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4-Phosphoranylidene-5(4*H*)-oxazolones – A Novel Synthesis and Properties

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Summary. 4-Phosphoranylidene-5(4*H*)-oxazolones (**2**), a hardly known class of phosphorus ylides, were readily prepared from 4-unsubstituted-5-(4*H*)-oxazolones (**1**) by treatment with Ph_3P-Br_2, Bu_3P-Br_2, Ph_3P-CCl_4, or Ph_3P-CBr_4 adducts in the presence of triethylamine in CH_2Cl_2 at room temperature in a novel, efficient one-pot procedure. The spectroscopic properties of the ylides are reported and discussed.

Keywords. 4-Phosphoranylidene-5(4*H*)-oxazolones; Phosphorus ylides; 5(4*H*)-Oxazolone enolate ion equivalent; 5-(4*H*)-Oxazolones; NMR.

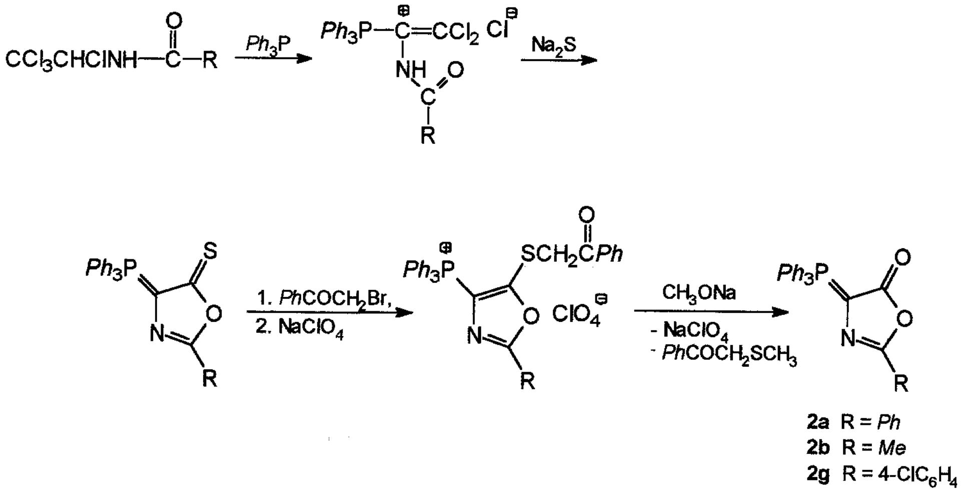
4-Phosphoranyliden-5(4*H*)-oxazolone – Eine neue Synthese und Eigenschaften

Zusammenfassung. 4-Phosphoranyliden-5(4*H*)-oxazolone, eine sehr wenig bekannte Gruppe der Phosphor-ylide, wurden auf einfache Weise nach einem neuen Eintopfverfahren mit guten Ausbeuten hergestellt. Als Ausgangsverbindungen wurden 4-unsubtituierte-5-(4*H*)-Oxazolone (**1**) eingesetzt, die unter der Einwirkung von Addukten wie Ph_3P-Br_2, Bu_3P-Br_2, Ph_3P-CCl_4 oder Ph_3P-CBr_4 in Anwesenheit von Triethylamin in CH_2Cl_2 bei Zimmertemperatur die Titelverbindungen liefern. Die spektroskopischen Eigenschaften der Ylide werden berichtet und diskutiert.

Introduction

4-Phosphoranylidene-5(4*H*)-oxazolones (**2**) are a hardly known class of phosphorus ylides derived from 5-(4*H*)-oxazolones. According to the best of our knowledge, only three ylides of this structure (**2a**–**b** and **2g**) have been reported in literature so far. In 1985–1986, *Lobanov et al.* [1–2] described a complicated, multistep synthesis of these ylides starting from N-(1,2,2,2-tetrachloroethyl)amides (Scheme 1). In spite of the lack of essential MS, ^{1}H-, and ^{13}C-NMR spectral data in *Lobanov*'s papers, the proposed ylide structure of the synthesized compounds seems to be correct.

The dipolar resonance structures of ylides **2** (Scheme 2, structures **II**–**IV**) are closely similar (isoelectronic) to the resonance structures of enolate ions derived from 5-(4*H*)-oxazolones. Enolate ions of 5-(4*H*)-oxazolones are intermediates of considerable importance in organic syntheses [3–5]; in many cases, however, the synthetic utility of reactions proceeding *via* such enolates is limited due to the competitive acylation of the enolate ion at position 4 by another oxazolone



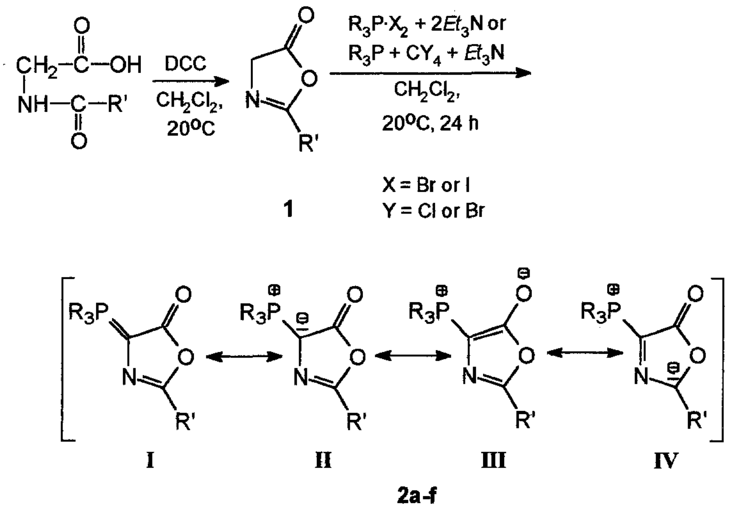
Scheme 1

molecule, which eventually yields a 5-(4*H*)-oxazolone dimerization product [6–12]. Ylides **2** are quite resistant to dimerization; therefore, they may be considered as promising synthetic equivalents for the enolate ions of 5(4*H*)-oxazolones [12].

In the present paper, we want to describe the facile and efficient one-pot synthesis of 4-phosphoranylidene-5(4*H*)-oxazolones from readily available 5(4*H*)-oxazolones, as well as both the physical and spectroscopic properties of the synthesized ylides.

Results and Discussion

The starting products **1** (4-unsubstituted-5(4*H*)-oxazolones) were prepared *in situ* by dehydration of the corresponding N-acylglycines with *DCC* in CH_2Cl_2 at ambient temperature. 5(4*H*)-Oxazolones, when treated with $Ph_3P\text{-}Br_2$ or $Bu_3P\text{-}Br_2$ adducts in the presence of two equivalents of triethylamine in CH_2Cl_2 at room temperature, gave ylides **2** in good or very good yields (Scheme 2, Table 1).



Scheme 2

Table 1. 4-Phosphoranylidene-5(4*H*)-oxazolones (**2**) and some of their spectral data

			R_3P/X_2	Yield[a]	M.p.	IR	MS	^{1}H-NMR	Elemental analyses (%)							
			or				$M^{+\cdot}$	($CDCl_3$/*TMS*)	Calcd.				Found			
No.	*R*	*R'*	R_3P/CY_4	(%)	(°C)	(cm^{-1})	(amu/%)	δ (ppm)	C	H	N	P	C	H	N	P
2a	Ph	Ph	Ph_3P/Br_2	96	186.5–187.5[b]	1682s[c]	421/34	7.73–7.48 (m, $20H_{arom}$)	76.95	4.78	3.32	7.35	76.61	4.91	3.47	7.08
2a	Ph	Ph	Ph_3P/CCl_4	13[d]												
2a	Ph	Ph	Ph_3P/CBr_4	19[d]												
2b	Me	Ph	Ph_3P/Br_2	51	206–206.5[e]	1687s	359/14	7.81–7.32 (m, $15H_{arom}$), 2.18 (s, 3H, CH_3)	73.53	5.05	3.90	8.62	73.20	5.32	4.11	8.51
2c	*t*-Bu	Ph	Ph_3P/Br_2	80	214.5–215.5	1679s	401/23	7.92–7.29 (m, $15H_{arom}$), 1.25 (s, 9H, $(CH_3)_3C$)	74.80	6.03	3.49	7.72	74.69	6.06	3.63	7.74
2d	*i*-Pr	Ph	Ph_3P/Br_2	91	150–152	1681s	387/18	7.93–7.43 (m, $15H_{arom}$), 2.79 (septet, 1H, CH, $J = 7$ Hz), 1.24 (d, 6H, $(CH_3)_2$ CH, $J = 7$ Hz)	74.41	5.72	3.62	7.99	74.59	5.89	3.40	7.78
2e	Ph	Bu	Bu_3P/Br_2	89	51–54	1675s	361/53	7.91–7.12 (m, $5H_{arom}$), 2.33–2.06 (m, 6H, CH_2CH_2P), 1.69–1.30 (m, 12H, $CH_3(CH_2)_2CH_2$), 1.07–0.86 (m, 9H, CH_3CH_2)	69.78	8.92	3.87	8.57	69.83	8.63	3.79	8.29
2f	*t*-Bu	Bu	Bu_3P/Br_2	82	46–49	1672s	341/39	2.23–2.06 (m, 6H, CH_2CH_2P), 1.63–1.42 (m, 12H, $CH_3(CH_2)_2CH_2$), 1.02–0.84 (m, 9H, CH_3CH_2)	66.83	10.63	4.10	9.07	67.00	10.78	4.28	8.86

[a] Based on N-acylglycine; [b] Ref. [1]: m.p. = 176–178 °C; [c] Ref. [1]: 1690 cm^{-1} (CH_2Cl_2); [d] the product was identical (IR, TLC) with ylide **2a** obtained by treatment of oxazolone **1a** with Ph_3PBr_2; [e] Ref. [2]: m.p. = 199–201 °C

Attempts to use $Ph_3P\text{-}CCl_4$ or $Ph_3P\text{-}CBr_4$ adducts in this reaction instead of $Ph_3P\text{-}Br_2$ were only partly successful; although we were able to obtain the expected ylide **2a**, the yields were rather poor.

We have also tried to synthesize the ylide **2h** (R = PhO, R' = Ph) from 2-phenyl-5(4*H*)-oxazolone and the $(PhO)_3P\text{-}I_2$ adduct, which had been described by *Rydon* and *Tonge* [13]. The IR spectrum of the reaction mixture revealed a complete disappearance of strong oxazolone bands at 1828 and 1666 cm^{-1} and the formation of a new strong band in the range of ylide absorption (at 1658 cm^{-1}) already after 3 h. However, attempts to isolate the reaction product failed, probably due to the instability of **2h**.

Ylides **2** were isolated from the reaction mixtures by evaporation of CH_2Cl_2 and extraction of the residue with hot benzene. After evaporation of the benzene, the crude ylides were purified by crystallization from benzene (**2a**–**2d**) or by column chromatography (**2e** and **2f**). Ylides **2** are crystalline, easily soluble in CH_2Cl_2, $CHCl_3$, and hot benzene, slightly or moderately soluble in benzene at room temperature (with the exception of **2e** and **2f** which are easily soluble in benzene even at room temperature), and rather insoluble in hexane. They are stable at room temperature, provided they are protected from moisture.

The structure of ylides **2** has been confirmed by satisfactory analytical (C, H, N and P) as well as spectral data (MS, IR, ^1H, ^{13}C, and ^{31}P NMR, see Tables 1 and 2).

The molecular ion peaks in the MS spectra of all ylides **2** are rather little intensive though easily detectable, in spite of using the EI method for generating ions. In the spectra of all ylides derived from triphenylphosphine (**2a**–**d**), the odd-electron $Ph_3P^{+\cdot}$ ion ($m/e = 262$) is of greatest abundance. Its further fragmentation, proceeding almost identically to that of the triphenylphosphine molecular ion, gives distinct peaks at $m/e = 183$, 152, 108, 77, and 51. In the spectra of ylides derived from tributylphosphine (**2e** and **2f**), the $Bu_3P^{+\cdot}$ ion peaks are very weak. In this case, the predominating fragmentation probably consists in the loss of the butene molecule (peaks at $m/e = M - 56$) followed by a splitting off of the $R'^{\cdot}$ radical, which gives a prominent peak at $m/e = 228$.

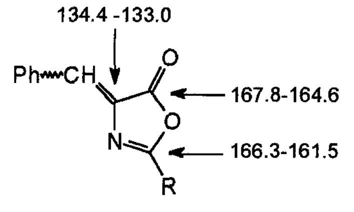
A strong band in the range 1690 – 1655 cm^{-1} in IR spectra is most diagnostic for ylides **2** (Table 1). This band can be assigned to the superimposed $\nu_{C=O}$ and $\nu_{C=N}$ stretching absorptions. The carbonyl absorption band of starting 5-(4*H*)-oxazolones at about 1825 – 1810 cm^{-1} [4] is, therefore, shifted towards lower frequencies by more than 120 cm^{-1} in ylides **2**, indicating a strong coupling between the free electron pair of the ylide and the carbonyl group (Scheme 2). A similar phenomenon has been observed in the case of other resonance stabilized phosphorus ylides with a phosphoranylidene group at the α-carbon relative to the carbonyl group [14].

The ^1H NMR spectral data presented in Table 1 confirm the proposed structure of ylides **2**. The ^{13}C chemical shifts and ^{13}C–^{31}P couplings for the $Ph_3P{=}C<$ or $Bu_3P{=}C<$ groups in ylides **2** (Table 2) are in good agreement with literature data for similar resonance stabilized ylides [15, 16]. It is noteworthy that the C-4 carbons of the oxazolone ring in ylides **2** are shielded by about 60–64 ppm compared to the corresponding carbons of 4-benzylidene-5(4*H*)-oxazolones **3** (Fig. 1). This indicates a high electron density at the ylide carbon as a result of a considerable contribution of resonance structure **II** (Scheme 2).

Table 2. ^{13}C and ^{31}P NMR spectral data of 4-phosphoranylidene-5(4*H*)-oxazolones (**2**)

			^{13}C NMR								^{31}P NMR
			$(C_6H_5)_3P=$ or $(C_4H_9)_3P=$ δ (ppm)/J_{C-P} (Hz)				Oxazolone ring δ (ppm)/J_{C-P} (Hz)			Other carbons δ (ppm)	δ (ppm)
No.	*R*	*R'*	C_1	C_2	C_3	C_4	C_2	C_4	C_5		
2a	Ph	Ph	123.2/93.2	133.9/10.5	129.2/12.8	133.3/2.9	150.1/21.2	73.2/157.8	170.6/34.0	124.8, 128.1, 128.3, 128.9 (other aromatic)	11.9[a]
2b	Me	Ph	123.8/93.5	134.0/10.6	129.2/12.8	133.1/2.8	150.0/21.5	69.2/159.5	171.4/33.8	15.8 (CH_3)	–
2c	*t*-Bu	Ph	123.9/93.0	134.0/10.5	129.0/12.5	133.0/3.0	159.2/20.3	69.2/159.3	171.8/34.8	33.7 $((CH_3)_3\mathit{C})$, 28.1 $((\mathit{C}H_3)_3C)$	10.3
2d	*i*-Pr	Ph	124.1/93.0	134.0/10.5	129.1/12.8	133.1/2.9	157.4/20.4	69.0/157.5	171.6/34.2	29.2$((CH_3)_2\mathit{C}H)$, 20.1 $((\mathit{C}H_3)_2CH)$	–
2e	Ph	Bu	20.4/54.1	23.89/15.1	23.72/4.0	13.5	149.4/19.7	73.4/144.2	170.3/32.3	129.0, 128.4, 128.0, 124.8 (other aromatic)	18.4
2f	*t*-Bu	Bu	20.6/54.5	23.86/15.0	23.77/3.6	13.5	158.3/18.8	69.3/145.9	171.3/32.7	33.5 $((CH_3)_3\mathit{C})$, 28.2 $((\mathit{C}H_3)_2CH)$	17.7

[a] Ref. [1]: 9.7 ppm



Z-**3a** R = *Ph*, *E*-**3a** R = *Ph*, *Z*-**3b** R = *Me*

Fig. 1. ^{13}C chemical shifts for the oxazolone ring of 4-benzylidene-5(4*H*)-oxazolones (solutions in $CDCl_3$) [17]

The ^{31}P chemical shift values for the ylides **2** (18.4–10.3 ppm) agree quite well with the value of 9.7 ppm quoted by *Lobanov et al.* for **2a** [1] and with the ^{31}P chemical shifts in some similar resonance stabilized phosphorus ylides (17.4–16.3 ppm) which have been reported by *Seno et al.* [16].

In summary, the presently reported route offers an easy access to 4-phosphoranylidene-5(4*H*)-oxazolones from readily available 4-unsubstituted-5-(4*H*)-oxazolones. The reported spectral data of ylides **2** fully confirm their structure.

Experimental

Melting points, determined in capillary tubes, are uncorrected. IR spectra were recorded on a Zeiss Specord-M 80 spectrophotometer; the measurements were carried out in CH_2Cl_2 (0.2 *M*) using cells of 0.075 mm. ^1H, ^{13}C, and ^{31}P NMR spectra were recorded in $CDCl_3$ on a Varian VXR-300 spectrometer at operating frequencies of 300, 75.5 and 121.4 MHz, respectively, in the FT mode. In the case of ^1H and ^{13}C NMR spectra, *TMS* was used as an internal standard; ^{31}P NMR spectra were recorded using 85% phosphoric acid as an external reference. Mass spectra were recorded on a Gas-Chromatograph Mass Spectrometer QP-2000 Shimadzu with EI ionization. Kieselgel 60 Merck (0.063–0.200 mm) was used for column chromatography. Triethylamine was purified according to the procedure given by *Sauer* [18]. The purification of CH_2Cl_2 has been described in our previous paper [19]. Benzene and ethyl acetate were distilled and dried over molecular sieves (4 Å).

4-Phosphoranylidene-5 (4H)-oxazolones (**2a–f**) *from 5(4H)-oxazolone* (**1**) *and Ph_3PBr_2 (General Procedure)*

DCC (1.65 g, 8 mmol) was added to a stirred suspension of N-acylglycine (9.6 mmol) in CH_2Cl_2 (20 ml). The mixture was stirred under nitrogen for 3 h, left standing overnight, and dicyclohexylurea was filtered off and washed with CH_2Cl_2. The filtrate contained 5-(4*H*)-oxazolone **1** dissolved in CH_2Cl_2.

A solution of bromine (1.54 g, 9.6 mmol) in CH_2Cl_2 (5 ml) was added at 0–5 °C under argon to a stirred solution of triphenylphosphine (2.51 g, 9.6 mmol) in CH_2Cl_2 (30 ml). The pale-yellow crystals of Ph_3PBr_2 precipitated almost immediately. The suspension was stirred at room temperature for 30 min, the mixture was cooled to 0–5 °C, and then triethylamine (3.35 ml, 24 mmol) and the solution of 5-(4*H*)oxazolone in CH_2Cl_2 were added with stirring. The mixture was stirred under argon for 3 h, left standing overnight at room temperature and then diluted with benzene (30 ml) to precipitate triethylamine hydrobromide. The precipitated salt was filtered off, the filtrate was evaporated to dryness *in vacuo*, and the residue was extracted three to five times with 10 ml of boiling benzene. The solvent was again evaporated to dryness *in vacuo* and, in the case of ylides **2a–d**, the crude ylide was recrystallized from benzene. The product was filtered off, washed with benzene, and dried *in vacuo* under elevated temperature. The crude ylides **2e–f** were purified by column chromatography on silica gel (25 ml) eluting with benzene/ethyl acetate in the ratio 2:1 (*v*/*v*).

Reaction of 2-phenyl-5(4H)-oxazolone with $(PhO)_3P$*-*I_2

The $(PhO)_3P$-I_2 adduct (iodotriphenoxyphosphonium iodide) was prepared according to the procedure given by *Rydon* and *Tonge* [13] by stirring triphenyl phosphite (2.51 ml, 9.6 mmol) and iodine (2.44 g, 9.6 mmol) under argon for 24 h at room temperature. The solidified reaction mixture was dissolved in CH_2Cl_2 (30 ml) and the solution was cooled to 0–5 °C. After that, triethylamine (3.35 ml, 24 mmol) and a solution of 2-phenyl-5-(4*H*)oxazolone (8 mmol) in CH_2Cl_2 (prepared as described above) were added with stirring. The mixture was stirred under argon for 3 h and left standing overnight at room temperature. The reaction progress was monitored by IR spectroscopy. The reaction mixture was worked up as described above. After extraction with boiling benzene and evaporation of the solvent, a black thick oil (5.19 g) was obtained which did not absorb in the 1800–1600 cm^{-1} region. The residue insoluble in benzene was proved to be almost pure triethylamine hydroiodide (IR).

2-Phenyl-4-triphenylphosphoranylidene-5(4H)-oxazolone (**2a**) *from 2-phenyl-5(4H)-oxazolone and* Ph_3P*-* CCl_4 *or* Ph_3P*-*CBr_4

A solution of 2-phenyl-5-(4*H*)-oxazolone in CH_2Cl_2 was prepared as described above. To a stirred solution of the oxazolone, triphenylphosphine (2.51 g, 9.6 mmol) and CCl_4 (20 ml, 0.2 mol) or CBr_4 (10 g, 30 mmol) were added under argon at room temperature. After 30 min, triethylamine (1.68 ml, 12 mmol) was added; the mixture was left standing at room temperature overnight and then diluted with benzene (30 ml). The precipitated triethylamine salt was filtered off, the filtrate was evaporated to dryness *in vacuo*, and the ylide was isolated from the residue by column chromatography on silica gel (25 ml) eluting with CH_2Cl_2/ethyl acetate in the ratio 2:1 (*v*/*v*). The crude ylide was recrystallized from benzene.

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