH}_3)_3$	H	1967, 176
$\text{PC}_6\text{H}_{18}\text{FN}_4$	$\text{FP}[\text{N}(\text{CH}_3)\text{N}(\text{CH}_3)_2]_2$	H	1969, 103
$\text{PC}_6\text{H}_{18}\text{F}_2\text{N}_3$	$\text{F}_2\text{P}[\text{N}(\text{CH}_3)_2]_3$	H; P (–65.5); F (–54)	1966, 76; 1967, 61; 1968, 124
$\text{PC}_6\text{H}_{18}\text{Ga}$	$\text{Ga}(\text{CH}_3)_3\text{P}(\text{CH}_3)_3$	H (T)	1969, 198
$\text{PC}_6\text{H}_{18}\text{GeN}$	$(\text{CH}_3)_3\text{GeN}=\text{P}(\text{CH}_3)_3$	H	1967, 73
$\text{PC}_6\text{H}_{18}\text{IN}_2$	$(\text{CH}_3)_2\text{P}^\oplus[\text{N}(\text{CH}_3)_2]_2\text{I}^\ominus$	H	1965, 18
$\text{PC}_6\text{H}_{18}\text{NSi}$	$(\text{CH}_3)_3\text{SiN}=\text{P}(\text{CH}_3)_3$	H	1967, 73, 176, 322
$\text{PC}_6\text{H}_{18}\text{NSn}$	$(\text{CH}_3)_3\text{SnN}=\text{P}(\text{CH}_3)_3$	H	1967, 73
$\text{PC}_6\text{H}_{18}\text{N}_3$	$\text{P}[\text{N}(\text{CH}_3)_2]_3$	H; P (121.5 – 123.0)	1964, 9; 1965, 12, 18, 84; 1966, 18, 36, 206; 1967, 277, 299; 1968, 153, 310; 1969, 72
$\text{PC}_6\text{H}_{18}\text{N}_3\text{O}$	$\text{OP}[\text{N}(\text{CH}_3)_2]_3$	^{14}N ; H; P (23)	1964, 2; 1965, 18, 23, 78, 84; 1966, 206; 1967, 198, 277; 1968, 91, 153, 287, 310
$\text{PC}_6\text{H}_{18}\text{N}_3\text{S}$	$\text{SP}[\text{N}(\text{CH}_3)_2]_3$	H; P	1965, 18, 23; 1966, 36; 1967, 277; 1968, 91; 1969, 105

PC ₆ H ₁₉ ClN ₃ O	[(CH ₃) ₂ N] ₃ PO, HCl	H	1969, 181
PC ₆ H ₁₉ Si	HP[Si(CH ₃) ₃] ₂	H; P (-237.4)	1967, 29
PC ₆ H ₂₀ ClN ₄	[(CH ₃) ₂ N]PNH ₂ , Cl	H; P (39.0)	1967, 65
PC ₇ H ₄ ClO ₃	ClPOC ₆ H ₄ C(O)O	P (151.2)	1965, 45
PC ₇ H ₄ ClO ₄	ClP(O)OC ₆ H ₄ C(O)O	P (-9.5)	1965, 45
PC ₇ H ₄ Cl ₃ O ₃	Cl ₂ P(O)OC ₆ H ₄ - <i>m</i> -C(O)Cl Cl ₂ P(O)OC ₆ H ₄ - <i>p</i> -C(O)Cl	P (2.6) P (1.4)	1966, 239 1966, 239
PC ₇ H ₅ F ₂ N ₂	C ₆ H ₅ PF ₂ =NCN	P (15.3); F (-66.5)	1967, 63
PC ₇ H ₆ ClO ₂	ClPOC ₆ H ₃ (CH ₃)O	P (177)	1969, 45
PC ₇ H ₇ Cl ₂	<i>p</i> -CH ₃ C ₆ H ₄ PCl ₂	H	1968, 15
PC ₇ H ₇ Cl ₂ S	C ₆ H ₅ CH ₂ P(S)Cl ₂ <i>p</i> -CH ₃ C ₆ H ₄ P(S)Cl ₂	P (85.0) P(75.3)	1966, 114 1966, 114
PC ₇ H ₇ F ₂	CH ₃ C ₆ H ₄ PF ₂ C ₆ H ₅ CH ₂ PF ₂	P (205.3); F (-94) P (223.8); F (-99.5)	1967, 52, 290 1967, 52, 290
PC ₇ H ₈ Cl ₂ O ₃	Cl ₂ P(O)CH=C=C(CH ₃)COOC ₂ H ₅	H	1968, 311
PC ₇ H ₉ F ₃ N	F ₃ P(C ₆ H ₅)NHCH ₃	F (-75; -43)	1967, 64
PC ₇ H ₉ N ₂ O ₂	(CH ₃) ₂ NPO(C ₆ H ₅)O	P (148)	1969, 45
PC ₇ H ₉ O	CH ₃ (C ₆ H ₅)P(O)H	H	1968, 33; 1969, 34
PC ₇ H ₉ O ₂	(CHCH ₂) ₂ P(O)OCH ₂ C≡CH CH ₃ (C ₆ H ₅)PO ₂ H CH ₃ O(C ₆ H ₅)P(O)H <i>p</i> -CH ₃ C ₆ H ₄ PO ₂ H ₂	H H H H; P (25.2)	1969, 190 1966, 36; 1968, 33, 56 1967, 113, 172 1968, 15
PC ₇ H ₉ S	CH ₃ P(S)(C≡CCH ₃) ₂	H	1965, 89
PC ₇ H ₁₀ Cl ₃ O ₃	Cl ₂ P(O)CH ₂ CCl=C(CH ₃)COOC ₂ H ₅	H	1968, 287
PC ₇ H ₁₀ NO ₃	C ₆ H ₅ CH(NH ₂)PO ₃ H ₂	H	1968, 142

Formula	Compound	Resonance	Reference
PC ₇ H ₁₀ NO ₅	CH ₃ OP(O)(O [⊖])CH(COOCH ₃)N [⊕] (CH ₃) ₃	H; P	1969, 346
PC ₇ H ₁₁ F ₆ O ₂	(C ₂ H ₅) ₂ POCH(CF ₃) ₂	H; P (68·8)	1968, 302
PC ₇ H ₁₁ N ₂ O ₇	(CH ₃ O) ₂ P(O)OC(C(O)NH) ₂ COCH ₃	H; P (-1·2)	1966, 242
PC ₇ H ₁₁ O ₅	HP(O)OCH(CH=CH ₂)C(CH ₃)C(O)CH ₃ O	H; P (14·0)	1968, 312
PC ₇ H ₁₂ ClO ₃	(C ₂ H ₅ O) ₂ P(O)C≡CCH ₂ Cl	H; P (-9·8)	1967, 21
PC ₇ H ₁₂ ClO ₆	(CH ₃ O) ₂ P(O)OC(CH ₃)[C(O)CH ₃]C(O)Cl	P (-3·2)	1968, 313
PC ₇ H ₁₂ Cl ₃ O ₅	(CH ₃ O) ₂ P(O)OC(CCl ₃)[C(O)CH ₃]CH ₃	H	1965, 35
PC ₇ H ₁₂ NO ₃	(C ₂ H ₅ O) ₂ P(O)CH=CHCN	H	1967, 99
PC ₇ H ₁₃	(C ₂ H ₅) ₂ PC=CCH ₃	H	1966, 243, 247
	(C ₂ H ₅) ₂ PCH=C=CH ₂	H	1967, 104; 1968, 99; 1969, 115
PC ₇ H ₁₃ Br ₂ O ₃	CH ₃ P[CH ₂ C(CH ₃)] ₂	H	1968, 100
	(C ₂ H ₅ O) ₂ P(O)CH ₂ CPBr=CHBr	H; P (20)	1967, 101, 108, 323, 324
	(CH ₃ O) ₂ P(O)CBrCHBr(CH ₂) ₃	H	1966, 43
PC ₇ H ₁₃ Cl ₂	CH ₃ P [⊕] (CH(CH ₃)CH) ₂ Cl, Cl [⊖]	H	1968, 61
PC ₇ H ₁₃ O	(C ₂ H ₅) ₂ P(O)C=CCH ₃	H	1966, 243, 247
	(C ₂ H ₅) ₂ P(O)CH=C=CH ₂	H	1967, 104, 296; 1969, 115
	CH ₃ P(O)[CH ₂ C(CH ₃)] ₂	H	1968, 100
	CH ₃ P(O)CH ₂ [CH(CH ₃)] ₂ CH	H	1968, 100
PC ₇ H ₁₃ O ₂	CH ₃ OP(O)CH=C(CH ₃)CH(CH ₃)CH ₂	H	1964, 8, 16

PC ₇ H ₁₃ O ₃	$\text{CH}_3\text{OP}(\text{O})\text{CH}_2\text{C}(\text{CH}_3)=\text{C}(\text{CH}_3)\text{CH}_2$	H	1964, 16
	$\text{C}_2\text{H}_5\text{OP}(\text{O})\text{CH}_2\text{CH}=\text{C}(\text{CH}_3)\text{CH}_2$	H	1964, 15
	$\text{CH}_3\text{OP}(\text{O})[\text{CH}_2\text{C}(\text{CH}_3)]_2$	H; P (-45.8)	1966, 66
	$(\text{C}_2\text{H}_5\text{O})_2\text{PCH}=\text{C}=\text{CH}_2$	H	1968, 99; 1969, 115
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{C}\equiv\text{CCH}_3$	¹³ C; H; P (-92)	1966, 63; 1967, 21; 1968, 20
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{C}_6\text{H}_7$	H	1967, 100
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}=\text{C}=\text{CH}_2$	H; P (11.1)	1967, 21, 296, 324; 1969, 115
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{CH}=\text{C}(\text{CH}_3)\text{CH}=\text{CH}_2$	H	1967, 310
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{C}\equiv\text{CH}$	H; P (18.6)	1967, 21, 324
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CH}=\text{CH}_2$	P (23.5)	1967, 108
PC ₇ H ₁₃ O ₄	$\text{CH}_3\text{OP}(\text{O})\text{OC}(\text{CH}_3)\text{CHC}(\text{CH}_3)_2$	H	1967, 311
	$\text{CH}_3\text{P}(\text{O})[\text{OC}(\text{CH}_3)=\text{CH}_2]_2$	H	1968, 297
	$\text{P}(\text{OCH}_2)_2\text{CC}_3\text{H}_7$	H; P (93)	1967, 218; 1968, 209
	$\text{CH}_3\text{OP}[\text{OC}(\text{CH}_3)_2]_2$	H; P (147)	1969, 94
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{C}\equiv\text{CCH}_2\text{OH}$	H	1967, 21
PC ₇ H ₁₃ O ₅	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{OCH}_2\text{C}\equiv\text{CH}$	H; P (-2)	1967, 21
	$\text{CH}_3\text{OP}(\text{O})[\text{OC}(\text{CH}_3)_2]_2$	H	1969, 94
	$\text{CH}_3\text{P}(\text{O})(\text{CH}_2\text{COOCH}_3)_2$	H	1968, 297
	$\text{CH}_2=\text{CHCH}(\text{OH})\text{C}(\text{CH}_3)\text{PO}_3\text{H}_2$	H; P (-4.1)	1968, 312
PC ₇ H ₁₃ O ₅	$\text{CH}_3(\text{CH}_2\text{O})_2\text{P}[\text{OC}(\text{CH}_3)]_2$	H; P (-27.0)	1968, 301
PC ₇ H ₁₃ O ₆	$(\text{CH}_2\text{O})_2\text{POCH}(\text{CH}_3)\text{COOC}_2\text{H}_5$	P (137)	1969, 109
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{OC}(\text{CH}_3)=\text{CHCOOCH}_3$	H; P (-6)	1961, 4; 1967, 325; 1968, 284, 285; 1969, 322
PC ₇ H ₁₄ BrO ₂	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CH}=\text{CHBr}$	H; P (24)	1967, 108, 326
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}=\text{CHCH}_2\text{Br}$	P (17)	1967, 326

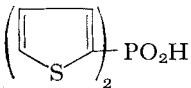
Formula	Compound	Resonance	Reference
PC ₇ H ₁₄ Br ₃	(C ₂ H ₅ O) ₂ P(O)CH ₂ CBr=CH ₂	H; P (22)	1967, 101, 108, 323, 324
	CH ₃ (CH ₂) ₄ CH(PBr ₂)CH ₂ Br	P (191)	1966, 222
	CH ₃ (CH ₂) ₄ CHBrCH ₂ PBr ₂	P (178)	1966, 222
PC ₇ H ₁₄ ClN ₂ O ₂	[NCH(CH ₃)] ₂ P(O)OCH(CH ₃)CH ₂ Cl	H	1966, 220
PC ₇ H ₁₄ ClO	C ₄ H ₉ P(Cl)CH ₂ COCH ₃	H	1968, 297
PC ₇ H ₁₄ ClO ₂	<i>t</i> -C ₄ H ₉ CH(CH ₂ O) ₂ PCl	H	1968, 78
	C ₄ H ₉ OP(Cl)[OC(CH ₃)=CH ₂]	H	1968, 297
PC ₇ H ₁₄ ClO ₃	OCH ₂ C(CH ₃)[CH(CH ₃)(OCH ₃)]CH ₂ OPCl	H; P (140·8)	1967, 161, 162
	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH=CHCl	H; P (24·5)	1967, 323, 326
PC ₇ H ₁₄ ClO ₃ S	(C ₂ H ₅ O) ₂ P(O)CH=CHCH ₂ Cl	P (17·4)	1967, 326
	(C ₂ H ₅ O) ₂ P(O)CH ₂ C(Cl)=CH ₂	H; P (22·6)	1967, 323
	(CH ₃ O) ₂ P(O)SCH ₂ CHClC(CH ₃)=CH ₂	H	1966, 74
PC ₇ H ₁₄ ClO ₄	(CH ₃ O) ₂ P(O)SCH(CH ₂ Cl)C(CH ₃)=CH ₂	H	1966, 74
	C ₂ H ₅ OP(O)(Cl)(CH ₂) ₂ COOC ₂ H ₅	H	1967, 313
PC ₇ H ₁₄ Cl ₃	CH ₃ (CH ₂) ₄ CH(PCl ₂)CH ₂ Cl	P (189)	1966, 222
	CH ₃ (CH ₂) ₄ CHClCH ₂ PCl ₂	P (191)	1966, 222
PC ₇ H ₁₄ NO	C ₂ H ₅ OP(CH=C=CH ₂)[N(CH ₃) ₂]	H	1968, 99; 1969, 115
PC ₇ H ₁₄ NO ₅	(CH ₃ O) ₂ P(O)OC(CH ₃)CHC(O)NHCH ₃	H	1968, 284
PC ₇ H ₁₄ N ₃ O ₃	OP(NHCOOC ₂ H ₅)[N(CH ₂) ₂] ₂	H	1965, 42
PC ₇ H ₁₄ O ₃	(CH ₃ O) ₂ P(O)C(C ₂ H ₅)=CHCH ₃	H	1966, 43
PC ₇ H ₁₅ F ₃ N	F ₃ P(CH ₃)NHC ₆ H ₄	P (-36·4); F (-73; -43; -32)	1967, 64
PC ₇ H ₁₅ N ₂	[(CH ₃) ₂ N] ₂ PC≡CCH ₃	H	1967, 106
	[(CH ₃) ₂ N] ₂ PCH=C=CH ₂	H	1967, 104; 1968, 99; 1969, 115
PC ₇ H ₁₅ N ₂ O	[(CH ₃) ₂ N] ₂ P(O)C≡CCH ₃	H	1967, 106
	[(CH ₃) ₂ N] ₂ P(O)CH=C=CH ₂	H	1967, 104, 296; 1969, 115

PC ₇ H ₁₅ N ₄	[(CH ₃) ₂ N] ₂ PN(CH ₃)N	H	1967, 119
PC ₇ H ₁₅ OS	(C ₂ H ₅) ₂ P(S)CH ₂ COCH ₃	H	1968, 297
PC ₇ H ₁₅ O ₂	C ₄ H ₉ P(O)O(CH ₂) ₃	H {P}	1964, 14
	C ₂ H ₅ P(O)(OC ₂ H ₅)CH ₂ CH=CH ₂	H	1966, 120
	(C ₂ H ₅) ₂ P(O)CH ₂ COCH ₃	H	1968, 297
	(C ₂ H ₅) ₂ PCH ₂ COOCH ₃	H	1968, 297
	<i>i</i> -C ₃ H ₇ OPOCH ₂ C(CH ₃) ₂ O	H	1969, 93
	<i>t</i> -C ₄ H ₉ POCH ₂ CH(CH ₃)O	H	1969, 93
PC ₇ H ₁₅ O ₃	C ₃ H ₇ P(O)O(CH ₂) ₄ O	H {P}	1964, 14
	CH ₃ OP[OC(CH ₃) ₂] ₂	H(T)	1966, 51
	(CH ₃ O) ₂ P(O)C(C ₂ H ₅)CHCH ₃	H	1967, 100
	C ₂ H ₅ OP(O)[OC(CH ₃) ₂](CH=CH ₂)H	P (1·7)	1967, 293
	(CH ₃ O) ₂ P(O)CH ₂ CH=C(CH ₃) ₂	H	1967, 327
	CH ₃ OPOCH ₂ CH(<i>t</i> -C ₄ H ₉)O (isom.)	H; P (134; 142)	1969, 94
	(C ₂ H ₅ O) ₂ P(O)CH=CHCH ₃	H	1967, 21; 1968, 314; 1969, 163
	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH=CH ₂	H; P (2·5)	1967, 21
	(C ₂ H ₅ O) ₂ POC(CH ₃)=CH ₂	H	1968, 297
	P(CH ₂ O) ₃ CC ₄ H ₉	H; P (-81·0)	1969, 71
	<i>t</i> -C ₄ H ₉ OPO(CH ₂) ₃ O	H	1969, 93
PC ₇ H ₁₅ O ₃ S	(C ₂ H ₅ O) ₂ P(O)SCH ₂ CH=CH ₂	H	1967, 307
PC ₇ H ₁₅ O ₇	(C ₂ H ₅ O) ₂ P(O)CH ₂ COCH ₃	¹³ C; H; P (19)	1966, 234; 1967, 22, 278; 1968, 20

Formula	Compound	Resonance	Reference
	$\text{C}_2\text{H}_5\text{OP}(\text{O})(\text{OCH}_2)_2\text{C}(\text{CH}_3)_2$	H	1967, 91; 1969, 86
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{C}(\text{O})\text{C}_2\text{H}_5$	H	1967, 166
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CH}(\text{CH}_3)\text{COCH}_3$	H	1967, 311
	$(\text{C}_2\text{H}_5\text{O})_2\text{PCH}_2\text{COOCH}_3$	H	1968, 297
	$\text{C}_2\text{H}_5(\text{C}_2\text{H}_5\text{O})\text{P}(\text{O})\text{CH}_2\text{COOCH}_3$	H	1968, 297
	$\text{CH}_3\text{OP}(\text{O})\text{OCH}_2\text{CH}(\text{t-C}_4\text{H}_9)\text{O}$	H; P (16)	1969, 94
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CHCH}_2\text{O}$	H	1969, 249
	$\text{t-C}_4\text{H}_9\text{OP}(\text{O})\text{O}(\text{CH}_2)_3\text{O}$	H	1969, 93
$\text{PC}_7\text{H}_{16}\text{O}_4\text{S}$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{S})\text{CH}_2\text{COOCH}_3$	H	1968, 213
$\text{PC}_7\text{H}_{16}\text{O}_5$	$(\text{CH}_3\text{O})_3\text{P}[\text{OC}(\text{CH}_3)]_2$ (stereois.)	H; P (-49; -55)	1965, 21, 45; 1966, 225, 239, 248; 1967, 86, 160; 1968, 73, 301; 1969, 147
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{COOCH}_3$	H	1968, 297
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}(\text{OH})\text{CH}_2\text{OCH}_3$	H	1969, 82
$\text{PC}_7\text{H}_{16}\text{ClO}_3$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$	H	1969, 82
$\text{PC}_7\text{H}_{16}\text{ClO}_3\text{S}$	$(\text{C}_2\text{H}_7\text{O})_2\text{P}(\text{O})\text{CH}_2\text{Cl}$	H	1966, 36
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{SCH}(\text{CH}_2\text{Cl})\text{C}_3\text{H}_7$	H	1966, 74
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{SCH}_2\text{CHClC}_3\text{H}_7$	H	1966, 74
$\text{PC}_7\text{H}_{16}\text{FO}_2$	$\text{CH}_3\text{P}(\text{O})(\text{F})[\text{OCH}(\text{CH}_3)\text{t-C}_4\text{H}_9]$	H	1969, 74, 160
$\text{PC}_7\text{H}_{16}\text{NO}_2$	$(\text{CH}_3)_2\text{NP}(\text{OCH}_2)_2\text{C}(\text{CH}_3)_2$	H	1968, 80
$\text{PC}_7\text{H}_{16}\text{NO}_2\text{S}$	$(\text{CH}_3)_2\text{NP}(\text{S})(\text{OCH}_2)_2\text{C}(\text{CH}_3)_2$	H	1968, 74
$\text{PC}_7\text{H}_{16}\text{NO}_4$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CH}_2\text{CONH}_2$	H	1966, 249
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{C}(\text{O})\text{NHC}_2\text{H}_5$	H	1967, 26
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{C}(\text{O})\text{NHC}_4\text{H}_9$	H	1967, 26
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{NH}_2$	H	1969, 82

PC ₇ H ₁₆ N ₂ NaO ₃ S	NaPO ₃ SCH ₂ C(NH ₂)NHC ₆ H ₁₁	H	1968, 292
PC ₇ H ₁₆ N ₃ O	(CH ₃) ₂ NP(NC ₂ H ₅) ₂ CO	H; P (81)	1969, 109
PC ₇ H ₁₇	(C ₂ H ₅) ₃ P=CH ₂	H	1968, 105, 107, 305
PC ₇ H ₁₇ N ₂ O	C ₂ H ₅ P(O)(NCH ₃) ₂ (CH ₂) ₃	H	1967, 314
PC ₇ H ₁₇ N ₂ O ₂	[(CH ₃) ₂ N] ₂ PCH ₂ COOCH ₃	H	1968, 297
	[(CH ₃) ₂ N] ₂ P(O)CH=CHOCH ₃	H	1969, 342
PC ₇ H ₁₇ N ₂ O ₂ S	(C ₂ H ₅ O) ₂ P(S)NCHN(CH ₃) ₂	H	1966, 56
PC ₇ H ₁₇ O ₂	(C ₂ H ₅) ₂ P(O)Oi-C ₃ H ₇	H	1968, 65
	(<i>i</i> -C ₃ H ₇) ₂ P(O)OCH ₃	H	1968, 65
	(<i>i</i> -C ₃ H ₇ O) ₂ PCH ₃	H; P (-52)	1969, 192
PC ₇ H ₁₇ O ₂ S ₃	(C ₂ H ₅ O) ₂ P(S)SCH ₂ SC ₂ H ₅	H	1968, 284, 285; 1969, 322
PC ₇ H ₁₇ O ₃	(C ₂ H ₅ O) ₂ P(Oi-C ₃ H ₇)	P (137.2)	1967, 293
	(CH ₃ O) ₂ P(O)CH ₂ CH(CH ₃)C ₂ H ₅	H	1967, 310
	(C ₂ H ₅ O) ₂ P(O)C ₃ H ₇	P (30)	1967, 21
	CH ₃ P(O)(OC ₆ H ₁₃)(OH)	H	1969, 74
PC ₇ H ₁₇ O ₄	(CH ₃ O) ₂ P(O)C(C ₂ H ₅) ₂ OH	H	1967, 100
	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH(OH)CH ₃	H; P (28.7)	1967, 22
PC ₇ H ₁₈	CH ₃ P [⊕] (C ₂ H ₅) ₃	P (37.8)	1967, 7
PC ₇ H ₁₈ Cl ₆ O ₂ Sb	CH ₃ O(C ₂ H ₅) ₂ (C ₂ H ₅ O)P [⊕] , SbCl ₆ [⊖]	H	1967, 308
PC ₇ H ₁₈ Cl ₆ O ₄ Sb	CH ₃ OP [⊕] (OC ₂ H ₅) ₃ , SbCl ₆ [⊖]	H; P (50)	1967, 69
PC ₇ H ₁₈ F ₂ N ₃	[(CH ₃) ₂ N] ₃ P=CF ₂	H; P (-65.5); F (-54.7)	1964, 9
PC ₇ H ₁₈ I	(CH ₃)(C ₂ H ₅) ₃ PI	P (36.5)	1967, 169, 244
PC ₇ H ₁₈ NO ₃	(C ₂ H ₅ O) ₂ P(O)NH <i>i</i> -C ₃ H ₇	H	1969, 110
PC ₇ H ₁₈ N ₂ O ₂	<i>i</i> -C ₃ H ₇ (C ₂ H ₅ O)P(O)N(CH ₃) ₂	H	1965, 92
PC ₇ H ₁₈ N ₃ O	[(CH ₃) ₂ N] ₂ P(O)NCH ₂ CHCH ₃	H	1966, 246
	[(CH ₃) ₂ NP(O)[N(CH ₃) ₂](CH ₂) ₃	H	1967, 314
PC ₇ H ₁₉ Ge	(CH ₃) ₃ P=CHGe(CH ₃) ₃	H	1968, 107
PC ₇ H ₁₉ Si	(CH ₃) ₃ P=CHSi(CH ₃) ₃	H	1967, 328; 1968, 107
PC ₇ H ₁₉ Sn	(CH ₃) ₃ P=CHSn(CH ₃) ₃	H	1968, 107

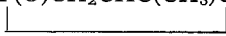
Formula	Compound	Resonance	Reference
PC ₇ H ₂₀ Al	(CH ₃) ₃ P ⁺ CH ₂ Al [−] (CH ₃) ₃	H	1968, 105, 107
PC ₇ H ₂₀ ClGe	(CH ₃) ₃ PCH ₂ Ge(CH ₃) ₃ Cl	H	1968, 107
PC ₇ H ₂₀ ClSi	(CH ₃) ₃ PCH ₂ Si(CH ₃) ₃ Cl	H	1968, 107
PC ₇ H ₂₀ IN ₂	CH ₃ (C ₆ H ₅)P ⁺ [N(CH ₃) ₂] ₂ , I [−]	H; P (59·4)	1969, 87
PC ₇ H ₂₀ N ₃ O ₂	[(CH ₃) ₂ N] ₂ P(O)NH(CH ₂) ₂ OCH ₃	H	1966, 246
PC ₇ H ₂₁ ClN ₃	CHP ⁺ [N(CH ₃) ₂] ₃ , Cl [−]	H; P (54·4)	1967, 67
PC ₇ H ₂₁ Cl ₆ N ₃ OSb	CH ₃ OP ⁺ [N(CH ₃) ₂] ₃ , SbCl ₆ [−]	H; P (38·0)	1969, 87
PC ₇ H ₂₁ Cl ₆ N ₃ SSb	CH ₃ SP ⁺ [N(CH ₃) ₂] ₃ , SbCl ₆ [−]	H; P (66·7)	1969, 87
PC ₇ H ₂₁ Cl ₆ N ₃ SbSe	CH ₃ SeP ⁺ [N(CH ₃) ₂] ₃ , SbCl ₆ [−]	H; P (63·5)	1969, 87
PC ₇ H ₂₁ IN ₃	CH ₃ P ⁺ [N(CH ₃) ₂] ₃ , I [−]	H	1965, 18, 91
PC ₇ H ₂₁ IN ₃ S	CH ₃ SP ⁺ [N(CH ₃) ₂] ₃ , I [−]	H	1969, 105, 347
PC ₈ F ₅ N ₂	C ₆ F ₅ P(CN) ₂	P (−121·3)	1968, 9
PC ₈ F ₅ N ₂ O ₂	C ₆ F ₅ P(NCO) ₂	P (70·5)	1968, 9
PC ₈ F ₅ N ₂ S ₂	C ₆ F ₅ P(NCS) ₂	P (62·2)	1968, 9
PC ₈ F ₅ N ₂ S ₃	C ₆ F ₅ P(S)(NCS) ₂	P (6·8)	1968, 9
PC ₈ H ₄ FN ₂	FC ₆ H ₄ P(CN) ₂	F	1968, 14
PC ₈ H ₄ F ₇	FC ₆ H ₄ P(CF ₃) ₂	F	1968, 14
PC ₈ H ₅ ClNO ₂ S	(C ₂ H ₅ O) ₂ P(O)NS(O)CH ₂ CH=CClCH ₂	H	1965, 93
PC ₈ H ₅ Cl ₂ O	Cl ₂ P(O)C≡CC ₆ H ₅	H	1965, 86
PC ₈ H ₆ Cl	(CH ₃) ₂ P ⁺ [CH(CH ₃)CH ₂] ₂ , Cl [−]	H	1968, 61
PC ₈ H ₆ ClF ₅ N	C ₆ F ₅ P[N(CH ₃) ₂]Cl	H; F (−129·0; −162·5; −151·0)	1966, 19
PC ₈ H ₆ F ₅	C ₆ F ₅ P(CH ₃) ₂	H; P (−478); F (−133; −164; −154)	1966, 10, 19; 1967, 11; 1969, 17
PC ₈ H ₆ F ₅ O	C ₆ F ₅ P(O)(CH ₃) ₂	P (29·7)	1967, 11
PC ₈ H ₆ F ₆ N	(CF ₃) ₂ PNHC ₆ H ₅	H(T)	1968, 144
PC ₈ H ₇ Cl ₇ O ₅	(CH ₃ O) ₂ P(O)C ₆ Cl ₄ OH	H; P (−2·7)	1968, 315

$\text{PC}_8\text{H}_7\text{O}_2\text{S}_2$		H	1966, 130
$\text{PC}_8\text{H}_7\text{O}_3$	$\text{C}_6\text{H}_5\text{CH}=\text{CHPO}_3^{2-}$	P (10.4)	1967, 7
$\text{PC}_8\text{H}_8\text{BrO}_3$	$\text{CHBr}=\text{C}(\text{C}_6\text{H}_5)\text{PO}_3\text{H}_2$	H; P (11.5)	1966, 241
$\text{PC}_8\text{H}_8\text{ClO}$	$\text{C}_6\text{H}_5(\text{CH}_2=\text{CH})\text{P}(\text{O})\text{Cl}$	H	1966, 250
$\text{PC}_8\text{H}_8\text{ClO}_3$	$\text{CHCl}=\text{C}(\text{C}_6\text{H}_5)\text{PO}_3\text{H}_2$	P (12.3)	1966, 241
$\text{PC}_8\text{H}_8\text{Cl}_3\text{O}_3\text{S}$	$(\text{CH}_3\text{O})_2\text{P}(\text{S})\text{OC}_6\text{H}_2\text{Cl}_3$	H	1968, 284, 285; 1969, 322
$\text{PC}_8\text{H}_8\text{NO}_2$	$(\text{CH}_2\text{O})_2\text{PN}(\text{CH}=\text{CH})_2$	P (124)	1969, 109
PC_8H_9	$\text{C}_6\text{H}_5\text{P}(\text{CH}_2)_2$	H; P (-234)	1969, 169
$\text{PC}_8\text{H}_9\text{ClNO}_5\text{S}$	$(\text{CH}_3\text{O})_2\text{P}(\text{S})\text{OC}_6\text{H}_3\text{Cl}(\text{NO}_2)$	H	1968, 284, 285; 1969, 322
$\text{PC}_8\text{H}_9\text{Cl}_2\text{O}$	$\text{C}_6\text{H}_5\text{P}(\text{O})(\text{CH}_2\text{Cl})_2$	H; P (-33.9)	1968, 299; 1969, 334
$\text{PC}_8\text{H}_9\text{Cl}_3\text{NO}_2\text{S}$	$\text{C}_6\text{H}_2\text{Cl}_3\text{OP}(\text{S})(\text{OCH}_3)\text{NHCH}_3$	H	1967, 116
$\text{PC}_8\text{H}_9\text{F}_6\text{O}_5$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{OC}(\text{CH}_3)[\text{C}(\text{O})\text{CF}_3]_2$	H; P (-3.2)	1968, 313
$\text{PC}_8\text{H}_9\text{Li}_2$	$\text{C}_6\text{H}_5\text{P}(\text{CH}_2\text{Li})_2$	P (-21)	1967, 329
$\text{PC}_8\text{H}_9\text{N}_2\text{O}_4$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{C}_6\text{H}_3, 2, 4-(\text{NO}_2)_2$	H	1969, 119
$\text{PC}_8\text{H}_9\text{O}_2\text{S}_4$	$\text{CH}_3\text{OP}(\text{S})\text{SC}(\text{S})\text{CSC}(\text{CH}_3)\text{C}(\text{CH}_3)\text{CO}$	H	1969, 148
$\text{PC}_8\text{H}_9\text{O}_3$	$\text{C}_6\text{H}_5\text{OP}(\text{OCH}_2)_2$	H; P (128)	1966, 50; 1968, 77, 301; 1969, 50
	$\text{CH}_2=\text{C}(\text{C}_6\text{H}_5)\text{PO}_3\text{H}_2$	H; P (14.4)	1966, 241
	$\text{CH}(\text{C}_6\text{H}_5)=\text{CHPO}_3\text{H}_2$	P (4.7)	1966, 241
	$\text{CH}_2\text{C}_6\text{H}_4\text{CHPO}_3\text{H}_2$	P (8.5)	1966, 241
	$\text{C}_6\text{H}_5\text{PO}(\text{OCH}_2)_2$	P (11.1)	1969, 343
$\text{PC}_8\text{H}_9\text{O}_4$	$\text{C}_6\text{H}_5\text{C}(\text{O})\text{OP}(\text{OCH}_2)_2$	H	1966, 77
	$\text{C}_2\text{H}_5\text{OP}(\text{O})\text{OC}_6\text{H}_4\text{O}$	P (10.0)	1966, 238

Formula	Compound	Resonance	Reference
$\text{PC}_8\text{H}_9\text{S}_2$	$\text{CH}_3\text{PSC}_6\text{H}_3(\text{CH}_3)\text{S}$	H	1967, 330
$\text{PC}_8\text{H}_9\text{S}_2\text{Se}$	$\text{CH}_3\text{P}(\text{Se})\text{SC}_6\text{H}_3(\text{CH}_3)\text{S}$	H	1967, 330
$\text{PC}_8\text{H}_9\text{S}_3$	$\text{CH}_3\text{P}(\text{S})\text{SC}_6\text{H}_3(\text{CH}_3)\text{S}$	H	1967, 330
$\text{PC}_8\text{H}_{10}\text{ClF}_4$	$(\text{C}_2\text{H}_5)_2\text{PC}=\text{CCl}(\text{CF}_2)_2$	H	1967, 331
$\text{PC}_8\text{H}_{10}\text{ClOS}$	$\text{CH}_3\text{P}(\text{SC}_6\text{H}_4\text{OCH}_3)\text{Cl}$	P (150)	1969, 335
$\text{PC}_8\text{H}_{10}\text{ClS}$	$\text{C}_6\text{H}_5\text{P}(\text{SC}_2\text{H}_5)\text{Cl}$	P (139)	1969, 335
$\text{PC}_8\text{H}_{10}\text{Cl}_3\text{N}_2\text{OS}$	$\text{C}_6\text{H}_2\text{Cl}_3\text{OP}(\text{S})(\text{NHCH}_3)_2$	H	1967, 116
$\text{PC}_8\text{H}_{10}\text{F}$	<i>m</i> - and <i>p</i> - $\text{FC}_6\text{H}_4\text{P}(\text{CH}_3)_2$	F	1967, 17; 1969, 18, 19
$\text{PC}_8\text{H}_{10}\text{FO}$	<i>m</i> - and <i>p</i> - $\text{FC}_6\text{H}_4\text{P}(\text{O})(\text{CH}_3)_2$	F	1967, 359; 1969, 18, 19
$\text{PC}_8\text{H}_{10}\text{FOS}_2$	$\text{C}_2\text{H}_5(\text{C}_6\text{H}_5)\text{P}(\text{O})\text{F}$	P (53.4); F (−80)	1967, 14
$\text{PC}_8\text{H}_{10}\text{FO}_2$	$\text{C}_2\text{H}_5\text{O}(\text{C}_6\text{H}_5)\text{P}(\text{S})$	H; P (−89.1); F (−28.7)	1968, 308
	$\text{C}_2\text{H}_5\text{O}(\text{C}_6\text{H}_5)\text{P}(\text{O})\text{F}$	P (14.9); F (−65.4)	1967, 13, 14; 1968, 295
	<i>m</i> - and <i>p</i> - $\text{FC}_6\text{H}_4\text{P}(\text{OCH}_3)_2$	F	1968, 14
$\text{PC}_8\text{H}_{10}\text{FO}_3$	<i>m</i> - and <i>p</i> - $\text{FC}_6\text{H}_4\text{P}(\text{O})(\text{OCH}_3)_2$	H; F	1967, 115; 1969, 18, 19
$\text{PC}_8\text{H}_{10}\text{FS}$	$\text{C}_6\text{H}_5\text{PF}(\text{SC}_2\text{H}_5)$	P (196)	1968, 12
$\text{PC}_8\text{H}_{10}\text{F}_3\text{S}$	$\text{F}_3\text{P}(\text{SC}_2\text{H}_5)\text{C}_6\text{H}_5$	H; P (−18.3); F (−14; −21; −71)	1968, 277, 316; 1969, 62
$\text{PC}_8\text{H}_{10}\text{F}_5$	$(\text{C}_2\text{H}_5)_2\text{PC}=\text{CF}(\text{CF}_2)_2$	H	1967, 231
$\text{PC}_8\text{H}_{10}\text{Li}$	$\text{CH}_3(\text{C}_6\text{H}_5)\text{PCH}_2\text{Li}$	P (−22.6)	1966, 132; 1967, 329
$\text{PC}_8\text{H}_{10}\text{NO}$	$\text{H}_2\text{PCH}_2\text{C}(\text{O})\text{NHC}_6\text{H}_5$	P (−144.5)	1967, 135
$\text{PC}_8\text{H}_{10}\text{NO}_2$	$(\text{CH}_3)_2\text{NPOC}_6\text{H}_4\text{O}$	P (150)	1969, 45

PC ₈ H ₁₀ NO ₃	HP(OC ₆ H ₄ NH)(OCH ₂ CH ₂ O) HP(OC ₆ H ₄ O)(OCH ₂ CH ₂ NH)	H; P (−37.7) P (−35)	1967, 165 1969, 45
PC ₈ H ₁₀ NO ₅ PC ₈ H ₁₀ NO ₅ S	(CH ₃ O) ₂ P(O)C ₆ H ₄ NO ₂ CH ₃ O(CH ₃ S)P(O)OC ₆ H ₄ NO ₂ (CH ₃ O) ₂ P(S)OC ₆ H ₄ NO ₂	H H; P (25.2) H	1969, 119 1965, 20 1968, 284, 285; 1969, 322
PC ₈ H ₁₁	(CH ₃) ₂ PC ₆ H ₅	¹³ C; H; P (−46)	1965, 3; 1966, 41, 132; 1967, 66, 329; 1968, 6, 7, 33, 54, 303; 1969, 50
PC ₈ H ₁₁ ClN	C ₂ H ₅ (C ₆ H ₅)PH CH ₃ (C ₆ H ₅)CHPH ₂ C ₆ H ₅ PCl[N(CH ₃) ₂]	H H(T) H; P (141)	1968, 28; 1969, 34 1969, 51 1965, 12; 1966, 36; 1967, 80; 1968, 80, 92
PC ₈ H ₁₁ ClNO PC ₈ H ₁₁ Cl ₂ N ₂ PC ₈ H ₁₁ Cl ₃ NO ₃ S	C ₆ H ₅ P(O)Cl[N(CH ₃) ₂] C ₆ H ₅ N=P[N(CH ₃) ₂]Cl ₂ (C ₂ H ₅ O) ₂ P(S)OCClCH(CCl) ₂ N	H H; P (−18.6) H	1966, 36; 1967, 80 1969, 348 1968, 284
PC ₈ H ₁₁ FN PC ₈ H ₁₁ FNO PC ₈ H ₁₁ FNS ₂ PC ₈ H ₁₁ F ₂ O PC ₈ H ₁₁ F ₃ N	C ₆ H ₅ PF[N(CH ₃) ₂] C ₆ H ₅ P(O)F[N(CH ₃) ₂] C ₆ H ₅ SP(S)F[N(CH ₃) ₂] F ₂ P(CH ₃) ₂ (OC ₆ H ₅) F ₃ P(C ₆ H ₅)[N(CH ₃) ₂]	H; P (159.8); F (−128.5) H H; P (94.0); F (−40.3) P (−11.7); F (−42) H; P (−53); F (−40.1; −68.1)	1965, 12; 1966, 36 1966, 36 1968, 308 1969, 62 1965, 12; 1966, 36; 1967, 50, 64
PC ₈ H ₁₁ F ₆ PC ₈ H ₁₁ O PC ₈ H ₁₁ OS	F ₃ P(CH ₃)(NHC ₆ H ₄ CH ₃) (C ₂ H ₅) ₂ PC(CF ₃)=CH(CF ₃) (CH ₃) ₂ P(O)C ₆ H ₅ C ₂ H ₅ O(C ₆ H ₅)P(S)H	F (−75; −42; −30) H; F (−57; −61.8) H P (65.3)	1967, 64 1967, 103 1967, 19 1966, 40; 1969, 162

Formula	Compound	Resonance	Reference
PC ₈ H ₁₁ O ₂	CH ₃ (CH ₃ O)P(O)C ₆ H ₅ C ₂ H ₅ OP(O)H(C ₆ H ₅) (CH ₃ O) ₂ PC ₆ H ₅	H H H; P (15·8)	1966, 133 1969, 74, 162 1969, 74, 162
PC ₈ H ₁₁ O ₂ S	CH ₃ O(C ₆ H ₅ SC ₂ H ₅)P(O)H (CH ₃ O) ₂ P(S)C ₆ H ₅	H H; P (9·0)	1966, 124 1966, 36; 1967, 113; 1969, 87
PC ₈ H ₁₁ O ₂ Se	C ₆ H ₅ P(Se)(OCH ₃) ₂ C ₆ H ₅ P(O)(OCH ₃)(SeCH ₃)	H; P (98) H; P (38·7)	1967, 113; 1969, 87 1967, 113
PC ₈ H ₁₁ O ₃	C ₆ H ₅ P(O)(OCH ₃) ₂	H; P (19·3)	1966, 36, 133; 1967, 113
PC ₈ H ₁₁ O ₃ S	C ₆ H ₅ SP(O)(OCH ₃) ₂	H	1967, 87
PC ₈ H ₁₁ O ₄	C ₆ H ₅ OP(O)(OCH ₃) ₂ (CH ₃ O) ₂ P(O)C ₆ H ₄ OH	¹³ C H	1965, 7; 1966, 240 1968, 317
PC ₈ H ₁₁ O ₅	(CH ₃ O) ₂ P(O)OC ₆ H ₄ OH	P (−4·1)	1968, 318
PC ₈ H ₁₁ O ₇ S	(CH ₂ O) ₂ P [⊕] (OC ₆ H ₅)H, HSO ₄ [⊖]	P (16)	1969, 50
PC ₈ H ₁₁ S	C ₆ H ₅ P(S)(CH ₃) ₂	H	1967, 19
PC ₈ H ₁₁ S ₃	C ₆ H ₅ P(S)(SCH ₃) ₂	H; P (83·5)	1967, 113
PC ₈ H ₁₂ Br	(CH ₃) ₂ P [⊕] (C ₆ H ₅)H, Br [⊖]	¹³ C; H{P, C}; P (−2·1)	1967, 66; 1968, 3, 7, 33
PC ₈ H ₁₂ N	(CH ₃) ₂ NP(C≡CCH ₃) ₂	H	1967, 106
PC ₈ H ₁₂ NO	(CH ₃) ₂ NP(O)(C≡CCH ₃) ₂	H	1967, 106
PC ₈ H ₁₂ NO ₂	(CH ₂ O) ₂ PN(CH ₂) ₄	P (138)	1969, 109
PC ₈ H ₁₂ NO ₃	(<i>i</i> -C ₃ H ₇)CHC(CN)P(O)(OC ₂ H ₅)OH (CH ₃ O) ₂ P(O)C ₆ H ₄ NH ₂	H H	1968, 319 1968, 317
PC ₈ H ₁₂ NO ₄	<i>p</i> -CH ₃ OC ₆ H ₄ CH(NH ₂)PO ₃ H ₂	H; P (13·3)	1968, 142, 296
PC ₈ H ₁₂ N ₂ NaO ₃ S	NaPO ₃ SCH ₂ C(NH ₂)(NHCH ₂ C ₆ H ₅)	H	1968, 292
PC ₈ H ₁₃ ClN	C ₆ H ₅ (CH ₃) ₂ PNH ₂ , Cl	H; P (42·8)	1967, 332; 1968, 54
PC ₈ H ₁₃ N ₂ O ₂	(CH ₃ NH) ₂ P(O)OC ₆ H ₅	H	1968, 284
PC ₈ H ₁₃ N ₂ O ₃	HP(O)[OC(CH ₃) ₂ CN] ₂	P (−0·1)	1967, 293

PC ₈ H ₁₃ N ₂ S	C ₆ H ₅ P(S)(NHCH ₃) ₂	H	1967, 318
PC ₈ H ₁₃ O ₂	CH ₂ =CHCH ₂ OP(O)CH ₂ CHC(CH ₃)CH ₂ 	H	1964, 15
PC ₈ H ₁₃ O ₂ S	(C ₂ H ₅ O) ₂ P- 	H	1969, 74
PC ₈ H ₁₃ O ₄ S	(CH ₃) ₂ (C ₆ H ₅)P [⊕] H, HSO ₄ [⊖]	H; P (-1)	1969, 50
PC ₈ H ₁₃ O ₅	(CH ₃ O) ₂ P(O)OCH(CH=CH ₂)C(CH ₃) (OH)C(O)CH ₃ CH ₃ OP(O)OCH(CH=CH ₂)C(CH ₃)[C(O)CH ₃]O 	H; P (0.5)	1968, 312
PC ₈ H ₁₃ O ₆ S	(CH ₃ O) ₂ (C ₆ H ₅)P [⊕] H, HSO ₄ [⊖]	P (54)	1969, 50
PC ₈ H ₁₄ ClO ₃	(C ₂ H ₅ O) ₂ P(O)C≡CCHClCH ₃	H	1967, 21
PC ₈ H ₁₄ Cl ₃ O ₅	[(CH ₂) ₂ CHCH ₂ O] ₂ P(O)Cl	H	1966, 213
PC ₈ H ₁₄ O ₃	(C ₂ H ₅ O) ₂ P(O)CH(CCl ₃)OCOCH ₃ <i>i</i> -C ₄ H ₉ OP(O)OCH(=CH ₂)CH=CH 	H; P (9.6)	1966, 234
PC ₈ H ₁₅ Cl ₂ O ₅	(C ₂ H ₅ O) ₂ P(O)CH(CHCl ₂)OC(O)CH ₃	H; P (13.2)	1967, 3
PC ₈ H ₁₅ N ₂ S ₂	C ₆ H ₅ P(S)(S [⊖])NHCH ₃ CH ₃ NH ₃ [⊕]	P (81.8)	1967, 126
PC ₈ H ₁₅ O ₃	(C ₂ H ₅ O) ₂ P(O)C≡CC ₂ H ₅	H; P (-8.5)	1965, 90; 1967, 21
	(CH ₃ O) ₂ P(O)C ₆ H ₅	H	1966, 43; 1967, 100
	(C ₂ H ₅ O) ₂ P(O)CH=CHCH ₃	H; P (13.5)	1967, 21
	(C ₂ H ₅ O) ₂ P(O)CH ₂ C≡CCH ₃	H; P (21.4)	1967, 100, 324
PC ₈ H ₁₅ O ₄	C ₃ H ₅ C(O)P(O)(OC ₂ H ₅) ₂	H	1967, 166
	(C ₂ H ₅ O) ₂ P(O)C≡CCH(OH)CH ₃	H; P (-3.5)	1967, 166
	C ₂ H ₅ P(O)(COCH ₃)CH ₂ COOC ₂ H ₅	H	1968, 297
	[(CH ₃) ₂ CO] ₂ POC(O)CH ₃	P (134.3)	1968, 304
PC ₈ H ₁₅ O ₅	(CH ₃ O) ₂ P(O)C(CH ₃)CHC(O)OC ₂ H ₅	H	1967, 325

Formula	Compound	Resonance	Reference
	$\text{CH}_3\text{OP}(\text{O})\text{OCH}(\text{C}_2\text{H}_5)\text{C}(\text{CH}_3)(\text{COCH}_3)\text{O}$	P (13·9; 15·2)	1968, 312
	(stereois.)		
	$\text{C}_2\text{H}_5\text{P}(\text{O})(\text{CH}_2\text{COOCH}_3)_2$	H	1968, 297
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}=\text{CHCOOCH}_3$	H; P	1969, 349
$\text{PC}_8\text{H}_{15}\text{O}_5\text{S}$	$\text{C}_2\text{H}_5\text{OP}(\text{S})(\text{CH}_2\text{COOCH}_3)_2$	H	1968, 297
$\text{PC}_8\text{H}_{15}\text{O}_6$	$\text{C}_2\text{H}_5\text{OP}(\text{O})(\text{CH}_2\text{COOCH}_3)_2$	H	1968, 297
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{OC}(\text{CH}_3)(\text{COCH}_3)_2$	H; P (−3·0)	1968, 313
$\text{PC}_8\text{H}_{15}\text{O}_7$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{CH}(\text{COOCH}_3)\text{CH}_2\text{COOCH}_3$	H	1965, 94
	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{OC}(\text{OC}_2\text{H}_5)\text{CHCOOCH}_3$	H; P (−6·6)	1965, 95
$\text{PC}_8\text{H}_{15}\text{O}_8$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{OC}(\text{CH}_3)(\text{COOCH}_3)_2$	H; P (4·6)	1967, 4
$\text{PC}_8\text{H}_{16}\text{BrO}_3$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{C}(\text{CH}_3)=\text{CHBr}$	H; P (22·9)	1967, 108, 326
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}=\text{C}(\text{CH}_3)\text{CH}_2\text{Br}$	P(16·5)	1967, 326
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CBr}=\text{CHCH}_3$	H; P (23)	1967, 73, 101, 108
$\text{PC}_8\text{H}_{16}\text{BrO}_4$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CBr}=\text{CHOC}_2\text{H}_5$	H	1969, 127
$\text{PC}_8\text{H}_{16}\text{Br}_2\text{Cl}$	$(\text{CH}_3)_2\text{P}^\oplus[\text{CH}(\text{CH}_3)\text{CHBr}]_2, \text{Cl}^\ominus$	H	1968, 61
$\text{PC}_8\text{H}_{16}\text{Cl}$	$\text{ClP}[\text{C}(\text{CH}_3)_2]_2\text{CHCH}_3$	H(T)	1969, 350
$\text{PC}_8\text{H}_{16}\text{ClN}_2\text{O}_2$	$[\text{NCH}(\text{CH}_3)]_2\text{P}(\text{O})\text{OCH}(\text{CH}_3)(\text{CH}_2)_2\text{Cl}$	H	1966, 220
	$[\text{NC}(\text{CH}_3)_2]_2\text{P}(\text{O})\text{O}(\text{CH}_2)_2\text{Cl}$	H	1966, 220
$\text{PC}_8\text{H}_{16}\text{ClN}_4$	$\text{C}_6\text{H}_5\text{NHPN}(\text{CH}_3)_2(\text{NH}_2)_2\text{Cl}$	H; P (28·7)	1969, 348
$\text{PC}_8\text{H}_{16}\text{ClO}_3$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CH}=\text{C}(\text{Cl})\text{CH}_3$	H; P (25)	1967, 101, 108, 323
$\text{PC}_8\text{H}_{16}\text{ClO}_5$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}(\text{CH}_2\text{Cl})\text{OC}(\text{O})\text{CH}_3$	H; P (17·5)	1967, 3
$\text{PC}_8\text{H}_{16}\text{Cl}_3$	$\text{CH}_3(\text{CH}_2)_5\text{CH}(\text{PCl}_2)\text{CH}_2\text{Cl}$	P (185)	1966, 222
	$\text{CH}_3(\text{CH}_2)_5\text{CHClCH}_2\text{PCl}_2$	P (191)	1966, 222
$\text{PC}_8\text{H}_{16}\text{NO}_2$	$[(\text{C}_2\text{H}_5)_2\text{N}] \text{P}(\text{O})\text{OC}(\text{CH}_3)\text{CHCH}_2$	H	1967, 311
$\text{PC}_8\text{H}_{16}\text{NO}_2\text{S}$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{NS}(\text{O})\text{CH}_2\text{CH}=\text{CHCH}_2$	H	1965, 93

PC ₈ H ₁₆ NO ₃	[(CH ₂) ₂ CHCH ₂ O] ₂ P(O)NH ₂	H	1966, 213
	(C ₂ H ₅ O) ₂ POC(CH ₃) ₂ CN	P (136.4)	1967, 293
PC ₈ H ₁₆ NO ₄	(C ₂ H ₅ O) ₂ P(O)OC(CH ₃) ₂ CN	P (-6.3)	1967, 293
	[(CH ₃) ₂ N](CH ₂ O) ₂ P[OC(CH ₃) ₂] ₂	P (-26.1)	1968, 301
PC ₈ H ₁₆ NO ₅	(CH ₃ O) ₂ P(O)OC(CH ₃)=CHC(O)N(CH ₃) ₂	H	1968, 283 to 285; 1969, 322
PC ₈ H ₁₇ F ₃ N	F ₃ P(C ₂ H ₅)NHC ₆ H ₁₁	F (-71; -47; -34)	1967, 64
PC ₈ H ₁₇ NO ₅	C ₂ H ₅ OP(O)(O [⊖])CH(COOCH ₃)N [⊕] (CH ₃) ₃	H; P(0)	1969, 346
PC ₈ H ₁₇ N ₂	[(CH ₃) ₂ N] ₂ PC(CH ₃)=C=CH ₂	H	1968, 99
PC ₈ H ₁₇ N ₂ O	[(CH ₃) ₂ N] ₂ P(O)C(CH ₃)=C=CH ₂	H	1967, 104; 1969, 115
PC ₈ H ₁₇ N ₄	(CH ₃) ₂ NPNCHC(CH ₃)N	H	1967, 119
	(CH ₃) ₂ NPNC(CH ₃)CHCHN	H	1967, 119
PC ₈ H ₁₇ O	CH ₃ P[(CH ₂) ₂] ₂ C(C ₂ H ₅)OH	H	1967, 75
PC ₈ H ₁₇ O ₂	CH ₃ P[(CH ₂) ₂] ₂ C(CH ₂ CH ₂ OH)OH	H	1967, 75
	C ₆ H ₁₁ (C ₂ H ₅ O)P(O)H	P (40.3)	1967, 172
	<i>t</i> -C ₄ H ₉ OPOCH ₂ C(CH ₃) ₂ O	H	1969, 93
PC ₈ H ₁₇ O ₂ S ₂	(C ₂ H ₅) ₂ P(O)CH=CHOC ₂ H ₅	H	1969, 342
PC ₈ H ₁₇ O ₃	(C ₂ H ₅ S) ₂ P(O)CH=CHOC ₂ H ₅	H	1969, 342
	(C ₂ H ₅ O) ₂ P(O)CH=C(CH ₃) ₂	H	1967, 327
	(C ₂ H ₅ O) ₂ P(O)CH=CHC ₂ H ₅	H	1968, 314; 1969, 163
	CH ₃ OP(OCH ₂) ₂ CH <i>t</i> -C ₄ H ₉	H	1968, 78; 1969, 172
	CH ₃ P(O)(OCH ₂) ₂ CH <i>t</i> -C ₄ H ₉	H	1969, 173
	P(OCH ₂) ₃ CC ₅ H ₁₁	P (92.8)	1969, 71
PC ₈ H ₁₇ O ₃ S	(C ₂ H ₅ O) ₂ P(O)C(SC ₂ H ₅)=CH ₂	H	1967, 332
	(C ₂ H ₅ O) ₂ P(O)SCH ₂ CH=CHCH ₃	H	1967, 307
	(C ₂ H ₅ O) ₂ P(O)CH=CHSC ₂ H ₅	H	1967, 332
	CH ₃ OP(S)(OCH ₂) ₂ CH <i>t</i> -C ₄ H ₉	H	1969, 173
PC ₈ H ₁₇ O ₄	(CH ₃ O) ₂ P(O)CH ₂ C(O)C(CH ₃) ₃	H	1966, 119

Formula	Compound	Resonance	Reference
PC ₈ H ₁₇ O ₄	(CH ₃ O) ₂ P(O)OC(C ₄ H ₉)=CH ₂	H	1966, 119
	(C ₂ H ₅ O) ₂ P(O)(CH ₂) ₂ COCH ₃	H; P (30·8)	1966, 249; 1967, 278
	<i>i</i> -C ₃ H ₇ OP(O)(OCH ₂) ₂ C(CH ₃) ₂	H	1967, 91
	CH ₃ OPOCH ₂ CH(CH ₃)(OCH ₃)CH ₂ O	H; P (137·9)	1967, 161
	CH ₃ P(O)OCH ₂ CH(CH ₃)(OCH ₃)C(CH ₃)CH ₂ O	H; P (29·7)	1967, 161
	(C ₂ H ₅ O) ₂ P(O)C(O) <i>i</i> -C ₃ H ₇	H	1967, 166
	(C ₂ H ₅ O) ₂ P(O)CH=CHOC ₂ H ₅	H; P (21·4)	1967, 278; 1969, 127
	(C ₂ H ₅ O) ₂ P(O)CH ₂ COC ₂ H ₅	H; P (20·1)	1967, 278
	(CH ₃ O) ₂ P(O)C(CH ₃) ₂ CH ₂ COCH ₃	H	1967, 311
	HP(OCH ₂) ₂ [OC(CH ₃) ₂] ₂	P (−30·4)	1968, 274; 1969, 179
	CH ₃ OP(O)(OCH ₂) ₂ CH <i>t</i> -C ₄ H ₉	H	1969, 173
	C ₂ H ₅ OP(O)[OC(CH ₃) ₂] ₂	H	1969, 86
PC ₈ H ₁₇ O ₄ S ₂	(C ₂ H ₅ O) ₂ P(S)SCH(CH ₃)OCOCH ₃	H	1967, 333
PC ₈ H ₁₇ O ₅	(C ₂ H ₅ O) ₂ P(O)CH ₂ COOC ₂ H ₅	H; P (19)	1967, 22
PC ₈ H ₁₈	(C ₂ H ₅) ₃ P [⊕] CH=CH ₂	H	1967, 99
PC ₈ H ₁₈ Cl	(<i>t</i> -C ₄ H ₉) ₂ PCl	P (144)	1968, 6
PC ₈ H ₁₈ ClO	(<i>t</i> -C ₄ H ₉) ₂ P(O)Cl	H	1965, 8
PC ₈ H ₁₈ ClO ₃	CH ₂ Cl(CH ₃ O)P(O)C(CH ₃)(OC ₂ H ₅) ₂	H	1966, 124
PC ₈ H ₁₈ CsO	(C ₄ H ₉) ₂ POCs	P (91·7)	1968, 320
PC ₈ H ₁₈ FO	[(CH ₃) ₂ CHCH ₂] ₂ P(O)F	P (71·3); F (−75·4)	1967, 13, 14; 1968, 295
PC ₈ H ₁₈ FO ₂	(C ₄ H ₉ O) ₂ PF	F (−60)	1969, 61
PC ₈ H ₁₈ FO ₃	(<i>i</i> -C ₄ H ₉ O) ₂ P(O)F	P (−9); F (−86)	1967, 14
PC ₈ H ₁₈ IN ₂	[(CH ₃) ₂ N] ₂ P [⊖] (CH ₃)CCH ₃ I [⊖]	H	1967, 106
PC ₈ H ₁₈ KO	(C ₄ H ₉) ₂ POK	P (94·2)	1968, 320
PC ₈ H ₁₈ NO ₂	(CH ₃) ₂ NP[OC(CH ₃) ₂] ₂	H	1966, 51
PC ₈ H ₁₈ NO ₂ S	(CH ₃) ₂ C(CH ₂ O) ₂ P(S)NH <i>i</i> -C ₃ H ₇	H	1967, 91
PC ₈ H ₁₈ NO ₃	(CH ₃) ₂ C(CH ₂ O) ₂ P(O)NHC ₃ H ₇	H	1967, 91; 1969, 97

	$i\text{-C}_4\text{H}_9(\text{CH}_3\text{O})\text{P}(\text{O})\text{C}(\text{O})\text{N}(\text{CH}_3)_2$	H	1967, 26
	$\text{HP}[\text{OC}(\text{CH}_3)_2]_2(\text{OCH}_2\text{CH}_2\text{NH})$	H; P (−47.3)	1968, 304
	$(\text{CH}_3)_2\text{NP}(\text{O})\text{OC}(\text{CH}_3)_2$	P (12.5)	1969, 343
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{N}=\text{C}(\text{CH}_3)\text{C}_2\text{H}_5$	P (3)	
	$(\text{C}_2\text{H}_5\text{O})_2\text{PONC}(\text{CH}_3)\text{C}_2\text{H}_5$	P (143)	1969, 351
$\text{PC}_8\text{H}_{16}\text{NO}_4$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{NCH}(\text{O}i\text{-C}_3\text{H}_7)$	H	1966, 55
	$(i\text{-C}_3\text{H}_7\text{O})_2\text{P}(\text{O})\text{C}(\text{O})\text{NHCH}_3$	H	1967, 34
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{N}=\text{C}(\text{CH}_3)\text{OC}_2\text{H}_5$	P (0)	1969, 351
	$(\text{C}_2\text{H}_5\text{O})_2\text{PON}=\text{C}(\text{CH}_3)\text{OC}_2\text{H}_5$	P (134)	1969, 351
$\text{PC}_8\text{H}_{16}\text{N}_3$	$\text{C}_4\text{H}_8\text{NP}[\text{N}(\text{CH}_3)\text{CH}_2]_2$	P (104.8)	1966, 224; 1968, 153, 303, 310
	$\text{P}[\text{N}(\text{CH}_3)\text{CH}_2]_3\text{CCH}_3$	H	1967, 334
$\text{PC}_8\text{H}_{16}\text{N}_3\text{O}$	$\text{OP}[\text{N}(\text{CH}_3)\text{CH}_2]_3\text{CCH}_3$	H	1967, 334
	$\text{C}_4\text{H}_8\text{NP}(\text{O})[\text{N}(\text{CH}_3)\text{CH}_2]_2$	P (23.1)	1968, 153, 310
$\text{PC}_8\text{H}_{16}\text{N}_3\text{S}$	$\text{SP}[\text{N}(\text{CH}_3)\text{CH}_2]_3\text{CCH}_3$	H	1967, 334
$\text{PC}_8\text{H}_{16}\text{ORb}$	$(\text{C}_4\text{H}_9)_2\text{PORb}$	P (94.8)	1968, 320
PC_8H_{19}	$(\text{C}_4\text{H}_9)_2\text{PH}$	P (−69.5)	1965, 3
	$(i\text{-C}_4\text{H}_9)_2\text{PH}$	P (−82)	1965, 3
	$(t\text{-C}_4\text{H}_9)_2\text{PH}$	P (−20.1)	1968, 6
	$\text{C}_6\text{H}_{17}\text{PH}_2$	P (−138)	1966, 4
	$(\text{C}_2\text{H}_5)_3\text{P}=\text{CHCH}_3$	H(T)	1968, 105, 107, 305
$\text{PC}_8\text{H}_{19}\text{BrNO}_3$	$(i\text{-C}_3\text{H}_7\text{O})_2\text{P}(\text{O})\text{NHCH}_2\text{CH}_2\text{Br}$	H	1969, 352
$\text{PC}_8\text{H}_{19}\text{ClN}$	$t\text{-C}_4\text{H}_9(\text{Cl})\text{PNH}t\text{-C}_4\text{H}_9$	H	1969, 112
$\text{PC}_8\text{H}_{19}\text{N}_2\text{OS}$	$[(\text{CH}_3)_2\text{N}]_2\text{P}(\text{O})\text{CH}=\text{CHSC}_2\text{H}_5$	H	1969, 342
$\text{PC}_8\text{H}_{19}\text{N}_2\text{O}_2$	$\text{HP}[\text{OCH}_2\text{C}(\text{CH}_3)\text{NH}]_2$	P (−58)	1968, 304
	$(\text{C}_4\text{H}_9)_2\text{P}(\text{O})\text{H}$	H	1968, 65
$\text{PC}_8\text{H}_{19}\text{O}_2\text{S}_2$	$\text{CH}_3\text{P}(\text{O})(\text{OCH}_3)\text{SCH}_2\text{SC}_5\text{H}_{11}$	H	1969, 101
	$\text{CH}_3\text{P}(\text{O})(\text{OC}_3\text{H}_7)\text{SCH}_2\text{Si-}i\text{-C}_3\text{H}_7$	H	1969, 101
	$\text{CH}_3\text{P}(\text{O})(\text{O}i\text{-C}_3\text{H}_7)\text{SCH}_2\text{Si-}i\text{-C}_3\text{H}_7$	H	1969, 101

Formula	Compound	Resonance	Reference
$\text{PC}_8\text{H}_{19}\text{O}_2\text{S}_3$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{S})\text{C}(\text{CH}_2)_2\text{SC}_2\text{H}_5$	H	1968, 284, 285; 1969, 322
$\text{PC}_8\text{H}_{19}\text{O}_3$	$(\text{C}_4\text{H}_9\text{O})_2\text{P}(\text{O})\text{H}$ $(s\text{-C}_4\text{H}_9\text{O})_2\text{P}(\text{O})\text{H}$ $(\text{C}_2\text{H}_5\text{O})_2\text{POC}(\text{CH}_3)_3$	^{17}O ; P (6·9) P (5·5) P (134·0)	1963, 1; 1967, 277 1967, 277 1967, 293
$\text{PC}_8\text{H}_{19}\text{O}_3$	$\text{C}_2\text{H}_5\text{OP}(\text{O}i\text{-C}_3\text{H}_7)_2$	P (137·3)	1967, 293
$\text{PC}_8\text{H}_{19}\text{O}_3\text{S}$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{St-C}_4\text{H}_9$ $(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{S})\text{O}i\text{-C}_3\text{H}_7$	H P (59·0)	1966, 52 1967, 293
$\text{PC}_8\text{H}_{19}\text{O}_3\text{S}_2$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{S}(\text{CH}_2)_2\text{SC}_2\text{H}_5$	H	1968, 282, 284
$\text{PC}_8\text{H}_{19}\text{O}_4$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})(\text{CH}_2)_2\text{OC}_4\text{H}_9$ $(\text{C}_4\text{H}_9\text{O})_2\text{PO}_2\text{H}$	H ^{13}C	1966, 251; 1967, 293 1968, 22
$\text{PC}_8\text{H}_{19}\text{O}_5$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}(\text{OH})\text{CH}_2\text{OC}_2\text{H}_5$ $(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{OCH}_3$	H H	1969, 82 1969, 82
$\text{PC}_8\text{H}_{19}\text{S}$	$(i\text{-C}_4\text{H}_9)_2\text{P}(\text{S})\text{H}$	P (13·4)	1966, 40
$\text{PC}_8\text{H}_{19}\text{Se}$	$(i\text{-C}_4\text{H}_9)_2\text{P}(\text{Se})\text{H}$	P (−5·3)	1966, 23
PC_8H_{20}	$\text{P}^\oplus(\text{C}_2\text{H}_5)_4$	H; P (40·5)	1966, 22; 1967, 7
$\text{PC}_8\text{H}_{20}\text{BF}_4\text{O}_4$	$(\text{C}_2\text{H}_5\text{O})_4\text{P}^\oplus\text{BF}_4^\ominus$	H; P (−2·4)	1969, 86
$\text{PC}_8\text{H}_{20}\text{Br}$	$(\text{C}_2\text{H}_5)_4\text{PBr}$	^{13}C ; P (40·2)	1968, 3, 6
$\text{PC}_8\text{H}_{20}\text{ClN}_2$	$[(\text{C}_2\text{H}_5)_2\text{N}]_2\text{PCl}$	H	1965, 18
$\text{PC}_8\text{H}_{20}\text{ClN}_2\text{O}$	$[(\text{C}_2\text{H}_5)_2\text{N}]_2\text{P}(\text{O})\text{Cl}$	H	1965, 18
$\text{PC}_8\text{H}_{20}\text{ClN}_2\text{S}$	$[(\text{C}_2\text{H}_5)_2\text{N}]_2\text{P}(\text{S})\text{Cl}$	H	1965, 18
$\text{PC}_8\text{H}_{20}\text{Cl}_6\text{O}_2\text{Sb}$	$(\text{C}_2\text{H}_5)_2(\text{C}_2\text{H}_5\text{O})_2\text{P}^\oplus\text{SbCl}_6^\ominus$	H	1967, 308
$\text{PC}_8\text{H}_{20}\text{Cl}_6\text{O}_3\text{Sb}$	$\text{C}_2\text{H}_5(\text{C}_2\text{H}_5\text{O})_3\text{P}^\oplus\text{SbCl}_6^\ominus$	H; P (4)	1967, 308
$\text{PC}_8\text{H}_{20}\text{Cl}_6\text{O}_4\text{Sb}$	$(\text{C}_2\text{H}_5\text{O})_4\text{P}^\oplus\text{SbCl}_6^\ominus$	H	1967, 308
$\text{PC}_8\text{H}_{20}\text{F}_3\text{N}_2$	$\text{F}_3\text{P}[\text{N}(\text{C}_2\text{H}_5)_2]_2$	F (−60·8; −69)	1966, 217
$\text{PC}_8\text{H}_{20}\text{I}$	$(\text{C}_2\text{H}_5)_4\text{PI}$	H; P (40·1)	1965, 39; 1967, 169, 244
$\text{PC}_8\text{H}_{20}\text{N}$	$(t\text{-C}_4\text{H}_9)_2\text{PNH}_2$	H	1968, 64
$\text{PC}_8\text{H}_{20}\text{NO}$	$\text{CH}_3\text{P}(\text{O}i\text{-C}_3\text{H}_7)[\text{N}(\text{C}_2\text{H}_5)_2]$	H; P (−92·5)	1969, 192

PC ₈ H ₂₀ NO ₂	(<i>t</i> -C ₄ H ₉ O)[(C ₂ H ₅) ₂ N]P(O)H	P (6·5)	1967, 172
PC ₈ H ₂₀ NO ₃	(CH ₃ O) ₂ P(O)CH(<i>i</i> -C ₃ H ₇)N(CH ₃) ₂	H	1965, 36
	(CH ₃ O)P(O)(O [⊖])CH(<i>i</i> -C ₃ H ₇)N [⊕] (CH ₃) ₃	H	1965, 36
	(CH ₂ O) ₂ P(O)C(C ₂ H ₅) ₂ N(CH ₃) ₂	P (50)	1969, 340
	(C ₂ H ₅ O) ₂ P(O)NH <i>t</i> -C ₄ H ₉	H	1969, 110
PC ₈ H ₂₀ NO ₃ S	O [⊖] P(S)O(CH ₂) ₂ CH(CH ₃)O, N [⊕] (CH ₃) ₄	H; P (112·8)	1969, 176
PC ₈ H ₂₀ NO ₄	(<i>i</i> -C ₃ H ₇ O) ₂ P(O)O(CH ₂) ₂	H; P (-10·8)	1967, 185
	(<i>i</i> -C ₃ H ₇ O) ₂ P(O)NH(CH ₂) ₂ OH	H; P (8·2)	1967, 185
PC ₈ H ₂₀ N ₂ O	[(CH ₃) ₂ N] ₂ P(O)NCH ₂ C(CH ₃) ₂	H	1966, 246
	[(CH ₃) ₂ N](C ₂ H ₅ O)PN(CH ₃)CN(CH ₃) ₂	H; P (128·8)	1968, 321
	[(CH ₃) ₂ N] ₂ P(O)CH=CHN(CH ₃) ₂	H	1969, 342
PC ₈ H ₂₀ N ₃ OS	[(CH ₃) ₂ N](C ₂ H ₅ O)P(S)N(CH ₃)CN(CH ₃) ₂	P (71·3)	1968, 321
PC ₈ H ₂₁ BN ₃	CH ₃ C[CH ₂ (CH ₃)N] ₃ PBH ₃	H	1967, 334
PC ₈ H ₂₁ BN ₃ O	CH ₃ C[CH ₂ (CH ₃)(BH ₃)N][CH ₂ (CH ₃)N] ₂ PO	H	1967, 334
PC ₈ H ₂₁ BN ₃ S	CH ₃ C[CH ₂ (CH ₃)(BH ₃)N][CH ₂ (CH ₃)N] ₂ PS	H	1967, 334
PC ₈ H ₂₁ ClNO ₃	(C ₂ H ₅ O) ₂ P(O)CH(<i>i</i> -C ₃ H ₇)NH ₃ Cl	P (21·3)	1968, 296
PC ₈ H ₂₁ O ₃ Si	(C ₂ H ₅ O)[(C ₂ H ₅) ₃ SiO]P(O)H	H	1967, 34
PC ₈ H ₂₁ Si	(CH ₃) ₃ SiCH=P(CH ₃) ₂ C ₂ H ₅	H	1968, 105, 107, 322
PC ₈ H ₂₂ AlO	(CH ₃) ₃ POAl(C ₂ H ₅) ₃	H	1965, 83
PC ₈ H ₂₂ ClSi	(CH ₃) ₂ (C ₂ H ₅)P [⊕] CH ₂ Si(CH ₃) ₃ , Cl [⊖]	H	1968, 322
	(CH ₃) ₃ P [⊕] CH(CH ₃)Si(CH ₃) ₃ , Cl [⊖]	H	1968, 107, 322
PC ₈ H ₂₂ N ₃ O	[(CH ₃) ₂ N] ₂ P(O)NH <i>t</i> -C ₄ H ₉	H	1968, 91
PC ₈ H ₂₂ N ₃ O ₂	[(CH ₃) ₂ N] ₂ P(O)NHCH(CH ₃)CH ₂ OCH ₃	H	1966, 246
PC ₈ H ₂₄ B ₂ N ₃	BH ₃ P[N(CH ₃)CH ₂] ₂ [N(BH ₂)CH ₂]CCH ₃	H	1967, 334
PC ₉ H ₁₆ ClF ₄	CF ₂ CCl=CF ₂ PHC ₆ H ₅	H; F (-80·8; -79·4; -90·6)	1967, 295
PC ₉ H ₉ Cl ₄ O ₅	(CH ₃ O) ₃ POC ₆ Cl ₄ O	H; P (-46·2)	1968, 315
PC ₉ H ₉ F ₁₂ O ₂	(CH ₃) ₃ P[OC(CF ₃) ₂] ₂	H; P (3·2); F (9·3)	1968, 302

Formula	Compound	Resonance	Reference
$\text{PC}_9\text{H}_9\text{F}_{12}\text{O}_2$	$(\text{CH}_3)_2[(\text{CF}_3)_2\text{CHO}]\text{POC}(\text{CF}_3)_2\text{CH}_2$ $\begin{array}{c} \text{---} \text{---} \text{---} \\ \\ \text{---} \end{array}$	H (T); P (-23.7); F	1968, 302
$\text{PC}_9\text{H}_9\text{F}_{12}\text{O}_5$	$(\text{CH}_3\text{O})_3\text{P}[\text{OC}(\text{CF}_3)_2]_2$	P (-50.1)	1966, 225; 1967, 335; 1968, 124, 310
$\text{PC}_9\text{H}_9\text{O}_3$	$\text{CH}_2=\text{C}=\text{CHP}(\text{O})(\text{OCH}_2\text{C}\equiv\text{CH})_2$	H	1967, 104; 1969, 115
$\text{PC}_9\text{H}_9\text{O}_4$	$\text{C}_6\text{H}_5\text{C}(\text{O})\text{OP}(\text{OCH}_2)_2$	H	1966, 50
$\text{PC}_9\text{H}_9\text{S}$	$(\text{CH}_3\text{C}\equiv\text{C})_3\text{PS}$	H	1965, 96
$\text{PC}_9\text{H}_{10}\text{ClO}_2$	$\text{C}_2\text{H}_5\text{P}(\text{CH}_2\text{COOCH}_3)\text{Cl}$ $\begin{array}{c} \text{---} \text{---} \text{---} \\ \\ \text{---} \end{array}$	H P (175)	1968, 297 1969, 45
$\text{PC}_9\text{H}_{10}\text{ClO}_2\text{S}$	$\text{ClP}(\text{S})\text{OCH}(\text{C}_6\text{H}_5)(\text{CH}_2)_2\text{O}$ $\begin{array}{c} \text{---} \text{---} \text{---} \\ \\ \text{---} \end{array}$	H	1969, 95
$\text{PC}_9\text{H}_{10}\text{ClO}_3$	$\text{ClP}(\text{O})\text{OCH}(\text{C}_6\text{H}_5)(\text{CH}_2)_2\text{O}$ $\begin{array}{c} \text{---} \text{---} \text{---} \\ \\ \text{---} \end{array}$	H	1969, 95
$\text{PC}_9\text{H}_{10}\text{Cl}_4\text{NO}_2\text{S}$	$\text{C}_6\text{HCl}_4\text{OP}(\text{S})(\text{OCH}_3)\text{NHC}_2\text{H}_5$	H	1967, 116
$\text{PC}_9\text{H}_{10}\text{KO}_4$	$\text{O}(\text{CH}_2)_2\text{CH}(\text{C}_6\text{H}_5)\text{OP}(\text{O})\text{O}^\ominus, \text{K}^\oplus$ $\begin{array}{c} \text{---} \text{---} \text{---} \\ \\ \text{---} \end{array}$	H	1969, 95
$\text{PC}_9\text{H}_{11}\text{Ba}_{\frac{1}{2}}\text{ClO}_5$	$\text{CH}_3\text{CHOHCH}_2\text{OP}(\text{O})(\text{O}^\ominus)(\text{OC}_6\text{H}_7\text{Cl}), \text{Ba}_{\frac{1}{2}}^\oplus$	H	1965, 88
$\text{PC}_9\text{H}_{11}\text{Ba}_{\frac{1}{2}}\text{NO}_7$	$\text{CH}_3\text{CHOHCH}_2\text{OP}(\text{O})(\text{O}^\ominus)(\text{OC}_6\text{H}_4\text{NO}_2), \text{Ba}_{\frac{1}{2}}^\oplus$	H	1965, 88
$\text{PC}_9\text{H}_{11}\text{Cl}_2\text{HgO}_3$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{CCl}_2\text{HgC}_6\text{H}_5$	H	1966, 252
$\text{PC}_9\text{H}_{11}\text{O}$	$\text{C}_6\text{H}_5\text{PO}(\text{CH}_2)_3$ $\begin{array}{c} \text{---} \text{---} \text{---} \\ \\ \text{---} \end{array}$	H; P (110.2)	1967, 138
$\text{PC}_9\text{H}_{11}\text{OS}$	$\text{C}_6\text{H}_5\text{P}(\text{S})\text{O}(\text{CH}_2)_3$ $\begin{array}{c} \text{---} \text{---} \text{---} \\ \\ \text{---} \end{array}$	H; P (102.4)	1967, 138
	$\text{C}_6\text{H}_5\text{SPO}(\text{CH}_2)_3$ $\begin{array}{c} \text{---} \text{---} \text{---} \\ \\ \text{---} \end{array}$	H; P (79.0)	1967, 138
$\text{PC}_9\text{H}_{11}\text{O}_2$	$\text{C}_6\text{H}_5\text{P}(\text{O})\text{O}(\text{CH}_2)_3$ $\begin{array}{c} \text{---} \text{---} \text{---} \\ \\ \text{---} \end{array}$	H; P (58.4)	1967, 138

PC ₉ H ₁₁ O ₂ S ₄	CH ₃ OP(S)SC(S)CSC(CH ₃)C(C ₂ H ₅)CO 	H	1969, 148
PC ₉ H ₁₁ O ₃	CH ₃ CH=C(C ₆ H ₅)PO ₃ H ₂ (<i>trans, cis</i>) C ₆ H ₄ (CH ₂) ₂ CHPO ₃ H ₂ C ₆ H ₅ P(O)OCH(CH ₃)CH ₂ O C ₆ H ₅ OPO(CH ₂) ₃ O 	H; P (14·8; 8·9) H; P (11·0) P (10·4; 11·0) H	1966, 241 1966, 241 1969, 343 1969, 93
PC ₉ H ₁₁ O ₄	C ₆ H ₅ OP(O)(OCH ₂) ₂ CH ₂ HCOC ₆ H ₄ P(O)(OCH ₃) ₂	H H	1968, 83; 1969, 93 1968, 317
PC ₉ H ₁₂ Ba _{1/2} O ₅	CH ₃ CHOHCH ₂ OP(O)(O [⊖])(OC ₆ H ₅), Ba [⊕] _{1/2}	H	1965, 88
PC ₉ H ₁₂ BrO ₂	BrC ₆ H ₄ CH ₂ P(O)(OCH ₃) ₂ BrCH ₂ C ₆ H ₄ P(O)(OCH ₃) ₂	H H	1967, 117 1966, 253
PC ₉ H ₁₂ BrO ₃	BrCH ₂ C ₆ H ₄ OP(O)(OCH ₃) ₂	H	1966, 253
PC ₉ H ₁₂ ClHgO ₃	(CH ₃ O) ₂ P(O)CHClHgC ₆ H ₅	H	1966, 252
PC ₉ H ₁₂ ClO ₂ S	(CH ₃ O) ₂ P(S)SCH ₂ SC ₆ H ₄ Cl	H	1968, 284, 285
PC ₉ H ₁₂ Cl ₂ NO ₃	CH ₃ O(C ₂ H ₅ NH)P(O)OC ₆ H ₃ Cl ₂	H	1969, 110
PC ₉ H ₁₂ FO ₂	C ₆ H ₅ (<i>i</i> -C ₃ H ₇ O)P(O)F	F (−64·9)	1967, 13; 1968, 295
PC ₉ H ₁₂ N	C ₆ H ₅ P(CH ₂) ₂ NHCH ₃ 	H	1967, 137
PC ₉ H ₁₂ NO ₂	C ₆ H ₅ P(O)OCH ₂ CH ₂ NCH ₃ (CH ₃) ₂ NPOC ₆ H ₃ (CH ₃)O 	H; P (35·7) P (150)	1969, 171 1969, 45
PC ₉ H ₁₂ NO ₃	HP(OC ₆ H ₄ O)[OCH(CH ₃)CH ₂ NH] HP(OC ₆ H ₄ O)[OCH ₂ CH ₂ NCH ₃] OC ₆ H ₄ OPO(CH ₂) ₂ NHCH ₃ 	P (−35) P (−99·5) P (130)	1969, 45, 178 1969, 45 1969, 45

Formula	Compound	Resonance	Reference
PC ₉ H ₁₂ NO ₃	C ₆ H ₅ OP(O)OCH ₂ CH ₂ NCH ₃	H; P (15·5)	1968, 76
PC ₉ H ₁₂ NO ₄	CH ₃ (C ₂ H ₅ O)P(O)C ₆ H ₄ NO ₂	H	1969, 119
PC ₉ H ₁₂ N ₃	P(CH ₂ CH ₂ CN) ₃	P (−23)	1966, 4; 1967, 244
PC ₉ H ₁₂ N ₃ O ₇	CH=CH(NH ₂)CNC(O)NCHOCH(CH ₂ OPO ₂ H)CH(OH)CHO	H	1969, 98
PC ₉ H ₁₃	CH ₃ C ₆ H ₄ P(CH ₃) ₂	H	1968, 15
PC ₉ H ₁₃ F	FC ₆ H ₄ P [⊕] (CH ₃) ₃	F	1965, 5
PC ₉ H ₁₃ FI	FC ₆ H ₄ P [⊕] (CH ₃) ₃ I [⊖]	F	1968, 13; 1969, 18, 19
PC ₉ H ₁₃ N ₂ S	(CH ₃) ₂ NPSC ₆ H ₄ NCH ₃	H	1968, 304
PC ₉ H ₁₃ O ₂	C ₆ H ₅ (<i>i</i> -C ₃ H ₇ O)P(O)H	H	1969, 162
PC ₉ H ₁₃ O ₃	(CH ₃ O) ₂ P(O)C ₆ H ₄ CH ₃	H	1966, 70, 253; 1967, 117; 1968, 317
PC ₉ H ₁₃ O ₄	(CH ₃ O) ₂ P(O)OC ₆ H ₄ CH ₃	H	1967, 117; 1968, 317
	(CH ₃ O) ₂ P(O)C ₆ H ₄ CH ₂ OH	H	1966, 253
PC ₉ H ₁₃ O ₅	(CH ₃ O) ₂ P(O)OC ₆ H ₄ OCH ₃	P (−3·7)	1966, 242; 1968, 301, 318
	(CH ₃ O) ₃ POC ₆ H ₄ O	H	1968, 124
PC ₉ H ₁₃ O ₇	CH ₃ OP(O)OC(CH ₃)(COCH ₃)C(OCH ₃)=CCOOH (isom.)	H; P (30·4; 29·8)	1969, 353
PC ₉ H ₁₄ Br	(CH ₃) ₃ P [⊕] C ₆ H ₅ , Br [⊖]	P (23·3)	1968, 6
PC ₉ H ₁₄ Cl ₆ O ₂ SSb	(CH ₃ O) ₂ (C ₆ H ₅)P [⊕] SCH ₃ , SbCl ₆ [⊖]	H; P (83·9)	1969, 87
PC ₉ H ₁₄ Cl ₆ O ₂ SbSe	(CH ₃ O) ₂ (C ₆ H ₅)P [⊕] SeCH ₃ , SbCl ₆ [⊖]	H; P (84·6)	1969, 87
PC ₉ H ₁₄ Cl ₆ O ₃ Sb	(CH ₃ O) ₃ (C ₆ H ₅)P [⊕] SbCl ₆ [⊖]	H; P (35·1)	1969, 87

PC ₉ H ₁₄ NO ₄	OCH(C ₆ H ₅)CH(CH ₂) ₂ OPO ₂ [⊖] , NH ₄ [⊕]	H	1967, 90
	(C ₂ H ₅ O) ₂ P(O)C ₅ H ₄ N	H	1969, 119
PC ₉ H ₁₄ NO ₅	(CH ₃ O) ₂ C ₆ H ₃ CH(NH ₂)PO ₃ H ₂	H	1968, 142
PC ₉ H ₁₄ N ₃ O ₈	CH=CH(NH ₂)CNC(O)NCHOCH(CH ₂ OH)CH(OH)CHOPO ₃ H ₂	H	1969, 119
	CH=CH(NH ₂)CNC(O)NCHOCH(CH ₂ OPO ₃ H ₂)CH(OH)CHOH	H	1969, 119
PC ₉ H ₁₅	P(CH ₂ CH=CH ₂) ₃	P (-34.3)	1967, 244
	P[CH(CH ₂) ₂] ₃	H; P (17.1)	1969, 354
PC ₉ H ₁₅ N ₂ O	CH ₃ [(CH ₃) ₂ N]P(O)NHC ₆ H ₅	H	1965, 82
PC ₉ H ₁₅ N ₂ O ₅ S	NH ₂ NHSO ₂ C ₆ H ₄ CH ₂ P(O)(OCH ₃) ₂	H	1966, 71
PC ₉ H ₁₅ N ₂ O ₇	(CH ₃ O) ₂ P(O)OCC(O)N(CH ₃)C(OCH ₃)NC(OCH ₃)	H; P (-1.3)	1966, 242
	(CH ₃ O) ₂ P(O)OC[C(OCH ₃)N] ₂ COCH ₃	H; P (-2.2)	1966, 242
PC ₉ H ₁₅ O ₃	CH ₂ =CHCH ₂ P(O)(OCH ₂ CH=CH ₂) ₂	H	1966, 254
	(C ₂ H ₅ O) ₂ P(O)C≡CC(CH ₃)=CH ₂	H; P (-9.2)	1967, 21
PC ₉ H ₁₅ O ₃ S	CH ₃ COCH ₂ P(S)[OC(CH ₃)=CH ₂] ₂	H	1968, 297
PC ₉ H ₁₅ O ₄	(CH ₃ O) ₂ P(O)C(OH)CH(CH ₂)CH=CHCH ₂	H{P}	1969, 80
PC ₉ H ₁₅ O ₅ S	CH ₃ COCH ₂ P(S)(CH ₂ COOCH ₃) ₂	H	1968, 297
PC ₉ H ₁₅ O ₆	P(CH ₂ COOCH ₃) ₂	H	1968, 297
PC ₉ H ₁₆ BrO ₄	(CH ₃ O) ₂ P(O)C(OH)CH(CHBr)(CH ₂) ₂ CHCH ₂	H	1969, 80
PC ₉ H ₁₆ ClN ₃	C ₆ H ₅ P [⊕] (NH ₂)[N(CH ₃)N(CH ₃) ₂], Cl [⊖]	H; P (39.9)	1967, 94
PC ₉ H ₁₆ NO ₃	(C ₂ H ₅ O) ₂ P(O)C(CN)=C(CH ₃) ₂	H	1968, 323
PC ₉ H ₁₇ Cl ₃ NO ₇	(C ₂ H ₅ O) ₂ P(O)CH(OCONHCOC ₂ H ₅)CH ₂ OCH ₃	H	1969, 82
PC ₉ H ₁₇ N ₂ O ₃ S	[(CH ₃) ₂ CO] ₂ P(S)O [⊖] , C ₃ H ₅ N ₂ [⊕]	P (144.3)	1969, 177

Formula	Compound	Resonance	Reference
PC ₉ H ₁₇ O	C ₆ H ₁₁ PO(CH ₂) ₃ 	H; P (123·1)	1967, 138
PC ₉ H ₁₇ O ₂	C ₆ H ₁₁ P(O)O(CH ₂) ₃ 	H; P (71·1)	1967, 138
PC ₉ H ₁₇ O ₃	P(OCH ₂) ₃ C(CH ₂) ₄ CH ₃	H	1966, 48
	CH ₂ =C=CHP(O)(O <i>i</i> -C ₃ H ₇) ₂	H	1967, 104; 1969, 115
	C ₃ H ₇ C≡CP(O)(OC ₂ H ₅) ₂	H	1967, 21
	CH ₂ =CHC(CH ₃)=CHP(O)(OC ₂ H ₅) ₂	H	1969, 163
PC ₉ H ₁₇ O ₃ S	SP(CH ₂ O) ₃ C(CH ₂) ₄ CH ₃	H	1968, 53
PC ₉ H ₁₇ O ₄	(CH ₃ O) ₂ P(O)CHC(CH ₂) ₅ O 	H	1967, 81
	OP(OCH ₂) ₃ C(CH ₂) ₄ CH ₃	H	1966, 48
	OP(CH ₂ O) ₃ C(CH ₂) ₄ CH ₃	H	1968, 53
	<i>i</i> -C ₃ H ₇ OP(O)(CH ₂ CHOCH ₂) ₂ 	H	1966, 254
	CH ₃ OP(O)[OCH ₂ CH(CH ₂) ₂] ₂	H	1966, 213
	(CH ₃ O) ₂ P(O)C(CH ₂) ₅ CHO	H	1967, 81
	(C ₂ H ₅ O) ₂ P(O)C(O)C ₄ H ₇	H	1967, 166
	(CH ₃ O)P(O)C(O)C ₆ H ₁₁	H	1967, 166
	(C ₂ H ₅ O) ₂ P(O)OC(CH ₃) ₂ C≡CH	H; P (-7·3)	1967, 21
	(CH ₃ O) ₂ P(O)C(OH)CH(CH ₂)(CH ₂) ₂ CHCH ₂ 	H	1969, 80
	(C ₂ H ₅ O) ₂ P(O)C(CH ₃)CHCOCH ₃	H	1969, 355
	(CH ₃ O) ₃ POC(=CH ₂)C(CH ₃)(COCH ₃)O 	P (-51·4)	1968, 313; 1969, 353
PC ₉ H ₁₇ S ₃	P(SCH ₂) ₃ CC ₅ H ₁₁	H; P (32·8)	1969, 71
PC ₉ H ₁₈	CH ₃ P[C(CH ₃) ₂] ₂ CCH ₃	H(T)	1968, 121
PC ₉ H ₁₈ BrO ₃	(C ₂ H ₅ O) ₂ P(O)CH ₂ CBr=C(CH ₃) ₂	H; P (24·2)	1967, 323

PC ₉ H ₁₈ ClN ₂ O ₂	[NC(CH ₃) ₂] ₂ P(O)OCH(CH ₃)CH ₂ Cl	H	1966, 220
PC ₉ H ₁₈ Cl ₃ N ₂ O	Cl ₃ P(NC ₄ H ₉) ₂ CO	H	1965, 6
PC ₉ H ₁₈ LiO ₅	CH ₃ CHOHCH ₂ OP(O)(O) [⊖] (OC ₆ H ₁₁), Li [⊕]	H	1965, 88
PC ₉ H ₁₈ NO ₂	(C ₂ H ₅) ₂ NP(O)O[C(CH ₃) ₂]CH ₂	H	1967, 311
PC ₉ H ₁₈ NO ₂ S	(C ₂ H ₅ O) ₂ P(O)NS(O)CH(CH ₃)CH=CHCH ₂	H	1965, 93
	(C ₂ H ₅ O) ₂ P(O)NS(O)CH ₂ CH=CHCHCH ₃	H	1965, 93
	(C ₂ H ₅ O) ₂ P(O)NS(O)CH ₂ CH=C(CH ₃)CH ₂	H	1965, 93
PC ₉ H ₁₈ NO ₃	(CH ₂ O) ₂ P(O)C[N(CH ₃) ₂ C ₄ H ₈	H; P	1968, 324
PC ₉ H ₁₈ N ₃ O ₃	(CH ₃ CHCH ₂ N) ₂ P(O)NHCOOC ₂ H ₅	H	1965, 42
PC ₉ H ₁₈ F ₂ O	(C ₄ H ₉) ₂ P(O)CHF ₂	H	1965, 97
PC ₉ H ₁₉ N ₂ O	[(CH ₃) ₂ N] ₂ P(O)CH=C=C(CH ₃) ₂	H	1969, 115
PC ₉ H ₁₉ N ₄	[(CH ₃)N] ₂ PNCHC(CH ₃)C(CH ₃)N	H	1967, 119
PC ₉ H ₁₉ O	CH ₃ P(O)[C(CH ₃) ₂] ₂ CHCH ₃	H	1967, 82
	(C ₃ H ₇) ₂ POC(CH ₃)=CH ₂	H	1968, 297
	C ₂ H ₅ P(CH ₂ CH ₂) ₂ CH ₂ CH ₂ OH	H	1969, 356
PC ₉ H ₁₉ O ₂	C ₄ H ₉ (C ₂ H ₅ O)PCH ₂ COCH ₃	H	1968, 297
	C ₅ H ₁₀ P(O)OC ₄ H ₉	H	1969, 142
PC ₉ H ₁₉ O ₂ S	C ₄ H ₉ (C ₂ H ₅ O)P(S)CH ₂ COCH ₃	H	1968, 297
	C ₄ H ₉ (C ₂ H ₅ O)P(S)OC(CH ₃)=CH ₂	H	1968, 297
PC ₉ H ₁₉ O ₂ S ₃	(C ₂ H ₅ S) ₂ P(O)(CH ₂) ₂ C(O)SC ₂ H ₅	H	1967, 313
PC ₉ H ₁₉ O ₃	C ₄ H ₉ P(O)(OCH ₂) ₂ C(CH ₃) ₂	H	1967, 91
	(C ₂ H ₅ O) ₂ POC(CH ₃) ₂ CH=CH ₂	H	1967, 293
	(C ₂ H ₅ O) ₂ P(O)CH=CH <i>i</i> -C ₃ H ₇	H	1968, 314
PC ₉ H ₁₉ O ₃ S	(C ₂ H ₅ O) ₂ P(O)SCH ₂ =CHC(CH ₃) ₂	H	1966, 52
	(C ₂ H ₅ O) ₂ P(O)SC(CH ₃) ₂ CH=CH ₂	H	1966, 52

Formula	Compound	Resonance	Reference
PC ₉ H ₁₉ O ₃ S	(C ₂ H ₅ O) ₂ P(O)SC ₅ H ₉	H	1966, 52
	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH=CHSC ₂ H ₅	H; P (24·7)	1967, 108
	(<i>i</i> -C ₃ H ₇ O) ₂ P(O)SCH ₂ CH=CH ₂	H	1967, 307
PC ₉ H ₁₉ O ₄	<i>t</i> -C ₄ H ₉ OP(O)(OCH ₂) ₂ C(CH ₃) ₂	H	1967, 91
	C ₂ H ₅ OPOCH ₂ [CH(CH ₃)(OCH ₃)]C(CH ₃)CH ₂ O	H; P (138·7)	1967, 161, 162
PC ₉ H ₁₉ O ₅	(C ₂ H ₅ O) ₂ P(O)C(O) <i>t</i> -C ₄ H ₉	H	1967, 166
	(C ₂ H ₅ O) ₂ P(O)CH=C(CH ₃)OC ₂ H ₅	H; P (21·6)	1967, 278
	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH=CHOC ₂ H ₅	H; P (27)	1967, 108, 278
	(C ₂ H ₅ O) ₂ P(O)(CH ₂) ₂ COOC ₂ H ₅	H	1966, 249; 1967, 313
	(C ₂ H ₅ O) ₂ P(O)CH ₂ COCH ₂ OC ₂ H ₅	H; P (19)	1967, 22, 278
PC ₉ H ₁₉ O ₆	(C ₂ H ₅ O) ₂ P(O)CH(OC ₂ H ₅)CH ₂ COOH	H	1966, 249
PC ₉ H ₂₀ BF ₄ O ₄	(C ₂ H ₅ O) ₂ P [⊕] (OCH ₂) ₂ C(CH ₃) ₂ , BF ₄ [⊖]	H; P (-4·3)	1969, 86
PC ₉ H ₂₀ NO ₂	(C ₂ H ₅) ₂ P(O)CH ₂ C(O)CH ₂ N(CH ₃) ₂	H	1968, 325
PC ₉ H ₂₀ NO ₂ S	(CH ₃) ₂ NP(S)(OCH ₂) ₂ C(CH ₃) ₂	H	1967, 91
PC ₉ H ₂₀ NO ₃	<i>t</i> -C ₄ H ₉ NHP(O)(OCH ₂) ₂ C(CH ₃) ₂	H	1967, 91; 1968, 74
	HP[OC(CH ₃) ₂] ₂ OCH(CH ₃)CH ₂ NH	H; P (-49·5)	1967, 164
PC ₉ H ₂₀ NO ₄	(C ₂ H ₅ O) ₂ P(O)CH=C(CH ₃)N(CH ₃) ₂	H; P (26·6)	1967, 278, 324
	(CH ₂ O) ₂ P(O)C(C ₂ H ₅) ₂ N(CH ₃) ₂	H; P (50)	1968, 324
	(C ₂ H ₅ O) ₂ P=NC(OCH ₃) <i>i</i> -C ₃ H ₇	P (138)	1969, 357
	(C ₂ H ₅) ₂ NP(O)(OCH ₂) ₂ C(CH ₃) ₂	H	1969, 97
	(C ₂ H ₅ O) ₂ P(O)NCH(O <i>i</i> -C ₄ H ₉)	H	1966, 55
	(C ₄ H ₉ O) ₂ P(O)NHCHO	H	1966, 235
	(C ₂ H ₅ O) ₂ P(O)(CH ₂) ₂ CONHC ₂ H ₅	H	1966, 249
	(C ₂ H ₅ O) ₂ P(O)CH ₂ C(O)CH ₂ N(CH ₃) ₂	H; P (19·7)	1967, 22
	(CH ₃ O) ₂ P(O)C(O)N(<i>i</i> -C ₃ H ₇) ₂	H	1967, 26; 1968, 29
	(C ₂ H ₅ O) ₂ P(O)C(O)N(C ₂ H ₅) ₂	H	1967, 26
	(<i>i</i> -C ₃ H ₇ O) ₂ P(O)C(O)N(CH ₃) ₂	H	1967, 26

PC ₉ H ₂₀ NO ₅	(<i>i</i> -C ₃ H ₇ O) ₂ P(O)C(O)NHC ₂ H ₅	H	1967, 26
PC ₉ H ₂₁	C ₂ H ₅ OP(O ₂ [⊖])C(CH ₃)(COOCH ₃)N [⊕] (CH ₃) ₃	H	1969, 346
	(C ₃ H ₇) ₃ P	P (-33)	1965, 3
	(<i>i</i> -C ₃ H ₇) ₃ P	H; P (19.4)	1965, 3; 1967, 244, 277; 1968, 6, 7; 1969, 354
PC ₉ H ₂₁ Cl ₂	(C ₃ H ₇) ₃ PCl ₂	H; P	1969, 282
PC ₉ H ₂₁ FN	CH ₃ PF[N(C ₄ H ₉) ₂]	P (167)	1967, 204; 1968, 12
PC ₉ H ₂₁ F ₃ N	F ₃ P(CH ₃)[N(C ₄ H ₉) ₂]	P (-38.8); F (-71; -34)	1967, 64
PC ₉ H ₂₁ N ₂ O ₃	[(CH ₃) ₂ N] ₂ POCH(CH ₃)COOC ₂ H ₅	P (144)	1969, 109
PC ₉ H ₂₁ O	(<i>i</i> -C ₃ H ₇) ₃ PO	P (55.0)	1967, 277
PC ₉ H ₂₁ O ₂	(<i>i</i> -C ₃ H ₇) ₂ P(O)Oi-C ₃ H ₇	H	1968, 65
PC ₉ H ₂₁ O ₂ S ₂	CH ₃ P(O)(OC ₄ H ₉)SCH ₂ Si-C ₃ H ₇	H	1969, 101
PC ₉ H ₂₁ O ₃	CH ₃ P(O)(Ot-C ₄ H ₉) ₂	H	1967, 336
	(<i>i</i> -C ₃ H ₇ O) ₃ P	P (137)	1967, 277, 293; 1969, 50
	(C ₂ H ₅ O) ₂ POCH ₂ C(CH ₃) ₃	P (137.2)	1967, 277
	CH ₃ OP(Ot-C ₄ H ₉) ₂	P (130.5)	1967, 277
PC ₉ H ₂₁ O ₃ S	(<i>i</i> -C ₃ H ₇ O) ₃ PS	P (62.5)	1967, 277
	(C ₂ H ₅ O) ₂ P(O)SC ₅ H ₁₁	H	1967, 307
PC ₉ H ₂₁ O ₃ Se	(<i>i</i> -C ₃ H ₇ O)PSe	P (67.9)	1967, 277
PC ₉ H ₂₁ O ₄	(C ₃ H ₇ O) ₃ PO	H{P}	1967, 85
	(<i>i</i> -C ₃ H ₇ O) ₃ PO	P (-3 to -6)	1967, 277, 293
PC ₉ H ₂₁ O ₅	(CH ₃ O) ₃ P[OC(CH ₃) ₂] ₂	P (-48.9)	1968, 318
	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH(OH)CH ₂ OC ₂ H ₅	H	1969, 82
PC ₉ H ₂₁ S	(<i>i</i> -C ₃ H ₇) ₃ PS	P (74.0)	1967, 277
PC ₉ H ₂₂	<i>i</i> -C ₃ H ₇ P [⊕] (C ₂ H ₅) ₃	P (42.8)	1967, 7
PC ₉ H ₂₂ Br	HP [⊕] (<i>i</i> -C ₃ H ₇) ₃ Br [⊖]	H; P (39.6)	1968, 7
PC ₉ H ₂₂ F ₂ N ₃	[(C ₂ H ₅) ₂ N] ₃ P=CF ₂	P (-58.0)	1964, 9
PC ₉ H ₂₂ NO	(C ₂ H ₅ O)[(CH ₃) ₂ N]PN(C ₂ H ₅)CN(CH ₃) ₂	H; P (128.1)	1968, 321

Formula	Compound	Resonance	Reference
$\text{PC}_9\text{H}_{22}\text{NOS}$	$(\text{C}_2\text{H}_5\text{O})[(\text{CH}_3)_2\text{N}]\text{P}(\text{S})\text{N}(\text{C}_2\text{H}_5)\text{CN}(\text{CH}_3)_2$	H; P (69·4)	1968, 321
$\text{PC}_9\text{H}_{22}\text{NO}_2$	$(t\text{-C}_6\text{H}_{11}\text{O})[(\text{C}_2\text{H}_5)_2\text{N}]\text{P}(\text{O})\text{H}$	P (6·4)	1967, 172
$\text{PC}_9\text{H}_{22}\text{NO}_3$	$\text{CH}_3\text{OP}(\text{O})(\text{O}^\ominus)\text{CH}(i\text{-C}_3\text{H}_7), \text{C}_3\text{H}_7\text{NH}_2^\oplus$	H	1965, 36
	$(\text{C}_4\text{H}_9\text{O})_2\text{P}(\text{O})\text{NHCH}_3$	H	1966, 55, 235
$\text{PC}_9\text{H}_{22}\text{N}_2\text{O}_2$	$\text{C}_4\text{H}_9\text{OP}(\text{O})\text{N}(i\text{-C}_3\text{H}_7)[\text{N}(\text{CH}_3)_2]$	H	1965, 92
$\text{PC}_9\text{H}_{22}\text{N}_3\text{O}$	$[(\text{CH}_3)_2\text{N}]_2\text{P}=\text{NC}(\text{OCH}_3)\text{C}_3\text{H}_7$	P (100)	1969, 357
$\text{PC}_9\text{H}_{22}\text{ClN}_3\text{O}$	$[(\text{CH}_3)_2\text{N}]_2\text{P}(\text{O})\text{NHCH}(\text{CH}_3)\text{CH}_2\text{Cl}$	H	1966, 246
	$[(\text{CH}_3)_2\text{N}]_2\text{P}(\text{O})\text{NHCH}_2\text{CH}(\text{CH}_3)\text{Cl}$	H	1966, 246
$\text{PC}_9\text{H}_{23}\text{ClNO}_3$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}(s\text{-C}_4\text{H}_9)\text{NH}_3^\oplus\text{Cl}^\ominus$	P (21·3)	1968, 296
$\text{PC}_9\text{H}_{23}\text{N}_2$	$\text{CH}_3\text{P}[\text{N}(\text{C}_2\text{H}_5)_2]_2$	H; P (−145·5)	1969, 192
$\text{PC}_9\text{H}_{23}\text{N}_4\text{Si}$	$\text{CH}_3\text{N}(\text{CH}_2)_2\text{N}(\text{CH}_3)\text{P}[\text{N}(\text{CH}_2)_2\text{NSi}(\text{CH}_3)_3]$	H	1967, 305
$\text{PC}_9\text{H}_{23}\text{OSi}$	$(\text{CH}_3)_3\text{SiO}(\text{CH}_2)_4\text{P}(\text{CH}_3)_2$	H; P (−53·6)	1968, 326
$\text{PC}_9\text{H}_{23}\text{O}_2$	$\text{CH}_3\text{P}(\text{O}s\text{-C}_4\text{H}_9)_2(\text{stereois.})$	H; P (185·4; 182·8; 179·6)	1969, 162
$\text{PC}_9\text{H}_{23}\text{O}_3\text{Si}$	$\text{C}_3\text{H}_7\text{O}[(\text{C}_2\text{H}_5)_3\text{SiO}]\text{P}(\text{O})\text{H}$	H	1967, 34
$\text{PC}_9\text{H}_{23}\text{O}_7\text{S}$	$\text{HP}^\oplus(\text{OC}_3\text{H}_7\text{-}i), \text{HSO}_4^\ominus$	P (16)	1969, 50
$\text{PC}_9\text{H}_{24}\text{AlO}$	$(\text{C}_2\text{H}_5)_3\text{POAl}(\text{CH}_3)_3$	H	1965, 83
$\text{PC}_9\text{H}_{24}\text{GeN}$	$(\text{CH}_3)_3\text{GeN}=\text{P}(\text{C}_2\text{H}_5)_3$	H	1967, 73
$\text{PC}_9\text{H}_{24}\text{NO}_3\text{Sn}$	$(\text{C}_2\text{H}_5)_3\text{SnN}(\text{CH}_3)\text{P}(\text{O})(\text{OCH}_3)_2$	H	1967, 299
$\text{PC}_9\text{H}_{24}\text{NSi}$	$(\text{CH}_3)_3\text{SiN}=\text{P}(\text{C}_2\text{H}_5)_3$	H	1967, 73, 322
$\text{PC}_9\text{H}_{24}\text{NSn}$	$(\text{CH}_3)_3\text{SnN}=\text{P}(\text{C}_2\text{H}_5)_3$	H	1967, 73
$\text{PC}_9\text{H}_{24}\text{N}_3\text{O}$	$[(\text{CH}_3)_2\text{NCH}_2]_3\text{PO}$	H; P (48·5)	1967, 291
$\text{PC}_9\text{H}_{24}\text{N}_3\text{O}_2$	$[(\text{CH}_3)_2\text{N}]_2\text{P}(\text{O})\text{NHC}(\text{CH}_3)_2\text{CH}_2\text{OCH}_3$	H	1966, 246
$\text{PC}_9\text{H}_{27}\text{AlNSi}$	$[(\text{CH}_3)_3\text{Si}][(\text{CH}_3)_3\text{Al}]\text{N}=\text{P}(\text{CH}_3)_3$	H	1967, 322
$\text{PC}_9\text{H}_{27}\text{GaNSi}$	$[(\text{CH}_3)_3\text{Si}][(\text{CH}_3)_3\text{Ga}]\text{N}=\text{P}(\text{CH}_3)_3$	H	1967, 322
$\text{PC}_9\text{H}_{27}\text{Ge}_3$	$\text{P}[\text{Ge}(\text{CH}_3)_3]_3$	H; P (−228)	1966, 57; 1967, 337; 1969, 14

PC ₉ H ₂₇ InNSi	[(CH ₃) ₃ Si][(CH ₃) ₃ In]N=P(CH ₃) ₃	H	1967, 322
PC ₉ H ₂₇ N ₆	P[N(CH ₃)N(CH ₃) ₂] ₃	H; P (101·5)	1967, 94
PC ₉ H ₂₇ Si ₃	P[Si(CH ₃) ₃] ₃	H; P (−251·2)	1967, 29; 1968, 327
PC ₉ H ₂₇ Sn ₃	P[Sn(CH ₃) ₃] ₃	P (−330)	1967, 237; 1969, 14
PC ₁₀ H ₇ Cl ₂ S	β-C ₁₀ H ₇ P(S)Cl ₂	P (74·4)	1966, 114
PC ₁₀ H ₉	C ₆ H ₅ P(CH=CH) ₂	H	1968, 101
PC ₁₀ H ₁₀ ClO ₅	(CH ₃ O) ₂ P(O)CClC ₆ H ₄ C(O)O 	H; P (9·7)	1967, 338
PC ₁₀ H ₁₀ F ₅	C ₆ F ₅ P(C ₂ H ₅) ₂	H; P (−23·4) F (−132·3; −164·3; −154·9)	1966, 19; 1967, 11
PC ₁₀ H ₁₁	C ₆ H ₅ P(CH ₂ CH) ₂	H	1968, 101
PC ₁₀ H ₁₁ O	C ₆ H ₅ P(O)(CH ₂ CH) ₂	H	1968, 101
PC ₁₀ H ₁₁ S	C ₆ H ₅ C≡CP(S)(CH ₃) ₂	H	1965, 89
PC ₁₀ H ₁₂ F ₅ N ₂	C ₆ F ₅ P[N(CH ₃) ₂] ₂	H; F (−140·2; −164·1; −157·1)	1966, 19
PC ₁₀ H ₁₂ NO	C ₆ H ₅ P(O)(CH=CH ₂)N(CH ₂) ₂	H	1966, 250
PC ₁₀ H ₁₂ N ₃ O ₃ S ₂	(CH ₃ O) ₂ P(S)SCH ₂ NC(O)C ₆ H ₄ N=N 	H	1968, 284, 285
PC ₁₀ H ₁₂ N ₃ O ₄ S	(CH ₃ O) ₂ P(O)SCH ₂ NC(O)C ₆ H ₄ N=N 	H	1968, 285
PC ₁₀ H ₁₃ ClNO	C ₆ H ₅ (CH ₂ ClCH ₂)P(O)N(CH ₂) ₂	H	1966, 250
PC ₁₀ H ₁₃ Cl ₃ NO ₂ S	C ₆ H ₂ Cl ₃ OP(S)(OCH ₃)NH <i>i</i> -C ₃ H ₇	H	1967, 116
PC ₁₀ H ₁₃ N ₂ O ₇	(C ₂ H ₅ O) ₂ P(O)C ₆ H ₃ (NO ₂) ₂	H	1969, 119
PC ₁₀ H ₁₃ O	(CH ₃) ₂ P(O)C(C ₆ H ₅)=CH ₂ C ₆ H ₅ POCH ₂ C(CH ₃) ₂ O 	H	1966, 119
		H	1969, 93
PC ₁₀ H ₁₃ O ₂	C ₆ H ₅ OPOCH ₂ C(CH ₃) ₂ O 	H	1969, 93

Formula	Compound	Resonance	Reference
PC ₁₀ H ₁₃ O ₃	C ₆ H ₅ P(O)[OCH(CH ₃)] ₂	P (8·4 – 7·1)	1969, 243
PC ₁₀ H ₁₃ O ₄	(CH ₃ O) ₂ P(O)CH ₂ C(O)C ₆ H ₅	H	1967, 121
	(CH ₃ O) ₂ P(O)O(CH ₂)CC ₆ H ₅	H	1967, 121
	C ₆ H ₅ OP(O)O(CH ₂) ₂ CH(CH ₃)O	H; P (–15)	1968, 83, 150; 1969, 175
	(CH ₃ O) ₂ P(O)CHCH(C ₆ H ₅)O	H	1967, 81
PC ₁₀ H ₁₄	C ₆ H ₅ (CH ₃) ₂ P [⊕] CH=CH ₂	H	1967, 99
PC ₁₀ H ₁₄ Cl	<i>t</i> -C ₄ H ₉ (C ₆ H ₅)PCl	P (69·6)	1968, 6
PC ₁₀ H ₁₄ ClO	<i>t</i> -C ₄ H ₉ (C ₆ H ₅)P(O)Cl	H	1965, 8
PC ₁₀ H ₁₄ ClO ₃	chlorofenchene phosphonic acid	H	1967, 339
PC ₁₀ H ₁₄ ClS ₂	C ₆ H ₅ P(S)(SC ₄ H ₉)Cl	P (88·2)	1967, 126
PC ₁₀ H ₁₄ Cl ₂ NO ₂ S	CH ₃ O(<i>i</i> -C ₃ H ₇ NH)P(S)OC ₆ H ₃ Cl ₂	H	1968, 284, 285; 1969, 110, 322
PC ₁₀ H ₁₄ Cl ₂ NO ₃	CH ₃ O(<i>i</i> -C ₃ H ₇ NH)P(O)OC ₆ H ₃ Cl ₂	H	1969, 110
PC ₁₀ H ₁₄ FO ₂	C ₆ H ₅ (C ₄ H ₉ O)P(O)F	P (15·7); F (–68)	1967, 14
PC ₁₀ H ₁₄ FO ₃	FC ₆ H ₄ P(O)(OC ₂ H ₅) ₂	F	1967, 17; 1969, 18, 19
PC ₁₀ H ₁₄ F ₁₂ N ₃ O ₂	(C ₄ H ₉ N)[CH ₂ N(CH ₃)] ₂ P[OC(CF ₃)] ₂	P (–31)	1968, 310
PC ₁₀ H ₁₄ N	C ₆ H ₅ P(CH ₂) ₂ NHCHCH ₃	H	1967, 137
PC ₁₀ H ₁₄ NO ₃	HP(OCH ₂) ₂ [OCH(C ₆ H ₅)CH ₂ NH]	P (–40)	1969, 45, 178
	HP(OC ₆ H ₄ O)[OCH ₂ C(CH ₃) ₂ NH]	P (–37)	1969, 45, 178
	OC ₆ H ₄ OPO(CH ₂) ₂ NHC ₂ H ₅	P (131)	1969, 45, 178
	HP(OC ₆ H ₄ O)(OCH ₂ CH ₂ NC ₂ H ₅)	P (–100)	1969, 45, 178

	HP[OC ₆ H ₃ (CH ₃)O]OCH(CH ₃)CH ₂ NH	H; P (−37·6)	1969, 178
PC ₁₀ H ₁₄ NO ₅	CH ₃ (<i>i</i> -C ₃ H ₇ O)P(O)OC ₆ H ₄ NO ₂	H	1969, 160
	(C ₂ H ₅ O) ₂ P(O)C ₆ H ₄ - <i>o</i> -NO ₂	P (10·5)	1969, 119
PC ₁₀ H ₁₄ NO ₅ S	(C ₂ H ₅ O)(C ₂ H ₅ S)P(O)OC ₆ H ₄ NO ₂	H; P (24·0)	1965, 20
	(C ₂ H ₅ O) ₂ P(S)OC ₆ H ₄ NO ₂	H	1968, 284, 285; 1969, 270
PC ₁₀ H ₁₄ NO ₆	(C ₂ H ₅ O) ₂ POC ₆ H ₄ NO ₂	H	1968, 285; 1969, 270
PC ₁₀ H ₁₄ NO ₆ S	(CH ₃ O) ₂ P(O)C(O)NH ₂ SO ₂ C ₆ H ₄ CH ₃	H	1968, 328; 1969, 79
PC ₁₀ H ₁₅	C ₆ H ₅ P(C ₂ H ₅) ₂	H; P (−16, −17·8)	1965, 3, 11; 1966, 206; 1968, 7, 302, 303
	C ₆ H ₅ (<i>t</i> -C ₄ H ₉)PH	P (−5·7)	1968, 6
PC ₁₀ H ₁₅ ClN	C ₆ H ₅ PCl[N(C ₂ H ₅) ₂]	H; P (140·4)	1965, 12; 1968, 92
	C ₆ H ₅ PCl[NH(<i>t</i> -C ₄ H ₉)]	H	1967, 80
PC ₁₀ H ₁₅ Cl ₂ N ₂	[(C ₂ H ₅) ₂ N]Cl ₂ P=NC ₆ H ₅	H; P (−21·6)	1965, 98; 1969, 348
PC ₁₀ H ₁₅ Cl ₆ N ₂ O ₉	(C ₂ H ₅ O) ₂ P(O)CH(OCONHCOCl ₃)CH ₂ (OCONHCOCl ₃)	H	1969, 82
PC ₁₀ H ₁₅ FN	C ₆ H ₅ PF[N(C ₂ H ₅) ₂]	H; P (156·0); F (−125·7)	1965, 12
PC ₁₀ H ₁₅ FNS ₂	C ₆ H ₅ SP(S)F[N(C ₂ H ₅) ₂]	H; P (94·0); F (−34·7)	1968, 308
PC ₁₀ H ₁₅ F ₃ N	C ₆ H ₅ PF ₃ [N(C ₂ H ₅) ₂]	H; P (−52·5); F (−43·5; −66·5)	1965, 12; 1967, 64
	C ₆ H ₅ PF ₃ (NH- <i>i</i> -C ₄ H ₉)	P (−52·5); F (−73; −53; −41)	1967, 64
PC ₁₀ H ₁₅ F ₆ O ₆	(CH ₃ O) ₃ POC(CF ₃) ₂ C(CH ₃)(COCH ₃)O	H; P (−52·6)	1966, 248
PC ₁₀ H ₁₅ N ₂ O	C ₆ H ₅ P(O)[N(CH ₃)CH ₂] ₂	H	1966, 225; 1967, 314
PC ₁₀ H ₁₅ O	C ₆ H ₅ P(O)(C ₂ H ₅) ₂	P (42·4)	1966, 206
	C ₆ H ₅ P(O)(C ₄ H ₉)H	H	1968, 35

Formula	Compound	Resonance	Reference
PC ₁₀ H ₁₅ OS ₂	C ₂ H ₅ (C ₂ H ₅ O)P(S)SC ₆ H ₅	H	1968, 283, 284
PC ₁₀ H ₁₅ O ₂	C ₆ H ₅ P(OC ₂ H ₅) ₂	¹³ C; H	1965, 7; 1966, 240; 1968, 25; 1969, 34
	CH ₃ P(O)(OC ₂ H ₅)CH ₂ C ₆ H ₅	H	1968, 304; 1969, 74
	C ₂ H ₅ P(O)(OC ₂ H ₅)C ₆ H ₅	H	1969, 34
PC ₁₀ H ₁₅ O ₃	C ₆ H ₅ P(O)(OC ₂ H ₅) ₂	¹³ C; H	1965, 7; 1966, 240; 1968, 347; 1969, 34
	(CH ₃ O) ₂ P(O)CH ₂ C ₆ H ₄ CH ₃	H	1967, 117
	(CH ₃ O) ₂ P(O)C ₆ H ₃ (CH ₃) ₂	H	1968, 317
PC ₁₀ H ₁₅ O ₃ S ₂	(CH ₃ O) ₂ P(S)OC ₆ H ₃ (CH ₃)SCH ₃	H	1968, 284, 285; 1969, 322
PC ₁₀ H ₁₅ O ₇	(CH ₃ O) ₂ P(O)CH ₂ C ₆ H ₄ OCH ₃	H	1967, 117
PC ₁₀ H ₁₅ O ₅	(C ₂ H ₅ O) ₂ P(O)OC ₆ H ₄ OH	H	1966, 42
	(CH ₃ O) ₂ P(O)C ₆ H ₃ (OCH ₃) ₂	H	1968, 317
PC ₁₀ H ₁₅ O ₇	(CH ₃ O) ₂ P(O)CC(O)OC(CH ₃)(COCH ₃)COCH ₃ (stereois.)	H; P (65·8)	1969, 353
PC ₁₀ H ₁₅ S	C ₆ H ₅ P(S)(C ₂ H ₅) ₂	P (52)	1966, 206
PC ₁₀ H ₁₅ S ₂	C ₆ H ₅ P(SC ₂ H ₅) ₂	H	1966, 18
PC ₁₀ H ₁₆ Br	(CH ₃) ₂ P [⊕] (C ₂ H ₅)C ₆ H ₅ , Br [⊖]	P (28·4)	1968, 6
	HP [⊕] (C ₂ H ₅) ₂ C ₆ H ₅ , Br [⊖]	H; P (18·3)	1968, 7
PC ₁₀ H ₁₆ FN ₂	C ₆ H ₄ FP[N(CH ₃) ₂] ₂	F	1968, 14
PC ₁₀ H ₁₆ NO ₃	C ₆ H ₅ P(O)(O [⊖])[O(CH ₂) ₂] [⊕] NH(CH ₃) ₂]	H; P (−5·1)	1969, 343
PC ₁₀ H ₁₇ ClN	(CH ₃) ₂ P [⊕] (C ₆ H ₅)N(CH ₃) ₂ , Cl [⊖]	H	1968, 54
PC ₁₀ H ₁₇ FN ₂	C ₆ H ₅ P [⊕] F[N(CH ₃) ₂] ₂	H; P (56·0); F (−86·7)	1965, 12; 1966, 36
PC ₁₀ H ₁₇ N ₂	C ₆ H ₅ P(NHC ₂ H ₅) ₂	H	1967, 95
	C ₆ H ₅ P[N(CH ₃) ₂] ₂	H	1966, 36; 1967, 80
PC ₁₀ H ₁₇ N ₂ O	C ₆ H ₅ P(O)[N(CH ₃) ₂] ₂	H	1965, 23; 1968, 91

PC ₁₀ H ₁₇ N ₂ O ₂	C ₆ H ₅ OP(O)[N(CH ₃) ₂] ₂	H	1968, 91
PC ₁₀ H ₁₇ N ₂ O ₂ S	CH ₃ [(CH ₃) ₂ N]P(H)=NSO ₂ C ₆ H ₄ CH ₃	H; P (-1.4)	1969, 15
PC ₁₀ H ₁₇ N ₂ O ₃	C ₂ H ₅ OP[OC(CH ₃) ₂ CN] ₂	P (135.6)	1967, 293
PC ₁₀ H ₁₇ N ₂ O ₄	C ₂ H ₅ OP(O)[OC(CH ₃) ₂ CN] ₂	P (-11)	1967, 293
PC ₁₀ H ₁₇ N ₂ S	C ₆ H ₅ P(S)[N(CH ₃) ₂] ₂	H	1965, 23; 1966, 36; 1968, 91
PC ₁₀ H ₁₇ N ₂ Se	C ₆ H ₅ P(S)(NHC ₂ H ₅) ₂	H	1967, 95, 318
	C ₆ H ₅ P(Se)(NHC ₂ H ₅) ₂	H	1967, 95
	C ₆ H ₅ P(Se)[N(CH ₃) ₂] ₂	H; P (84.6)	1969, 87
PC ₁₀ H ₁₇ O ₈	(CH ₃ O) ₂ P(O)C(COOH)=C(OCH ₃)C(CH ₃)C(CH ₃)- -(COCH ₃)OH	H	1969, 353
PC ₁₀ H ₁₈ ClO ₃	(C ₂ H ₅ O) ₂ P(O)C ₆ H ₅ Cl	H	1966, 256
PC ₁₀ H ₁₈ Cl ₃ O ₅	(C ₃ H ₇ O) ₂ P(O)CH(CCl ₃)OC(O)CH ₃	H; P (10)	1967, 3
PC ₁₀ H ₁₈ I	CH ₃ P [⊕] (CH ₂ CH=CH ₂) ₃ I [⊖]	P (25.2)	1967, 244
PC ₁₀ H ₁₈ NO ₃	(C ₂ H ₅ O) ₂ P(O)C(CN)=CH- <i>i</i> -C ₃ H ₇	H{P}	1968, 323
PC ₁₀ H ₁₉	(C ₄ H ₉) ₂ PC≡CH	H	1966, 247; 1967, 20
	(<i>s</i> -C ₄ H ₉) ₂ PC≡CH	¹³ C; H	1968, 21
	C ₅ H ₁₀ NP(O)(OCH ₂) ₂ C(CH ₃)CH ₂ Br	H	1968, 149
PC ₁₀ H ₁₉ ClNO ₃	C ₅ H ₁₀ NP(O)(OCH ₂) ₂ C(CH ₃)CH ₂ Cl	H	1968, 149
PC ₁₀ H ₁₉ ClNO ₅	(CH ₃ O) ₂ P(O)OC(CH ₃)=CClC(O)N(C ₂ H ₅) ₂	H	1968, 285
PC ₁₀ H ₁₉ CIN ₃	C ₆ H ₅ P [⊕] [N(CH ₃) ₂] ₂ NH ₂ , Cl [⊖]	H; P (41.0)	1967, 65
PC ₁₀ H ₁₉ Cl ₂ O ₅	(C ₃ H ₇ O) ₂ P(O)CH(CHCl ₂)OC(O)CH ₃	H; P (13.8)	1967, 3
PC ₁₀ H ₁₉ Cl ₃ NO ₇	(C ₂ H ₅ O) ₂ P(O)CH(OCONHCOC ₂ H ₅)CH ₂ OC ₂ H ₅	H	1969, 82
	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH(OCONHCOC ₂ H ₅)CH ₂ OCH ₃	H	1969, 82
	HP[OCH(CH ₃)CH(COOCH ₃)NH] ₂	H	1969, 45
PC ₁₀ H ₁₉ N ₂ O ₂			
PC ₁₀ H ₁₉ N ₂ S ₂	C ₆ H ₅ P(S)(S [⊖])N(CH ₃) ₂ , (CH ₃) ₂ NH ₂ [⊕]	P (92.8)	1967, 126
PC ₁₀ H ₁₉ O	(C ₄ H ₉) ₂ P(O)C≡CH	¹³ C; H	1967, 20; 1968, 21
PC ₁₀ H ₁₉ O ₃	(C ₂ H ₅ O) ₂ P(O)C ₆ H ₅	H	1966, 256
	HP(O)[OC(CH ₃) ₂ CH=CH ₂] ₂	P (-3.2)	1967, 293
	(C ₂ H ₅ O) ₂ P(O)C≡CC ₄ H ₉	H	1967, 21

Formula	Compound	Resonance	Reference
PC ₁₀ H ₁₉ O ₃	CH ₃ P[(CH ₂) ₂] ₂ C(CH ₂ COOC ₂ H ₅)OH	H	1967, 75
	C ₄ H ₉ OP[OC(CH ₃)=CH ₂] ₂	H	1968, 297
PC ₁₀ H ₁₉ O ₄	(C ₂ H ₅ O) ₂ P(O)C(O)C ₅ H ₉	H	1967, 166
	C ₂ H ₅ P(CH ₂ COOC ₂ H ₅) ₂	H	1968, 297
	C ₄ H ₉ P(CH ₂ COOCH ₃) ₂	H	1968, 297
	(C ₂ H ₅ O) ₂ P(O)C(CH ₃)CHC(O)C ₂ H ₅	H	1969, 355
PC ₁₀ H ₁₉ O ₅	(CH ₃) ₂ C=C(COOC ₂ H ₅)CH ₂ P(O)(OC ₂ H ₅)OH	H	1967, 327
PC ₁₀ H ₁₉ O ₆	(CH ₃ O) ₃ POCH(CH=CH ₂)C(CH ₃)O	H; P (50·9)	1968, 312
PC ₁₀ H ₁₉ O ₆ S ₂	(CH ₃ O) ₂ P(S)SCH(COOC ₂ H ₅)CH ₂ COOC ₂ H ₅	H	1968, 284, 285; 1969, 322
PC ₁₀ H ₁₉ O ₇ S	(CH ₃ O) ₂ P(O)SCH(COOC ₂ H ₅)(CH ₂ CO ₂ C ₂ H ₅)H	H	1968, 285; 1969, 322
PC ₁₀ H ₂₀ ClN ₂ O ₂	[NC(CH ₃) ₂] ₂ P(O)OCH(CH ₃)(CH ₂) ₂ Cl	H	1966, 220
PC ₁₀ H ₂₀ ClN ₄	C ₆ H ₅ NHPN(C ₂ H ₅) ₂ (NH ₂) ₂ Cl	H; P (26·0)	1969, 348
PC ₁₀ H ₂₀ ClO ₅	(C ₃ H ₇ O) ₂ P(O)CH(CH ₂ Cl)OC(O)CH ₃	H; P (17·8)	1967, 3
PC ₁₀ H ₂₀ LiO ₅	(CH ₃) ₂ C(OH)CH ₂ OPO ₃ (C ₆ H ₁₁) [⊖] Li [⊕]	H	1965, 99
	(CH ₃) ₂ C(OPO ₃ C ₆ H ₁₁) [⊖] CH ₂ OH, Li [⊕]	H	1965, 99
PC ₁₀ H ₂₀ NO ₂	(C ₂ H ₅) ₂ NP(O)OC(CH ₃)CHC(CH ₃) ₂	H	1967, 311
PC ₁₀ H ₂₀ NO ₂ S	(C ₂ H ₅ O) ₂ P(O)NS(O)CH ₂ C(CH ₃)=C(CH ₃)CH ₂	H	1965, 93
PC ₁₀ H ₂₀ NO ₃	(C ₂ H ₅ O) ₂ P(O)C≡CN(C ₂ H ₅) ₂	H	1965, 100
	(CH ₂ O) ₂ P(O)C[N(CH ₃) ₂] ₂ C ₅ H ₁₀	H; P (48)	1968, 324; 1969, 340
	C ₅ H ₁₀ NP(O)(OCH ₂) ₂ C(CH ₃) ₂	H	1968, 149
PC ₁₀ H ₂₀ NO ₆	(C ₂ H ₅ O) ₂ P(O)CH(OCOCH ₃)CH ₂ NH(OCH ₃)	H	1969, 82
PC ₁₀ H ₂₁ ClNO ₃	[CH ₃ (CH ₂ Cl)CHO][(C ₂ H ₅) ₂ N]P(O)OC(CH ₃)=CH ₂	H	1967, 340
PC ₁₀ H ₂₁ Cl ₂ O	C ₈ H ₁₇ P(O)(CH ₂ Cl) ₂	H; P (45·4)	1968, 299; 1969, 334
PC ₁₀ H ₂₁ O ₂	(C ₂ H ₅) ₂ P(O)C(CH ₃) ₂ CH ₂ COCH ₃	H	1967, 341
PC ₁₀ H ₂₁ O ₃	(C ₂ H ₅) ₂ P(O)C(CH ₃) ₂ CH ₂ COOCH ₃	H	1967, 341

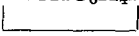
PC ₁₀ H ₂₁ O ₃ S	(C ₂ H ₅ O) ₂ P(O)C(CH ₃)=CHCH ₃	H	1968, 314
	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH=C(CH ₃)SC ₂ H ₅	H; P (25·9)	1967, 21, 108
	(C ₂ H ₅ O) ₂ P(O)CH ₂ C(SC ₂ H ₅)=CHCH ₃	H; P (24·2)	1967, 108
	(C ₂ H ₅ O) ₂ P(O)CH ₂ C(CH ₃)=CHSC ₂ H ₅	H; P (24·8)	1967, 108
PC ₁₀ H ₂₁ O ₄	(<i>i</i> -C ₃ H ₇ O) ₂ P(O)SCH ₂ CH=CHCH ₃	H	1967, 307
	(C ₂ H ₅) ₂ C(CH ₂ O) ₂ P(O)O- <i>i</i> -C ₃ H ₇	H	1967, 91
	(C ₂ H ₅ O) ₂ P(O)CH ₂ C(OC ₂ H ₅)=CHCH ₃	H; P (25·9)	1967, 278, 326
	(C ₂ H ₅ O) ₂ P(O)CH= C(OC ₂ H ₅)C ₂ H ₅	H; P (21·7)	1967, 278
PC ₁₀ H ₂₁ O ₅	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH= C(CH ₃)OC ₂ H ₅	H; P (27·7)	1967, 278
	(C ₂ H ₅ O) ₂ P(O)CH ₂ C(CH ₃)=CHOC ₂ H ₅	H; P (24·7)	1967, 108
	(C ₄ H ₉ O) ₂ P(O)CH ₂ COOH	H	1965, 87
	(C ₂ H ₅ O) ₃ P[OC(CH ₃) ₂]	P (− 51·3)	1966, 225
	(CH ₃ O) ₂ P(O)C(OH)CH ₂ C(CH ₃) ₂ OC(CH ₃) ₂	H	1966, 43
PC ₁₀ H ₂₁ O ₆	(CH ₃ O) ₃ POCH(C ₂ H ₅)C(CH ₃)(COCH ₃)O	P (− 51·3)	1968, 312
	(CH ₃ O) ₃ POC(CH ₃)(COCH ₃)C(CH ₃) ₂ O	H	1969, 147
	(CH ₃ O) ₃ POC(CH ₃)OC(CH ₃) ₂ C(CH ₃)O	H	1969, 147
PC ₁₀ H ₂₁ S	(C ₄ H ₉) ₂ P(S)CH=CH ₂	P (44)	1966, 44
PC ₁₀ H ₂₂ BF ₄ O ₄	(C ₂ H ₅ O) ₂ P [⊕] [OC(CH ₃) ₂] ₂ , BF ₄ [⊖]	H	1969, 86
PC ₁₀ H ₂₂ Br	(CH ₃) ₂ P [⊕] [C(CH ₃) ₂] ₂ CHCH ₃ , Br [⊖]	H	1967, 82
PC ₁₀ H ₂₂ NO ₄	(C ₂ H ₅ O) ₂ P(O)CH ₂ C(O)N(C ₂ H ₅) ₂	H	1965, 100
	(<i>i</i> -C ₃ H ₇ O) ₂ P(O)C(O)NH- <i>i</i> -C ₃ H ₇	H	1967, 26
	(C ₃ H ₇ O) ₂ P(O)C(O)NH- <i>i</i> -C ₃ H ₇	H	1968, 29
PC ₁₀ H ₂₂ NO ₅	(C ₂ H ₅ O) ₂ P(O)C [⊖] (COOCH ₃)N [⊕] (CH ₃) ₃	H; P (17)	1969, 346
PC ₁₀ H ₂₂ N ₃	P[N(CH ₃)CH ₂] ₃ CC ₃ H ₇	H	1969, 71
PC ₁₀ H ₂₃	C ₁₀ H ₂₁ PH ₂	H; P (− 139)	1966, 14
	C ₂ H ₅ P(C ₄ H ₉) ₂	H	1967, 20

Formula	Compound	Resonance	Reference
PC ₁₀ H ₂₃ BrNO ₄	(C ₂ H ₅ O) ₂ P(O)CH(COCH ₃)N [⊕] (CH ₃) ₃ , Br [⊖]	H	1969, 346
PC ₁₀ H ₂₃ INO ₄	(C ₂ H ₅ O) ₂ P(O)CH ₂ C(O)CH ₂ N [⊕] (CH ₃) ₃ , I [⊖]	H; P (17·9)	1967, 22
PC ₁₀ H ₂₃ INO ₅	(C ₂ H ₅ O) ₂ P(O)CH(COOCH ₃)N [⊕] (CH ₃) ₃ , I [⊖]	H; P (10)	1969, 346
PC ₁₀ H ₂₃ O	C ₂ H ₅ P(O)(C ₄ H ₉) ₂	H	1967, 20
PC ₁₀ H ₂₃ O ₂ S ₂	CH ₃ P(O)(OC ₅ H ₁₁)SCH ₂ S(<i>i</i> -C ₃ H ₇)	H	1969, 101
	CH ₃ P(O)(O- <i>i</i> -C ₃ H ₇)SCH ₂ SC ₅ H ₁₁	H	1969, 101
PC ₁₀ H ₂₃ O ₃	HP(O)(OC ₅ H ₁₁) ₂	P (6·1)	1967, 277
	HP(O)[OCH(CH ₃)(C ₃ H ₇)] ₂	P (3·5)	1967, 277
	HP(O)[OCH(C ₂ H ₅) ₂] ₂	P (5·7)	1967, 277
	HP(O)[OCH(CH ₃)(<i>i</i> -C ₃ H ₇)] ₂	P (4·8)	1967, 277
	HP(O)[OC(CH ₃) ₂ (C ₂ H ₅)] ₂	P (−3·5)	1967, 293; 1969, 340
	C ₂ H ₅ OP[OCH(CH ₃)(C ₂ H ₅)] ₂	P (138·4)	1967, 293
	C ₂ H ₅ OP(O- <i>t</i> -C ₄ H ₉) ₂	P (131·1)	1967, 293
PC ₁₀ H ₂₃ O ₃ S	C ₂ H ₅ OP(S)(O- <i>t</i> -C ₄ H ₉) ₂	P (50·2)	1967, 293
PC ₁₀ H ₂₃ O ₃ Se	C ₂ H ₅ OP(Se)(O- <i>t</i> -C ₄ H ₉) ₂	P (45·2)	1967, 293
PC ₁₀ H ₂₃ O ₄	(C ₂ H ₅ O) ₂ P(O)(CH ₂) ₂ OC ₄ H ₉	H	1966, 251; 1969, 82
	(<i>i</i> -C ₃ H ₇ O) ₂ P(O)O- <i>t</i> -C ₄ H ₉	H	1966, 257
	C ₂ H ₅ OP(O)(O- <i>t</i> -C ₄ H ₉) ₂	P (−10)	1967, 293
PC ₁₀ H ₂₄ Br	CH ₃ P [⊕] (<i>i</i> -C ₃ H ₇) ₃ , Br [⊖]	P (45·5)	1966, 5; 1968, 6
PC ₁₀ H ₂₄ Cl ₆ O ₂ Sb	(C ₂ H ₅) ₂ (C ₂ H ₅ O)(<i>i</i> -C ₄ H ₉ O)P [⊕] SbCl ₆ [⊖]	H	1967, 308
PC ₁₀ H ₂₄ I	CH ₃ P [⊕] (<i>i</i> -C ₃ H ₇) ₃ , I [⊖]	P (44·2)	1967, 244
PC ₁₀ H ₂₄ N	(C ₆ H ₅) ₂ P(CH ₂) ₂ N(C ₂ H ₅) ₂	P (−20·4)	1965, 101
PC ₁₀ H ₂₄ NO ₃	(CH ₃ O) ₂ P(O)CH(<i>i</i> -C ₃ H ₇)NHC ₄ H ₉	H	1965, 36
	CH ₃ OP(O)(O [⊖])CH(<i>i</i> -C ₃ H ₇)N [⊕] H(CH ₃)C ₄ H ₉	H	1965, 36
	C ₂ H ₅ OC(<i>i</i> -C ₃ H ₇)NP[N(CH ₃) ₂] ₂	H; P (97·1)	1968, 321
	(C ₂ H ₅ O) ₂ P(O)N(<i>i</i> -C ₃ H ₇)C ₃ H ₇	H	1968, 29
PC ₁₀ H ₂₄ N ₃ OS	C ₂ H ₅ OC(<i>i</i> -C ₃ H ₇)NP(S)[N(CH ₃) ₂] ₂	P (70)	1968, 321
PC ₁₀ H ₂₅ ClN ₃ O	[(CH ₃) ₂ N] ₂ P(O)NHC(CH ₃) ₂ CH ₂ Cl	H	1966, 246
	[(CH ₃) ₂ N] ₂ P(O)NHCH ₂ C(CH ₃) ₂ Cl	H	1966, 246

PC ₁₀ H ₂₅ N ₂	[(C ₂ H ₅) ₂ NCH ₂] ₂ PH	P (-101.9)	1966, 4
PC ₁₀ H ₂₅ N ₂ O ₂	[(C ₂ H ₅) ₂ NCH ₂] ₂ PO ₂ H	P (30.3)	1967, 291
PC ₁₀ H ₂₅ NO ₄	[(CH ₃) ₂ N] ₂ P(O)NH(CH ₂) ₂ N(CH ₂) ₄	H	1966, 246
PC ₁₀ H ₂₅ O ₃ Si	(C ₂ H ₅ O) ₂ POSi(C ₂ H ₅) ₃	H	1967, 34
PC ₁₀ H ₂₅ Si	(C ₂ H ₅) ₃ P=CHSi(CH ₃) ₃	H	1968, 105, 107
PC ₁₀ H ₂₆ N ₃ O	(CH ₃) ₂ NP(O)(NH <i>t</i> -C ₄ H ₉) ₂	H	1968, 91
PC ₁₀ H ₂₇ GeSi	(CH ₃) ₃ P=C[Si(CH ₃) ₃][Ge(CH ₃) ₃]	H	1967, 316
PC ₁₀ H ₂₇ SiSn	(CH ₃) ₃ P=C[Si(CH ₃) ₃][Sn(CH ₃) ₃]	H	1967, 176
PC ₁₀ H ₂₇ Si ₂	(CH ₃) ₃ P=C[Si(CH ₃) ₃] ₂	H	1967, 316
PC ₁₀ H ₂₇ Sn ₂	(CH ₃) ₃ P=C[Sn(CH ₃) ₃] ₂	H	1968, 107
PC ₁₀ H ₂₈ ClN ₂ Si ₂	<i>t</i> -C ₄ H ₉ P(Cl)[NHSi(CH ₃) ₃] ₂ [=NSi(CH ₃) ₃]	H	1968, 65
PC ₁₀ H ₂₈ N ₅	[(CH ₃) ₂ N] ₃ P[N(CH ₃)CH ₂] ₂	P (122.0)	1966, 224
PC ₁₀ H ₂₉ N ₂ Si ₂	<i>t</i> -C ₄ H ₉ P[NHSi(CH ₃) ₃] ₂	H	1968, 65
PC ₁₁ H ₁₀ ClNO ₄	C ₆ H ₄ ClC(=NO ₂)P(O)(OC ₂ H ₅) ₂	H	1968, 142
PC ₁₁ H ₁₀ N	CH ₃ (C ₆ H ₅)NP(C≡CH) ₂	H	1967, 106
PC ₁₁ H ₁₀ NS ₂	C ₆ H ₅ P(S)(S [⊖])N [⊕] C ₅ H ₅	P (-82)	1966, 77; 1967, 126
PC ₁₁ H ₁₁ F ₆ O ₂	C ₂ H ₅ (C ₆ H ₅)POCH(CF ₃) ₂	H; P (53.5)	1968, 302
PC ₁₁ H ₁₁ NO ₄	C ₆ H ₅ C(=NOH)P(O)(OC ₂ H ₅) ₂	H	1968, 142
PC ₁₁ H ₁₂ NO ₃	β-C ₁₀ H ₇ CH(NH ₂)PO ₃ H ₂	H	1968, 142
	C ₆ H ₅ CHC(CN)P(O)(OC ₂ H ₅)OH	H	1968, 319
PC ₁₁ H ₁₂ NO ₄ S ₂	(CH ₃ O) ₂ P(S)SCH ₂ N[C(O)] ₂ C ₂ H ₄	H	1968, 284, 285; 1969, 322
PC ₁₁ H ₁₃	C ₆ H ₅ PCH ₂ CH=C(CH ₃)CH ₂	H	1967, 108; 1968, 100
	C ₆ H ₅ PCH ₂ CH ₂ C(CH ₃)=CH	H	1968, 100
PC ₁₁ H ₁₃ Br ₂	C ₆ H ₅ P [⊕] (Br)CH ₂ CHC(CH ₃)CH ₂ , Br [⊖]	H; P (89)	1967, 108; 1968, 100
PC ₁₁ H ₁₃ Cl ₂	C ₆ H ₅ P [⊕] (Cl)CH ₂ CHC(CH ₃)CH ₂ , Cl [⊖]	H; P (99)	1967, 108; 1968, 100

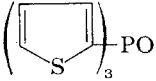
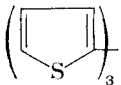
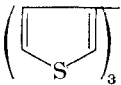
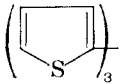
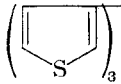
Formula	Compound	Resonance	Reference
PC ₁₁ H ₁₃ O	C ₆ H ₅ P(O)CH ₂ C(CH ₃)=CHCH ₂ └──────────┘	H	1967, 101, 108; 1968, 100
	C ₆ H ₅ P(O)CH ₂ CH=CHCHCH ₃ └──────────┘	H	1968, 100
	C ₆ H ₅ P(O)CH ₂ CH ₂ CH=CCH ₃ └──────────┘	H	1968, 100
	C ₆ H ₅ P(O)CH ₂ CH ₂ C(CH ₃)=CH └──────────┘	H	1968, 100
PC ₁₁ H ₁₃ O ₆	C ₆ H ₅ P(CH ₂ CH ₂) ₂ CO	H	1969, 76
PC ₁₁ H ₁₃ S	(CH ₃ O) ₂ P(O)OCH(COC ₆ H ₅)CHO C ₆ H ₅ P(S)(CH ₂) ₂ C(CH ₃)=CH └──────────┘	H; P (-2.6) H; P (64.4)	1969, 337 1969, 20
PC ₁₁ H ₁₄ ClO ₃	C ₆ H ₅ CH ₂ P(O)O(CH ₂) ₂ CH(CH ₂ Cl)O └──────────┘	H	1966, 121
PC ₁₁ H ₁₄ Cl ₃ N ₂ O	Cl ₃ PN(C ₄ H ₉)C(O)NC ₆ H ₅ └──────────┘	H	1965, 6
PC ₁₁ H ₁₄ N	(CH ₃) ₂ NP(C ₆ H ₅)C≡CCH ₃	H	1967, 80, 106
	(CH ₃) ₂ NP(C ₆ H ₅)CH=C=CH ₂	H	1968, 99; 1969, 115
PC ₁₁ H ₁₄ NO	C ₆ H ₅ P(O)(CH=CH ₂)NHCH ₂ CH=CH ₂ (CH ₃) ₂ NP(O)(C ₆ H ₅)CH=C=CH ₂	H H	1966, 250 1969, 115
PC ₁₁ H ₁₅ Cl ₂ O ₂ S ₃	(C ₂ H ₅ O) ₂ P(S)SCH ₂ SC ₆ H ₃ Cl ₂	H	1968, 285
PC ₁₁ H ₁₅ Cl ₃ NO ₂ S	C ₆ H ₅ Cl ₃ OP(S)(OCH ₃)NH- <i>t</i> -C ₄ H ₉	H	1967, 116
PC ₁₁ H ₁₅ F ₃ N	F ₃ P(C ₆ H ₅)N(C ₂ H ₅) ₂	F (-72, -47)	1967, 64
PC ₁₁ H ₁₅ N ₂ O ₃	CH ₃ OPO(CH ₂) ₂ N(CH ₃)C(O)NC ₆ H ₅ └──────────┘	H	1969, 171
PC ₁₁ H ₁₅ O ₂	C ₆ H ₅ P(OCH ₂) ₂ C(CH ₃) ₂	H	1968, 80
PC ₁₁ H ₁₅ O ₃	C ₆ H ₅ OP(OCH ₂) ₂ C(CH ₃) ₂	H; P (115)	1967, 88; 1968, 80, 301

PC ₁₁ H ₁₅ O ₄	C ₆ H ₅ P(O)(OCH ₂) ₂ C(CH ₃) ₂	H	1968, 74
	C ₆ H ₅ OP(O)(OCH ₂) ₂ C(CH ₃) ₂	H; P	1967, 91, 1968, 74, 83, 150
	(C ₂ H ₅ O) ₂ P(O)C(O)C ₆ H ₅	P (-2)	1967, 338
	C ₆ H ₅ OP(O)[OCH(CH ₃) ₂ CH ₂	H; P (-13.9)	1968, 83
PC ₁₁ H ₁₅ O ₅	C ₆ H ₅ OP(O)OC(CH ₃) ₂ (CH ₂) ₂ O	H; P (-15.9)	1969, 175
	(CH ₃ O) ₂ P(O)CHC(CH ₃)(C ₆ H ₅)O	H	1967, 81
	(CH ₃ O) ₃ POC(C ₆ H ₅)=CHO	H; P (-45.4)	1965, 21
	(CH ₂ O) ₄ PCH(OH)C ₆ H ₅	H; P (-18)	1968, 154
PC ₁₁ H ₁₆ ClHgO ₃	(CH ₃ O) ₂ P(O)C ₆ H ₄ CH ₂ COOCH ₃	H	1966, 253
PC ₁₁ H ₁₆ ClO	(C ₂ H ₅ O) ₂ P(O)CHClHgC ₆ H ₅	H	1966, 252
PC ₁₁ H ₁₆ ClO ₂ S ₃	HP(O)(C ₄ H ₉)CH ₂ C ₆ H ₄ Cl	H	1968, 35
	(C ₂ H ₅ O) ₂ P(S)SCH ₂ SC ₆ H ₄ Cl	H	1968, 284, 285; 1969, 322
PC ₁₁ H ₁₆ Cl ₂ NO ₃	CH ₃ O(<i>t</i> -C ₄ H ₉ NH)P(O)OC ₆ H ₃ Cl ₂	H	1969, 110
PC ₁₁ H ₁₆ N	C ₆ H ₅ P(CH ₂) ₂ NHCHC ₂ H ₅	H	1967, 137
	C ₆ H ₅ P(CH ₂) ₂ NHC(CH ₃) ₂	H	1967, 137
PC ₁₁ H ₁₆ NO ₂	(CH ₃) ₂ NPOC ₆ H ₃ (<i>i</i> -C ₃ H ₇)O	P (148)	1969, 45
PC ₁₁ H ₁₆ NO ₃	HP[OC ₆ H ₃ (CH ₃)O][OCH ₂ C(CH ₃) ₂ NH]	P (-37.7)	1969, 45, 178
PC ₁₁ H ₁₆ NO ₅	(C ₂ H ₅ O) ₂ P(O)CH ₂ C ₆ H ₄ NO ₂	H	1965, 102; 1967, 116
PC ₁₁ H ₁₇ F ₃ N	F ₃ P(CH ₃ C ₆ H ₄)N(C ₂ H ₅) ₂	F	1967, 64
PC ₁₁ H ₁₇ N ₂ O	C ₆ H ₅ P(O)[N(CH ₃) ₂](CH ₂) ₃	H	1967, 314
	(CH ₃) ₂ NPOCH(CH ₃)CH ₂ NC ₆ H ₅ (stereois.)	P (121; 132)	1969, 109

Formula	Compound	Resonance	Reference
PC ₁₁ H ₁₇ N ₃	(CH ₃) ₂ NPNCHC ₆ H ₄ N 	H	1967, 119
PC ₁₁ H ₁₇ O	C ₄ H ₉ (C ₆ H ₅ CH ₂)P(O)H	H	1968, 35
	CH ₃ (C ₆ H ₅)P(O) <i>t</i> -C ₄ H ₉	H	1969, 154
PC ₁₁ H ₁₇ O ₃	(C ₂ H ₅ O) ₂ P(O)C ₆ H ₄ CH ₃	H	1968, 317
PC ₁₁ H ₁₇ O ₄	(C ₂ H ₅ O) ₂ P(O)CHOHC ₆ H ₅	H	1966, 42
	(C ₂ H ₅ O) ₂ P(O)C ₆ H ₄ OCH ₃	H	1968, 317
PC ₁₁ H ₁₈ ClO ₃	(C ₂ H ₅ O) ₂ P(O)C ₇ H ₈ Cl	H	1966, 256
PC ₁₁ H ₁₈ Cl ₂ NO ₃	(C ₂ H ₅ O) ₂ P(O)CH(NH ₃ Cl)C ₆ H ₄ Cl	H	1968, 142
PC ₁₁ H ₁₈ NO ₃	<i>t</i> -C ₄ H ₉ C ₆ H ₄ CH(NH ₂)PO ₃ H ₂	H	1968, 142
PC ₁₁ H ₁₈ NO ₄	C ₆ H ₅ OP(O)[N(CH ₃) ₂][OCH(CH ₃)CH ₂ OH]	H; P (27·3)	1969, 343
PC ₁₁ H ₁₈ N ₂ O	C ₆ H ₅ P(O)N(<i>i</i> -C ₃ H ₇)[N(CH ₃) ₂]	H	1965, 92
PC ₁₁ H ₁₉ ClNO ₃	(C ₂ H ₅ O) ₂ P(O)CH(NH ₃ Cl)C ₆ H ₅	H; P (17·5)	1968, 142, 296
PC ₁₁ H ₁₉ NO ₂	C ₆ H ₅ P(O)(O [⊖])H, C ₅ H ₁₀ NH ₃ [⊕]	H	1966, 18
PC ₁₁ H ₁₉ N ₂ O ₅ S	(C ₂ H ₅ O) ₂ P(O)CH ₂ C ₆ H ₄ SO ₂ NHNH ₂	H	1966, 71
PC ₁₁ H ₁₉ O ₃	(C ₂ H ₅ O) ₂ P(O)C ₇ H ₉	H	1966, 256
PC ₁₁ H ₁₉ O ₇ S ₂	(CH ₃ O) ₂ P(S)SCH(COOC ₂ H ₅)(CH ₂ C(O)COOC ₂ H ₅)	H	1968, 283
PC ₁₁ H ₁₉ O ₉	(C ₂ H ₅ O) ₂ P(O)OC(COCH ₃)(COOCH ₃) ₂	H; P (-2)	1967, 4
PC ₁₁ H ₁₉ SSi	CH ₃ (C ₆ H ₅)P(S)CH ₂ Si(CH ₃) ₃	H; P (36·6)	1966, 132
PC ₁₁ H ₂₀ Cl ₆ N ₂ OSb	C ₆ H ₅ (CH ₃ O)P [⊕] [N(CH ₃) ₂] ₂ , SbCl ₆ [⊖]	H; P (57·5)	1969, 87
PC ₁₁ H ₂₀ Cl ₆ N ₂ SSb	C ₆ H ₅ (CH ₃ S)P [⊕] [N(CH ₃) ₂] ₂ , SbCl ₆ [⊖]	H; P (74·0)	1969, 87
PC ₁₁ H ₂₀ Cl ₆ N ₂ SbSe	C ₆ H ₅ (CH ₃ Se)P [⊕] [N(CH ₃) ₂] ₂ , SbCl ₆ [⊖]	H; P (68·9)	1969, 87
PC ₁₁ H ₂₀ IN ₂	CH ₃ (C ₆ H ₅)P [⊕] (NHC ₂ H ₅) ₂ , I [⊖]	H	1967, 95
PC ₁₁ H ₂₀ NS ₂	C ₆ H ₅ (CH ₃ S)PS [⊖] , (CH ₃) ₄ N [⊕]	H	1967, 113
PC ₁₁ H ₂₀ N ₃ O ₂ S	[(CH ₃) ₂ N] ₂ P(H)=NSO ₂ C ₆ H ₄ CH ₃	H; P (21·5)	1969, 15
PC ₁₁ H ₂₁ O ₃	(C ₂ H ₅ O) ₂ P(O)C ₆ H ₈ CH ₃	H	1966, 256
	(C ₂ H ₅ O) ₂ P(O)C≡CC ₅ H ₁₁	H	1967, 21
	CH ₃ P(O)(OH)O-bornyl	H	1967, 168

PC ₁₁ H ₂₁ O ₃ S	(C ₂ H ₅ O) ₂ P(O)S(2-norbornyl)	H	1966, 52
PC ₁₁ H ₂₁ O ₄	(C ₂ H ₅ O) ₂ P(O)CHC(CH ₂) ₅ O	H	1966, 245; 1967, 81
	(C ₂ H ₅ O) ₂ P(O)C(CH ₂) ₅ CHO	H	1966, 245; 1967, 81
	(C ₂ H ₅ O) ₂ P(O)C ₆ H ₈ OCH ₃	H	1966, 256
	<i>i</i> -C ₃ H ₇ OP(O)[OCH ₂ CH(CH ₂) ₂] ₂	H	1966, 213
	(C ₂ H ₅ O) ₂ P(O)C(O)C ₆ H ₁₁	H	1967, 166
	(C ₂ H ₅ O) ₂ P(O)C≡CCH ₂ O- <i>t</i> -C ₄ H ₉	H; P (-9.5)	1967, 21
	(C ₂ H ₅ O) ₂ P(O)C(CH ₃)=CHC(O) <i>i</i> -C ₃ H ₇	H	1969, 355
PC ₁₁ H ₂₁ O ₆	(CH ₃ O) ₃ PO(C ₄ H ₉)C(CH ₃)(COCH ₃)O	H; P (-53.1)	1966, 248
PC ₁₁ H ₂₁ O ₇	(C ₂ H ₅ O) ₂ P(O)OC(OC ₂ H ₅)CHCOOC ₂ H ₅	H; P (-8.9)	1965, 95
	(C ₂ H ₅ O) ₂ P(O)OC(OC ₂ H ₅)C(CH ₃)COOCH ₃	H	1965, 95
	(C ₂ H ₅ O) ₂ P(O)CH(COOC ₂ H ₅) ₂	P (12.8)	1965, 95
	(CH ₃ O) ₃ P[OC(CH ₃)C(O)CH ₃] ₂ (stereois.)	H; P (-54.8; -52.6)	1966, 258
PC ₁₁ H ₂₂ N	(C ₂ H ₅) ₂ PC(NC ₆ H ₁₁)H	H	1968, 329
PC ₁₁ H ₂₂ NO ₃	(C ₂ H ₅) ₂ P(O)CH ₂ C(O)CH ₂ (C ₄ H ₉ O)	H	1968, 325
PC ₁₁ H ₂₂ NO ₆	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH(OCOCH ₃)CH ₂ NHCOCH ₃	H	1969, 82
PC ₁₁ H ₂₂ NS	(C ₂ H ₅) ₂ P(S)CH ₂ N(CH ₂ CH=CH ₂) ₂	P (51.4)	1966, 40
PC ₁₁ H ₂₂ N ₃ O ₃	(CH ₃ CHCH ₂ N) ₂ P(O)NHCOOC ₂ H ₅	H	1965, 42
PC ₁₁ H ₂₂ O ₄	(C ₂ H ₅ O) ₂ P(O)OC ₆ H ₉ CH ₃	H	1967, 121
PC ₁₁ H ₂₂ O ₅	(CH ₃ O) ₂ P(O)C(OH)CH ₂ C(CH ₃) ₂ OC(CH ₃) ₂	H	1969, 80
PC ₁₁ H ₂₃ O	(C ₄ H ₉) ₂ PCH ₂ COCH ₃	H	1968, 297
PC ₁₁ H ₂₃ O ₃	(C ₂ H ₅ O) ₂ P(O)C ₆ H ₁₀ CH ₃	H	1966, 256
	(C ₄ H ₉ O) ₂ PCH ₂ COCH ₃	H	1968, 297
	(C ₄ H ₉ O) ₂ POC(CH ₃)=CH ₂	H	1968, 297
PC ₁₁ H ₂₃ O ₄	(C ₄ H ₉ O) ₂ P(O)OC(CH ₃)=CH ₂	H	1968, 297

Formula	Compound	Resonance	Reference
$PC_{11}H_{23}O_5$	$(i-C_3H_7O)_3P[OC(CH_3)_2]$	P (-53.2)	1965, 21
	$(C_2H_5O)_2P(O)CH(OC_2H_5)CH_2COC_2H_5$	H	1966, 249
	$(C_2H_5O)_2P(O)CH=C(OC_2H_5)CH_2OC_2H_5$	H; P (25)	1967, 278
	$(C_2H_5O)_2P(O)CH_2C(O)CH_2Ot-C_4H_9$	H; P (18.7)	1967, 22
$PC_{11}H_{24}NO_2$	$(i-C_4H_9)_2P(O)C(O)N(CH_3)_2$	H	1967, 26
	$(C_2H_5)_2P(O)CH_2C(O)CH_2N(C_2H_5)_2$	H	1968, 325
$PC_{11}H_{24}NO_3$	$(C_2H_5)_2C(CH_2O)_2P(O)NHt-C_4H_9$	H	1967, 91
	$(C_2H_5O)_2P(O)CH=CHCH_2N(C_2H_5)_2$	P (19.9)	1967, 108
$PC_{11}H_{24}NO_4$	$(C_2H_5O)_2P(O)CH_2C(O)CH_2N(C_2H_5)_2$	H; P (17.8)	1967, 22
	$(CH_3O)_2P(O)C(O)N(i-C_4H_9)_2$	H	1967, 26
	$(CH_3O)_2P(O)C(O)N(s-C_4H_9)_2$	H	1967, 26
	$(C_2H_5O)_2P(O)C(O)N(i-C_3H_7)_2$	H	1967, 26; 1968, 29
	$(i-C_3H_7O)_2P(O)C(O)N(C_2H_5)_2$	H	1967, 26
	$(s-C_4H_9O)_2P(O)C(O)N(CH_3)_2$	H	1967, 26
	$(i-C_4H_9O)_2P(O)C(O)NHC_2H_5$	H	1967, 26
	$(C_2H_5)_3GeSCSP(C_2H_5)_2$	H	1967, 342
	$(C_2H_5O)_2P(O)CH=C[N(CH_3)_2]CH_2N(CH_3)_2$	H; P (24.7)	1967, 278
$PC_{11}H_{25}N_2O_3$	$CH_3P(O)(Oi-C_5H_{11})_2$	H; P	1968, 109, 156
$PC_{11}H_{25}O_3$	$(i-C_3H_7O)_2P(O)SC_5H_{11}$	H	1967, 307
$PC_{11}H_{25}O_3S$	$(C_2H_5O)_2P(O)C[N(CH_3)_2](C_2H_5)_2$	H; P (32.5)	1968, 324; 1969, 340
$PC_{11}H_{26}NO_3$	$(t-C_4H_9)_2P(Cl)=NSi(CH_3)_3$	H	1968, 64
$PC_{11}H_{27}ClNSi$	$(C_4H_9)_2POSi(CH_3)_3$	P (116.0)	1967, 343
$PC_{11}H_{27}OSi$	$[(CH_3)_2N]_2P(O)NHCH(CH_3)CH_2N(CH_2)_4$	H	1966, 246
$PC_{11}H_{27}N_4O$	$(t-C_4H_9)_2PNHGe(CH_3)_3$	H	1968, 64
$PC_{11}H_{28}GeN$	$(t-C_4H_9)_2PNHSi(CH_3)_3$	H	1968, 64
$PC_{11}H_{28}NSi$	$(CH_3)_2P[NSi(CH_3)_3]N[Si(CH_3)_3]_2$	H	1968, 65
$PC_{11}H_{33}N_2Si_3$			
$PC_{12}BrF_{10}$	$(C_6F_5)_2PBr$	P (13.0)	1966, 7

PC ₁₂ ClF ₁₀	(C ₆ F ₅) ₂ PCl	P (12-37); F (-129; -160; -148)	1966, 7, 19; 1969, 17
PC ₁₂ F ₁₁ O	(C ₆ F ₅) ₂ P(O)F	F (-131.5; -158.2; -141.5)	1969, 17
PC ₁₂ HF ₁₀	(C ₆ H ₅) ₂ PH	H; P (-143); F (-130.0; -161.8; -151.9)	1966, 7, 19; 1967, 11
PC ₁₂ HF ₁₀ O	(C ₆ F ₅) ₂ P(O)H	H	1966, 26
PC ₁₂ H ₅ BrF ₅	C ₆ H ₅ (C ₆ F ₅)PBr	H; P (39.3)	1966, 7
PC ₁₂ H ₅ ClF ₅	C ₆ H ₅ (C ₆ F ₅)PCl	H; P (57.1)	1966, 7
PC ₁₂ H ₆ F ₅	C ₆ H ₅ (C ₆ F ₅)PH	H; P (-92.2)	1966, 7; 1967, 11
PC ₁₂ H ₈ ClF ₂	(C ₆ H ₄ - <i>p</i> -F) ₂ PCl	H; P (79); F	1969, 19, 120
	(C ₆ H ₄ - <i>m</i> -F) ₂ PCl	P (74.7); F	1969, 18, 120
PC ₁₂ H ₈ ClF ₂ O	(C ₆ H ₄ F) ₂ P(O)Cl	F	1969, 18, 19
PC ₁₂ H ₈ ClO ₄	(OC ₆ H ₄ O) ₂ PCl	P (-9.7)	1966, 238
PC ₁₂ H ₉ F ₂	(C ₆ H ₄ F) ₂ PH	F	1969, 18, 19
PC ₁₂ H ₉ OS ₃		H	1969, 123
PC ₁₂ H ₉ S ₃	 P ; 	H	1969, 124 to 126
PC ₁₂ H ₉ S ₄	 PS ; 	H	1969, 124, 126
PC ₁₂ H ₁₀ Br ₃	(C ₆ H ₅) ₂ P [⊕] Br ₂ , Br [⊖]	P (55.6)	1968, 8

Formula	Compound	Resonance	Reference
PC ₁₂ H ₁₀ Cl	(C ₆ H ₅) ₂ PCl	¹³ C; H; P (81·5)	1965, 7; 1966, 141, 240; 1967, 198, 277; 1968, 103; 1969, 50, 120
PC ₁₂ H ₁₀ ClO	(C ₆ H ₅) ₂ P(O)Cl	P (42·7)	1967, 277
PC ₁₂ H ₁₀ ClO ₂	(C ₆ H ₅ O) ₂ PCl	P (159)	1965, 45
PC ₁₂ H ₁₀ ClO ₃	(C ₆ H ₅ O) ₂ P(O)Cl	P (−6·2)	1965, 45
	C ₆ H ₅ (ClC ₆ H ₃ OH)PO ₂ H	H	1965, 79
PC ₁₂ H ₁₀ ClS	(C ₆ H ₅) ₂ P(S)Cl	P (79·5)	1966, 111; 1967, 277
PC ₁₂ H ₁₀ Cl ₃	(C ₆ H ₅) ₂ PCl ₃	P (73)	1968, 168, 288
PC ₁₂ H ₁₀ Cl ₃ O ₄	(C ₆ H ₅) ₂ P [⊕] Cl ₂ , ClO ₄ [⊖]	P (93·2)	1967, 276
PC ₁₂ H ₁₀ Cl ₃ Sb	(C ₆ H ₅) ₂ P [⊕] Cl ₂ , SbCl ₆ [⊖]	P (93·2)	1967, 276
PC ₁₂ H ₁₀ Cs	(C ₆ H ₅) ₂ PCs	P (0·0)	1965, 103
PC ₁₂ H ₁₀ CsO	(C ₆ H ₅) ₂ POCs	P (84·0)	1968, 320
PC ₁₂ H ₁₀ FO	(C ₆ H ₅) ₂ P(O)F	P (40·5); F (4·1)	1967, 14, 103, 331
PC ₁₂ H ₁₀ FO ₃	(C ₆ H ₅ O) ₂ P(O)F	P (−20·3); F (−82)	1967, 14
PC ₁₂ H ₁₀ FS	(C ₆ H ₅) ₂ P(S)F	P (102·0)	1968, 8
PC ₁₂ H ₁₀ FS ₃	(C ₆ H ₅ S) ₂ P(S)F	P (112); F (−26·4)	1968, 308
PC ₁₂ H ₁₀ F ₃	(C ₆ H ₅) ₂ PF ₃	F	1967, 331
PC ₁₂ H ₁₀ F ₃ S	C ₆ H ₅ (C ₆ H ₅ S)PF ₃	H; P (−23·6); F (−13·6; −71·3)	1968, 316; 1969, 62
PC ₁₂ H ₁₀ F ₄ N	(C ₆ H ₅) ₂ NPF ₄	F (−59·8)	1968, 268
PC ₁₂ H ₁₀ K	(C ₆ H ₅) ₂ PK	P (−12·4)	1965, 103
PC ₁₂ H ₁₀ KO	(C ₆ H ₅) ₂ POK	P (86·8)	1968, 320
PC ₁₂ H ₁₀ Li	(C ₆ H ₅) ₂ PLi	P (−23·0)	1965, 103
PC ₁₂ H ₁₀ LiO	(C ₆ H ₅) ₂ POLi	P (88·9)	1968, 320
PC ₁₂ H ₁₀ Na	(C ₆ H ₅) ₂ PNa	P (−24·4)	1965, 103
PC ₁₂ H ₁₀ NaO	(C ₆ H ₅) ₂ PONa	P (90·5)	1968, 320

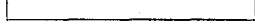
PC ₁₂ H ₁₀ NaS ₂	C ₆ H ₅ P [⊕] (S [⊖]) ₂ , Na [⊕]	P (62·0)	1968, 8
PC ₁₂ H ₁₀ ORb	(C ₆ H ₅) ₂ PORb	P (88·4)	1968, 320
PC ₁₂ H ₁₀ O ₂	(C ₆ H ₅) ₂ PO ₂ [⊖]	P (19·5)	1967, 9
PC ₁₂ H ₁₀ Rb	(C ₆ H ₅) ₂ PRb	P (−7·8)	1965, 103
PC ₁₂ H ₁₁	(C ₆ H ₅) ₂ PH	H; P (−41)	1965, 3, 103; 1966, 204; 1967, 11, 30; 1968, 36
PC ₁₂ H ₁₁ N ₂ O ₂	HP(OC ₆ H ₄ NH) ₂	H; P (−47·5)	1967, 165
PC ₁₂ H ₁₁ O	(C ₆ H ₅) ₂ P(O)H	H; P (25·9)	1967, 42; 1968, 35
PC ₁₂ H ₁₁ OS	(C ₆ H ₅) ₂ P(S)OH	P (18·5)	1968, 36
PC ₁₂ H ₁₁ O ₂	(C ₆ H ₅) ₂ PO ₂ H	P (76·0)	1967, 277
		H; P (25·5)	1965, 79; 1967, 9, 277
PC ₁₂ H ₁₁ O ₃	C ₆ H ₅ (C ₆ H ₄ OH)PO ₂ H	H	1965, 79
	(C ₆ H ₅ O) ₂ POH	P (0·0)	1967, 277
PC ₁₂ H ₁₁ O ₄	(C ₆ H ₅ O) ₂ PO ₂ H	P (−11·5)	1967, 188
PC ₁₂ H ₁₁ S	(C ₆ H ₅) ₂ P(S)H	P (19·6)	1966, 40
PC ₁₂ H ₁₁ S ₂	(C ₆ H ₅) ₂ PS ₂ H	P (56·5)	1967, 277
PC ₁₂ H ₁₁ Se	(C ₆ H ₅) ₂ P(Se)H	P (5·8)	1966, 23
PC ₁₂ H ₁₂ ClO ₄ S	(C ₆ H ₅) ₂ P [⊕] (H)Cl, HSO ₄ [⊖]	P (46)	1969, 50
PC ₁₂ H ₁₂ Cl ₂ N	(C ₆ H ₅) ₂ P [⊕] (NH ₂)Cl, Cl [⊖]	P (51)	1965, 34
PC ₁₂ H ₁₂ NS	(C ₆ H ₅) ₂ P(S)NH ₂	P (54)	1967, 344; 1968, 8
PC ₁₂ H ₁₃	C ₆ H ₅ P[C(CH ₃)=CH] ₂	H	1967, 70
	C ₆ H ₅ P[CH=C(CH ₃)] ₂	H; P (−2·5)	1969, 20, 358
PC ₁₂ H ₁₃ NO ₅	CH ₃ OC ₆ H ₄ C(=NOH)P(O)(OC ₂ H ₅) ₂	H	1968, 142
PC ₁₂ H ₁₃ N ₂	C ₆ H ₅ PCH ₂ C(CN)C(NH ₂)(CH ₂) ₂	H	1969, 76
PC ₁₂ H ₁₃ N ₆ O	[(CH ₃) ₂ N] ₂ P(O)NC(NH ₂)(C ₆ H ₅)N	H	1968, 285
PC ₁₂ H ₁₃ O ₆ S	(C ₆ H ₅) ₂ P [⊕] (OH) ₂ , HSO ₄ [⊖]	P (53·0)	1968, 8

Formula	Compound	Resonance	Reference
PC ₁₂ H ₁₃ S	C ₆ H ₅ P(S)[C(CH ₃)=CH] ₂	H; P (45·7)	1968, 101; 1969, 20, 358
PC ₁₂ H ₁₄ ClN ₂	(C ₆ H ₅) ₂ P [⊕] (NH ₂) ₂ , Cl [⊖]	H; P (32)	1967, 65
PC ₁₂ H ₁₄ ClO ₃	C ₆ H ₅ CHCH=C(CH ₃)OP(O)O(CH ₂) ₂ Cl	H	1966, 220
PC ₁₂ H ₁₄ Cl ₃ O ₄	(C ₂ H ₅ O) ₂ P(O)OC(C ₆ H ₅ Cl ₂)CHCl	H	1968, 284
PC ₁₂ H ₁₄ NO	C ₆ H ₅ P(CH ₂) ₂ NHCH(C ₄ H ₉ O)	H	1967, 137
PC ₁₂ H ₁₄ NO ₄ S	(C ₂ H ₅ O) ₂ P(S)NC(O)C ₆ H ₄ C(O)	H	1966, 56
PC ₁₂ H ₁₅	C ₆ H ₅ P[CH ₂ C(CH ₃)] ₂	H; P (−34·5)	1967, 291; 1969, 76, 358
	CH ₃ P(CH ₂) ₂ C(C ₆ H ₅)=CHCH ₂	H	1967, 75
PC ₁₂ H ₁₅ F ₁₂ O ₂	(C ₂ H ₅) ₃ P[OC(CF ₃) ₂] ₂	P (11·7)	1968, 302
	(C ₂ H ₅) ₃ [(CF ₃) ₂ CHO]POC(CF ₃) ₂ CHCH ₃ (stereios.)	P (−15·7); F (−79; −74·6; −75·9)	1968, 302
PC ₁₂ H ₁₅ F ₁₂ O ₅	(C ₂ H ₅ O) ₃ P[OC(CF ₃) ₂] ₂	P (−53·2); F (−70·8)	1966, 225; 1967, 335; 1968, 303; 1969, 20
PC ₁₂ H ₁₅ O ₂ S	C ₆ H ₅ P(S)(CH ₂ COCH ₃) ₂	H	1968, 297
PC ₁₂ H ₁₅ O ₃	(C ₂ H ₅ O) ₂ P(O)C≡CC ₆ H ₅	H; P (−9)	1967, 21
PC ₁₂ H ₁₅ O ₄	C ₆ H ₅ P(CH ₂ COOCH ₃) ₂	H	1968, 297
PC ₁₂ H ₁₅ O ₅	(C ₂ H ₅ O) ₂ P(O)CHC ₆ H ₄ C(O)O	P (13·2)	1967, 338
	C ₆ H ₅ OP(CH ₂ COOCH ₃) ₂	H	1968, 297
	CH ₃ O(CH ₂ O) ₂ POC(CH ₃)=C(C ₆ H ₅)O	P (−28)	1968, 301

	$\text{C}_6\text{H}_5(\text{CH}_2\text{O})_2\text{P}[\text{OC}(\text{C}_6\text{H}_5)]_2$ (diastereois)	P (−30·8; −36·7)	1968, 301
$\text{PC}_{12}\text{H}_{15}\text{S}$	$\text{C}_6\text{H}_5\text{P}(\text{S})[\text{CH}_2\text{C}(\text{CH}_3)]_2$	H; P (45·3)	1969, 20
$\text{PC}_{12}\text{H}_{16}\text{BF}_6\text{N}_2$	$(\text{CH}_3\text{C}_5\text{H}_4\text{N})_2\text{BH}_2$, PF_6	^{11}B ; H	1968, 330
$\text{PC}_{12}\text{H}_{16}\text{Br}$	$\text{CH}_3(\text{C}_6\text{H}_5\text{CH}_2)\text{P}^\oplus(\text{CH}_2\text{CH})_2$, $\text{Br}^\ominus$	H	1968, 100
$\text{PC}_{12}\text{H}_{16}\text{ClO}_2$	$\text{C}_6\text{H}_5\text{P}(\text{O})(\text{OH})\text{CH}_2\text{CCl}=\text{CHC}_3\text{H}_7$	H	1966, 259
$\text{PC}_{12}\text{H}_{16}\text{ClO}_2\text{S}$	$\text{C}_2\text{H}_5\text{OP}(\text{O})\text{CH}_2\text{CH}(\text{SC}_6\text{H}_4\text{Cl})(\text{CH}_2)_2$	H	1966, 134
$\text{PC}_{12}\text{H}_{16}\text{ClO}_3$	$\text{CH}_3(\text{CH}_2\text{Cl})\text{C}(\text{CH}_2\text{O})_2\text{P}(\text{O})\text{CH}_2\text{C}_6\text{H}_5$	H	1967, 91
$\text{PC}_{12}\text{H}_{16}\text{ClO}_4$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CHCH}(\text{C}_6\text{H}_4\text{Cl})\text{O}$	H	1967, 81
$\text{PC}_{12}\text{H}_{16}\text{F}_{12}\text{N}_3\text{O}_2$	$(\text{CH}_3)_2\text{NP}[\text{N}(\text{CH}_3)\text{CH}_2]_2\text{O}[\text{C}(\text{CF}_3)_2]_2\text{O}$	P (−28·3)	1968, 124, 186
$\text{PC}_{12}\text{H}_{16}\text{NO}_2$	$\text{C}_6\text{H}_5(\text{CH}_2=\text{CH})\text{P}(\text{O})\text{N}(\text{CH}_2)_4\text{O}$	H	1966, 250
$\text{PC}_{12}\text{H}_{16}\text{NO}_6$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{C}(\text{O})\text{C}_6\text{H}_4\text{NO}_2$	H	1967, 121
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{OC}(=\text{CH}_2)\text{C}_6\text{H}_4\text{NO}_2$	H	1967, 121
$\text{PC}_{12}\text{H}_{16}\text{N}_3\text{O}_3\text{S}_2$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{S})\text{SCH}_2\text{NC}(\text{O})\text{C}_6\text{H}_4\text{N}=\text{N}$	H	1968, 284
$\text{PC}_{12}\text{H}_{16}\text{N}_5\text{O}_3$	$\text{C}_6\text{H}_5\text{NHP}(\text{O})[\text{N}(\text{CH}_2)_2\text{NHC}(\text{O})]_2$	H	1961, 5
$\text{PC}_{12}\text{H}_{17}$	$\text{C}_6\text{H}_5\text{PCH}_2\text{CH}(\text{CH}_3)\text{C}(\text{CH}_3)_2$	H	1967, 82
$\text{PC}_{12}\text{H}_{17}\text{N}_2\text{O}_7$	$(i\text{-C}_3\text{H}_7\text{O})_2\text{P}(\text{O})\text{C}_6\text{H}_3(\text{NO}_2)_2$	H	1969, 119
$\text{PC}_{12}\text{H}_{17}\text{N}_2\text{S}$	$\text{C}_6\text{H}_5\text{P}(\text{S})(\text{NCH}_2\text{CHCH}_3)_2$	H; P (101·5)	1967, 113
$\text{PC}_{12}\text{H}_{17}\text{O}$	$\text{C}_6\text{H}_5\text{P}(\text{O})\text{CH}_2\text{CH}(\text{CH}_3)\text{C}(\text{CH}_3)_2$	H	1967, 82
	$\text{CH}_3\text{P}[(\text{CH}_2)_2]_2\text{C}(\text{C}_6\text{H}_5)\text{OH}$	H	1967, 75
$\text{PC}_{12}\text{H}_{17}\text{O}_2$	$\text{C}_6\text{H}_5\text{P}[\text{OC}(\text{CH}_3)_2]_2$	H(T)	1966, 51

Formula	Compound	Resonance	Reference
PC ₁₂ H ₁₇ O ₂ S	C ₂ H ₅ OP(O)CH ₂ CH(SC ₆ H ₅)CH ₂ CH ₂	H	1966, 134
PC ₁₂ H ₁₇ O ₃	C ₆ H ₅ OP[OC(CH ₃) ₂] ₂	H(T)	1966, 51
	C ₆ H ₅ CH ₂ P(O)(OCH ₂) ₂ C(CH ₃) ₂	H	1967, 91; 1968, 74
	C ₆ H ₅ P(O)[OC(CH ₃) ₂] ₂	P (6)	1969, 343
PC ₁₂ H ₁₇ O ₄	(C ₂ H ₅ O) ₂ P(O)CHCH(C ₆ H ₅)O	H	1966, 245; 1967, 81
	(C ₂ H ₅ O) ₂ P(O)CH(C ₆ H ₅)CHO	H	1966, 245; 1967, 81
	(C ₂ H ₅ O) ₂ P(O)CH ₂ C(O)C ₆ H ₅	H	1967, 121
	(C ₂ H ₅ O) ₂ P(O)OC(=CH ₂)C ₆ H ₅	H	1967, 121
	(C ₂ H ₅ O) ₂ P(O)C(O)CH ₂ C ₆ H ₅	H	1968, 93
	C ₆ H ₅ OP(O)OCH(CH ₃)CH ₂ C(CH ₃) ₂ O	H; P (-14)	1968, 83, 150; 1969, 175
PC ₁₂ H ₁₇ O ₅	(CH ₃ O) ₃ POC(CH ₃)C(C ₆ H ₅)O	H; P (-49.5)	1966, 258; 1968, 301
PC ₁₂ H ₁₈ Br	CH ₃ (C ₆ H ₅ CH ₂)P [⊕] (CH ₂) ₄ , Br [⊖]	H	1969, 356
PC ₁₂ H ₁₈ NO	(C ₂ H ₅) ₂ NP(O)(C ₆ H ₅)CH=CH ₂	H	1966, 250
PC ₁₂ H ₁₈ NO ₃	C ₆ H ₅ (<i>i</i> -C ₃ H ₇ O)P(O)C(O)N(CH ₃) ₂	H	1967, 26
	(CH ₂ O) ₂ P(O)C(CH ₃)(C ₆ H ₅)N(CH ₃) ₂	H; P (48)	1968, 324; 1969, 340
	(C ₂ H ₅ O) ₂ P=NC(OCH ₃)C ₆ H ₅	P (135)	1969, 357
	HP[OCH(CH ₃)CH ₂ NH][OC ₆ H ₃ (CH ₃)O]	H; P (-37.6)	1969, 178
PC ₁₂ H ₁₈ NO ₄	(CH ₃ O) ₂ P(O)C(O)N(C ₂ H ₅)C ₆ H ₄ CH ₃	H	1968, 29
PC ₁₂ H ₁₈ NO ₅	(<i>i</i> -C ₃ H ₇ O) ₂ P(O)C ₆ H ₄ NO ₂	H; P (8.5)	1969, 119
PC ₁₂ H ₁₈ NO ₆ S	(C ₂ H ₅ O) ₂ P(O)C(O)NHSO ₂ C ₆ H ₄ CH ₃	H	1968, 328; 1969, 161
PC ₁₂ H ₁₈ N ₃ O	C ₆ H ₅ NHP(O)[C(CH ₃) ₂ N] ₂	H	1966, 220
PC ₁₂ H ₁₈ N ₃ O ₃	P[OC(CH ₃) ₂ (C≡N)] ₃	P (143.5)	1967, 293
PC ₁₂ H ₁₈ N ₃ O	OP[OC(CH ₃) ₂ (C≡N)] ₃	P (-15.4)	1967, 293

PC ₁₂ H ₁₉	C ₆ H ₅ P(<i>n</i> -C ₃ H ₇) ₂	H(T); P (10)	1965, 3; 1967, 244; 1968, 6, 7, 66; 1969, 162
PC ₁₂ H ₁₉ ClN	C ₆ H ₅ P(C ₃ H ₇) ₂	P (-27.7)	1967, 8
PC ₁₂ H ₁₉ ClNO ₃	(C ₃ H ₇) ₂ NP(Cl)(C ₆ H ₅)	H	1968, 92
	CH ₃ O(CH ₃ NH)P(O)OC ₆ H ₃ (Cl) <i>t</i> -C ₄ H ₉	H	1968, 284, 285; 1969, 322
PC ₁₂ H ₁₉ N ₂ O	(CH ₃) ₂ NPOCH(C ₆ H ₅)CH(CH ₃)NCH ₃	P (130)	1969, 109
PC ₁₂ H ₁₉ O ₂	(CH ₃) ₂ C ₆ H ₃ P(O)(CH)O- <i>s</i> -C ₄ H ₉ (stereo.)	H; P (22.1; 20.9)	1969, 162
PC ₁₂ H ₁₉ O ₃	C ₂ H ₅ C ₆ H ₄ P(O)(OC ₂ H ₅) ₂	H	1968, 317
	C ₆ H ₅ P(O)(<i>Oi</i> -C ₃ H ₇) ₂	H	1969, 101
	CH ₃ (C ₆ H ₅)CHP(O)(OC ₂ H ₅) ₂	H	1969, 51
PC ₁₂ H ₁₉ O ₃ S	CH ₃ (C ₆ H ₅)CHSP(O)(OC ₂ H ₅) ₂	H	1966, 52, 260
PC ₁₂ H ₁₉ O ₅	(CH ₃ O) ₂ P(O)CH(OCH ₃)C(CH ₃)(C ₆ H ₅)OH	H	1967, 81
PC ₁₂ H ₁₉ O ₈	(C ₂ H ₅ O) ₂ P(O)CH[C(O)COOC ₂ H ₅](CH ₂) ₂ OCO	H	1965, 104
PC ₁₂ H ₂₀ Br	C ₆ H ₅ P [⊕] (C ₂ H ₅) ₃ , Br [⊖]	P (36.3)	1968, 6
	C ₆ H ₅ (CH ₃) ₂ P [⊕] C ₄ H ₉ , Br [⊖]	P (26.2)	1968, 6
	C ₆ H ₅ (<i>i</i> -C ₃ H ₇) ₂ P [⊕] H, Br [⊖]	H; P (32.0)	1968, 7
	(C ₃ H ₅) ₄ P [⊕] Br [⊖]	H	1969, 354
PC ₁₂ H ₂₀ N	(C ₂ H ₅) ₂ NP(C ₆ H ₅) ₂	H; P (60.8)	1969, 333
PC ₁₂ H ₂₀ NO ₃	(C ₂ H ₅ O) ₂ P(O)NHC ₆ H ₄ C ₂ H ₅	H	1965, 102
	C ₆ H ₅ P(O)[N(CH ₃) ₂][O[CH(CH ₃) ₂]OH]	P (24.2)	1969, 343
PC ₁₂ H ₂₀ NO ₄	(C ₂ H ₅ O) ₂ P(O)CH(OH)CH ₂ NHC ₆ H ₅	H	1969, 82
	C ₆ H ₅ OP(O)(O [⊖])OCH ₂ CH(CH ₃)•(CH ₃) ₃ NH [⊕]	P (-6.9)	1969, 359
	C ₆ H ₅ N [⊕] (CH ₃) ₃ O [⊖] P(O)OCH ₂ CH(CH ₃)O	P (ca. 15)	1969, 359
PC ₁₂ H ₂₀ N ₃ O	[(CH ₃) ₂ N] ₂ P=N(OCH ₃)C ₆ H ₅	P (98)	1969, 357
PC ₁₂ H ₂₁ ClNO ₄	CH ₃ OC ₆ H ₄ CH(NH ₃ Cl)P(O)(OC ₂ H ₅) ₂	H; P (18.2)	1968, 142, 296
PC ₁₂ H ₂₁ Cl ₃ NO ₇	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH(OCONHCCOCl ₃)CH ₂ OC ₂ H ₅	H	1969, 82
PC ₁₂ H ₂₁ N ₂	C ₆ H ₅ P(NH- <i>i</i> -C ₃ H ₇) ₂	H	1967, 95
PC ₁₂ H ₂₁ N ₂ O	C ₆ H ₅ P(O)(NH- <i>i</i> -C ₃ H ₇) ₂	H	1967, 95

Formula	Compound	Resonance	Reference
PC ₁₂ H ₂₁ N ₂ O ₃ S ₂	(C ₂ H ₅ O) ₂ P(S)OCNC(<i>i</i> -C ₃ H ₇)NC(CH ₃)CH 	H	1968, 284, 285; 1969, 322
PC ₁₂ H ₂₁ N ₂ O ₄	(C ₂ H ₅ O) ₂ P(O)OCNC(<i>i</i> -C ₃ H ₇)NC(CH ₃)CH 	H	1968, 296
PC ₁₂ H ₂₁ N ₂ S	C ₆ H ₅ P(S)(NHC ₃ H ₇) ₂ C ₆ H ₅ P(S)(NH- <i>i</i> -C ₃ H ₇) ₂	H H(T)	1967, 318 1967, 95; 1968, 145; 1969, 111
PC ₁₂ H ₂₁ N ₂ Se	C ₆ H ₅ P(Se)(NH- <i>i</i> -C ₃ H ₇) ₂	H	1968, 145
PC ₁₂ H ₂₁ O ₃ Si	HP(O)[OSi(C ₂ H ₅) ₂ C ₆ H ₅](OC ₂ H ₅)	H	1967, 34
PC ₁₂ H ₂₁ O ₄	(CH ₂ CH ₂ CHO) ₄ PH	P (-32)	1968, 154
PC ₁₂ H ₂₁ O ₅	(C ₂ H ₅ O) ₂ P(O)CH=C(CH ₂) ₄	H	1967, 327
PC ₁₂ H ₂₁ O ₆	P(CH ₂ COOC ₂ H ₅) ₃	H	1968, 297
PC ₁₂ H ₂₂ Cl ₃ O ₅	(<i>i</i> -C ₄ H ₉ O) ₂ P(O)CH(CCl ₃)OC(O)CH ₃	H; P (11·4)	1967, 3
PC ₁₂ H ₂₃ Cl ₂ O ₅	(C ₄ H ₉ O) ₂ P(O)CH(CHCl ₂)OC(O)CH ₃ (<i>i</i> -C ₄ H ₉ O) ₂ P(O)CH(CHCl ₂)OC(O)CH ₃	H; P (13·5) H; P (14·1)	1967, 3 1967, 3
PC ₁₂ H ₂₃ N ₄	C ₆ H ₅ P[N(CH ₃)N(CH ₃) ₂] ₂	H; P (80·2)	1967, 94
PC ₁₂ H ₂₃ O	(C ₆ H ₁₁) ₂ P(O)H	P (46·4)	1967, 172
PC ₁₂ H ₂₃ O ₃	(C ₂ H ₅ O) ₂ P(O)C ₆ H ₇ (CH ₃) ₂ C ₂ H ₅ OP[OC(CH=CH ₂)(CH ₃) ₂] ₂ (C ₂ H ₅ O) ₂ P(O)C≡CC ₆ H ₁₃ CH ₃ (CH ₃ O)P(O)O-bornyl	H P (132·1) H; P (-8·8) H	1966, 256 1967, 293 1967, 21 1967, 168
PC ₁₂ H ₂₃ O ₄	(C ₂ H ₅ O) ₂ P(O)C(O)C ₇ H ₁₃ [CH ₂ =CH(CH ₃) ₂ CO] ₂ PO	H P (-13·1)	1967, 166 1967, 293
PC ₁₂ H ₂₄	<i>t</i> -C ₄ H ₉ P[C(CH ₃) ₂] ₂ CCH ₃	H(T)	1968, 121
PC ₁₂ H ₂₄ ClO ₅	(C ₄ H ₉ O) ₂ P(O)CH(CH ₂ Cl)OC(O)CH ₃ (<i>i</i> -C ₄ H ₉ O) ₂ P(O)CH(CH ₂ Cl)OC(O)CH ₃	H; P (18·1) H; P (21·8)	1967, 3 1967, 3
PC ₁₂ H ₂₄ Cl ₂ NO ₃	[CH ₃ (CH ₂ Cl)CHO][(C ₂ H ₅) ₂ N]P(O)OC(CH ₂ Cl)=CH ₂	H	1967, 340
PC ₁₂ H ₂₄ NO ₂	(C ₂ H ₅) ₂ P(O)CH ₂ C(O)CH ₂ N(CH ₂) ₅	H	1968, 325
PC ₁₂ H ₂₄ N ₃ OS	[(CH ₃) ₂ N] ₂ P(O)NH(CH ₂) ₂ SC ₆ H ₅	H	1966, 246

PC ₁₂ H ₂₅ ClNO ₃	[CH ₃ (CH ₂ Cl)CHO][[(C ₃ H ₇) ₂ N]P(O)OC(CH ₃)=CH ₂	H	1967, 340
PC ₁₂ H ₂₅ N ₂ O ₂	(C ₅ H ₁₀ NCH ₂) ₂ PO ₂ H	P (16·0)	1967, 301
PC ₁₂ H ₂₅ N ₄ S ₂	(C ₂ H ₅) ₂ NCNP(S)(C ₂ H ₅)SC[N(C ₂ H ₅) ₂ N]	H; P (68·5)	1968, 137
PC ₁₂ H ₂₅ O	C ₈ H ₁₇ P(CH ₂ CH ₂) ₂ O	P (−52)	1969, 44
PC ₁₂ H ₂₅ O ₃ Sn	(C ₂ H ₅ O) ₂ P(O)C≡CSn(C ₂ H ₅) ₃	H	1967, 319
PC ₁₂ H ₂₅ O ₄	HP[OC(CH ₃) ₂] ₄	P (−39·8)	1968, 304; 1969, 179
PC ₁₂ H ₂₆ NO ₃	(C ₂ H ₅ O) ₂ P(O)C[N(CH ₃) ₂]C ₅ H ₁₀	H; P (31)	1968, 324; 1969, 340
PC ₁₂ H ₂₆ N ₃	P[N(CH ₃)CH ₂] ₃ CC ₅ H ₁₁	H; P (86·6)	1969, 71
PC ₁₂ H ₂₇	C ₁₂ H ₂₅ PH ₂	H; P (−139)	1966, 4, 14
	C ₁₀ H ₂₁ P(CH ₃) ₂	H; P (−32)	1966, 14
	(C ₄ H ₉) ₃ P	¹³ C; H; P (−325)	1965, 3; 1966, 206; 1967, 244, 277; 1968, 6, 7, 22, 164, 211, 303; 1969, 21, 50, 249, 354
	(<i>i</i> -C ₄ H ₉) ₃ P	P (−45·3)	1965, 3; 1967, 8, 244
	(<i>s</i> -C ₄ H ₉) ₃ P	P (7·9)	1967, 244; 1968, 6
	<i>t</i> -C ₄ H ₉ P(C ₄ H ₉) ₂	H; P (−4·6)	1968, 6
	C ₄ H ₉ P(<i>t</i> -C ₄ H ₉) ₂	H; P (26·6)	1968, 6
	P(<i>t</i> -C ₄ H ₉) ₃	H; P (63)	1969, 78
PC ₁₂ H ₂₇ Br ₂	(C ₄ H ₉) ₃ PBr ₂	H; P (105)	1967, 345
PC ₁₂ H ₂₇ Br ₄ Hg	(C ₄ H ₉) ₃ P [⊕] Br, HgBr ₃ [⊖]	H; P (102)	1967, 345
PC ₁₂ H ₂₇ Cl ₂	(C ₄ H ₉) ₃ PCl ₂	H; P (105)	1967, 191, 345; 1968, 164
PC ₁₂ H ₂₇ Cl ₇ Sb	(C ₄ H ₉) ₃ PCl [⊕] , SbCl ₆ [⊖]	H; P (102)	1967, 191, 345
PC ₁₂ H ₂₇ F ₂	(C ₄ H ₉) ₃ PF ₂	F (−34·2)	1967, 61
PC ₁₂ H ₂₇ F ₂ O ₂ Sn	(C ₄ H ₉) ₃ SnOPOF ₂	P (−25·5); F (−82·3)	1967, 282
PC ₁₂ H ₂₇ F ₂ S ₃	(C ₄ H ₉ S) ₃ PF ₂	F (−72·3)	1967, 61
PC ₁₂ H ₂₇ GeO	(C ₂ H ₅) ₃ GeOC=(CH ₂)P(C ₂ H ₅) ₂	H	1969, 341

Formula	Compound	Resonance	Reference
PC ₁₂ H ₂₇ O	(C ₄ H ₉) ₃ PO	P (43)	1965, 85; 1966, 106; 1967, 277, 345
PC ₁₂ H ₂₇ OS ₃	(C ₄ H ₉ S) ₃ PO	H	1968, 285
PC ₁₂ H ₂₇ O ₃	(C ₄ H ₉ O) ₃ P	P (140)	1967, 277
	(<i>t</i> -C ₄ H ₉ O) ₃ P	H; P (138·2)	1967, 293
	[CH ₃ (C ₂ H ₅)CHO] ₃ P	P (139·1)	1967, 293
	C ₂ H ₅ OP(O <i>neo</i> -C ₅ H ₁₁) ₂	P (137·2)	1967, 293
PC ₁₂ H ₂₇ O ₃ S	(C ₄ H ₉ O) ₃ PS	P (66·5)	1967, 277
	(<i>t</i> -C ₄ H ₉ O) ₃ PS	H; P (41·2)	1967, 293
PC ₁₂ H ₂₇ O ₃ Se	(<i>t</i> -C ₄ H ₉ O) ₃ PSe	H; P (31·1)	1967, 293
PC ₁₂ H ₂₇ O ₄	(C ₃ H ₇ O) ₂ P(O)(CH ₂) ₂ OC ₄ H ₉	H	1966, 251
	(<i>i</i> -C ₃ H ₇ O) ₂ P(O)(CH ₂) ₂ OC ₄ H ₉	H	1966, 251
	(C ₃ H ₇ O) ₂ P(O)(CH ₂) ₂ O <i>i</i> -C ₄ H ₉	H	1966, 251
	(C ₄ H ₉ O) ₃ PO	¹³ C; H; P (1)	1966, 105; 1967, 277; 1968, 22, 109, 157; 1969, 74
	(<i>t</i> -C ₄ H ₉ O) ₃ PO	H; P (−13·3)	1967, 293
	C ₂ H ₅ OP(O)(O <i>neo</i> -C ₅ H ₁₁) ₂	P (−1·0)	1967, 293
PC ₁₂ H ₂₇ S	(C ₂ H ₅) ₂ P(S)C ₈ H ₁₇	P (52·6)	1966, 40
	(C ₄ H ₉) ₃ PS	P (53; 48)	1966, 106; 1967, 277
	(<i>t</i> -C ₄ H ₉) ₃ PS	H	1967, 68
PC ₁₂ H ₂₇ S ₃	(C ₄ H ₉ S) ₃ P	H	1968, 285
PC ₁₂ H ₂₈	(<i>t</i> -C ₄ H ₉) ₃ P [⊕] H	P (58·3)	1969, 12
PC ₁₂ H ₂₈ Br	(C ₄ H ₉) ₃ P [⊕] H, Br [⊖]	¹³ C; H; P (11·9)	1968, 7, 22
	(C ₃ H ₇) ₄ P [⊕] , Br [⊖]	P (31·9)	1968, 6
PC ₁₂ H ₂₈ Br ₄ N	(C ₃ H ₇) ₄ NPBr ₄	P (<i>ca.</i> 150)	1969, 11
PC ₁₂ H ₂₈ F ₂ NOS	(C ₃ H ₇) ₄ N [⊕] , F ₂ P(O)S [⊖]	P (46·5); F (−34)	1967, 281
PC ₁₂ H ₂₈ NO ₂	(<i>t</i> -C ₅ H ₁₁ O) ₂ PN(CH ₃) ₂	P (135)	1969, 340
PC ₁₂ H ₂₉ IN	C ₂ H ₅ (C ₆ H ₅) ₂ P [⊕] (CH ₂) ₂ N(C ₂ H ₅) ₂ , I [⊖]	P (30·2)	1965, 101

$\text{PC}_{12}\text{H}_{29}\text{N}_4\text{O}$	$[(\text{CH}_3)_2\text{N}]_2\text{P}(\text{O})\text{NHC}(\text{CH}_3)_2\text{CH}_2\text{N}(\text{CH}_2)_4$	H	1966, 246
$\text{PC}_{12}\text{H}_{29}\text{O}_4\text{S}$	$(\text{C}_4\text{H}_9)_3\text{PH}, \text{HSO}^\oplus$	H; P (12)	1969, 50
$\text{PC}_{12}\text{H}_{30}\text{AlO}$	$(\text{C}_2\text{H}_5)_3\text{POAl}(\text{C}_2\text{H}_5)_3$	H	1965, 83
$\text{PC}_{12}\text{H}_{30}\text{Cl}_2\text{N}_3$	$[(\text{C}_2\text{H}_5)_2\text{N}]_3\text{PCl}_2$	H	1968, 90
$\text{PC}_{12}\text{H}_{30}\text{N}_3$	$[(\text{C}_2\text{H}_5)_2\text{N}]_3\text{P}$	H	1965, 18
$\text{PC}_{12}\text{H}_{30}\text{N}_3\text{O}$	$[(\text{C}_2\text{H}_5)_2\text{N}]_3\text{PO}$	H	1965, 18; 1968, 90
$\text{PC}_{12}\text{H}_{30}\text{N}_3\text{S}$	$[(\text{C}_2\text{H}_5)_2\text{N}]_3\text{PS}$	H	1965, 18
$\text{PC}_{12}\text{H}_{31}\text{O}_3\text{Si}_2$	$\text{HP}(\text{O})[\text{OSi}(\text{C}_2\text{H}_5)_3]_2$	H	1967, 34
$\text{PC}_{12}\text{H}_{33}\text{AlNSi}$	$(\text{C}_2\text{H}_5)_3\text{PN}[\text{Al}(\text{CH}_3)_3]\text{Si}(\text{CH}_3)_3$	H	1967, 322
	$(\text{CH}_3)_3\text{PN}[\text{Al}(\text{C}_2\text{H}_5)_3]\text{Si}(\text{CH}_3)_3$	H	1967, 322
$\text{PC}_{12}\text{H}_{35}\text{GaNSi}$	$(\text{C}_2\text{H}_5)_3\text{PN}[\text{Ga}(\text{CH}_3)_3]\text{Si}(\text{CH}_3)_3$	H	1967, 322
$\text{PC}_{12}\text{H}_{33}\text{InNSi}$	$(\text{C}_2\text{H}_5)_3\text{PN}[\text{In}(\text{CH}_3)_3]\text{Si}(\text{CH}_3)_3$	H	1967, 322
$\text{PC}_{12}\text{H}_{33}\text{LiN}_3\text{S}_2$	$t\text{-C}_4\text{H}_9[(\text{CH}_3)_2\text{N}]_2\text{P}[\text{NLiSi}(\text{CH}_3)_3]\text{NSi}(\text{CH}_3)_3$	H	1968, 65
$\text{PC}_{12}\text{H}_{33}\text{N}_4\text{Sn}$	$[(\text{CH}_3)_2\text{N}]_3\text{P}=\text{NSn}(\text{C}_2\text{H}_5)_3$	H	1967, 299
$\text{PC}_{12}\text{H}_{34}\text{N}_3\text{Si}_2$	$t\text{-C}_4\text{H}_9[(\text{CH}_3)_2\text{N}]_2\text{P}[\text{NHSi}(\text{CH}_3)_3]\text{NSi}(\text{CH}_3)_3$	H	1968, 65
$\text{PC}_{12}\text{H}_{36}\text{ClSn}_4$	$\text{ClP}[\text{Sn}(\text{CH}_3)_3]_4$	H	1969, 14
$\text{PC}_{13}\text{F}_{10}\text{N}$	$(\text{C}_6\text{F}_5)_2\text{PC}=\text{N}$	P (-100.2)	1968, 9
$\text{PC}_{13}\text{F}_{10}\text{NO}$	$(\text{C}_6\text{F}_5)_2\text{PN}=\text{C}=\text{O}$	P (17.0)	1968, 9
$\text{PC}_{13}\text{F}_{10}\text{NS}$	$(\text{C}_6\text{F}_5)_2\text{PN}=\text{C}=\text{S}$	P (12.4)	1968, 9
$\text{PC}_{13}\text{F}_{10}\text{NS}_2$	$(\text{C}_6\text{F}_5)_2\text{P}(\text{S})\text{N}=\text{C}=\text{S}$	P (-4.2)	1968, 9
$\text{PC}_{13}\text{H}_3\text{F}_{10}$	$(\text{C}_6\text{F}_5)_2\text{PCH}$	P (-52.2)	1967, 11
$\text{PC}_{13}\text{H}_3\text{F}_{10}\text{O}$	$(\text{C}_6\text{F}_5)_2\text{P}(\text{O})\text{CH}_3$	P (18.7)	1967, 11
$\text{PC}_{13}\text{H}_8\text{F}_5$	$\text{CF}_3\text{P}(\text{C}_6\text{H}_4\text{F})_2$	F	1968, 14
$\text{PC}_{13}\text{H}_9\text{Cl}_2\text{O}_4$	$\text{Cl}_2\text{P}(\text{O})\text{OC}_6\text{H}_4\text{COOC}_6\text{H}_5$	P (3.7)	1965, 45
$\text{PC}_{13}\text{H}_9\text{Cl}_4\text{O}_2$	$\text{Cl}_2\text{P}(\text{O})\text{OC}_6\text{H}_4\text{CCl}_2\text{C}_6\text{H}_5$	P (0.0)	1965, 45; 1966, 261
$\text{PC}_{13}\text{H}_9\text{Cl}_4\text{O}_3$	$\text{Cl}_2\text{P}(\text{O})\text{OC}_6\text{H}_4\text{CCl}_2\text{OC}_6\text{H}_5$	P (0.0)	1965, 45; 1966, 261
$\text{PC}_{13}\text{H}_{10}\text{Cl}$	$\text{ClPC}_6\text{H}_4\text{C}_6\text{H}_4\text{CH}_2$	H	1968, 120
$\text{PC}_{13}\text{H}_{10}\text{FN}_2$	$(\text{C}_6\text{H}_5)_2\text{PF}=\text{NCN}$	P (50.3); F (-82.1)	1967, 63
$\text{PC}_{13}\text{H}_{10}\text{N}$	$(\text{C}_6\text{H}_5)_2\text{PC}\equiv\text{N}$	P (-33.8)	1966, 262

Formula	Compound	Resonance	Reference
PC ₁₃ H ₁₀ NS	(C ₆ H ₅) ₂ P(S)C≡N	P (23·9)	1966, 262
PC ₁₃ H ₁₁	HPC ₆ H ₄ C ₆ H ₄ CH ₂ 	H	1968, 120
PC ₁₃ H ₁₁ Cl ₂ O ₇ S ₂	CH ₃ P(O)(OC ₆ H ₄ SO ₂ Cl) ₂	H	1966, 75
PC ₁₃ H ₁₁ F ₂	CH ₃ P(C ₆ H ₄ F) ₂	F	1969, 18, 19
PC ₁₃ H ₁₁ F ₂ O	CH ₃ P(O)(C ₆ H ₄ F) ₂	F	1969, 18, 19
	CH ₃ OP(C ₆ H ₄ F) ₂	F	1969, 18, 19
PC ₁₃ H ₁₁ F ₂ S	CH ₃ P(S)(C ₆ H ₄ F) ₂	F	1969, 18, 19
PC ₁₃ H ₁₁ NNaO ₂	(C ₆ H ₅) ₂ P(O)N [⊖] CHO, Na [⊕]	H	1966, 235
PC ₁₃ H ₁₁ O ₃	(C ₆ H ₅) ₂ CHPO ₃ ^{2⊖}	P (16·5)	1967, 7
PC ₁₃ H ₁₂ BrO	C ₆ H ₅ (BrC ₆ H ₄ CH ₂)P(O)H	H	1968, 35
PC ₁₃ H ₁₂ Cl	CH ₂ ClP(O)(C ₆ H ₅) ₂	H	1968, 56
PC ₁₃ H ₁₂ ClO ₃	C ₆ H ₅ P(O)(OH)CH(C ₆ H ₄ Cl)OH	H	1968, 56
PC ₁₃ H ₁₂ Li	(C ₆ H ₅) ₂ PCH ₂ Li	P (2·6)	1967, 329
PC ₁₃ H ₁₂ NO ₂	(C ₆ H ₅) ₂ P(O)NHCHO	H	1966, 235
PC ₁₃ H ₁₃	CH ₃ P(C ₆ H ₅) ₂	H; P (−28)	1965, 3; 1966, 41; 1967, 79, 244, 329; 1968, 7, 54, 259
	HP(C ₆ H ₅)CH ₂ C ₆ H ₅	H	1969, 360
PC ₁₃ H ₁₃ ClN	CH ₃ (C ₆ H ₅)NP(Cl)(C ₆ H ₅)	H	1968, 92
PC ₁₃ H ₁₃ Cl ₂ O ₅	(CH ₃ O) ₂ P(O)O(C ₁₀ H ₄ Cl ₂)OCH ₃	H; P (−3·8)	1968, 315
PC ₁₃ H ₁₃ F ₂ O ₂	CH ₃ PF ₂ (OC ₆ H ₅) ₂	H; P; F (−18)	1968, 316; 1969, 62
PC ₁₃ H ₁₃ F ₂ S	(C ₆ H ₅) ₂ PF ₂ (SCH ₃)	H; P (−39); F (−25·0)	1968, 316; 1969, 62
PC ₁₃ H ₁₃ O	CH ₃ P(O)(C ₆ H ₅) ₂	H	1967, 19, 239; 1968, 56
	HP(O)(C ₆ H ₅)CH ₂ C ₆ H ₅	H	1968, 35; 1969, 34
	CH ₃ OP(C ₆ H ₅) ₂	P (115)	1969, 50

PC ₁₃ H ₁₃ OS	CH ₃ OP(S)(C ₆ H ₅) ₂	H; P (83·4)	1967, 87, 113; 1968, 8; 1969, 87
PC ₁₃ H ₁₃ OSe	CH ₃ SP(O)(C ₆ H ₅) ₂	H; P (42·5)	1967, 9, 113
PC ₁₃ H ₁₃ O ₂	CH ₃ OP(Se)(C ₆ H ₅) ₂	H; P (88·5)	1967, 113; 1969, 87
	C ₆ H ₅ (C ₆ H ₅ CH ₂)PO ₂ H	H	1965, 79; 1968, 56
	CH ₃ OP(O)(C ₆ H ₅) ₂	H; P (32·5)	1967, 9, 113; 1969, 87
	CH ₂ (OH)P(O)(C ₆ H ₅) ₂	H	1968, 56
PC ₁₃ H ₁₃ O ₅	HOP(O)OC(CH ₃) ₂ C(CH ₃)(COCH ₃)O	H	1967, 140
PC ₁₃ H ₁₃ S	CH ₃ P(S)(C ₆ H ₅) ₂	H	1967, 19
PC ₁₃ H ₁₃ S ₂	CH ₃ SP(S)(C ₆ H ₅) ₂	H; P (65·2)	1967, 113; 1968, 8
PC ₁₃ H ₁₄ Br	CH ₃ (C ₆ H ₅) ₂ P [⊕] H, Br [⊖]	H; P (−2·2)	1968, 89
PC ₁₃ H ₁₄ N	CH ₃ (C ₆ H ₅)NP(C≡CCH ₃) ₂	H	1967, 80, 106
PC ₁₃ H ₁₄ NO ₄	C ₆ H ₅ P(O)(O [⊖])O(CH ₂) ₂ N [⊕] H(C ₆ H ₅)	P (−5·7)	1969, 359
PC ₁₃ H ₁₄ NS	CH ₃ NHP(S)(C ₆ H ₅) ₂	P (61·2)	1968, 8
PC ₁₃ H ₁₅ ClN	CH ₃ (C ₆ H ₅) ₂ P [⊖] (NH ₂), Cl [⊖]	H; P (38)	1967, 65; 1968, 54
PC ₁₃ H ₁₅ ClNO ₃	(C ₂ H ₅ O) ₂ P(O)C(CN)=CH(C ₆ H ₄ Cl)	H {P}	1968, 323
PC ₁₃ H ₁₅ NO ₆	(C ₂ H ₅ O) ₂ P(O)CH(NH ₃ [⊕] Cl)C ₆ H ₅ (OCH ₃) ₂	H	1968, 142
PC ₁₃ H ₁₅ N ₂ O	CH ₃ (O)(NHC ₆ H ₅) ₂	H	1965, 82
PC ₁₃ H ₁₅ O ₅	(CH ₃ O) ₂ P(O)C ₁₀ H ₆ (OCH ₃)	H; P (−3·3)	1968, 315
	(CH ₃ O) ₃ POC ₁₀ H ₆ O	H; P (−45·5)	1968, 315
PC ₁₃ H ₁₅ O ₅ S	CH ₃ O(C ₆ H ₅) ₂ P [⊕] H, HSO ₄ [⊖]	H; P (56)	1969, 50
PC ₁₃ H ₁₆ ClO ₃	C ₆ H ₅ CHCH=C(CH ₃)OP(O)OCH(CH ₃)CH ₂ Cl	H	1966, 220
PC ₁₃ H ₁₆ FO ₆	(CH ₃ O) ₂ P(O)OC(CH ₃)(COCH ₃)[C(O)C ₆ H ₄ F]	H; P (−2·9)	1968, 313
PC ₁₃ H ₁₆ NO ₃	(C ₂ H ₅ O) ₂ P(O)C(CN)=CH(C ₆ H ₅)	H {P}	1968, 323
PC ₁₃ H ₁₆ NO ₈	(CH ₃ O) ₂ P(O)OC(CH ₃)(COCH ₃)C ₆ H ₄ NO ₂	H; P (−2·7)	1968, 313
PC ₁₃ H ₁₇ N ₄ O ₇ S ₂	CH ₃ P(O)(OC ₆ H ₄ SO ₂ NHNH ₂) ₂	H	1966, 71

Formula	Compound	Resonance	Reference
PC ₁₃ H ₁₇ O ₆	(CH ₃ O) ₂ P(O)OC(CH ₃)(COCH ₃)C(O)C ₆ H ₅	H; P (-3.0)	1968, 313
PC ₁₃ H ₁₈ Br	CH ₃ (C ₆ H ₅ CH ₂)P [⊕] CH ₂ CH=C(CH ₃)CH ₂ , Br [⊖]	H	1968, 100
PC ₁₃ H ₁₈ ClO ₃	C ₆ H ₅ CH ₂ P(O)(OCH ₂) ₂ C(CH ₂ Cl)C ₂ H ₅	H	1967, 91
PC ₁₃ H ₁₈ N	C ₆ H ₅ P(CH ₂) ₂ NHC(CH ₂) ₄		1967, 137
PC ₁₃ H ₁₈ NO	C ₆ H ₅ (CH ₂ =CH)P(O)N(CH ₂) ₅	H	1966, 250
PC ₁₃ H ₁₈ NO ₄	(CH ₃) ₂ NP[O(CH ₂) ₂ O]OC(CH ₃)=C(C ₆ H ₅)O	P (-269)	1968, 301
PC ₁₃ H ₁₈ NO ₅	(C ₂ H ₅ O) ₂ P(O)C(OH)C ₆ H ₄ N(CH ₃)CO	H	1966, 263
PC ₁₃ H ₁₈ NO ₅ S	(C ₂ H ₅ O) ₂ P(S)NHCOCOOCH ₃	H	1966, 264
PC ₁₃ H ₁₉	C ₆ H ₅ PCH ₂ C(CH ₃) ₂ C(CH ₃) ₂	H	1967, 82; 1969, 76
PC ₁₃ H ₁₉ ClNO ₅	CH ₃ [<i>t</i> -C ₄ H ₉ (CH ₃)CHO]P(O)OC ₆ H ₃ Cl(NO ₂)	H	1969, 160
PC ₁₃ H ₁₉ O	C ₆ H ₅ P(O)CH ₂ C(CH ₃) ₂ C(CH ₃) ₂	H	1967, 82
PC ₁₃ H ₁₉ O ₂ S	C ₂ H ₅ OP(O)CH ₂ CH(SC ₆ H ₄ CH ₃)CH ₂ CH ₂	H	1966, 134
PC ₁₃ H ₁₉ O ₃	CH ₃ (C ₆ H ₅)CHP(O)(OCH ₂) ₂ C(CH ₃) ₂	H	1967, 91; 1968, 74
PC ₁₃ H ₁₉ O ₃ S	(C ₂ H ₅ O) ₂ P(O)S-indanyl	H	1966, 52, 260
PC ₁₃ H ₁₉ O ₄	(C ₂ H ₅ O) ₂ P(O)CHC(CH ₃)(C ₆ H ₅)O	H	1966, 245; 1967, 81
	(C ₂ H ₅ O) ₂ P(O)C(CH ₃)(C ₆ H ₅)CHO	H	1966, 245; 1967, 81
	(C ₂ H ₅ O) ₂ P(O)OC(C ₆ H ₅)=CHCH ₃	H	1967, 121
	(C ₂ H ₅ O) ₂ P(O)CH(CH ₃)CO(C ₆ H ₅)	H	1967, 121
	(C ₂ H ₅ O) ₂ P(O)CH ₂ CH=CHOC ₆ H ₅	H; P (25.5)	1967, 101, 108

	$\text{C}_6\text{H}_5\text{OP}(\text{O})\text{OCH}(i\text{-C}_3\text{H}_7)\text{C}(\text{CH}_3)_2\text{CH}_2\text{O}$ (stereois.)	H; P (−10.3; −14.4)	1969, 175
$\text{PC}_{13}\text{H}_{19}\text{O}_5$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{COOCH}_2\text{C}_6\text{H}_5$	H	1965, 87
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{C}(\text{O})\text{C}_6\text{H}_4\text{OCH}_3$	H	1967, 121
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{OC}(=\text{CH}_2)\text{C}_6\text{H}_4\text{OCH}_3$	H	1967, 121
	$(\text{CH}_3\text{O})_2(\text{C}_6\text{H}_5\text{CH}_2\text{O})\text{P}[\text{OC}(\text{CH}_3)]_2$	H; P (−49.8)	1968, 73
$\text{PC}_{13}\text{H}_{19}\text{O}_7$	$(\text{CH}_3\text{O})_3\text{POC}(\text{CH}_3)(\text{COCH}_3)\text{C}(\text{C}_5\text{H}_4\text{O})\text{O}$	H; P (−50.3)	1968, 318
$\text{PC}_{13}\text{H}_{20}\text{Br}$	$\text{CH}_3(\text{C}_6\text{H}_5)\text{P}^\oplus\text{CH}_2\text{CH}(\text{CH}_3)\text{C}(\text{CH}_3)_2, \text{Br}^\ominus$	H	1967, 82
	$\text{CH}_3(\text{C}_6\text{H}_5\text{CH}_2)\text{P}^\oplus(\text{CH}_2)_3\text{CHCH}_3, \text{Br}^\ominus$	H	1969, 356
$\text{PC}_{13}\text{H}_{20}\text{N}$	$\text{C}_6\text{H}_5\text{P}(\text{CH}_2)_2\text{NHC}(\text{C}_2\text{H}_5)_2$	H; P (0.0)	1967, 137
$\text{PC}_{13}\text{H}_{20}\text{NO}_3$	$\text{HP}[\text{OC}_6\text{H}_5(i\text{-C}_3\text{H}_7)\text{O}]\text{OCH}_2\text{C}(\text{CH}_3)_2\text{NH}$	H; P (−37.4)	1969, 178
$\text{PC}_{13}\text{H}_{20}\text{NO}_5$	$\text{CH}_3[\text{CH}_3\text{CH}(t\text{-C}_4\text{H}_9)\text{O}]\text{P}(\text{O})\text{C}_6\text{H}_4\text{NO}_2$	H	1969, 160
$\text{PC}_{13}\text{H}_{21}\text{N}_2\text{O}_3$	$(\text{C}_2\text{H}_5\text{O})_2\text{PN}(\text{C}_2\text{H}_5)\text{CONHC}_6\text{H}_5$	P	1969, 361
$\text{PC}_{13}\text{H}_{21}\text{N}_4\text{O}_5$	$[(\text{CH}_3)_2\text{N}]_2\text{P}(\text{O})\text{NH}(\text{CH}_2)_2\text{OC}(\text{O})\text{C}_6\text{H}_4\text{NO}_2$	H	1966, 246
$\text{PC}_{13}\text{H}_{21}\text{O}$	$\text{CH}_3(\text{C}_6\text{H}_5)\text{P}(\text{O})\text{C}(\text{CH}_3)_2\text{CH}(\text{CH}_3)_2$	H	1968, 68
$\text{PC}_{13}\text{H}_{22}\text{Br}$	$\text{CH}_3(i\text{-C}_3\text{H}_7)_2\text{P}^\oplus\text{C}_6\text{H}_5, \text{Br}^\ominus$	P (42.0)	1968, 6
$\text{PC}_{13}\text{H}_{22}\text{I}$	$\text{CH}_3(i\text{-C}_3\text{H}_7)_2\text{P}^\oplus\text{C}_6\text{H}_5, \text{I}^\ominus$	P (40.9)	1967, 244
$\text{PC}_{13}\text{H}_{22}\text{NO}_4$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{NHC}_6\text{H}_5$	H	1969, 82
	$\text{C}_6\text{H}_5\text{N}^\oplus(\text{CH}_3)_3\text{O}^\ominus\text{P}(\text{O})\text{O}[\text{CH}(\text{CH}_3)]_2\text{O}$	P (14)	1969, 359
$\text{PC}_{13}\text{H}_{22}\text{N}_3\text{O}$	$[(\text{CH}_3)_2\text{N}]_2\text{PN}=\text{C}(\text{C}_6\text{H}_5)\text{OC}_2\text{H}_5$	H; P (99.5; 104.4)	1968, 321
$\text{PC}_{13}\text{H}_{22}\text{N}_3\text{OS}$	$[(\text{CH}_3)_2\text{N}]_2\text{P}(\text{S})\text{N}=\text{C}(\text{C}_6\text{H}_5)\text{OC}_2\text{H}_5$	P (69.8)	1968, 321
$\text{PC}_{13}\text{H}_{23}$	$(\text{C}_4\text{H}_9)_2\text{PC}_6\text{H}_5$	P (−26.2)	1968, 6
	$(i\text{-C}_4\text{H}_9)_2\text{PC}_6\text{H}_5$	P (−34.2)	1968, 6
	$(s\text{-C}_4\text{H}_9)_2\text{PC}_6\text{H}_5$	P (2)	1968, 6

Formula	Compound	Résonance	Reference
PC ₁₃ H ₂₃ ClNO ₅	(C ₂ H ₅ O) ₂ P(O)CH(NH ₃ [⊖] Cl)C ₆ H ₃ (OCH ₃) ₂	H	1968, 142
PC ₁₃ H ₂₃ O ₅	(C ₂ H ₅ O) ₂ P(O)CH=C(CH ₂) ₅	H	1967, 327
PC ₁₃ H ₂₃ O ₉	(C ₂ H ₅ O) ₂ P(O)OC(COCH ₃)(COOC ₂ H ₅) ₂	H; P (-3.9)	1967, 4
PC ₁₃ H ₂₄ IN ₂	CH ₃ (C ₆ H ₅)P [⊕] (NH <i>i</i> -C ₃ H ₇) ₂ I [⊖]	H	1967, 95
	(C ₅ H ₉) ₂ P(O)C(O)N(CH ₃) ₂	H	1967, 26
	(C ₅ H ₉) ₂ P(O)C(O)NHC ₂ H ₅	H	1967, 26
PC ₁₃ H ₂₄ N ₃ OS	[(CH ₃) ₂ N] ₂ P(O)NHCH(CH ₃)CH ₂ SC ₆ H ₅	H	1966, 246
	[(CH ₃) ₂ N] ₂ P(O)NHCH ₂ CH(CH ₃)SC ₆ H ₅	H	1966, 246
PC ₁₃ H ₂₅ O ₄	C ₆ H ₁₁ C(O)P(O)(O- <i>i</i> -C ₃ H ₇) ₂	H	1967, 166
PC ₁₃ H ₂₅ O ₆	(CH ₃ O) ₃ PO(C ₆ H ₁₀)C(CH ₃)(COCH ₃)O	H; P (-54.3)	1966, 248
PC ₁₃ H ₂₆ NO ₃	(C ₂ H ₅ O) ₂ P(O)CH=C(CH ₃)CH ₂ NC ₅ H ₁₀	H; P (16.5)	1967, 101, 108
PC ₁₃ H ₂₆ N ₃ O ₃	OP(NHCOOC ₂ H ₅)[NCH(CH ₃)C(CH ₃) ₂] ₂	H	1965, 42
PC ₁₃ H ₂₇ O ₇	(CH ₃ O) ₃ P[OC(CH ₃)COCH ₃] ₂ (diastereois.)	P (-54.8; -52.6)	1968, 318
PC ₁₃ H ₂₈ IN ₄ S ₂	(C ₂ H ₅) ₂ N [⊖] CNP(SCH ₃)(C ₂ H ₅) ₂ N, I [⊖]	P (63.0)	1968, 137
PC ₁₃ H ₂₈ NO ₂	[(C ₂ H ₅) ₂ CH] ₂ P(O)C(O)N(CH ₃) ₂	H	1967, 26
	[(C ₂ H ₅) ₂ CH] ₂ P(O)C(O)NHC ₂ H ₅	H	1967, 26
PC ₁₃ H ₂₈ NO ₄	(C ₄ H ₉ O) ₂ P(O)NCH(O- <i>s</i> -C ₄ H ₉)	H	1966, 55
	(C ₂ H ₅ O) ₂ P(O)C(O)N(<i>i</i> -C ₄ H ₉) ₂	H	1967, 26
	(<i>i</i> -C ₃ H ₇ O) ₂ P(O)C(O)N(<i>i</i> -C ₃ H ₇) ₂	H	1967, 26; 1968, 29
	(<i>i</i> -C ₄ H ₉ O) ₂ P(O)C(O)N(C ₂ H ₅) ₂	H	1967, 26
	(<i>s</i> -C ₄ H ₉ O) ₂ P(O)C(O)N(C ₂ H ₅) ₂	H	1967, 26
	[(CH ₃) ₂ CH(CH ₃)CHO] ₂ P(O)C(O)N(CH ₃) ₂	H	1967, 26
	[(CH ₃) ₂ CH(CH ₃)CHO] ₂ P(O)C(O)NHC ₂ H ₅	H	1967, 26
PC ₁₃ H ₂₈ N ₃ O ₅	[(CH ₃) ₂ N] ₃ POC ₃ (COOC ₂ H ₅) ₂	H; P (38.2)	1965, 84

PC ₁₃ H ₂₉	CH ₃ (C ₁₂ H ₂₅)PH	P (−85.3)	1966, 14
PC ₁₃ H ₂₉ O	CH ₃ (C ₁₂ H ₂₅)P(O)H	P (33.9)	1966, 14
PC ₁₃ H ₂₉ O ₂	CH ₃ (C ₁₂ H ₂₅)PO ₂ H	P (51)	1966, 14
PC ₁₃ H ₃₀	CH ₃ (C ₄ H ₉) ₃ P [⊕]	P (32.3)	1967, 7
PC ₁₃ H ₃₀ Br	CH ₃ (<i>s</i> -C ₄ H ₉) ₃ P [⊕] Br [⊖]	P (44.2)	1968, 6
	CH ₃ (<i>t</i> -C ₄ H ₉)(C ₄ H ₉) ₂ P [⊕] Br [⊖]	P (41.5)	1968, 6
PC ₁₃ H ₃₀ I	CH ₃ (<i>s</i> -C ₄ H ₉) ₃ P [⊕] I [⊖]	P (43.4)	1967, 244
	CH ₃ (<i>i</i> -C ₄ H ₉) ₃ P [⊕] I [⊖]	P (28.0)	1967, 244
	CH ₃ (C ₄ H ₉) ₃ P [⊕] I [⊖]	¹³ C; P (31.3)	1967, 16, 244
	CH ₃ (<i>t</i> -C ₄ H ₉) ₃ P [⊕] I [⊖]	H	1967, 68
PC ₁₃ H ₃₀ NS	(<i>i</i> -C ₄ H ₉) ₂ P(S)CH ₂ N(CH ₂) ₅	P (47.4)	1966, 40
PC ₁₄ H ₅ F ₁₀	C ₂ H ₅ P(C ₆ F ₅) ₂	P (−44.0)	1967, 11
PC ₁₄ H ₅ F ₁₀ O	C ₂ H ₅ P(O)(C ₆ F ₅) ₂	P (19.3)	1967, 11
PC ₁₄ H ₆ F ₁₀ N	(CH ₃) ₂ NP(C ₆ F ₅) ₂	H; F (−135.6; −162.7; −153.5)	1966, 19
PC ₁₄ H ₁₁	(C ₆ H ₅) ₂ PC≡CH	H	1966, 243, 247, 265
PC ₁₄ H ₁₁ F ₂ O ₂	(CH ₃) ₂ (C ₆ H ₅)P[OC(CF ₃) ₂] ₂	H; P (−10.9); F (9.7)	1968, 303
PC ₁₄ H ₁₁ O	(C ₆ H ₅) ₂ P(O)C≡CH	H	1966, 243, 247
PC ₁₄ H ₁₁ S	C ₆ H ₅ P(S)(C≡CCH=CH ₂) ₂	H	1965, 96
PC ₁₄ H ₁₂ Cl ₃ S ₃	C ₆ H ₅ P(S)(SCH ₃)SCH ₂ C ₆ H ₂ Cl ₃	H	1967, 113
PC ₁₄ H ₁₂ NaO ₄	(C ₆ H ₅ CHO) ₂ PO ₂ [⊖] Na [⊕]	H	1967, 90
PC ₁₄ H ₁₃	C ₆ H ₅ PCH(CH) ₆ CH	H; P (−181)	1966, 67
	┌──────────┐ C₆H₅PCH(CH)₄CH(CH)₂ (stereois.) └──────────┘	H; P (−79; −14)	1966, 67
	┌──────────┐ CH₂=CHP(C₆H₅)₂ └──────────┘	P (−11.7)	1967, 8
PC ₁₄ H ₁₃ Cl ₂	(C ₆ H ₄) ₂ P [⊕] CH ₃ (CH ₂ Cl), Cl [⊖]	H	1968, 60
PC ₁₄ H ₁₃ I ₂	(C ₆ H ₄) ₂ P [⊕] CH ₃ (CH ₂ I), I [⊖]	H	1968, 60

Formula	Compound	Resonance	Reference
$\text{PC}_{14}\text{H}_{13}\text{N}_2\text{O}_3\text{S}$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{S})\text{OCN}(\text{CH})_2\text{NCH}$	H	1968, 285
$\text{PC}_{14}\text{H}_{13}\text{O}$	$\text{C}_6\text{H}_5\text{P}(\text{O})\text{CH}(\text{CH})_4\text{CH}(\text{CH})_2$ (stereois.)	H; P (38; 26)	1966, 67
$\text{PC}_{14}\text{H}_{13}\text{O}_3$	$(\text{C}_6\text{H}_5)_2\text{PCOCH}_3$	H	1967, 346; 1968, 307
	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{CH}_2\text{COOH}$	H	1965, 87
	$\text{C}_6\text{H}_5\text{CH}=\text{C}(\text{C}_6\text{H}_5)\text{PO}_3\text{H}_2$	P (11·0)	1966, 241
	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{OC}(\text{O})\text{CH}_3$	H	1967, 347
$\text{PC}_{14}\text{H}_{13}\text{O}_4$	$\text{CH}_3\text{C}_6\text{H}_4\text{OP}(\text{O})\text{OC}_6\text{H}_4\text{CH}_2\text{O}$	H	1969, 74
	$\text{C}_6\text{H}_5\text{OP}(\text{O})\text{OC}_6\text{H}_3(\text{CH}_3)\text{CH}_2\text{O}$	H	1969, 74
	$\text{OCH}(\text{C}_6\text{H}_5)\text{CH}(\text{C}_6\text{H}_5)\text{OPO}_2\text{H}$	P (16)	1969, 359
$\text{PC}_{14}\text{H}_{13}\text{S}$	$(\text{C}_6\text{H}_5)_2\text{P}(\text{S})\text{CH}=\text{CH}_2$	P (37·5)	1966, 216
$\text{PC}_{14}\text{H}_{14}\text{BrO}$	$(\text{C}_6\text{H}_4)_2\text{P}^\oplus\text{CH}_3(\text{CH}_2\text{OH}), \text{Br}^\ominus$	H	1968, 60
$\text{PC}_{14}\text{H}_{14}\text{I}$	$(\text{C}_6\text{H}_4)_2\text{P}^\oplus(\text{CH}_3)_2, \text{I}^\ominus$	H	1968, 60
$\text{PC}_{14}\text{H}_{14}\text{NO}_3$	$\text{HP}(\text{OC}_6\text{H}_4\text{O})\text{OCH}(\text{C}_6\text{H}_5)\text{CH}_2\text{NH}$	P (−36)	1969, 45, 178
$\text{PC}_{14}\text{H}_{14}\text{NO}_4\text{S}$	$\text{C}_6\text{H}_5(\text{C}_2\text{H}_5\text{O})\text{P}(\text{S})\text{OC}_6\text{H}_4\text{NO}_2$	H	1968, 284, 285
$\text{PC}_{14}\text{H}_{14}\text{NS}$	$(\text{C}_6\text{H}_5)_2\text{P}(\text{S})\text{CH}_2\text{CH}_2\text{CN}$	P (34·7)	1966, 40
$\text{PC}_{14}\text{H}_{15}$	$\text{C}_2\text{H}_5\text{P}(\text{C}_6\text{H}_5)_2$	H; P (−12)	1965, 3; 1967, 79; 1968, 7, 302, 303
$\text{PC}_{14}\text{H}_{15}\text{BrNO}_3$	$(\text{C}_6\text{H}_5\text{O})_2\text{P}(\text{O})\text{NHCH}_2\text{CH}_2\text{Br}$	H	1969, 352
$\text{PC}_{14}\text{H}_{15}\text{ClN}$	$\text{CH}_3(\text{C}_6\text{H}_5\text{CH}_2)\text{NP}(\text{Cl})(\text{C}_6\text{H}_5)$	H	1968, 92
	$\text{C}_2\text{H}_5(\text{C}_6\text{H}_5)\text{NP}(\text{Cl})(\text{C}_6\text{H}_5)$	H	1968, 92
$\text{PC}_{14}\text{H}_{15}\text{Cl}_2\text{N}_2$	$\text{C}_6\text{H}_5\text{N}=\text{P}[\text{N}(\text{CH}_3)\text{CH}_2\text{C}_6\text{H}_5]\text{Cl}_2$	H; P (−19·8)	1969, 348
$\text{PC}_{14}\text{H}_{15}\text{F}_2\text{S}$	$\text{C}_2\text{H}_5\text{S}(\text{C}_6\text{H}_5)_2\text{PF}_2$	H; P (−39·2); F (−25·2)	1968, 316; 1969, 62

PC ₁₄ H ₁₅ O	C ₂ H ₅ OP(C ₆ H ₅) ₂	¹³ C; P (109·8)	1965,7; 1966, 106, 225, 240; 1968, 25
	(CH ₃) ₂ P(O)C ₆ H ₄ OC ₆ H ₅	H	1967, 348
	(C ₆ H ₅ CH ₂) ₂ P(O)H	P (35)	1967, 172; 1968, 35
PC ₁₄ H ₁₅ OS	C ₂ H ₅ OP(S)(C ₆ H ₅) ₂	P (79·8)	1966, 106
	CH ₃ SCH ₂ P(O)(C ₆ H ₅) ₂	H	1967, 349
PC ₁₄ H ₁₅ O ₂	C ₂ H ₅ OP(O)(C ₆ H ₅) ₂	P (31·1)	1965, 85; 1966, 106, 266; 1969, 119
	CH ₃ OCH ₂ P(O)(C ₆ H ₅) ₂	H	1967, 349
PC ₁₄ H ₁₅ O ₅	CH ₃ OP(O)OC(CH ₃) ₂ C(CH ₃)(COCH ₃)O	H	1967, 140
PC ₁₄ H ₁₅ O ₆	C ₆ H ₅ P(O)OC(CH ₃)(COCH ₃)C(OCH ₃)=CCOOH (stereois.)	H; P (43·5; 42·2)	1969, 353
PC ₁₄ H ₁₅ S	CH ₃ SCH ₂ P(C ₆ H ₅) ₂	H	1967, 349
PC ₁₄ H ₁₆ Br	(CH ₃) ₂ P [⊕] (C ₆ H ₅) ₂ , Br [⊖]	P (22·1)	1966, 5
	C ₂ H ₅ P [⊕] H(C ₆ H ₅) ₂ , Br [⊖]	H; P (8·3)	1968, 7
PC ₁₄ H ₁₆ ClO ₅ S	(C ₂ H ₅ O) ₂ P(S)OC ₆ H ₃ OCOC(Cl)C(CH ₃) ₂	H	1968, 284, 285; 1969, 322
PC ₁₄ H ₁₆ Cl ₆ OSSb	CH ₃ O(CH ₃ S)P [⊕] (C ₆ H ₅) ₂ , SbCl ₆ [⊖]	H; P (86·6)	1969, 87
PC ₁₄ H ₁₆ OSbSe	CH ₃ O(CH ₃ Se)P [⊕] (C ₆ H ₅) ₂ , SbCl ₆ [⊖]	H; P (87·8)	1969, 87
PC ₁₄ H ₁₆ O ₂ Sb	(CH ₃ O) ₂ P [⊕] (C ₆ H ₅) ₂ , SbCl ₆ [⊖]	P (61·3)	1968, 8; 1969, 87
PC ₁₄ H ₁₆ S ₂ Sb	(CH ₃ S) ₂ P [⊕] (C ₆ H ₅) ₂ , SbCl ₆ [⊖]	P (77·3)	1968, 8
PC ₁₄ H ₁₆ Cl ₇ NSb	(CH ₃) ₂ NP [⊕] Cl(C ₆ H ₅) ₂ , SbCl ₆ [⊖]	P (72·5)	1968, 8
PC ₁₄ H ₁₆ N	(CH ₃) ₂ NP(C ₆ H ₅) ₂	H; (T); P (66·2)	1966, 36; 1967, 277; 1969, 105
PC ₁₄ H ₁₆ NO	(CH ₃) ₂ NP(O)(C ₆ H ₅) ₂	H; P (3·0 or 29·6)	1965, 23; 1967, 9, 92; 1968, 8, 91; 1969, 87
PC ₁₄ H ₁₆ NO ₃	(CH ₃) ₂ NP(O)(C ₆ H ₅) ₂	H	1968, 91
PC ₁₄ H ₁₆ NO ₄	C ₆ H ₅ P(O)(O [⊖])OCH ₂ CH(CH ₃), C ₅ H ₅ N [⊕] H	P (−7·1)	1969, 359

Formula	Compound	Resonance	Reference
PC ₁₄ H ₁₆ NO ₄	C ₆ H ₅ NC ₅ H ₅ [⊕] O [⊖] P(O)OCH ₂ CH(CH ₃)O	P (<i>ca.</i> 15)	1969, 359
PC ₁₄ H ₁₆ NS	(CH ₃) ₂ NP(S)(C ₆ H ₅) ₂	H; (T); P (41·0 or 70·9)	1967, 92, 277; 1968, 8, 91; 1969, 87, 105
PC ₁₄ H ₁₆ NSe	(CH ₃) ₂ NP(Se)(C ₆ H ₅) ₂	H; P (72·0)	1969, 87
PC ₁₄ H ₁₆ N ₂ S ₂	(CH ₃) ₂ NCNP(S)(C ₆ H ₅) ₂ S [⊖]	P (37; 40)	1967, 344
PC ₁₄ H ₁₇ ClNO ₃	(C ₂ H ₅ O) ₂ P(O)C(CN)=C(CH ₃)C ₆ H ₄ Cl	H	1968, 323
PC ₁₄ H ₁₇ ClNO ₅	(CH ₃ O) ₂ P(O)OC=C(Cl)C(CH ₃)(C ₆ H ₅)C(O)NCH ₃	H	1969, 345
PC ₁₄ H ₁₇ N ₂ S ₂	(CH ₃) ₂ NC(S)NHP(S)(C ₆ H ₅) ₂	P (50·9)	1967, 344
PC ₁₄ H ₁₇ O	(C ₆ H ₅) ₂ P(O)CH(CH ₃)CH=CH ₂	H	1966, 267
PC ₁₄ H ₁₈ ClN ₂	(CH ₃) ₂ NP [⊕] (NH ₂)(C ₆ H ₅) ₂ Cl [⊖]	H; P (39·9)	1967, 65
PC ₁₄ H ₁₈ ClO ₃	C ₆ H ₅ CHCH=C(CH ₃)OP(O)OCH(CH ₃)(CH ₂) ₂ Cl	H	1966, 220
PC ₁₄ H ₁₈ F ₁₂ N ₃ O ₂	(CH ₂) ₄ NP[N(CH ₃)CH ₂] ₂ [OC(CF ₃) ₂] ₂	P (−30·9)	1968, 303
PC ₁₄ H ₁₈ NO ₃	(C ₂ H ₅ O) ₂ P(O)C(CN)=C(CH ₃)C ₆ H ₅	H	1968, 323
PC ₁₄ H ₁₈ NO ₄	(C ₂ H ₅ O) ₂ P(O)C(CN)=CH(C ₆ H ₄ OCH ₃)	H{P}	1968, 323
PC ₁₄ H ₁₈ NO ₅ S	(CH ₃) ₂ NP [⊕] (OH)(C ₆ H ₅) ₂ , HSO ₄ [⊖]	P (50·0)	1968, 8
PC ₁₄ H ₁₈ NO ₆ S	(CH ₂ =CHCH ₂ O) ₂ P(O)C(O)NHSO ₂ C ₆ H ₄ CH ₃	H	1968, 328; 1969, 161
PC ₁₄ H ₁₉ O ₄	C ₆ H ₅ OP(O)[OCH ₂ CH(CH ₃) ₂] ₂	H	1966, 213
	(C ₂ H ₅ O) ₂ P(O)C(O)CHCH ₂ CHC ₆ H ₅	H	1967, 166
PC ₁₄ H ₁₉ O ₅	C ₂ H ₅ OP(O)(OH)CH ₂ C(COOC ₂ H ₅)=CHC ₆ H ₅	H	1967, 327
PC ₁₄ H ₁₉ O ₆	(CH ₃ O) ₂ P(O)OC(CH ₃)=CHC(O)OCH(CH ₃)C ₆ H ₅	H	1968, 284, 285; 1969, 123
PC ₁₄ H ₁₉ O ₇	(CH ₃ O) ₂ P(O)OC(CH ₃)(COCH ₃)C(O)C ₆ H ₄ OCH ₃	H; P (−3·0)	1968, 313
PC ₁₄ H ₂₀	C ₆ H ₅ P[C(CH ₃) ₂] ₂ CCH ₃	H(T)	1968, 121
PC ₁₄ H ₂₀ BF ₆ N ₂	[NC ₅ H ₃ (CH ₃) ₂] ₂ BH ₂ [⊕] PF ₆ [⊖]	¹¹ B; H	1968, 330

PC ₁₄ H ₂₀ BI	CH ₃ (C ₆ H ₅ CH ₂)P [⊕] [CH ₂ C(CH ₃) ₂] ₂ , Br [⊖]	H	1968, 100
PC ₁₄ H ₂₀ ClN ₄	C ₆ H ₅ NHPN[(CH ₃)CH ₂ C ₆ H ₅](NH ₂) ₂ Cl	H; P (27·8)	1969, 348
PC ₁₄ H ₂₀ F ₅ N ₂	C ₆ F ₅ P(NH- <i>t</i> -C ₄ H ₉) ₂	H; F (−137·7; −162·1; −155·7)	1966, 19
PC ₁₄ H ₂₀ N	C ₆ F ₅ P[N(C ₂ H ₅) ₂] ₂ C ₆ H ₅ P(CH ₂) ₂ NHC(CH ₂) ₅	H; P (79·2) H	1966, 7 1967, 137
PC ₁₄ H ₂₀ NO ₄	(CH ₃) ₂ N[O(CH ₂) ₃ O]POC(CH ₃)=C(C ₆ H ₅)O	H; P	1968, 301
PC ₁₄ H ₂₀ NO ₆	(CH ₃ O) ₂ P(O)OC(CH ₃)(COCH ₃)[C(O)NHC ₆ H ₄ CH ₃]	H; P (−2·5)	1968, 313
PC ₁₄ H ₂₁	C ₆ H ₅ PC(CH ₃) ₂ CH(CH ₃)C(CH ₃) ₂	H	1967, 82
PC ₁₄ H ₂₁ O	C ₆ H ₅ P(O)C(CH ₃) ₂ CH(CH ₃)C(CH ₃) ₂	H	1967, 82
PC ₁₄ H ₂₁ O ₂	(CH ₃) ₂ P(O)C ₁₂ H ₂₅	H	1967, 329
PC ₁₄ H ₂₁ O ₃ S	C ₆ H ₅ P(O)[C(CH ₃) ₂] ₂ CHCH ₃	H	1968, 122
PC ₁₄ H ₂₁ O ₄	CH ₃ (C ₆ H ₅)P(O)OC ₆ H ₁₀ (CH ₃) (C ₂ H ₅ O) ₂ P(O)CH ₂ C(CH ₃)=CHSC ₆ H ₅ (C ₂ H ₅ O) ₂ P(O)CH(C ₆ H ₅)CH ₂ COCH ₃ (C ₂ H ₅ O) ₂ P(O)OC(C ₆ H ₅)C(CH ₃) ₂ C ₆ H ₅ OP(O)OCHC(CH ₃) ₂ CH(C ₃ H ₇)O	H H; P (24·2) H H P (−16·5; −10·9)	1967, 151; 1968, 140 1967, 108 1966, 249 1967, 121 1968, 150
PC ₁₄ H ₂₁ O ₅	(C ₂ H ₅ O) ₂ P(O)CH(CH ₃)COC ₆ H ₄ OCH ₃	H	1967, 81
PC ₁₄ H ₂₁ O ₆	(C ₂ H ₅ O) ₂ P(O)C(CH ₃)(CHO)C ₆ H ₄ OCH ₃ (CH ₃ O) ₃ POCH(C ₆ H ₅)C(CH ₃)(COCH ₃)O	H H; P (−51·5)	1967, 81 1967, 350, 351
PC ₁₄ H ₂₂ Br	CH ₃ (C ₆ H ₅)P [⊕] CCH ₂ C(CH ₃) ₂ C(CH ₃) ₂ , Br [⊖]	H	1967, 82
PC ₁₄ H ₂₂ NO ₃	HP[OC(CH ₃) ₂] ₂ OCH(C ₆ H ₅)CH ₂ NH (C ₂ H ₅ O) ₂ P(O)C[N(CH ₃) ₂]=CHC ₆ H ₅	H; P (−49·5) H	1967, 164 1968, 93

Formula	Compound	Resonance	Reference
PC ₁₄ H ₂₂ NO ₆ S	(C ₃ H ₇ O) ₂ P(O)C(O)NHSO ₂ C ₆ H ₄ CH ₃	H	1968, 328; 1969, 161
PC ₁₄ H ₂₃	C ₆ H ₅ P(C ₄ H ₉) ₂	P (-26)	1965, 3; 1967, 244, 277; 1968, 7; 1969, 249
	C ₆ H ₅ P(<i>i</i> -C ₄ H ₉) ₂	P (-34·2)	1967, 8
	C ₆ H ₅ P(<i>s</i> -C ₄ H ₉) ₂	P (1·8)	1967, 8
	P[C(<i>t</i> -C ₄ H ₉)CH] ₂ C- <i>t</i> -C ₄ H ₉	H	1968, 101
PC ₁₄ H ₂₃ ClN	(C ₄ H ₉) ₂ NPCl(C ₆ H ₅)	H	1968, 92
PC ₁₄ H ₂₃ Cl ₂ N ₂	C ₆ H ₅ N=P[N(C ₄ H ₉) ₂]Cl ₂	H; P (-22·1)	1969, 348
PC ₁₄ H ₂₃ N ₄ O ₄ S	PC ₁₄ H ₂₃ N ₄ O ₄ S	H	1967, 352
PC ₁₄ H ₂₃ N ₄ O ₅	[(CH ₃) ₂ N] ₂ P(O)NHCH(CH ₃)CH ₂ OC(O)C ₆ H ₄ NO ₂	H	1966, 246
PC ₁₄ H ₂₃ O	C ₆ H ₅ P(O)(C ₄ H ₉) ₂	P (45·2)	1967, 277
PC ₁₄ H ₂₃ O ₂	C ₆ H ₅ P(OC ₄ H ₉) ₂	H; P (155-7)	1966, 225; 1969, 333
PC ₁₄ H ₂₃ S	C ₆ H ₅ P(S)(C ₄ H ₉) ₂	P (47·6)	1967, 277
PC ₁₄ H ₂₄ Br	C ₂ H ₅ (C ₆ H ₅)P [⊕] (<i>i</i> -C ₃ H ₇) ₂ , Br [⊖]	P (42·2)	1966, 5; 1968, 6
	H(C ₆ H ₅)P [⊕] (C ₄ H ₉) ₂ , Br [⊖]	H; P (12·2)	1968, 7
	C ₂ H ₅ (C ₆ H ₅)P [⊕] (C ₃ H ₇) ₂ , Br [⊖]	P (32·1)	1968, 6
PC ₁₄ H ₂₄ NO ₃	(C ₂ H ₅ O) ₃ P=NC ₆ H ₄ C ₂ H ₅	H	1965, 102
	(C ₂ H ₅ O) ₂ P(O)C[N(CH ₃) ₂](CH ₃)C ₆ H ₅	P (26)	1969, 340
PC ₁₄ H ₂₄ NO ₄	C ₆ H ₅ P(O)[N(CH ₃) ₂][OC(CH ₃) ₂ OH]	P (21·1)	1969, 343
PC ₁₄ H ₂₄ NO ₄ S ₃	(<i>i</i> -C ₃ H ₇ O) ₂ P(S)S(CH ₂) ₂ NHSO ₂ C ₆ H ₅	H	1968, 284
PC ₁₄ H ₂₄ N ₃ O	C ₂ H ₅ OC(C ₆ H ₅ CH ₂)NP[N(CH ₃) ₂] ₂	H	1968, 321
	C ₂ H ₅ OC(CH ₃ C ₆ H ₄)NP[N(CH ₃) ₂] ₂	H; P (99·7; 104·4)	1968, 321
PC ₁₄ H ₂₅ BrNOS ₃	C ₆ H ₅ (CH ₃ S)P(S)S(CH ₂) ₂ N [⊕] (CH ₃)C ₄ H ₁₀ O, Br [⊖]	H	1967, 113
PC ₁₄ H ₂₅ ClN ₃	C ₆ H ₅ N=P[N(C ₂ H ₅) ₂] ₂ Cl	H	1965, 98
PC ₁₄ H ₂₅ N ₂	C ₈ H ₁₇ P(CH ₂ CH ₂ C≡N) ₂	P (-25·7)	1966, 4; 1967, 244
	C ₆ H ₅ P(NH- <i>t</i> -C ₄ H ₉) ₂	H	1967, 95
PC ₁₄ H ₂₅ N ₂ S	C ₆ H ₅ P(S)(NHC ₄ H ₉) ₂	H	1967, 318
PC ₁₄ H ₂₅ O ₂	C ₄ H ₅ P(Os-C ₄ H ₉) ₂ (stereois.)	H; P (160·7; 159·2; (158·1)	1969, 162

PC ₁₄ H ₂₆ NO ₂	(CH ₃) ₂ NP[OC(C ₅ H ₁₀)] ₂	P (147)	1969, 362
PC ₁₄ H ₂₇ O ₃	(C ₄ H ₉ O) ₂ P(O)C≡CC ₄ H ₉	H	1967, 21
	(CH ₃ O) ₂ P(O)CCH(CH ₂) ₁₀	H	1967, 100
PC ₁₄ H ₂₇ SSi ₂	C ₆ H ₅ P(S)[CH ₂ Si(CH ₃) ₃] ₂	H; P (38·8)	1966, 132
PC ₁₄ H ₂₈ ClN ₄	C ₆ H ₅ NHPN(C ₄ H ₉) ₂ (NH ₂) ₂ Cl	H; P (26·6)	1969, 348
PC ₁₄ H ₂₈ Cl ₂ NO ₃	[CH ₃ (CH ₂ Cl)CHO][C(C ₄ H ₉) ₂ N]P(O)OC(CH ₂ Cl)=CH ₂	H	1967, 340
PC ₁₄ H ₂₉ ClNO ₃	[CH ₃ (CH ₂ Cl)CHO][C(C ₄ H ₉) ₂ N]P(O)OC(CH ₃)=CH ₂	H	1967, 340
PC ₁₄ H ₂₉ Cl ₂ O	C ₁₂ H ₂₅ P(O)(CH ₂ Cl) ₂	H	1968, 299; 1969, 334
PC ₁₄ H ₂₉ O ₄	(CH ₃ O) ₂ P(O)C ₁₂ H ₂₂ (OH)	H	1967, 100
PC ₁₄ H ₃₀ Li	CH ₃ (C ₁₂ H ₂₅)PCH ₂ Li	P (−35·2)	1967, 329
PC ₁₄ H ₃₀ NO ₂	(C ₂ H ₅)C ₆ H ₁₂ (<i>i</i> -C ₃ H ₇ O)P(O)C(O)N(CH ₃) ₂	H	1967, 26
PC ₁₄ H ₃₁	C ₁₂ H ₂₅ P(CH ₃) ₂	H; P (−52·6)	1966, 14; 1967, 329
PC ₁₄ H ₃₁ GeO	(C ₂ H ₅) ₂ PCH(CH ₃)CH=CHOGe(C ₂ H ₅) ₃	H	1968, 331
PC ₁₄ H ₃₁ O	C ₁₂ H ₂₅ P(O)(CH ₃) ₂	H; P (47)	1966, 14, 268
PC ₁₄ H ₃₁ O ₄	(C ₄ H ₉ O) ₂ P(O)(CH ₂) ₂ OC ₄ H ₉	H	1966, 251
PC ₁₄ H ₃₂	C ₂ H ₅ P [⊕] (C ₄ H ₉) ₃	P (35·5)	1967, 7
PC ₁₄ H ₃₂ BF ₄ O	C ₂ H ₅ OP [⊕] (C ₄ H ₉) ₃ , BF ₄ [⊖]	H; P (98)	1968, 332
PC ₁₄ H ₃₂ Br	C ₂ H ₅ P [⊕] (C ₄ H ₉) ₃ Br [⊖]	P (36·6)	1966, 5
PC ₁₄ H ₃₂ N	C ₁₂ H ₂₅ (CH ₃) ₂ P=NH	P (18)	1966, 268
PC ₁₄ H ₃₃ GeO	(C ₂ H ₅) ₂ PCH(C ₃ H ₇)OGe(C ₂ H ₅) ₃	H	1968, 331
PC ₁₄ H ₃₃ O	(C ₆ H ₅) ₂ P(O)C(CH ₃)=C=CC ₆ H ₅ (CH ₃) ₅	H	1969, 166
PC ₁₄ H ₃₅ O ₃ Si ₂	C ₂ H ₅ OP[OSi(C ₂ H ₅) ₃] ₂	H	1967, 34
PC ₁₄ H ₃₆ GeN ₂ Si	(<i>t</i> -C ₄ H ₉) ₂ PN[Si(CH ₃) ₃]=NGe(CH ₃) ₃	H	1968, 64
	(<i>t</i> -C ₄ H ₉) ₂ PN[Ge(CH ₃) ₃]=NSi(CH ₃) ₃	H	1968, 64
PC ₁₄ H ₄₄ O	(C ₆ H ₁₁) ₂ P(O)C(CH ₃)=C=CC ₆ H ₅ (CH ₃) ₅	H	1969, 166
PC ₁₅ H ₁₀ ClF ₄	(C ₆ H ₅) ₂ PCF ₂ CCl=CF ₂	H; F (−94·7; −79·8; −78·0)	1967, 295
	(C ₆ H ₅) ₂ PCF=CClCF ₃	H; F (<i>cis</i> −58·8; −83·6 <i>trans</i> −60·8; −91·4)	1968, 98

Formula	Compound	Resonance	Reference
PC ₁₅ H ₁₀ ClF ₄ O	(C ₆ H ₅) ₂ P(O)CF ₂ CCl=CF ₂	H; F (−105·9; −76·4; −74·8)	1967, 295
PC ₁₅ H ₁₁ F ₆ O ₂	(C ₆ H ₅) ₂ POCH(CF ₃) ₂	H; P (39·2)	1968, 302
PC ₁₅ H ₁₃	(C ₆ H ₅) ₂ PC≡CCH ₃	H	1966, 243, 247, 265
	(C ₆ H ₅) ₂ PCH=C=CH ₂	H	1968, 99; 1969, 115
PC ₁₅ H ₁₃ ClNO ₆	CH ₃ (NO ₂ C ₆ H ₄ O)P(O)OCH ₂ C(O)C ₆ H ₄ Cl	H (T)	1969, 159
PC ₁₅ H ₁₃ N ₂ O ₈	CH ₃ (NO ₂ C ₆ H ₄ O)P(O)OCH ₂ C(O)C ₆ H ₄ NO ₂	H (T)	1969, 159
PC ₁₅ H ₁₃ O	(C ₆ H ₅) ₂ P(O)C≡CCH ₃	H	1966, 243, 247
	(C ₆ H ₅) ₂ P(O)CH=C=CH ₂	H	1966, 61; 1967, 104; 1968, 56; 1969, 115
PC ₁₅ H ₁₃ S	(C ₆ H ₅) ₂ P(S)C≡CCH ₃	H	1966, 243, 247
PC ₁₅ H ₁₄ NOS ₃	CH ₃ OP(S)SC(S)C(C ₆ H ₄)CNC ₆ H ₄ CH ₃	H	1969, 363
PC ₁₅ H ₁₄ NO ₂ S ₂	CH ₃ OP(S)SC(O)C(C ₆ H ₄)CNC ₆ H ₄ CH ₃	H	1969, 363
PC ₁₅ H ₁₄ NO ₂ S ₃	CH ₃ OP(S)SC(S)C(C ₆ H ₄)CNC ₆ H ₄ OCH ₃	H	1969, 363
PC ₁₅ H ₁₄ NO ₃ S ₂	CH ₃ OP(S)SC(O)C(C ₆ H ₄)CNC ₆ H ₄ OCH ₃	H	1969, 363
PC ₁₅ H ₁₄ NO ₆	CH ₃ (NO ₂ C ₆ H ₄ O)P(O)OCH ₂ C(O)C ₆ H ₅	H (T)	1969, 159
PC ₁₅ H ₁₅	(C ₆ H ₅) ₂ PCH ₂ CH=CH ₂	P (−17·1)	1967, 8
	(C ₆ H ₅) ₂ PCH(CH ₂) ₂	H; P (1·9)	1968, 333; 1969, 354
PC ₁₅ H ₁₅ N ₂ O ₆	NO ₂ C ₆ H ₄ OP(O)(CH ₃)OCH ₂ C(C ₆ H ₅)NOH	H	1968, 334
PC ₁₅ H ₁₅ N ₃	(C ₆ H ₅ N) ₃ P	H	1969, 122
PC ₁₅ H ₁₅ N ₃ O	(C ₆ H ₅ N) ₃ PO	H	1969, 122
PC ₁₅ H ₁₅ O	(C ₆ H ₅) ₂ P(O)CH=CHCH ₃	H	1965, 47
	(C ₆ H ₅) ₂ P(O)CH ₂ CH=CH ₂	H	1965, 87; 1968, 56
	(C ₆ H ₅) ₂ PCH ₂ COCH ₃	H	1968, 297
	(C ₆ H ₅) ₂ P(O)CH(CH ₂) ₂	H	1968, 333

PC ₁₅ H ₁₅ O ₂	(C ₆ H ₅) ₂ P(O)CH ₂ COCH ₃	H	1965, 105; 1968, 297
	(C ₆ H ₅) ₂ P(O)OC(CH ₃)=CH ₂	H	1965, 105; 1968, 297
PC ₁₅ H ₁₆ ClO	(C ₆ H ₄) ₂ P ⁺ CH ₃ (CH ₂ OCH ₃), Cl ⁻	H	1968, 60
PC ₁₅ H ₁₆ I	(C ₆ H ₄) ₂ P ⁺ CH ₃ (C ₂ H ₅), I ⁻	H	1968, 60
PC ₁₅ H ₁₆ KN ₂ S ₂	(C ₆ H ₅) ₂ P(S)N=C(S ⁻)N(CH ₃) ₂ , K ⁺	H; P (40.7)	1967, 221, 244, 353
PC ₁₅ H ₁₆ N	C ₆ H ₅ P(CH ₂) ₂ NHCHC ₆ H ₅	H; P (-2.9)	1967, 137
PC ₁₅ H ₁₆ NO ₃	HP[OC ₆ H ₃ (CH ₃)O]OCH(C ₆ H ₅)CH ₂ NH	H; P (-35.2)	1969, 178
	OC ₆ H ₄ OPO(CH ₂) ₂ NHCH ₂ C ₆ H ₅	P (132)	1969, 45
	HP(OC ₆ H ₄ O)O(CH ₂)NCH ₂ C ₆ H ₅	P (-100)	1969, 45
PC ₁₅ H ₁₇	(C ₆ H ₅) ₂ P- <i>i</i> -C ₃ H ₇	P (0.2)	1965, 3; 1968, 6, 7; 1969, 354
	(C ₆ H ₅) ₂ PC ₃ H ₇	P (-17.6)	1967, 8
	CH ₃ P(C ₆ H ₄ CH ₃) ₂	H	1968, 15
PC ₁₅ H ₁₇ Br	(C ₆ H ₅) ₂ P ⁺ C ₃ H ₇ , Br ⁻	H	1967, 354
PC ₁₅ H ₁₇ N ₂ S ₂	(C ₆ H ₅) ₂ P(S)NHC(S)N(CH ₃) ₂	H	1967, 353
PC ₁₅ H ₁₇ N ₄	(C ₆ H ₅) ₂ PNCHNN(CH ₃) ₂ N	H; P (26.4)	1967, 355
PC ₁₅ H ₁₇ O	CH ₃ P(O)(C ₆ H ₇ CH ₃) ₂	H	1968, 15
PC ₁₅ H ₁₇ OS	(C ₆ H ₅) ₂ P(S)(CH ₂) ₃ OH	P (42.4)	1966, 40
PC ₁₅ H ₁₇ O ₂	(C ₆ H ₅) ₂ P(O)O <i>i</i> -C ₃ H ₇	H	1966, 266
	(C ₆ H ₅) ₂ P(O)OC ₃ H ₇	H	1967, 52
	C ₆ H ₅ C ₆ H ₄ P(O)CH ₃ (CH ₂ OCH ₃)	H	1968, 60
	(C ₆ H ₅) ₂ P(O)(CH ₂) ₃ OH	H	1968, 118
PC ₁₅ H ₁₇ O ₆	C ₆ H ₅ (CH ₃ O)P(O)CC(O)OC(CH ₃)(COCH ₃)COCH ₃	H; P (80.9; 84.0)	1969, 353
	(stereois.)		
PC ₁₅ H ₁₈ Br	H(<i>i</i> -C ₃ H ₇)P ⁺ (C ₆ H ₅) ₂ , Br ⁻	H; P (14.0)	1968, 7

Formula	Compound	Resonance	Reference
PC ₁₅ H ₁₈ IS	CH ₃ (C ₆ H ₅) ₂ P [⊕] CH ₂ SCH ₃ , I [⊖]	H	1967, 349
PC ₁₅ H ₁₈ N	(CH ₃) ₂ NCH ₂ P(C ₆ H ₅) ₂	H	1967, 349
PC ₁₅ H ₁₈ NO	(CH ₃) ₂ NCH ₂ P(O)(C ₆ H ₅)	H	1967, 349
PC ₁₅ H ₁₈ NO ₄	β-C ₁₀ H ₇ C(=NOH)P(O)(OC ₂ H ₅) ₂	H	1968, 142
	C ₆ H ₅ OP(O)(O [⊖])OCH ₂ CH(CH ₃)N [⊕] H ₂ C ₆ H ₅	H; P (-7.4)	1969, 359
	C ₆ H ₅ NC ₅ H ₅ [⊕] O [⊖] P(O)O[CH(CH ₃)] ₂ O	P (14)	1969, 359
	(C ₆ H ₅) ₂ NH ₂ [⊕] O [⊖] P(O)OCH ₂ CH(CH ₃)O	P (ca. 14)	1969, 359
PC ₁₅ H ₁₈ NS	(C ₆ H ₅) ₂ P(S)(NH- <i>i</i> -C ₃ H ₇)	H	1968, 145
PC ₁₅ H ₁₈ N ₃ O	[CH ₃ NCH=CHCH=C] ₃ PO	H	1969, 123
PC ₁₅ H ₁₈ O ₃ S	[OC(CH ₃)=CHCH=C] ₃ PS	H	1969, 124
PC ₁₅ H ₁₉ ClN	CH ₃ (C ₆ H ₅) ₂ P [⊕] N(CH ₃) ₂ , Cl [⊖]	H	1968, 54
PC ₁₅ H ₁₉ Cl ₆ NOSb	CH ₃ O(C ₆ H ₅) ₂ P [⊕] N(CH ₃) ₂ , SbCl ₆ [⊖]	H; P (57.5)	1968, 8; 1969, 87
PC ₁₅ H ₁₉ Cl ₆ NSSb	CH ₃ S(C ₆ H ₅) ₂ P [⊕] N(CH ₃) ₂ , SbCl ₆ [⊖]	H; P (67.5)	1968, 8; 1969, 87
PC ₁₅ H ₁₉ Cl ₆ NSbSe	CH ₃ Se(C ₆ H ₅) ₂ P [⊕] N(CH ₃) ₂ , SbCl ₆ [⊖]	H; P (65.7)	1969, 87
PC ₁₅ H ₁₉ IN	CH ₃ P [⊕] (C ₆ H ₅) ₂ N(CH ₃) ₂ , I [⊖]	H; P (50.0)	1969, 87
PC ₁₅ H ₁₉ NO ₄	(C ₂ H ₅ O) ₂ P(O)C(=NOH)C ₆ H ₄ - <i>t</i> -C ₄ H ₉	H	1968, 142
PC ₁₅ H ₁₉ N ₂ O ₅ S ₂	CH ₃ O[<i>o</i> -C ₆ H ₄ (OH)]P(O) <i>S</i> -benzylthiuronium	H	1967, 143
PC ₁₅ H ₁₉ N ₂ S ₂	(C ₆ H ₅) ₂ P(S)N=C(SCH ₃)N(CH ₃) ₂	P (41.6)	1967, 221, 344
	(C ₆ H ₅) ₂ P(SCH ₃)=NC(S)N(CH ₃) ₂	P (32.0)	1967, 221, 344
PC ₁₅ H ₁₉ OSi	(C ₆ H ₅) ₂ POSi(CH ₃) ₃	P (94.1)	1967, 343
PC ₁₅ H ₁₉ O ₄ Si ₂	CH ₃ P(O)[OSi(CH ₃)C ₆ H ₅] ₂ O	H	1965, 106
PC ₁₅ H ₁₉ O ₇	C ₆ H ₅ (CH ₃ O)P(O)C(COOH=C(OCH ₃)C(CH ₃)(COCH ₃)OH	H	1969, 353
PC ₁₅ H ₁₉ Si	(C ₆ H ₅) ₂ PSi(CH ₃) ₃	H{Si, P}	1969, 2
PC ₁₅ H ₁₉ Sn	(C ₆ H ₅) ₂ PSn(CH ₃) ₃	H{Sn, P}	1969, 2, 14

PC ₁₅ H ₂₀ F ₃ O ₆	(CH ₃ O) ₃ POC(CF ₃)(C ₆ H ₅)C(CH ₃)(COCH ₃)O (stereois.)	H; P (−52·5; −49·6)	1966, 248
PC ₁₅ H ₂₀ NO ₄	(C ₂ H ₅ O) ₂ P(O)C(CN)=C(CH ₃)C ₆ H ₄ OCH ₃	H	1968, 323
PC ₁₅ H ₂₀ O ₄	C ₆ H ₅ OP(O)O[CH(CHCH ₃)] ₃ O	H; P	1968, 83
PC ₁₅ H ₂₁ ClNO ₃	(C ₂ H ₅ O) ₂ P(O)CH(NH ₃ Cl)β-C ₁₀ H ₇	H	1968, 142
PC ₁₅ H ₂₁ O ₂	(CH ₃) ₃ P [⊖] CH(C ₆ H ₅)=C(COCH ₃)C(O [⊖])CH ₃	P (109)	1968, 124, 152
PC ₁₅ H ₂₁ O ₅	(CH ₃ O) ₃ POC(CH ₃)C(COCH ₃)CH(C ₆ H ₅)	H; P (−27·9)	1966, 106; 1967, 160; 1968, 124, 152, 312
PC ₁₅ H ₂₁ O ₇	C ₂ H ₅ OP(O)(OH)CH ₂ C(COOC ₂ H ₅)=C(C ₆ H ₅)CH ₃	H	1967, 327
	C ₆ H ₅ O[(CH ₃) ₂ C(CH ₂ O) ₂ P[OC(CH ₃)] ₂	P (−56·6)	1968, 301
	(CH ₃ O) ₃ POCH(COC ₆ H ₅)C(CH ₃)(COCH ₃)O	H; P (−50·1)	1965, 21; 1966, 258
	(CH ₃ O) ₃ POCH(C ₆ H ₄ CHO)C(CH ₃)(COCH ₃)O (stereois.)	H; P (−49·6; −51·1)	1967, 350, 351
PC ₁₅ H ₂₂ N	C ₆ H ₅ P(CH ₂) ₂ NHC(CH ₂) ₆	H	1967, 137
PC ₁₅ H ₂₂ NO ₈	(CH ₃ O) ₃ POC(CH ₃)(C ₆ H ₄ NO ₂)C(CH ₃)(COCH ₃)O (stereois.)	H; P (−54·0; −52·4)	1966, 248
PC ₁₅ H ₂₃ N ₂ O ₄ S	(C ₂ H ₅ O) ₂ P(S)NHCOC(O)NH-C ₃ H ₇	H	1966, 264
PC ₁₅ H ₂₃ O	C ₆ H ₅ P(O)C(CH ₃) ₂ CH(CH ₃) ₂ CH CH ₃ P(O)C(CH ₃) ₂ CH(CH ₃)C(CH ₃) ₂ C ₆ H ₄	H H{P}	1967, 356 1968, 67
PC ₁₅ H ₂₃ O ₃	(CH ₃) ₂ C(CH ₂ O) ₂ P(O)CH ₂ C ₆ H ₂ (CH ₃) ₃	H	1968, 74
PC ₁₅ H ₂₃ O ₅	(C ₂ H ₅ O) ₂ P(O)CH(C ₆ H ₅)CH ₂ COOC ₂ H ₅	H	1966, 249

Formula	Compound	Resonance	Reference
PC ₁₅ H ₂₃ O ₆	(CH ₃ O) ₃ POC(CH ₃)(C ₆ H ₅)C(CH ₃)(COCH ₃)O	H; P (-54.2)	1966, 248
PC ₁₅ H ₂₄ Br	CH ₃ (C ₆ H ₅)P [⊕] C(CH ₃) ₂ CH(CH ₃)C(CH ₃) ₂ , Br [⊖]	H	1967, 82
PC ₁₅ H ₂₄ NO	C ₆ H ₅ CH ₂ NHP(O)[C(CH ₃) ₂] ₂ CHCH ₃	H	1969, 350
PC ₁₅ H ₂₄ NO ₃	(CH ₃) ₂ C(CH ₂ O) ₂ P(O)CH(NHC ₃ H ₇)C ₆ H ₅	H	1968, 74
	C ₂ H ₅ O(C ₆ H ₅)P(O)C(O)N(<i>i</i> -C ₃ H ₇) ₂	H	1968, 29
PC ₁₅ H ₂₄ NO ₅ S ₃	C ₆ H ₅ P(S)(SCH ₃)S(CH ₂) ₂ N [⊕] H(C ₄ H ₁₀ O), COO [⊖] COOH	H	1967, 113
PC ₁₅ H ₂₅ N ₆ O	[(CH ₃) ₂ N] ₂ P(O)NC(CH ₃)NNCNHC ₆ H ₅	H	1966, 137
PC ₁₅ H ₂₅ O	CH ₃ P(O)C(CH ₃) ₂ CH(CH ₃)C(CH ₃) ₂ C ₆ H ₆	H; {P}	1967, 356; 1968, 67
PC ₁₅ H ₂₆ Br	C ₃ H ₇ (C ₆ H ₅)P [⊕] (<i>i</i> -C ₃ H ₇) ₂ , Br [⊖]	P (39.9)	1966, 5; 1968, 6
	C ₆ H ₅ P [⊕] (C ₃ H ₇) ₂ , Br [⊖]	P (29.3)	1968, 6
	CH ₃ (C ₆ H ₅)P [⊕] (<i>i</i> -C ₄ H ₉) ₂ , Br [⊖]	P (26.5)	1968, 6
PC ₁₅ H ₂₆ I	CH ₃ (C ₆ H ₅)P [⊕] (C ₄ H ₉) ₂ , Br [⊖]	P (28.2)	1967, 244
PC ₁₅ H ₂₇	(C ₅ H ₉) ₃ P	P (4.5-1.0)	1967, 8, 244, 277; 1968, 6
PC ₁₅ H ₂₇ ClNO ₃	(C ₂ H ₅ O) ₂ P(O)CH(NH ₃ [⊖] Cl [⊕])CHC ₆ H ₄ - <i>t</i> -C ₄ H ₉	H; P (17.4)	1968, 142, 296
PC ₁₅ H ₂₇ Ge ₃	P[C≡CGe(CH ₃) ₃] ₃	H	1969, 364
PC ₁₅ H ₂₇ O	(C ₅ H ₉) ₃ PO	P (67.5)	1967, 277
PC ₁₅ H ₂₇ O ₃	[(CH ₃) ₂ (CH ₂ =CH)CO] ₃ P	P (140.2)	1967, 293
PC ₁₅ H ₂₇ O ₄	[(CH ₃) ₂ (CH ₂ =CH)CO] ₃ PO	P (-13.1)	1967, 293
PC ₁₅ H ₂₇ S	(C ₅ H ₉) ₃ PS	P (70.1)	1967, 277
PC ₁₅ H ₂₇ Si ₃	P[C≡CSi(CH ₃) ₃] ₃	H	1969, 364
PC ₁₅ H ₂₈ IN ₂	CH ₃ (C ₆ H ₅)P [⊕] [N(C ₂ H ₅) ₂] ₂ , I [⊖]	H	1962, 4
	CH ₃ (C ₆ H ₅)P [⊕] (NH- <i>t</i> -C ₄ H ₉) ₂ , I [⊖]	H	1967, 95
PC ₁₅ H ₂₈ NO ₂	(C ₅ H ₉) ₂ P(O)C(O)N(C ₂ H ₅) ₂	H	1967, 26

PC ₁₅ H ₂₉ N ₂ O ₂	O(CH ₂) ₂ N(C ₆ H ₁₁)POCH ₂ NHC ₆ H ₁₁	H	1968, 304
PC ₁₅ H ₂₉ O ₃	(CH ₃ O) ₂ P(O)CCH(CH ₂) ₁₁	H	1967, 100
PC ₁₅ H ₃₀	(C ₅ H ₁₀) ₃ P	P (-34)	1966, 4
PC ₁₅ H ₃₀ BrO ₂	(C ₄ H ₉) ₃ P [⊕] CH=CHCOOH, Br [⊖]	H	1969, 349
PC ₁₅ H ₃₀ NO ₇	C ₂ H ₅ O[(C ₂ H ₅) ₂ N]P(O)OC(C ₂ H ₅)(COOC ₂ H ₅) ₂	H; P (-0.3)	1967, 4
PC ₁₅ H ₃₀ N ₃ O	[(CH ₂) ₄ NCH ₂] ₃ PO	H; P (48.4)	1967, 291
PC ₁₅ H ₃₀ N ₃ O ₃	OP(NHCOOC ₂ H ₅)[NC(CH ₃) ₂ C(CH ₃) ₂] ₂	H	1965, 42
PC ₁₅ H ₃₀ N ₃ O ₄	[(C ₂ H ₅)C=NO] ₂ P(O)N=C(C ₂ H ₅) ₂	P (0.0)	1968, 335
PC ₁₅ H ₃₁ O ₃	[O(CH ₂) ₂ NCH ₂] ₃ PO	H; P (50.6)	1967, 291
PC ₁₅ H ₃₁ O ₄	CH ₃ (C ₁₂ H ₂₅)P(O)CH ₂ COOH	H; P (48.7)	1967, 329
PC ₁₅ H ₃₂	(CH ₃ O) ₂ P(O)C ₁₃ H ₂₄ (OH)	H	1967, 100
PC ₁₅ H ₃₂	CH ₂ =CHCH ₂ P [⊕] (C ₄ H ₉) ₃	P (32.4)	1967, 7
PC ₁₅ H ₃₂ I	C ₂ H ₅ (C ₄ H ₉) ₃ PI	¹³ C	1968, 22
PC ₁₅ H ₃₂ NO ₂	(<i>s</i> -C ₅ H ₁₁) ₂ P(O)C(O)N(C ₂ H ₅) ₂	H	1967, 26
PC ₁₅ H ₃₂ NO ₄	(<i>i</i> -C ₃ H ₇ O) ₂ P(O)C(O)N(<i>i</i> -C ₄ H ₉) ₂	H	1967, 26
	(C ₆ H ₁₃ O) ₂ P(O)C(O)N(CH ₃) ₂	H	1967, 26
	[(CH ₃) ₂ C ₄ H ₈ O] ₂ P(O)C(O)N(CH ₃) ₂	H	1967, 26
	(C ₆ H ₁₃ O) ₂ P(O)C(O)NHC ₂ H ₅	H	1967, 26
PC ₁₅ H ₃₃ O ₃	(C ₅ H ₁₁ O) ₃ P	P (134.5)	1967, 277
	(<i>s</i> -C ₅ H ₁₁ O) ₃ P	P (140.5)	1967, 277
	(<i>i</i> -C ₅ H ₁₁ O) ₃ P	P (143.5)	1967, 277
	[CH ₃ (<i>i</i> -C ₃ H ₇)CHO] ₃ P	P (142.0)	1967, 277
	[C ₂ H ₅ (CH ₃) ₂ CO] ₃ P	P (138.6)	1967, 293
PC ₁₅ H ₃₃ O ₃ S	(C ₅ H ₁₁ O) ₃ PS	P (64.2)	1967, 277
	(<i>s</i> -C ₅ H ₁₁ O) ₃ PS	P (62.8)	1967, 277
	(<i>i</i> -C ₅ H ₁₁ O) ₃ PS	P (64.3)	1967, 277
	[CH ₃ (<i>i</i> -C ₃ H ₇)CHO] ₃ PS	P (66.8)	1967, 277
	(<i>t</i> -C ₄ H ₉ CH ₂ O) ₃ PS	P (68.5)	1967, 293
PC ₁₅ H ₃₃ O ₃ Se	(<i>t</i> -C ₄ H ₉ CH ₂ O) ₃ PSe	P (72.6)	1967, 293

Formula	Compound	Resonance	Reference
PC ₁₅ H ₃₃ O ₄	(C ₅ H ₁₁ O) ₃ PO	P (-4.0)	1967, 277
	(<i>s</i> -C ₅ H ₁₁ O) ₃ PO	P (-4.4)	1967, 277
	(<i>i</i> -C ₅ H ₁₁ O) ₃ PO	P (-4.0)	1967, 277
	[CH ₃ (<i>i</i> -C ₃ H ₇)CHO] ₃ PO	P (-2.2)	1967, 277
	(<i>t</i> -C ₄ H ₉ CH ₂ O) ₃ PO	P (-0.6)	1967, 293
	[C ₂ H ₅ (CH ₃) ₂ CO] ₃ PO	P (-12.9)	1967, 293
	<i>i</i> -C ₃ H ₇ (C ₄ H ₉) ₃ P [⊕]	P (38.0)	1967, 7
PC ₁₅ H ₃₄	(CH ₃) ₃ P [⊕] C ₁₂ H ₂₅ , I [⊖]	H; P (26.3)	1966, 14
PC ₁₅ H ₃₄ I	[(C ₂ H ₅) ₂ NCH ₂] ₃ PF ₂	F (-51.0)	1967, 61
PC ₁₅ H ₃₆ F ₂ N ₃	(C ₄ H ₉) ₃ P=NSi(CH ₃) ₃	P (9)	1966, 268
PC ₁₅ H ₃₆ NSi	[(C ₂ H ₅) ₂ NCH ₂] ₃ P	P (-65.5)	1966, 4; 1967, 244, 291
PC ₁₅ H ₃₆ N ₃	[(C ₂ H ₅) ₂ NCH ₂] ₃ P		
PC ₁₅ H ₃₆ N ₃ O	[(C ₂ H ₅) ₂ NCH ₂] ₃ PO	H; P (43.2)	1967, 291
PC ₁₅ H ₃₉ AlNSi	(C ₂ H ₅) ₃ PN[Al(C ₂ H ₅) ₃][Si(CH ₃) ₃]	H	1967, 322
PC ₁₆ H ₁₀ FN	(C ₆ F ₅) ₂ PNH- <i>t</i> -C ₄ H ₉	H; F (-136.7; -162.1; -152.5)	1966, 19
PC ₁₆ H ₁₁	(C ₆ H ₅) ₂ P(C≡C) ₂ H	H	1966, 234, 247
PC ₁₆ H ₁₁ F ₆	(C ₆ H ₅) ₂ PC(CF ₃)=CHCF ₃	H	1965, 107
PC ₁₆ H ₁₃ O ₃	C ₆ H ₅ [C ₁₀ H ₆ (OH)]PO ₂ H	H	1965, 79
PC ₁₆ H ₁₅	(C ₆ H ₅) ₂ PC(CH ₃)=C=CH ₂	H	1966, 61
PC ₁₆ H ₁₅ Cl ₂ O ₃	(C ₂ H ₅) ₂ (C ₆ H ₅)P [⊕] CC(O)C(O)(CCl) ₂ CO [⊖]	P (25.6)	1965, 85
PC ₁₆ H ₁₅ F ₅ N	C ₆ H ₅ (C ₆ F ₅)PN(C ₂ H ₅) ₂	H; P (47.0)	1966, 7
PC ₁₆ H ₁₅ F ₁₂ O ₂	C ₂ H ₅ (C ₆ H ₅)[(CF ₃) ₂ CHO]POC(CF ₃) ₂ CHCH ₃ (stereois.)	P (-21.7; -30.3); F	1968, 302
PC ₁₆ H ₁₅ O	(C ₂ H ₅) ₂ (C ₆ H ₅)P[OC(CF ₃) ₂] ₂	P (-1.1); F (9.8)	1968, 14, 303
	(C ₆ H ₅) ₂ P(O)C(CH ₃)=C=CH ₂	H	1966, 61; 1969, 115

PC ₁₆ H ₁₆ BrO ₅ PC ₁₆ H ₁₆ ClO ₄	(CH ₃ O) ₂ P(O)CBr(C ₆ H ₅)COC ₆ H ₅ (C ₂ H ₅) ₂ (C ₆ H ₅)P [⊕] CC(O)C(O)CCIC(OH)CO [⊖]	H; P (-4.1) P (23)	1968, 309 1965, 85
PC ₁₆ H ₁₆ I PC ₁₆ H ₁₆ NOS ₃	CH ₃ (C ₆ H ₅) ₂ P [⊕] C≡CCH ₃ , I [⊖] CH ₃ C ₆ H ₄ NC(C ₆ H ₄)CC(S)SP(S)OC ₂ H ₅	H H	1966, 73, 247 1969, 363
PC ₁₆ H ₁₆ NO ₂ S ₂ PC ₁₆ H ₁₆ NO ₂ S ₃	CH ₃ C ₆ H ₄ NC(C ₆ H ₄)CC(O)SP(S)OC ₂ H ₅ CH ₃ OC ₆ H ₄ NC(C ₆ H ₄)CC(S)SP(S)OC ₂ H ₅	H H	1969, 363 1969, 363
PC ₁₆ H ₁₆ NO ₃ S ₂	CH ₃ OC ₆ H ₄ NC(C ₆ H ₄)CC(O)SP(S)OC ₂ H ₅	H	1969, 363
PC ₁₆ H ₁₆ NO ₆ PC ₁₆ H ₁₆ NO ₇ PC ₁₆ H ₁₆ N ₃ O ₈	CH ₃ (NO ₂ C ₆ H ₄ O)P(O)OCH ₂ C(O)C ₆ H ₄ CH ₃ CH ₃ (NO ₂ C ₆ H ₄ O)P(O)OCH ₂ C(O)OCH ₂ C(O)C ₆ H ₄ OCH ₃ CH=CH(NHCOC ₆ H ₅)CNC(O)N-	H(T) H(T) H	1969, 159 1969, 159 1969, 98
	-CHOCH(CH ₂ OPO ₃ H ₂)[CH(OH)] ₂	H	1969, 98
PC ₁₆ H ₁₇ N ₂ O ₃	C ₆ H ₅ PO(CH ₂) ₂ N(CH ₃)C(O)NC ₆ H ₅	H; P (116)	1969, 171
PC ₁₆ H ₁₇ N ₂ O ₉ PC ₁₆ H ₁₇ O ₄	(CH ₃ O) ₂ P(O)OCH(C ₆ H ₄ NO ₂)CH(OH)C ₆ H ₄ NO ₂ (CH ₃ O) ₂ P(O)CHC(C ₆ H ₅) ₂ O	H; P (-0.5) H	1967, 163 1966, 245
PC ₁₆ H ₁₈ F ₂ N PC ₁₆ H ₁₈ N	(CH ₃ O) ₂ P(O)C(C ₆ H ₅) ₂ CHO (C ₂ H ₅) ₂ NP(C ₆ H ₄ F) ₂ C ₆ H ₅ P(CH ₂) ₂ NHCCH ₃ (C ₆ H ₅)	H F H	1966, 245 1969, 18, 19 1967, 137
PC ₁₆ H ₁₈ NO ₂ PC ₁₆ H ₁₈ NO ₃	(C ₆ H ₅) ₂ P(O)NCH(O- <i>t</i> -C ₄ H ₉) (CH ₃) ₂ NP[OCH(C ₆ H ₅)] ₂ C ₆ H ₅ OP(O)CH(C ₆ H ₅)CH(CH ₃)NCH ₃	H P (145) H; P (13.4)	1966, 55 1969, 362 1968, 76

Formula	Compound	Resonance	Reference
	$\text{C}_6\text{H}_5\text{OP}(\text{O})\text{CH}_2\text{CH}(\text{CH}_3)\text{NCH}_2\text{C}_6\text{H}_5$ (stereois.)	H; P (15·2; 17)	1968, 76
$\text{PC}_{16}\text{H}_{19}$	$\text{C}_4\text{H}_9\text{P}(\text{C}_6\text{H}_5)_2$	P (−26·2)	1965, 3
	<i>i</i> - $\text{C}_4\text{H}_9\text{P}(\text{C}_6\text{H}_5)_2$	P (−17·1)	1968, 7; 1969, 249
	<i>s</i> - $\text{C}_4\text{H}_9\text{P}(\text{C}_6\text{H}_5)_2$	P (−21)	1967, 8; 1968, 6
	<i>t</i> - $\text{C}_4\text{H}_9\text{P}(\text{C}_6\text{H}_5)_2$	P (−3·2)	1967, 8; 1968, 6
		H; P (17·1)	1967, 8, 79; 1968, 6
$\text{PC}_{16}\text{H}_{19}\text{ClN}$	<i>i</i> - $\text{C}_3\text{H}_7(\text{C}_6\text{H}_5\text{CH}_2)\text{NPCI}(\text{C}_6\text{H}_5)$	H{P, C}	1969, 190
$\text{PC}_{16}\text{H}_{19}\text{N}_2\text{O}$	$(\text{CH}_3)_2\text{NPOCH}(\text{C}_6\text{H}_5)\text{CH}_2\text{NC}_6\text{H}_5$ (stereois.)	H	1968, 92
		P (120; 130)	1969, 109
$\text{PC}_{16}\text{H}_{19}\text{N}_2\text{O}_2$	$\text{HP}[\text{OCH}(\text{C}_6\text{H}_5)\text{CH}_2\text{NH}]_2$	H; P (−54·6)	1967, 164; 1969, 45
$\text{PC}_{16}\text{H}_{19}\text{N}_2\text{S}_2$	$(\text{C}_6\text{H}_5)_2\text{P}(\text{S})\text{N}=\text{C}(\text{SCH}_3)\text{N}(\text{CH}_3)_2$	H	1967, 353
	$(\text{C}_6\text{H}_5)_2\text{P}(\text{SCH}_3)=\text{NC}(\text{S})\text{N}(\text{CH}_3)_2$	H	1967, 353
$\text{PC}_{16}\text{H}_{19}\text{O}$	$\text{C}_2\text{H}_5\text{P}(\text{O})(\text{C}_6\text{H}_4\text{CH}_3)_2$	H	1968, 15
	$\text{C}_4\text{H}_9\text{OP}(\text{C}_6\text{H}_5)_2$	H; P (111·1)	1969, 333
$\text{PC}_{16}\text{H}_{19}\text{O}_2$	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{O}-t\text{-C}_4\text{H}_9$	H	1966, 257
	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{O}-i\text{-C}_4\text{H}_9$	H	1967, 152
$\text{PC}_{16}\text{H}_{20}\text{Br}$	$\text{CH}_3(i\text{-C}_3\text{H}_7)\text{P}^\oplus(\text{C}_6\text{H}_5)_2, \text{Br}^\ominus$	P (30·9)	1966, 5; 1968, 6
	$(\text{C}_2\text{H}_5)_2\text{P}^\oplus(\text{C}_6\text{H}_5)_2, \text{Br}^\ominus$	P (31·3)	1968, 6
	$\text{H}(\text{C}_4\text{H}_9)\text{P}^\oplus(\text{C}_6\text{H}_5)_2, \text{Br}^\ominus$	H; P (2·1)	1968, 7
	$(\text{CH}_3)_2\text{P}^\oplus(\text{C}_6\text{H}_5)\text{CH}(\text{CH}_3)\text{C}_6\text{H}_5, \text{Br}^\ominus$	H(T){P}	1969, 157
	$(\text{CH}_3)_2\text{P}^\oplus(\text{C}_6\text{H}_4\text{CH}_3)_2, \text{I}^\ominus$	H	1968, 15
$\text{PC}_{16}\text{H}_{20}\text{I}$	$(\text{C}_6\text{H}_5)_2\text{PO}(\text{CH}_2)_2\text{N}(\text{CH}_3)_2$	P (112·2)	1968, 336
$\text{PC}_{16}\text{H}_{20}\text{NO}$	$(\text{C}_6\text{H}_5)_2\text{NH}_2^\oplus, \text{O}^\ominus\text{P}(\text{O})\text{O}[\text{CH}(\text{CH}_3)]_2\text{O}$	P (ca. 15)	1969, 359
$\text{PC}_{16}\text{H}_{21}\text{O}_6$	$(\text{CH}_3\text{O})_3\text{POC}(\text{CH}_3)_2\text{C}(\text{CH}_3)(\text{COCH}_3)\text{O}$	H	1967, 140

PC ₁₆ H ₂₃	(C ₅ H ₉) ₂ PC ₆ H ₅	P (1·6)	1967, 8; 1968, 6
PC ₁₆ H ₂₃ Ge ₂	C ₆ H ₅ P[C≡CGe(CH ₃) ₃] ₂	H	1969, 364
PC ₁₆ H ₂₃ O ₇	(CH ₃ O) ₃ POC(C ₆ H ₅)(COCH ₃)C(CH ₃)(COCH ₃)O (stereois.)	H; P (−54·7; −52·4)	1966, 258
PC ₁₆ H ₂₃ Pb ₂	C ₆ H ₅ P[C≡CPb(CH ₃) ₃] ₂	H	1969, 364
PC ₁₆ H ₂₃ Si ₂	C ₆ H ₅ P[C≡CSi(CH ₃) ₃] ₂	H	1969, 364
PC ₁₆ H ₂₃ Sn ₂	C ₆ H ₅ P[C≡CSn(CH ₃) ₃] ₂	H	1969, 364
PC ₁₆ H ₂₅ N ₂	C ₆ H ₅ P(NC ₅ H ₁₀) ₂	H	1966, 18
PC ₁₆ H ₂₅ N ₂ O	(CH ₃) ₂ NPOCH(C ₆ H ₅)CH ₂ NC ₆ H ₄ (stereois.)	P (132; 135)	1969, 109
PC ₁₆ H ₂₅ N ₄ S ₃	(C ₂ H ₅) ₂ NCNP(S)(SC ₆ H ₅)SC[N(C ₂ H ₅) ₂]N	P (61·0)	1968, 137
PC ₁₆ H ₂₅ O ₂	CH ₃ (C ₆ H ₅)P(O)OC ₆ H ₁₀ (<i>i</i> -C ₃ H ₇)	H	1967, 151
PC ₁₆ H ₂₆ Br	CH ₃ (C ₆ H ₅ CH ₂)P [⊕] C(CH ₃) ₂ CH(CH ₃)C(CH ₃) ₂ , Br [⊖]	H	1967, 82; 1969, 170
PC ₁₆ H ₂₆ NO ₆ S	(C ₄ H ₉ O) ₂ P(O)C(O)NHOSO ₂ C ₆ H ₄ CH ₃	H	1968, 328; 1969, 161
PC ₁₆ H ₂₇ N ₄ O ₄ S	Diethyl 2-{3-(2-methyl-4-aminopyrimidin-5-yl)methyl-3a-methylperhydrofuro[2,3- <i>d</i>]thiazole}phosphonate	H	1967, 352
PC ₁₆ H ₂₇ O ₂	(CH ₃) ₂ C ₆ H ₃ PH(O)(Os-C ₄ H ₉) ₂ (stereois.)	H; P (158·3; 156·6; 153·3)	1969, 162
PC ₁₆ H ₂₈ Br	C ₂ H ₅ (C ₆ H ₅) ₂ P [⊕] (<i>i</i> -C ₄ H ₉) ₂ Br [⊖]	P (29·9)	1968, 6
	C ₂ H ₅ (C ₆ H ₅) ₂ P [⊕] (<i>s</i> -C ₄ H ₉) ₂ Br [⊖]	P (41·2)	1968, 6
PC ₁₆ H ₂₉ N ₂	C ₆ H ₅ P[CH ₂ N(C ₂ H ₅) ₂] ₂	P (−51·3)	1966, 4; 1967, 244
PC ₁₆ H ₂₉ O	(C ₂ H ₅) ₂ P(O)C(<i>t</i> -C ₄ H ₉)=C=C(CH ₂) ₃ CHCH ₃	H	1969, 365
PC ₁₆ H ₃₀ Br	CH ₃ P [⊕] (C ₅ H ₉) ₃ , Br [⊖]	P (40·0)	1966, 5; 1968, 6
PC ₁₆ H ₃₀ GeNO	(C ₂ H ₅) ₂ PC(O)N(C ₆ H ₅)Ge(C ₂ H ₅) ₃	H	1967, 342
PC ₁₆ H ₃₀ GeNS	(C ₂ H ₅) ₂ PC(S)N(C ₆ H ₅)Ge(C ₂ H ₅) ₂	H	1967, 342
PC ₁₆ H ₃₀ I	CH ₃ P [⊕] (C ₅ H ₉) ₃ , I [⊖]	P (40·2)	1967, 244
PC ₁₆ H ₃₀ NO ₄	(C ₆ H ₁₁ O) ₂ P(O)C(O)N(CH ₂) ₄	H	1968, 29
PC ₁₆ H ₃₂ BrO ₂	(C ₄ H ₉) ₃ P [⊕] CH=CHCOOCH ₃ , Br [⊖]	H	1969, 349

Formula	Compound	Resonance	Reference
PC ₁₆ H ₃₂ ClO ₂	(C ₄ H ₉) ₂ P ⁺ CH=CHCOOCH ₃ , Cl [−]	H	1969, 349
PC ₁₆ H ₃₂ NO ₂	(CH ₃) ₂ NP[OCHC(CH ₃) ₂] ₂ (isom.)	P (144;150)	1969, 362
PC ₁₆ H ₃₃ O	C ₁₂ H ₂₅ P(CH ₂ CH ₂) ₂ O	P (−52)	1969, 44
PC ₁₆ H ₃₄ ClO ₂	(C ₄ H ₉) ₃ P ⁺ CH ₂ COOC ₂ H ₅ , Cl [−]	H	1965, 87
PC ₁₆ H ₃₅	C ₁₂ H ₂₅ P(C ₂ H ₅) ₂	H; P (−25)	1966, 14
	HP(C ₈ H ₁₇) ₂	P(−71·5)	1966, 51
PC ₁₆ H ₃₅ O	C ₁₂ H ₂₅ P(O)(C ₂ H ₅) ₂	H; P (−56·1)	1966, 14, 40
	C ₁₄ H ₂₉ P(O)(CH ₃) ₂	P (37·2)	1966, 40
PC ₁₆ H ₃₅ O ₃	HP(O)(OC ₈ H ₁₇) ₂	P (7·4)	1967, 277
PC ₁₆ H ₃₅ O ₄	(C ₃ H ₇ O) ₂ P(O)(CH ₂) ₂ OC ₈ H ₁₇	H	1966, 251
PC ₁₆ H ₃₅ S	C ₁₂ H ₂₅ P(S)(C ₂ H ₅) ₂	P (51·6)	1966, 40
	C ₁₄ H ₂₉ P(S)(CH ₃) ₂	P (34·1)	1966, 40
PC ₁₆ H ₃₆	(C ₄ H ₉) ₄ P ⁺	P (33·9)	1967, 7
PC ₁₆ H ₃₆ Br	(C ₄ H ₉) ₄ P ⁺ Br [−]	¹³ C; P (33·9)	1966, 5; 1968, 22; 1969, 21
PC ₁₆ H ₃₆ Br ₄ N	(C ₄ H ₉) ₄ N ⁺ PBr ₄ [−]	P (150)	1969, 11
PC ₁₆ H ₃₇ NOS	C ₁₂ H ₂₅ (CH ₃) ₂ P=N=S(O)(CH ₃) ₂	H	1967, 357
PC ₁₆ H ₃₇ O ₂	(C ₄ H ₉) ₃ P(OC ₂ H ₅) ₂	H; P (−38)	1968, 332
PC ₁₇ H ₁₁ F ₁₀ O ₅	(CH ₃ O) ₃ POCH(C ₆ F ₅)OCHC ₆ F ₅ (isom.)	H; P (−34·1; −38·4)	1969, 75
PC ₁₇ H ₁₃	(C ₆ H ₅) ₂ P(C≡C) ₂ CH ₃	H	1966, 243, 247
PC ₁₇ H ₁₃ F ₆	C(C ₆ H ₅)[CH=C(CH ₃)] ₂ PC(CF ₃)=CCF ₃	H	1968, 168
PC ₁₇ H ₁₃ O	(C ₆ H ₅) ₂ P(O)(C≡C) ₂ CH ₃	H	1966, 243, 247
PC ₁₇ H ₁₃ S	(C ₆ H ₅) ₂ P(S)(C≡C) ₂ CH ₃	H	1966, 243, 247
	CH ₃ P(S)(C≡CC ₆ H ₅) ₂	H	1965, 89
PC ₁₇ H ₁₅ O ₅	(CH ₃ O)(CH ₂ O) ₂ P[OC(C ₆ H ₄)] ₂	H; P	1968, 301
PC ₁₇ H ₁₆ NO ₃	(C ₆ H ₅) ₂ C=C(CN)P(O)(OC ₂ H ₅)OH	H	1968, 319

PC ₁₇ H ₁₇ O	(C ₆ H ₅) ₂ P(O)CH=C=C(CH ₃) ₂	H	1966, 61
PC ₁₇ H ₁₇ O ₂	(CH ₃) ₃ POC ₁₄ H ₈ O (phenanthr.)	H; P (-3.0)	1968, 303
PC ₁₇ H ₁₇ O ₃	CH ₃ P(O)CH(CH ₂ COOCH ₃)C ₆ H ₄ C ₆ H ₄	H; P (33)	1967, 358
PC ₁₇ H ₁₇ O ₅	(CH ₃ O) ₃ P[OC(C ₆ H ₄)] ₂	H; P (-45)	1965, 21; 1966, 225, 242; 1968, 301, 309; 1969, 366
PC ₁₇ H ₁₇ O ₆	(CH ₃ O) ₂ P(O)O(C ₁₄ H ₈)OCH ₃	H; P (-2.8)	1968, 315
PC ₁₇ H ₁₈ Br	(CH ₃ O)(CH ₂ O) ₂ P[OC(C ₆ H ₅)] ₂	H; P (-28.1)	1968, 301
PC ₁₇ H ₁₉	(CH ₃ O) ₃ P(O)C ₁₄ H ₈ O ₂	P (-44.7)	1965, 84
PC ₁₇ H ₁₉	C ₆ H ₅ (C ₆ H ₅ CH ₂)P [⊕] (CH ₂ CH) ₂ , Br [⊖]	H	1968, 101
PC ₁₇ H ₁₉ N ₂ O ₉	C ₅ H ₉ P(C ₆ H ₅) ₂	P (-3.9)	1967, 8; 1968, 6
	(CH ₃ O) ₃ P[OCH(C ₆ H ₄ - <i>p</i> -NO ₂)] ₂ (stereois.)	H; P (-49.6; -50.2)	1967, 163, 350; 1969, 75
PC ₁₇ H ₁₉ O ₂	(CH ₃ O) ₃ P(O)CH[C ₆ H ₄ - <i>o</i> -NO ₂] ₂	H; P (-50.1)	1967, 28, 350
PC ₁₇ H ₁₉ O ₅	CH ₃ (C ₆ H ₅) ₂ P[OC(CH ₃)] ₂	P (-27.2)	1968, 152
	(CH ₃ O) ₃ P[OC(C ₆ H ₅)] ₂	P (-53)	1965, 45; 1966, 239
		H; P (-49.5)	1965, 21; 1966, 225; 1968, 124, 301
PC ₁₇ H ₂₀	(C ₆ H ₅) ₂ P [⊕] (CH ₂) ₅	P (-16.5)	1966, 269
PC ₁₇ H ₂₀ N	C ₆ H ₅ P(CH ₂) ₂ NHC(C ₂ H ₅)C ₆ H ₅	H	1967, 137
PC ₁₇ H ₂₀ NOS	(C ₆ H ₅) ₂ P(S)CH ₂ N(C ₂)H ₂ O(CH ₂) ₂	P (35.3)	1966, 40
PC ₁₇ H ₂₀ NO ₂	(C ₆ H ₅) ₂ P(O)CH ₂ N(CH ₂) ₄ O	H	1968, 56
PC ₁₇ H ₂₀ NS	(C ₆ H ₅) ₂ P(S)CH ₂ N(CH ₂) ₄	P (36.1)	1966, 40
PC ₁₇ H ₂₁	(<i>t</i> -C ₅ H ₁₁)P(C ₆ H ₅) ₂	P (15.4)	1967, 8; 1968, 6
	(<i>neo</i> -C ₅ H ₁₁)P(C ₆ H ₅) ₂	P (-23.9)	1967, 8; 1968, 6
PC ₁₇ H ₂₁ O	(C ₆ H ₅) ₂ P(O)CH ₂ C(CH ₃) ₃	H	1965, 108

Formula	Compound	Resonance	Reference
PC ₁₇ H ₂₁ O ₂	(C ₆ H ₅) ₂ P(O)O- <i>neo</i> -C ₅ H ₁₁	H	1967, 152
PC ₁₇ H ₂₁ O ₄	(C ₆ H ₅) ₂ CHOP(O)(OC ₂ H ₅) ₂	H	1969, 74
PC ₁₇ H ₂₁ O ₅	(CH ₃ O) ₃ P[OCH(C ₆ H ₅)] ₂	P	1968, 124
PC ₁₇ H ₂₁ O ₇	(CH ₃ O) ₃ POC(CH ₃)(COCH ₃)C(C ₉ H ₆ O)O	H; P (-50)	1968, 318
PC ₁₇ H ₂₂ Br	C ₂ H ₅ (<i>i</i> -C ₃ H ₇)P [⊕] (C ₆ H ₅) ₂ Br [⊖]	P (36·2)	1966, 5; 1968, 6
	CH ₃ (<i>i</i> -C ₄ H ₉)P [⊕] (C ₆ H ₅) ₂ Br [⊖]	P (22·5)	1968, 6
	CH ₃ (<i>s</i> -C ₄ H ₉)P [⊕] (C ₆ H ₅) ₂ Br [⊖]	P (30·2)	1968, 6
	CH ₃ (<i>t</i> -C ₄ H ₉)P [⊕] (C ₆ H ₅) ₂ Br [⊖]	H; P (33·0)	1968, 6
	CH ₃ (C ₂ H ₅)P [⊕] (CH ₂ C ₆ H ₅) ₂ Br [⊖]	H	1969, 156
	CH ₃ (<i>i</i> -C ₃ H ₇)P [⊕] (CH ₂ C ₆ H ₅)C ₆ H ₅ Br [⊖]	H	1969, 156
PC ₁₇ H ₂₂ Cl ₆ N ₂ S ₂ Sb	CH ₃ S(C ₆ H ₅) ₂ P [⊕] N=C(SCH ₃)[N(CH ₃) ₂], SbCl ₆ [⊖]	P (36·8)	1967, 221, 344
PC ₁₇ H ₂₂ N	(C ₆ H ₅) ₂ PCH ₂ N(C ₂ H ₅) ₂	P (-27·3)	1966, 4; 1967, 244; 1968, 36
PC ₁₇ H ₂₂ NO	(C ₆ H ₅) ₂ P(O)CH ₂ N(C ₂ H ₅) ₂	H; P (24·7)	1968, 36
PC ₁₇ H ₂₂ NO ₃	(C ₂ H ₅ O) ₂ P(O)CH(NHC ₆ H ₅)C ₆ H ₅	P (23·5)	1969, 340
PC ₁₇ H ₂₂ NS	(C ₆ H ₅) ₂ P(S)CH ₂ N(C ₂ H ₅) ₂	P (34·4)	1966, 40
PC ₁₇ H ₂₄ N ₃ S ₂	(C ₆ H ₅) ₂ P(S)NC(S [⊖])N(CH ₃) ₂ , (CH ₃) ₂ NH [⊕]	H	1967, 353
PC ₁₇ H ₂₅ N ₂ O ₂	[(CH ₃) ₂ N] ₂ P(O)CH(C ₆ H ₅)CH ₂ COC ₆ H ₅	H	1966, 42
PC ₁₇ H ₂₆ Br	CH ₃ (C ₅ H ₉) ₂ P [⊕] C ₆ H ₅ , Br [⊖]	P (36·4)	1966, 5; 1968, 6
PC ₁₇ H ₂₇ N ₄ OS ₂	(C ₂ H ₅) ₂ NCNP(S)(C ₆ H ₄ OCH ₃)SC[N(C ₂ H ₅) ₂]N	P (56·5)	1968, 137
PC ₁₇ H ₂₇ O ₂	CH ₃ (C ₆ H ₅)P(O)O-menthyl	H	1967, 151; 1968, 140
PC ₁₇ H ₂₇ O ₅	(C ₄ H ₉) ₂ P(O)CH ₂ COOCH ₂ C ₆ H ₅	H	1965, 87
PC ₁₇ H ₂₈ IN ₄ S ₂	(C ₂ H ₅) ₂ N [⊕] CNP(SCH ₃)(SC ₆ H ₅)SC[N(C ₂ H ₅) ₂]N, I [⊖]		1968, 137
PC ₁₇ H ₂₉ O	(C ₂ H ₅) ₂ P(O)C(CH ₃)=C=CC ₁₀ H ₁₆	H	1969, 272
PC ₁₇ H ₃₀ O	(C ₂ H ₅) ₂ P(O)C(CH ₃)=C=C ₁₀ H ₁₇	H	1967, 156
PC ₁₇ H ₃₁ GeO	(C ₂ H ₅) ₂ PCH(C ₆ H ₅)OGc(C ₂ H ₅) ₃	H	1968, 331

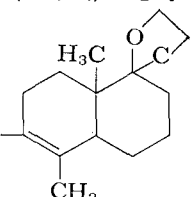
PC ₁₇ H ₃₂ NO ₂	(C ₆ H ₁₁) ₂ P(O)C(O)N(C ₂ H ₅) ₂	H	1967, 26
PC ₁₇ H ₃₂ N ₃ O ₄	(C ₅ H ₄ N)OPO ₃ (NH ₃ C ₆ H ₁₁) ₂	H	1969, 338
PC ₁₇ H ₃₃ O ₂	CH ₃ (C ₆ H ₁₁)P(O)O-menthyl	H	1967, 151; 1968, 140
PC ₁₇ H ₃₃ O ₃	(CH ₃ O) ₂ P(O)CCH(CH ₂) ₁₃	H	1967, 100
PC ₁₇ H ₃₅ N ₂ O ₆	(C ₂ H ₅) ₂ P(O)OC(C ₂ H ₅)(COOC ₂ H ₅) ₂	H; P (-2.6)	1967, 4
PC ₁₇ H ₃₅ O ₄	(CH ₃ O) ₂ P(O)C ₁₅ H ₂₈ OH	H	1967, 100
PC ₁₇ H ₃₅ Si ₃ S	[(CH ₃) ₃ Si] ₂ CHP(S)(C ₆ H ₅)CH ₂ Si(CH ₃) ₃	H	1966, 132
PC ₁₇ H ₃₆ ClO ₃	CH ₂ ClP(O)[OCH ₂ CH(C ₂ H ₅)C ₄ H ₉] ₂	H	1969, 162
PC ₁₇ H ₃₆ NO ₂	(C ₅ H ₁₁) ₂ P(O)C(O)N(<i>i</i> -C ₃ H ₇) ₂	H	1968, 29
PC ₁₇ H ₃₆ NO ₃	C ₈ H ₁₇ (C ₄ H ₉ O)P(O)C(O)(C ₂ H ₅) ₂	H	1967, 26
PC ₁₇ H ₃₆ NO ₄	(C ₆ H ₁₃ O) ₂ P(O)C(O)NHC ₄ H ₉	H	1967, 26
	(<i>i</i> -C ₄ H ₉ O) ₂ P(O)C(O)N(<i>s</i> -C ₄ H ₉) ₂	H	1967, 26
	(C ₆ H ₁₃ O) ₂ P(O)C(O)N(C ₂ H ₅) ₂	H	1967, 26
PC ₁₇ H ₃₈ O	(C ₄ H ₉) ₃ P ⁺ OCH ₂ C(CH ₃) ₃	P (-3.8)	1967, 345
PC ₁₇ H ₄₀ NSi	(CH ₃) ₂ (C ₁₂ H ₂₅)P=NSi(CH ₃) ₃	H; P (6)	1966, 268
PC ₁₈ F ₁₅	(C ₆ F ₅) ₃ P	P (-77.9; -75.5); F (-131; -161; -149)	1966, 7, 19, 73; 1967, 11; 1968, 9, 263; 1969, 17, 121
PC ₁₈ F ₁₅ Cl ₂	(C ₆ F ₅) ₃ PCl ₂	P (-104.7); F (-128.9, -158.9, -146.3)	1966, 73
PC ₁₈ F ₁₅ O	(C ₆ F ₅) ₃ PO	P (-8); F (-132.5; -158.4; -142.6)	1966, 63, 73, 237; 1969, 17, 121
PC ₁₈ F ₁₅ S	(C ₆ F ₅) ₃ PS	P (-8.6); F (-132.2; -158.9; -144.5)	1966, 73; 1969, 17
PC ₁₈ F ₁₇	(C ₆ F ₅) ₃ PF ₂	F (-132.4; -159.4; -146.0)	1969, 17
PC ₁₈ H ₅ F ₁₀	C ₆ H ₅ P(C ₆ F ₅) ₂	P (-48.7); F (-129.2; -160.8; -150.5)	1966, 10; 1967, 11; 1968, 263; 1969, 121, 276

Formula	Compound	Resonance	Reference
PC ₁₈ H ₅ F ₁₀ O	C ₆ H ₅ P(O)(C ₆ F ₅) ₂	P (0·7); F	1967, 11; 1968, 314
PC ₁₈ H ₅ F ₁₂ O ₂	C ₆ H ₅ PF ₂ (OC ₆ F ₅) ₂	P (−63·6); F (−41·0)	1969, 62
PC ₁₈ H ₆ F ₉	(C ₆ H ₂ F ₃) ₃ P	P (−78·5)	1969, 121
PC ₁₈ H ₉ F ₆	(2,5-F ₂ C ₆ H ₃) ₃ P	P (−34·5)	1969, 121
	(2,6-F ₂ C ₆ H ₃) ₃ P	P (−78·5)	1969, 121
PC ₁₈ H ₁₀ BCl ₃ F ₅	C ₆ F ₅ P(C ₆ H ₅) ₂ BCl ₃	F (−120·4; −158·7; −143·8)	1969, 17
PC ₁₈ H ₁₀ F ₅	C ₆ F ₅ P(C ₆ H ₅) ₂	P (−26·3); F (−127·7; −161·0; −150·6)	1966, 10; 1967, 11; 1968, 263; 1969, 17, 121
PC ₁₈ H ₁₀ F ₅ O	C ₆ F ₅ P(O)(C ₆ H ₅) ₂	P (18·7); F (−128·8); −160·1; −147·3)	1967, 11; 1969, 17, 121
PC ₁₈ H ₁₀ F ₅ S	C ₆ F ₅ P(S)(C ₆ H ₅) ₂	F (−128·1; −160·1; −148·6)	1969, 17
PC ₁₈ H ₁₀ F ₇ O	C ₆ F ₅ OPF ₂ (C ₆ H ₅) ₂	P (−46·6)	1969, 62
PC ₁₈ H ₁₁ ClF ₅	C ₆ F ₅ P [⊕] (C ₆ H ₅) ₂ H, Cl [⊖]	F (−125·6; −156·6; −140·4)	1966, 10; 1969, 17
PC ₁₈ H ₁₂ Cl ₃ O ₁₀ S ₃	OP(OC ₆ H ₄ SO ₂ Cl) ₃	H	1966, 75
PC ₁₈ H ₁₂ F ₃	(<i>p</i> -FC ₆ H ₄) ₃ P	H{P,F}; P (−8·8); F	1967, 17; 1968, 13; 1969, 18, 118, 120
	(<i>m</i> -FC ₆ H ₄) ₃ P	P (−6·5); F	1969, 19, 120
PC ₁₈ H ₁₂ F ₃ O	(<i>p</i> -FC ₆ H ₄) ₃ PO	H; F	1967, 17, 115; 1968, 13; 1969, 18, 19
PC ₁₈ H ₁₂ F ₃ S	(<i>p</i> -FC ₆ H ₄) ₃ PS	H{P}; F	1967, 17; 1969, 118
PC ₁₈ H ₁₂ N	P(C ₆ H ₄) ₃ N	P (−80)	1969, 13
PC ₁₈ H ₁₃ F ₂	C ₆ H ₅ P(C ₆ H ₄ F) ₂	F	1969, 19
PC ₁₈ H ₁₃ F ₂ S	C ₆ H ₅ SP(C ₆ H ₄ F) ₂	F	1969, 18, 19
PC ₁₈ H ₁₃ O ₅	C ₆ H ₅ OP(OC ₆ H ₄ O) ₂	P (−29·8)	1968, 124

PC ₁₈ H ₁₄ F	C ₆ H ₄ FP(C ₆ H ₅) ₂	F	1967, 17; 1968, 14; 1969, 18
PC ₁₈ H ₁₄ FO	C ₆ H ₄ FP(O)(C ₆ H ₅) ₂	F	1968, 13, 14; 1969, 18, 19
PC ₁₈ H ₁₄ FS	C ₆ H ₄ FP(S)(C ₆ H ₅) ₂	F	1967, 17; 1969, 18, 19
PC ₁₈ H ₁₄ NO ₃	(C ₆ H ₅) ₂ P(O)C ₆ H ₄ NO ₂	H	1969, 119
PC ₁₈ H ₁₅	(C ₆ H ₅) ₃ P	¹³ C; H; P (−6 to −8)	1965, 3, 7, 85, 103; 1966, 69, 78, 141, 240, 262; 1967, 198, 244, 277, 359; 1968, 22, 103, 303, 332; 1969, 50, 120, 354
PC ₁₈ H ₁₅ AlBr ₃	(C ₆ H ₅) ₃ PAIBr ₃	²⁷ Al	1967, 23
PC ₁₈ H ₁₅ AlCl ₅	(C ₆ H ₅) ₃ P [⊕] Cl, AlCl ₄ [⊖]	P (65)	1967, 191, 345
PC ₁₈ H ₁₅ Cl ₂	(C ₆ H ₅) ₃ PCl ₂	P (63)	1967, 345; 1968, 168, 288
PC ₁₈ H ₁₅ Cl ₂ O ₄	(C ₆ H ₅) ₃ P [⊕] Cl, ClO ₄ [⊖]	P (65·7)	1967, 276
PC ₁₈ H ₁₅ Cl ₇ Sb	(C ₆ H ₅) ₃ P [⊕] Cl, SbCl ₆ [⊖]	P (65·0)	1967, 191, 276, 345
PC ₁₈ H ₁₅ FI	H(C ₆ H ₄ F)P [⊕] (C ₆ H ₅) ₂ , I [⊖]	F	1968, 14
PC ₁₈ H ₁₅ FIO	C ₆ H ₄ FP [⊕] (OH)(C ₆ H ₅) ₂ , I [⊖]	F	1968, 14
PC ₁₈ H ₁₅ F ₂	(C ₆ H ₅) ₃ PF ₂	P (−58·1); F (−39·8)	1967, 61; 1968, 303
PC ₁₈ H ₁₅ F ₂ O	(C ₆ H ₅) ₂ PF ₂ (OC ₆ H ₅)	H; P (−34·4); F (−33·3)	1968, 316; 1969, 62
PC ₁₈ H ₁₅ F ₂ O ₂	C ₆ H ₅ PF ₂ (OC ₆ H ₅) ₂	H; P (−69); F (−35)	1968, 316; 1969, 62
PC ₁₈ H ₁₅ F ₂ O ₃	(C ₆ H ₅ O) ₃ PF ₂	F (−73·0)	1967, 61
PC ₁₈ H ₁₅ F ₂ S	C ₆ H ₅ SPF ₂ (C ₆ H ₅) ₂	H; P; F (−23·5)	1968, 316; 1969, 62
PC ₁₈ H ₁₅ O	(C ₆ H ₅) ₃ PO	¹³ C; H; P (−27·0)	1965, 7, 78, 85; 1966, 106, 240, 270; 1967, 92, 198, 277; 1968, 103, 110, 303, 332, 337
	C ₆ H ₅ OP(C ₆ H ₅) ₂	P (111)	1967, 329
	C ₆ H ₅ (C ₆ H ₅ C ₆ H ₄)P(O)H	H	1968, 35
PC ₁₈ H ₁₅ O ₂	C ₆ H ₅ P(OC ₆ H ₅) ₂	P (157·9)	1966, 225

Formula	Compound	Resonance	Reference
$\text{PC}_{18}\text{H}_{15}\text{O}_3$	$\text{P}(\text{OC}_6\text{H}_5)_3$	^{13}C ; P (127.8)	1966, 141, 225; 1967, 198, 277; 1968, 22, 301; 1969, 50
$\text{PC}_{18}\text{H}_{15}\text{O}_3\text{S}$	$\text{SP}(\text{OC}_6\text{H}_5)_3$	P (53.4)	1967, 277
$\text{PC}_{18}\text{H}_{15}\text{O}_4$	$\text{OP}(\text{OC}_6\text{H}_5)_3$	P (−17 to −18)	1965, 45; 1966, 239; 1967, 198, 277
$\text{PC}_{18}\text{H}_{15}\text{O}_5$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{OC}_{16}\text{H}_8(\text{OH})$	H; P (0.3)	1968, 315
$\text{PC}_{18}\text{H}_{15}\text{S}$	$\text{SP}(\text{C}_6\text{H}_5)_3$	P (42.6)	1966, 106, 111; 1967, 277; 1968, 338
$\text{PC}_{18}\text{H}_{16}\text{NO}$	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{CH}_2(\text{C}_5\text{H}_4\text{N})$	H	1966, 271
	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{C}_6\text{H}_4\text{-o-NH}_2$	H	1969, 119
$\text{PC}_{18}\text{H}_{17}\text{ClN}$	$(\text{C}_6\text{H}_5)_3\text{P}^\oplus\text{NH}_2, \text{Cl}^\ominus$	H; P (30)	1967, 65
$\text{PC}_{18}\text{H}_{17}\text{N}_2\text{S}$	$\text{C}_6\text{H}_5\text{P}(\text{S})(\text{NHC}_6\text{H}_5)_2$	H	1967, 318
$\text{PC}_{18}\text{H}_{17}\text{O}_4\text{S}$	$\text{HP}^\oplus(\text{C}_6\text{H}_5)_3, \text{HSO}_4^\ominus$	H; P (5)	1969, 50
$\text{PC}_{18}\text{H}_{17}\text{O}_7\text{S}$	$\text{HP}^\oplus(\text{OC}_6\text{H}_5)_3, \text{HSO}_4^\ominus$	P (10)	1969, 50
$\text{PC}_{18}\text{H}_{18}\text{BF}_4\text{N}_2\text{S}_2$	$\text{P}(\text{CSC}_6\text{H}_4\text{NCH}_3)_2^\oplus, \text{BF}_4^\ominus$	H	1966, 272
$\text{PC}_{18}\text{H}_{18}\text{NO}_4$	$(\text{CH}_3)_2\text{N}(\text{CH}_2\text{O})_2\text{P}[\text{OC}(\text{C}_6\text{H}_4)]_2$	H; P (−21.3)	1968, 301
$\text{PC}_{18}\text{H}_{19}\text{O}_5$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{CH}(\text{COC}_6\text{H}_5)(\text{CH}_2\text{COC}_6\text{H}_5)$	P (24.8)	1966, 106
$\text{PC}_{18}\text{H}_{19}\text{O}_6$	$(\text{CH}_3\text{O})_3\text{POC}(\text{C}_6\text{H}_5)(\text{COC}_6\text{H}_5)\text{O}$	H; P (−49.3)	1965, 21, 84; 1966, 242
$\text{PC}_{18}\text{H}_{20}\text{Br}$	$\text{C}_6\text{H}_5(\text{C}_6\text{H}_5\text{CH}_2)\text{P}^\oplus\text{CH}_2\text{CH}=\text{C}(\text{CH}_3)\text{CH}_2, \text{Br}^\ominus$	H	1968, 100
	$\text{C}_6\text{H}_5(\text{C}_6\text{H}_5\text{CH}_2)\text{P}^\oplus\text{CH}_2\text{CH}_2\text{C}(\text{CH}_3)=\text{CH}, \text{Br}^\ominus$	H	1968, 100
$\text{PC}_{18}\text{H}_{20}\text{NO}_3$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{N}=\text{C}=\text{C}(\text{C}_6\text{H}_5)_2$	H	1965, 109
	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})$ -2-phenyl-3-indolyl	H	1965, 102
$\text{PC}_{18}\text{H}_{20}\text{NO}_4$	$(\text{CH}_3)_2\text{N}(\text{CH}_2\text{O})_2\text{P}[\text{OC}(\text{C}_6\text{H}_5)]_2$	P (−26.4)	1968, 301
$\text{PC}_{18}\text{H}_{21}$	$\text{C}_6\text{H}_{11}\text{P}(\text{C}_6\text{H}_5)_2$	P (−4.4)	1965, 3; 1967, 8; 1968, 6, 7

PC ₁₈ H ₂₁ N ₂ O ₄ S	(C ₂ H ₅ O) ₂ P(S)NHCOC(O)NHC ₆ H ₅	H	1966, 264
PC ₁₈ H ₂₁ N ₂ O ₉	(C ₂ H ₅ O) ₂ P(O)OCH(C ₆ H ₄ NO ₂)CH(OH)C ₆ H ₄ NO ₂	H	1967, 163
PC ₁₈ H ₂₁ N ₄ O ₆ S	(C ₂ H ₅ O) ₂ P(S)NHCOC(O)(NH) ₂ C ₆ H ₄ NO ₂	H	1966, 264
PC ₁₈ H ₂₁ N ₆ O ₁₀ S ₃	OP(OC ₆ H ₄ SO ₂ NHNH ₂) ₃	H	1966, 71
PC ₁₈ H ₂₁ O	(C ₂ H ₅) ₂ POCCH(C ₆ H ₅) ₂	H	1969, 341
PC ₁₈ H ₂₁ O ₂	(C ₂ H ₅) ₂ P(O)CH=C(CH ₃)CH(CH ₃)OCH ₃	H	1967, 154
	(C ₂ H ₅) ₂ POC(O)CH(C ₆ H ₅) ₂	H	1969, 341
PC ₁₈ H ₂₁ O ₃	C ₂ H ₅ O(C ₆ H ₅) ₂ P[OC(CH ₃)] ₂	P (-27.7)	1966, 225
PC ₁₈ H ₂₁ O ₄	(C ₂ H ₅ O) ₂ P(O)CH-C(C ₆ H ₅) ₂ O	H	1966, 245; 1967, 81
	(C ₂ H ₅ O) ₂ P(O)C(C ₆ H ₅) ₂ CHO	H	1966, 245; 1967, 81
	(C ₂ H ₅ O) ₂ P(O)OC(C ₆ H ₅)=CHC ₆ H ₅	H	1967, 121
PC ₁₈ H ₂₁ S	C ₆ H ₁₁ P(S)(C ₆ H ₅) ₂	P (48.6)	1966, 40
PC ₁₈ H ₂₂	C ₆ H ₅ P [⊕] (CH ₂ C ₆ H ₅)[CH=C(CH ₃)](CH ₂) ₂	H	1967, 108
	C ₆ H ₅ P [⊕] (CH ₂ C ₆ H ₅)CH ₂ C(CH ₃)CH=CH ₂	H	1967, 108
PC ₁₈ H ₂₂ Br	CH ₃ (C ₆ H ₉)P [⊕] (C ₆ H ₅) ₂ , Br [⊖]	P (29.8)	1966, 5; 1968, 6
	H(C ₆ H ₁₁)P [⊕] (C ₆ H ₅) ₂ , Br [⊖]	H; P (10.5)	1968, 7
	C ₆ H ₅ (C ₆ H ₅ CH ₂)P [⊕] (CH ₂) ₃ CHCH ₃ , Br [⊖]	H	1969, 356
PC ₁₈ H ₂₂ F ₂ N	(C ₃ H ₇) ₂ NP(C ₆ H ₄ F) ₂	F	1969, 18, 19
PC ₁₈ H ₂₂ NS	(C ₆ H ₅) ₂ P(S)CH ₂ N(CH ₂) ₅	P (34.6)	1966, 40
PC ₁₈ H ₂₃ F ₆	CH ₃ C[CH=C(<i>t</i> -C ₄ H ₉)] ₂ PC(CF ₃)=CCF ₃	H	1968, 339
PC ₁₈ H ₂₃ S	C ₆ H ₁₃ P(S)(C ₆ H ₅) ₂	P (41.5)	1966, 40, 44
PC ₁₈ H ₂₄ Br	CH ₃ (<i>t</i> -C ₅ H ₁₁)P [⊕] (C ₆ H ₅) ₂ , Br [⊖]	P (32.9)	1968, 6
	CH ₃ (<i>neo</i> -C ₅ H ₁₁)P [⊕] (C ₆ H ₅) ₂ , Br [⊖]	P (20.0)	1968, 6
	C ₂ H ₅ (<i>i</i> -C ₄ H ₉)P [⊕] (C ₆ H ₅) ₂ , Br [⊖]	P (28.0)	1968, 6
	C ₂ H ₅ (<i>s</i> -C ₄ H ₉) ₂ P [⊕] (C ₆ H ₅) ₂ , Br [⊖]	P (35.8)	1968, 6
	C ₂ H ₅ (<i>t</i> -C ₄ H ₉)P [⊕] (C ₆ H ₅) ₂ , Br [⊖]	P (39.9)	1968, 6

Formula	Compound	Resonance	Reference
	$(C_3H_7)_2P^{\oplus}(C_6H_5)_2, Br^{\ominus}$	P (26.2)	1968, 6
	$CH_3(C_4H_9)P^{\oplus}(CH_2C_6H_5)C_6H_5, Br^{\ominus}$	H	1969, 156
$PC_{18}H_{27}$	$(C_5H_{11})_2PC_6H_5$	P (2.5)	1965, 3; 1967, 8; 1968, 7
$PC_{18}H_{27}F_{12}O_2$	$(C_4H_9)_3P[OC(CF_3)_2]_2$	P (7.3); F (-70)	1968, 303
$PC_{18}H_{28}Br$	$C_2H_5(C_6H_9)_2P^{\oplus}C_6H_5, Br^{\ominus}$	P (37.3)	1966, 5; 1968, 6
	$H(C_6H_{11})_2P^{\oplus}C_6H_5, Br^{\ominus}$	H; P (20.8)	1968, 7
$PC_{18}H_{29}O_4$	$(C_4H_9O)_2(C_6H_5)P[OC(CH_3)]_2$	P (-36.1)	1966, 225
$PC_{18}H_{30}IN_4OS_2$	$(C_2H_5)_2-$ $N^{\oplus}CNP(SCH_3)(C_6H_4OCH_3)SC[N(C_2H_5)_2]N, I^{\ominus}$		1968, 137
$PC_{18}H_{31}Ge$	$(C_2H_5)_2PC(C_6H_5)=CHGe(C_2H_5)_3$	H	1967, 342, 360
	$(C_2H_5)_2PCH=C(C_6H_5)Ge(C_2H_5)_3$	H	1967, 342, 360
$PC_{18}H_{31}O_2$	$(t-C_4H_9)CCH_2CHCH(t-C_4H_9)PO_2H$	H	1968, 102
$PC_{18}H_{32}Br$	$C_6H_5P^{\oplus}(C_4H_9)_3, Br^{\ominus}$	P (30.5)	1968, 6
$PC_{18}H_{32}NO_3$	$(i-C_4H_9O)_2P(O)N(i-C_3H_7)CH_2C_6H_5$	H	1968, 29
$PC_{18}H_{32}O_6$		H	1969, 367
$PC_{18}H_{33}$	$(C_6H_{11})_3P$	P (7)	1965, 3; 1967, 8, 244; 1968, 6, 7
$PC_{18}H_{34}Br$	$HP^{\oplus}(C_6H_{11})_3, Br^{\ominus}$	H; P (27.9)	1968, 7
$PC_{18}H_{35}N_4$	$C_6H_5N=P[N(C_2H_5)_2]_3$	H	1965, 98

PC ₁₈ H ₃₅ O ₄ S	HP [⊕] (C ₆ H ₁₁) ₃ , HSO ₄ [⊖]	H; P (2)	1969, 50
PC ₁₈ H ₃₆ N ₃ O	[C ₅ H ₁₀ NCH ₂] ₃ PO	H; P (40-50)	1967, 291; 1968, 36
PC ₁₈ H ₃₈ NO ₃	(<i>t</i> -C ₅ H ₁₁ O) ₂ P(O)C[N(CH ₃) ₂]C ₅ H ₁₀	P (23·6)	1969, 340
PC ₁₈ H ₃₈ O	(C ₄ H ₉) ₃ P [⊕] CH ₂ C(O)C(CH ₃) ₃	H	1966, 119
PC ₁₈ H ₃₉ O ₄	C ₈ H ₁₇ O(CH ₂) ₂ P(O)(OC ₄ H ₉) ₂	H	1966, 251
PC ₁₈ H ₃₉ O ₇	(C ₄ H ₉ OCCH ₂ CH ₂ O) ₃ PO	P	1967, 198
PC ₁₈ H ₄₀ Cl	C ₁₂ H ₂₅ P [⊕] (C ₂ H ₅) ₃ Cl [⊖]	H; P (37)	1966, 14
PC ₁₈ H ₄₅ O ₃ Si ₃	P[OSi(C ₂ H ₅) ₃] ₃	H	1967, 34
PC ₁₉ H ₈ F ₁₀ N	(C ₆ F ₅) ₂ PNHCH ₂ C ₆ H ₅	H	1966, 19
PC ₁₉ H ₁₃	(C ₆ H ₅) ₂ P(C≡C) ₃ CH ₃	H	1966, 243, 247
	P(C ₆ H ₄) ₂ CC ₆ H ₅	H	1968, 340
PC ₁₉ H ₁₄ Br ₂ N	C ₆ H ₅ P(C ₆ H ₃ Br) ₂ NCH ₃	H	1967, 361
PC ₁₉ H ₁₄ F ₃	(C ₆ H ₄ F) ₃ P=CH ₂	F	1968, 13
	(C ₆ H ₅) ₂ PC ₆ H ₄ CF ₃	P (-10·9)	1969, 33
PC ₁₉ H ₁₄ NO	C ₆ H ₅ (C ₆ H ₅ OC ₆ H ₄)PCN	P (-35·5)	1966, 262
PC ₁₉ H ₁₄ NOS	C ₆ H ₅ (C ₆ H ₅ OC ₆ H ₄)P(S)CN	P (23·0)	1966, 262
PC ₁₉ H ₁₅ ClIO	CH ₃ (C ₆ H ₅)P [⊕] C ₆ H ₄ OC ₆ H ₃ Cl, I [⊖]	H	1968, 341
PC ₁₉ H ₁₅ F ₃ I	CH ₃ P [⊕] (C ₆ H ₄ F) ₃ N, I [⊖]	H; P (-4·8)	1969, 13
PC ₁₉ H ₁₅ O	(C ₆ H ₅) ₂ PC ₆ H ₄ (HCO)	H	1965, 110
	C ₆ H ₅ P(O)C ₆ H ₄ C ₆ H ₄ CH ₂	H	1967, 362
PC ₁₉ H ₁₅ O ₂	(C ₆ H ₅) ₂ PC ₆ H ₄ COOH	H	1968, 342
PC ₁₉ H ₁₆ BrO	(C ₆ H ₅) ₂ P(O)C ₆ H ₄ CH ₂ Br	H	1966, 62
PC ₁₉ H ₁₆ F	C ₆ H ₄ F(C ₆ H ₅) ₂ P=CH ₂	F	1968, 13, 14
PC ₁₉ H ₁₆ IO	CH ₃ (C ₆ H ₅)P [⊕] (C ₆ H ₄) ₂ O, I [⊖]	H	1968, 341
PC ₁₉ H ₁₆ N	C ₆ H ₅ P(C ₆ H ₄) ₂ NCH ₃	H	1967, 361
PC ₁₉ H ₁₆ NaO ₂	(C ₆ H ₅) ₂ CHP(O)(C ₆ H ₅)ONa	H	1966, 123
PC ₁₉ H ₁₇	(C ₆ H ₅) ₃ P=CH ₂	H; P (20·3)	1967, 192, 363; 1968, 108, 169, 337

Formula	Compound	Resonance	Reference
	$\text{C}_6\text{H}_5\text{CH}_2\text{P}(\text{C}_6\text{H}_5)_2$	$\text{P} (-10.4)$	1967, 8; 1968, 6
	$\text{CH}_3\text{C}_6\text{H}_4\text{P}(\text{C}_6\text{H}_5)_2$	H	1968, 15, 16
$\text{PC}_{19}\text{H}_{17}\text{Br}_2$	$\text{CH}_2\text{BrP}^\oplus(\text{C}_6\text{H}_5)_3, \text{Br}^\ominus$	H; P (22.6)	1966, 5; 1968, 56, 60
$\text{PC}_{19}\text{H}_{17}\text{Cl}_2$	$\text{CH}_2\text{ClP}^\oplus(\text{C}_6\text{H}_5)_3, \text{Cl}^\ominus$	H; P (23.8)	1966, 5; 1968, 56, 60
$\text{PC}_{19}\text{H}_{17}\text{FI}$	$\text{CH}_3(\text{C}_6\text{H}_4\text{F})\text{P}^\oplus(\text{C}_6\text{H}_5)_2, \text{I}^\ominus$	F	1968, 13, 14
$\text{PC}_{19}\text{H}_{17}\text{I}_2$	$\text{CH}_2\text{IP}^\oplus(\text{C}_6\text{H}_5)_3, \text{I}^\ominus$	H	1968, 56, 60
$\text{PC}_{19}\text{H}_{17}\text{O}$	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{C}_6\text{H}_4\text{CH}_3$	H	1966, 70, 253; 1967, 117; 1968, 15, 16
	$\text{CH}_3(\text{C}_6\text{H}_5)\text{P}(\text{O})\text{C}_6\text{H}_4\text{OC}_6\text{H}_5$	H	1967, 348
	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{CH}_2\text{C}_6\text{H}_5$	H	1968, 56
$\text{PC}_{19}\text{H}_{17}\text{O}_2$	$\text{C}_6\text{H}_5\text{CH}_2\text{C}_6\text{H}_4\text{P}(\text{O})(\text{C}_6\text{H}_5)\text{OH}$	H	1966, 123
	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{OCH}_2\text{C}_6\text{H}_5$	H	1966, 253
	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{CH}(\text{OH})\text{C}_6\text{H}_5$	H	1968, 56
	$(\text{C}_6\text{H}_5)_2\text{CHP}(\text{O})(\text{C}_6\text{H}_5)\text{OH}$	H	1968, 56
$\text{PC}_{19}\text{H}_{17}\text{O}_5$	$(\text{CH}_3\text{O})_3\text{POC}_{16}\text{H}_8\text{O}$	H; P (-44.5)	1968, 315
$\text{PC}_{19}\text{H}_{17}\text{S}$	$\text{CH}_3\text{C}_6\text{H}_4\text{P}(\text{S})(\text{C}_6\text{H}_5)_2$	H	1968, 15, 16
	$\text{CH}_3\text{SC}_6\text{H}_4\text{P}(\text{C}_6\text{H}_5)_2$	H	1968, 232
$\text{PC}_{19}\text{H}_{18}$	$\text{CH}_3\text{P}^\oplus(\text{C}_6\text{H}_5)_3$	P (22.6)	1967, 7
$\text{PC}_{19}\text{H}_{18}\text{Br}$	$\text{CH}_3\text{P}^\oplus(\text{C}_6\text{H}_5)_3, \text{Br}^\ominus$	P (22.7)	1966, 5; 1967, 363; 1968; 170
$\text{PC}_{19}\text{H}_{18}\text{ClO}$	$(\text{C}_6\text{H}_5)_3\text{P}^\oplus\text{CH}_2\text{OH}, \text{Cl}^\ominus$	H; P (17.7)	1966, 5; 1968, 56, 60
$\text{PC}_{19}\text{H}_{18}\text{Cl}_6\text{OSb}$	$\text{CH}_3\text{OP}^\oplus(\text{C}_6\text{H}_5)_3, \text{SbCl}_6^\ominus$	H; P (65.0)	1967, 92; 1969, 87
$\text{PC}_{19}\text{H}_{18}\text{Cl}_6\text{O}_4\text{Sb}$	$\text{CH}_3\text{OP}^\oplus(\text{OC}_6\text{H}_5)_3, \text{SbCl}_6^\ominus$	H	1967, 69
$\text{PC}_{19}\text{H}_{18}\text{Cl}_6\text{SSb}$	$\text{CH}_3\text{SP}^\oplus(\text{C}_6\text{H}_5)_3, \text{SbCl}_6^\ominus$	H; P (46.6)	1969, 87
$\text{PC}_{19}\text{H}_{18}\text{Cl}_6\text{SbSe}$	$\text{CH}_3\text{SeP}^\oplus(\text{C}_6\text{H}_5)_3, \text{SbCl}_6^\ominus$	H; P (35.8)	1969, 87
$\text{PC}_{19}\text{H}_{18}\text{I}$	$\text{CH}_3\text{P}^\oplus(\text{C}_6\text{H}_5)_3, \text{I}^\ominus$	^{13}C ; H; P (20)	1967, 244; 1968, 22, 169; 1969, 13
$\text{PC}_{19}\text{H}_{18}\text{IO}_2$	$\text{CH}_3(\text{C}_6\text{H}_5)\text{P}^\oplus(\text{OC}_6\text{H}_5)_2, \text{I}^\ominus$	P (73.0)	1967, 244

PC ₁₉ H ₁₈ IO ₃	CH ₃ P [⊕] (OC ₆ H ₅) ₃ , I [⊖]	P (39·2)	1967, 244
PC ₁₉ H ₁₉ ClNO ₅	(CH ₃ O) ₂ P(O)OC=CClC(C ₆ H ₅) ₂ C(O)NCH ₃	H	1969, 345
PC ₁₉ H ₁₉ O ₆	CH ₃ OP(O)OC(C ₆ H ₅)(COOC ₆ H ₅)C(CH ₃)(COCH ₃)O	H	1966, 258
PC ₁₉ H ₂₀ Br	C ₆ H ₅ (C ₆ H ₅ CH ₂)P [⊕] [C(CH ₃)=CH] ₂ , Br [⊖]	H	1968, 101
PC ₁₉ H ₂₀ NO ₄	[(CH ₃) ₂ N][O(CH ₂) ₃ O]P[OC(C ₆ H ₄) ₂]	P (-40·7)	1968, 301
PC ₁₉ H ₂₀ N ₂ O ₃	[CH ₂ N(CH ₃) ₂] ₂ POC(COC ₆ H ₅)=C(C ₆ H ₅)O	P (-31·9)	1966, 242
PC ₁₉ H ₂₁ NO	C ₆ H ₅ [(CH ₃) ₂ N]P(O)C(C ₆ H ₅)=C=C(CH ₃) ₂	H	1969, 165
PC ₁₉ H ₂₁ N ₂ O ₃	CH ₃ O[CH ₂ N(CH ₃) ₂] ₂ P[OC(C ₆ H ₄) ₂]	P (-33·5)	1968, 301
PC ₁₉ H ₂₁ O ₂	(C ₆ H ₅) ₂ P(O)CH=C=C(CH ₃)CH(OCH ₃)CH ₃	H	1967, 155
PC ₁₉ H ₂₁ O ₅	(CH ₃ O) ₃ P=C(COC ₆ H ₅)(CH ₂ COC ₆ H ₅)	H; P (56·2)	1965, 1; 1966, 106
PC ₁₉ H ₂₁ O ₇	(CH ₃ O) ₃ P[OCH(COC ₆ H ₅) ₂]	H; P (-46·9)	1965, 21
PC ₁₉ H ₂₂	CH ₃ (C ₆ H ₉)P [⊕] (C ₆ H ₅) ₂	H	1966, 273
PC ₁₉ H ₂₃ N ₂ O ₃	CH ₃ O[CH ₂ N(CH ₃) ₂] ₂ P(OC(C ₆ H ₅)) ₂	H; P (-38·6)	1968, 153, 301
PC ₁₉ H ₂₃ O ₂	(C ₆ H ₅) ₂ P(O)C(CH ₃)=C(CH ₃)CH(CH ₃)OCH ₃	H	1967, 154
PC ₁₉ H ₂₃ O ₂ S	(C ₆ H ₅) ₂ P(S)CH(COOH)C ₅ H ₁₁	H; P (46)	1966, 44
	(C ₆ H ₅) ₂ P(S)CH(COOH)CH ₂ - <i>t</i> -C ₄ H ₉	H; P (48·3)	1966, 44
PC ₁₉ H ₂₃ O ₅	CH ₃ O(C ₆ H ₅ CH ₂ O) ₂ P[OC(CH ₃) ₂]	H; P (-50·6)	1968, 73
PC ₁₉ H ₂₄ Br	C ₂ H ₅ (C ₆ H ₉)P [⊕] (C ₆ H ₅) ₂ , Br [⊖]	P (34·8)	1966, 5; 1968, 6
	CH ₃ (C ₆ H ₁₁)P [⊕] (C ₆ H ₅) ₂ , Br [⊖]	P (26·7)	1968, 6
PC ₁₉ H ₂₆ Br	C ₂ H ₅ (<i>neo</i> -C ₆ H ₁₁)P [⊕] (C ₆ H ₅) ₂ , Br [⊖]	P (25·8)	1968, 6
	C ₂ H ₅ (C ₃ H ₇)P [⊕] (CH ₂ C ₆ H ₅) ₂ , Br [⊖]	H	1969, 156
	C ₂ H ₅ (C ₄ H ₉)P [⊕] (CH ₂ C ₆ H ₅)C ₆ H ₅ , Br [⊖]	H	1969, 156
PC ₁₉ H ₂₆ NO ₃	(CH ₃) ₃ C ₆ H ₂ C ₆ H ₄ NHP(O)(OC ₂ H ₅) ₂	H	1966, 274
PC ₁₉ H ₂₇ N ₄ OS ₂	(C ₂ H ₅) ₂ NCNP(S)(C ₆ H ₄ OCH ₃)SC[N(CH ₂) ₅]N	P (57·5)	1968, 137
PC ₁₉ H ₂₇ O ₅	(CH ₂ CH ₂ CHO) ₄ PCH(OH)C ₄ H ₅	H; P (-20)	1968, 154
PC ₁₉ H ₃₀ Br	C ₃ H ₇ (C ₅ H ₉) ₂ P [⊕] C ₆ H ₅ , Br [⊖]	P (35·6)	1966, 5; 1968, 6

Formula	Compound	Resonance	Reference
$\text{PC}_{19}\text{H}_{31}\text{O}_2$	$\text{CH}_3(\text{C}_6\text{H}_{11})_2\text{P}^+\text{C}_6\text{H}_5, \text{Br}^-$	P (34·0)	1968, 6
$\text{PC}_{19}\text{H}_{33}\text{GeO}$	$\text{C}_6\text{H}_5(\text{C}_3\text{H}_7)\text{P}(\text{O})\text{O-menthyl}$	H	1967, 151; 1968, 140
$\text{PC}_{19}\text{H}_{33}\text{O}_5$	$(\text{C}_2\text{H}_5)_2\text{PCH}(\text{C}_6\text{H}_5)\text{CH}=\text{CHOGe}(\text{C}_6\text{H}_5)_3$	H	1968, 331
	$(i\text{-C}_3\text{H}_7\text{O})_3\text{POC}_6(\text{CH}_3)_4\text{O}$	P (−49·7)	1968, 303
$\text{PC}_{19}\text{H}_{36}\text{I}$	$\text{CH}_3\text{P}^+(\text{C}_6\text{H}_{11})_3, \text{I}^-$	P (33·9)	1967, 244
$\text{PC}_{19}\text{H}_{37}\text{O}_3$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{CCH}(\text{CH}_2)_{15}$	H	1967, 100
$\text{PC}_{19}\text{H}_{39}\text{O}$	$(\text{C}_4\text{H}_9)_2\text{P}(\text{O})(\text{CH}_2)_9\text{CH}=\text{CH}_2$	P (51·0)	1968, 336
	$(\text{C}_4\text{H}_9)_2\text{P}(\text{O})(\text{CH}_2)_9\text{CH}=\text{CH}_2$	P (131·2)	1968, 336
$\text{PC}_{19}\text{H}_{39}\text{O}_4$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})\text{C}_{17}\text{H}_{32}(\text{OH})$	H	1967, 100
$\text{PC}_{19}\text{H}_{40}\text{NO}_4$	$(\text{C}_6\text{H}_{13}\text{O})_2\text{P}(\text{O})\text{C}(\text{O})\text{N}(i\text{-C}_3\text{H}_7)_2$	H	1968, 29
$\text{PC}_{20}\text{H}_{13}\text{F}_6$	$\text{C}_6\text{H}_5\text{P}(\text{C}_6\text{H}_4\text{CF}_3)_2$	P (−14·5)	1969, 33
$\text{PC}_{20}\text{H}_{15}\text{ClNO}$	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{CH}(\text{CN})\text{C}_6\text{H}_4\text{Cl}$	H	1968, 88
$\text{PC}_{20}\text{H}_{15}\text{F}_{12}\text{O}_2$	$\text{C}_2\text{H}_5(\text{C}_6\text{H}_5)_2\text{P}[\text{OC}(\text{CF}_3)_2]_2$	P (−6·1); F (−69)	1968, 302, 303
	$(\text{CF}_3)_2\text{CHO}(\text{C}_6\text{H}_5)_2\text{POC}(\text{CF}_3)_2\text{CHCH}_3$	P (−32·1); F (−77·9; 1968, 302 −72·5; −74·9; −75·7)	
$\text{PC}_{20}\text{H}_{15}\text{F}_{12}\text{O}_3$	$\text{C}_2\text{H}_5\text{O}(\text{C}_6\text{H}_5)_2\text{P}[\text{O}(\text{CF}_3)_2]_2$	P (−21·6)	1966, 225
$\text{PC}_{20}\text{H}_{15}\text{O}$	$(\text{C}_6\text{H}_5)_3\text{P}=\text{C}=\text{C}=\text{O}$	P (2·6)	1966, 270; 1968, 110
$\text{PC}_{20}\text{H}_{15}\text{S}$	$(\text{C}_6\text{H}_5)_3\text{P}=\text{C}=\text{C}=\text{S}$	P (−7·7)	1966, 270; 1968, 110
$\text{PC}_{20}\text{H}_{16}\text{ClN}_4\text{O}$	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{NNHNNCCHC}_6\text{H}_4\text{Cl}$	H	1968, 88
$\text{PC}_{20}\text{H}_{16}\text{N}$	$(\text{C}_6\text{H}_5)_3\text{P}=\text{CH}(\text{CN})$	H	1967, 192
$\text{PC}_{20}\text{H}_{17}$	$(\text{C}_6\text{H}_5)_2\text{PCH}=\text{CHC}_6\text{H}_5$	H; P (13)	1965, 111; 1966, 275; 1967, 364
	$(\text{C}_6\text{H}_5)_2\text{PC}_6\text{H}_4\text{CH}=\text{CH}_2$	H{P}	1968, 104
$\text{PC}_{20}\text{H}_{17}\text{F}_{10}\text{O}_5$	$(\text{C}_2\text{H}_5\text{O})_3\text{P}[\text{OCH}(\text{C}_6\text{F}_5)]_2$	P (−50·5; −54·0)	1968, 124, 303

	$(C_2H_5O)_3POCH(C_6F_5)OCHC_6F_5$	P (−37.7; −41.6)	1968, 124, 303
PC ₂₀ H ₁₇ N ₄ O	$(C_6H_5)_2P(O)NNHNCCHC_6H_5$	H	1968, 88
PC ₂₀ H ₁₇ O	$(C_6H_5)_2P(O)CH=CHC_6H_5$	H	1965, 112; 1967, 99
	$(C_6H_5)_3P=CHC(O)H$	H	1967, 192
PC ₂₀ H ₁₈ Br	$(C_6H_5)_3P^{\oplus}CH=CH_2, Br^{\ominus}$	H	1966, 135
PC ₂₀ H ₁₈ BrO	$(C_6H_5)_2P(O)CH_2CHBrC_6H_5$	H	1965, 112
PC ₂₀ H ₁₈ ClO ₂	$(C_6H_5)_3P^{\oplus}CH_2COOH, Cl^{\ominus}$	H	1965, 87
	$CH_3O(C_6H_5)P(O)C(C_6H_5)_2Cl$	H	1966, 82
PC ₂₀ H ₁₈ IO	$C_2H_5(C_6H_5)P^{\oplus}(C_6H_4)_2O, I^{\ominus}$	H	1968, 341
PC ₂₀ H ₁₈ NO ₄ S	$(C_6H_5)_2P(O)C(O)NHSO_2C_6H_4CH_3$	H	1968, 328; 1969, 161
PC ₂₀ H ₁₈ NO ₆ S	$(C_6H_5O)_2P(O)C(O)NHSO_2C_6H_4CH_3$	H	1968, 328; 1969, 161
PC ₂₀ H ₁₈ S	$(C_6H_5)_2P(S)CH=CHC_6H_5$	H	1965, 112
PC ₂₀ H ₁₉	$C_6H_5P(CH_2C_6H_5)_2$	P (−12.1)	1967, 8; 1968, 6
	$(C_6H_5)_3P=C_2H_4$	H; P (14.6)	1967, 363; 1968, 169, 337
	$C_6H_5P(C_6H_4CH_3)_2$	H	1968, 15, 16
PC ₂₀ H ₁₉ BrNO	$(C_6H_5)_3P^{\oplus}C(CH_3)=NOH, Br^{\ominus}$	H	1965, 113
PC ₂₀ H ₁₉ Br ₂	$(C_6H_5)_3P^{\oplus}(CH_2)_2Br, Br^{\ominus}$	H	1966, 135
PC ₂₀ H ₁₉ O	$(C_6H_5)_2P(O)(CH_2)_2C_6H_5$	H	1965, 112
	$C_6H_5P(O)(C_6H_4CH_3)_2$	H	1968, 15, 16
PC ₂₀ H ₁₉ O ₅	$(C_6H_5)_2P(O)CC(O)OC(CH_3)(COCH_3)COCH_3$	H; P (81.7)	1969, 353
PC ₂₀ H ₁₉ S	$C_6H_5P(S)(C_6H_4CH_3)_2$	H	1968, 15, 16
PC ₂₀ H ₁₉ S ₂	$C_6H_5P(C_6H_4SCH_3)_2$	H	1968, 232
PC ₂₀ H ₂₀	$C_2H_5P^{\oplus}(C_6H_5)_2$	P (26.2)	1967, 7
PC ₂₀ H ₂₀ BF ₄ O	$C_2H_5OP^{\oplus}(C_6H_5)_3, BF_4^{\ominus}$	H; P (62)	1968, 332
PC ₂₀ H ₂₀ Br	$C_2H_5P^{\oplus}(C_6H_5)_3, Br^{\ominus}$	H; P (26.2)	1966, 5; 1967, 363; 1968, 56
	$CH_3(C_6H_5CH_2)P^{\oplus}(C_6H_5)_2, Br^{\ominus}$	P (22.8)	1968, 6
PC ₂₀ H ₂₀ BrO	$(C_6H_5)_3P^{\oplus}CH_2CH_2OH, Br^{\ominus}$	H	1966, 135
PC ₂₀ H ₂₀ ClO	$(C_6H_5)_3P^{\oplus}CH_2OCH_3, Cl^{\ominus}$	H	1968, 60

Formula	Compound	Resonance	Reference
PC ₂₀ H ₂₀ I	CH ₃ (C ₆ H ₅) ₂ P [⊕] (C ₆ H ₄ CH ₃), I [⊖]	H	1968, 15, 16
PC ₂₀ H ₂₀ O	(C ₆ H ₅) ₂ P(O)(CH ₃)=C=C(CH ₂) ₂ CCH ₃	H	1967, 156
PC ₂₀ H ₂₁ O	(C ₆ H ₅) ₂ P(O)CH=C=C ₅ H ₇ CH ₃	H	1969, 165, 365
PC ₂₀ H ₂₁ O ₂	(CH ₃ O) ₂ P[C(C ₆ H ₅)CH] ₂ CCH ₃	P (178·2)	1968, 75
PC ₂₀ H ₂₁ O ₅	(C ₂ H ₅ O) ₂ P(O)CH=C(C ₆ H ₄) ₂	H	1967, 327
PC ₂₀ H ₂₁ O ₆	(C ₆ H ₅) ₂ P(O)CC(O)O[C(C(CH ₃)OH] ₂ COCH ₃	H	1969, 353
	(C ₆ H ₅) ₂ P(O)C(COOH)=C(OCH ₃)C(CH ₃)(OH)-COCH ₃	H	1969, 353
PC ₂₀ H ₂₂ BF ₄ N ₂ S ₂	P(CSC ₆ H ₄ NC ₂ H ₅) ₂ [⊕] , BF ₄ [⊖]	P (24·9)	1966, 272
PC ₂₀ H ₂₃ F ₁₂ O ₄	C ₆ H ₅ (C ₄ H ₉ O) ₂ P[OC(CF ₃) ₂] ₂	P (-33·4)	1966, 225
PC ₂₀ H ₂₃ O ₂	(C ₆ H ₅) ₂ P(O)C(CH ₃)=C=C(CH ₃)CH(OCH ₃)CH ₃	H	1967, 155
	C ₆ H ₅ (C ₂ H ₅) ₂ POC ₁₀ H ₈ O	P (0·9)	1968, 124
PC ₂₀ H ₂₃ O ₄	C ₆ H ₅ (CH ₃ O) ₂ PCH(C ₆ H ₅)C(COCH ₃)=C(CH ₃)O	H; P (-16·7; -13·3)	1968, 124, 152, 303
	(stereois.)		
PC ₂₀ H ₂₃ O ₅	(C ₂ H ₅ O) ₃ POC ₁₄ H ₈ O	P (-47·1)	1966, 225
	(C ₂ H ₅ O) ₂ P(O)CH=C(C ₆ H ₅) ₂	H	1967, 327
PC ₂₀ H ₂₃ O ₇	(CH ₃ O) ₃ POC(C ₆ H ₅)(COCH ₃)CH(COC ₆ H ₅)O	H; P (-49·4)	1966, 258
PC ₂₀ H ₂₄ Br	CH ₃ (C ₆ H ₅)P [⊕] (CH ₂ C ₆ H ₅)C ₆ H ₉ , Br [⊖]	H	1969, 156
PC ₂₀ H ₂₄ N ₃ O ₂	(CH ₃) ₂ NP[N(CH ₃)CH ₂] ₂ OC ₁₄ H ₈ O	P (-29·8)	1968, 124, 301
PC ₂₀ H ₂₅	(C ₆ H ₅) ₂ PCH=CH(CH ₂) ₅ CH ₃	H	1966, 275
PC ₂₀ H ₂₅ N ₂ O ₄	C ₆ H ₅ OP(O)(O [⊖])O(CH ₂) ₂ NHC ₆ H ₅ , C ₆ H ₅ NH ₃ [⊕]	H; P (-6·9)	1969, 359

PC ₁₈ H ₁₄ F	C ₆ H ₄ FP(C ₆ H ₅) ₂	F	1967, 17; 1968, 14; 1969, 18
PC ₁₈ H ₁₄ FO	C ₆ H ₄ FP(O)(C ₆ H ₅) ₂	F	1968, 13, 14; 1969, 18, 19
PC ₁₈ H ₁₄ FS	C ₆ H ₄ FP(S)(C ₆ H ₅) ₂	F	1967, 17; 1969, 18, 19
PC ₁₈ H ₁₄ NO ₃	(C ₆ H ₅) ₂ P(O)C ₆ H ₄ NO ₂	H	1969, 119
PC ₁₈ H ₁₅	(C ₆ H ₅) ₃ P	¹³ C; H; P (−6 to −8)	1965, 3, 7, 85, 103; 1966, 69, 78, 141, 240, 262; 1967, 198, 244, 277, 359; 1968, 22, 103, 303, 332; 1969, 50, 120, 354
PC ₁₈ H ₁₅ AlBr ₃	(C ₆ H ₅) ₃ PAlBr ₃	²⁷ Al	1967, 23
PC ₁₈ H ₁₅ AlCl ₅	(C ₆ H ₅) ₃ P [⊕] Cl, AlCl ₄ [⊖]	P (65)	1967, 191, 345
PC ₁₈ H ₁₅ Cl ₂	(C ₆ H ₅) ₃ PCl ₂	P (63)	1967, 345; 1968, 168, 288
PC ₁₈ H ₁₅ Cl ₂ O ₄	(C ₆ H ₅) ₃ P [⊕] Cl, ClO ₄ [⊖]	P (65·7)	1967, 276
PC ₁₈ H ₁₅ Cl ₇ Sb	(C ₆ H ₅) ₃ P [⊕] Cl, SbCl ₆ [⊖]	P (65·0)	1967, 191, 276, 345
PC ₁₈ H ₁₅ FI	H(C ₆ H ₄ F)P [⊕] (C ₆ H ₅) ₂ , I [⊖]	F	1968, 14
PC ₁₈ H ₁₅ FIO	C ₆ H ₄ FP [⊕] (OH)(C ₆ H ₅) ₂ , I [⊖]	F	1968, 14
PC ₁₈ H ₁₅ F ₂	(C ₆ H ₅) ₃ PF ₂	P (−58·1); F (−39·8)	1967, 61; 1968, 303
PC ₁₈ H ₁₅ F ₂ O	(C ₆ H ₅) ₂ PF ₂ (OC ₆ H ₅)	H; P (−34·4); F (−33·3)	1968, 316; 1969, 62
PC ₁₈ H ₁₅ F ₂ O ₂	C ₆ H ₅ PF ₂ (OC ₆ H ₅) ₂	H; P (−69); F (−35)	1968, 316; 1969, 62
PC ₁₈ H ₁₅ F ₂ O ₃	(C ₆ H ₅ O) ₃ PF ₂	F (−73·0)	1967, 61
PC ₁₈ H ₁₅ F ₂ S	C ₆ H ₅ SPF ₂ (C ₆ H ₅) ₂	H; P; F (−23·5)	1968, 316; 1969, 62
PC ₁₈ H ₁₅ O	(C ₆ H ₅) ₃ PO	¹³ C; H; P (−27·0)	1965, 7, 78, 85; 1966, 106, 240, 270; 1967, 92, 198, 277; 1968, 103, 110, 303, 332, 337
	C ₆ H ₅ OP(C ₆ H ₅) ₂	P (111)	1967, 329
	C ₆ H ₅ (C ₆ H ₅ C ₆ H ₄)P(O)H	H	1968, 35
PC ₁₈ H ₁₅ O ₂	C ₆ H ₅ P(OC ₆ H ₅) ₂	P (157·9)	1966, 225

Formula	Compound	Resonance	Reference
$\text{PC}_{21}\text{H}_{12}\text{F}_9$	$\text{P}(\text{C}_6\text{H}_4\text{CF}_3)_3$	P (o : -18.5 ; m : -5.0 ; p : -6.0)	1969, 33
$\text{PC}_{21}\text{H}_{17}\text{BrN}$	$(\text{C}_6\text{H}_5)_3\text{P}^\oplus\text{CH}=\text{CHCN}$, $\text{Br}^\ominus$	H	1969, 349
$\text{PC}_{21}\text{H}_{17}\text{O}$	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{CH}=\text{C}=\text{CHC}_6\text{H}_5$	H	1966, 61
$\text{PC}_{21}\text{H}_{18}\text{BrO}_2$	$(\text{C}_6\text{H}_5)_3\text{P}^\oplus\text{CH}=\text{CHCOOH}$, $\text{Br}^\ominus$	H	1969, 349
$\text{PC}_{21}\text{H}_{19}$	$(\text{C}_6\text{H}_5)_2\text{PC}_6\text{H}_4\text{CH}_2\text{CH}=\text{CH}_2$	H	1966, 72; 1968, 194
$\text{PC}_{21}\text{H}_{19}\text{BrClO}$	$(\text{C}_6\text{H}_5)_3\text{P}^\oplus\text{CH}(\text{CH}_3)\text{C}(\text{O})\text{Cl}$, $\text{Br}^\ominus$	H	1966, 115
$\text{PC}_{21}\text{H}_{19}\text{O}$	$(\text{C}_6\text{H}_5)_3\text{P}=\text{CHCOCH}_3$	H	1967, 192, 365
$\text{PC}_{21}\text{H}_{19}\text{O}_2$	$(\text{C}_6\text{H}_5)_3\text{P}=\text{CHCOOCH}_3$	H; P (17.6)	1966, 270; 1967, 192; 1968, 170
$\text{PC}_{21}\text{H}_{19}\text{O}_3$	$(\text{C}_6\text{H}_5)_2\text{P}(\text{O})\text{C}_6\text{H}_4\text{CH}_2\text{COOCH}_3$	H	1966, 253
$\text{PC}_{21}\text{H}_{19}\text{O}_4$	$\text{C}_6\text{H}_5\text{OP}(\text{O})\text{OCH}_2\text{C}(\text{C}_6\text{H}_5)_2\text{CH}_2\text{O}$	H; P (-15.4)	1969, 175
$\text{PC}_{21}\text{H}_{20}$	$\text{CH}_2=\text{CHCH}_2\text{P}^\oplus(\text{C}_6\text{H}_5)_3$	P (21.4)	1967, 7
$\text{PC}_{21}\text{H}_{20}\text{Br}$	$\text{CH}_2=\text{CHCH}_2\text{P}^\oplus(\text{C}_6\text{H}_5)_3\text{Br}^\ominus$	P (21.1)	1966, 5
	$\text{CH}_3\text{CH}=\text{CHP}^\oplus(\text{C}_6\text{H}_5)_3$, $\text{Br}^\ominus$	H	1966, 135
	$\text{CH}_2=\text{C}(\text{CH}_3)\text{P}^\oplus(\text{C}_6\text{H}_5)_3$, $\text{Br}^\ominus$	H	1966, 135
	$\text{CH}_2\text{CH}_2\text{CHP}^\oplus(\text{C}_6\text{H}_5)_3$, $\text{Br}^\ominus$	H	1968, 333
$\text{PC}_{21}\text{H}_{20}\text{BrO}$	$\text{CH}_3\text{C}(\text{O})\text{CH}_2\text{P}^\oplus(\text{C}_6\text{H}_5)_3$, $\text{Br}^\ominus$	P (19.4)	1966, 5; 1969, 19
$\text{PC}_{21}\text{H}_{20}\text{BrO}_2$	$\text{CH}_3\text{OC}(\text{O})\text{CH}_2\text{P}^\oplus(\text{C}_6\text{H}_5)_3$, $\text{Br}^\ominus$	P (20.3)	1966, 5
$\text{PC}_{21}\text{H}_{20}\text{Cl}$	$\text{CH}_2=\text{CHCH}_2\text{P}^\oplus(\text{C}_6\text{H}_5)_3$, $\text{Cl}^\ominus$	H	1968, 56
$\text{PC}_{21}\text{H}_{20}\text{ClO}$	$\text{CH}_3\text{C}(\text{O})\text{CH}_2\text{P}^\oplus(\text{C}_6\text{H}_5)_3$, $\text{Cl}^\ominus$	H	1967, 118
$\text{PC}_{21}\text{H}_{20}\text{ClO}_2$	$\text{CH}_3\text{C}(\text{O})\text{OCH}_2\text{P}^\oplus(\text{C}_6\text{H}_5)_3$, $\text{Cl}^\ominus$	H	1968, 56
$\text{PC}_{21}\text{H}_{20}\text{FO}$	$\text{CH}_3\text{C}(\text{O})\text{CH}_2\text{P}^\oplus(\text{C}_6\text{H}_5)_3$, $\text{F}^\ominus$	H	1969, 19
$\text{PC}_{21}\text{H}_{20}\text{I}$	$\text{CH}_3(\text{CH}_2=\text{CHC}_6\text{H}_4)\text{P}^\oplus(\text{C}_6\text{H}_5)_2$, $\text{I}^\ominus$	H	1968, 104
$\text{PC}_{21}\text{H}_{20}\text{N}$	$\text{C}_6\text{H}_5\text{P}[\text{C}_6\text{H}_3(\text{CH}_3)]_2\text{NCH}_3$	H	1967, 361

PC ₂₁ H ₂₀ NO	(C ₆ H ₅) ₃ PCH ₂ C(CH ₃)=NO └──────────┘	H	1968, 343
PC ₂₁ H ₂₁	P(CH ₂ C ₆ H ₅) ₃ C ₂ H ₅ CH=P(C ₆ H ₅) ₃ <i>i</i> -C ₃ H ₆ =P(C ₆ H ₅) ₃ P(C ₆ H ₄ CH ₃) ₃ (C ₆ H ₅) ₃ P=C(CH ₃) ₂ (C ₆ H ₅) ₃ P [⊕] (CH ₂) ₃ Br, Br [⊖]	P (-13; -10) P (12 to 10) P (11·3) H P (10 to 11)	1967, 8, 244; 1968, 6 1967, 359, 363; 1968, 337 1967, 363 1968, 15, 16, 103, 260 1968, 337
PC ₂₁ H ₂₁ Br ₂	(C ₆ H ₅) ₃ P [⊕] CH ₂ C(=NOH)CH ₃ , Cl [⊖]	P (24·0)	1966, 5
PC ₂₁ H ₂₁ ClNO	(C ₆ H ₅) ₂ P(O)CH=C=C ₇ H ₁₀	H	1968, 343
PC ₂₁ H ₂₁ O	OP(C ₆ H ₄ CH ₃) ₃ (C ₆ H ₅) ₃ P(CH ₂) ₃ O └──────────┘	H H H	1967, 153 1967, 117; 1968, 15, 16 1967, 366
PC ₂₁ H ₂₁ O ₃	P(OCH ₂ C ₆ H ₅) ₃ P(C ₆ H ₄ OCH ₃) ₃	H; P (138·6) H{P}	1968, 73 1969, 118
PC ₂₁ H ₂₁ O ₃ S	SP(C ₆ H ₄ OCH ₃) ₃	H{P}	1969, 118
PC ₂₁ H ₂₁ O ₄	OP(OC ₆ H ₄ CH ₃) ₃	H	1967, 117; 1969, 74
PC ₂₁ H ₂₁ S	SP(C ₆ H ₄ CH ₃) ₃	H	1968, 15, 16
PC ₂₁ H ₂₁ S ₃	P(C ₆ H ₄ SCH ₃) ₃	H	1968, 232
PC ₂₁ H ₂₂	<i>i</i> -C ₃ H ₇ P [⊕] (C ₆ H ₅) ₃	P (30·9)	1967, 7
PC ₂₁ H ₂₂ BF ₄ S	(C ₆ H ₅) ₃ P [⊕] CH [⊖] S [⊕] (CH ₃) ₂ , BF ₄ [⊖]	H	1967, 367
PC ₂₁ H ₂₂ Br	C ₃ H ₇ P [⊕] (C ₆ H ₅) ₃ , Br [⊖] <i>i</i> -C ₃ H ₇ P [⊕] (C ₆ H ₅) ₃ , Br [⊖] C ₂ H ₅ (C ₆ H ₅ CH ₂)P [⊕] (C ₆ H ₅) ₂ , Br [⊖] CH ₃ (C ₆ H ₅)P [⊕] (CH ₂ C ₆ H ₅) ₂ , Br [⊖] CH ₃ (C ₆ H ₅)P [⊕] (CH ₂ C ₆ H ₅)C ₆ H ₄ CH ₃ , Br [⊖]	P (24·1) P (30·9) P (28·3) P (27·4)	1966, 5; 1967, 363 1966, 5; 1967, 363 1968, 6 1968, 6
PC ₂₁ H ₂₂ BrO	(C ₆ H ₅) ₃ P [⊕] CH(CH ₃)CH ₂ OH, Br [⊖]	H	1969, 156
PC ₂₁ H ₂₂ Cl	C ₆ H ₅ CH ₂ (C ₆ H ₅) ₂ P [⊕] CH ₂ OCH ₃ , Br [⊖] C ₃ H ₇ P [⊕] (C ₆ H ₅) ₃ , Cl [⊖]	H H	1966, 135 1967, 349 1967, 118

Formula	Compound	Resonance	Reference
PC ₂₁ H ₂₂ I	<i>i</i> -C ₃ H ₇ P [⊕] (C ₆ H ₅) ₃ , I [⊖]	H	1966, 122
	CH ₃ (C ₆ H ₅)P [⊕] (C ₆ H ₄ CH ₃) ₂ , I [⊖]	H	1968, 15, 16
PC ₂₁ H ₂₂ NO	(C ₆ H ₅) ₂ P(O)CH ₂ C ₆ H ₄ N(CH ₃) ₂	H	1967, 368
PC ₂₁ H ₂₃ B ₂ F ₈ S	(C ₆ H ₅) ₃ P [⊕] CH ₂ S [⊖] (CH ₃) ₂ , 2BF ₄ [⊖]	H	1967, 367
PC ₂₁ H ₂₃ O	(C ₆ H ₅) ₂ P(O)C(CH ₃)=C=C ₅ H ₇ (CH ₃)	H	1969, 164, 165
	(C ₆ H ₅) ₂ P(O)CH=C=C ₆ H ₉ (CH ₃)	H	1969, 165
PC ₂₁ H ₂₃ O ₂	(C ₆ H ₅) ₂ P(O)CH=C=CCH(OCH ₃)(CH ₂) ₄	H	1969, 164
PC ₂₁ H ₂₄ ClOSi	(C ₆ H ₅) ₃ P [⊕] OSi(CH ₃) ₃ , Cl [⊖]	P (42·2)	1969, 368
PC ₂₁ H ₂₄ GeN	(C ₆ H ₅) ₃ PNGe(CH ₃) ₃	H	1967, 73
PC ₂₁ H ₂₄ NSi	(C ₆ H ₅) ₃ PNSi(CH ₃) ₃	H	1967, 73, 322
PC ₂₁ H ₂₄ NSn	(C ₆ H ₅) ₃ PNSn(CH ₃) ₃	H	1967, 73
PC ₂₁ H ₂₅ N ₂ O ₄	C ₆ H ₅ OP(O)(O [⊖])OCH ₂ CH(CH ₃)NHC ₆ H ₅ , C ₆ H ₅ NH ₃ [⊕]	H; P (-7·7)	1969, 359
PC ₂₁ H ₂₅ N ₂ O ₉	(C ₂ H ₅ O) ₃ P[OCH(C ₆ H ₄ NO ₂)] ₂	H; P (ca. -50)	1967, 163
PC ₂₁ H ₂₅ O ₂	(C ₆ H ₅) ₂ P(O)CH=C=C(CH ₃)CH(OCH ₃) <i>i</i> -C ₃ H ₇	H	1967, 155
PC ₂₁ H ₂₅ O ₅	(<i>i</i> -C ₃ H ₇ O) ₃ P[OC(C ₆ H ₄)] ₂	P (-48·9)	1965, 21
PC ₂₁ H ₂₅ O ₇	(CH ₃ O) ₃ POC(C ₆ H ₅)(COC ₆ H ₅)C(CH ₃)(COCH ₃ O)	H; P (-54·7; -52·7)	1966, 258
	(stereois.)		
PC ₂₁ H ₂₆ BIN	[(C ₆ H ₅) ₃ P(CH ₃) ₃ NBH ₂] [⊕] , I [⊖]	H	1969, 26
PC ₂₁ H ₂₇ O ₅	(<i>i</i> -C ₃ H ₇ O) ₃ P[OC(C ₆ H ₅)] ₂	P (-53·9)	1965, 21
PC ₂₁ H ₂₇ O ₉	P[OC(CH ₃)(COOC ₂ H ₅)C≡CH] ₃	H	1968, 311
	OP[OC(CH ₃)(COOC ₂ H ₅)C≡CH] ₂ - [CH=C=C(CH ₃)COOC ₂ H ₅]	H	1968, 311
PC ₂₁ H ₂₈ Br	C ₆ H ₅ (C ₆ H ₅ CH ₂)P [⊕] [C(CH ₃) ₂]CHCH ₃ , Br [⊖]	H	1969, 170
PC ₂₁ H ₂₈ N ₃ O ₃	[(CH ₃) ₂ N] ₃ P [⊕] OC [⊖] (COC ₆ H ₅) ₂	H; P (35·9)	1965, 84; 1966, 242; 1968, 309
PC ₂₁ H ₂₉ O	CH ₃ (C ₆ H ₅)P(O)C(CH ₃) ₂ CH(CH ₃)C(CH ₃) ₂ C ₆ H ₅	H{P}	1968, 67
PC ₂₁ H ₃₀ Br	C ₄ H ₉ (<i>t</i> -C ₅ H ₁₁)P [⊕] (C ₆ H ₅) ₂ , Br [⊖]	P (38·5)	1968, 6

PC ₂₁ H ₃₀ I	C ₆ H ₅ (CH ₃) ₂ P [⊕] CH ₂ C(CH ₃) ₂ C(CH ₃) ₂ C ₆ H ₅	H{P}	1968, 67
PC ₂₁ H ₃₀ NO	C ₆ H ₅ [(CH ₃) ₂ N]P(O)C(CH ₃)=C=C ₁₀ H ₁₆	H	1969, 165
PC ₂₁ H ₃₀ N ₅ O ₇	[(CH ₂) ₂ CHCH ₂ O] ₂ P(O) (2',3'-isopropylidene-adenosine-5)	H	1966, 213
PC ₂₁ H ₃₁ O ₄	CH ₃ (CH ₃ O)P(O)O(C ₁₉ H ₂₅ O)	H	1967, 168
PC ₂₁ H ₃₃ O ₄	CH ₃ (CH ₃ O)P(O)O(C ₁₉ H ₂₇ O)	H	1967, 168
PC ₂₁ H ₃₅ O ₅	(CH ₃ O) ₂ P(O) (hydroxyandrostane)	H	1967, 167
PC ₂₁ H ₄₂ N ₃ O	[CH ₃ CH(CH ₂) ₄ NCH ₂] ₃ PO	P (50·9)	1968, 36
	[CH(CH ₃)(CH ₂) ₄ NCH ₂] ₃ PO	P (49·4)	1968, 36
	[CH ₂ CH(CH ₃)(CH ₂) ₃ NCH ₂] ₃ PO	P (50·4)	1968, 36
PC ₂₁ H ₄₄ NO ₄	(C ₈ H ₁₇ O) ₂ P(O)C(O)N(C ₂ H ₅) ₂	H	1967, 26
	(C ₇ H ₁₅ O) ₂ P(O)C(O)N(<i>i</i> -C ₃ H ₇) ₂	H	1968, 29
PC ₂₁ H ₄₆ I	CH ₃ (C ₄ H ₉)P [⊕] (C ₈ H ₁₇) ₂ , I [⊖]	P (30·2)	1967, 244
PC ₂₂ H ₁₅ F ₂ O ₂	(C ₆ H ₅) ₃ P=CC(O)CF ₂ CO	P (3·0)	1968, 110
PC ₂₂ H ₁₅ F ₆	(C ₆ H ₅) ₃ P=C=C(CF ₃) ₂	P (4·1); F (−61·4)	1967, 102
PC ₂₂ H ₁₅ S	C ₆ H ₅ P(S)(C≡CC ₆ H ₅) ₂	H	1965, 96
PC ₂₂ H ₁₆ BF ₁₀	(C ₆ H ₅) ₃ P [⊕] CH=C(CF ₃) ₂ , BF ₄ [⊖]	H; P (17·3); F (−58·4; −64·3; −151·7)	1967, 102
PC ₂₂ H ₁₆ ClF ₆	(C ₆ H ₅) ₃ P [⊕] CH=C(CF ₃) ₂ , Cl [⊖]	H; P (17·3); F (−58·1; −63·2)	1967, 102
PC ₂₂ H ₁₇	C ₆ H ₅ P[C(C ₆ H ₅)=CH] ₂	H	1969, 77
PC ₂₂ H ₁₇ O ₂	(C ₆ H ₅) ₃ P=CC(O)CH ₂ CO	H; P (−4·4)	1968, 110
PC ₂₂ H ₁₇ O ₃	(C ₆ H ₅) ₃ P=CC(O)OC(O)CH ₂	H; P (13)	1964, 10; 1968, 344
	(C ₆ H ₅) ₃ P=CC(O)CH ₂ OCO	H	1967, 369

Formula	Compound	Resonance	Reference
PC ₂₂ H ₁₇ O ₅	C ₆ H ₅ O(CH ₂ O) ₂ P[OC(C ₆ H ₄) ₂	P (−27·0)	1968, 301
PC ₂₂ H ₁₈ NO ₂	(C ₆ H ₅) ₃ P [⊕] C[C(O)NHC(O)] [⊖] CH ₂	H	1968, 344
PC ₂₂ H ₁₉ N ₂ O ₂	(C ₆ H ₅) ₂ P(O)NNC(CH ₃)OC=CHC ₆ H ₅	H	1968, 88
PC ₂₂ H ₁₉ O ₂	C ₆ H ₅ (CH ₃) ₂ POC ₁₄ H ₈ O	P (−9·6)	1968, 303
PC ₂₂ H ₁₉ O ₃	(C ₆ H ₅) ₃ P [⊕] [CH ₂ C(O)] ₂ [⊖] O	H	1963, 8
PC ₂₂ H ₁₉ O ₅	C ₆ H ₅ (CH ₂ O) ₂ P[OC(C ₆ H ₅) ₂	P (−32·2)	1968, 301
PC ₂₂ H ₂₀ BrO ₂	(C ₆ H ₅) ₃ P [⊕] CH=CHCOOCH ₃ , Br [⊖]	H	1969, 349
PC ₂₂ H ₂₀ ClO ₂	(C ₆ H ₅) ₃ P [⊕] CH=CHCOOCH ₃ , Cl [⊖]	H	1969, 349
PC ₂₂ H ₂₁	(C ₆ H ₅) ₂ PC ₆ H ₄ (CH ₂) ₂ CCH ₃	H	1968, 194
PC ₂₂ H ₂₁ Cl ₂ O	Cl ₂ P(O)C(C ₆ H ₄ CH ₃) ₃	H	1967, 117
PC ₂₂ H ₂₁ N ₂ O ₇ S	(C ₆ H ₅) ₃ P [⊕] N(COOCH ₃)N(SO ₃ [⊖])COOCH ₃	P (53)	1969, 324
PC ₂₂ H ₂₁ O ₂	(C ₆ H ₅) ₃ P=C(CH ₃)COOCH ₃	H (T)	1966, 140
	(C ₆ H ₅) ₃ P=CHCOOC ₂ H ₅	H; P (16·8)	1966, 270; 1967, 192; 1968, 171
PC ₂₂ H ₂₁ O ₃	(C ₆ H ₅) ₂ P(O)CH(C ₆ H ₅)CH ₂ COOCH ₃	H	1969, 369
PC ₂₂ H ₂₁ O ₄	C ₆ H ₅ (C ₆ H ₅ O) ₂ P[OC(CH ₃) ₂	P (−42·4)	1966, 225
PC ₂₂ H ₂₁ O ₅	(C ₆ H ₅ O) ₃ P[OC(CH ₃) ₂	P (−64·7)	1966, 225; 1968, 301
PC ₂₂ H ₂₂ Br	CH ₃ CH=C(CH ₃)P [⊕] (C ₆ H ₅) ₃ , Br [⊖]	H	1966, 135
PC ₂₂ H ₂₂ BrO	CH ₃ C(O)CH(CH ₃)P [⊕] (C ₆ H ₅) ₃ , Br [⊖]	H	1966, 135
PC ₂₂ H ₂₂ BrO ₂	(C ₆ H ₅) ₃ P [⊕] CH ₂ COOC ₂ H ₅ , Br [⊖]	H	1968, 170
PC ₂₂ H ₂₂ Cl	CH ₂ =C(CH ₃)CH ₂ P [⊕] (C ₆ H ₅) ₃ , Cl [⊖]	P (21·0)	1966, 5
	CH ₃ CH=CHCH ₂ P [⊕] (C ₆ H ₅) ₃ , Cl [⊖]	H	1966, 276
PC ₂₂ H ₂₂ ClN ₂ O ₄	P[C(CH ₃) ₂ C ₆ H ₄ NC ₂ H ₅] ₂ , ClO ₄ [⊖]	P (48·8)	1966, 272
PC ₂₂ H ₂₃	(C ₆ H ₅) ₃ P=CHC ₃ H ₇	P (13)	1967, 165, 363; 1968, 337

	$(C_6H_5)_3P=C(CH_3)C_2H_5$	P (10·5)	1967, 363
PC ₂₂ H ₂₃ Br ₂	$(C_6H_5)_3P^+(CH_2)_4Br, Br^-$	P (24·2)	1966, 5
PC ₂₂ H ₂₃ N ₂ O	$(C_6H_5)_2PN(C_6H_5)C(O)NHC_3H_7$	H	1967, 370
PC ₂₂ H ₂₃ O	$(C_6H_5)_2P(O)C(CH_3)=C=C_7H_{10}$	H	1967, 153
PC ₂₂ H ₂₄	$C_4H_9P^+(C_6H_5)_3$	P (24·0)	1967, 7
PC ₂₂ H ₂₄ BF ₄ S	$(C_6H_5)_3P^+CH^+S^-(CH_3)C_2H_5, BF_4^-$	H	1967, 367
PC ₂₂ H ₂₄ Br	$C_4H_9P^+(C_6H_5)_3, Br^-$	P (24·0)	1966, 5; 1967, 363
	$s-C_4H_9P^+(C_6H_5)_3, Br^-$	H; P (30·2)	1966, 5, 135; 1967, 363
	$i-C_3H_7(C_6H_5CH_2)P^+(C_6H_5)_2, Br^-$	P (35·9)	1968, 6
	$C_2H_5(C_6H_5CH_2)_2P^+C_6H_5, Br^-$	H; P (30·1)	1968, 6; 1969, 156
	$CH_3(C_6H_5)P^+(CH_2C_6H_5)CH(CH_3)C_6H_5, Br^-$	H	1969, 156
PC ₂₂ H ₂₄ BrO	$(C_6H_5)_3P^+CH(CH_3)CH(OH)CH_3$	H	1966, 135
PC ₂₂ H ₂₄ I	$t-C_4H_9P^+(C_6H_5)_3, I^-$	P (34·7)	1966, 5
	$CH_3P^+(CH_2C_6H_5)_3, I^-$	P (26·5)	1967, 244
	$CH_3P^+(C_6H_4CH_3)_3, I^-$	H	1968, 15, 16
PC ₂₂ H ₂₄ IO ₃	$CH_3P^+(C_6H_4OCH_3)_3, I^-$	H{P}	1969, 118
PC ₂₂ H ₂₄ N	$(C_6H_5)_3P=N-t-C_4H_9$	H	1965, 109
PC ₂₂ H ₂₅ Br ₂ F ₈ S	$(C_6H_5)_3P^+CH_2S^+(CH_3)C_2H_5, 2 Br^-$	H	1967, 367
PC ₂₂ H ₂₅ ClN	$(C_6H_5)_3P^+NH-t-C_4H_9, Cl^-$	H	1965, 109
PC ₂₂ H ₂₅ IN	$(C_6H_5)_2P^+(CH_3)(CH_2)_2N(CH_3)C_6H_5, I^-$	H	1967, 371
PC ₂₂ H ₂₅ N ₂ O ₇	$(C_2H_5O)_3P[OC(C_6H_4)NHC(O)]_2$	H	1966, 263
PC ₂₂ H ₂₅ O	$(C_6H_5)_2P(O)C(CH_3)=C=C_6H_5CH_3$	H	1969, 165
PC ₂₂ H ₂₅ O ₂	$(C_6H_5)_3P(OC_2H_5)_2$	H; P (-54)	1968, 332
	$(C_6H_5)_2P(O)C(CH_3)=C=CCH(OCH_3)(CH_2)_4$	H	1969, 164
PC ₂₂ H ₂₅ Si	$(C_6H_5)_3P=CHSi(CH_3)_3$	H	1967, 328
PC ₂₂ H ₂₆ ISi	$(C_6H_5)_3P^+CH_2Si(CH_3)_3, I^-$	H	1965, 108
PC ₂₂ H ₂₇ O	$(C_6H_5)_2P(O) geranyl$	H	1966, 267
PC ₂₂ H ₂₇ O ₂	$(C_6H_5)_2P(O)C(CH_3)=C=C(CH_3)CH(OCH_3)i-C_3H_7$	H	1967, 155
PC ₂₂ H ₂₈ NO ₄	$(CH_3)_2NP[OC(CH_3)]_2[OC(C_6H_5)]_2$	P (-35·5)	1968, 304

Formula	Compound	Resonance	Reference
PC ₂₂ H ₂₆ N ₃ O ₂	(CH ₂) ₄ NP[N(CH ₃)CH ₂] ₂ [OC(C ₆ H ₅)] ₂	H; P (-41.8)	1968, 153
PC ₂₂ H ₂₆ N ₃ O ₆	(CH ₂) ₄ NP[N(CH ₃)CH ₂] ₂ [OCH(C ₆ H ₄)NO ₂] ₂	H; P (o: -42.4; m: -41.4; p: -42.3)	1968, 310
PC ₂₂ H ₂₉ O	(C ₆ H ₅) ₂ POC ₆ H ₁₀ C(CH ₃) ₃	H	1966, 62
PC ₂₂ H ₂₉ O ₂	(C ₆ H ₅) ₂ P(O)OC ₆ H ₁₀ C(CH ₃) ₃	H	1966, 62;
	(C ₆ H ₅) ₂ P(O)O menthyl	H	1967, 151; 1968, 140
PC ₂₂ H ₃₀ N ₃ O ₂	[(CH ₃) ₂ N] ₃ P=C(COC ₆ H ₅)(CH ₂ COC ₆ H ₅)	P (63.2)	1965, 84
PC ₂₂ H ₃₁ ClN ₃ O ₂	[(CH ₃) ₂ N] ₃ P ⁺ CH(COC ₆ H ₅)(CH ₂ COC ₆ H ₅), Cl ⁻	P (54.9)	1966, 106
PC ₂₂ H ₃₂ I	(CH ₃) ₂ (C ₆ H ₅)P ⁺ C(CH ₃) ₂ CH(CH ₃)C(CH ₃) ₂ C ₆ H ₅ , I ⁻	H; P	1968, 67
PC ₂₂ H ₄₅ O	(C ₂ H ₅) ₂ PO(CH ₂) ₈ CH=CH(CH ₂) ₇ CH ₃	P (135.3)	1968, 336
	(C ₂ H ₅) ₂ P(O)(CH ₂) ₈ CH=CH(CH ₂) ₇ CH ₃	P (51.0)	1968, 336
PC ₂₃ H ₁₇	P[C(C ₆ H ₅)=CH] ₂ CC ₆ H ₅	H; P (178.2)	1966, 68
PC ₂₃ H ₁₇ O ₅	(CH ₃ O) ₃ POC ₁₄ H ₈ O	P (-44.7)	1968, 303
PC ₂₃ H ₁₉ O ₃	[(C ₆ H ₅)CCH] ₂ CH(C ₆ H ₅)PO ₂ H	H	1968, 102
	(C ₆ H ₅) ₃ P ⁺ CC(O ⁻)OC(O)CH(CH ₃)	H	1968, 344
PC ₂₃ H ₂₁ BrNO ₂	(C ₆ H ₅) ₃ P ⁺ CH=CHC(=NOH)COCH ₃ , Br ⁻	H	1968, 345
PC ₂₃ H ₂₁ O	(C ₆ H ₅) ₂ P(O)(CH=CH) ₂ CHC ₆ H ₅	H	1966, 267
	(C ₆ H ₅) ₂ P(O)C(C ₆ H ₅)=C=C(CH ₃) ₂	H	1969, 165
PC ₂₃ H ₂₁ O ₃	(C ₆ H ₅) ₃ P=C(COOCH ₃)CH ₂ CHO	H	1964, 10
PC ₂₃ H ₂₂ BrO	(C ₆ H ₅) ₃ P ⁺ CH ₂ CH=CHCOCH ₃ , Br ⁻	H	1968, 345
PC ₂₃ H ₂₂ BrO ₂	(C ₆ H ₅) ₃ P ⁺ CH ₂ CH=CHCOOCH ₃ , Br ⁻	H	1968, 345
PC ₂₃ H ₂₂ ClO ₂	(C ₆ H ₅) ₃ P ⁺ CH ₂ CH=CHCOOCH ₃ , Cl ⁻	H	1968, 346
PC ₂₃ H ₂₂ O	(C ₆ H ₅) ₃ P=CHCH=CHCOCH ₃	H	1968, 345

PC ₂₃ H ₂₃	(C ₆ H ₅) ₃ P=C ₅ H ₈	P (4·8)	1967, 363
PC ₂₃ H ₂₃ O ₂	(C ₆ H ₅) ₃ P=C(CH ₃)COOC ₂ H ₅	H	1968, 171
PC ₂₃ H ₂₄ BF ₄ O ₂	(C ₆ H ₅) ₃ P [⊕] CH=C(OCH ₃)OC ₂ H ₅ , BF ₄ [⊖]	H	1969, 206
PC ₂₃ H ₂₄ Br	C ₅ H ₉ P [⊕] (C ₆ H ₅) ₃ , Br [⊖]	H; P (30·7)	1966, 5, 277; 1967, 363
PC ₂₃ H ₂₅	(C ₆ H ₅) ₃ P=C ₅ H ₁₀	P	1967, 363; 1968, 337
PC ₂₃ H ₂₆ BF ₄ S	(C ₆ H ₅) ₃ P [⊕] CH [⊖] S [⊕] (C ₂ H ₅) ₂ , BF ₄ [⊖]	H	1967, 367
PC ₂₃ H ₂₆ Br	(C ₆ H ₅) ₃ P [⊕] CH(C ₂ H ₅) ₂ , Br [⊖]	P (30·1)	1966, 5; 1967, 363
	C ₃ H ₇ (C ₆ H ₅)P [⊕] (CH ₂ C ₆ H ₅) ₂ , Br [⊖]	P (24·4)	1968, 6
	C ₂ H ₅ P [⊕] (CH ₂ C ₆ H ₅) ₃ , Br [⊖]	P (28·7)	1968, 6
	CH ₃ (C ₆ H ₅)P [⊕] (CH ₂ C ₆ H ₅)C ₆ H ₂ (CH ₃) ₂	H	1969, 156
PC ₂₃ H ₂₆ I	<i>neo</i> -C ₅ H ₁₁ P [⊕] (C ₆ H ₅) ₃ , I [⊖]	H	1965, 108
	C ₂ H ₅ (CH ₃) ₂ CP [⊕] (C ₆ H ₅) ₃ , I [⊖]	P (36·7)	1966, 5
	C ₂ H ₅ P [⊕] (C ₆ H ₄ CH ₃) ₃ , I [⊖]	H	1968, 15
PC ₂₃ H ₂₆ O	(C ₆ H ₅) ₂ P(O)CH=C=C ₇ H ₇ (CH ₃) ₃	H	1969, 166
	(C ₆ H ₅) ₃ P [⊕] OCH ₂ C(CH ₃) ₃	P (-4)	1967, 345
PC ₂₃ H ₂₇ B ₂ F ₈ S	(C ₆ H ₅) ₃ P [⊕] CH ₂ S [⊕] (C ₂ H ₅) ₂ , 2BF ₄ [⊖]	H	1967, 367
PC ₂₃ H ₂₆ ISi	(C ₆ H ₅) ₃ P [⊕] CH(CH ₃)Si(CH ₃) ₃ , I [⊖]	H	1965, 108
PC ₂₃ H ₂₆ I ₂ N	(C ₆ H ₅) ₂ P [⊕] (CH ₃)(CH ₂) ₂ N [⊕] (CH ₃) ₂ C ₆ H ₅ , 2I [⊖]	H	1967, 257
PC ₂₃ H ₂₈ N ₃ O ₃	(CH ₂) ₄ N[CH ₂ (CH ₃)N] ₂ POC(COC ₆ H ₅)C(C ₆ H ₅)O	P (-37·5)	1968, 153
PC ₂₃ H ₂₉ O ₅	(<i>i</i> -C ₃ H ₇ O) ₃ POC ₁₄ H ₈ O	H	1969, 366
PC ₂₃ H ₃₁ N ₄ O ₅ S	Diethyl 2-{3-(2-methyl-4-benzoylamino-pyrimidin-5-yl)-methyl-3a-methylperhydrofuro[2,3- <i>d</i>]thiazole}phosphate	H	1967, 352
PC ₂₃ H ₃₁ O ₂	C ₆ H ₅ (C ₆ H ₅ CH ₂)P(O)O menthyl	H	1968, 35
PC ₂₃ H ₃₂ NO ₂	C ₆ H ₅ [O(CH ₂) ₂ N]P(O)C(CH ₃)=C=C ₁₀ H ₁₆	H	1969, 165
PC ₂₃ H ₃₃ O	(C ₆ H ₁₁) ₂ P(O)C(C ₆ H ₅)=C=C(CH ₃) ₂	H	1969, 165
PC ₂₃ H ₃₅ O ₄	CH ₃ (CH ₃ O)P(O)O(C ₂₁ H ₂₉ O)	H	1967, 168
PC ₂₃ H ₃₇ O ₆	(CH ₃ O) ₂ P(O) hydroxypregnenedione	H	1967, 167
PC ₂₃ H ₄₆ NO ₄	[(CH ₃) ₃ C ₆ H ₈ O] ₂ P(O)C(O)N(<i>i</i> -C ₃ H ₇) ₂	H	1967, 26

Formula	Compound	Resonance	Reference
PC ₂₄ H ₁₅ Br ₂	C ₆ H ₅ P[C(C ₆ H ₄ Br)=CH] ₂	H	1967, 70
PC ₂₄ H ₁₅ F ₁₂ O ₂	(C ₆ H ₅) ₃ P[OC(CF ₃) ₂] ₂	H; P (-22.2 -18.6); F (-65.2)	1966, 225, 278; 1967, 102; 1968, 303
PC ₂₄ H ₁₅ F ₁₂ O ₄	C ₆ H ₅ (C ₆ H ₅ O) ₂ P[OC(CF ₃) ₂] ₂	P (-40.1)	1966, 225
PC ₂₄ H ₁₅ F ₁₂ O ₅	(C ₆ H ₅ O) ₃ P[OC(CF ₃) ₂] ₂	P (-64.1)	1966, 225; 1967, 335
PC ₂₄ H ₁₅ S	(C ₆ H ₅ C≡C) ₃ PS	H	1965, 96
PC ₂₄ H ₁₇	(C ₆ H ₄) ₄ PH	H	1966, 25
	C ₆ H ₅ P[C(C ₆ H ₅)=CH ₂]	H	1967, 70
PC ₂₄ H ₁₇ N ₂ O ₆	(C ₆ H ₄) ₄ P [⊕] H(NO ₃) ₂ [⊖]	H	1966, 279
PC ₂₄ H ₁₉ FI	CH ₃ (C ₆ H ₄ F)P [⊕] (C ₆ H ₅) ₂ , I [⊖]	F	1968, 14
PC ₂₄ H ₁₉ O ₅	(C ₆ H ₅ O) ₃ POC ₆ H ₄ O	P (-60.8)	1968, 124
PC ₂₄ H ₂₀ Br	(C ₆ H ₅) ₄ P [⊕] Br [⊖]	¹³ C	1969, 21
PC ₂₄ H ₂₀ I	(C ₆ H ₅) ₂ P [⊕] I [⊖]	P (23.2)	1966, 5; 1967, 359
PC ₂₄ H ₂₁ ClN	(C ₆ H ₅) ₃ P [⊕] NHC ₆ H ₅ , Cl [⊖]	H	1966, 280
PC ₂₄ H ₂₁ ClNO ₅	(CH ₃ O) ₂ P(O)OC=CClC(C ₆ H ₅) ₂ C(O)NC ₆ H ₅	H	1969, 345
PC ₂₄ H ₂₁ Cl ₆ O ₆	(C ₆ H ₅ Cl ₂ OCH ₂ CH ₂ O) ₃ P	H	1968, 285
PC ₂₄ H ₂₁ IN	(C ₆ H ₅) ₃ P [⊕] CH ₂ (C ₆ H ₄ N), I [⊖]	H	1966, 271
PC ₂₄ H ₂₁ O ₃	CH ₃ OP(O)[C(C ₆ H ₅)CH] ₂ C(OH)C ₆ H ₅	H	1968, 75
PC ₂₄ H ₂₃ BrNO ₃	(C ₆ H ₅) ₃ P [⊕] C(CH ₃)=CHC(=NOCH ₃)COOH, Br [⊖]	H	1968, 345
PC ₂₄ H ₂₃ O	(C ₆ H ₅) ₂ P(O)CH=C=C(CH ₃)CH(CH ₃)C ₆ H ₅	H	1967, 155
	(C ₆ H ₅) ₃ P=CHCH=C(CH ₃)COCH ₃	H	1968, 345
PC ₂₄ H ₂₃ O ₂	C ₂ H ₅ (C ₆ H ₅) ₂ POC ₁₀ H ₈ O	P (-9.3)	1968, 124
	C ₆ H ₅ (C ₂ H ₅) ₂ POC ₁₄ H ₈ O	P (0.9)	1968, 303
PC ₂₄ H ₂₃ O ₃	(C ₆ H ₅) ₃ P=C(COCH ₃)CH ₂ COOCH ₃	H	1967, 122

	$(C_6H_5)_3P=C(COCH_3)COOC_2H_5$	H	1967, 372
PC ₂₄ H ₂₃ O ₄	$(C_6H_5)_3P=C(COOCH_3)CH_2COOCH_3$	H	1964, 10
PC ₂₄ H ₂₄	$C_6H_9P^{\oplus}(C_6H_5)_3$	H	1966, 273
PC ₂₄ H ₂₄ Br	$CH_3(C_6H_5)P^{\oplus}(CH_2C_6H_5-\alpha-C_{10}H_9)$	H	1969, 156
PC ₂₄ H ₂₄ BrO	$C_6H_9OP^{\oplus}(C_6H_5)_3, Br^{\ominus}$	H	1966, 116
	$(C_6H_5)_3P^{\oplus}CH_2CH=C(CH_3)COCH_3, Br^{\ominus}$	H	1968, 345
PC ₂₄ H ₂₄ ClO ₃	$(C_6H_5)_3CP(O)(OCH_2)_2C(CH_3)CH_2Cl$	H	1967, 91
PC ₂₄ H ₂₄ O ₃	$(C_6H_5)_3P^{\oplus}CH(COCH_3)COOC_2H_5$	H	1967, 372
PC ₂₄ H ₂₅	$(C_6H_5)_3P=C(CH_2)_5$	P (6·4)	1967, 363; 1968, 337
PC ₂₄ H ₂₅ O ₂	$(CH_3C_6H_4)_3P=CHCOOCH_3$	H	1967, 192
	$(C_6H_5)_3P=C=C(OC_2H_5)_2$	H	1969, 206
PC ₂₄ H ₂₅ O ₃	$(C_6H_5)_3CP(O)(OCH_2)_2C(CH_3)_2$	H	1967, 91; 1968, 74
PC ₂₄ H ₂₆ Br	$C_6H_{11}P^{\oplus}(C_6H_5)_3, Br^{\ominus}$	P (26·6)	1966, 5; 1967, 363
PC ₂₄ H ₂₆ BrO ₂	$C_6H_9P^{\oplus}(CH_2C_6H_5)_2CH_2COOC_2H_5$	H	1969, 156
PC ₂₄ H ₂₇	$(C_6H_5)_3P=C_6H_{12}$	P	1967, 363
PC ₂₄ H ₂₇ O	$(C_6H_5)_2P(O)CH=C=C_{10}H_{16}$	H	1969, 165
PC ₂₄ H ₂₈ Br	$C_6H_{13}P^{\oplus}(C_6H_5)_3, Br^{\ominus}$	P (24·4)	1966, 5; 1967, 363
	$C_2H_5(C_3H_7)CHP^{\oplus}(C_6H_5)_3, Br^{\ominus}$	P (30·3)	1967, 363
	$C_4H_9(C_6H_5)P^{\oplus}(CH_2C_6H_5)_2, Br^{\ominus}$	P (28·7)	1968, 6
	$t-C_4H_9(C_6H_5)P^{\oplus}(CH_2C_6H_5)_2, Br^{\ominus}$	H	1969, 156
PC ₂₄ H ₂₈ I	$(C_6H_5)_3P^{\oplus}CH(CH_3)-t-C_4H_9, I^{\ominus}$	H	1965, 108
PC ₂₄ H ₂₈ O	$(C_6H_5)_2P(O)C(CH_3)=C=C_7H_7(CH_3)_3$	H	1969, 299
PC ₂₄ H ₂₉ O	$(C_6H_5)_2P(O)C(t-C_4H_9)=C=C_5H_7CH_3$	H	1969, 164, 165
	$(C_6H_5)_2P(O)CH=C=C_6H_9-t-C_4H_9$	H	1969, 165
PC ₂₄ H ₃₀ NSn	$(C_6H_5)_3P=NSn(C_6H_5)_3$	H	1967, 299
PC ₂₄ H ₃₁ O ₆	$(i-C_3H_7O)_3POC(C_6H_5)C(COC_6H_5)O$	H; P (-49·3)	1965, 21
PC ₂₄ H ₃₃ AlNSi	$(C_6H_5)_3PN[Al(CH_3)_3][Si(CH_3)_3]$	H	1967, 322
PC ₂₄ H ₃₃ GaNSi	$(C_6H_5)_3PN[Ga(CH_3)_3][Si(CH_3)_3]$	H	1967, 322
PC ₂₄ H ₃₃ N ₂ O ₂	$C_4H_9[(CH_3)_2N]_2P=C(COC_6H_5)CH_2COC_6H_5$	H; P (63·2)	1966, 106
PC ₂₄ H ₃₅ GeO	$(C_2H_5)_2P(O)[C(C_6H_5)]_2COGe(C_2H_5)_3$	H	1969, 341

Formula	Compound	Resonance	Reference
PC ₂₄ H ₃₅ N ₂ O ₂	(C ₂ H ₅) ₂ NP[OC ₆ H ₃ (CH ₃)CH ₂]OC ₆ H ₃ (CH ₃)CHN(C ₂ H ₅) ₂	H; P (−28)	1967, 373
PC ₂₄ H ₃₅ S	C ₁₂ H ₂₅ P(S)(C ₆ H ₅) ₂	P (41·5)	1966, 40
PC ₂₄ H ₃₇ O ₇	(CH ₃ O) ₂ P(O)(C ₂₂ H ₃₁ O ₄)	H	1967, 270
PC ₂₄ H ₄₂ NO ₆ S	(C ₈ H ₁₇ O) ₂ P(O)C(O)NHSO ₂ C ₆ H ₄ CH ₃	H	1968, 328; 1969, 161
PC ₂₄ H ₅₁	HP(C ₁₂ H ₂₅) ₂	H; P (−71)	1966, 14
	P(C ₈ H ₁₇) ₃	P (−31·8)	1966, 4; 1967, 244, 277
PC ₂₄ H ₅₁ Cl ₂	P[CH ₂ C(C ₂ H ₅)(CH ₂) ₃ CH ₃] ₃	P (−48·5)	1967, 244
PC ₂₄ H ₅₁ O	(C ₈ H ₁₇) ₃ PCl ₂	H; P	1969, 344
PC ₂₄ H ₅₁ S	(C ₈ H ₁₇) ₃ PO	H; P (47·4)	1966, 105; 1967, 277
	(C ₈ H ₁₇) ₃ PS	P (54·8)	1967, 277
PC ₂₅ H ₁₅ F ₆ O ₂	(C ₆ H ₅) ₃ P=CC(O)[C(CF ₃) ₂]CO	P (1·9); F (−57·1)	1968, 110
PC ₂₅ H ₁₇ F ₆ N ₂	(C ₆ H ₅) ₃ P [⊕] CH ₂ C(CF ₃) ₂ C [⊖] (CN) ₂	H; P (24·8); F (−68·3)	1967, 102
PC ₂₅ H ₁₈ Cl ₃ O ₄	(C ₆ H ₅ O) ₂ P(O)C ₆ H ₃ ClCCl ₂ C ₆ H ₅	P (−19·6)	1966, 261
PC ₂₅ H ₁₉	CH ₃ P(C ₆ H ₄) ₄	H	1966, 281
PC ₂₅ H ₁₉ ClO	C ₆ H ₅ (C ₆ H ₅ CH ₂)P [⊕] (C ₆ H ₄) ₂ O, Cl [⊖]	H	1968, 46
PC ₂₅ H ₁₉ Cl ₂ O ₅	(C ₆ H ₅ O) ₂ P(O)OC ₆ H ₄ CCl ₂ OC ₆ H ₅	P (−18·9)	1965, 45
PC ₂₅ H ₁₉ O ₆	(C ₆ H ₅ O) ₂ P(O)OC ₆ H ₄ C(O)OC ₆ H ₅	P (−18·5)	1965, 45; 1966, 239
PC ₂₅ H ₂₀ AsF ₈	CF ₃ PF ₅ , As(C ₆ H ₅) ₄	F(−70·9; −75·7)	1969, 67
PC ₂₅ H ₂₁ BrNO ₂	(C ₆ H ₅) ₃ P [⊕] CH ₂ C ₆ H ₄ NO ₂ , Br [⊖]	P (+24·0)	1966, 5
PC ₂₅ H ₂₁ NO ₂	(C ₆ H ₅) ₃ P [⊕] CH ₂ C ₆ H ₄ NO ₂	H	1967, 117
PC ₂₅ H ₂₁ O	(C ₆ H ₅) ₂ P(O)CH(C ₆ H ₅) ₂	H	1966, 82; 1968, 56
PC ₂₅ H ₂₂ Br	C ₆ H ₅ CH ₂ P [⊕] (C ₆ H ₅) ₃ , Br [⊖]	P (23·5)	1966, 5
	C ₇ H ₇ P [⊕] (C ₆ H ₅) ₃ , Br [⊖]	P (22·6)	1966, 5
PC ₂₅ H ₂₂ Cl	C ₆ H ₅ CH ₂ P [⊕] (C ₆ H ₅) ₃ , Cl [⊖]	H	1967, 118; 1968, 170

PC ₂₅ H ₂₃ O ₂	(CH ₃ O) ₂ P[C(C ₆ H ₅)CH] ₂ CC ₆ H ₅	H; P (62.2)	1968, 75
PC ₂₅ H ₂₃ O ₃	CH ₃ OP(O)[C(C ₆ H ₅)CH] ₂ C(OCH ₃)C ₆ H ₅	H	1968, 75
PC ₂₅ H ₂₃ O ₅	C ₆ H ₅ O[(CH ₃) ₂ C(CH ₂ O) ₂]P[OC(C ₆ H ₅)] ₂	H; P (-48.7)	1968, 301
PC ₂₅ H ₂₄ O	(C ₆ H ₅) ₂ P(O)C(CH ₃)=C=C(CH ₃)C ₆ H ₅	H	1967, 155
PC ₂₅ H ₂₅ ClNO ₂	(C ₆ H ₅) ₃ P [⊕] CH=CHC(=NOH)CO- <i>i</i> -C ₃ H ₇ , Cl [⊖]	H	1968, 345
PC ₂₅ H ₂₅ O ₂	(C ₆ H ₅) ₂ P(O)C(C ₆ H ₅)=C=C(CH ₃)CH(OCH ₃)CH ₃	H	1967, 155
PC ₂₅ H ₂₅ O ₃	CH ₃ O(C ₆ H ₅) ₂ PCH(C ₆ H ₅)C(COCH ₃)C(CH ₃)O	H; P (-25.7)	1968, 124, 152
PC ₂₅ H ₂₅ O ₅	(CH ₃ O) ₂ P(O)C(CH ₂ COC ₆ H ₅)C(OCH ₂ C ₆ H ₅)C ₆ H ₅ , Br [⊖]	H; P (22.0)	1966, 106
PC ₂₅ H ₂₆ BrO	C ₆ H ₅ O[(CH ₃) ₂ C(CH ₂ O)] ₂ P[OC(C ₆ H ₅)] ₂	P (-53.7)	1968, 301
PC ₂₅ H ₂₆ NO ₃	(C ₆ H ₅) ₃ P [⊕] O norbornyl, Br [⊖]	H	1965, 114
PC ₂₅ H ₂₇ O ₅	(C ₆ H ₅) ₂ P(O)CH(C ₆ H ₅)CH ₂ C(=NOH)CO- <i>i</i> -C ₃ H ₇	H	1968, 345
PC ₂₅ H ₂₈ I	(C ₆ H ₅ CH ₂ O) ₃ P[OC(CH ₃)] ₂	H; P (-51.3)	1968, 73
	(C ₆ H ₅) ₃ P [⊕] C(CH ₃)C ₅ H ₁₀ , I [⊖]	P (35.1)	1966, 5
PC ₂₅ H ₂₉ O	(C ₆ H ₅) ₂ P(O)C(CH ₃)=C=C ₁₀ H ₁₆	H	1968, 146; 1969, 165
PC ₂₅ H ₃₀ O	(C ₆ H ₅) ₂ P(O)C(CH ₃)=C=C ₁₀ H ₁₇	H	1967, 156
PC ₂₅ H ₃₃ Ge ₂	(C ₆ H ₅) ₃ P=C[Ge(CH ₃) ₃] ₂	H	1967, 328
PC ₂₅ H ₃₃ Sn ₂	(C ₆ H ₅) ₃ P=C[Sn(CH ₃) ₃] ₂	H	1967, 328
PC ₂₅ H ₃₅	(C ₄ H ₉) ₃ P=C ₁₃ H ₈ (fluorenylidene)	H	1967, 374
PC ₂₅ H ₅₃	CH ₃ P(C ₁₂ H ₂₅) ₂	H; P (-34)	1966, 14
PC ₂₅ H ₅₄ I	CH ₃ P [⊕] (C ₈ H ₁₇) ₃ , I [⊖]	P (30.5)	1967, 244
PC ₂₅ H ₅₇ O ₃ Sn ₂	CH ₃ P(O)[OSn(C ₄ H ₉) ₃] ₂	P{H}	1969, 140
PC ₂₆ H ₁₇ F ₁₂ O ₄	(C ₆ H ₅) ₃ P [⊕] CHC(CF ₃) ₂ , (CF ₃ COO) ₂ H [⊖]	H; P (-7.5); F (-58.6; -64.4; -76.0)	1967, 102
PC ₂₆ H ₁₈ N ₃ O	(C ₆ H ₅) ₃ P=C ₈ H ₃ N ₃ O	H	1965, 115
PC ₂₆ H ₁₉ N ₂ O ₂	(C ₆ H ₅) ₃ P=C=C=NC ₆ H ₄ NO ₂	P (1.6)	1968, 110
PC ₂₆ H ₂₀ AsF ₁₀	(CF ₃) ₂ PF ₄ , As(C ₆ H ₅) ₄	P (-70.8; -78.9)	1969, 67
PC ₂₆ H ₂₀ N	(C ₆ H ₅) ₃ P=C=C=NC ₆ H ₅	P (2.4)	1968, 110, 338

Formula	Compound	Resonance	Reference
PC ₂₆ H ₂₁	(C ₆ H ₅) ₂ PC(C ₆ H ₅)=CHC ₆ H ₅	H	1966, 282
	C ₆ H ₅ P[C(C ₆ H ₄ CH ₃)=CH] ₂	H	1967, 70
PC ₂₆ H ₂₁ BrNO	(C ₆ H ₅) ₃ PCH ₂ C(C ₆ H ₄ Br)=NO	H	1968, 343
PC ₂₆ H ₂₁ O ₂	(C ₆ H ₅) ₂ P(O)C ₆ H ₄ CH ₂ COC ₆ H ₅	H	1966, 266
PC ₂₆ H ₂₂ Br	(C ₆ H ₅) ₃ P [⊕] CHC ₆ H ₄ CH ₂ , Br [⊖]	H	1967, 300
PC ₂₆ H ₂₂ BrO	(C ₆ H ₅) ₃ P [⊕] CH ₂ COC ₆ H ₅ , Br [⊖]	H	1967, 118
PC ₂₆ H ₂₂ Br ₂ NO	(C ₆ H ₅) ₃ P [⊕] CH ₂ C(=NOH)C ₆ H ₄ Br, Br [⊖]	H	1968, 343
PC ₂₆ H ₂₂ NO	(C ₆ H ₅) ₃ PON=C(C ₆ H ₅)CH ₂	H; P (−37·0)	1967, 139; 1968, 343
PC ₂₆ H ₂₂ O	(C ₆ H ₅) ₃ P [⊕] CH ₂ C(O)C ₆ H ₅	H	1966, 119
PC ₂₆ H ₂₃ BrNO	(C ₆ H ₅) ₃ P [⊕] CH ₂ C(=NOH)C ₆ H ₅ , Br [⊖]	H	1967, 375; 1968, 343, 347
PC ₂₆ H ₂₃ O	(C ₆ H ₅) ₂ P(O)CH(C ₆ H ₅)CH ₂ C ₆ H ₅	H	1967, 376; 1969, 369
PC ₂₆ H ₂₃ OS	(C ₆ H ₅) ₂ P(S)CH ₂ C(OH)(C ₆ H ₅) ₂	H; P (34·6)	1967, 329
PC ₂₆ H ₂₃ O ₂	(C ₆ H ₅) ₂ P(O)CH ₂ C(OH)(C ₆ H ₅) ₂	H; P (33·1)	1967, 329
PC ₂₆ H ₂₃ O ₅	(C ₂ H ₅ O) ₃ POC ₁₄ H ₈ O	P (−47·1)	1968, 303
PC ₂₆ H ₂₄	(C ₆ H ₅) ₃ P [⊕] CH ₂ C ₆ H ₄ CH ₃	H	1967, 117
PC ₂₆ H ₂₄ Br	(C ₆ H ₅) ₃ P [⊕] CH ₂ C ₆ H ₄ CH ₃ , Br [⊖]	H{P}	1967, 118; 1969, 118
	(C ₆ H ₅) ₂ P [⊕] (CH ₂ C ₆ H ₅) ₂ , Br [⊖]	P (27·0)	1968, 6
PC ₂₆ H ₂₄ ClO ₄	(C ₆ H ₅) ₃ P [⊕] C(COOCH ₃)C(COOCH ₃) ₂ , Cl [⊖]	H	1967, 372
PC ₂₆ H ₂₄ N ₃ O ₂	(CH ₃) ₂ N[N(CH ₃)CH ₂] ₂ POC ₁₄ H ₈ O	P (−29·8)	1968, 303
PC ₂₆ H ₂₄ O	(C ₆ H ₅) ₃ P [⊕] CH ₂ C ₆ H ₄ OCH ₃	H	1967, 117
PC ₂₆ H ₂₅ N ₂ O ₃	(C ₆ H ₅) ₃ P [⊕] CC(O [⊖])N(NC ₄ H ₈ O)C(O)CH ₂	H	1968, 344
PC ₂₆ H ₂₅ O	(C ₆ H ₅) ₂ P(O)C(C ₆ H ₅)=C=C(CH ₂) ₃ CHCH ₃	H	1969, 164, 165
PC ₂₆ H ₂₇ O ₂	C ₆ H ₅ (C ₂ H ₅) ₂ P=C(COC ₆ H ₅)CH ₂ COC ₆ H ₅	H; P (21·1)	1966, 106

PC ₂₆ H ₂₈ ClO ₂	C ₆ H ₅ (C ₂ H ₅) ₂ P ⁺ CH(COC ₆ H ₅)CH ₂ COC ₆ H ₅ , Cl [−]	P (34·1)	1966, 106
PC ₂₆ H ₃₁ O ₂	C ₆ H ₅ (β-C ₁₀ H ₇)P(O)O menthyl	H	1968, 140
PC ₂₆ H ₃₃ OSi	(C ₄ H ₉) ₂ POSi(C ₆ H ₅) ₃	P (122·8)	1967, 343
PC ₂₆ H ₃₅ O ₅	(C ₄ H ₉ O) ₃ POC ₁₄ H ₈ O	P (−47·3)	1966, 225
PC ₂₆ H ₅₆ I	(CH ₃) ₂ P ⁺ (C ₁₂ H ₂₅) ₂ , I [−]	H; P (29·5)	1966, 14
PC ₂₇ H ₁₇ F ₆	C ₆ H ₅ C[CH=C(C ₆ H ₅)] ₂ PC(CF ₃)=CCF ₃	H; P (−65)	1968, 339
PC ₂₇ H ₁₇ F ₁₂ O ₂	(C ₆ H ₅) ₃ P ⁺ CHC(CF ₃) ₂ , (CF ₃ CO) ₂ CH [−]	H; P (18·1); F (−58·6; −63·8; −76·7)	1967, 102
PC ₂₇ H ₂₀ I	C ₆ H ₅ P ⁺ (C ₆ H ₄ CH ₃) ₃ , I [−]	H	1968, 15
PC ₂₇ H ₂₁ O	(C ₆ H ₅) ₂ P(O)CH=C=C(C ₆ H ₅) ₂ (C ₆ H ₅) ₂ P(O)CHC(C ₆ H ₅)CC ₆ H ₅	H H	1966, 61 1968, 63
PC ₂₇ H ₂₂ N	(C ₆ H ₅) ₃ P=C=C=NC ₆ H ₄ CH ₃	P (3·0)	1968, 110
PC ₂₇ H ₂₃ O ₅	(C ₆ H ₅ O) ₃ POC(CH ₃)=C(C ₆ H ₅)O	P	1968, 301
PC ₂₇ H ₂₄ Br	(C ₆ H ₅) ₃ P ⁺ CH ₂ CH=CHC ₆ H ₅ , Br [−] CH ₃ (C ₆ H ₅) ₃ P ⁺ (CH ₂ C ₆ H ₅) fluorenyl	P (22·2) H	1966, 5 1969, 156
PC ₂₇ H ₂₄ BrO	(C ₆ H ₅) ₃ P ⁺ CH ₂ COC ₆ H ₄ CH ₃ , Br [−]	H	1967, 118
PC ₂₇ H ₂₄ ClO ₂	(C ₆ H ₅) ₃ P ⁺ CH ₂ COOCH ₂ C ₆ H ₅ , Cl [−]	H	1965, 87
PC ₂₇ H ₂₄ NO	(C ₆ H ₅) ₃ PCH(CH ₃)C(C ₆ H ₅)=NO	H	1968, 343, 347
PC ₂₇ H ₂₄ O ₂	(C ₆ H ₅) ₃ P ⁺ CH ₂ C ₆ H ₇ OC(O)CH ₃	H	1967, 117
PC ₂₇ H ₂₅ BrNO	(C ₆ H ₅) ₃ P ⁺ CH(CH ₃)C(=NOH)C ₆ H ₅ , Br [−]	H	1967, 375; 1968, 347
PC ₂₇ H ₂₅ ClNO	(C ₆ H ₅) ₃ P ⁺ CH(CH ₃)C(=NOH)C ₆ H ₅ , Cl [−]	H	1968, 343
PC ₂₇ H ₂₅ O	(C ₆ H ₅) ₂ P(O)C(C ₆ H ₅)=C=C ₇ H ₁₀	H	1967, 153
PC ₂₇ H ₂₅ O ₂	(C ₆ H ₅) ₂ P(O)CH(C ₆ H ₅)CH(C ₆ H ₅)OCH ₃	H	1967, 376
PC ₂₇ H ₂₆ BrO	(C ₆ H ₅) ₃ P ⁺ CH(CH ₃)CH(C ₆ H ₅)OH, Br [−]	H	1967, 359

Formula	Compound	Resonance	Reference
PC ₂₇ H ₂₇	C ₄ H ₉ P[C(C ₆ H ₅)=CH] ₂ CHC ₆ H ₅	H	1967, 112
PC ₂₇ H ₂₇ O ₂	(C ₂ H ₅ O) ₂ P[C(C ₆ H ₅)=CH] ₂ CC ₆ H ₅ (C ₆ H ₅) ₂ P(O)C(C ₆ H ₅)=C=CCH(OCH ₃)(CH ₂) ₄	P H	1968, 75 1969, 164
PC ₂₇ H ₂₈ IO	CH ₃ (C ₆ H ₅) ₂ P ⁺ CH ₂ C(OH)(C ₆ H ₅) ₂ , I ⁻	H; P (20·7)	1967, 329
PC ₂₇ H ₂₉ O ₂	(C ₆ H ₅) ₂ P(O)(C ₆ H ₅)=C=C(CH ₃)CH(OCH ₃)- <i>i</i> -C ₃ H ₇	H	1967, 155
PC ₂₇ H ₃₀ ClO ₄	(C ₆ H ₅) ₃ P ⁺ CHC(C ₃ H ₇)=CC ₃ H ₇ , ClO ₄ ⁻	H	1968, 63
PC ₂₇ H ₃₃ O	(C ₆ H ₅) ₂ P(O)CH ₂ (CH) ₄ C ₉ H ₁₇	H	1966, 267
PC ₂₇ H ₃₇ N ₄ O ₇	(CH ₃ O) ₂ P(O) methyloestrenone	H	1967, 270
PC ₂₇ H ₃₈ ClO ₄	(C ₄ H ₉) ₃ P ⁺ CHC(C ₆ H ₅)=CC ₆ H ₅ , ClO ₄ ⁻	H	1968, 63
PC ₂₇ H ₃₉ N ₄ O ₇	(CH ₃ O) ₂ P(O) hydroxymethyloestrene	H	1967, 270
PC ₂₇ H ₆₀ N ₈ O	[(C ₄ H ₉) ₂ NCH ₂] ₃ PO	H	1967, 291
PC ₂₈ H ₁₈ N ₃	(C ₆ H ₅) ₃ PC(CH) ₃ CC(CN)=C(CN) ₂	H	1967, 377
PC ₂₈ H ₁₉ ClN ₃ O ₄	(C ₆ H ₅) ₃ P ⁺ C(CH) ₃ CC(CN)=C(CN) ₂ , ClO ₄ ⁻	H	1967, 377
PC ₂₈ H ₂₁ F ₂ N ₂ O	(C ₆ H ₅) ₂ P(O)NHC(CH ₂ C ₆ H ₄ F)C(CN)C ₆ H ₄ F	H	1968, 88
PC ₂₈ H ₂₂ NO	(C ₆ H ₅) ₃ P ⁺ CC(O ⁻)N(C ₆ H ₅)C(O)CH ₂	H	1968, 344
PC ₂₈ H ₂₃ N ₂ O	(C ₆ H ₅) ₂ P(O)NHC(CH ₂ C ₆ H ₅)C(CN)C ₆ H ₅	H	1968, 88
PC ₂₈ H ₂₃ O ₂	(C ₆ H ₅) ₃ POC ₁₀ H ₈ O	P (-15·6)	1968, 124
	C ₂ H ₅ (C ₆ H ₅) ₂ POC ₁₄ H ₈ O	P (-9·3)	1968, 303

PC ₂₈ H ₂₃ O ₃	(C ₆ H ₅) ₂ P(O)CH(COC ₆ H ₅)CH ₂ COC ₆ H ₅ C ₂ H ₅ O(C ₆ H ₅) ₂ POC ₁₄ H ₈ O	P (27·5) P (−16·3)	1966, 106 1966, 225
PC ₂₈ H ₂₄ NO ₂	(C ₆ H ₅) ₃ P [⊕] C(COCH ₃)=CO [⊖] NHC ₆ H ₅	H	1967, 365
PC ₂₈ H ₂₅	C ₄ H ₉ P(C ₆ H ₄) ₄	H	1966, 281
PC ₂₈ H ₂₅ O	(C ₆ H ₅) ₃ P=CHCO(CH ₂) ₂ C ₆ H ₅	H	1967, 192
PC ₂₈ H ₂₅ O ₂	(C ₆ H ₅) ₃ P=C(C ₆ H ₅)COOC ₂ H ₅	H	1968, 171
PC ₂₈ H ₂₅ O ₃	C ₂ H ₅ O(C ₆ H ₅) ₂ P[OC(C ₆ H ₅)] ₂	P (−27·0)	1966, 225
PC ₂₈ H ₂₅ O ₄ S	(C ₆ H ₅) ₃ P=CHSO ₂ CH(CH ₃)COOC ₆ H ₅	H	1967, 74
PC ₂₈ H ₂₅ O ₇ S ₂	CH ₃ P(O)(C ₆ H ₄ SO ₂ OC ₆ H ₄) ₂ C(CH ₃) ₂	H	1968, 348
PC ₂₈ H ₂₆ Cl	(C ₆ H ₅) ₃ P [⊕] CH ₂ CH=CHC ₆ H ₄ CH ₃ , Cl [⊖]	H	1966, 276
PC ₂₈ H ₂₆ F ₃ O ₄	(C ₆ H ₅) ₃ P [⊕] CH(COOC ₂ H ₅) ₂ , CF ₃ COO [⊖]	H	1967, 378
PC ₂₈ H ₂₆ N ₃ O ₂	(CH ₂) ₄ NP[N(CH ₃)CH ₂] ₂ OC ₁₇ H ₈ O	P (−35·1)	1968, 303
PC ₂₈ H ₃₁ O ₄	C ₆ H ₅ (C ₄ H ₉ O) ₂ POC ₁₄ H ₈ O	P (−29·6)	1966, 225
PC ₂₈ H ₃₂ Cl	(C ₆ H ₅) ₃ P [⊕] geranyl, Cl [⊖]	H	1968, 346
PC ₂₈ H ₃₃ O ₄	C ₆ H ₅ (C ₄ H ₉ O) ₂ P[OC(C ₆ H ₅)] ₂	P (−36·6)	1966, 225
PC ₂₈ H ₃₄ BrO	(C ₆ H ₅) ₃ P [⊕] CH ₂ CH=C(CH ₃)(CH ₂) ₃ C(CH ₃) ₂ OH, Br [⊖]	H	1968, 346
PC ₂₈ H ₃₉ O ₂	(C ₄ H ₉) ₃ P=C(COC ₆ H ₅)CH ₂ COC ₆ H ₅	H; P (21·3)	1966, 106
PC ₂₈ H ₄₀ ClO ₂	(C ₄ H ₉) ₃ P [⊕] CH(COC ₆ H ₅)CH ₂ COC ₆ H ₅ , Cl [⊖]	P (35·7)	1966, 106
PC ₂₈ H ₄₉ N ₄ S ₂	(C ₆ H ₁₁) ₂ NCNP(S)(C ₂ H ₅)SC[N(C ₆ H ₁₁) ₂]N	P (65·0)	1968, 137
PC ₂₉ H ₂₀ NO ₄	(C ₆ H ₅) ₃ P=CC(O)C(=CHC ₆ H ₆ NO ₂)CO	H; P (1·2)	1968, 110
PC ₂₉ H ₂₃	C ₆ H ₅ P[C(C ₆ H ₅)=CH] ₂ CHC ₆ H ₅	H	1967, 112
PC ₂₉ H ₂₃ O	C ₆ H ₅ P(O)[C(C ₆ H ₅)=CH] ₂ CHC ₆ H ₅	H	1967, 112

Formula	Compound	Resonance	Reference
$\text{PC}_{29}\text{H}_{24}\text{NO}_2$	$(\text{C}_6\text{H}_5)_3\text{P}^+\text{CC}(\text{O}^-)\text{N}(\text{C}_6\text{H}_5)\text{CHCH}_3$	H	1968, 344
$\text{PC}_{29}\text{H}_{25}\text{O}_2$	$\text{C}_6\text{H}_5\text{P}(\text{O})\text{C}(\text{C}_6\text{H}_5)(\text{OH})\text{CHC}(\text{C}_6\text{H}_5)\text{CH}_2\text{CHC}_6\text{H}_5$ $\text{C}_6\text{H}_5\text{P}^-(\text{OH})_2\text{C}(\text{C}_6\text{H}_5)\text{CHC}(\text{C}_6\text{H}_5)\text{CHCC}_6\text{H}_5, \text{H}^+$	H; P (30) H; P (-22)	1966, 283 1966, 283
$\text{PC}_{29}\text{H}_{25}\text{O}_5$	$(\text{CH}_3\text{O})_3\text{P}(\text{OC}_{13}\text{H}_8)_2$	H; P (-46.7)	1967, 335
$\text{PC}_{29}\text{H}_{27}$	$\text{CH}_3\text{P}[\text{C}_6\text{H}_3(\text{CH}_3)]_4$	H(T)	1968, 151
$\text{PC}_{29}\text{H}_{27}\text{O}_4\text{S}$	$(\text{C}_6\text{H}_5)_3\text{P}=\text{C}(\text{CH}_3)\text{SO}_2\text{CH}(\text{CH}_3)\text{COOC}_6\text{H}_5$	H	1967, 74
$\text{PC}_{29}\text{H}_{28}\text{NO}$	$(\text{C}_6\text{H}_5)_3\text{PON}=\text{C}[\text{C}_6\text{H}_2(\text{CH}_3)_3]\text{CH}_2$ $(\text{C}_6\text{H}_5)_3\text{PON}=\text{C}(\text{C}_6\text{H}_5\text{CHCH}_3\text{H}_7)$	H; P (-39.4) H	1967, 139 1968, 343
$\text{PC}_{29}\text{H}_{29}\text{BrNO}$	$(\text{C}_6\text{H}_5)_3\text{P}^+\text{CH}(\text{C}_3\text{H}_7)\text{C}(=\text{NOH})\text{C}_6\text{H}_5, \text{Br}^-$	H	1968, 343
$\text{PC}_{29}\text{H}_{29}\text{O}$	$(\text{CH}_3\text{C}_6\text{H}_4)_2\text{P}(\text{O})\text{CH}(\text{C}_6\text{H}_4\text{CH}_3)\text{CH}_2\text{C}_6\text{H}_5$	H	1967, 376
$\text{PC}_{29}\text{H}_{31}\text{O}_3$	$\text{CH}_3\text{OP}(\text{O})\text{OC}_{27}\text{H}_{26}\text{CH}_2$	H	1967, 270
$\text{PC}_{29}\text{H}_{31}\text{O}_4$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}[\text{C}(\text{C}_6\text{H}_4\text{OCH}_3)=\text{CH}]_2\text{CC}_6\text{H}_5$	P	1968, 75
$\text{PC}_{29}\text{H}_{34}\text{ClO}_4$	$(\text{C}_6\text{H}_5)_3\text{P}^+\text{CHC}(\text{C}_4\text{H}_9)\text{CC}_4\text{H}_9, \text{ClO}_4^-$	H	1968, 63
$\text{PC}_{29}\text{H}_{37}\text{BrN}_3\text{O}_2$	$[(\text{CH}_3)_2\text{N}]_3\text{P}^+\text{C}(\text{CH}_2\text{COC}_6\text{H}_5)\text{C}(\text{C}_6\text{H}_5)\text{OCH}_2\text{C}_6\text{H}_5, \text{Br}^-$	H; P (50.4)	1966, 106
$\text{PC}_{29}\text{H}_{49}\text{O}_3$	$\text{CH}_3(\text{CH}_3\text{O})\text{P}(\text{O})\text{OC}_{27}\text{H}_{43}$	H	1967, 168
$\text{PC}_{29}\text{H}_{50}\text{BrO}_4$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})$ bromoketcholestane	H	1967, 167
$\text{PC}_{29}\text{H}_{51}\text{Br}_2\text{O}_3$	$(\text{CH}_3\text{O})_2\text{PO}$ dibromocholestane	H	1966, 43; 1967, 167
$\text{PC}_{29}\text{H}_{51}\text{O}_3$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})$ cholestene	H	1967, 167
$\text{PC}_{29}\text{H}_{51}\text{O}_4$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})$ epoxycholestane	H	1967, 167
$\text{PC}_{29}\text{H}_{52}\text{BrO}_4$	$(\text{CH}_3\text{O})_2\text{P}(\text{O})$ bromohydroxycholestane	H	1966, 43; 1967, 167
$\text{PC}_{29}\text{H}_{52}\text{IN}_4\text{S}_2$	$(\text{C}_6\text{H}_{11})_2\text{N}^+\text{CNP}(\text{SCH}_3)(\text{C}_2\text{H}_5)\text{SC}[\text{N}(\text{C}_6\text{H}_{11})_2]\text{N}, \text{I}^-$	P (58.8)	1968, 137

PC ₂₉ H ₅₃ O ₃	(CH ₃ O) ₂ P(O) cholestane	H	1967, 167
PC ₂₉ H ₅₃ O ₄	(CH ₃ O) ₂ P(O) hydroxycholestane	H	1967, 167
PC ₂₉ H ₆₂ NS	(C ₂ H ₅) ₂ P(S)CH ₂ N(C ₁₂ H ₂₅) ₂	P (52.2)	1966, 40
PC ₃₀ H ₁₉ ClF ₃ O ₂	(C ₆ H ₅) ₃ P=CC(O)C[C(CF ₃)(C ₆ H ₄ Cl)]CO	P (1.9); F (-57.8)	1968, 110
PC ₃₀ H ₂₀ Cl ₅	(C ₆ H ₄ Cl) ₅ P	P (-86.8)	1968, 288
PC ₃₀ H ₂₀ NO ₂	(C ₆ H ₅) ₃ P=CC(O)C(CHC ₆ H ₄ CN)CO	H; P (0.0)	1968, 110
PC ₃₀ H ₂₀ N ₃	(C ₆ H ₅) ₃ P=C(C ₆ H ₅)C(CN)=C(CN) ₂	H	1965, 115
PC ₃₀ H ₂₁	C ₆ H ₅ P(C ₆ H ₄) ₄	H	1966, 281
PC ₃₀ H ₂₁ O ₃	(C ₆ H ₅) ₃ PCC(O)C(CHC ₆ H ₄ CHO)CO	H	1968, 110
PC ₃₀ H ₂₄ BrO	(C ₆ H ₅) ₃ P ⁺ CH ₂ CO(β-C ₁₀ H ₇), Br ⁻	H	1968, 343
PC ₃₀ H ₂₄ NO	(C ₆ H ₅) ₃ PCH ₂ C(β-C ₁₀ H ₇)=NO	H	1968, 343
PC ₃₀ H ₂₅	P(C ₆ H ₅) ₅	P (-88.7)	1968, 288
PC ₃₀ H ₂₅ As ₂	C ₆ H ₅ P[As(C ₆ H ₅) ₂] ₂	P (36.1)	1969, 14
PC ₃₀ H ₂₅ BrNO	(C ₆ H ₅) ₃ P ⁺ CH ₂ C(=NOH)β-C ₁₀ H ₇ , Br ⁻	H	1968, 343
PC ₃₀ H ₂₅ OSi	(C ₆ H ₅) ₂ POSi(C ₆ H ₅) ₃	P (98.0)	1967, 343
PC ₃₀ H ₂₅ O ₃	(C ₆ H ₅) ₃ P=C(COC ₆ H ₅)C(=CH ₂)COOCH ₃	H	1965, 116
PC ₃₀ H ₂₅ O ₅	P(OC ₆ H ₅) ₅	P (-85.6)	1968, 124
PC ₃₀ H ₂₅ Sn	(C ₆ H ₅) ₂ PSn(C ₆ H ₅) ₃	P (-56)	1967, 337
PC ₃₀ H ₂₆ NSi	(C ₆ H ₅) ₂ PNHSi(C ₆ H ₅) ₃	P	1966, 284
PC ₃₀ H ₂₇ N ₂ O ₃	(C ₆ H ₅) ₂ P(O)NHC(CH ₂ C ₆ H ₄ OCH ₃)C(CN)C ₆ H ₄ OCH ₃	H	1968, 88
PC ₃₀ H ₂₇ N ₄ O ₃	(C ₆ H ₅) ₃ P=NCNN(COOCH ₃)C[OC ₆ H ₃ (CH ₃) ₂]N	P (18.5)	1969, 360
PC ₃₀ H ₂₇ O	(C ₆ H ₅) ₂ P(O)C(C ₆ H ₅)=C=C(CH ₃)CH(CH ₃)C ₆ H ₅	H	1967, 109
PC ₃₀ H ₂₇ O ₃	C ₂ H ₅ O(C ₆ H ₅) ₂ P=C(COC ₆ H ₅)(CH ₂ COC ₆ H ₅)	H; P (54.2)	1966, 106
PC ₃₀ H ₂₈ N ₂ O ₈	(C ₆ H ₅) ₃ P=C(CO ₂ CH ₃)CHC(CO ₂ CH ₃)CH[N(CO ₂ CH ₃)] ₂	H; P (21.5)	1969, 360

Formula	Compound	Resonance	Reference
$PC_{30}H_{29}$	$C_2H_5[C_6H_3(CH_3)_4]$	H(T)	1968, 151
$PC_{30}H_{31}O$	$(C_6H_5)_2P(O)C(C_6H_5)=C=C_{10}H_{16}$	H	1968, 146; 1969, 165
$PC_{30}H_{32}Cl$	$CH_3(t-C_4H_9)(C_6H_5)P^{\oplus}C_6H_4CH(C_6H_5)_2, Cl^{\ominus}$	H	1966, 285
$PC_{30}H_{26}O_4$	$OP(OC_6H_4-t-C_4H_9)_3$	P	1967, 198
$PC_{30}H_{47}O_3$	$HP(O)(OC_6H_4C_9H_{19})_3$	P (8·8)	1967, 277
$PC_{30}H_{47}O_5$	$(i-C_3H_7O)_2P(O)C_{24}H_{32}O_2$	H	1966, 104
$PC_{30}H_{51}O_4$	$CH_3P(O)(OH)O(C_{29}H_{47}O)$	H	1967, 168
$PC_{30}H_{53}O_4$	$CH_3P(O)(OH)O(C_{29}H_{49}O)$	H	1967, 168
$PC_{31}H_{20}F_3$	$C_{13}H_8=P(C_6H_4F)_3$	F	1968, 13
$PC_{31}H_{21}F_3I$	$C_{13}H_9P^{\oplus}(C_6H_4F)_3, I^{\ominus}$	F	1968, 13
$PC_{31}H_{23}$	$CH_3C_6H_4P(C_6H_4)_4$	H	1966, 281
	$C_{13}H_8=P(C_6H_5)_3$	H	1967, 374
$PC_{31}H_{23}O$	$CH_3OC_6H_4P(C_6H_4)_4$	H	1966, 281
$PC_{31}H_{24}N_3O$	$(C_6H_5)_3P=C(C_6H_5)CC(CN)C(O)NCNHCH_3$	H	1965, 115
$PC_{31}H_{25}IN_3O$	$(C_6H_5)_3P=C(C_6H_5)CC(CN)C(O)NCNH_2^{\oplus}CH_3, I^{\ominus}$	H	1965, 115
$PC_{31}H_{25}O$	$(C_6H_5)_2P(O)C_6H_4CH(C_6H_5)_2$	H	1966, 285
$PC_{31}H_{26}Br$	$(C_6H_5)P^{\oplus}CH(C_6H_5)_2, Br^{\ominus}$	P (21·4)	1966, 5
$PC_{31}H_{29}O_7$	$(CH_3O)_3P[OC(C_6H_5)COC_6H_5]_2$	P (-48·0)	1967, 335; 1968, 318
$PC_{31}H_{53}O_4$	$CH_3(CH_2O)P(O)O(\alpha\text{-amyryl})$	H	1967, 168
$PC_{31}H_{54}BrO_5$	$(CH_2O)_2P(O)$ bromoacetoxystereanil	H	1966, 43; 1967, 167
$PC_{31}H_{55}O_4$	$CH_3(CH_2O)P(O)O$ dimethylcholestenyl	H	1967, 168
$PC_{32}H_{23}Br_8O_5$	$(C_2H_5O)_3P(OC_{13}H_4Br_4)_2$	H; P (-48)	1967, 141
$PC_{32}H_{23}N_2$	$(C_6H_5)_3P=C(CH)_3C(C_6H_5)=C(CN)_2$	H	1967, 170
$PC_{32}H_{23}O_2$	$(C_6H_5)_3POC_{14}H_8O$	P (-15·6)	1966, 225; 1968, 303

PC ₃₂ H ₂₃ O ₇	C ₆ H ₅ (C ₆ H ₅ O) ₂ POC ₁₄ H ₈ O	P (−38·1)	1966, 225
PC ₃₂ H ₂₃ O ₅	(C ₆ H ₅ O) ₃ POC ₁₄ H ₈ O	P (−58·7)	1965, 21; 1966, 225; 1968, 301, 309
PC ₃₂ H ₂₄ N ₃ O ₂	(C ₆ H ₅) ₃ P=C(CH) ₃ CH(C ₆ H ₄ NO ₂)CH(CN) ₂	H; P	1967, 377
PC ₃₂ H ₂₄ N ₃ O ₇	(C ₆ H ₅) ₃ P [⊕] CH=CHC ₆ H ₅ , picrate	H	1967, 376
PC ₃₂ H ₂₅ N ₂	(C ₆ H ₅) ₃ P=C(CH) ₃ CH(C ₆ H ₅)CH(CN) ₂	H; P	1967, 377
PC ₃₂ H ₂₅ O ₄	C ₆ H ₅ (C ₆ H ₅ O) ₂ P[OC(C ₆ H ₅)] ₂	P (−43·2)	1966, 225
PC ₃₂ H ₂₅ O ₅	(C ₆ H ₅ O) ₃ P[OC(C ₆ H ₅)] ₂	P (−62·5)	1965, 21; 1966, 225; 1968, 301, 309
PC ₃₂ H ₂₆ NO	(C ₆ H ₅) ₃ P=NC(O)CH(C ₆ H ₅) ₂	H	1965, 109; 1966, 280
PC ₃₂ H ₂₆ NO ₂	(C ₆ H ₅) ₃ P [⊕] C(COCH ₃)=CO [⊖] NHC ₁₀ H ₇	H	1967, 365
PC ₃₂ H ₂₇ ClNO	(C ₆ H ₅) ₃ P [⊕] =NHC(O)CH(C ₆ H ₅) ₂ , Cl [⊖]	H	1965, 109; 1966, 280
PC ₃₂ H ₂₇ O ₅	(C ₆ H ₅) ₃ PCHC(C ₆ H ₅)O[C(COOCH ₃)] ₂	H	1965, 116
PC ₃₂ H ₂₆ NO	(C ₆ H ₅) ₃ PON(C ₆ H ₅)CH(C ₆ H ₅)CH ₂	H; P (−58·6)	1967, 76
PC ₃₂ H ₂₆ O ₅	(C ₆ H ₅) ₃ P=C(COOCH ₃)CH(COOCH ₃)CH ₂ COC ₆ H ₅	H	1965, 116
PC ₃₂ H ₃₁ O ₅	(C ₂ H ₅ O) ₃ P(OC ₁₃ H ₈) ₂	H; P (−49·3)	1967, 335
PC ₃₂ H ₄₄ BrO	(C ₆ H ₅) ₃ CCH ₂ OP [⊕] (C ₄ H ₉) ₃ , Br [⊖]	H	1966, 286
PC ₃₃ H ₂₅ BrNO ₂	(C ₆ H ₅) ₃ P [⊕] C(COC ₆ H ₄ Br)=C(O [⊖])NHC ₆ H ₅	H	1967, 365
PC ₃₃ H ₂₆ ClO ₄	(C ₆ H ₅) ₃ P [⊕] CHC(C ₆ H ₅)CC ₆ H ₅ , ClO ₄ [⊖]	H	1968, 63
PC ₃₃ H ₂₆ NO ₂	(C ₆ H ₅) ₃ P [⊕] C(COC ₆ H ₅)=C(O [⊖])NHC ₆ H ₅	H	1967, 365
PC ₃₃ H ₂₇	(C ₆ H ₅) ₃ P=C ₁₃ H ₆ (CH ₃) ₂	H	1967, 374
PC ₃₃ H ₂₇ N ₂ O	(C ₆ H ₅) ₃ PC(CH) ₃ CH(C ₆ H ₄ OCH ₃)CH(CN) ₂	H; P	1967, 377
PC ₃₃ H ₂₇ O	(C ₆ H ₅) ₃ P=C(C ₆ H ₅)C(O)CH ₂ C ₆ H ₅	H	1967, 139
PC ₃₃ H ₂₉ ClNS	(C ₆ H ₅) ₂ CHC(SCH ₃)NP [⊕] (C ₆ H ₅) ₃ , Cl [⊖]	H	1966, 377
PC ₃₃ H ₃₀ Br	CH ₃ (C ₆ H ₅)P [⊕] (CH ₂ C ₆ H ₅)C ₁₃ H ₁₁ , Br [⊖]	H	1969, 156
	C ₆ H ₅ P [⊕] (CH ₂ C ₆ H ₅) ₂ C ₁₃ H ₁₁ , Br [⊖]	H	1969, 156

Formula	Compound	Resonance	Reference
$\text{PC}_{33}\text{H}_{30}\text{ClSn}$	$(\text{C}_6\text{H}_5)_2\text{PCH}(\text{CH}_2\text{Cl})\text{CH}_2\text{Sn}(\text{C}_6\text{H}_5)_3$	H	1965, 117
$\text{PC}_{33}\text{H}_{33}\text{AlNSi}$	$(\text{CH}_3)_3\text{SiNP}(\text{C}_6\text{H}_5)_2\text{C}_6\text{H}_4\text{Al}(\text{C}_6\text{H}_5)_2$	H	1967, 379
$\text{PC}_{33}\text{H}_{33}\text{GaNSi}$	$(\text{CH}_3)_3\text{SiNP}(\text{C}_6\text{H}_5)_2\text{C}_6\text{H}_4\text{Ga}(\text{C}_6\text{H}_5)_2$	H	1967, 379
$\text{PC}_{33}\text{H}_{34}\text{BrO}_2$	$\text{C}_6\text{H}_5(\text{C}_2\text{H}_5)_2\text{P}^\oplus\text{C}(\text{CH}_2\text{COC}_6\text{H}_5)\text{C}(\text{OCH}_2\text{C}_6\text{H}_5)\text{C}_6\text{H}_5, \text{Br}^\ominus$	H; P (28·0)	1966, 106
$\text{PC}_{33}\text{H}_{63}\text{O}_4$	$(\text{C}_2\text{H}_5\text{O})_2\text{P}(\text{O})\text{O-methyl cholesteryl}$	H	1969, 367
$\text{PC}_{34}\text{H}_{23}\text{F}_2\text{N}_2\text{O}_3$	$(\text{C}_6\text{H}_5)_3\text{PC}[\text{C}(\text{O})\text{NC}_6\text{H}_4\text{F}]_2\text{CO}$	H; P (17·6); F (−114·3)	1968, 110
$\text{PC}_{34}\text{H}_{23}\text{N}_7\text{O}_7$	$(\text{C}_6\text{H}_5)_3\text{PC}[\text{C}(\text{O})\text{NC}_6\text{H}_4\text{NO}_2]_2\text{CO}$	H; P (17·6)	1968, 110
$\text{PC}_{34}\text{H}_{24}\text{N}_3$	$(\text{C}_6\text{H}_5)_3\text{PC}(\text{CH})_3\text{CC}(\text{CN})(\text{C}_6\text{H}_5)\text{CH}(\text{CN})_2$	H	1967, 377
$\text{PC}_{34}\text{H}_{25}\text{N}_2\text{O}_3$	$(\text{C}_6\text{H}_5)_3\text{PC}[\text{C}(\text{O})\text{NC}_6\text{H}_5]_2\text{CO}$	H; P (17·1)	1968, 110
$\text{PC}_{35}\text{H}_{46}\text{BrO}_2$	$(\text{C}_4\text{H}_9)_3\text{P}^\oplus\text{C}(\text{CH}_2\text{COC}_6\text{H}_5)\text{C}(\text{OCH}_2\text{C}_6\text{H}_5)\text{C}_6\text{H}_5, \text{Br}^\ominus$	H; P (28·8)	1966, 106
$\text{PC}_{36}\text{H}_{23}\text{N}_4\text{O}_3$	$(\text{C}_6\text{H}_5)_3\text{PC}[\text{C}(\text{O})\text{NC}_6\text{H}_4\text{CN}]_2\text{CO}$	H; P (18·1)	1968, 110
$\text{PC}_{36}\text{H}_{29}\text{N}_2\text{O}_3$	$(\text{C}_6\text{H}_5)_3\text{PC}[\text{C}(\text{O})\text{NC}_6\text{H}_4\text{CH}]_2\text{CO}$	H; P (17·4)	1968, 110
$\text{PC}_{36}\text{H}_{30}$	$\text{CH}_3(\text{C}_6\text{H}_5)_3\text{P}^\oplus[\text{C}(\text{C}_6\text{H}_5)=\text{CH}]_2\text{C}(\text{C}_6\text{H}_5)_2$	H	1966, 287
$\text{PC}_{36}\text{H}_{30}\text{As}_3$	$\text{P}[\text{As}(\text{C}_6\text{H}_5)_2]_3$	P (−59·1)	1969, 14
$\text{PC}_{36}\text{H}_{75}$	$(\text{C}_{12}\text{H}_{25})_3\text{P}$	H; P (36)	1966, 14
$\text{PC}_{36}\text{H}_{75}\text{O}$	$(\text{C}_{12}\text{H}_{25})_3\text{PO}$	H; P (53)	1966, 14
$\text{PC}_{37}\text{H}_{27}\text{BrNO}_2$	$(\text{C}_6\text{H}_5)_3\text{P}^\oplus\text{C}(\text{COC}_6\text{H}_4\text{Br})=\text{CO}^\ominus\text{NH}-\alpha\text{-C}_{10}\text{H}_7$	H	1967, 365

PC ₃₇ H ₂₈ NO ₂	(C ₆ H ₅) ₃ P ⁺ C(COC ₆ H ₅)=CO [−] NH-α-C ₁₀ H ₇	H	1967, 365
PC ₃₇ H ₃₀ Cl	(C ₆ H ₅) ₃ P ⁺ C ₆ H ₄ C(C ₆ H ₅) ₂ , Cl [−]	H	1966, 285
PC ₃₇ H ₃₅	<i>i</i> -C ₃ H ₇ C ₆ H ₄ P(C ₆ H ₄ CH ₃) ₄	H(T)	1967, 158; 1968, 151
PC ₃₇ H ₇₆ Br	CH ₃ P ⁺ (C ₁₂ H ₂₅) ₃ , Br [−]	H; P (32)	1966, 14
PC ₃₇ H ₇₉ NOS	C ₁₈ H ₃₇ (CH ₃) ₂ P=N=S(O)CH ₃ (C ₁₆ H ₃₃)	H	1967, 357
PC ₃₈ H ₂₆ Cl ₂ N ₂	(C ₆ H ₅) ₂ CHC(NC ₆ H ₃ Cl ₂)N=P(C ₆ H ₅) ₃	H	1966, 247
PC ₃₈ H ₃₀ ClO	(C ₆ H ₅) ₃ P ⁺ OC(C ₆ H ₅)C(C ₆ H ₅) ₂ , Cl [−]	H; P (63)	1965, 109
PC ₃₈ H ₃₀ Cl ₃ N ₂	(C ₆ H ₅) ₃ P ⁺ NC(NHC ₆ H ₃ Cl ₂)CH(C ₆ H ₅) ₂ , Cl [−]	H	1966, 247
PC ₃₈ H ₃₀ N ₃ O ₂	(C ₆ H ₅) ₃ P=NC(NC ₆ H ₄ NO ₂)CH(C ₆ H ₅) ₂	H	1966, 247
PC ₃₈ H ₃₁	C ₁₀ H ₇ P[C ₆ H ₃ (CH ₃)] ₄	H(T)	1966, 101; 1968, 151
PC ₃₈ H ₃₁ CIN ₃ O ₂	(C ₆ H ₅) ₃ P ⁺ NC(NHC ₆ H ₄ NO ₂)CH(C ₆ H ₅) ₂ , Cl [−]	H	1966, 247
PC ₃₈ H ₃₁ N ₂	(C ₆ H ₅) ₃ P=NC(NC ₆ H ₅)CH(C ₆ H ₅) ₂	H	1966, 247
PC ₃₈ H ₃₁ Sn	(C ₆ H ₅) ₂ PC(CH ₂ Cl)=CHSn(C ₆ H ₅) ₃	H	1965, 117
PC ₃₈ H ₃₂ CIN ₂	(C ₆ H ₅) ₃ P ⁺ NC(NHC ₆ H ₅)CH(C ₆ H ₅) ₂ , Cl [−]	H	1966, 247
PC ₃₈ H ₃₂ NO	(C ₆ H ₅) ₃ PON(C ₆ H ₅)CH(C ₆ H ₅)CHC ₆ H ₅	H; P (−57.9)	1967, 76
PC ₃₈ H ₃₃ Sn	(C ₆ H ₅) ₂ PCH(C ₆ H ₅)CH ₂ Sn(C ₆ H ₅) ₃	H	1965, 117
PC ₃₉ H ₃₂ N	(C ₆ H ₅) ₃ P=C(C ₆ H ₅)C(CH ₂ C ₆ H ₅)=NC ₆ H ₅	H; P (11)	1967, 139, 375
PC ₃₉ H ₃₉ AlNSi	(C ₆ H ₅) ₃ PN[Al(C ₆ H ₅) ₃]Si(CH ₃) ₃	H	1967, 379
PC ₃₉ H ₃₉ GaNSi	(C ₆ H ₅) ₃ PN[Ga(C ₆ H ₅) ₃]Si(CH ₃) ₃	H	1967, 379
PC ₃₉ H ₇₂ N ₃ O	[(C ₆ H ₁₁) ₂ NCH ₂] ₃ PO	H	1967, 291
PC ₄₀ H ₃₃	C ₄ H ₄ P[C ₆ H ₃ (CH ₃)] ₄	H(T)	1966, 101; 1968, 151
PC ₄₀ H ₃₆ N ₃	(C ₆ H ₅) ₃ P=NC[NC ₆ H ₄ N(CH ₃) ₂]CH(C ₆ H ₅) ₂	H	1966, 280
PC ₄₀ H ₃₇ CIN ₃	(C ₆ H ₅) ₃ P ⁺ NC[NHC ₆ H ₄ N(CH ₃) ₂]CH(C ₆ H ₅) ₂ , Cl [−]	H	1966, 280
PC ₄₁ H ₃₄ BrO ₂	(C ₆ H ₅) ₃ P ⁺ C(CH ₂ COC ₆ H ₅)C(OCH ₂ C ₆ H ₅)C ₆ H ₅ , Br [−]	H; P (20.9)	1966, 106
PC ₄₁ H ₅₉ O ₃	(C ₆ H ₅ CH ₂ O) ₂ P(O) cholesteryl	H	1967, 167
PC ₄₂ H ₃₃	C ₁₄ H ₉ P[C ₆ H ₃ (CH ₃)] ₄	H(T)	1966, 101

Formula	Compound	Resonance	Reference
$\text{PC}_{42}\text{H}_{35}\text{Sn}_2$	$\text{C}_6\text{H}_5\text{P}[\text{Sn}(\text{C}_6\text{H}_5)_3]_2$	P (−163)	1967, 337; 1969, 324
$\text{PC}_{42}\text{H}_{38}\text{N}$	$(\text{C}_6\text{H}_5)_3\text{P}=\text{C}[\text{C}_6\text{H}_2(\text{CH}_3)_3]\text{C}(\text{O})\text{CH}_2\text{C}_6\text{H}_5$	H; P (11·5)	1967, 139
$\text{PC}_{45}\text{H}_{69}\text{O}_3$	$\text{P}(\text{OC}_6\text{H}_4\cdot\text{C}_9\text{H}_{19})_3$	P (141·0)	1967, 277
$\text{PC}_{45}\text{H}_{69}\text{O}_3\text{S}$	$\text{SP}(\text{OC}_6\text{H}_4\cdot\text{C}_9\text{H}_{19})_3$	P (74·0)	1967, 277
$\text{PC}_{45}\text{H}_{69}\text{O}_4$	$\text{OP}(\text{OC}_6\text{H}_4\cdot\text{C}_9\text{H}_{19})_3$	P (−4·3)	1967, 277
$\text{PC}_{47}\text{H}_{37}\text{N}_2$	$[(\text{C}_6\text{H}_5)_2\text{N}]_2\text{P}[\text{C}(\text{C}_6\text{H}_5)=\text{CH}]_2\text{CC}_6\text{H}_5$	H; P (29·5)	1969, 145
$\text{PC}_{48}\text{H}_{31}\text{N}_2\text{Si}_2$	$(\text{C}_6\text{H}_5)_3\text{SiNHP}(\text{C}_6\text{H}_5)_2=\text{NSi}(\text{C}_6\text{H}_5)_3$	P	1966, 284
$\text{PC}_{54}\text{H}_{45}\text{Sn}_3$	$\text{P}[\text{Sn}(\text{C}_6\text{H}_5)_3]_3$	P (−323)	1967, 337; 1969, 14
P₂			
$\text{P}_2\text{CH}_2\text{O}_6$	$\text{CH}_2(\text{PO}_3^{2-})_2$	P (15·4)	1967, 123
$\text{P}_2\text{CH}_3\text{Cl}_4\text{N}$	$\text{CH}_3\text{N}(\text{PCl}_2)_2$	H; P	1967, 96; 1968, 89; 1969, 370
$\text{P}_2\text{CH}_3\text{Cl}_4\text{N}_3\text{O}_2\text{S}$	$\text{CH}_3\text{C}(\text{PCl}_2=\text{N})_2\text{SO}_2$	P (15·1)	1966, 98
$\text{P}_2\text{CH}_3\text{F}_4\text{N}$	$\text{CH}_3\text{N}(\text{PF}_2)_2$	H; P (141·5); F (−74·6)	1967, 96; 1968, 89; 1969, 31, 61, 370
$\text{P}_2\text{CH}_4\text{Cl}_2\text{O}_6$	$\text{CCl}(\text{PO}_3\text{H}_2)_2$	P (7·9)	1967, 12, 380; 1968, 349
$\text{P}_2\text{CH}_4\text{Na}_2\text{O}_7$	$\text{CH}(\text{PO}_3\text{NaH})_2\text{OH}$	P (15·0)	1967, 380
$\text{P}_2\text{CH}_4\text{Na}_2\text{O}_8$	$\text{C}(\text{PO}_3\text{NaH})_2(\text{OH})_2$	P (14·5)	1967, 380
$\text{P}_2\text{CH}_4\text{O}_7$	$\text{O}=\text{C}(\text{PO}_3\text{H}_2)_2$	P (13·0)	1967, 12
P_2CH_6	$\text{CH}_2(\text{PH}_2)_2$	H; P (−122; −126)	1965, 118; 1966, 15, 16

$P_2CH_6O_6$	$CH_2(PO_3H_2)_2$	H; P (17 to 18)	1967, 12, 371; 1968, 56, 349; 1969, 332
$P_2CH_6O_7$	$CH(PO_3H_2)_2OH$	P (16.1)	1967, 12
$P_2CN_4O_7$	$OC(PO_3Na_2)_2$	P (0.0)	1967, 380
$P_2C_2H_4F_4O_2$	$(F_2POCH_2)_2$	F (-49.0)	1963, 3
$P_2C_2H_4O_6$	$(CH_2PO_3^-)_2$	P (23.2)	1967, 7
$P_2C_2H_5Cl_4N$	$C_2H_5N(PCl_2)_2$	H; P	1967, 96; 1968, 89
$P_2C_2H_5F_4N$	$C_2H_5N(PF_2)_2$	H; P (145.3); F (-72.5)	1968, 89; 1969, 60, 61
$P_2C_2H_6BCl_6N_3$	$N_3P_2Cl_6B(CH_3)_2$	P (28)	1968, 136
$P_2C_2H_6BaO_8$	$[(CH_3O)_2PO^-]_2, Ba^{2+}$	H	1967, 90
$P_2C_2H_6Cl_2N_2O_2$	$[CH_3NP(O)Cl]_2$ (isom.)	H; P (-3; 0)	1966, 53
$P_2C_2H_6Cl_2N_2S_2$	$[CH_3NP(S)Cl]_2$	P (51.5)	1966, 83
$P_2C_2H_6Cl_6N_2$	$(CH_3NPCl_3)_2$	H; P (-77.5)	1965, 98; 1966, 53, 83, 288; 1968, 136
$P_2C_2H_6F_6N_2$	$(CH_3NPF_3)_2$	H; P (-70); F (-79)	1966, 79; 1967, 59; 1968, 57; 1969, 65
$P_2C_2H_6O_7$	$(CH_3O)_2P_2O_5^{2-}$	^{13}C ; P (-2.7)	1968, 3
$P_2C_2H_8$	$(CH_2PH_2)_2$	H; P (-130.8)	1965, 118; 1966, 147
$P_2C_2H_8O_6$	$(CH_2PO_3H_2)_2$	H; P (27.4)	1967, 371; 1969, 332
	$CH_3CH(PO_3H_2)_2$	P (22.6)	1967, 12; 1968, 349
$P_2C_2H_8O_7$	$CH_3C(OH)(PO_3H_2)_2$	P (19.8)	1967, 12
	$(CH_3OPO_2H)_2O$	H	1968, 57
$P_2C_2H_{10}Ge$	$(CH_3)_2Ge(PH_2)_2$	H	1969, 136
$P_2C_2H_{10}Si$	$(CH_3)_2Si(PH_2)_2$	H	1969, 136
$P_2C_2H_{16}ClN_7$	$(NH_2)_3P=NP(NH_2)(NHCH_3)_2Cl$	P (16.5)	1967, 285
$P_2C_3H_6Cl_4O_2$	$(CH_3)_2C[P(O)Cl_2]_2$	H; P (45.1)	1966, 15
$P_2C_3H_6F_3$	$CF_3P=P^+(CH_3)_2$	H{P, F}	1967, 40
$P_2C_3H_6O_3$	$P(OCH_2)_3P$	H(^{13}C , P)	1966, 37; 1969, 3

Formula	Compound	Resonance	Reference
$P_2C_3H_6O_5$	$OP(OCH_2)_3PO$	H	1966, 37
$P_2C_3H_6O_6$	$(CH_2)_3(PO_3^{2-})_2$	P (22.4)	1967, 7
$P_2C_3H_6O_6$	$CH_2=CHCH_2(PO_3H_2)_2$	P (20.5)	1968, 349
$P_2C_3H_6O_8$	$CH(CH_2COOH)(PO_3H_2)_2$	P (20.0)	1968, 349
$P_2C_3H_9ClO_4$	$CH_3(CH_3O)P(O)(CH_3)P(O)Cl$	H; P	1967, 186
$P_2C_3H_6O_9$	$CH(CH_2PO_3H_2)_2$	P (24.19)	1968, 349
$P_2C_3H_{10}$	$(CH_3)_2C(PH_2)_2$	H; P (-74)	1966, 15
	$(CH_2)_3(PH_2)_2$	H; P (-138.6)	1965, 118; 1966, 16
$P_2C_3H_{10}ClFNSi$	$(CH_3)_3SiNHP(S)ClF$	H; P (68.4); F (73.4)	1969, 69
$P_2C_3H_{10}F_2NSSi$	$(CH_3)_3SiNHP(S)F_2$	H; P (66.6); F (40.2)	1969, 69
$P_2C_3H_{10}O_6$	$(CH_3)_2C(PO_3H_2)_2$	P (27)	1967, 12; 1968, 349
$P_2C_3H_{10}O_7$	$(CH_3O)_2P(O)O(CH_3O)PO_2H$	H; P	1966, 138
$P_2C_3H_{11}NO_6$	$CH_3N(CH_2PO_3H_2)_2$	H; P (ca. 9)	1966, 212
$P_2C_4F_8I_2$	$[(CF_2)_2PI]_2$	F	1962, 2
$P_2C_4F_{12}S_2$	$(CF_3)_2P(S)SP(CF_3)_2$	F (-58.9; -53.8)	1969, 57
$P_2C_4H_6Cl_4N_4O_2$	$[Cl_2PNN=C(CH_3O)]_2$	H; P (-52.7)	1969, 149
$P_2C_4H_6F_6$	$(CH_3)_2PP(CF_3)_2$	H; P (-56; 12.1); F (-47.4)	1967, 28, 40; 1968, 55
$P_2C_4H_9F_3$	$(CH_3)_3PPCF_3$	H; P; F	1967, 28
$P_2C_4H_{10}Cl_2F_4N_2$	$(CH_3NPF_2CH_2Cl)_2$	H	1966, 36
$P_2C_4H_{10}Cl_2N_2O_2$	$[C_2H_5NP(O)Cl]_2$ (isom.)	H; P (-5.7; -3.1)	1966, 53
$P_2C_4H_{10}Cl_6N_2$	$(C_2H_5N=PCl_3)_2$	H; P (-79.0)	1965, 98; 1966, 53, 288
$P_2C_4H_{10}F_2S_4Zn$	$Zn[SP(S)F(C_2H_5)]_2$	H; F (-49.7)	1968, 350
$P_2C_4H_{10}K_2$	$[P(C_2H_5)K]_2$	P (-79.6)	1965, 27

$P_2C_4H_{12}$	$(CH_2)_4(PH_2)_2$ $[(CH_3)_2P]_2$	P (-138) ^{13}C ; H{P, ^{13}C }	1965, 11; 1966, 16 1967, 28, 54, 83, 124, 125; 1968, 22, 57, 113
$P_2C_4H_{12}BaO_8$	$[(CH_3O)_2P(O)O^-]_2, Ba^{2+}$	H	1969, 95
$P_2C_4H_{12}Cl_2O_6$	$[(CH_3O)_2PO]_2CCl_2$	H; P (10.0)	1968, 349
$P_2C_4H_{12}F_6O_3$	$CH_3(CH_3O)_3P^+, PF_6^-$	H; P; F	1965, 43
$P_2C_4H_{12}NNaS_2$	$[(CH_3)_2P(S)]_2^+N, Na^+$	H; P (43.8)	1968, 111
$P_2C_4H_{12}N_2O_2S_2$	$[CH_3SP(O)NCH_3]_2$	H	1966, 53
$P_2C_4H_{12}N_4O_2$	$[(CH_3)_2NP(O)N]_2$	P (18.7)	1965, 78
$P_2C_4H_{12}O$	$O(CH_2CH_2PH_2)_2$	H	1969, 44
$P_2C_4H_{12}O_4S_3$	$[(CH_3O)_2P(S)]_2S$	P (83.5)	1966, 218
$P_2C_4H_{12}O_4S_4$	$[(CH_3O)_2P(S)]_2S_2$	P (83.5)	1966, 218
$P_2C_4H_{12}O_5$	$[CH_3(CH_3O)P(O)]_2O$	H; P	1967, 186
$P_2C_4H_{12}O_6$	$[(CH_3O)_2P(O)]_2$	H	1967, 381; 1968, 57
$P_2C_4H_{12}O_7$	$[(CH_3O)_2P(O)]_2O$	H	1967, 381
$P_2C_4H_{12}S$	$(CH_3)_2P(S)P(CH_3)_2$	H; P	1967, 28; 1968, 113
$P_2C_4H_{12}S_2$	$[(CH_3)_2P(S)]_2$	H	1965, 28; 1968, 113
$P_2C_4H_{13}NO_6$	$C_2H_5N(CH_2PO_3H_2)_2$	H; P (ca. 8)	1967, 315
$P_2C_4H_{14}N_4S_2$	$[CH_3NHP(S)NCH_3]_2$	P (60)	1966, 83
$P_2C_4H_{20}ClN_7$	$[C_2H_5NHP(NH_2)_2]_2N^+, Cl^-$	P (ca. 15)	1966, 288
	$C_2H_5NHP(NH_2)_2^+NHP(NH_2)_2=NC_2H_5, Cl^-$	P	1966, 288
$P_2C_4H_{20}N_7$	$C_2H_5NHP(NH_2)_2NHP(NH_2)=NH(NHC_2H_5)$	P	1966, 288
$P_2C_5H_3BF_{12}O_2$	$CH_3B[OP(CF_3)_2]_2$	^{11}B ; H; P (81.3); F (-67.5)	1969, 27
$P_2C_5H_6Cl_5O_2$	$C_4H_9CCl[P(O)Cl_2]_2$	H; P (32.9)	1966, 15
$P_2C_5H_{10}Cl_4O_2$	$C_4H_9CH[P(O)Cl_2]_2$	H; P (34.6)	1966, 15
$P_2C_5H_{12}$	$C_5H_{10}PH_2$	P (-139)	1966, 15
$P_2C_5H_{13}NaO_6$	$[(CH_3O)_2P(O)]_2CH^-, Na^+$	H; P (45.5)	1967, 371; 1968, 349
$P_2C_5H_{13}N_3$	$N[(CH_3)_2PN]_2CH$	H; P (27.1)	1967, 355; 1968, 94

Formula	Compound	Resonance	Reference
$P_2C_5H_{14}$	$C_4H_9CH(PH_2)_2$	H; P (-109)	1966, 15
$P_2C_5H_{14}O_6$	$C_4H_9CH(PO_3H_2)_2$	P (23·3)	1966, 15; 1968, 349
	$[(CH_3O)_2P(O)]_2CH_2$	H; P (23·0)	1967, 371; 1968, 349
$P_2C_5H_{15}NS_2$	$(CH_3)_2P(S)N=P(SCH_3)(CH_3)_2$	H; P (45·3; 34·6)	1968, 111
$P_2C_5H_{19}N_5S_2$	$[(CH_3NH)_2P(S)]_2NCH_3$	P (73)	1966, 83
$P_2C_6H_4ClF_4N$	$C_6H_4Cl(PF_2)_2$	P (131·3); F (-68·1)	1969, 61
$P_2C_6H_4F_4O_2$	$C_6H_4(OPF_2)_2$	F (-44·9)	1963, 3
$P_2C_6H_5Cl_3FNS$	$C_6H_5PCl_2=NP(S)ClF$	P (20·6; 49·1); F (75·9)	1969, 69
$P_2C_6H_5F_4N$	$C_6H_5(PF_2)_2$	P (132·7); F (-68·2)	1969, 61
$P_2C_6H_6B_2Cl_4F_{12}N_2$	$[(CF_3)_2PN(CH_3)BCl_2]_2$	^{11}B ; P	1968, 24
$P_2C_6H_{12}O_6$	$[(CH_2O)_2POCH_2]_2$	P (134)	1968, 154
$P_2C_6H_{14}Cl_2N_2O_2$	$[C_3H_7NP(O)Cl]_3$ (isom.)	H; P (-2·4; -1·1)	1966, 53
$P_2C_6H_{14}Cl_6N_2$	$(C_3H_7NPCl_3)_2$	H; P (-79)	1965, 98; 1966, 53, 288
$P_2C_6H_{14}O_6$	$[(CH_3O)_2P(O)CH]_2$	H	1967, 128
$P_2C_6H_{15}ClF_6$	$(C_2H_5)_3P^{\oplus}Cl, PF_6^{\ominus}$	F	1967, 382
$P_2C_6H_{15}ClO_5$	$(CH_3O)_2P(O)CH_2P(OC_2H_5)CH_2Cl$	P (21·7; 38·9)	1969, 332
$P_2C_6H_{15}Li$	$(C_2H_5)_2PP(C_2H_5)Li$	P (-17·1; -112·8)	1965, 27
$P_2C_6H_{15}N_3$	$N[P(CH_3)_2N]_2CCH_3$	H; P (29·9)	1968, 94
$P_2C_6H_{15}N_3O_4$	$CH_3C[NP(OCH_3)_2]_2N$	H; P (26·6)	1969, 106
$P_2C_6H_{16}$	$[CH_3(C_2H_5)P]_2$	P (-46·2)	1968, 11
	$(CH_3)_3P=CHP(CH_3)_2$	H	1968, 107
$P_2C_6H_{16}ClN_3$	$N[P(CH_3)_2N]_2^{\oplus}CCH_3, Cl^{\ominus}$	H; P (36·4)	1968, 94
$P_2C_6H_{16}F_4N_2$	$[CH_3NPF_2C_2H_5]_2$	H	1966, 36
$P_2C_6H_{16}F_6S_2$	$(CH_3)_2P^{\oplus}(CH_2SCH_3)_2, PF_6^{\ominus}$	H	1969, 128

$P_2C_6H_{16}N_2O_4$	$[(CH_2)_2NCH_2PO_2H_2]_2$	P (9.5)	1967, 301
$P_2C_6H_{16}O_6$	$[(CH_3O)_2P(O)CH_2]_2$	H	1967, 371
$P_2C_6H_{16}O_7$	$(CH_3O)_2P(O)OCH(CH_3)P(O)(OCH_3)_2$	H; P (1.1; 22.3)	1967, 178
$P_2C_6H_{18}Al_2Br_4N_2$	$[(CH_3)_3PNAIBr_2]_2$	H	1967, 176
$P_2C_6H_{18}Br_3N_3OS$	$[(CH_3)_2N]_3P^{\oplus}OP(S)Br_2, Br^{\ominus}$	P (47.6; -89.0)	1969, 368
$P_2C_6H_{18}Cl_3N_3OS$	$[(CH_3)_2N]_3P^{\oplus}OP(S)Cl_2, Cl^{\ominus}$	P (53.7; 40.1)	1969, 368
$P_2C_6H_{18}Cl_3N_3O_2$	$[(CH_3)_2N]_3P^{\oplus}OP(O)Cl_2, Cl^{\ominus}$	P (55.8; -9.1)	1969, 368
$P_2C_6H_{18}F_6N_2$	$CH_3PF_5^{\ominus}, CH_3P^{\oplus}F[N(CH_3)_2]_2$	H; P (-126.8; 70.9); F (-82.2; -57.5; -46.4)	1966, 228
$P_2C_6H_{18}INS_2$	$[CH_3SP(CH_3)_2]_2N^{\oplus}, I^{\ominus}$	H; P (43.5)	1968, 111
$P_2C_6H_{18}N_4O_2$	$[CH_3NP(O)N(CH_3)_2]_2$	H; P (7.0)	1966, 53
$P_2C_6H_{18}N_4S_2$	$\{[(CH_3)_2N]_2P(S)NCH_3\}_2$	P (62)	1966, 83
$P_2C_6H_{18}N_6$	$P[N(CH_3)N(CH_3)]_3P$	H	1967, 371; 1968, 57
$P_2C_6H_{18}N_6O_2$	$OP[N(CH_3)N(CH_3)]_3PO$	H	1967, 371
$P_2C_6H_{18}N_6S_2$	$SP[N(CH_3)N(CH_3)]_3PS$	H	1967, 371; 1968, 57
$P_2C_6H_{20}BF_6IN$	$[(CH_3)_3P(CH_3)_3NBH_2]^{\oplus}, PF_6^{\ominus}$	^{11}B ; H	1969, 26
$P_2C_6H_{24}ClN_7$	$[C_3H_7NHP(NH_2)_2]_2N^{\oplus}, Cl^{\ominus}$	P (ca. 15)	1966, 288
$P_2C_6H_{24}N_7$	$C_3H_7NHP(NH_2)_2NHP(NH_2)_2(=NH)NHC_3H_7$	P (ca. 15)	1966, 288
$P_2C_7H_5Cl_4N_3$	$C_6H_5C(NPCl_2)_2N$	P (41.6)	1969, 106
$P_2C_7H_{10}O_6$	$C_6H_5CH_2(PO_3H_2)_2$	P (21.0)	1968, 349
$P_2C_7H_{18}Cl_2$	$CH_3P(Cl)P(C_2H_5)_3, Cl$	H	1969, 344
$P_2C_7H_{18}I_2$	$(CH_3)_2C[P(CH_3)_2]_2^{\oplus}, 2I^{\ominus}$	H	1968, 351
$P_2C_7H_{18}H_4$	$N[P(CH_3)_2N]_2CN(CH_3)_2$	H; P (31.3)	1968, 94
$P_2C_7H_{21}NO_4$	$(CH_3O)(C_2H_5)_2P=NP(O)(OCH_3)_2$	P (2; 53)	1969, 371
$P_2C_8H_2F_{18}$	$CF_3CH_2C[CF_3]_2CF_3$	H; F	1967, 103
$P_2C_8H_{10}O_4$	$HOP(O)CHCH(CH=CHPO_2H)CHCHCH=CH$	H	1969, 146
$P_2C_8H_{12}F_4$	$[(CH_3)_2PCF_2]_2$	H; F (-109.6)	1967, 331

Formula	Compound	Resonance	Reference
$P_2C_8H_{18}Cl_2N_2$	$[(CH_3)_3CNPCl]_2$	H	1969, 112
$P_2C_8H_{18}Cl_6N_2$	$[C_4H_9N=PCl_3]_2$	H; P (-79.3)	1965, 98; 1966, 288
$P_2C_8H_{18}N_4O_2$	$[(CH_3)_2NPN(COCH_3)]_2$	H; P (154)	1968, 126
	$[OC(CH_3)=NNP(CH_3)_2]_2$	H; P (-425)	1969, 149
$P_2C_8H_{18}O_8$	$[(CH_3O)_2P(O)OC(CH_3)]_2$	H; P (-2.8; -4.1)	1968, 309
	$(CH_3O)_2P(O)OC(CH_3)(COCH_3)P(O)(OCH_3)_2$	P (-6.9; 19.7)	1968, 309
$P_2C_8H_{20}$	$[(C_2H_5)_2P]_2$	P (-34.2)	1965, 11; 1967, 126
$P_2C_8H_{20}BaO_8$	$[(C_2H_5O)_2PO_2^-]_2, Ba^{2+}$	H	1967, 90
$P_2C_8H_{20}Cl_2S_4Sn$	$Cl_2Sn[S(S)P(C_2H_5)_2]_2$	H	1967, 177
$P_2C_8H_{20}F_6N_2$	$C_2H_5[CH_2N(CH_3)]_2P^+F, C_2H_5PF_5^-$	P (76.7; -126.5); F (-67.1; -57.4; -56.0)	1968, 352
$P_2C_8H_{20}O_4S_2$	$[(C_2H_5O)_2P(S)]_2$	H; P (-37.2)	1967, 127
$P_2C_8H_{20}O_4S_3$	$[(C_2H_5O)_2P(S)]_2S$	P (78.0)	1966, 218
$P_2C_8H_{20}O_4S_4$	$[(C_2H_5O)_2P(S)S]_2$	P (84.0)	1966, 218
$P_2C_8H_{20}O_5S$	$(C_2H_5O)_2P(S)OP(OC_2H_5)_2$	H; P (-56.1; 16.0)	1967, 127
	$(C_2H_5O)_2P(S)P(O)(OC_2H_5)_2$	H; P (-39.5; -106.7)	1967, 127; 1968, 113
$P_2C_8H_{20}O_5S_2$	$[(C_2H_5O)_2P(S)]_2O$	H; P (-60.1)	1967, 127; 1968, 25, 284
	$(C_2H_5O)_2P(S)SP(O)(OC_2H_5)_2$	H; P (-34.0; -98.4)	1967, 127
$P_2C_8H_{20}O_6$	$[(C_2H_5O)_2P(O)]_2$	H; P (-105.8)	1967, 127, 381
	$(C_2H_5O)_2P(O)OP(OC_2H_5)_2$	H; P (-122; 15.2)	1967, 127
$P_2C_8H_{20}O_6S$	$(C_2H_5O)_2P(S)OP(O)(OC_2H_5)_2$	H; P (-58.4; -126.4)	1967, 127
$P_2C_8H_{20}O_7$	$[(C_2H_5O)_2P(O)]_2O$	H; P (-11 to -16)	1967, 69, 185, 381; 1968, 282

$P_2C_8H_{20}S_4Zn$	$Zn[SP(S)(C_2H_5)_2]_2$	H; P (-125)	1967, 127
$P_2C_8H_{21}Cl$	$(C_2H_5)_3PP(CH_3)_2Cl$	H	1967, 177
$P_2C_8H_{22}Si$	$[(C_2H_5)_2P]_2SiH_2$	H; P (-42.2; 37.7)	1969, 344
$P_2C_8H_{24}N_2O_3$	$[(CH_3)_2N]_2P(O)]_2O$	H	1967, 182
$P_2C_8H_{24}N_2Si$	$[(CH)_3PN]_2Si(CH_3)_2$	H	1968, 284
$P_2C_8H_{28}ClN_7$	$[C_4H_9NHP(NH_2)_2]_2N^{\oplus}, Cl^{\ominus}$	H	1967, 316
$P_2C_8H_{28}N_7$	$C_4H_9NHP(NH_2)_2NHP(NH_2)(=NH)NHC_2H_5$	P (ca. 15)	1966, 288
$P_2C_9H_{20}Br_2O_6$	$[(C_2H_5O)_2P(O)]_2CBr_2$	P (ca. 15)	1966, 288
$P_2C_9H_{20}Cl_2O_6$	$[(C_2H_5O)_2P(O)]_2CCl_2$	H; P (8.5)	1968, 349
$P_2C_9H_{21}NaO_6$	$[(C_2H_5O)_2P(O)]_2CH^{\oplus}, Na^{\ominus}$	H; P (8.5)	1968, 349
$P_2C_9H_{21}N_3O_3$	$[CH_3N(CH_2)_2OP]_2(OCH_2CH_2)NCH_3$	H; P (41.5)	1967, 371; 1968, 349
		H; P	1968, 349
$P_2C_9H_{22}$	$(C_4H_9)_2C(PH_2)_2$	H; P (-91)	1966, 15
$P_2C_9H_{22}O_4S_4$	$[(C_2H_5O)_2P(S)S]_2CH_2$	H	1968, 284, 285; 1969, 322
$P_2C_9H_{22}O_6$	$[(C_2H_5O)_2P(O)]_2CH_2$	H; P (19.0)	1967, 371; 1968, 56, 349; 1969, 332
	$(PO_3H_2)_2C(C_4H_9)_2$	P (26.0)	1968, 349
$P_2C_9H_{24}Si$	$(CH_3)_3PC[P(CH_3)_2]Si(CH_3)_3$	H	1968, 107
$P_2C_9H_{26}N_4O_2$	$\{[(CH_3)_2N]_2P(O)\}_2CH_2$	H	1969, 372
$P_2C_{10}H_{10}N_2S_5$	$[C_5H_5N^{\oplus}P(S)S^{\ominus}]_2S$	P (105.5)	1967, 126
$P_2C_{10}H_{13}NaO_4$	$NaOP(O)CHCH(CH=CHP(O)OC_2H_5)CHCHCH=CH$	P (78)	1969, 146
$P_2C_{10}H_{14}O_4$	$HOP(O)CHCH[CH=CHP(O)OC_2H_5]CHCH=CH$	H	1969, 146
$P_2C_{10}H_{15}Li$	$C_2H_5(C_6H_5)PP(C_2H_5)Li$	H	1968, 113
$P_2C_{10}H_{16}O_6S_2$	$[(CH_3O)_2P(S)O]_2C_6H_4$	H	1968, 284, 285

Formula	Compound	Resonance	Reference
$P_2C_{10}H_{20}O_4S_3$	$[(CH_3)_2C(CH_2O)_2P(S)]_2S$	H	1967, 91
$P_2C_{10}H_{20}O_5S_2$	$[(CH_3)_2C(CH_2O)_2P(S)]_2O$	H	1967, 91
	$(CH_3)_2C(CH_2O)_2P(S)SP(O)(COCH_2)_2C(CH_3)_2$	H	1967, 91
$P_2C_{10}H_{20}O_6$	$[(C_2H_5O)_2P(O)C]_2$	H	1965, 90
$P_2C_{10}H_{20}O_6S$	$(CH_3)_2C(CH_2O)_2P(O)OP(S)(OCH_2)_2C(CH_3)_2$	H; P (-24; 44)	1967, 91
$P_2C_{10}H_{20}O_7$	$[(CH_3)_2C(CH_2O)_2P(O)]_2O$	H	1967, 91
$P_2C_{10}H_{22}Cl_6N_2$	$[C_5H_{11}N=PCl_3]_2$	H; P (-78)	1966, 288
$P_2C_{10}H_{22}O_6$	$[(C_2H_5O)_2P(O)CH]_2$	H	1967, 383
$P_2C_{10}H_{23}Cl_2N_5$	$CH_3C=NPCL_2=NP(NH-t-C_4H_9)_2=N$	H; P (39.3; 10.3)	1969, 106
$P_2C_{10}H_{24}$	$C_9H_{19}CH(PH_2)_2$	P (-105)	1966, 15
$P_2C_{10}H_{24}O_6$	$[(C_2H_5O)_2P(O)CH_2]_2$	H; P (26.8)	1967, 371, 384; 1968, 143; 1969, 322
$P_2C_{10}H_{25}NO_3$	$(C_2H_5)_3P=NP(O)(OC_2H_5)_2$	P (1.3; 32)	1969, 371
$P_2C_{10}H_{25}NO_4$	$(C_2H_5)_3P=NP(O)(C_2H_5)_2$	P (0; 29)	1969, 371
	$C_2H_5O(C_2H_5)_2P=NP(O)(OC_2H_5)_2$	P (0; 52)	1969, 371
$P_2C_{10}H_{25}NO_6$	$(C_2H_5O)_3P=NP(O)(OC_2H_5)_2$	P (3; 3)	1969, 371
	$C_2H_5OP(O_2^-)CH[P(O)(OC_2H_5)_2]N^+(CH_3)_3$	P (11; -4)	1969, 346
$P_2C_{10}H_{26}Si$	$(CH_3)_2Si[P(C_2H_5)_2]_2$	H	1967, 182
	$(CH_3)_2Si[(CH_2)_2P(CH_3)_2]_2$	H	1969, 373
$P_2C_{10}H_{27}ISi$	$(CH_3)_3PC[Si(CH_3)_3]P^+(CH_3)_3, I^-$	H	1968, 107
$P_2C_{10}H_{30}Al_2N_2$	$[(CH_3)_3PAl(CH_3)_2]_2$	H	1967, 176
$P_2C_{11}H_{24}O_7$	$[(C_2H_5O)_2P(O)CH_2]_2CO$	H; P (19.4)	1967, 278
$P_2C_{11}H_{26}$	$C_{10}H_{21}CH(PH_2)_2$	P (-10.8)	1966, 15
$P_2C_{11}H_{26}NNaO_6$	$[(C_2H_5O)_2P(O)]_2C^+N(CH_3)_2, Na^+$	P (33)	1968, 353; 1969, 346
$P_2C_{11}H_{26}N_2$	$CH_2[PCH_2N(C_2H_5)_2]_2$	H	1965, 118
$P_2C_{11}H_{26}O_6$	$(CH_2)_3[P(O)(OC_2H_5)_2]_2$	P (29.3)	1969, 332

$P_2C_{11}H_{27}Cl$	$(C_3H_7)_3PP(CH_3)_2Cl$	H; P (-47.9; 22.5)	1969, 344
$P_2C_{11}H_{27}NO_6$	$[(C_2H_5O)_2P(O)]_2CHN(CH_3)_2$	H; P (18)	1968, 93, 353
$P_2C_{11}H_{33}AlN_2Si$	$(CH_3)_3PN[Al(CH_3)_3]Si(CH_3)_2NP(CH_3)_3$	H	1967, 316
$P_2C_{11}H_{33}GaN_2Si$	$(CH_3)_3PN[Ga(CH_3)_3]Si(CH_3)_2NP(CH_3)_3$	H	1967, 316
$P_2C_{12}H_{10}Cl_2FNS$	$(C_6H_5)_2PCl=NP(S)ClF$	P (30.5; 50.7); F (78.7)	1969, 69
$P_2C_{12}H_{10}Cl_3NO$	$(C_6H_5)_2PCl=NP(O)Cl_2$	P	1967, 286
$P_2C_{12}H_{10}Cl_5N$	$(C_6H_5PCl_2)_2NCl$	P (417)	1967, 385
$P_2C_{12}H_{10}N_2O_2$	$[C_6H_5P(O)N]_2$	P (29.4)	1965, 78
$P_2C_{12}H_{10}S_4$	$[C_6H_5P(S)S]_2$	P (71.3)	1967, 277
$P_2C_{12}H_{12}K_2O_4$	$[C_6H_5P(O)OK]_2$	P (5.2)	1967, 386
$P_2C_{12}H_{12}K_2S_4$	$[C_6H_5P(S)SK]_2$	P (95.2)	1967, 386
$P_2C_{12}H_{12}O_3$	$[C_6H_5P(O)H]_2O$	H	1965, 48; 1966, 18
$P_2C_{12}H_{12}O_5$	$[C_6H_5PO_2H]_2O$	P (9.8)	1967, 277
$P_2C_{12}H_{15}N_8O_2$	$\{[(CH_3)_2N]_2PNN=C(CH_3)O\}_2$	H; P (-40.5)	1969, 149
$P_2C_{12}H_{16}O_4$	$C_2H_5OP(O)CHCH[CH=CHP(O)OC_2H_5]CHCHCH=CH$	H; P (70; 83)	1969, 146
$P_2C_{12}H_{19}N_3$	$N[P(CH_3)_2N]_2CCH_2C_6H_5$	H; P (31.1)	1968, 94
$P_2C_{12}H_{22}O_4$	$C_2H_5OP(O)CHCH[(CH_2)_2P(O)OC_2H_5]CHCH(CH_2)_2$	P (70; 77)	1969, 146
$P_2C_{12}H_{26}Cl_6N_2$	$[C_6H_{13}N=PCl_3]_2$	H; P (-79.1)	1966, 288
$P_2C_{12}H_{26}O_6S_4$	$[(C_2H_5O)_2P(S)SCHOCH_2]_2$	H	1968, 285
$P_2C_{12}H_{27}Cl_3O_2$	$(C_4H_9)_3P^{\oplus}OP(O)Cl_2, Cl^{\ominus}$	P (104.5; -10.1)	1969, 368
$P_2C_{12}H_{27}Cl_5O$	$(C_4H_9)_3POP(Cl)_5$	P (103.5; -296.0)	1969, 135
$P_2C_{12}H_{28}$	$[C_2H_5(C_4H_9)P]_2$	P (-37.5)	1965, 29
	$[(C_2H_5)_2P]_2(CH_2)_4$	P (-46.0)	1965, 29
	$C_{11}H_{23}CH(PH_2)_2$	P (-107)	1966, 15
$P_2C_{12}H_{28}BaO_8$	$[(C_3H_7O)_2PO_2^{\ominus}]_2, Ba^{2\oplus}$	H	1967, 90

Formula	Compound	Resonance	Reference
$P_2C_{12}H_{28}N_2$	$[(C_2H_5)_2NCH_2PCH_2]_2$	H	1965, 118
$P_2C_{12}H_{28}O_2$	$[(C_2H_5)_2P(O)(CH_2)_2]_2$	P (55.9)	1968, 336
$P_2C_{12}H_{28}O_5S_2$	$[(C_3H_7O)_2P(S)]_2O$	H	1968, 285
$P_2C_{12}H_{28}O_6$	$[(C_2H_5O)_2P(O)(CH_2)_2]_2$	P (31.5)	1969, 332
$P_2C_{12}H_{28}S_2$	$[(C_2H_5)_2P(S)(CH_2)_2]_2$	P (39.4)	1965, 11
	$[C_2H_5(C_4H_9)P(S)]_2$	P (47.6)	1965, 29
$P_2C_{12}H_{29}NO_6$	$[(C_2H_5O)_2P(O)]_2C^{\ominus}N^{\oplus}(CH_3)_3$	H; P (28)	1968, 353; 1969, 346
$P_2C_{12}H_{29}N_5O_2$	$CH_3C=NP(OCH_3)_2=NP(NHt-C_4H_9)_2=N$	H; P (19.6)	1969, 106
$P_2C_{12}H_{30}INO_6$	$[(C_2H_5O)_2P(O)]_2CHN^{\oplus}(CH_3)_3, I^{\ominus}$	H; P (11)	1968, 353; 1969, 346
$P_2C_{12}H_{30}N_6$	$[CH_3N(CH_2)_2NCH_3PN(CH_3)_2CH_2]_2$	H	1967, 305
$P_2C_{12}H_{36}Cl_2N_6O_8S_2$	$[(CH_3)_2N)_3P^{\oplus}(S)]_2, ClO_4^{\ominus}$	H	1969, 105, 247
$P_2C_{13}H_{28}Br_2O_6$	$[(i-C_3H_7O)_2P(O)]_2CBr_2$	H; P (7.0)	1967, 380; 1968, 349
$P_2C_{13}H_{28}Cl_2O_6$	$[(i-C_3H_7O)_2P(O)]_2CCl_2$	H; P (6.5)	1968, 349
$P_2C_{13}H_{28}I_2O_6$	$[(i-C_3H_7O)_2P(O)]_2CI_2$	H; P (10.5)	1968, 349
$P_2C_{13}H_{28}O_7$	$(C_2H_5O)_2P(O)CH_2CH=C(CO_2H_5)P(O)(OC_2H_5)_2$	H; P (30.6; 27.7)	1967, 278
$P_2C_{13}H_{29}BrO_6$	$[(i-C_3H_7O)_2P(O)]_2CHBr$	H; P (12.0)	1968, 349
		P (11.8)	1967, 380
$P_2C_{13}H_{29}ClO_6$	$[(i-C_3H_7O)_2P(O)]_2CHCl$	H; P (11.5)	1968, 349
$P_2C_{13}H_{29}IO_6$	$[(i-C_3H_7O)_2P(O)]_2CHI$	H; P (13.5)	1968, 349
$P_2C_{13}H_{29}NaO_6$	$[(i-C_3H_7O)_2P(O)]_2CHNa$	H; P (40.5)	1968, 349
$P_2C_{13}H_{30}$	$[(i-C_3H_7)_2P]_2CH_2$	P (17.8)	1966, 15
$P_2C_{13}H_{30}Cl_2$	$(C_4H_9)_3P^{\oplus}P(CH_3)Cl, Cl^{\ominus}$	H; P (-14.7; 16.5)	1969, 344
$P_2C_{13}H_{30}N_2$	$[(C_2H_5)_2NCH_2P]_2(CH_2)_3$	H	1965, 118
$P_2C_{13}H_{30}O_6$	$[(C_2H_5O)_2P(O)]_2CHC_4H_9$	P (23.4)	1966, 15
	$[(i-C_3H_7O)_2P(O)]_2CH_2$	H; P (17.5)	1968, 349
		P (17.8)	1967, 380
$P_2C_{13}H_{31}NO_4$	$C_3H_7O(C_2H_5)_2P=NP(O)(OC_3H_7)_2$	P (0; 51)	1969, 371

$P_2C_{13}H_{33}NO_{11}S$	$(C_3H_7O)_3P=NP(O)(C_2H_5)_2$ $[(C_2H_5O)_2P(O)]_2CHN^+(CH_3)_3, SO_3CH_3^-$	P (0; 32) H; P (11)	1969, 371 1969, 346
$P_2C_{14}H_{14}O_2$ $P_2C_{14}H_{16}$	$(CH_3OC_6H_4P)_2$ $[CH_3(C_6H_5)P]_2$	P (-22.4) H(T); P (-41.7)	1967, 126 1965, 11; 1966, 99; 1968, 141
$P_2C_{14}H_{16}F_4N_2$ $P_2C_{14}H_{16}NNaS_2$ $P_2C_{14}H_{16}N_2$ $P_2C_{14}H_{18}N_4S_2$ $P_2C_{14}H_{30}Cl_6N_2$ $P_2C_{14}H_{32}N_2$ $P_2C_{14}H_{33}Cl$ $P_2C_{14}H_{33}ClN_6$	$[CH_3NP(C_6H_5)F_2]_2$ $(CH_3)_2P(S)N=P(C_6H_5)_2S^-, Na^+$ $[CH_3(C_6H_5)PN]_2$ $[C_6H_5NHP(S)NCH_3]_2$ $(C_7H_{15}N=PCl_3)_2$ $[(C_2H_5)_2NCH_2P(CH_2)_2]_2$ $(C_4H_9)_3PP(CH_3)_2Cl$ $CH_3C=NP(NHt-C_4H_9)Cl=NP(NHt-C_4H_9)=N$	H H; P (43.3; 37.6) H; P (62.5) P (54) H; P (-79.7) H H; P (-51.0; 21.2) H; P (12.4)	1966, 36, 53 1968, 111 1969, 199 1966, 83 1966, 288 1965, 118 1969, 344 1969, 106
$P_2C_{14}H_{40}N_6$	$[(CH_3)_2N]_3P^+CH_2]_2$	H	1967, 371
$P_2C_{15}H_{19}NS_2$ $P_2C_{15}H_{26}Cl_2N_5$	$CH_3S(CH_3)_2P=NP(S)(C_6H_5)_2$ $(CH_3)_2P(S)N=P(SCH_3)(C_6H_5)_2$ $C_6H_5C=NPCL_2=NP(NHt-C_4H_9)_2=N$	H; P (37.2; 43.2) H; P (44.7; 24.2) H; P (13.2)	1968, 111 1968, 111 1969, 106
$P_2C_{15}H_{29}N_7$ $P_2C_{15}H_{34}O_6$	$C_6H_5C\{NP[N(CH_3)_2]_2\}_2N$ $[(i-C_3H_7O)_2P(O)]_2C(CH_3)_2$	H; P (32.3) H; P (25.6)	1969, 106 1966, 15
$P_2C_{16}H_{14}F_{10}N_2$ $P_2C_{16}H_{19}N_3$	$[CH_3NP(C_6H_4CF_3)F_2]_2$ $(CH_3)_2PNC(CH_3)NP(C_6H_5)_2N$	H H; P (31.3; 14.7)	1966, 36 1968, 94
$P_2C_{16}H_{20}$ $P_2C_{16}H_{20}ClN_3$	$[C_2H_5(C_6H_5)P]_2$ (isom.) $(CH_3)_2PNH^+C(CH_3)NP(C_6H_5)_2N, Cl^-$	P (-21.5; -28.3) H; P (16.8; 40.3); F (40.3)	1965, 11 1968, 94
$P_2C_{16}H_{20}F_6N_2$	$[CH_2N(CH_3)]_2P^+(C_6H_5)F, C_6H_5PF_5^-$	H; P (56.1; -138); F (-78.7; -61.0; -57.4)	1968, 352

Formula	Compound	Resonance	Reference
$P_2C_{16}H_{20}S_2$	$(C_6H_5)_2P(S)P(S)(C_2H_5)_2$	P (26·0; 57·7)	1965, 29
$P_2C_{16}H_{22}F_6N_2$	$[(CH_3)_2N]_2P^{\oplus}(C_6H_5)F, C_6H_5PF_5^{\ominus}$	P (56·0; -136·0); F (-57·3; -60·9; -86·7)	1966, 228
$P_2C_{16}H_{22}INS_2$	$CH_3S(CH_3)_2P=NP^{\oplus}(SCH_3)(C_6H_5)_2, I^{\ominus}$	H; P (46·7; 34·7)	1968, 111
$P_2C_{16}H_{22}N_4$	$C_6H_5P[N(CH_3)N(CH_3)]_2PC_6H_5$	H; P (29·9)	1969, 199
$P_2C_{16}H_{23}N_3O$	$[(CH_3)_2N]_2P(H)=NP(O)(C_6H_5)_2$	H; P (22·4; 12·0)	1969, 15
$P_2C_{16}H_{23}N_3O_2S$	$[(CH_3)_2N]_2P(H)=NP(S)(OC_6H_5)_2$	H; P (23·3; 52·7)	1969, 15
$P_2C_{16}H_{23}N_3S$	$[(CH_3)_2N]_2P(H)=NP(S)(C_6H_5)_2$	H; P (24·4; 42·5)	1969, 15
$P_2C_{16}H_{26}N_2O_6S_2$	$(C_2H_5O)_2P(S)NHCOC(O)NHP(S)(OC_2H_5)_2$	H	1966, 264
$P_2C_{16}H_{32}$	$(C_2H_5)_2PP(C_6H_{11})_2$	H; P (-42·2; -13·8)	1965, 11, 29; 1968, 113
$P_2C_{16}H_{32}S_2$	$(C_2H_5)_2P(S)P(S)(C_6H_{11})_2$	H; P (47·6; 57·1)	1965, 29; 1968, 113
$P_2C_{16}H_{34}Cl_6N_2$	$(C_6H_{17}N=PCl_3)_2$	P (-79·8)	1966, 288
$P_2C_{16}H_{36}$	$[(t-C_4H_9)_2P]_2$	P (40)	1966, 34
$P_2C_{16}H_{36}BaO_8$	$[(C_4H_9O)_2PO_2^{\ominus}]_2, Ba^{2\oplus}$	H	1967, 90
$P_2C_{16}H_{36}S_3$	$[(t-C_4H_9)_2P(S)]_2S$	P (118·0)	1966, 34
$P_2C_{17}H_{25}Cl_2N_5$	$C_6H_5C\{NP[N(CH_2)_5]Cl\}_2N$	H; P (38·3)	1969, 106
$P_2C_{17}H_{38}O_6$	$[(i-C_3H_7O)_2P(O)]_2CHC_4H_9$	P (21·6)	1966, 15
$P_2C_{18}H_{15}Cl_3OS$	$(C_6H_5)_3P^{\oplus}OP(S)Cl_2, Cl^{\ominus}$	P (65·2; 42·8)	1969, 368
$P_2C_{18}H_{15}Cl_3O_2$	$(C_6H_5)_3P^{\oplus}OP(O)Cl_2, Cl^{\ominus}$	P (65·0; -7·3)	1969, 368
$P_2C_{18}H_{15}Cl_5O$	$(C_6H_5)_3POP_2Cl_5$	P (67·2; -297)	1969, 135
$P_2C_{18}H_{15}NS_3$	$C_6H_5P(S)N(C_6H_5)P(S)(C_6H_5)S$	P (61·0)	1967, 126, 142
$P_2C_{18}H_{22}O_6$	$[(CH_3O)_2P(O)C_6H_4CH]_2$	H	1966, 253
$P_2C_{18}H_{22}O_8$	$[(CH_3O)_2P(O)OC_6H_5]_2$	H; P (-3·1)	1968, 309
$P_2C_{18}H_{24}O_2$	$[(CH_3O)_2P(O)C_6H_4CH_2]_2$	H	1966, 253
$P_2C_{18}H_{25}NO_2$	$(C_2H_5O)_3P=NP(O)(C_6H_5)_2$	P (0; 8)	1969, 371

$P_2C_{18}H_{32}S_2$	$C_2H_5O(C_6H_5)_2P=NP(O)(OC_2H_5)_2$	P (0; 19)	1969, 371
$P_2C_{18}H_{38}Cl_6N_2$	$C_6H_5P(S)(S^\ominus)P^\oplus(C_4H_9)_3$	P (6·8; 60·0)	1966, 77; 1967, 126
$P_2C_{18}H_{40}O_2$	$[C_9H_{19}N=PCl_3]_2$	P (-79·8)	1966, 288
$P_2C_{18}H_{43}N_7$	$[(C_4H_9)_2P(O)CH_2]_2$	P (54·3)	1968, 336
	$CH_3C[NP(NHt-C_4H_9)_2]_2N$	H; P (13·6)	1969, 106
$P_2C_{19}H_{18}F_2OS$	$CH_3(C_6H_5)_3P^\oplus P(O)F_2(S^\ominus)$	F (-34·2)	1967, 281
$P_2C_{19}H_{34}OS_2$	$CH_3OC_6H_4P(S)(S^\ominus)P^\oplus(C_4H_9)_3$	P (7·4; 60·0)	1966, 77; 1967, 126
$P_2C_{19}H_{37}N_7$	$C_6H_5C=NP[N(CH_3)_2]_2=NP(NHt-C_4H_9)_2=N$	H; P (18·8)	1969, 106
$P_2C_{20}H_{18}O_2$	$[C_6H_5P(O)(CH=CH)_2]_2$	H	1968, 101
$P_2C_{20}H_{21}O_9$	$[(CH_3O)_2P(O)O]_2C_{16}H_8OH$	H; P (-1·0)	1968, 315
$P_2C_{20}H_{28}$	$[C_2H_5)_2PC_6H_4]_2$	H	1969, 155
$P_2C_{20}H_{36}OS_2$	$C_2H_5OC_6H_4P(S)(S^\ominus)P^\oplus(C_4H_9)_3$	P (6·8; 60·9)	1966, 77; 1967, 126
$P_2C_{20}H_{42}Cl_6N_2$	$(C_{10}H_{21}N=PCl_3)_2$	P (-77·9)	1966, 288
$P_2C_{20}H_{44}O_2$	$[(C_2H_5)_2P(O)(CH_2)_6]_2$	P (55·5)	1968, 336
$P_2C_{21}H_{26}BF_6N$	$[(C_6H_5)_3P(CH_3)_3NBH_2]^\oplus, PF_6^\ominus$	H	1969, 26
$P_2C_{21}H_{37}N_7$	$C_6H_5C\{[NP(CH_3)_2]N(CH_2)_5\}_2N$	H; P (30·1)	1969, 106
$P_2C_{21}H_{46}O_6$	$[(i-C_3H_7O)_2P(O)]_2C(C_4H_9)_2$	P (24·5)	1966, 15
	$[(i-C_3H_7O)_2P(O)]_2CHC_8H_{17}$	P (22·2)	1966, 15
$P_2C_{21}H_{50}N_4$	$\{[(C_2H_5)_2NCH_2]_2P\}_2CH_2$	H; P (-56·5)	1966, 16
$P_2C_{22}H_{16}F_{12}$	$(C_6H_5)_3P^\oplus CHC(CF_3)_2, PF_6^\ominus$	H; P (17·8; -150·0); F (-59·3; -65·3; -72·9)	1967, 102
$P_2C_{22}H_{24}O_{10}$	$[(CH_3O)_3P(O)O]_2C_{16}H_8$	H; P (-44·3)	1968, 315
$P_2C_{22}H_{34}BrN_3O$	$(CHO)_2P(O)O[C(C_6H_5)_2]OP^\oplus[N(CH_3)_2]_3, Br^\ominus$	P (-4·2; 34·2)	1968, 309
$P_2C_{22}H_{34}O_6$	$[CH_3(CH_3O)P(O)O]_2C_{18}H_{22}$	H	1967, 168
$P_2C_{22}H_{34}S_2$	$\beta-C_{10}H_6P(S)(S^\ominus)P^\oplus(C_4H_9)_3$	P (9·5; 61·6)	1967, 126
$P_2C_{22}H_{36}O_{10}$	$[(CH_3O)_3POC(CH_3)(COCH_3)CH_2]_2C_6H_4$ (isom.)	P (-49·3; -49·5)	1967, 351
$P_2C_{22}H_{36}O_{12}$	$[(CH_3O)_3POC(CH_3)(COCH_3)CHO]_2C_6H_4$	H; P (-51·1)	1967, 350, 351

Formula	Compound	Resonance	Reference
$P_2C_{22}H_{36}O_{12}$	$(CH_3O)_3POCH(C_6H_4OCHO)CH-$ $[C_6H_4CHC(CH_3)(COCH_3)OP(OCH_3)_8O]O$	H; P (-50.1)	1967, 350
$P_2C_{22}H_{40}O_2$	<i>m</i> - $[(C_4H_9)_2P(O)]_2C_6H_4$ <i>p</i> - $[(C_4H_9)_2P(O)]_2C_6H_4$	P (133.0) P (134.6)	1968, 336 1968, 336
$P_2C_{22}H_{52}N_4$	$\{[(C_2H_5)_2NCH_2]_2P\}_2(CH_2)_2$	H; P (-48.7)	1966, 16
$P_2C_{23}H_{54}N_4$	$\{[(C_2H_5)_2NCH_2]_2P\}_2(CH_2)_3$	H; P (-52.9)	1966, 16
$P_2C_{24}H_{20}$	$(C_6H_5)_4P_2$	H; P	1969, 344
$P_2C_{24}H_{20}Br_2N$	$[(C_6H_5)_2PBr]_2N^{\oplus}$	P (33.2)	1967, 9
$P_2C_{24}H_{20}ClFOS$	$(C_6H_5)_4P^{\oplus}S^{\ominus}P(O)FCl$	F (-43.6)	1967, 58
$P_2C_{24}H_{20}ClNS$	$(C_6H_5)_2P(S)=NP(C_6H_5)_2Cl$	P (45.1; 30.2)	1967, 92
$P_2C_{24}H_{20}Cl_4N$	$[(C_6H_5)_2PCl]_2^{\oplus}N, Cl^{\ominus}$	P (43.6)	1967, 92
$P_2C_{24}H_{20}Cl_8NSb$	$[(C_6H_5)_2PCl]_2^{\oplus}N, SbCl_8^{\ominus}$	P (43.5)	1967, 92
$P_2C_{24}H_{20}KNOS$	$[(C_6H_5)_2P(S)NP(O)(C_6H_5)_2]^{\ominus}, K^{\oplus}$	P (34.7; 12.4)	1967, 92, 344
$P_2C_{24}H_{20}KNS_2$	$[C_6H_5)_2P(S)]_2^{\oplus}, K^{\oplus}$	P (35.6)	1967, 344; 1968, 111
$P_2C_{24}H_{20}NOS$	$(C_6H_5)_2P(S)NP(C_6H_5)_2O^{\ominus}$	P (35; 38)	1967, 344
$P_2C_{24}H_{20}NO_2$	$[(C_6H_5)_2PO^{\ominus}]_2N^{\oplus}$	P (12.7)	1967, 9
$P_2C_{24}H_{20}NS_2$	$(C_6H_5)_2P(S^{\ominus})=N(C_6H_5)_2P(S)$	P (35 to 38)	1966, 232; 1967, 344
$P_2C_{24}H_{20}O_5$	$[(C_6H_5)_2P(O)]_2O$	P (32.2)	1967, 277
$P_2C_{24}H_{21}NOS$	$(C_6H_5)_2P(S)NHP(O)(C_6H_5)_2$	P (54.2; 22.1)	1967, 92, 344
$P_2C_{24}H_{21}NS_2$	$[(C_6H_5)_2P(S)]_2NH$	P (55.1)	1966, 232; 1967, 344
$P_2C_{24}H_{22}NO_2$	$[C_6H_5)_2POH]_2N^{\oplus}$	P (25.1)	1967, 9
$P_2C_{24}H_{22}N_2S$	$(C_6H_5)_2P(S)N=P(C_6H_5)_2NH_2$	P (42.6; 20.6)	1967, 92
$P_2C_{24}H_{23}ClN_2S$	$(C_6H_5)_2P(S)NHP^{\oplus}(C_6H_5)_2NH_2, Cl$	P (55.9; 40.7)	1967, 92
$P_2C_{24}H_{32}$	$(C_6H_5)_2PP(C_6H_{11})_2$	H; P (-28.8; -8.2)	1965, 11, 29; 1968, 113
$P_2C_{24}H_{32}S_2$	$(C_6H_5)_2P(S)P(S)(C_6H_{11})_2$	P (20.9; 64.0)	1965, 29

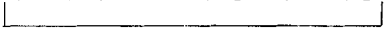
$P_2C_{24}H_{52}O_6$	$C_{11}H_{23}CH[P(O)(Oi-C_3H_7)_2]_2$	P (22·2)	1966, 15
$P_2C_{24}H_{56}N_4$	$\{[(C_2H_5)_2NCH_2]_2P(CH_2)_2\}_2$	P (-53·2)	1966, 16
$P_2C_{25}H_{18}Br_4O_2$	$[(C_6H_4Br)_2P(O)]_2CH_2$	H	1968, 18
$P_2C_{25}H_{18}Cl_4O_2$	$[(C_6H_4Cl)_2P(O)]_2$	H	1968, 18
$P_2C_{25}H_{20}O_2$	$[(C_6H_5)_2P(O)CH]_2$	H	1967, 371
$P_2C_{25}H_{20}S_2$	$[(C_6H_5)_2P(S)CH]_2$	H	1967, 371
$P_2C_{25}H_{21}N_3$	$N[(C_6H_5)_2PN]_2CH$	H; P (14·4)	1967, 196, 335
$P_2C_{25}H_{22}$	$[(C_6H_5)_2P]_2CH_2$	H; P (-22·2)	1967, 329, 371, 387; 1968, 297; 1969, 374
$P_2C_{25}H_{22}F_4$	$[(C_6H_5)_2PF_2]_2CH_2$	H; F (-27·6)	1969, 375
$P_2C_{25}H_{22}N_4$	$N[P(C_6H_5)_2N]_2CNH_2$	H; P (21·7)	1968, 94
$P_2C_{25}H_{22}O$	$(C_6H_5)_2P(O)(CH_2)_2P(C_6H_5)_2$	H	1967, 371
$P_2C_{25}H_{22}O_2$	$[(C_6H_5)_2P(O)]_2CH_2$	H	1967, 371, 387; 1968, 18, 297
$P_2C_{25}H_{22}S_2$	$[(C_6H_5)_2P(S)]_2CH_2$	H; P (34·5)	1967, 329, 387
$P_2C_{25}H_{22}Se_2$	$[(C_6H_5)_2P(Se)]_2CH_2$	H	1967, 387
$P_2C_{25}H_{23}NOS$	$(C_6H_5)_2P(S)N=P(C_6H_5)_2OCH_3$	H; P (41·8; 28·9)	1967, 92, 344
	$CH_3S(C_6H_5)_2P=NP(O)(C_6H_5)_2$	H; P (26·7; 13·3)	1967, 92, 344
$P_2C_{25}H_{23}NS_2$	$CH_3S(C_6H_5)_2P=NP(S)(C_6H_5)_2$	H; P (42·4; 29·2)	1966, 232; 1967, 344; 1968, 111
$P_2C_{25}H_{26}Cl_2N_2$	$[(C_6H_5)_2PNH_2]_2CH_2Cl_2$	H; P (22)	1969, 374
$P_2C_{25}H_{46}O_2$	$[(C_6H_{11})_2P(O)]_2CH_2$	H	1965, 71
$P_2C_{25}H_{54}O_2$	$[(C_6H_{13})_2P(O)]_2CH_2$	H	1965, 71
$P_2C_{26}H_{22}$	$[(C_6H_5)_2PCH]_2$	H	1967, 371; 1969, 347
$P_2C_{26}H_{23}N_3$	$N[(C_6H_5)_2PN]_2CCH_3$	H; P (15·6)	1967, 97; 1968, 94
$P_2C_{26}H_{24}$	$[(C_6H_5)_2PCH_2]_2$	H	1967, 371, 387
$P_2C_{26}H_{24}ClN$	$(C_6H_5)_2PCH=CHP(NH_2)(C_6H_5)_2$, Cl	H	1969, 374
$P_2C_{26}H_{24}ClN_3$	$CH_3C[NP(C_6H_5)_2]_2NH^{\oplus}$, $Cl^{\ominus}$	H; P (19·0)	1967, 97; 1968, 94
$P_2C_{26}H_{24}O$	$[(C_6H_5)_2PCH_2]_2O$	H	1967, 349

Formula	Compound	Resonance	Reference
$P_2C_{26}H_{24}O_2$	$[(C_6H_5)_2P(O)CH_2]_2$	H; P (35·8)	1967, 371, 387; 1968, 336
$P_2C_{26}H_{24}S_2$	$[(C_6H_5)_2POCH_2]_2$ $[(C_6H_5)_2P(S)CH_2]_2$	P (115·2) H; P (79·2)	1968, 336 1967, 371, 387; 1968, 336
$P_2C_{26}H_{24}Se_2$	$[(C_6H_5)_2P(Se)CH_2]_2$	H	1967, 387
$P_2C_{26}H_{26}Cl_6^-$ -NOSSb	$CH_3S(C_6H_5)_2P^{\oplus}N=P(C_6H_5)_2OCH_3, SbCl_6^{\ominus}$	H; P (38·8; 35·3)	1967, 344
$P_2C_{26}H_{26}Cl_6^-$ -NS ₂ Sb	$[CH_3S(C_6H_5)_2P]_2^{\oplus}N, SbCl_6^{\ominus}$	H; P (38·4)	1967, 344; 1968, 111
$P_2C_{26}H_{26}NO_2$	$[(C_6H_5)_2POCH_3]_2N^{\oplus}$	P (35·0)	1967, 9
$P_2C_{26}H_{26}NS_2$	$[CH_3S(C_6H_5)_2P]_2^{\oplus}N$	P (38·9)	1966, 232
$P_2C_{26}H_{26}N_2S$	$[CH_3NP(C_6H_5)_2]_2S$	H	1967, 388
$P_2C_{26}H_{26}O_2Si$	$[(C_6H_5)_2PO]_2Si(CH_3)_2$	P (98·1)	1967, 100
$P_2C_{26}H_{26}S_4Sn$	$[(C_6H_5)_2P(S)]_2Sn(CH_3)_2$	H	1967, 177
$P_2C_{26}H_{26}N_2$	$[(C_6H_5)_2P(NH_2)CH_2]_2$	H	1969, 374
$P_2C_{26}H_{26}N_2S$	$CH_3S[NP(C_6H_5)_2]_2CH$	H	1967, 149
$P_2C_{26}H_{26}N_3$	$[(C_6H_5)_2PNHCH_3]_2N^{\oplus}$	P (20·9)	1967, 9
$P_2C_{26}H_{29}BrN_2S$	$CH_3S[NP(C_6H_5)_2]_2^{\oplus}CH_2, Br^{\ominus}$	H	1967, 149
$P_2C_{26}H_{30}Br_2N_2S$	$(CH_3)_2S[NP^{\oplus}(C_6H_5)_2]_2, 2Br^{\ominus}$	H	1967, 149
$P_2C_{26}H_{30}O_4$	$[C_6H_5(C_2H_5)_2P^{\oplus}C^{\ominus}C(O)C(O)]_2$	P (26)	1965, 85
$P_2C_{26}H_{30}Cl_2N_4$	$[(C_6H_5)_2PNH_2]_2NN(CH_3)_2, Cl_2$	H; P (1·5)	1967, 94
$P_2C_{26}H_{57}Cl$	$(C_6H_{17})_3PP(CH_3)_2Cl$	H; P (-25·9; 14·5)	1969, 344
$P_2C_{27}H_{26}O_4$	$C_6H_5P(O)(OCH_3)C_6H_4CH(C_6H_5)P(O)(OCH_3)C_6H_5$	H	1966, 82
$P_2C_{27}H_{26}Br_2O$	$(C_6H_5)_2P^{\oplus}CH_2P^{\oplus}(C_6H_5)_2CH_2OCH_2, 2Br^{\ominus}$	H	1967, 349

$P_2C_{27}H_{26}Cl_2O$	$(C_6H_5)_2P^{\oplus}CH_2P^{\oplus}(C_6H_5)_2CH_2OCH_2, 2Cl^{\ominus}$	H	1967, 349
$P_2C_{27}H_{26}N_4$	$N[P(C_6H_5)_2N]_2CN(CH_3)_2$	H; P (19·3)	1968, 94
$P_2C_{27}H_{26}O_2$	$[(C_6H_5)_2P(O)]_2(CH_2)_3$	P (34·4)	1968, 336
$P_2C_{27}H_{27}I$	$[CH_3(C_6H_5)_2P]_2^{\oplus}CH, I^{\ominus}$	H	1967, 371
$P_2C_{27}H_{27}IO$	$(C_6H_5)_2P^{\oplus}(CH_3)(CH_2)_2P(O)(C_6H_5)_2, I^{\ominus}$	H	1967, 371
$P_2C_{27}H_{28}I_2$	$[(C_6H_5)_2P^{\oplus}CH_3]_2CH_2, 2I^{\ominus}$	H	1967, 371, 387
$P_2C_{28}H_{20}F_4$	$[(C_6H_5)_2PC(CF_2)_2]_2$	H; F (−108·6)	1967, 331
$P_2C_{28}H_{20}F_6$	$[(C_6H_5)_2PC(CF_3)_2]_2$	H; F (−58)	1967, 103
$P_2C_{28}H_{26}Br_2$	$(C_6H_5)_2P^{\oplus}(CH)_2P^{\oplus}(C_6H_5)_2(CH_2)_2, 2Br^{\ominus}$	H; P (2·8)	1966, 204; 1967, 364, 371
$P_2C_{28}H_{27}BrO$	$(C_6H_5)_2P(O)(CH)_2P^{\oplus}(C_6H_5)_2C_2H_5, Br^{\ominus}$	H	1967, 389
$P_2C_{28}H_{28}$	$[(C_6H_5)_2P(CH_2)_2]_2$	P (14·4)	1966, 204
$P_2C_{28}H_{28}Br_2$	$[(C_6H_5)_2P^{\oplus}CH_2CH_2]_2, 2Br^{\ominus}$	H	1967, 371
$P_2C_{28}H_{28}Br_2O$	$[(C_6H_5)_2P^{\oplus}(CH_2)CH_2]_2O, 2Br^{\ominus}$	H	1967, 349
$P_2C_{28}H_{28}I_2$	$[CH_3P^{\oplus}(C_6H_5)_2CH]_2, 2I^{\ominus}$	H	1967, 371, 387
$P_2C_{28}H_{28}O_2$	$[(C_6H_5CH_2)_2P(O)]_2$	H	1966, 289
	$[C_6H_5(C_6H_5CH_2)P(O)CH_2]_2$	H	1967, 371
$P_2C_{28}H_{30}I_2$	$[CH_3(C_6H_5)_2P^{\oplus}CH_2]_2, 2I^{\ominus}$	H	1967, 371
$P_2C_{28}H_{32}N_3$	$[(CH_3)_2NP(C_6H_5)]_2N^{\oplus}$	P (25·4)	1967, 9
$P_2C_{28}H_{44}O_2$	$[(C_4H_9)_2POC_6H_4]_2$	P (133·7)	1968, 336
$P_2C_{29}H_{18}F_{12}O_2$	$[(CF_3C_6H_4)_2P(O)]_2CH_2$	H	1968, 18
$P_2C_{29}H_{24}F_6O_4$	$(CH_3OC_6H_4)_2P(O)CH_2P(O)(C_6H_4CF_3)_2$	H	1968, 18
$P_2C_{29}H_{30}O_2$	$[(CH_3C_6H_4)_2P(O)]_2CH_2$	H	1968, 18
$P_2C_{29}H_{30}O_6$	$[(CH_3OC_6H_4)_2P(O)]_2CH_2$	H	1968, 18
$P_2C_{29}H_{32}I_2$	$[CH_3(C_6H_5)_2P^{\oplus}]_2(CH_2)_3, 2I^{\ominus}$	H	1967, 371
$P_2C_{29}H_{62}O_6$	$[(i-C_3H_7O)_2P(O)]_2C(C_8H_{17})_2$	P (25·5)	1966, 15
$P_2C_{29}H_{65}NO$	$[C_{12}H_{25}(CH_3)_2P]_2N^{\oplus}CH_3O^{\ominus}$	P (32)	1966, 268
$P_2C_{30}H_{25}As$	$C_6H_5As[P(C_6H_5)_2]_2$	P (−15·3)	1969, 14

Formula	Compound	Resonance	Reference
$P_2C_{30}H_{26}ClN$	$(C_6H_5)_2PC_6H_4P(NH_2)(C_6H_5)_2, Cl$	H	1969, 374
$P_2C_{30}H_{26}Cl_2N_2$	$[(C_6H_5)_2PNH_2]_2C_6H_4, Cl_2$	H	1969, 374
$P_2C_{30}H_{34}Br_2S_2$	$[(C_6H_5)_2(CH_3SCH_2)P^{\oplus}CH_2]_2, 2Br^{\ominus}$	H	1967, 349
$P_2C_{30}H_{34}Cl_2S_2$	$[(C_6H_5)_2(CH_3SCH_2)P^{\oplus}CH_2]_2, 2Cl^{\ominus}$	H	1967, 349
$P_2C_{30}H_{34}I_2$	$[CH_3(C_6H_5)(C_6H_5CH_2)P^{\oplus}CH_2]_2, 2I^{\ominus}$	H	1967, 371
$P_2C_{31}H_{25}N_3$	$N[P(C_6H_5)_2N]_2CC_6H_5$	H; P (17·3)	1967, 97; 1968, 94
$P_2C_{31}H_{26}ClN_3$	$HN[P(C_6H_5)_2N]_2^{\oplus}CC_6H_5, Cl^{\ominus}$	H; P (21·9)	1967, 97; 1968, 94
$P_2C_{31}H_{26}O_3$	$(C_6H_5)_2P(O)CH(C_6H_5)OP(O)(C_6H_5)_2$	H	1967, 368
$P_2C_{31}H_{50}O_2$	$[(C_4H_9)_2POC_6H_4]_2C(CH_3)_2$	P (130·7)	1968, 336
$P_2C_{32}H_{27}N_3$	$N[P(C_6H_5)_2N]_2CCH_2C_6H_5$	H; P (15·9)	1967, 97; 1968, 94
$P_2C_{32}H_{26}ClN_3$	$HN[P(C_6H_5)_2N]_2^{\oplus}CCH_2C_6H_5, Cl^{\ominus}$	H; P (19·9)	1967, 97; 1968, 94
$P_2C_{32}H_{28}O_4$	$(C_6H_5)_2P(O)CH(C_6H_4OCH_3)OP(O)(C_6H_5)_2$	H	1967, 368
$P_2C_{32}H_{30}I_2$	$[CH_3(C_6H_5)_2P^{\oplus}]_2C_6H_4, 2I^{\ominus}$	H	1967, 371
$P_2C_{32}H_{32}O_4$	$[(C_6H_5)_2P(CH_3)=C(COOCH_3)]_2$	H	1967, 378
$P_2C_{32}H_{70}O_4Sn$	$[(C_6H_{13})_2P(O)O]_2Sn(C_4H_9)_2$	P{H}	1969, 140
$P_2C_{33}H_{29}Br$	$(C_6H_5)_2PCH=CHP^{\oplus}(CH_2C_6H_5)(C_6H_5)_2, Br^{\ominus}$	H; P (−3·2; 4·6)	1966, 204
$P_2C_{33}H_{32}I_2$	$(C_6H_5)_3P^{\oplus}(CH_2)_2P^{\oplus}(C_6H_5)_2CH_3, 2I^{\ominus}$	H	1967, 371
$P_2C_{34}H_{31}BrO_5$	$(CH_3O)_2P(O)O[C(C_6H_5)_2OP^{\oplus}(C_6H_5)_3, Br^{\ominus}]$	P (−4·3; 65·9)	1968, 309
$P_2C_{35}H_{74}O_6$	$[(i-C_3H_7O)_2P(O)]_2C(C_{11}H_{23})_2$	P (25·5)	1966, 15
$P_2C_{36}H_{30}ClN$	$[(C_6H_5)_3P=NP(C_6H_5)_3Cl]$	H; P (20·1)	1968, 254
$P_2C_{36}H_{30}Cl_4N_3Sb$	$[(C_6H_5)_3P]_2N^{\oplus}_3, SbCl_4^{\ominus}$	P	1967, 390
$P_2C_{36}H_{44}O_2$	$[(C_6H_5)_2P(O)(CH_2)_6]_2$	P (35·3)	1968, 336
	$[(C_6H_5)_2PO(CH_2)_6]_2$	P (110·1)	1968, 336
$P_2C_{37}H_{30}$	$[(C_6H_5)_3P]_2C$	P (−4·3)	1966, 78
$P_2C_{37}H_{31}Br$	$[(C_6H_5)_3P]_2^{\oplus}CH, Br^{\ominus}$	H	1967, 371

$P_2C_{37}H_{32}Br_2$	$[(C_6H_5)_3P^\oplus]_2CH_2, 2Br^\ominus$	H	1967, 371
$P_2C_{37}H_{32}N_2$	$[(C_6H_5)_2P(=NC_6H_5)]_2CH_2$	H	1966, 113
$P_2C_{38}H_{30}O_2$	$[(C_6H_5)_3P]_2C^\oplus CO_2^\ominus$	P (3·6)	1968, 110
$P_2C_{38}H_{37}$	$[(C_6H_5)_3P^\ominus CH_2]_2$	P (24·7)	1966, 269
$P_2C_{38}H_{34}Br_2$	$[(C_6H_5)_3P^\oplus CH_2]_2, 2Br^\ominus$	H	1967, 371
$P_2C_{39}H_{33}IO_2$	$[(C_6H_5)_3P]_2^\oplus CCOOCH_3, I^\ominus$	H; P (21·4)	1966, 290
$P_2C_{39}H_{36}Br_2$	$[(C_6H_5)_2P^\oplus CH_2C_6H_5]_2CH_2, 2Br^\ominus$	H	1966, 113
	$[(C_6H_5)_3P^\oplus]_2(CH_2)_3, 2Br^\ominus$	P (23·2)	1966, 5
$P_2C_{40}H_{30}F_6O$	$(C_6H_5)_3POC(CF_3)_2C=P(C_6H_5)_3$	H; P (7·3; -54·0); F (-71·2)	1967, 123
$P_2C_{40}H_{31}BF_{10}O$	$[(C_6H_5)_3P]_2^\oplus CC(CF_3)_2OH, BF_4^\ominus$	H; P (22); F (-70·3; -150·3)	1967, 102
$P_2C_{40}H_{32}Br_2$	$(C_6H_5)_2P^\oplus CH=C(C_6H_5)P^\oplus(C_6H_5)_2CHCC_6H_5, 2Br^\ominus$	H; P (-3·5)	1967, 364
$P_2C_{40}H_{33}ClO_3$	$(C_6H_5)_3P^\oplus CH(COOH)COHP(C_6H_5)_3, Cl^\ominus$	H	1966, 291
$P_2C_{40}H_{36}$	$[C_6H_5CH_2P^\oplus(C_6H_5)_2CH]_2$	H; P (3·8)	1966, 269
$P_2C_{40}H_{36}Br_2$	$[(C_6H_5)CHCH_2P^\oplus(C_6H_5)_2]_2, 2Br^\ominus$	H; P (20·4)	1967, 364
$P_2C_{40}H_{36}Br_2$	$[C_6H_5CH_2P^\oplus(C_6H_5)_2CH_2]_2, 2Br^\ominus$	H	1967, 371
$P_2C_{40}H_{38}Br_2O$	$[C_6H_5CH_2P^\oplus(C_6H_5)_2CH_2]_2O, 2Br^\ominus$	H	1967, 349
$P_2C_{40}H_{42}Al_2N_2$	$[(C_6H_5)_3P=Al(CH_3)_3]_2$	H	1965, 119
$P_2C_{40}H_{42}Ga_2N_2$	$[(C_6H_5)_3P=NGa(CH_3)_3]_2$	H	1965, 119
$P_2C_{40}H_{42}In_2N_2$	$[(C_6H_5)_3P=NIIn(CH_3)_3]_2$	H	1965, 119
$P_2C_{41}H_{33}BF_4O_2$	$(C_6H_5)_3P^\oplus C(CH_3)C(O)C[P(C_6H_5)_3]CO, BF_4^\ominus$	H	1968, 110
$P_2C_{41}H_{33}IO_2$	$(C_6H_5)_3P^\oplus C(CH_3)C(O)C[P(C_6H_5)_3]CO, I^\ominus$	H; P (0·0; 25·8)	1968, 110
$P_2C_{41}H_{35}ClO_3$	$(C_6H_5)_3PCH(COOCH_3)COCH_2P^\oplus(C_6H_5)_3, Cl^\ominus$	H	1966, 291
$P_2C_{42}H_{36}O_4$	$[(C_6H_5)_3P=C(COOCH_3)]_2$	H(T)	1967, 378

Formula	Compound	Resonance	Reference
$P_2C_{42}H_{42}Br_2$	$[C_6H_5(C_6H_5CH_2)_2P^{\oplus}CH_2]_2, 2Br^{\ominus}$	H	1967, 371
$P_2C_{44}H_{32}F_{12}O_5$	$[(C_6H_5)_3P]_2^{\oplus}CC(CF_3)_2OH, (CF_3COO)_2H^{\ominus}$	H; P (21.2); F (-71.4; -76.2)	1967, 102
$P_2C_{44}H_{35}NS$	$[(C_6H_5)_3P]_2^{\oplus}CCS^{\ominus}NC_6H_5$	P (12.1)	1968, 338
$P_2C_{44}H_{36}Br_2$	$[(C_6H_5)_3P^{\oplus}CH]_2C_6H_4, 2Br^{\ominus}$	H	1967, 300
$P_2C_{44}H_{38}Br_2$	$[(C_6H_5)_3P^{\oplus}CH_2]_2C_6H_4, 2Br^{\ominus}$	P (22.8)	1966, 5
$P_2C_{45}H_{37}ClO_6$	$[(C_6H_5)_3PCC(O)OCH_2CO][[(C_6H_5)_3PC(COCH_3)C(O)CH_2Cl]$ 	H	1967, 369
$P_2C_{46}H_{36}O_3$	$[(C_6H_5)CCH]_2CH(C_6H_5)P(O)_2O$ 	H	1968, 102
$P_2C_{46}H_{39}ClO_6$	$[(C_6H_5)_3PCC(O)OCH_2CO][[(C_6H_5)_3PC(COC_2H_5)C(O)CH_2Cl]$ 	H	1967, 369
$P_2C_{48}H_{42}O_8$	$[(C_6H_5)_3P=C(COOCH_3)C(COOCH_3)]_2$	H; P (22.9)	1967, 372
$P_2C_{48}H_{44}Cl_2O_{16}$	$[(C_6H_5)_3P^{\oplus}CH(COOCH_3)C(COOCH_3)]_2, 2ClO_4^{\ominus}$	H; P (28.9)	1967, 372
$P_2C_{50}H_{44}O_7$	$[CH_3OC_6H_4CCH(C_6H_5)CCHCH(C_6H_4OCH_3)P(O)]_2O$	H	1968, 102
$P_2C_{53}H_{41}IN_4O_4$	$(C_6H_5)_3P^{\oplus}C(CH_3)C(=NC_6H_4NO_2)C[=P(C_6H_5)_3]C=$ 		
	$=NC_6H_4NO_2, I^{\ominus}$	H; P (27.7; -3.7)	1968, 33
$P_2C_{53}H_{43}IN_2$	$(C_6H_5)_3P^{\oplus}C(CH_3)C(=NC_6H_5)C[=P(C_6H_5)_3]C=NC_6H_5, I^{\ominus}$ 	H; P (28.1; -4.4)	1968, 110, 338
$P_2C_{55}H_{47}IN_2$	$(C_6H_5)_3P^{\oplus}C(CH_3)C(=NC_6H_4CH_3)C[=P(C_6H_5)_3]C=$ 		
	$=NC_6H_4CH_3, I^{\ominus}$	H; P (28.2; -4.4)	1968, 110, 338

P₃			
$P_3CH_3Cl_5N_3O$	$N_3P_3Cl_5(OCH_3)$	H; P (16·7; 22·5)	1966, 49; 1967, 130
$P_3CH_4Cl_5N_4$	$N_3P_3Cl_5(NHCH_3)$	P (22·9)	1968, 114
$P_3CH_4F_5N_4$	$N_3P_3F_5(NHCH_3)$	H; F (−62·5; −70·7)	1969, 152
$P_3C_2H_2Cl_5F_3N_3O$	$N_3P_3Cl_5(OCH_2CF_3)$	H; P (16·5; 22·7)	1966, 49; 1967, 130
$P_3C_2H_5Cl_5N_3O$	$N_3P_3Cl_5(OC_2H_5)$	H; P (13·6; 21·3)	1966, 49; 1967, 130
$P_3C_2H_6Br_5N_4$	$N_3P_3Br_5[N(CH_3)_2]$	H; P (−39·3; 4·5)	1966, 93; 1968, 91
$P_3C_2H_6Cl_5N_4$	$N_3P_3Cl_5[N(CH_3)_2]$	H; P (22·4; 20·5)	1965, 24; 1966, 49, 93; 1967, 130; 1968, 91
$P_3C_2H_6F_5N_4$	$N_3P_3F_5[N(CH_3)_2]$	H; F (−63·0; −70·9)	1969, 152
$P_3C_2H_8Cl_4N_5$	$N_3P_3Cl_4(NHCH_3)_2$	H; P (22·2; 21·6; 20·1; 12·3)	1967, 148; 1968, 114
$P_3C_2H_9O_8$	$PO_2H(CH_2PO_3H_2)_2$	H; P (37·3; 17·5)	1968, 300; 1969, 303
$P_3C_2H_{12}Cl_2N_7$	$N_3P_3Cl_2(NH_2)_2(NHCH_3)_2$	P (23; 16·5)	1968, 114
$P_3C_3H_7Cl_5N_3O$	$N_3P_3Cl_5(Oi-C_3H_7)$	H; P (12·6; 21·7)	1966, 49; 1967, 130
$P_3C_3H_9F_9N_3$	$(F_3PNCH_3)_3$	H	1966, 36
$P_3C_3H_{11}O_7$	$CH_3P(O)(CH_2PO_3H_2)_2$	H	1969, 334
$P_3C_3H_{12}NO_9$	$N(CH_2PO_3H_2)_3$	H; P(<i>ca.</i> 8·5)	1966, 212; 1967, 315, 391
$P_3C_3H_{12}NO_{10}$	$ON(CH_2PO_3H_2)_3$	H; P (<i>ca.</i> 5·5)	1967, 391
$P_3C_4H_{10}Cl_4N_3S_2$	$N_3P_3Cl_4(SC_2H_5)_2$	P	1967, 130
$P_3C_4H_{12}Br_4N_5$	$N_3P_3Br_4[N(CH_3)_2]_2$	H; P (<i>ca.</i> −36·7; 10·0)	1966, 93; 1968, 91
$P_3C_4H_{12}Cl_2F_2N_5$	$N_3P_3Cl_2F_2[N(CH_3)_2]_2$	H	1969, 153

Formula	Compound	Resonance	Reference
$P_3C_4H_{12}Cl_4N_5$	$N_3P_3Cl_4[N(CH_3)_2]_2$	H; P	1965, 24; 1966, 93; 1967, 130, 146; 1968, 91, 129
$P_3C_4H_{12}F_4N_2$	$N_3P_3F_4[N(CH_3)_2]_2$	H	1969, 151
$P_3C_4H_{13}O_{10}$	$CH_3P(O_2H)OP(O)(OCH_3)OP(O)(OCH_3)_2$	H; P	1966, 138
$P_3C_6H_{10}Cl_5N_4$	$N_3P_3Cl_5NC_5H_{10}$	H	1966, 88
$P_3C_5H_{12}F_3$	$CF_3[P(CH_3)_2]_2$	F	1967, 83
$P_3C_5H_{15}O_5$	$CH_3P(O)[OP(O)(OCH_3)CH_3]_2$	H; P	1967, 186
$P_3C_6BF_{18}O_3$	$B[OP(CF_3)_2]_3$	^{11}B ; H; P (36.3) F (-66.8)	1969, 27
$P_3C_6F_{10}N_3$	$N_3P_3F_6(C_6F_5)$	F	1968, 127
$P_3C_6H_5Cl_5N_3O$	$N_3P_3Cl_5(OC_6H_5)$	P	1967, 130
$P_3C_6H_6Cl_4N_5$	$N_3P_3Cl_4(NH)_2C_6H_4$	H; P (21.5)	1966, 90
$P_3C_6H_{15}K_2$	$C_2H_5P[P(C_2H_5)K]_2$	P (-78.5; -23.9)	1965, 27, 29
$P_3C_6H_{15}Na_2$	$C_2H_5P[P(C_2H_5)Na]_2$	P	1965, 27
$P_3C_6H_{15}O_4S_3$	$[C_2H_5P(S)O]_3O$	H	1968, 355
$P_3C_6H_{16}Cl_4N_5$	$N_3P_3Cl_3(NHC_2H_5)(NHt-C_4H_9)$	H	1968, 129
$P_3C_6H_{17}F_{12}N$	$(CH_3)_2P^+CH_2N^+(CH_3)_3, 2PF_6^-$	H	1969, 128
$P_3C_6H_{18}Br_3N_6$	$N_3P_3Br_3[N(CH_3)_2]_3$	H; P (15.4)	1966, 93; 1968, 91
$P_3C_6H_{18}Cl_3N_6$	$N_3P_3Cl_3[N(CH_3)_2]_3$	H; P (27.6; 26.1; 21.6)	1965, 24; 1966, 93; 1968, 91, 136
$P_3C_6H_{18}N_3O_6$	$N_3P_3(OCH_3)_6$	P (23.2)	1966, 6
$P_3C_6N_9S_6$	$N_3P_3(NCS)_6$	P (30)	1968, 114
$P_3C_7H_{19}O_3$	$CH_3P(O)[CH_2P(O)(CH_3)_2]_2$	P (39.6; 42.4)	1969, 334
$P_3C_7H_{19}O_8$	$CH_3OP(O)[CH_2P(O)(OCH_3)_2]_2$	H	1969, 332
$P_3C_8H_{11}Cl_5N_5$	$N_3P_3Cl_5[NHC_6H_4N(CH_3)_2]$	H	1966, 92
$P_3C_8H_{20}Cl_2N_3S_4$	$N_3P_3Cl_2(SC_2H_5)_4$	H	1966, 84

$P_3C_8H_{20}Cl_4N_5$	$N_3P_3Cl_4(NHt-C_4H_9)_2$	H	1968, 129
$P_3C_8H_{21}O_8$	$C_2H_5OP(O)[CH_2P(O)(OCH_3)_2]_2$	H	1969, 332
$P_3C_8H_{24}Cl_2N_7$	$N_3P_3Cl_2[N(CH_3)_2]_4$	H; P (23·9; 30·5)	1965, 24; 1968, 91
$P_3C_8H_{28}N_9$	$N_3P_3[N(CH_3)_2]_4(NH_2)_2$	H	1966, 88
$P_3C_{10}H_{17}Cl_3N_5O$	$N_3P_3Cl_3(OC_6H_5)[N(CH_3)_2]_2$	H	1967, 146
$P_3C_{10}H_{20}Cl_4N_5$	$N_3P_3Cl_4(NC_5H_{10})_2$	H	1966, 88
$P_3C_{10}H_{28}Cl_2N_7$	$N_3P_3Cl_2[N(CH_3)_2]_2(NHt-C_3H_7)_2$	H	1966, 85
$P_3C_{11}H_{27}O_7$	$CH_3P(O)[CH_2P(O)(OC_2H_5)_2]_2$	H; P (34·5; 21·3)	1968, 299; 1969, 332
$P_3C_{12}H_{10}Cl_4N_3S_2$	$N_3P_3Cl_4(SC_6H_5)_2$	P	1967, 130
$P_3C_{12}H_{10}F_4N_3$	$N_3P_3F_4(C_6H_5)_2$	P (38; 12; 11); F (−49; −50; −65; −70)	1967, 144; 1968, 50, 130
$P_3C_{12}H_{12}Cl_4N_5$	$N_3P_3Cl_4(NHC_6H_5)_2$	P (−20·4; −2·3)	1966, 80; 1967, 130
$P_3C_{12}H_{12}F_{16}N_3O_6$	$N_3P_3(OCH_2CF_3)_6$	P (19·2)	1966, 6
$P_3C_{12}H_{29}O_7$	$C_2H_5P(O)[CH_2P(O)(OC_2H_5)_2]_2$	H; P (38·6; 21·1)	1968, 299; 1969, 334
$P_3C_{12}H_{29}O_8$	$C_2H_5OP(O)[CH_2P(O)(OC_2H_5)_2]_2$	H; P (37·3; 20·0)	1967, 2; 1969, 332
$P_3C_{12}H_{30}LiSi$	$[(C_2H_5)_2P]_3SiLi$	H	1967, 182
$P_3C_{12}H_{30}N_3O_6$	$N_3P_3(OC_2H_5)_6$	H; P (16·8)	1966, 6, 87; 1968, 57
$P_3C_{12}H_{31}Si$	$[(C_2H_5)_2P]_3SiH$	H	1967, 182
$P_3C_{12}H_{36}N_9$	$N_3P_3[N(CH_3)_2]_6$	H; P (25)	1965, 24; 1968, 91, 136
$P_3C_{13}H_{33}Si$	$[(C_2H_5)_2P]_3SiCH_3$	H	1967, 182
$P_3C_{13}H_{38}N_9$	$N_3P_3[N(CH_3)_2]_5NHt-C_3H_7$	H	1966, 85
$P_3C_{14}H_{16}Cl_3N_4$	$N_3P_3Cl_3(C_6H_5)_2[N(CH_3)_2]$	H	1969, 150
$P_3C_{14}H_{17}O_6$	$PO_2H[CH_2P(O)(C_6H_5)OH]_2$	H	1969, 332
$P_3C_{14}H_{33}O_7$	$C_{12}H_{25}P(O)[CH_2PO_2H]_2$	H; P (45·8; 16·3)	1969, 334
$P_3C_{14}H_{33}O_8$	$C_4H_9OP(O)[CH_2P(O)(OC_2H_5)_2]_2$	H; P (37·4; 20·4)	1968, 300; 1969, 332
$P_3C_{14}H_{40}N_9$	$N_3P_3[N(CH_3)_2]_4(NHt-C_3H_7)_2$	H	1966, 85
$P_3C_{14}H_{42}BF_4N_9$	$N_3P_3[N(CH_3)_2]_4[N^{\oplus}(CH_3)_3]_2, 2BF_4^{\ominus}$	H	1968, 135

Formula	Compound	Resonance	Reference
$P_3C_{15}H_{30}Cl_3N_6$	$N_3P_3Cl_3(NC_5H_{10})_3$	H	1966, 88
$P_3C_{15}H_{33}O_8$	$C_2H_5OP(O)[CH_2P(O)(OC_2H_5)]_2-$ $-[CH(CH_2CH=CH_2)P(O)(OC_2H_5)_2]$	H	1967, 2
$P_3C_{15}H_{34}N_7OS_2$	$CH_3OC_6H_4P(S)(SH)\{N=P[N(CH_3)_2]_2\}_2NH_2$	H; P (76.4; 7.9; 17.9)	1969, 100
$P_3C_{15}H_{40}N_9$	$N_3P_3[N(CH_3)_2]_5NC_5H_{10}$	H	1966, 88
$P_3C_{16}H_{22}Cl_2N_5$	$N_3P_3(C_6H_5)_2[N(CH_3)_2]_2Cl_2$	H	1967, 146; 1969, 150
$P_3C_{16}H_{26}N_7$	$N_3P_3(C_6H_5)_2[N(CH_3)_2]_2C(NH_2)_2$	H	1969, 150
$P_3C_{16}H_{35}N_8O$	$N_3P_3[N(CH_3)_2]_5(C_6H_5)$	H	1966, 86
$P_3C_{16}H_{44}N_9$	$N_3P_3[N(CH_3)_2]_4(NHt-C_4H_9)_2$	H	1965, 33
	$N_3P_3[N(CH_3)_2]_2(NHt-C_3H_7)_4$	H	1966, 85
$P_3C_{18}H_{12}N_3O_6$	$N_3P_3(C_6H_4O_2)_3$	P (13.3)	1966, 90
$P_3C_{18}H_{15}Br_3N_3$	$N_3P_3Br_3(C_6H_5)_3$ (isom.)	P (16.3; 17.8; 196.6)	1968, 133
$P_3C_{18}H_{15}F_3N_3$	$N_3P_3F_3(C_6H_5)_3$ (isom.)	P (31.2; 27.3; 8.6); F (-49.1; -68)	1968, 130
$P_3C_{18}H_{15}K_2$	$(C_6H_5P)_3K_2$	P	1966, 292
$P_3C_{18}H_{18}N_9$	$N_3P_3[C_6H_4(NH)_2]_3$	H; P (24.5)	1966, 90
$P_3C_{18}H_{21}N_6O_3$	$N_3P_3(NH_2)_3(OC_6H_5)_3$	H	1966, 129
$P_3C_{18}H_{37}O_8$	$C_2H_5OP(O)[CH(CH_2CH=CH_2)P(O)(OC_2H_5)_2]_2$	H	1967, 2
$P_3C_{18}H_{41}O_7$	$C_8H_{17}P(O)[CH_2P(O)(OC_2H_5)_2]_2$	H; P (37.2; 20.8)	1969, 334
$P_3C_{18}H_{41}O_8$	$C_4H_9OP(O)[CH_2P(O)(Oi-C_3H_7)_2]_2$	H; P (37.3; 18.5)	1968, 300; 1969, 332
$P_3C_{18}H_{42}N_3O_9$	$(C_6H_{11}NHPO_3H_2)_3$	P (-21.9)	1966, 65
$P_3C_{18}H_{44}N_9$	$N_3P_3[N(CH_3)_2]_4(NC_5H_{10})_2$	H	1966, 88
$P_3C_{20}H_{16}Cl_2-$ $F_{12}N_5O_4$	$N_3P_3(OCH_2CF_3)_4(NHC_6H_4Cl)_2$	H; P (6.9; 16.2)	1966, 80

$P_3C_{20}H_{20}F_{12}N_5O_4$	$N_3P_3(OCH_2CF_3)_4(NHC_6H_5)_2$	H; P (6·4; 16·4)	1966, 80; 1967, 130
$P_3C_{20}H_{22}Cl_2N_5$	$N_3P_3Cl_2(C_6H_5)_2[N(CH_3)_2](NHC_6H_5)$	H	1969, 150
$P_3C_{20}H_{30}N_3O_4$	$N_3P_3(C_6H_5)_2(OC_2H_5)_4$	H	1966, 87; 1968, 57
$P_3C_{20}H_{34}N_7$	$N_3P_3(C_6H_5)_2[N(CH_3)_2]_4$	H	1969, 150
$P_3C_{20}H_{34}N_7O_2$	$N_3P_3(OC_6H_5)_2[N(CH_3)_2]_4$	H	1966, 86
$P_3C_{20}H_{40}Cl_2N_7$	$N_3P_3Cl_2(NC_6H_{10})_4$	H	1966, 88
$P_3C_{20}H_{48}N_3O_7$	$C_6H_{11}NH_2P(O_2H)[CH_2PO_3H_2, C_6H_{11}NH_2]_2$	P (28·7; 15)	1969, 332
$P_3C_{21}H_{18}N_3S_6$	$N_3P_3[SC_6H_3(CH_3)S]_3$	H	1966, 90
$P_3C_{21}H_{41}O_8$	$C_2H_5OP(O)[CH(CH_2CH=CH_2)P(O)(OC_2H_5)_2]-$ $-[CH_2CH=CH_2)P(O)(OC_2H_5)_2]$	H	1967, 2
$P_3C_{21}H_{48}N_9$	$N_3P_3[N(CH_3)_2]_3(NC_5H_{10})_3$	H	1966, 88
$P_3C_{22}H_{24}F_{12}N_5O_4$	$N_3P_3(OCH_2CF_3)_4(NHC_6H_4CH_3)_2$	H	1966, 80
$P_3C_{22}H_{27}N_6$	$N_3P_3(C_6H_5)_3[N(CH_2)_2]_3$	H	1966, 96
$P_3C_{22}H_{49}O_7$	$C_{12}H_{25}P(O)[CH_2P(O)(OC_2H_5)_2]_2$	H; P (36·9; 21·1)	1968, 299; 1969, 334
$P_3C_{22}H_{49}O_8$	$C_4H_9OP(O)[CH_2P(O)(OC_4H_9)_2]_2$	P (37·4; 20·7)	1968, 300; 1969, 332
$P_3C_{24}H_{20}Cl_2N_3$	$N_3P_3Cl_2(C_6H_5)_4$	P (17·2)	1968, 114
$P_3C_{24}H_{20}Cl_2N_3O_2$	$N_3P_3Cl_2(C_6H_5)_2(OC_6H_5)_2$	P (16·6; 21·9)	1966, 95
$P_3C_{24}H_{20}Cl_8N$	$[(C_6H_5)_2PCl]_2^+N, PCl_6^-$	P (43·3)	1967, 92
$P_3C_{24}H_{20}F_2N_3$	$N_3P_3F_2(C_6H_5)_4$	P (27·3; 62)	1968, 130
$P_3C_{24}H_{24}Cl_2N_3O_2$	$N_3P_3Cl_2(C_6H_5)_2(OC_6H_5)_2$	H	1966, 97
$P_3C_{24}H_{24}N_5$	$N_3P_3(C_6H_5)_4(NH_2)_2$	H	1966, 97
$P_3C_{24}H_{24}N_5O_2$	$N_3P_3(C_6H_5)_2(OC_6H_5)_2(NH_2)_2$	H	1966, 97
$P_3C_{24}H_{24}N_5O_4$	$N_3P_3(C_6H_5)_4(NH_2)_2$	H	1966, 97
$P_3C_{24}H_{33}N_6O_3$	$N_3P_3(OC_6H_5)_3[N(CH_3)_2]_3$	H	1966, 86
$P_3C_{24}H_{33}Sn_3$	$[C_6H_5PSn(CH_3)_2]_3$	H	1968, 95
$P_3C_{24}H_{34}N_7$	$N_3P_3(C_6H_5)_2[N(CH_3)_2]_2NHC_6H_5$	H	1969, 150
$P_3C_{24}H_{37}O_6$	$C_2H_5OP(O)[CH_2P(O)(C_6H_5)OC_4H_9]_2$	H; P (38·8; 33·6)	1968, 300
$P_3C_{24}H_{45}O_8$	$C_2H_5OP(O)[C(CH_2CH=CH_2)P(O)(OC_2H_5)_2]_2$	H	1967, 2
$P_3C_{24}H_{52}N_9$	$N_3P_3[N(CH_3)_2]_2(NC_5H_{10})_4$	H	1966, 88

Formula	Compound	Resonance	Reference
$P_3C_{25}H_{24}N_3$	$N_3P_3(C_6H_5)_4(CH_3)H$	H; P (12·9; 6·9)	1968, 40
$P_3C_{25}H_{57}O_3Si$	$[(C_4H_9)_2PO]_3SiCH_3$	P (119·0)	1967, 343
$P_3C_{26}H_{25}O_4$	$[(C_6H_5)_2P(O)CH_2]_2PO_2H$	H	1969, 332
$P_3C_{26}H_{26}N_3$	$N_3P_3(C_6H_5)_4(C_2H_5)H$	H; P (15·5; 12·5)	1968, 40
$P_3C_{26}H_{27}ClN_3$	$(CH_3)_2P^{\oplus}NH[P(C_6H_5)_2N]_2, Cl^{\ominus}$	P (39·6; 18·8)	1969, 376
$P_3C_{26}H_{28}N_5$	$N_3P_3(C_6H_5)_4(NHCH_3)_2$	P (19·5; 18)	1968, 114
$P_3C_{26}H_{33}Sn_2$	$C_4H_9Sn(PC_6H_5)_3SnC_4H_9$	P (−5·2)	1969, 377
$P_3C_{26}H_{41}O_5$	$C_{12}H_{25}P(O)[CH_2P(O)(C_6H_5)OH]_2$	H	1969, 334
$P_3C_{28}H_{29}O_4$	$C_2H_5OP(O)[CH_2P(O)(C_6H_5)_2]_2$	H	1969, 332
$P_3C_{28}H_{30}N_3O_2$	$N_3P_3(C_6H_5)_4(OC_2H_5)_2$	H	1966, 87; 1968, 57
$P_3C_{28}H_{32}N_5$	$N_3P_3(C_6H_5)_4[N(CH_3)_2]_2$	H	1969, 150
$P_3C_{28}H_{32}N_5O_2$	$N_3P_3(C_6H_5)_2(OC_6H_5)_2[N(CH_3)_2]_2$	H	1966, 95
$P_3C_{28}H_{32}N_5O_4$	$N_3P_3(OC_6H_5)_4[N(CH_3)_2]_2$	H	1966, 86
$P_3C_{28}H_{34}N_7$	$N_3P_3(C_6H_5)_2[N(CH_3)_2]_2(NHC_6H_5)_2$	H	1969, 150
$P_3C_{30}H_{25}ClN_3O_5$	$N_3P_3(OC_6H_5)_5Cl$	P	1967, 130
$P_3C_{30}H_{25}N$	$(C_6H_5)_2PP(C_6H_5)=NP(C_6H_5)_2$	P	1967, 385
$P_3C_{30}H_{25}Sn_2$	$(C_6H_5P)_3(SnC_6H_5)_2$	P	1969, 14
$P_3C_{30}H_{26}N_3O$	$N_3P_3(C_6H_5)_4(OC_6H_5)H$	H; P (14·5; 5·8)	1968, 40
$P_3C_{30}H_{60}N_9$	$N_3P_3(NC_5H_{10})_6$	H	1966, 88
$P_3C_{31}H_{28}N_3OS$	$N[P(C_6H_5)_2N]_2P(SCH_3)(SC_6H_5)$	H	1969, 100
$P_3C_{31}H_{28}N_3S_2$	$N[P(C_6H_5)_2N]_2P(C_6H_4OCH_3)SH$	P (21·6; 45·8)	1969, 100
$P_3C_{31}H_{29}IN_3S_2$	$(C_6H_5S)(CH_3S)P^{\oplus}NH[(C_6H_5)_2N]_2, I^{\ominus}$	H	1969, 100
$P_3C_{32}H_{29}O_3$	$C_6H_5P(O)[CH_2P(O)(C_6H_5)_2]_2$	P (27·6)	1969, 334

$P_3C_{32}H_{30}N_3OS$	$N_3P_6(C_6H_5)_4(C_6H_4OCH_3)(SCH_3)$	H; P (14·1; 27·0)	1969, 100
$P_3C_{32}H_{31}IN_3OS$	$(CH_3OC_6H_4)(CH_3S)P^{\oplus}NH[P(C_6H_5)_2N]_2I^{\ominus}$	H; P (21·4; 38·1)	1969, 100
$P_3C_{32}H_{31}N_4O_5$	$N_3P_3(OC_6H_5)_5[N(CH_3)_2]$	H	1966, 86
$P_3C_{32}H_{34}N_7$	$N_3P_3(C_6H_5)_2(NHC_6H_5)_3[N(CH_3)_2]$	H	1969, 150
$P_3C_{33}H_{51}O_{17}$	$(CH_3O)_3POCH[C_6H_4CHC(CH_3)(COCH_3)OP(OCH_3)_3]_2O$	H; P (−49·9)	1967, 350
$P_3C_{34}H_{57}O_5$	$C_{12}H_{25}P(O)[CH_2P(O)(OC_4H_9)C_6H_5]_2$	H; P (37·7; 34·9)	1968, 299; 1969, 334
$P_3C_{36}H_{30}As$	$As[P(C_6H_5)_2]_3$	P (−15·2)	1969, 14
$P_3C_{36}H_{30}N_3$	$N_3P_3(C_6H_5)_6$	P (14·2)	1965, 34; 1968, 114
$P_3C_{36}H_{30}N_3O_6$	$N_3P_3(OC_6H_5)_6$	P (10·5)	1966, 6, 90
$P_3C_{36}H_{34}ClN_4$	$H_2N[P(C_6H_5)_2N]_2P(C_6H_5)_2NH_2, Cl$	P (31·6; 18·1)	1969, 378
$P_3C_{37}H_{33}O_3Si$	$[(C_6H_5)_2PO]_3SiCH_3$	P (97·7)	1967, 343
$P_3C_{37}H_{37}Cl_2N_4$	$[(C_6H_5)_2PNH]_2NNCH_3[P(C_6H_5)_2], Cl_2$	H; P (36·7)	1967, 94
$P_3C_{37}H_{38}Cl_2N_5$	$[(C_6H_5)_2PNH][(C_6H_5)_2PNH_2]NNCH_3[H_2NP(C_6H_5)_2], Cl_2$	H; P (126)	1967, 94
$P_3C_{38}H_{49}O_3$	$C_{12}H_{25}P(O)[CH_2P(O)(C_6H_5)_2]_2$	H; P (42·6; 28·6)	1968, 299; 1969, 334
$P_3C_{40}H_{31}F_{12}O$	$[(C_6H_5)_3P]_2^{\oplus}CC(CF_3)_2OH, PF_6^{\ominus}$	H; P (−144·8; 22); F (−71·6; −72·5)	1967, 102
$P_3C_{43}H_{35}Cl_3$	$[(C_6H_5P]_2^{\oplus}CP(C_6H_5)Cl, 2Cl^{\ominus}$	P (67·9; 25·9)	1966, 78
$P_3C_{48}H_{66}N_{15}$	$N_3P_3[NHC_6H_4N(CH_3)_2]_6$	H	1966, 92
$P_3C_{49}H_{40}Cl$	$[(C_6H_5)_3P]_2^{\oplus}CP(C_6H_5)_2, Cl^{\ominus}$	H; P 26·0; −1·5)	1966, 78
$P_3C_{49}H_{40}ClO$	$[(C_6H_5)_3P]_2^{\oplus}CP(O)(C_6H_5)_2, Cl^{\ominus}$	P (23·2; 26·9)	1966, 78
$P_3C_{50}H_{43}I_2$	$[(C_6H_5)_3P]_2C^{\oplus}P^{\oplus}(C_6H_5)_2CH_3, 2I^{\ominus}$	H; P (25·6; 22·6)	1966, 78
$P_3C_{51}H_{46}ClOS$	$[(C_6H_5)_3P]_2C^{\oplus}P(S)(C_6H_5)_2, Cl^{\ominus}$	H; P (24·7; 44·0)	1966, 78

Formula	Compound	Resonance	Reference
$P_3C_{54}Cl_3N_3S$	$[(C_6H_5)_3PN]_3S, Cl_3$	H; P (16·0)	1968, 254
$P_3C_{55}H_{45}F_8N_2$	$[(C_6H_5)_3P]_2^{\oplus}C^{\oplus}P(C_6H_5)_2N_2C_6H_5, 2BF^{\ominus}$	P (38·9; 24·1)	1966, 78
$P_3C_{56}H_{46}I_2$	$[(C_6H_5)_3P]_2^{\oplus}C^{\oplus}P(C_6H_5)_2CH_2C_6H_5, 2I_4^{\ominus}$	H; P (27·0; 28·5)	1966, 78
P₄			
$P_4C_2Cl_{14}N_6$	$(Cl_3P=NN=CClNPCl_3)_2$	P (15·2; -78·8)	1965, 32
$P_4C_3H_{12}O_{10}$	$OP(CH_2PO_3H_2)_3$	H; P (37·8; 15·3)	1968, 298; 1969, 333
$P_4C_4F_{12}$	$(PCF_3)_4$	P (-74·8); F(T)	1967, 159
$P_4C_6F_{12}N_4$	$N_4P_4F_7(C_6F_5)$	F	1968, 127
$P_4C_6H_{18}Cl_4N_6O_2$	$[ClP(O)(NCH_3)_2P(NCH_3)Cl]_2$	P (4; -73)	1966, 83
$P_4C_6H_{18}Cl_4N_6S_2$	$[ClP(S)(NCH_3)_2P(NCH_3)Cl]_2$	P (55·3; -68)	1966, 83
$P_4C_6H_{18}F_5N_7$	$N_4P_4F_5[N(CH_3)_2]_3$	H	1969, 379
$P_4C_6H_{20}N_2O_{12}$	$(CH_2)_2[N(CH_2PO_3H_2)_2]_2$	P	1966, 212
$P_4C_7H_{22}N_2O_{12}$	$(CH_2)_3[N(CH_2PO_3H_2)_2]_2$	P	1966, 212
$P_4C_8H_{20}$	$(PC_2H_5)_4$	P (-15·7)	1965, 29
$P_4C_8H_{20}Na_2$	$[C_2H_5PP(C_2H_5)Na]_2$	P	1965, 27
$P_4C_8H_{20}O_{12}$	$[C_2H_5OP(O)O]_4$	P (-29)	1963, 5
	$(C_2H_5O)_2P(O)OP(O)[OP(O)OC_2H_5]_2O$	P (-16; -42; -29)	1963, 5
$P_4C_8H_{24}F_4N_8$	$N_4P_4F_4[N(CH_3)_2]_4$	H	1969, 379
$P_4C_8H_{24}N_2O_{12}$	$(CH_2)_4[N(CH_2PO_3H_2)_2]_2$	P	1966, 212
$P_4C_8H_{24}N_4$	$N_4P_4(CH_3)_8$	H{ ¹³ C; ³¹ P}	1968, 3
$P_4C_9H_{24}O_4$	$OP[CH_2P(O)(CH_3)_2]_3$	H; P (36·9; 43·1)	1969, 333
$P_4C_9H_{24}O_{10}$	$OP[CH_2P(O)(OCH_3)_2]_3$	H; P (31·0; 22·8)	1968, 298; 1969, 333

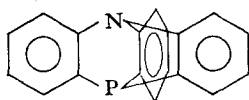
$P_4C_9H_{26}N_2O_{12}$	$(CH_2)_5[N(CH_2PO_3H_2)_2]_2$	P	1966, 212
$P_4C_{10}H_{28}N_2O_{12}$	$(CH_2)_6[N(CH_2PO_3H_2)_2]_2$	P	1966, 212
$P_4C_{11}H_{30}N_2O_{12}$	$(CH_2)_7[N(CH_2PO_3H_2)_2]_2$	P	1966, 212
$P_4C_{12}H_{30}N_2O_{12}$	$CH_2C_6H_{10}CH_2[N(CH_2PO_3H_2)_2]_2$	P	1966, 212
$P_4C_{12}H_{32}N_2O_{12}$	$(CH_2)_8[N(CH_2PO_3H_2)_2]_2$	P	1966, 212
$P_4C_{13}H_{34}N_2O_{12}$	$(CH_2)_9[N(CH_2PO_3H_2)_2]_2$	P	1966, 212
$P_4C_{14}H_{36}N_2O_{12}$	$(CH_2)_{10}[N(CH_2PO_3H_2)_2]_2$	P	1966, 212
$P_4C_{15}H_{36}O_{10}$	$OP[CH_2P(O)(OC_2H_5)_2]_3$	H; P (34.0; 21.0)	1968, 298; 1969, 333
$P_4C_{15}H_{38}N_2O_{12}$	$(CH_2)_{11}[N(CH_2PO_3H_2)_2]_2$	P	1966, 212
$P_4C_{16}H_{36}$	$(Pt-C_4H_9)_4$	P (-57.8)	1966, 293
$P_4C_{16}H_{40}N_2O_{12}$	$(CH_2)_{12}[N(CH_2PO_3H_2)_2]_2$	P	1966, 212
$P_4C_{18}H_{16}Cl_5N_4$	$N_3P_3Cl_5[N=P(C_6H_5)_3]$	P (ca. 20; 15)	1968, 132
$P_4C_{18}H_{17}Cl_4N_5$	$N_3P_3Cl_4(NH_2)[N=P(C_6H_5)_3]$	P (16; 11; -2)	1967, 147; 1968, 114 132
$P_4C_{18}H_{45}Cl_3$	$[(C_2H_5)_3P]_3PCl_3$	H	1969, 344
$P_4C_{21}H_{24}O_7$	$OP[CH_2P(O)(C_6H_5)OH]_3$	P (35.3; 29.8)	1969, 333
$P_4C_{21}H_{48}O_{10}$	$OP[CH_2P(O)(Oi-C_3H_7)_2]_3$	H; P (28.9; 18.6)	1968, 298; 1969, 333
$P_4C_{24}F_{20}$	$(PC_6F_5)_4$	P (-67.0)	1967, 392
$P_4C_{24}H_{20}$	$(PC_6H_5)_4$	H	1969, 344
$P_4C_{24}H_{20}Cl_4N_4$	$N_4P_4Cl_4(C_6H_5)_4$	H	1966, 96
	$N_3P_3Cl_4(C_6H_5)[N=P(C_6H_5)_3]_3$	P (15.8; 2.4; 14)	1968, 132
$P_4C_{24}H_{20}Li_2$	$[C_6H_5PP(C_6H_5)Li]_2$	P (8.2; -86.0)	1965, 27
$P_4C_{26}H_{56}Cl_4N_8$	$N_4P_4Cl_4(C_6H_{11}NCH_3)_4$	H{P}	1968, 134
$P_4C_{27}H_{60}O_{10}$	$OP[CH_2P(O)(OC_4H_9)_2]_2$	P (29.7; 19.6)	1968, 298; 1969, 333

Formula	Compound	Resonance	Reference
$P_4C_{32}H_{44}N_8$	$N_4P_4(C_6H_5)_4[N(CH_3)_2]_4$	H	1966, 96
$P_4C_{32}H_{72}N_{12}$	$N_4P_4(NHCH_3)_4(C_6H_{11}NCH_3)_4$	H{P}	1968, 134
$P_4C_{33}H_{48}O_7$	$OP[CH_2P(O)(OC_4H_9)C_6H_5]_3$	H; P (29.0; 34.7)	1968, 298; 1969, 333
$P_4C_{35}H_{41}N_9O$	$N_4P_4(C_6H_5)_4(NHCH_3)_3[N(CH_3)CONHC_6H_5]$	H	1966, 96
$P_4C_{36}H_{30}$	$P[P(C_6H_5)_2]_3$	P (−16.9; −27.0)	1969, 14
$P_4C_{36}H_{50}F_{10}N_6$	$\{CH_3N(C_6H_5)P^{\oplus}[N(CH_3)CH_2]_2(C_6H_5PF_5^{\ominus})_2$	H; P (49.5; −136); F (−60.7; −57.0)	1968, 352
$P_4C_{39}H_{36}O_4$	$OP[CH_2P(O)(C_6H_5)_2]_3$	P (31.0; 24.4)	1968, 298; 1969, 333
$P_4C_{39}H_{77}N_{13}O$	$N_4P_4(NHCH_3)_3(CH_3NC_6H_{11})_4(CH_3NCONHC_6H_5)$	H{P}	1968, 134
$P_4C_{42}H_{42}O_2$	$[(C_6H_5CH_2)_2P(O)P(C_6H_5CH_2)]_2$	H	1966, 289
$P_4C_{48}H_{40}ClN$	$[(C_6H_5)_2PP(C_6H_5)_2]_2^{\oplus}N, Cl^{\ominus}$	P (28.3; 21.8; −16.5; −23.0)	1965, 11; 1967, 385
$P_4C_{49}H_{40}F_6$	$[(C_6H_5)_3P]_2C^{\oplus}P(C_6H_5)_2, PF_6^{\ominus}$	H; P (26.5; −1.4; −144.2)	1966, 78
$P_4C_{51}H_{108}O_{10}$	$OP[CH_2P(O)(OC_8H_{17})_2]_3$	H; P (29.3; 21.0)	1968, 298; 1969, 333
P₅ and Higher			
$P_5C_5F_{15}$	$(PCF_3)_5$	P (8.2); F(T)	1967, 159
$P_5C_5H_{15}$	$(PCH_3)_5$	H	1969, 328
$P_5C_6H_{14}N_5$	$N_5P_5F_9(C_6F_5)$	F	1968, 127
$P_5C_{18}H_{15}Cl_7N_5$	$N_3P_3Cl_4(N=P(Cl)_3)[N=P(C_6H_5)_3]$	P (19; 18.5; −11.8; −20.3)	1967, 147; 1968, 114

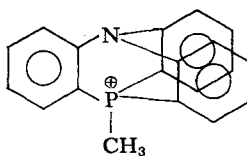
$P_5C_{30}F_{25}$	$P(C_6F_5)_5$	F (-126.4; -160.1; -149.5)	1966, 294
$P_5C_{30}H_{25}$	$P(C_6H_5)_5$	P	1966, 295
$P_5C_{36}H_{30}Cl_4N_5$	$N_3P_3Cl_4[N=P(C_6H_5)_3]_2$	P (13.4; 5.5; -11.6)	1968, 132
$P_5C_{40}H_{45}N_8$	$N_4P_4(C_6H_5)_4(NHCH_3)_3[N(CH_3)P(C_6H_5)_2]$	H	1966, 96
$P_5C_{50}H_{43}F_{12}$	$[(C_6H_5)_3P]_2C^{\oplus}P^{\oplus}(C_6H_5)_2CH_3, 2PF_6^{\ominus}$	H; P (25.8; 22.7; -143.9)	1966, 78
$P_5C_{72}H_{60}Cl_3N_3S$	$\{[(C_6H_5)_3PN]_3S\}Cl_3 \cdot 2P(C_6H_5)_3$	H; P (25; 11; 7.3)	1968, 254
$P_6C_2Cl_{10}N_6O_4$	$[Cl_3P=NN=C(OPOCl_2)NPCl_3]_2$	P (15.2; 6.6; -78.8)	1965, 32
$P_6C_4H_{12}F_{10}N_8$	$N_6P_6F_{10}[N(CH_3)_2]$	H; F (-59)	1969, 151
$P_6C_6F_{16}N_6$	$N_6P_6F_{11}(C_6F_5)$	F	1968, 127
$P_6C_6H_{18}F_9N_9$	$N_6P_6F_9[N(CH_3)_2]_3$	H; F	1969, 151
$P_6C_{12}H_{10}Cl_8N_6$	$[C_6H_5P(NPCl_2)_2N]_2$	P	1968, 128
$P_6C_{72}H_{60}-$ -ClGeN ₃ O ₆	$[(C_6H_5)_2P(O)NP(C_6H_5)_2O]_3GeCl$	P (31.3)	1968, 11
$P_6C_{72}H_{60}-$ -ClN ₃ O ₆ Si	$[(C_6H_5)_2P(O)NP(C_6H_5)_2O]_3SiCl$	P (29.4)	1968, 11
$P_6C_{72}H_{60}-$ -ClN ₃ O ₆ Sn	$[(C_6H_5)_2P(O)NP(C_6H_5)_2O]_3SnCl$	P (35.7)	1968, 11
$P_7C_6F_{18}N_7$	$N_7P_7F_{13}(C_6F_5)$	F	1968, 127
$P_8C_6F_{20}N_8$	$N_8P_8F_{15}(C_6F_5)$	F	1968, 127
$(PC_2H_6NO_2)_n$	$[NP(OCH_3)_2]_n$	H; P (-2)	1966, 6

Formula	Compound	Resonance	Reference
$(\text{PC}_4\text{H}_4\text{F}_6\text{NO}_2)_n$	$[\text{NP}(\text{OCH}_2\text{CF}_3)_2]_n$	H; P (-6); F (-76.6)	1966, 6
$(\text{PC}_4\text{H}_{10}\text{NO}_2)_n$	$[\text{NP}(\text{OC}_2\text{H}_5)_2]_n$	H; P (-5.8)	1966, 6
$(\text{PC}_4\text{H}_{12}\text{N}_3)_n$	$[\text{NP}(\text{NHC}_2\text{H}_5)_2]_n$	H; P (-25.1)	1966, 91
$(\text{PC}_6\text{H}_5)_n$	$(\text{PC}_6\text{H}_5)_n$	P (-9)	1965, 11
		P (-4.4)	1966, 295; 1967, 126
$(\text{PC}_6\text{H}_5\text{O}_2)_n$	$(\text{C}_6\text{H}_5\text{PO}_2)_n$	P (1)	1967, 126
$(\text{PC}_6\text{H}_7\text{O})_n$	$(\text{CH}_3\text{OC}_6\text{H}_4\text{P})_n$	P (-11.8)	1967, 126
$(\text{PC}_7\text{H}_9\text{O})_n$	$(\text{C}_2\text{H}_5\text{OC}_6\text{H}_4\text{P})_n$	P (-12.0)	1967, 126
$(\text{PC}_{10}\text{H}_6)_n$	$(\beta\text{-C}_{10}\text{H}_6\text{P})_n$	P (3.3)	1967, 126
$(\text{PC}_{10}\text{H}_{20}\text{N}_3)_n$	$[\text{NP}(\text{NC}_5\text{H}_{10})_2]_n$	H; P (-6.2)	1966, 91
$(\text{PC}_{12}\text{H}_{10}\text{NO}_2)_n$	$[\text{NP}(\text{OC}_6\text{H}_5)_2]_n$	H; P (-17.1)	1966, 6
$(\text{PC}_{12}\text{H}_{12}\text{N}_3)_n$	$[\text{NP}(\text{NHC}_6\text{H}_5)_2]_n$	H; P (-12.5)	1966, 91
$(\text{PC}_{24}\text{H}_{53}\text{O}_4\text{Sn}_2)_n$	$\{[(\text{C}_4\text{H}_9)_2\text{SnO}]_2\text{P}(\text{O})(\text{C}_8\text{H}_{17})\text{O}\}_n$	P{H}	1969, 140
$(\text{P}_2\text{C}_2\text{H}_2\text{Cl}_6\text{N}_6)_n$	$(\text{Cl}_3\text{PN}=\text{C}=\text{NNHPCl}_3\text{NHN}=\text{C}=\text{N})_n$	P (-61.7; -85.0)	1965, 32
$(\text{PC}_{14}\text{H}_{30}\text{S})-$ $-(\text{PC}_{10}\text{H}_{21}\text{O}_2\text{S})_n$	$(\text{C}_4\text{H}_9)_2\text{P}(\text{S})(\text{CHC}_5\text{H}_{11})[\text{CH}_2\text{CH}(\text{COOCH}_3)\text{P}(\text{S})(\text{C}_4\text{H}_9)_2]_n$	P (58)	1966, 216

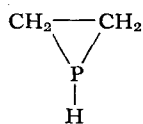
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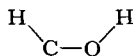
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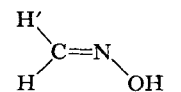
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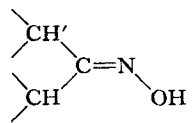


4



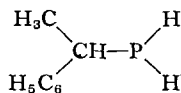
$J(^{15}\text{N}-^1\text{H}) + \text{ve}$
 $J(^{15}\text{N}-^1\text{H}') - \text{ve}$

5

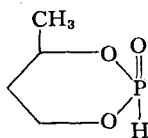


$J(^{15}\text{N}-\text{CH}) + \text{ve}$
 $J(^{15}\text{N}-\text{CH}') + \text{ve}$

6



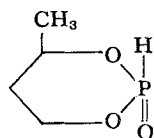
7



$^1\text{J}(\text{P}-\text{H}) = 713 \text{ Hz}$

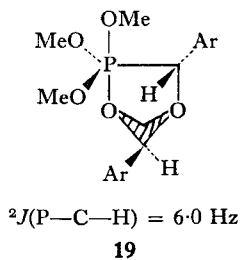
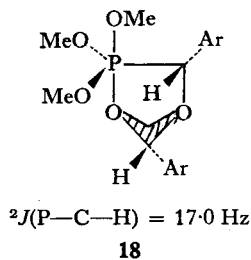
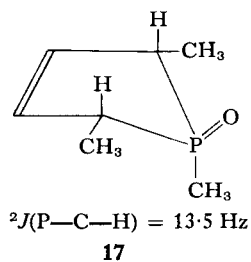
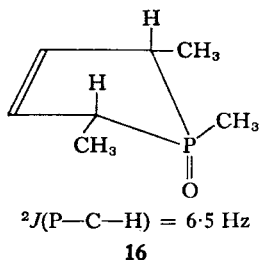
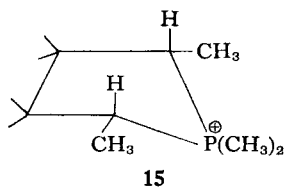
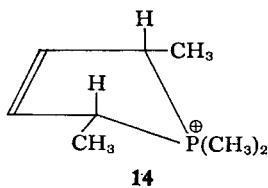
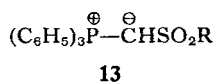
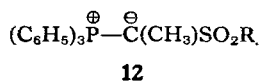
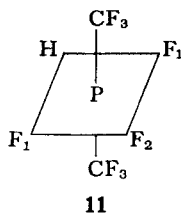
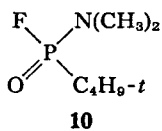
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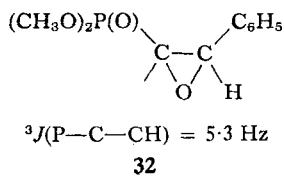
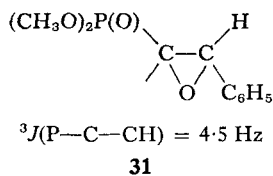
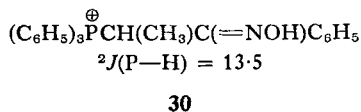
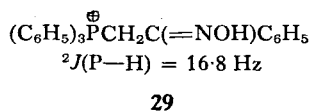
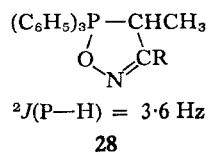
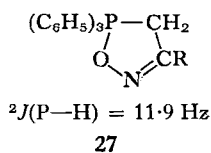
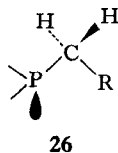
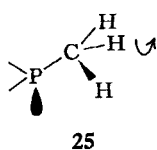
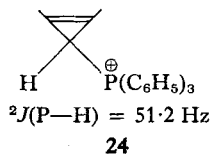
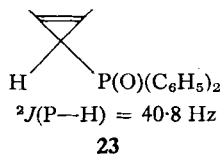
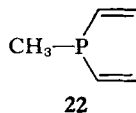
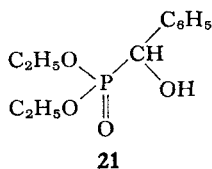
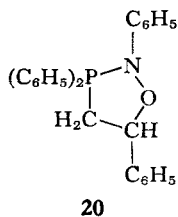
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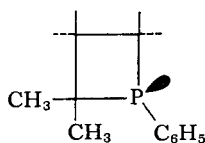


$^1\text{J}(\text{P}-\text{H}) = 667 \text{ Hz.}$

9

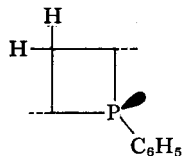






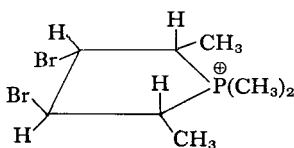
$$^3J(\text{P}-\text{C}-\text{CH}_3) = 19.5 \text{ and } 6.5 \text{ Hz}$$

33



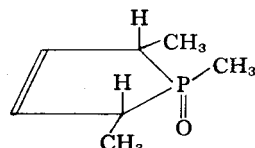
$$^3J(\text{P}-\text{C}-\text{CH}) = 3.5 \text{ and } 0.0 \text{ Hz}$$

34



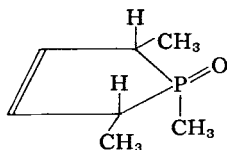
$$^3J(\text{P}-\text{C}-\text{CH}_3) = 16.5 \text{ and } 16.2 \text{ Hz}$$

35



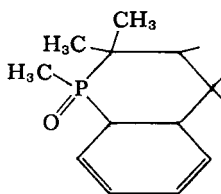
$$^3J(\text{P}-\text{C}-\text{CH}_3) = 14.0 \text{ Hz}$$

36



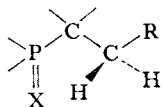
$$^3J(\text{P}-\text{C}-\text{CH}_3) = 15.0 \text{ Hz}$$

37

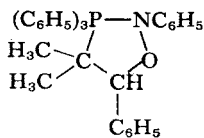


$$^3J(\text{P}-\text{C}-\text{CH}_3) = \text{ca. } 15 \text{ and } 13 \text{ Hz}$$

38

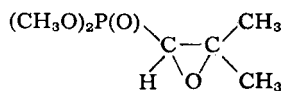


39



$$^3J(\text{P}-\text{C}-\text{CH}) = 18 \text{ and } 21 \text{ Hz}$$

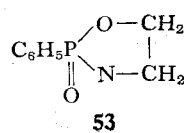
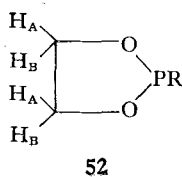
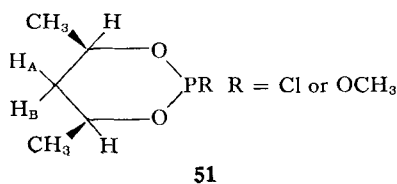
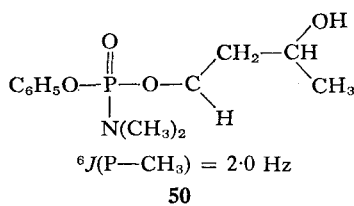
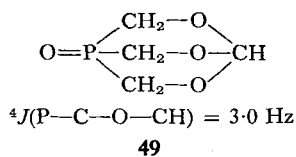
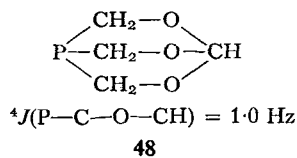
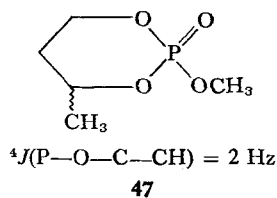
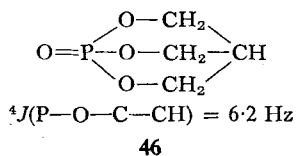
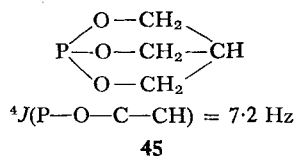
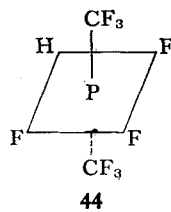
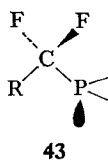
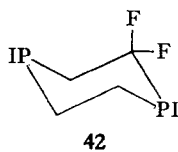
40

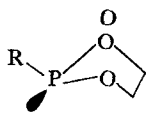


$$^4J(\text{P}-\text{CH}_3) = 10.2 \text{ trans}$$

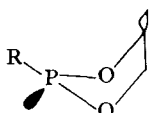
$$7.7 \text{ cis}$$

41

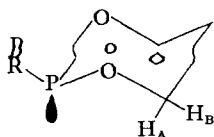




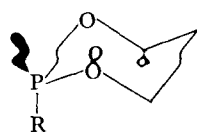
54a



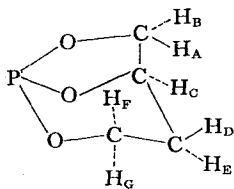
54b



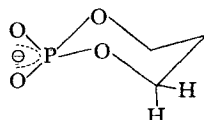
55a



55b



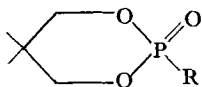
56



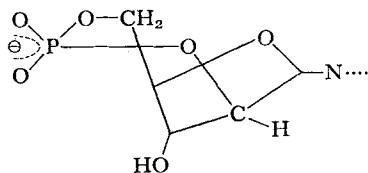
$J(\text{trans})$ ca. 22 to 28 Hz

$J(\text{cis})$ ca. 2 Hz

57

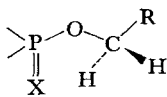


58

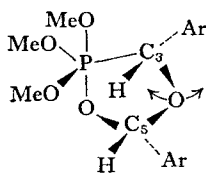


$^3J(\text{P}-\text{O}-\text{CH}) = 18 \text{ Hz}$

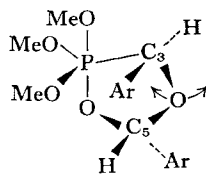
59



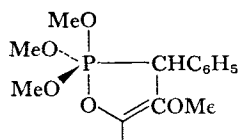
60



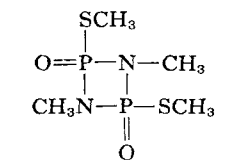
cis
61a



trans
61b

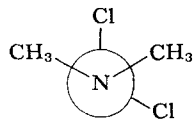


62

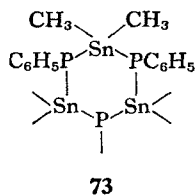
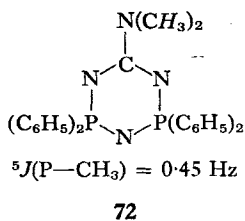
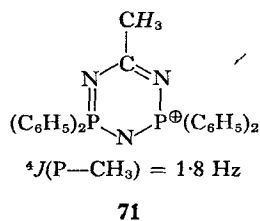
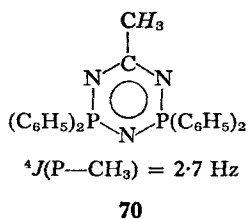
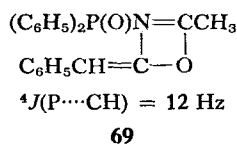
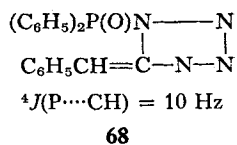
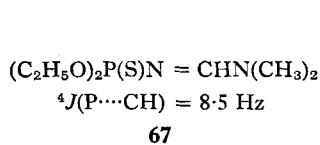
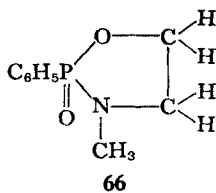
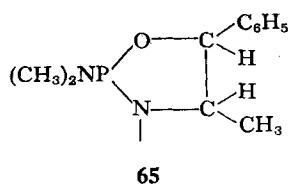


$^5J(\text{PNPSCH}) = 0.2 \text{ Hz}$

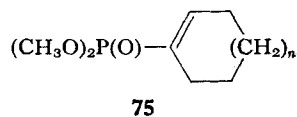
63

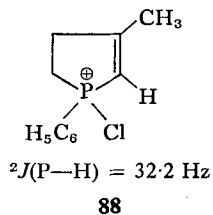
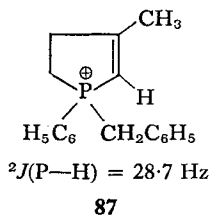
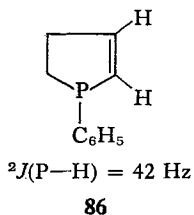
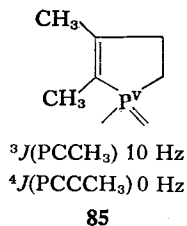
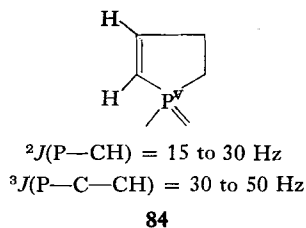
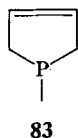
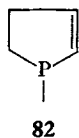
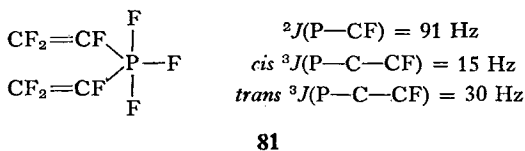
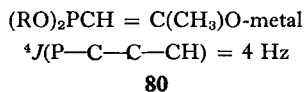
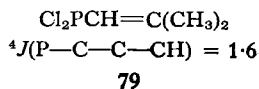
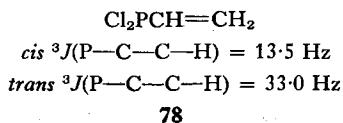
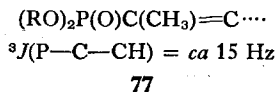
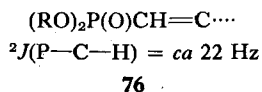


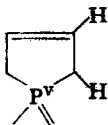
64



74 in Table XIX

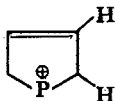






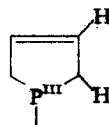
$^2J(\text{PCH}) -10 \text{ to } 20 \text{ Hz}$
 $^3J(\text{PCCH}) +20 \text{ to } 45 \text{ Hz}$

89



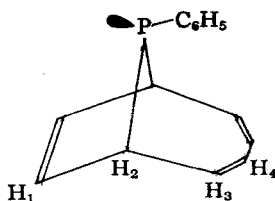
$^2J(\text{PCH}) -8 \text{ to } 10 \text{ Hz}$
 $^3J(\text{PCCH}) +25 \text{ to } 38 \text{ Hz}$

90



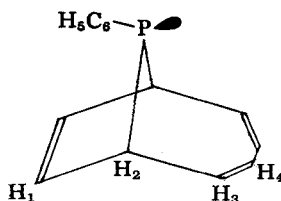
$^2J(\text{PCH}) 5 \text{ to } 8 \text{ Hz}$
 $^3J(\text{PCCH}) 5 \text{ to } 8 \text{ Hz}$

91



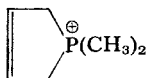
$^3J(\text{P}-\text{H}_1) 11.9 (21.2) \text{ Hz}$
 $^2J(\text{P}-\text{H}_2) 18.3 (\text{ca. } 14.7) \text{ Hz}$
 $^3J(\text{P}-\text{H}_3) \geq 5 (\pm 20.7) \text{ Hz}$
 $^4J(\text{P}-\text{H}_4) \leq 5 (\mp 3.0) \text{ Hz}$

92



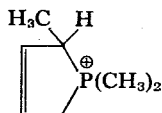
$^3J(\text{P}-\text{H}_1) 3.4 (25.2) \text{ Hz}$
 $^2J(\text{P}-\text{H}_2) 2.2 (\text{ca } 10.3) \text{ Hz}$
 $^3J(\text{P}-\text{H}_3) \pm 13.1 (\leq 5) \text{ Hz}$
 $^4J(\text{P}-\text{H}_4) \mp 3.0 (\geq 15) \text{ Hz}$

93



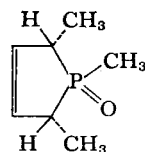
$^2J(\text{P}-\text{CH}) 10.6 \text{ Hz}$

94



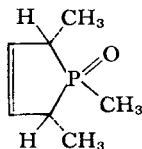
$^2J(\text{P}-\text{CH}) 8.7 \text{ Hz}$
 $^3J(\text{PCCH}_3) 17.5 \text{ Hz}$

95



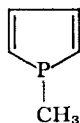
$^2J(\text{P}-\text{CH}) 6.5 \text{ Hz}$
 $^3J(\text{PCCH}_3) 14.0 \text{ Hz}$

96



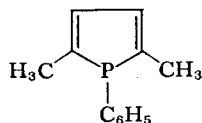
$^2J(\text{P}-\text{CH}) 13.5 \text{ Hz}$
 $^3J(\text{PCCH}_3) 15.0 \text{ Hz}$

97



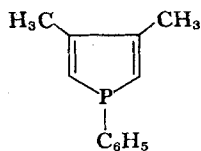
$^2J(\text{P}-\text{CH}) 38.5 \text{ Hz}$
 $^3J(\text{PCCH}) 13.8 \text{ Hz}$

98

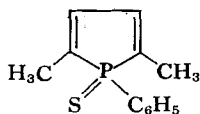


$^3J(\text{PCCH}) 12.5 \text{ Hz}$
 $^3J(\text{PCCH}_3) 10 \text{ Hz}$

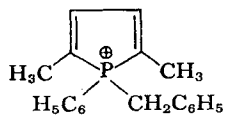
99

 $^2J(\text{P}-\text{CH})$ 37.5 Hz $^4J(\text{PCCCH}_3)$ 3.5 Hz

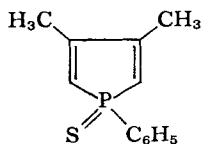
100

 $^3J(\text{PCCH})$ 40 Hz $^3J(\text{PCCH}_3)$ 13 Hz

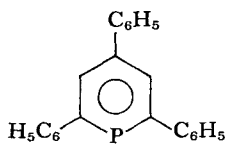
101

 $^3J(\text{PCCH}_3)$ 13 Hz

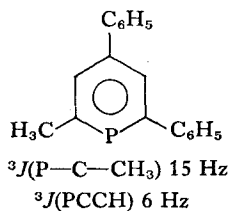
102

 $^2J(\text{P}-\text{CH})$ 30.5 Hz $^4J(\text{PCCCH}_3)$ 2 Hz

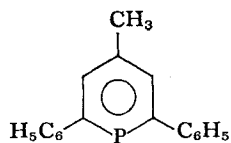
103

 $^3J(\text{PCCH})$ 6 Hz

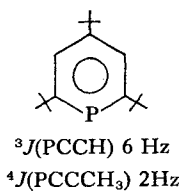
104

 $^3J(\text{P}-\text{C}-\text{CH}_3)$ 15 Hz $^3J(\text{PCCH})$ 6 Hz

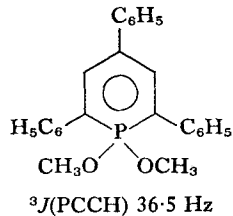
105

 $^3J(\text{PCCH})$ 6 Hz $^5J(\text{PCCCCCH}_3)$ 3.5 Hz

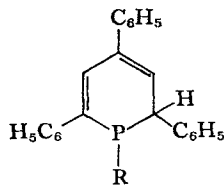
106

 $^3J(\text{PCCH})$ 6 Hz $^4J(\text{PCCCH}_3)$ 2 Hz

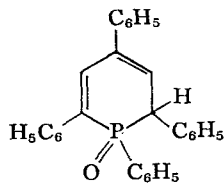
107

 $^3J(\text{PCCH})$ 36.5 Hz

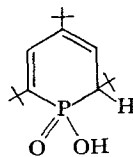
108



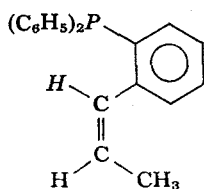
109

 $^2J(\text{P}-\text{CH})$ 16.5 Hz $^3J(\text{PCCH})$ 16.5 Hz

110

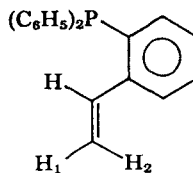


111



$$^4J(\text{P}-\text{H}) = 4.3 \text{ Hz}$$

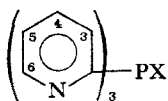
112



$$^6J(\text{P}-\text{H}_1) = 1.1 \text{ Hz}$$

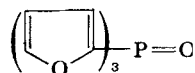
$$^6J(\text{P}-\text{H}_2) = 0.1 \text{ Hz}$$

113



114

PX =	P:	P=O	P=S
$^3J(\text{P}-\text{H}_3)$	1.7	5.7	6.5
$^4J(\text{P}-\text{H}_4)$	2.0	4.3	4.5
$^5J(\text{P}-\text{H}_5)$	1.2	2.4	3.0
$^4J(\text{P}-\text{H}_6)$	0.5	1.2	0.6

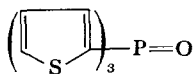


$$^3J(\text{P}-\text{H}_3) = 2.0 \text{ Hz}$$

$$^4J(\text{P}-\text{H}_4) = 1.7 \text{ Hz}$$

$$^4J(\text{P}-\text{H}_5) = 2.7 \text{ Hz}$$

115

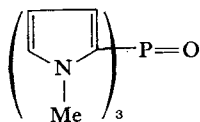


$$^3J(\text{P}-\text{H}_3) = 8.0 \text{ Hz}$$

$$^4J(\text{P}-\text{H}_4) = 2.1 \text{ Hz}$$

$$^4J(\text{P}-\text{H}_5) = 4.6 \text{ Hz}$$

116

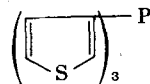


$$^3J(\text{P}-\text{H}_3) = 4.1 \text{ Hz}$$

$$^4J(\text{P}-\text{H}_4) = 3.3 \text{ Hz}$$

$$^4J(\text{P}-\text{H}_5) = 3.7 \text{ Hz}$$

117

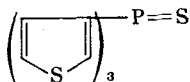


$$^3J(\text{P}-\text{H}_2) = 4.2 \text{ Hz}$$

$$^3J(\text{P}-\text{H}_4) = 2.6 \text{ Hz}$$

$$^4J(\text{P}-\text{H}_5) = 1.0 \text{ Hz}$$

118

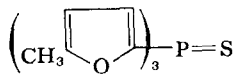


$$^3J(\text{P}-\text{H}_2) = 8.8 \text{ Hz}$$

$$^3J(\text{P}-\text{H}_4) = 4.3 \text{ Hz}$$

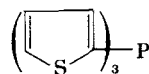
$$^4J(\text{P}-\text{H}_5) = 2.1 \text{ Hz}$$

119



$$^5J(\text{P}-\text{CH}_3) = 0.45 \text{ Hz}$$

120

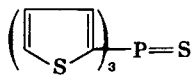


$$^3J(\text{P}-\text{H}_3) = 6.1 \text{ Hz}$$

$$^4J(\text{P}-\text{H}_4) = 1.3 \text{ Hz}$$

$$^4J(\text{P}-\text{H}_5) = 0.3 \text{ Hz}$$

121

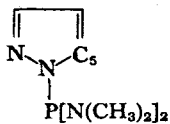


$$^3J(\text{P}-\text{H}_3) \quad 8.9 \text{ Hz}$$

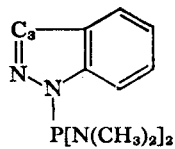
$$^4J(\text{P}-\text{H}_4) \quad 1.9 \text{ Hz}$$

$$^4J(\text{P}-\text{H}_5) \quad 4.4 \text{ Hz}$$

122



123



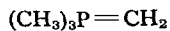
124



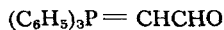
$$^2J(\text{P}=\text{CH}) = 13.5 \text{ Hz}$$

$$^2J(\text{P}-\text{CH}) = 4.3 \text{ Hz}$$

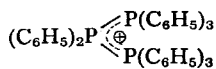
125



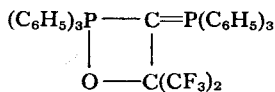
126



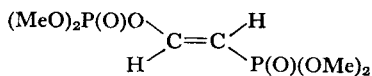
127



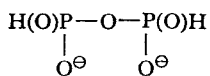
128



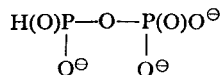
129



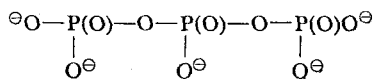
130



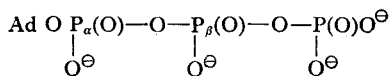
131



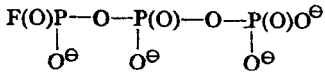
132



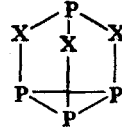
133



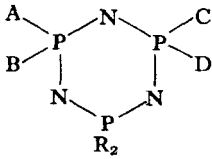
134



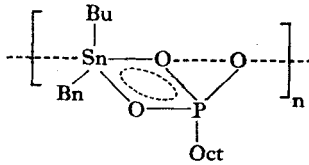
135

X = S, $^2J(\text{PSP}) = 71 \text{ Hz}$ X = Se, $^2J(\text{PSeP}) \approx 72 \text{ Hz}$

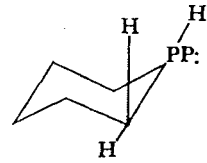
136



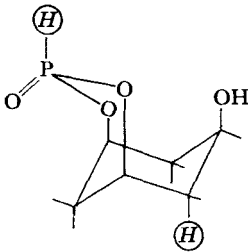
137



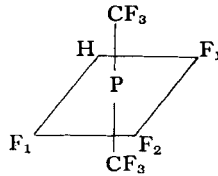
138



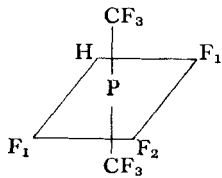
139



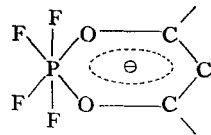
140

 $^2J(\text{H—F}_1) = 70 \text{ Hz}$ $^2J(\text{H—F}_2) = 18 \text{ Hz}$ $^3J(\text{H—CF}_3) = 9.5 \text{ Hz}$

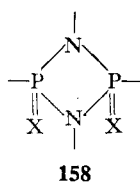
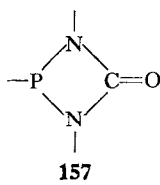
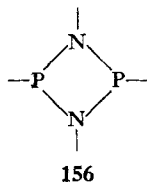
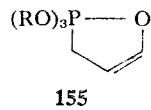
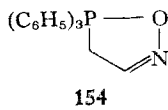
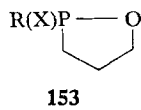
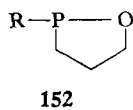
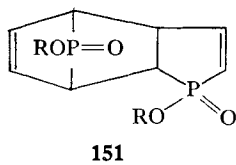
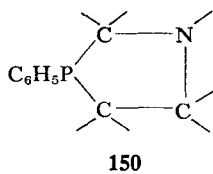
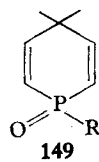
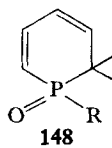
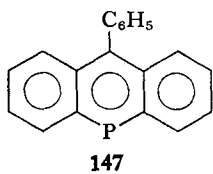
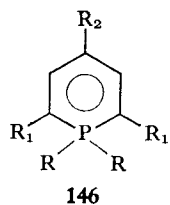
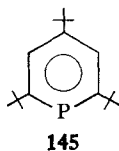
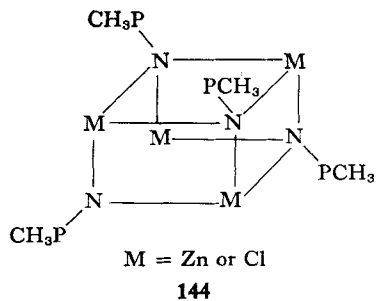
141

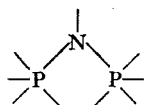
 $^2J(\text{F}_1\text{—F}_2) = 25 \text{ Hz}$ $^3J(\text{F}_1\text{—CF}_3) = 12.5 \text{ Hz}$ $^3J(\text{F}_2\text{—CF}_3) = 15.5 \text{ Hz}$

142

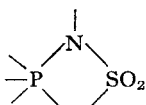
 $^2J(\text{F}_{\text{ax}}\text{—F}_{\text{eq}}) = 59.4 \text{ Hz}$

143

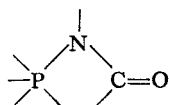




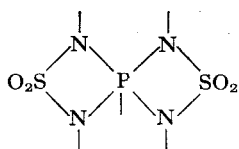
159



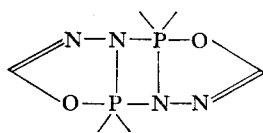
160



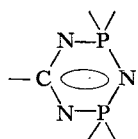
161



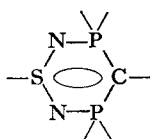
162



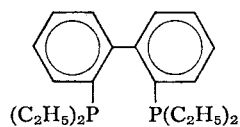
163



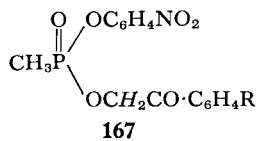
164



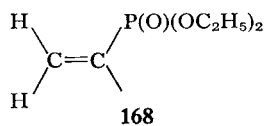
165



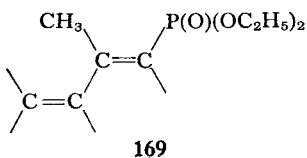
166



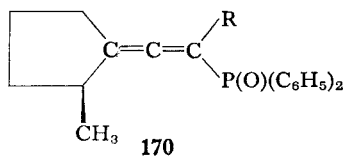
167



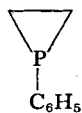
168



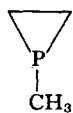
169



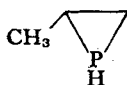
170



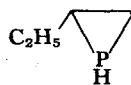
171



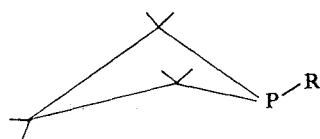
172



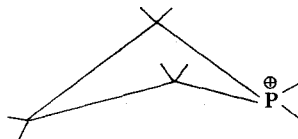
173



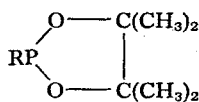
174



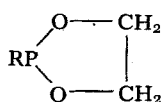
175



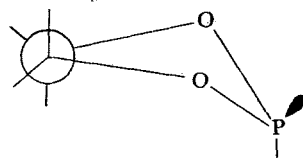
176



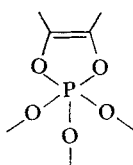
177



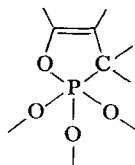
178



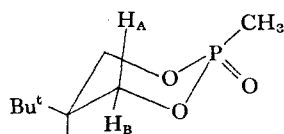
179



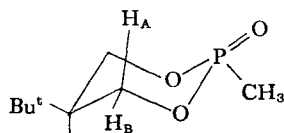
180



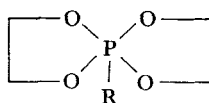
181

 $^3J(\text{P}-\text{H}_\text{A})$ 6.4 Hz $^3J(\text{P}-\text{H}_\text{B})$ 22.7 Hz

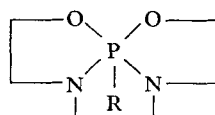
182a

 $^3J(\text{P}-\text{H}_\text{A})$ 4.1 Hz $^3J(\text{P}-\text{H}_\text{B})$ 20.2 Hz

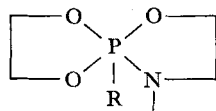
182b



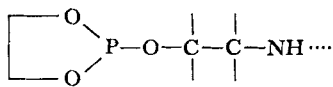
183



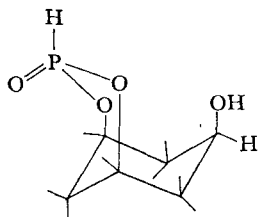
184



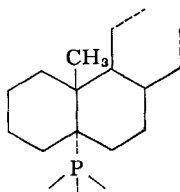
185



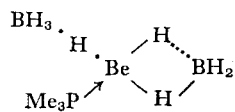
186



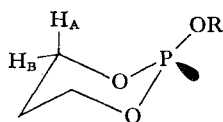
187



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