α-Chlorination and Carbonyl Olefination; Synthesis of Phenyl 1-Chloro-1-alken-1-yl Sulfides

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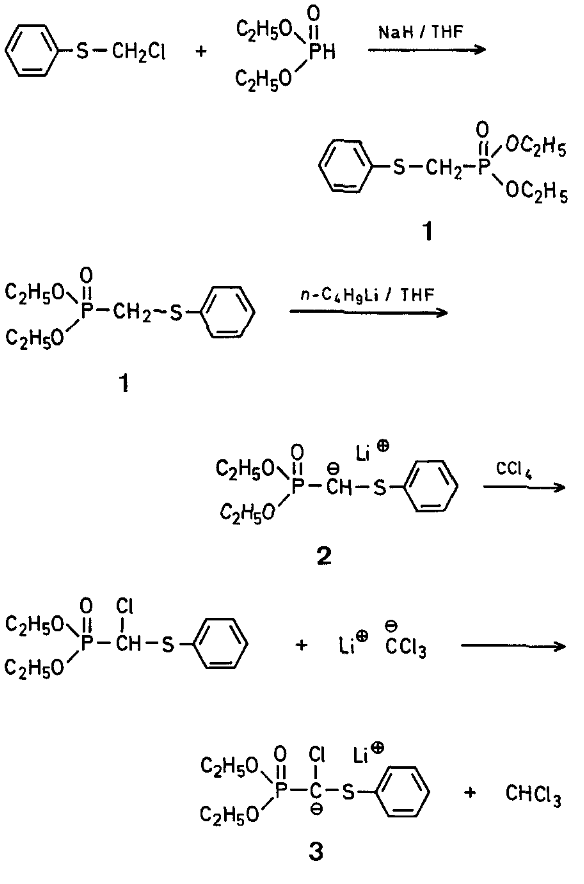
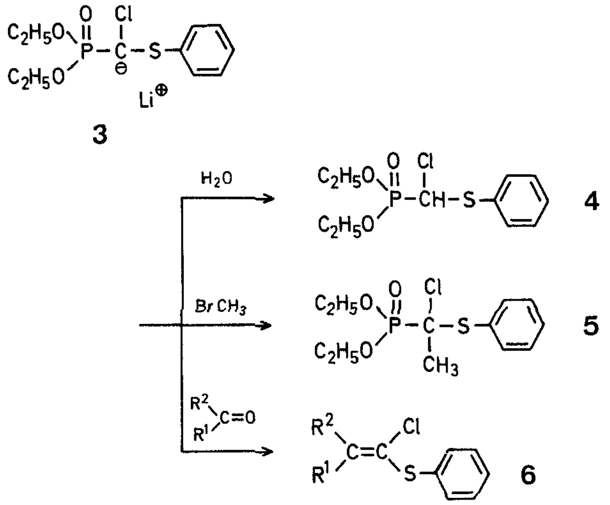
The method of carbonyl olefination with α-chlorination, a variation of the Wittig-Horner reaction, represents an efficient route to many interesting compounds[1]. In the course of studies on the behaviour of a number of phosphonates we have found that arylthiomethanephosphonates also undergo this reaction.

A suitable method for the preparation of diethyl phenylthiomethanephosphonate (**1**) in 71% yield consists of the conversion of thioanisole into chloromethyl phenyl sulfide using *N*-chlorosuccinimide[2] and subsequent condensation with sodium diethyl phosphite in tetrahydrofuran.

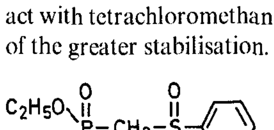


Compound **1**, thus obtained, can be metallated to give the lithiated phosphonate **2** by treatment with *n*-butyllithium at low temperature in tetrahydrofuran; subsequent chlorination by tetrachloromethane produces the phosphonate **3** which affords, upon aqueous work-up, a 92% yield of diethyl phenylthiochloromethanephosphonate (**4**). The reactions of **3** with alkyl halides or with carbonyl compounds have also been employed for the preparation of diethyl 1-chloro-1-phenylthioalkanephosphonates (e.g. **5**) and phenyl 1-chloro-1-alken-1-yl sulfides **6**, respectively (our results are summarised in the Table).



The yields of alkenes **6** are usually moderate. We have found that the lithium salt **3** reacts with aromatic aldehydes as well as with ketones. This is in contrast to the behaviour of the lithium salt of diethyl phenylthiomethanephosphonate which does not react with ketones[3].

It is noteworthy that neither the lithium salts of **7** nor **8** react with tetrachloromethane under these conditions because of the greater stabilisation.



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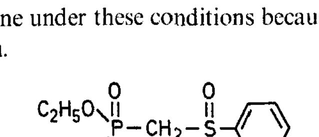

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In the present reaction it appears that the formation of salts of the type **3** is accompanied by partial decomposition as the mixture acquires a darkish colour after addition of tetrachloromethane. It was first considered that the decomposition was promoted by lithium salts. Thus a series of reactions were carried out in tetrahydrofuran in the presence of varying amounts of lithium chloride or bromide and in their absence, "salt free" conditions.

In contrast to the reactions of dichloromethanephosphonates[4], approximately the same results are obtained on using lithium chloride or bromide. However, it seems to be advantageous to carry out the reaction in the presence of a stoichiometric amount of lithium bromide. Work up of the reaction mixture was achieved by aqueous treatment followed by extraction with ether. The crude products were purified by simple filtration on neutral alumina using petroleum ether as eluent.

Preparation of Diethyl Phenylthiomethanephosphonate (1):
Sodium hydride (24 g, 0.5 mol) is washed twice by decantation with petroleum ether and resuspended in dry tetrahydrofuran

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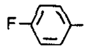
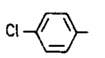
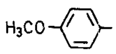
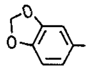
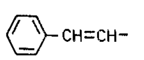
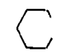
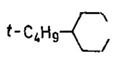
Table. Preparation of Phenyl 1-Chloro-1-alken-1-yl Sulfides (**6**)

R^1	R^2	Salts	m.p.	Yield (%)	Elemental Analyses[a]				
	H	LiBr	oil	64	$C_{14}H_{10}ClFS$	calc.	C 63.51	H 3.78	Cl 13.42
		LiBr + LiCl		56	(264.5)	found	64.01	3.99	12.80
	H	LiBr	oil	65	$C_{14}H_{10}Cl_2S$	calc.	C 59.78	H 3.55	Cl 25.26
		LiBr + LiCl		49	(280.9)	found	59.75	3.49	24.86
	H	LiBr	oil	68	$C_{15}H_{13}ClOS$	calc.	C 65.09	H 4.70	Cl 12.83
		"salt free"		58	(276.5)	found	65.49	4.87	12.34
	H	LiBr	50°	53	$C_{15}H_{11}ClO_2S$	calc.	C 61.96	H 3.78	Cl 12.22
		LiBr + LiCl		52	(290.5)	found	61.12	3.96	12.15
	H	LiBr	oil	46	$C_{16}H_{13}ClS$	calc.	C 70.45	H 4.77	Cl 13.02
					(272.5)	found	69.90	4.87	12.58
		LiBr	oil	60	$C_{13}H_{15}ClS$	calc.	C 65.40	H 6.28	Cl 14.88
					(238.5)	found	64.95	6.37	14.56
		LiBr	63°	51	$C_{17}H_{23}ClS$	calc.	C 69.26	H 7.80	Cl 12.08
					(294.5)	found	70.07	8.05	12.52

[a] Many of these analysis values are outside the normally accepted accuracy limits (±0.3%); better values could not be obtained because the analysis methods used are not really adapted to molecules containing sulfur and chlorine.

(200 ml). A solution of diethyl phosphite (69 g, 0.5 mol) in dry tetrahydrofuran (100 ml) is added slowly. Hydrogen is evolved and the exothermic reaction has to be cooled with water. When the addition is complete the mixture is heated at 60°, chloromethyl phenyl sulfide (80 g, 0.5 mol) in dry tetrahydrofuran (50 ml) is added, and the mixture heated under reflux for 7 h. The resultant mixture is cooled and poured into cold water. The mixture is extracted with dichloromethane (3 × 50 ml), the combined organic extracts are dried with magnesium sulfate, the solvent is removed under reduced pressure, and the residue distilled under vacuum; yield: 92.3 g (71%); b.p. 145–150°/0.5 torr.

$C_{11}H_{17}O_3P$	calc.	C 50.77	H 6.54
(260)	found	50.89	6.70

Phenyl 1-Chloro-1-alken-1-yl Sulfides 6; General Procedure:

Under nitrogen diethyl phenylthiomethanephosphonate (**1**; 5.2 g, 0.02 mol) is dissolved in tetrahydrofuran (80 ml). The mixture is cooled to −70° and a solution of *n*-butyllithium (0.02 mol + 10%) in ether is added drop-wise. The mixture is stirred at −70° for 15 min, tetrachloromethane (3.2 g, 0.02 mol) in tetrahydrofuran (20 ml) is added, and stirring is continued for 15 min during which time the solution acquires a darkish colour. The carbonyl compound (0.02 mol) is added, stirring is continued at −65° for 2 h, and at room temperature for 1 h. The mixture is then hydrolysed by addition of water (40 ml), the product is extracted with ether (3 × 50 ml), the combined organic layers are dried with magnesium sulfate, and the solvent is removed under reduced pressure. The residue is purified by column chromatography on alumina (40 g) using petroleum ether as eluent.

Preparation of Diethyl Phenylthiochloromethanephosphonate (4) by Hydrolysis:

The solution of the salt **3** is prepared as described above. To the darkish solution is added water (40 ml). The mixture is extracted with dichloromethane (2 × 50 ml), the combined organic extracts are dried with magnesium sulfate, the solvent is removed under reduced pressure, and the residue is purified by precipitation of impurities using petroleum ether; yield: 5.3 g (90%).

$C_{11}H_{16}ClO_3PS$	calc.	C 44.82	H 5.43
(294.5)	found	44.53	5.62

Preparation of Diethyl 1-Chloro-1-phenylthioethanephosphonate (5):

The solution of the salt **3** is prepared as described above. To the darkish solution is added at −65° methyl iodide (3.1 g, 0.02 mol + 10%). The mixture is allowed to warm to room temperature and hydrolysed with water (40 ml). The product is extracted with dichloromethane (2 × 50 ml), the combined organic extracts are dried with magnesium sulfate, the solvent is removed under reduced pressure, and the residue purified by precipitation of impurities using petroleum ether; yield: 5.3 g (86%).

$C_{12}H_{18}ClO_3PS$	calc.	H 46.68	H 5.83
(308.5)	found	46.73	5.70

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