Synthesis of Dialkyl Alkoxycarbonylmethanephosphonates (Alkyl Dialkoxyphosphinylacetates) using Phase-Transfer Catalysis

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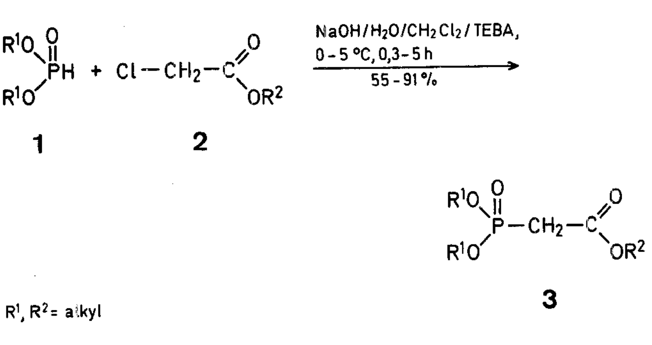
A facile method for the preparation of dialkyl alkoxycarbonylmethanephosphonates under phase-transfer catalysis is described.

Phase-transfer catalysis has been used in numerous *C*-alkylation, *O*-alkylation, and *N*-alkylation procedures[1,2] whereas its use for *P*-alkylation is still quite limited. It has been reported[3,4] that dialkyl phosphites undergo alkylation with electrophilic alkenes or benzyl chloride in the presence of potassium carbonate and tetrabutylammonium bromide or crown ethers in a solid-liquid two-phase system. Dialkyl aminocarbonylmethanephosphonates have been obtained by alkylation of dialkyl phosphites in liquid-liquid two-phase systems[5]. We report here that the reaction of dialkyl phosphites (**1**) with alkyl chloroacetates (**2**) affording dialkyl alkoxycarbonylmethanephosphonates (**3**) may be conveniently carried out under liquid-liquid phase-transfer catalysis.



Most of the dialkyl phosphites **1** and alkyl chloroacetates **2** are easily hydrolyzable in aqueous alkali metal hydroxide. We have found, however, that when the dichloromethane solution of dialkyl phosphites **1** and chloroacetates **2** containing a catalytic amount of quaternary ammonium salt are treated with 50% aqueous sodium hydroxide at 0–5 °C and the reaction is monitored by ^{1}H-N.M.R. till disappearance of the starting material, dialkyl alkoxycarbonylmethane-

Table 1. Dialkyl Alkoxycarbonylmethanephosphonates (**3**, Alkyl Dialkoxyphosphinylacetates) prepared

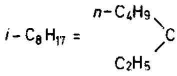
3	R^1	R^2	Reaction Time [min]	Yield[a] [%]	b.p. [°C]/torr	Molecular Formula[b] or Lit. b.p. [°C]/torr	M.S.[c] *m/e* ($M^+ + 1$)
a	C_2H_5	C_2H_5	20	55	90-93°/0.3	100-103°/0.4[6]	225
b	C_2H_5	i-C_3H_7	20	71	87-89°/0.3	$C_9H_{19}O_5P$ (238.2)	239
c	C_2H_5	t-C_4H_9	50	70	93-95°/0.3	93-95/0.3[7]	253
d	C_2H_5	c-C_6H_{11}	35	67	114-116°/0.2	$C_{12}H_{23}O_5P$ (278.3)	279
e	C_2H_5	i-C_8H_{17}[d]	30	60	130-132°/0.3	$C_{14}H_{29}O_5P$ (308.3)	309
f	i-C_3H_7	i-C_3H_7	90	78	89-91°/0.3	$C_{11}H_{23}O_5P$ (266.3)	267
g	i-C_3H_7	t-C_4H_9	110	83	90-92°/0.3	$C_{12}H_{25}O_5P$ (280.3)	281
h	i-C_3H_7	c-C_6H_{11}	110	81	124-126°/0.4	$C_{14}H_{27}O_5P$ (306.4)	307
i	i-C_3H_7	i-C_8H_{17}[d]	145	64	122-124°/0.4	$C_{16}H_{33}O_5P$ (336.4)	337
j	n-C_4H_9	i-C_3H_7	50	80	118-120°/0.25	$C_{13}H_{27}O_5P$ (294.4)	295
k	n-C_4H_9	t-C_4H_9	100	91	128-130°/0.25	$C_{14}H_{29}O_5P$ (308.4)	309
l	n-C_4H_9	c-C_6H_{11}	100	75	134-136°/0.2	$C_{16}H_{31}O_5P$ (334.4)	335
m	n-C_4H_9	i-C_8H_{17}[d]	180	69	155-156°/0.6	$C_{18}H_{37}O_5P$ (364.5)	365
n	i-C_8H_{17}[d]	i-C_3H_7	160	76	155-158°/0.05[e]	$C_{21}H_{43}O_5P$ (406.5)	407
o	i-C_8H_{17}[d]	t-C_4H_9	300	79	158-160°/0.05[e]	$C_{22}H_{45}O_5P$ (420.6)	421
p	i-C_8H_{17}[d]	c-C_6H_{11}	120	75	163-165°/0.05[e]	$C_{24}H_{47}O_5P$ (446.6)	447
q	i-C_8H_{17}[d]	i-C_8H_{17}[d]	200	65	173-175°/0.05[e]	$C_{26}H_{53}O_5P$ (476.7)	477

[a] Yield of distilled product.

[b] Satisfactory microanalysis obtained: C ±0.36, H ±0.30, P ±0.24; exceptions: **3l** (C −0.55), **3g** (C −0.61).

[c] Recorded with a Finnigan 4021 spectrometer.

[d]



$$i\text{-}C_8H_{17} = \overset{n\text{-}C_4H_9}{\underset{C_2H_5}{>}}CH{-}CH_2{-}$$

[e] Boiling point of bulb-to-bulb short-path distillation, bath temperature.

Table 2. Spectral Data of Compounds **3**

3	I.R. (film)[a], ν[cm^{-1}]			1H-N.M.R. (CCl_4/TMS_{int})[b] δ[ppm]
	P—O—C	P=O	C=O	
a	970, 1030	1270	1740	4.1 (m, 6H, 3O—CH_2); 2.82 (d, 2H, P—CH_2); 1.35 (m, 9H, 3CH_3)
b	970, 1030	1275	1735	4.95 (m, 1H, O—CH); 4.1 (m, 4H, 2O—CH_2); 2.81 (d, 2H, P—CH_2); 1.35 (m, 12H, 4CH_3)
c	970, 1030	1285	1730	4.1 (m, 4H, 2O—CH_2); 2.75 (d, 2H, P—CH_2); 1.45 [s, 9H, $C(CH_3)_3$]; 1.30 (t, 6H, 2CH_3)
d	970, 1025	1265	1730	4.68 (m, 1H, O—CH); 4.05 (m, 4H, 2O—CH_2); 2.74 (d, 2H, P—CH_2); 1.45 [m, 16H, $(CH_2)_5$ + 2CH_3]
e	970, 1025	1270	1738	4.0 (m, 6H, 3O—CH_2); 2.73 (d, 2H, P—CH_2); 1.2 [m, 21H, CH + 4CH_2 + 4CH_3]
f	990, 1020	1278	1740	4.78 (m, 3H, 3O—CH); 2.75 (d, 2H, P—CH_2); 1.29 [m, 18H, 3$CH(C\underline{H}_3)_2$]
g	980, 1020	1285	1730	4.65 (m, 2H, 2O—CH); 2.70 (d, 2H, P—CH_2); 1.45 [s, 9H, $C(CH_3)_3$]; 1.31 [d, 12H, 2$CH(C\underline{H}_3)_2$]
h	980, 1030	1270	1730	4.7 (m, 3H, 3O—CH); 2.75 (d, 2H, P—CH_2); 1.54 [m, 10H, $(CH_2)_2$]; 1.33 [d, 12H, 2$CH(C\underline{H}_3)_2$]
i	990, 1020	1270	1738	4.62 (m, 2H, 2O—CH); 3.97 (d, 2H, O—CH_2); 2.77 (d, 2H, P—CH_2); 1.2 [m, 27H, CH + 4CH_2 + 6CH_3]
j	990, 1025	1270	1738	4.95 (m, 1H, O—CH); 3.95 (q, 4H, 2O—CH_2); 2.80 (d, 2H, P—CH_2); 1.5 (m, 8H, 2CH_2—$C\underline{H}_2$—$C\underline{H}_2$—CH_3); 1.1 [m, 12H, 2$(CH_2)_3$—$C\underline{H}_3$ + $CH(C\underline{H}_3)_2$]
k	990, 1025	1285	1738	4.0 (q, 4H, 2O—CH_2); 2.75 (d, 2H, P—CH_2); 1.45 [m, 17H, 2CH_2—$C\underline{H}_2$—$C\underline{H}_2$—CH_3 + $C(CH_3)_3$]; 0.95 (t, 6H, 2CH_3)
l	990, 1025	1270	1735	4.75 (m, 1H, O—CH); 4.0 (q, 4H, 2O—CH_2); 2.80 (d, 2H, P—CH_2); 1.6 [m, 18H, 2CH_2—$C\underline{H}_2$—$C\underline{H}_2$—CH_3 + $(CH_2)_5$]; 0.98 (t, 6H, 2CH_3)
m	990, 1030	1280	1745	4.0 (m, 6H, 3O—CH_2); 2.82 (d, 2H, P—CH_2); 1.42 [m, 17H, CH + 8CH_2]; 0.97 (t, 12H, 4CH_3)
n	990, 1020	1275	1740	5.0 (m, 1H, O—CH); 4.0 (t, 4H, 2O—CH_2); 2.90 (d, 2H, P—CH_2); 1.2 [m, 36H, 2CH + 8CH_2 + 6CH_3]
o	980, 1020	1280	1730	3.8 (m, 4H, 2O—CH_2); 2.60 (d, 2H, P—CH_2); 1.35 [s, 9H, $C(CH_3)_3$]; 1.2 [m, 18H, 2CH + 8CH_2]; 0.82 (t, 12H, 4CH_3)
p	985, 1020	1270	1740	3.9 (m, 4H, 2O—CH_2); 4.7 (m, 1H, O—CH); 2.73 (d, 2H, P—CH_2); 1.35 [m, 28H, 2CH + 13CH_2]; 0.93 (t, 12H, 4CH_3)
q	985, 1020	1270	1740	3.9 (m, 6H, 3O—CH_2); 2.72 (d, 2H, P—CH_2); 1.28 [m, 27H, 3CH + 12CH_2]; 0.93 (t, 18H, 6CH_3)

[a] Recorded with a Specord 75-IR spectrometer.

[b] Recorded with a 60 MHz Varian EM-360L spectrometer.

phosphonates (**3**) are obtained as the products. Triethylbenzylammonium chloride (TEBA) is more effective than tetrabutylammonium bromide (TBAB) and trioctylmethylammonium chloride in catalyzing the reaction. It should be mentioned that changes of the reaction temperature and of the order of mixing the reagents as well as the use of sodium hydroxide solution of lower concentration leads to the formation of complex hydrolysis products and low yields of products **3**. The present paper describes a mild and convenient method for the preparation of dialkyl alkoxycarbonylmethanephosphonate.

Preparation of Dialkyl Alkoxycarbonylmethanephosphonates (3) using Phase-Transfer Catalysis; General Procedure:

To a stirred mixture of a dialkyl phosphite (**1**; 0.03 mol), an alkyl chloroacetate (**2**; 0.03 mol), and triethylbenzylammonium chloride (411 mg, 1.8 mmol) in dichloromethane (20 ml) at 0°C, 50% aqueous sodium hydroxide (7.5 ml) is added dropwise. The temperature of the exothermic reaction is kept at 0–5°C by external cooling for the appropriate reaction time (Table 1). The mixture is then diluted with dichloromethane (30 ml) and water (30 ml), the organic layer is separated, washed with water (2 x 30 ml), and dried with sodium sulfate. The residue obtained after removal of the solvent is purified by distillation.

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