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STUDIES ON ORGANOPHOSPHORUS COMPOUNDS—XXXVII†

SYNTHESES OF Δ^5-1,2,3-DIAZAPHOSPHOLINES AND INDOLES FROM HYDRAZONES

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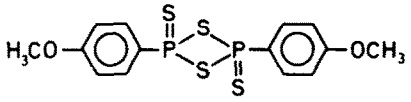
Abstract—2,4-Bis(4-methoxyphenyl-1,3,2,4-dithiadiphosphetane-2,4-disulfide, **1**, reacts with phenylhydrazones of methylketones to give Δ^5-1,2,3-diazaphospholines, **3**; in one case 2-methyl-3-phenylindole, **4**, was also isolated. Phenylhydrazones of cyclopentanone and cyclohexanone similarly yield the corresponding annulated P-heterocycles, **6a**, **6b** and as by-products the indoles **7a** and **7b**, respectively. The sole product from the reaction of **1** with the phenylhydrazone of 1,3-diphenyl-2-propanone is 2-benzyl-3-phenylindole, **9**. A mechanism for the formation of the diazaphospholines is suggested.

The reagent 2,4 - bis(4 - methoxyphenyl) - 1,3,2,4 - dithiadiphosphetane - 2,4 - disulfide, **1**, has been shown to be quite versatile in thiation of different carbonyl compounds,[1] and it is also known that nucleophiles attack



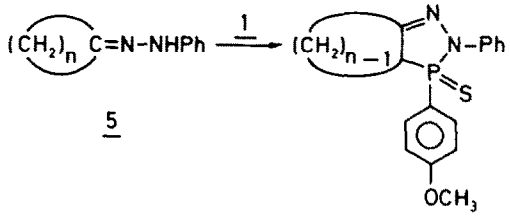
1

1 at the phosphorus atom.[2,3] In certain cases, where the substrate contains two functional groups or can react in different ways, P-heterocycles are formed.[1,4-10] As an extension of our general studies on the reagent **1**, its reaction with phenylhydrazones of ketones to give Δ^5 - 1,2,3 - diazaphospholines and indoles are reported in this paper.

RESULTS AND DISCUSSION

The phenylhydrazones, **2a–g**, derived from acyclic ketones, were reacted with **1** in anhydrous benzene at 50–80° (Table 1) and as the sole product in most cases Δ^5 - 1,2,3 - diazaphospholines, **3**, were produced in high yields. In one case only, (**2f**, R = $-CH_2Ph$), 2 - methyl - 3 - phenylindole, **4**, was isolated.

The same type of reaction took place, when the phenylhydrazones of cyclopentanone, **5a**, and cyclohexanone, **5b**, were reacted with **1**. However, besides the P-heterocycles **6a** and **6b**, respectively, also the condensed indoles, **7a** and **7b**, were formed due to a Fischer indole synthesis, catalyzed by **1**.



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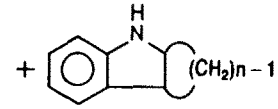
6

5, **6**, **7**; a : n = 4
b : n = 5



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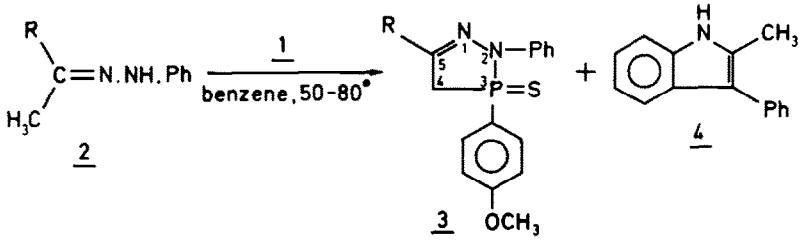
Reaction times, yields, m.ps and analytical data are given in Experimental and Table 1. The structures of **3** and **6** were proved by elementary analyses, MS, ^1H, ^{13}C, and ^{31}P NMR (Table 2 and Experimental). The mass spectra of **3** and **6** all showed molecular ions ($M^{\cdot+}$) and in many cases (**3a–3g**) $M^{\cdot+} - 33$ corresponding to the loss



2

3

4

2,3	a	b	c	d	e	f	g
R	CH_3	C_2H_5	$CH_2CH_2CH_3$	$(CH_3)_2CH$	$(CH_3)_3C$	CH_2Ph	Ph

†Part XXXVI; A. A. El-Barbary and S.-O. Lawesson, *Tetrahedron* **37**, 2641 (1981).

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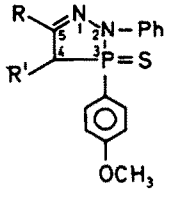
Table 1. Experimental and analytical data of products

Starting compound	Product	Reaction time (h)	Reaction temp.(°C)	Yield (%)	M.p. (°C)	Analyses Calc. (Found) (%) C	H	N	P	S
2a	3a	3	50	58	128	60.75 (60.65)	5.38 (5.38)	8.86 (8.80)	9.81 (9.49)	10.13 (9.46)
2b	3b	2 1/4	80	83	112	61.82 (61.58)	5.76 (5.82)	8.49 (8.40)	9.39 (9.55)	9.70 (9.33)
2c	3c	2 1/2	80	85	110	*				
2d	3d	4	80	70	101	62.79 (62.78)	6.10 (6.19)	8.14 (8.22)	9.01 (9.00)	9.30 (8.76)
2e	3e	1 1/2	80	70	134	63.69 (63.32)	6.24 (6.45)	7.82 (7.85)	8.66 (8.76)	8.94 (8.65)
2f	3f	4	80	64	126	*				
	4			52	61[14]					
2g	3g	6	80	69	176	66.67 (65.15)	5.03 (4.88)	7.41 (7.09)	8.20 (7.92)	8.47 (7.99)
5a	6a	2 1/2	80	21	138	63.16 (62.04)	5.56 (5.51)	8.19 (7.84)	9.06 (8.69)	9.36 (9.28)
	7a			13	106[15]					
5b	6b	2 1/4	80	40	142	64.04 (63.85)	5.90 (5.91)	7.87 (7.92)	8.71 (9.53)	8.99 (8.46)
	7b			50	120[15]					
8	9	3 1/2	80	71	101[15]					

* M.p.

Table 2. ^{13}C and ^{31}P NMR data of the ring carbons in Δ^5 - 1,2,3 - diazaphospholine derivatives

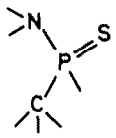


R	R'	δC_4 (ppm)	$^1J_{^{31}P-^{13}C(4)}$ (Hz)	δC_5 (ppm)	$^2J_{^{31}P-^{13}C(5)}$ (Hz)	$\delta_{^{31}P}$ (ppm)
CH_3-	H	46.9	77.1	149.2	2.2	68.7
CH_3-CH_2-	H	45.8	77.1	153.4	2.2	68.4
n-CH_3-CH_2-CH_2-	H	45.4	77.02	154.2	2.1	68.1
$(CH_3)_2$-CH-	H	43.7	77.8	156.8	1.9	68.6
$(CH_3)_3$-C-	H	42.9	77.7	159.0	2.1	69.8
Ph-	H	43.7	77.4	148.1	4.4	69.7
C_6H_5-CH_2-	H	44.6	76.7	149.3	3.2	69.2
-CH_2-CH_2-CH_2-		54.6	77.9	163.0	3.3	87.9
-CH_2-$(CH_2)_2$-CH_2-		49.3	75.6	155.3	3.3	73.6

(Solvent: $CDCl_3$; ^{13}C chemical shifts relative to TMS; ^{31}P chemical shifts relative to 85% H_3PO_4).

of SH, was the base peak. Also $m/e = 105$ ($Ph-\overset{\oplus}{N}\equiv N$), always found in the mass spectra of phenylhydrazones,[11,12] was abundant for most compounds (3 and 6). From the ^1H NMR of 3 it is obvious that there is a $\diagdown C{=}N \diagup$ function in the molecule as the $-CH_2-$ group appears as a doublet in the region 2.25–3.80 (2 H, J_{PH} 10 Hz, coupling to P). From the ^{13}C NMR-spectra (Table 2) the presence of sp^3-hybridized carbons (C-4) in compound 3 needs no comments and the same arguments for the structure of 6 can be used. The ^{31}P NMR spectra showed one absorption in the region δ

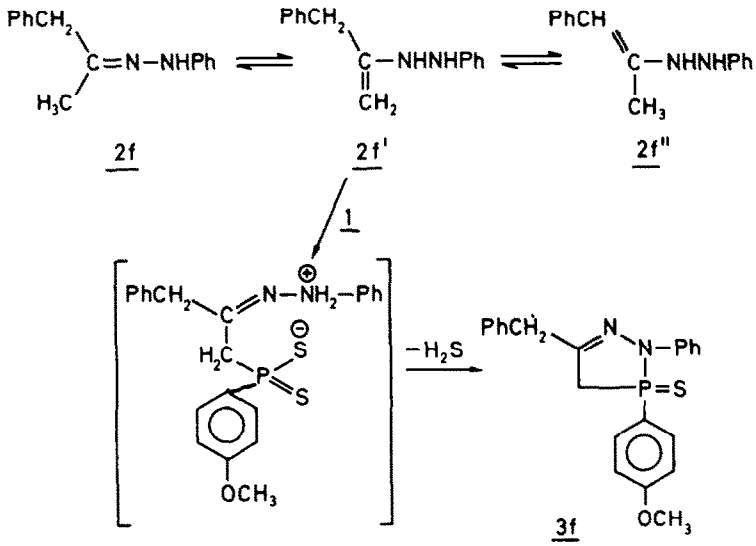
68.1–73.6 (exceptionally, **6a** absorbs at 87.2 ppm), which is typical for the structure:[13]



In the ^{1}H NMR spectra of **3b**, **3c** and **3f** there are doublets at 3.40, 3.45, and 2.25 ppm corresponding to the CH_2–P hydrogens, respectively. (No absorption of a methine-group is observed). In the ^{13}C NMR spectra the absorption of the CH_2 group (C-4) appeared at 45.8 and 45.4 ppm for **3b** and **3c**, respectively. In **3f**, there are two signals at 38.9 and 44.6 ppm corresponding to the absorption of the Ph–$\underline{C}H_2$ ($^3J_{CCCP}$ = 3.9 Hz) and P–$\underline{C}H_2$ ($^1J_{CP}$ = 76.7 Hz) groups, respectively.

The structures of compounds **4**,[14] **7a**,[15] and **7b**,[16] are known and also confirmed by ^{1}H NMR and mass spectra.

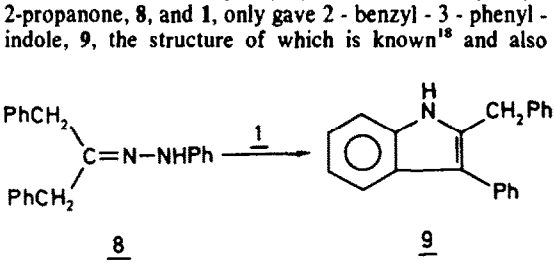
As to the mechanism for the formation of **3** (and **6**) it is suggested that the hydrazone is in equilibrium with its tautomeric enehydrazine(s), one of which will react with **1** to give a salt, which at elevated temperature loses H_2S[17] to produce **3** (R = $PhCH_2$):



Scheme 1.

In all cases the tautomer **2f'** is the reacting species and no other P-heterocycle than **3** is isolated. In that connection it should be noted that the reaction of **1** with the phenylhydrazones of 1 - phenyl - 2 - propanone, cyclopentanone and cyclohexanone also produced the indoles **4**, **7a**, and **7b**, respecteively, besides the P-heterocycles.

The reaction of the phenylhydrazone of 1,3-diphenyl-2-propanone, **8**, and **1**, only gave 2 - benzyl - 3 - phenyl - indole, **9**, the structure of which is known[18] and also confirmed by MS and ^{1}H NMR. No P-heterocycle was isolated in this case (steric reason). The reaction of hydrazones of aldehydes (CH_3CHO, $PhCH_2CHO$) with **1** did not give any P-heterocycles. The phenylhydrazone of diphenylketone, when reacted with **1** under different conditions, gave a complex reaction mixture (no thioketone).



8 **9**

EXPERIMENTAL

^{1}H NMR spectra were recorded at 60 MHz on a Varian A-60 spectrometer. ^{13}C and ^{31}P NMR spectra were obtained on a Varian EM 360 instrument at 20.14 MHz and 32.19 MHz, respectively. $CDCl_3$ was used as solvent and TMS as internal reference standard. Chemical shifts are expressed as δ-values. Also ^{31}P chemical shifts are reported positive low field to (external) H_3PO_4. Mass spectra were recorded on a Micromass 7070 F mass spectrometer operating at 70 eV using direct inlet. Elementary analyses were carried out by Novo Microanalytical Laboratory, Novo Industri A/S, Novo Allé, DK-2880 Bagsvaerd. Silica gel 60 (Merck) was used for column chromatography. The light petroleum used boiled below 45°. M.ps are uncorrected.

Starting materials. Compound **1** (now available from Fluka AG, CH-9470 Buchs SG) was prepared as described earlier.[1] The other starting compounds were prepared by known methods: **2a**,[19] **2b**,[20] **2c**,[21] **2d**,[22] **2e**,[23] **2f**,[24] **2g**,[25] **5a**,[26] **5b**,[27] **8**.[28]

General procedure for the reaction of **2a–g**, **4a**, **4b** *and* **8** *with* **1**. 0.01 mole of the starting compound and 4.04 g (0.01 mole) of **1** were refluxed in 10 ml of anhydrous benzene with stirring until no more of the starting material could be detected (tlc). After cooling to room temperature the excess of **1** was filtered off. Then the reaction mixture was evaporated on silica gel under reduced pressure and applied to a silica gel column using ether/light petroleum as eluent. The reaction conditions, physical and analytical data are summarized in Table 1.

Compound **3a**. Ms: *m/e* (%): 316($M^{\cdot+}$, 100), 283($M^{\cdot+}$–SH, 100), 163(66), 121 (100), 105($Ph–\overset{\oplus}{N}\equiv\overset{\oplus}{N}$, 15), 91($Ph\overset{\oplus}{N}$, 8). ^{1}H NMR ($CDCl_3$): δ 2.20(3H, S, CH_3) 3.40(2H, d, J_{PH} 10 Hz, CH_2–P), 3.85(3H, S, OCH_3), 6.80–7.50(7H, m, Ph and m-protons), 7.80(2H, dd, J_{PH} 15 Hz, J_{HH} 9 Hz, ortho protons).

Compound **3b**. Ms: *m/e* (%), 330($M^{\cdot+}$, 24), 297($M^{\cdot+}$–SH, 23), 122(33), 105(35), 91(9), 77(100). ^{1}H NMR ($CDCl_3$): δ 1.25(3H, t, J 7 Hz, CH_3), 2.5(2H, q, J 7 Hz, $\underline{C}H_2CH_3$), 3.4(2H, d, J 9 Hz, $\underline{C}H_2$–P), 3.8(3H, S, OCH_3) 6.8–7.3 (7H, m, Ph and m-protons), 7.85(2H, dd, J_{PH} 15 Hz and J_{HH} 9 Hz, ortho protons).

Compound **3c**. Ms *m/e* (%), 344($M^{\cdot+}$, 97), 311($M^{\cdot+}$–SH, 78),

122(8), 105(5), 91(15). ^{1}H NMR ($CDCl_3$): δ 1.1(3H, t, $\underline{C}H_3$), 1.45–2.0(2H, m, CH_3–$\underline{C}H_2$–CH_2), 2.5(2H, t, $\underline{C}H_2$–C=N), 3.45(2H, d, J 10 Hz, $\underline{C}H_2$–P), 3.85(3H, S, OCH_3), 6.8–7.3(7H, m, Ph and m-protons), 7.85(2H, dd J_{PH} 15 Hz, J_{HH} 9 Hz, ortho protons).

Compound **3d**. Ms% *m/e* (%): 344($M^{\cdot+}$, 9), 311($M^{\cdot+}$–SH, 100), 244(33), 105(36), 91(50). ^{1}H NMR ($CDCl_3$): δ 1.25(6H, d, J 10 Hz, $HC(\underline{C}H_3)_2$), 2.4–2.8(1H, m, $\underline{C}H$–C=N), 3.45(2H, d, J 10 Hz, $\underline{C}H_2$–P), 3.85(3H, S, OCH_3), 6.8–7.3(7H, m, Ph and m-protons), 7.8 (2H, dd, J_{PH} 15 Hz, J_{HH} 9 Hz, ortho protons).

Compound **3e**. Ms: *m/e* (%): 358($M^{\cdot+}$, 100), 343($M^{\cdot+}$–CH_3, 40), 325(M^+–SH, 100), 105(6), 91(5). ^{1}H NMR ($CDCl_3$): δ 1.35 (9H, S, $(\underline{C}H_3)_3$–C), 3.55(2H, d, J 10 Hz, $\underline{C}H_2$–P), 3.9(3H, S, OCH_3), 6.9–7.35(7H, m, Ph and m-protons), 7.8(2H, dd, J_{PH} 15 Hz, J_{HH} 9 Hz, ortho protons).

Compound **3f**: Ms: *m/e* (%), 392($M^{\cdot+}$, 100), 359($M^{\cdot+}$–SH, 80), 260(11), 122(11), 91(56), 77(18). ^{1}H NMR ($CDCl_3$): δ 2.25 (2H, d, J 10 Hz, $\underline{C}H_2$–P), 3.78(3H, S, OCH_3), 3.82(2H, S, $\underline{C}H_2$–C=N), 6.7–7.5(12 H, m, Ph and m-protons), 7.8(2H, dd J_{PH} 15 Hz, J_{HH} 9 Hz, ortho protons).

Compound **3g**: Ms: *m/e* (%), 378($M^{\cdot+}$, 100), 345($M^{\cdot+}$–SH, 100), 121(86), 105(90), 91(28). ^{1}H NMR ($CDCl_3$): δ 3.8 (2H, d, J 10 Hz, $\underline{C}H_2$–P), 3.9(3H, S, OCH_3) 6.9–7.8(12H, m, Ph and m-protons), 7.9(2H, dd J_{PH} 15 Hz, J_{HH} 9 Hz, ortho prodons).

Compound **4**: Ms: *m/e* (%), 207(M^+, 85), 120(75).

Compound **6a**. Ms: *m/e* (%), 342($M^{\cdot+}$, 100), 309($M^{\cdot+}$–SH, 25), 105(8), 91(12), 77(28). ^{1}H NMR ($CDCl_3$): δ 1.65–2.9(6H, m, $3\underline{C}H_2$), 3.0–3.7(1H, m, N=$\underline{C}$H–P), 3.9(3H, S, $O\underline{C}H_3$), 6.8–7.35(7H, m, Ph and m-protons), 8.0(2H, dd, J_{PH} 15 Hz, J_{HH} 9 Hz, ortho protons).

Compounds **6b**. Ms: *m/e* (%): 356 ($M^{\cdot+}$, 100), 323($M^{\cdot+}$–SH, 52), 171(55), 105(10), 91(10).

^{1}H NMR ($CDCl_3$): δ 1.5–2.8(8H, m, $4\underline{C}H_2$), 3.2–3.5(1H, m, N=$\underline{C}$H–P), 3.85(3H, S, $O\underline{C}H_3$), 6.8–7.4(7H, m, Ph and m-protons), 7.85(2H, dd, J_{PH} 15 Hz, J_{HH} 9 Hz, ortho protons).

Compound **7a**. Ms: *m/e* (%), 157($M^{\cdot+}$, 100), 141(50), 131(100), 103(100), 65(100).

Compound **7b**. Ms: *m/e* (%), 171($M^{\cdot+}$, 71), 143 (100).

Compound **9**. Ms: *m/e* (%), 283($M^{\cdot+}$, 70), 206(100), 178(18), 77(66).

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