Heterocyclic Methylenephosphoranes

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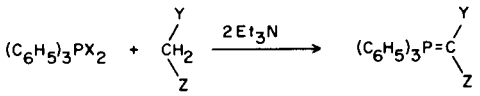
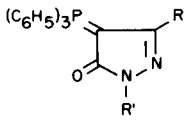
As part of a program directed toward the preparation of stable methylenephosphoranes (1,2,3), it was of interest to synthesize systems in which the carbanionic moiety of the ylide was contained in a heterocyclic ring. With the appropriate substituents in the ring it should be possible to construct stabilized structures of this type.

The synthetic route which was found to be most convenient for the desired heterocyclic methylenephosphoranes employed the method of Horner and Oediger (4,5). These authors were able to prepare stable phosphoranes (III) by the action of triphenylphosphine dihalide (I) and triethylamine on compounds containing a reactive methylene group such as II. The Y and Z groups were electron-withdrawing substituents such as a carboalkoxy, a cyano or an acyl function.



I II III

This method was applied successfully by us to several heterocyclic systems containing activated methylene groups. Substituted pyrazolones, rhodanines, oxindoles and barbituric acids reacted to give the corresponding methylenephosphoranes IV-VII.



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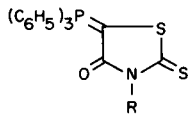

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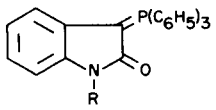

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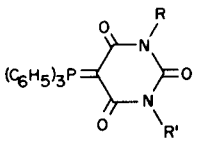

VII

The yields, as shown in Table I, were generally good and the heterocyclic methylenephosphoranes were quite stable even upon prolonged refluxing in alcoholic solvents. The infrared spectra of these compounds (Table III) are characterized by peaks at 1443-1439 cm^{-1} (aryl group attached to phosphorus) and at 1112-1110 cm^{-1} (aromatic vibration involving some phosphorus-carbon stretching). The carbonyl absorption band of the starting heterocyclics at 1740-1680 cm^{-1} is shifted to 1629-1603 cm^{-1} in the methylenephosphoranes indicating substantial contribution of resonance form IX to the overall structure.

VIII IX

Attempts to isolate methylenephosphoranes from heterocyclic compounds which contained an *N*-hydrogen amide function, such as rhodanine, oxindole or barbituric acid, were unsuccessful. Apparently, enolization which can occur with these compounds leads to attack by nitrogen on the triarylphosphine dibromide rather than the desired carbon-phosphorus bond formation.

Besides demonstrating that this reaction operates well with suitably activated heterocyclic systems, this work has indicated in a general way that functional groups, other than those reported by Horner and Oediger (4,5), should be capable of providing sufficient activation for phosphorane formation. In addition, this reaction has been extended to other triarylphosphines besides triphenylphosphine (in contrast, tributylphosphine did not yield any isolable product under the reaction conditions).

EXPERIMENTAL

Melting points are uncorrected. Infrared spectra were determined in chloroform using a Perkin-Elmer 137 spectrophotometer.

TABLE I

Synthesis of Heterocyclic Methylenephosphoranes

No.	Heterocyclic Compound	Triarylphosphine	Reaction conditions Solvent (a)	Time, hr.	M.p., °C	Yield %
1	3-Methyl-1-phenyl-2-pyrazoline-5-one	$(C_6H_5)_3P$	B	2	247-248 (b)	98
2	1,3-Diphenyl-2-pyrazoline-5-one	$(C_6H_5)_3P$	B	16	234-235 (b)	78
3	3-Methyl-1-(*p*-nitrophenyl)-2-pyrazoline-5-one	$(C_6H_5)_3P$	D	3	261-262 (c)	49
4	3-Methyl-1-phenyl-2-pyrazoline-5-one	$(p\text{-}CH_3OC_6H_4)_3P$	B	1	224-225 (d)	67
5	3-Methyl-1-(*p*-nitrophenyl)-2-pyrazoline-5-one	$(p\text{-}CH_3OC_6H_4)_3P$	D	5	216-217 (e)	52
6	3-Methyl-1-phenyl-2-pyrazoline-5-one	$[p\text{-}(CH_3)_2NC_6H_4][C_6H_5]_2P$	B	1	253-254 (f)	57
7	3-Phenylrhodanine	$(C_6H_5)_3P$	B	2	245-246 (g)	22
8	3-Ethylrhodanine	$(C_6H_5)_3P$	B	4	207-208 (f)	92
9	1-Ethyloxindole	$(C_6H_5)_3P$	B	4	251-253 (f)	73
10	1,3-Dicyclohexyl-barbituric acid	$(C_6H_5)_3P$	B	2	316-318 (d)	65

(a) B = benzene; D = dioxane. (b) Recrystallized from methanol. (c) Recrystallized from ethanol. (d) Recrystallized from methanol-water mixture. (e) Recrystallized from benzene. (f) Recrystallized from benzene-petroleum ether mixture. (g) Recrystallized from chloroform-ethanol mixture.

TABLE II

Analyses of Heterocyclic Methylenephosphoranes

No.	Formula	C Calcd.	C Found	H Calcd.	H Found	N Calcd.	N Found	P Calcd.	P Found	S Calcd.	S Found
1	$C_{28}H_{23}N_2OP$	77.40	77.59	5.33	5.19	6.45	6.49	7.13	6.88		
2	$C_{33}H_{25}N_2OP$	79.82	80.03	5.07	5.14	5.64	5.47	6.24	6.40		
3	$C_{28}H_{22}N_3O_3P$	70.14	70.07	4.62	4.48	8.76	8.46	6.46	6.63		
4	$C_{31}H_{29}N_2O_4P$	70.98	70.66	5.57	5.56	5.34	5.37	5.90	6.01		
5	$C_{31}H_{28}N_3O_6P$	65.37	65.02	4.96	5.13	7.38	7.12	5.44	5.62		
6	$C_{30}H_{28}N_3OP$	75.45	75.53	5.91	5.79	8.80	8.94	6.49	6.71		
7	$C_{27}H_{20}NOPS_2$	69.06	69.35	4.29	4.26	2.98	2.95	6.60	6.58	13.66	12.99
8	$C_{23}H_{20}NOPS_2$	65.54	65.96	4.78	4.93	3.32	3.59	7.35	7.41	15.21	15.36
9	$C_{28}H_{24}NOP$	79.79	79.56	5.74	5.63	3.32	3.63	7.35	7.37		
10	$C_{34}H_{37}N_2O_3P$	73.89	74.12	6.75	6.68	5.07	5.26	5.60	5.50		

TABLE III

Infrared Spectral Data on Heterocyclic Methylenephosphoranes

No.	ν, cm^{-1}								
1	2960 (m), 1249 (m),	1613 (s), 1110 (s),	1596 (s), 1047 (w),	1498 (s), 1028 (w),	1481 (m), 1008 (w),	1439 (s), 1002 (m),	1404 (s), 908 (w),	1365 (s), 842 (w),	1347 (s), 692 (s).
2	2965 (m), 1111 (s),	1615 (s), 1072 (w),	1492 (m), 1021 (m),	1471 (w), 1005 (w),	1440 (s), 976 (w),	1401 (s), 920 (w),	1348 (s), 692 (s).	1254 (m),	1139 (w),
3	2970 (w), 1111 (s),	1627 (s), 1045 (w),	1591 (m), 1010 (w),	1508 (s), 1003 (w),	1440 (m), 858 (m),	1409 (m), 830 (w),	1368 (m), 689 (m).	1320 (s),	1252 (m),
4	2966 (m), 1261 (s),	1603 (s), 1186 (s),	1508 (s), 1111 (s),	1462 (m), 1030 (m),	1442 (w), 1009 (w),	1413 (m), 908 (w),	1369 (w), 836 (m),	1348 (m), 692 (m).	1295 (m),
5	2955 (w), 1323 (s), 835 (m),	1629 (s), 1298 (m), 689 (m).	1604 (s), 1263 (s),	1578 (w), 1186 (s),	1506 (s), 1112 (s),	1466 (w), 1047 (w),	1443 (w), 1031 (m),	1409 (m), 1008 (w),	1365 (w), 858 (w),
6	2970 (m), 1250 (m),	1612 (s), 1111 (s),	1522 (m), 1048 (w),	1512 (m), 1028 (w),	1491 (w), 1001 (m),	1441 (m), 947 (w),	1409 (m), 817 (m),	1370 (s), 691 (s).	1348 (s),
7	2960 (m), 1030 (m),	1627 (s), 1003 (m),	1487 (w), 844 (w),	1441 (m), 689 (m).	1364 (m),	1258 (m),	1192 (s),	1111 (s),	1090 (m),
8	2975 (m), 1089 (m),	1626 (s), 1030 (w),	1492 (m), 1004 (m),	1442 (s), 984 (w),	1401 (m), 893 (w),	1380 (w), 690 (m).	1322 (m),	1213 (s),	1112 (s),
9	2995 (m), 1194 (m), 829 (w),	1613 (s), 1136 (w), 690 (w).	1586 (s), 1111 (s),	1481 (m), 1097 (w),	1443 (s), 1032 (w),	1370 (s), 1014 (w),	1353 (m), 1004 (w),	1300 (s), 961 (w),	1285 (m), 934 (w),
10	2925 (m), 1335 (s),	1700 (s), 1263 (w),	1627 (s), 1111 (m),	1612 (s), 1032 (w),	1493 (w), 1007 (w),	1443 (s), 903 (w),	1402 (s), 689 (m).	1385 (s),	1370 (s),

Materials.

The compounds which were not available commercially were prepared by literature methods. The 3-methyl-1-(*p*-nitrophenyl)-2-pyrazoline-5-one was synthesized according to Sumpter and Wilken (6) and the 1,3-dicyclohexylbarbituric acid by the method of Bose and Garratt (7). The tris (*p*-methoxyphenyl)phosphine (8) and *p*-dimethylaminophenyldiphenylphosphine (9) were prepared by well-documented techniques. The benzene and dioxane were dried before use. The triethylamine was purified by distillation.

General Procedure for the Synthesis of Heterocyclic Methylenephosphoranes (Table I).

The reactions were carried out under a nitrogen atmosphere. To a 2 l. three-necked flask equipped with stirrer, thermometer and dropping funnel was added 0.10 mole of the triarylphosphine dissolved in 300 ml. of benzene or dioxane. The solution was cooled to 5° and 0.10 mole of bromine in 50 ml. of benzene or dioxane was added dropwise with stirring over 10 minutes keeping the temperature below 10°. The triarylphosphine dibromide formed as an orange oil. To this mixture was added a solution of 0.10 mole of the heterocyclic compound and 0.22 mole of triethylamine dissolved in 150 ml. of benzene or dioxane keeping the temperature below 15°. After the addition the dropping funnel was replaced by a condenser. The reaction mixture was heated to reflux in the case of benzene, or to 80° when dioxane was used, for the time period designated in Table I. After cooling to room temperature the triethylamine hydrobromide was removed by filtration and the filtrate was evaporated. In some cases the product was partially insoluble in benzene or dioxane and would be collected with the triethylamine hydrobromide. In order to prevent loss of product the hydrobromide was thoroughly washed with water and any remaining solid was added to the filtrate. The combined solids were then recrystallized from the

appropriate solvents to give the yields of heterocyclic methylenephosphoranes shown in Table I. The analyses are recorded in Table II.

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