

Synthesis of α (Diphenylphosphinoyl) Ketones by Acylation of Alkyl Phosphine Oxides

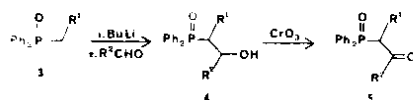
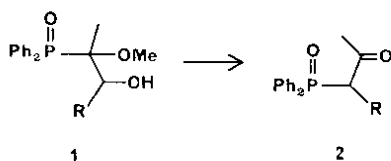
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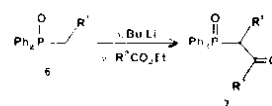
Summary: Direct acylation of primary alkyl diphenylphosphine oxides with butyl-lithium and carboxylate esters is a general synthesis of $\text{Ph}_2\text{PO} \cdot \text{CHR}^1 \cdot \text{CO} \cdot \text{R}^2$.

In the course of our work on diphenylphosphinoyl (Ph_2PO) migration,¹ we have found α - Ph_2PO ketones (e.g. 2) to be useful intermediates,²⁻⁶ as they may be further modified e.g. by alkylation,³⁻⁵ or bromination.³ These ketones were themselves the products of Ph_2PO migration in one series of rearrangements.^{7,8} (1 \rightarrow 2).



The published methods⁹⁻¹⁶ for the synthesis of α - Ph_2PO ketones deal with isolated compounds and make no claim to be general, so we mostly made our intermediates (5) by addition of alkyl phosphine oxides (3) to aldehydes and oxidation of the resulting alcohols (4). The literature does however include reports of direct acylation of the lithium¹⁴ or copper¹⁶ derivatives of phosphine oxides (3) with acid chlorides[†] and low yielding syntheses of a few compounds by acylation of phosphine oxides (3) with acetate¹⁵ or benzoate^{13,15} esters. We have ourselves⁶ acylated the lithium derivatives of two phosphine oxides (3, $\text{R}^1 = \text{Me}_3\text{SiCH}_2$ and

Et) with ethyl benzoate and we felt that the reaction (6 \rightarrow 7) might provide a general synthesis of α - Ph_2PO ketones. We now report that this is indeed the case.



The primary alkyl diphenylphosphine oxides (6), most conveniently made by alkaline hydrolysis of the corresponding triphenyl phosphonium salts,^{6,18} are treated with *n*-butyl-lithium (BuLi) at -78°C in dry tetrahydrofuran (THF). Strictly dry reagents and apparatus seem to be important. The neat ester is dripped in fairly rapidly to quench the red or orange colour of the lithium derivative; work up at room temperature with ammonium chloride solution then gives good yields of the ketone (7) (table 1).

Table 1. Synthesis of α - Ph_2PO Ketones (7)

Entry	R^1	R^2	Yield/%
1	H	Me	80
2	H	Et	62
3	H	<i>n</i> -Pr	53
4	H	Ph	81
5	H	OMe	75
6	H	$\text{CH}_2\text{CH}_2\text{CO}_2\text{Me}$	35 ^a
7	Me	Me	66
8	Me	Et	63
9	Me	<i>n</i> -Pr	51
10	Me	Ph	73
11	Et	Et	35
12	Et	Ph	59
13	Ph	Me	b
14	CH_2Ph	Ph	82

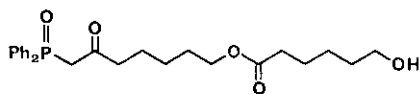
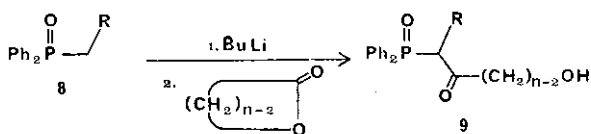
a. 64% based on recovered starting material.

b. Gave a roughly 50:50 mixture of starting material and product which we could not separate.

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† This method is a general synthesis of the corresponding phosphonate esters, see refs. 16 and 17.

The methyl phosphine oxide (6, $R^1 = H$) gives high yields with benzoate and acetate esters, but with increasing substitution either in the phosphine oxide (e.g. entries 2, 8, and 12, table 1) or in the ester (e.g. entries 1, 2 and 3) yields are lower, but are mostly in the 60-80% range. The benzyl phosphine oxide (6, $R^1 = Ph$) gave a poor yield of product which we could not separate from starting material. Reaction with dimethyl carbonate gave a high yield of the ester (7, $R^1 = H$, $R^2 = OMe$) (entry 5), but dimethyl succinate (entry 6) gave considerable amounts of starting material and only a 35% yield of the keto-ester (7, $R^1 = H$, $R^2 = CH_2-CH_2CO_2Me$). All the successful reactions are on primary alkyl phosphine oxides: isopropyl diphenylphosphine oxide gave a red lithium derivative which gave high yields of adducts with aldehydes,^{2-4,6} but which gave only starting material on attempted reaction with esters.



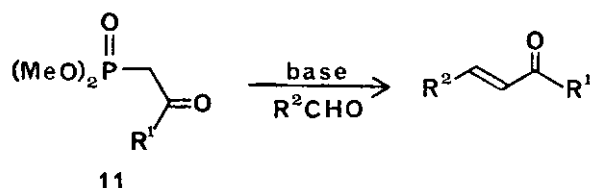
The method also works well with lactones to give ω -hydroxy-alkyl ketones (9) in high yield. Here the work-up with ammonium chloride solution must also be carried out at -78°C otherwise further reaction, e.g. to give (10), occurs. Five-, six-, and seven-membered lactones all give good yields (table 2). Though phosphonium ylids are acylated by esters¹⁴ they are *alkylated*

Table 2. *Reactions of Lactones with Phosphine Oxide Anions*

Entry	R	n	Yield of (9)/%
1	H	5	74
2	H	6	82
3	H	7	51 ^a
4	Me	7	86

^aPlus 26% (10)

by lactones,¹⁹ nucleophilic attack occurring at saturated carbon with carboxylate ion as leaving group.



The Horner-Wittig reaction²⁰ fails with these ketones as it often does with the analogous phosphonium salts and phosphoramides.²¹ Only with the phosphonate esters, e.g. (11) is the reaction even partly successful.²¹ We hope to use reduction of the α - Ph_2PO ketones (7) to alter the natural stereochemistry⁵ of the Horner-Wittig reaction, and we have already succeeded in using the dianions of (7) in reactions with aldehydes and ketones.²²

Experimental

I.r. spectra were taken on a Perkin-Elmer 257, (as a thin film or nujol mull), n.m.r. spectra on a Varian HA100D, Varian EM 360A or a Hitachi-Perkin-Elmer R24A, mass spectra on an A.E.I. MS30, and high resolution mass spectra on an A.E.I. MS902 machine. T.l.c. was run on silica gel GF 254 eluted with ethyl acetate (EtOAc). BuLi refers to n-butyl-lithium (used as a 1.55 M solution in hexane) and dry THF to tetrahydrofuran freshly distilled off lithium aluminium hydride. All the esters were distilled, stored over 4A sieves, and, immediately before use, passed through Alumina UG₁.

1-Diphenylphosphinoylpropan-2-one (7; $R^1 = H$, $R^2 = Me$). — Methyl diphenylphosphine oxide (1 g) in dry THF (20 ml) was stirred, at -78°C and under nitrogen, with BuLi (3.3 ml) for 0.25 h. Dry EtOAc (0.46 g) was added dropwise with stirring at -78°C , the solution allowed to warm up to room temperature, and 10% aq. ammonium chloride solution (30 ml) added. The solution was extracted with EtOAc (3 x 50 ml), the combined organic layers dried (Na_2SO_4), and evaporated under reduced pressure to give the ketone (7; $R^1 = H$, $R^2 = Me$) (0.95 g, 80%) as needles, m.p. $125-127^\circ\text{C}$ (from EtOAc), (lit.¹⁰ 128°C). R_F 0.17 (EtOAc), spectroscopic details²³ (n.m.r. and i.r.) agree with those already reported, m/e 258 (M^+ , 33%), 215 ($\text{Ph}_2\text{POCH}_2^+$, 48), 201 (Ph_2PO^+ , 100). (Found: M^+ , 258.0813. $\text{C}_{15}\text{H}_{15}\text{O}_2\text{P}$ requires M^+ , 258.0810).

1-Diphenylphosphinoylbutan-2-one (7; $R^1 = H$, $R^2 = Et$). — In the same way as above, methyl diphenylphosphine oxide (1 g), BuLi (3.3 ml), and ethyl propionate (0.35 g) gave the ketone (7; $R^1 = H$, $R^2 = Me$) (0.77 g, 62%) as needles, m.p. $104-106^\circ\text{C}$ (from EtOAc). R_F 0.25 (EtOAc), δ (CDCl_3) 0.95 (3H, t, J_{HH} 6 Hz, CH_2Me), 2.65 (2H, q, J_{HH} 6 Hz, CH_2Me), 4.60 (2H,

d, J_{PH} 16 Hz, PCH_2), 7.40-7.90 (10H, m, Ph_2PO), ν_{max} 1705 (C=O) 1440 (P-Ph) and 1180 cm^{-1} (P=O), m/e 272 (M^+ , 272.0968 $\text{C}_{16}\text{H}_{17}\text{O}_2\text{P}$ requires M^+ , 272.0966).

1-Diphenylphosphinoylpentan-2-one, (7; $R^1 = \text{H}$, $R^2 = n\text{-Pr}$). — In the same way as above, methyldiphenylphosphine oxide (1 g), BuLi (3.3 ml), and ethyl butyrate (0.59 g) gave the ketone (7, $R^1 = \text{H}$, $R^2 = n\text{-Pr}$) (0.70 g, 53%) as needles, m.p. 110-111° C (from EtOAc) (lit.²⁴ 110-111° C). R_F 0.32 (EtOAc), n.m.r. data agree with that previously reported,²⁴ ν_{max} 1700 (C=O), 1440 (P-Ph), and 1180 cm^{-1} (P=O), m/e 286 (M^+ , 28%), 215 ($\text{Ph}_2\text{POCH}_2^+$, 100), 201 (Ph_2PO^+ , 88). (Found: M^+ , 286.1124. $\text{C}_{17}\text{H}_{19}\text{O}_2\text{P}$ requires M^+ , 286.1122).

2-Diphenylphosphinoyl-1-phenylethanone, (7, $R^1 = \text{H}$, $R^2 = \text{Ph}$). — In the same way as above, methyldiphenylphosphine oxide (1 g), BuLi (3.3 ml), and ethyl benzoate (0.77 g) gave the ketone (7, $R^1 = \text{H}$, $R^2 = \text{Ph}$) (1.18 g, 81%) as needles, m.p. 138-139° C (from EtOAc) (lit.²⁴ 139-141° C). R_F 0.34 (EtOAc) n.m.r. and i.r. data²³ correspond to that already reported, m/e 320 (M^+ , 20%), 243 ($\text{Ph}_2\text{POCH}_2\text{CO}^+$, 15), 201 (Ph_2PO^+ , 100). (Found: M^+ , 320.0972. $\text{C}_{20}\text{H}_{17}\text{O}_2\text{P}$ requires M^+ , 320.0966).

Methyl 2-diphenylphosphinoylacetate, (7, $R^1 = \text{H}$, $R^2 = \text{OMe}$). — In the same way as above, methyldiphenylphosphine oxide (0.5 g), BuLi (1.6 ml), and dimethyl carbonate (0.25 ml) gave the ester (7, $R^1 = \text{H}$, $R^2 = \text{OMe}$) (475 mg, 75%) as needles, m.p. 116-117° C [from EtOAc-light petroleum (b.p. 60-80° C)] (lit.²⁵ 116-116.5° C). R_F 0.15 (EtOAc), δ (CDCl_3) 3.50 (2H, d, J_{PH} 15 Hz, PCH_2), 3.55 (3H, s, OMe), 7.30-8.00 (10H, m, Ph_2PO), ν_{max} 1725 (C=O), 1440 (P-Ph), and 1190 cm^{-1} (P=O), m/e 274 (M^+ , 12%), 201 (Ph_2PO^+ , 100). (Found: M^+ , 274.0770. $\text{C}_{15}\text{H}_{15}\text{O}_3\text{P}$ requires M^+ , 274.0759).

Methyl 5-diphenylphosphinoyl-4-oxopentanoate, (7, $R^1 = \text{H}$, $R^2 = \text{CH}_2\text{CH}_2\text{CO}_2\text{Me}$). — In the same way as above, methyldiphenylphosphine oxide (1 g), BuLi (3.3 ml), and dimethyl succinate (0.75 g) gave, after column chromatography on silica, (eluted with EtOAc), recovered methyldiphenylphosphine oxide (413 mg, 41%), and the ketoester (7, $R^1 = \text{H}$, $R^2 = \text{CH}_2\text{CH}_2\text{CO}_2\text{Me}$) 535 mg, 35%) as needles, m.p. 78-80° C (from EtOAc). R_F 0.22 (EtOAc), δ (CDCl_3) 2.50 (2H, t, J_{HH} 7 Hz, $\text{CH}_2\text{CH}_2\text{CO}_2\text{Me}$), 3.05 (2H, t, J_{HH} 7 Hz, $\text{CH}_2\text{CH}_2\text{CO}_2\text{Me}$), 3.70 (2H, d, J_{PH} 16 Hz, PCH_2), 7.30-7.90 (10 H, m, Ph_2PO), ν_{max} 1740 (CO_2Me), 1700 (C=O), 1440 (P-Ph), and 1175 cm^{-1} (P=O), m/e 330 (M^+ , 11%), 271 ($M - \text{CO}_2\text{Me}$, 18), 201 (Ph_2PO^+ , 100). (Found: M^+ , 330.1005. $\text{C}_{18}\text{H}_{19}\text{O}_4\text{P}$ requires M^+ , 330.0089).

3-Diphenylphosphinoylbutan-2-one, (7, $R^1 = R^2 = \text{Me}$). — In the same way as above, ethyldiphenylphos-

phine oxide (1 g), BuLi (3.1 ml), and ethyl acetate (0.43 g) gave the ketone (7, $R^1 = \text{Me}$, $R^2 = \text{Me}$) (0.77 g, 66%) as needles, m.p. 117-119° C (from EtOAc). R_F 0.19 (EtOAc), δ (CDCl_3) 1.40 (3H, dd, J_{HH} 6 Hz, J_{PH} 14 Hz, CHMe), 2.25 (3H, s, MeCO), 3.70 (1H, dq, J_{HH} 6 Hz, J_{PH} 12 Hz, CHMe), 7.40-7.95 (10H, m, Ph_2PO), ν_{max} 1710 (C=O), 1440 (P-Ph), and 1180 cm^{-1} (P=O), m/e 272 (M^+ , 13%), 257 ($\text{Ph}_2\text{POCHMeCO}^+$, 10), 201 (Ph_2PO^+ , 100). (Found: M^+ , 272.0985. $\text{C}_{16}\text{H}_{17}\text{O}_2\text{P}$ requires M^+ , 272.0966).

2-Diphenylphosphinoylpentan-3-one, (7, $R^1 = \text{Me}$, $R^2 = \text{Et}$). — In the same way as above, ethyldiphenylphosphine oxide (1 g), BuLi (3.1 ml) and ethyl propionate (0.50 g) gave, after column chromatography on silica (eluted with EtOAc), the ketone (7; $R^1 = \text{Me}$, $R^2 = \text{Et}$) (0.78 g, 63%) as rhombic crystals, m.p. 93-94° C [from EtOAc-light petroleum (b.p. 40-60° C)]; R_F 0.32 (EtOAc), δ (CDCl_3) 0.70 (3H, t, J_{HH} 7 Hz, CH_2Me), 1.30 (3H, dd, J_{HH} 7 Hz, J_{PH} 15 Hz, CHMe), 2.35 (2H, q, J_{HH} 7 Hz, CH_2Me), 3.65 (1H, dq, J_{HH} 7 Hz, J_{PH} 16 Hz, PCHMe), 7.10-8.05 (10H, m, Ph_2PO), ν_{max} 1700 (C=O), 1440 (P-Ph), and 1180 cm^{-1} (P=O), m/e 286 (M^+ , 12%), 201 (Ph_2PO^+ , 100). (Found: M^+ , 286.1128. $\text{C}_{17}\text{H}_{19}\text{O}_2\text{P}$ requires M^+ , 286.1123).

2-Diphenylphosphinoylhexan-3-one, (7, $R^1 = \text{Me}$, $R^2 = n\text{-Pr}$). — In the same way, ethyldiphenylphosphine oxide (1 g), BuLi (3.1 ml), and ethyl butyrate (0.56 g) gave, after column chromatography on silica (eluted with EtOAc), the ketone (7, $R^1 = \text{Me}$, $R^2 = n\text{-Pr}$) (659 mg, 51%) as needles m.p. 98-99° C (from EtOAc). R_F 0.42 (EtOAc), δ (CDCl_3) 0.75 (3H, t, J_{HH} 7 Hz, $\text{CH}_2\text{CH}_2\text{Me}$), 1.40 (3H, dd, J_{HH} 7 Hz, J_{PH} 16 Hz, PCHMe), 1.45 (2H, sextet, J_{HH} 7 Hz, $\text{CH}_2\text{CH}_2\text{Me}$), 2.50 (2H, t, J_{HH} 7 Hz, $\text{CH}_2\text{CH}_2\text{Me}$), 3.58 (1H, dq, J_{HH} 7 Hz, J_{PH} 14 Hz, PCHMe), 7.30-7.95 (10H, m, Ph_2PO), ν_{max} 1700 (C=O), 1440 (P-Ph), and 1190 cm^{-1} (P=O), m/e 300 (M^+ , 14%), 201 (Ph_2PO^+ , 100). (Found: M^+ , 300.1289. $\text{C}_{18}\text{H}_{21}\text{O}_2\text{P}$ requires M^+ , 300.1279).

2-diphenylphosphinoyl-1-phenylpropan-1-one, (7, $R^1 = \text{Me}$, $R^2 = \text{Ph}$). — In the same way, ethyldiphenylphosphine oxide (1 g), BuLi (3.1 ml), and ethyl benzoate (0.72 g) gave the ketone (7; $R^1 = \text{Me}$, $R^2 = \text{Ph}$) (1.06 g, 73%), as needles, m.p. 152-154° C (from EtOAc - 4% methanol) (lit.²³ 154-155° C). R_F 0.26 (EtOAc), n.m.r. and i.r. data²³ agree with that previously reported, m/e 334 (M^+ , 12%), 201 (Ph_2PO^+ , 100). Found: M^+ , 334.1122. $\text{C}_{21}\text{H}_{19}\text{O}_2\text{P}$ requires M^+ , 334.1122).

4-diphenylphosphinoylhexan-3-one, (7, $R^1 = R^2 = \text{Et}$). — In the same way, n-propyldiphenylphosphine oxide (1 g), BuLi (2.9 ml), and ethyl propionate (0.46 g) gave the ketone (7; $R^1 = \text{Et}$, $R^2 = \text{Et}$) (426 mg, 35%) as needles m.p. 105-107° C (from EtOAc). R_F

0.35 (EtOAc), δ (CDCl₃) 0.88 (3H, t, J_{HH} 8 Hz, Me), 1.92 (3H, t, J_{HH} 8 Hz, Me), 1.40-2.40 (2H, complex AB system, PCHCH₂Me), 2.52 (2H, q, J_{HH} 8 Hz, COCH₂Me), 3.50 (1H, ddd, J_{PH} 14 Hz, J_{HHA} 11 Hz, J_{HHB} 3 Hz, PCH), 7.30-7.95 (10H, m, Ph₂PO), ν_{max} 1700 (C=O), 1440 (P-Ph), and 1180 cm⁻¹ (P=O), m/e 300 (M^+ , 100%), 229 (Ph₂POCHMe⁺, 65), 201 (Ph₂PO⁺, 72). (Found: M^+ , 300.1265. C₁₈H₂₁O₂P requires M^+ , 300.1279).

2-diphenylphosphinoyl-1-phenylbutan-1-one, (7, R¹ = Ph). — In the same way, n-propyldiphenylphosphine oxide (1 g), BuLi (2.9 ml), and ethyl benzoate (0.70 g) gave the ketone (7, R¹ = Et, R² = Ph) (0.83 g, 59%) as needles, m.p. 154-156° C (from EtOAc) (lit⁶, 156-159° C). R_F 0.32 (EtOAc), n.m.r., i.r., and m.s. data⁶ correspond to that previously reported. (Found: M^+ , 348.1271, C₂₂H₂₁O₂P requires M^+ , 348.1279).

Attempted preparation of 1,2-diphenyl-2-diphenylphosphinoylethanone¹³ (7; R¹ = R² = Ph). — Using the same method as above, benzoate (0.33 g) gave what appeared to be a roughly 50:50 mixture of starting material and required product. Separation was not achieved owing to the almost complete insolubility of the mixture.

1, 3-Diphenyl-2-dephenylphosphinoylpropan-1-one, (7; R¹ = CH₂Ph, R² = Ph). As above, phenethyldiphenylphosphine oxide (1 g), BuLi (2.3 ml), and phenyl benzoate (0.56 g) gave the ketone (7; R¹ = CH₂Ph, R² = Ph) (1.14 g, 82%) as needles, m.p. 156-158° C (from EtOAc). R_F 0.46 (EtOAc), δ (CDCl₃) 3.25 (1H, ddd, J_{HHA} 3 Hz, J_{HAB} 12 Hz, J_{HAP} 10 Hz, PCHCH_AH_B), 3.40 (1H, ddd, J_{HAB} 6 Hz, J_{HAB} 12 Hz, J_{HBP} 6 Hz, PCHCH_AH_B), 4.85 (1H, ddd, J_{HHA} 3 Hz, J_{HBB} 11 Hz, J_{HP} 16 Hz, PCH), 7.05-8.05 (20H, m, Ph₂PO, Ph), ν_{max} 1675 (C=O), 1440 (P-Ph), and 1180 cm⁻¹ (P=O), m/e 410 (M^+ , 44%), 202 (Ph₂POH⁺, 100). (Found: M^+ , 410.1427. C₂₇H₂₃O₂P requires M^+ , 410.1435).

1-Diphenylphosphinoyl-5-hydroxypentan-2-one, (9, R = H, n = 5). — In the same way as above, but with addition of the NH₄Cl (aq) solution at -78° C, methyl-diphenylphosphine oxide, BuLi (3.3 ml), and γ -butyrolactone (0.48 g) gave the hydroxyketone (9; R = H, n = 5) (1.04 g, 74%) as needles, m.p. 100-102° C (from EtOAc - diisopropyl ether). R_F 0.10 (EtOAc), δ (CDCl₃) 1.80 (2H, quintet, J_{HH} 6 Hz, CH₂CH₂CH₂OH), 2.80 (2H, t, J_{HH} 6 Hz, COCH₂CH₂), 3.50 (2H, t, J_{HH} 6 Hz, CH₂CH₂OH), 3.62 (2H, d, J_{PH} 15 Hz, PCH₂), 3.80 (1H, broad s, OH), 7.20-7.95 (10H, m, Ph₂PO), ν_{max} 3380 (OH), 1710 (C=O), 1440 (P-Ph), and 1180 cm⁻¹ (P=O), m/e 302 (M^+ , 0.1%), 284 (M-H₂O, 74), 201 (Ph₂PO⁺, 100). (Found: M^+ , 302.1075. C₁₇H₁₉O₃P requires M^+ , 302.1072).

1-Diphenylphosphinoyl-6-hydroxyhexan-2-one, (9, R=H, n=6). — In the same way as for (9, R=H, n=5), methyl-diphenylphosphine oxide (1 g), BuLi (3.3 ml), and δ -valerolactone (0.50 g) gave the hydroxyketone (9, R=H n=6) (1.2 g, 82%) as needles, m.p. 78-81° C (from EtOAc - diisopropyl ether). R_F 0.13 (EtOAc), δ (CDCl₃) 1.20 - 1.95 (4H, m, CH₂CH₂CH₂OH), 2.60 (2H, t, J_{HH} 7 Hz, COCH₂CH₂), 3.45 (2H, t, J_{HH} 7 Hz, CH₂OH), 3.57 (2H, d, J_{PH} 15 Hz, PCH₂), 4.0 (1H, broad s, OH), 7.20 - 7.90 (10H, m, Ph₂PO) ν_{max} 3350 (OH), 1710 (C=O), 1440 (P-Ph), and 1180 cm⁻¹ (P=O), m/e 316 (M^+ , 2%), 298 (M-H₂O, 32), 201 (Ph₂PO⁺, 100). (Found: M^+ , 316.1218. C₁₈H₂₁O₃P requires M^+ , 316.1228).

1-Diphenylphosphinoyl-7-hydroxyheptan-2-one, (9; R=H, n=7). — Using essentially the same method as above, but allowing the reaction to warm to room temperature before addition of the NH₄Cl solution, methyl-diphenylphosphine oxide (1 g), BuLi (3.3 ml), and ϵ -caprolactone (0.58 g) gave, after column chromatography on silica (elution with EtOAc), the hydroxyketone (9; R=H, n=7) (1.18 g, 51%) as needles, m.p. 80-82° C (from EtOAc). R_F 0.14 (EtOAc), δ (CDCl₃) 1.10-1.75 (6H, m, (CH₂)₃CH₂OH), 2.65 (2H, t, J_{HH} 7 Hz, COCH₂CH₂), 3.30 (1H, broad s, OH), 3.55 (2H,

t, J_{HH} 7 Hz, CH₂OH), 3.65 (2H, d, J_{PH} 14 Hz, PCH₂), 7.30 - 7.95 (10H, m, Ph₂PO), ν_{max} 3360 (OH), 1700 (C=O), 1440 (P-Ph), and 1185 cm⁻¹ (P=O), m/e 330 (M^+ , 1.2%), 243 (Ph₂POCH₂CO⁺, 12), 215 (Ph₂POCH₂⁺, 56), 201 (Ph₂PO⁺, 100), (Found: M^+ , 330.1378. C₁₉H₂₃O₃P requires M , 330.1385), together with 7-diphenylphosphinoyl-6-oxoheptyl 6-hydroxyhexanoate, (10), (820 mg, 26%) as a viscous oil, R_F 0.24 (EtOAc), δ (CDCl₃) 1.10 - 1.85 (12 H, m, COCH₂(CH₂)₃ and (CH₂)₃CH₂OH), 2.30 (2H, t, J_{HH} 7 Hz, CH₂CO₂),

2.68 (2H, t, J_{HH} 7 Hz, COCH₂), 3.52 (2H, t, J_{HH} 6 Hz, CH₂OH), 3.65 (2H, d, J_{PH} 15 Hz, CH₂P), 3.70 (1H, broad s, OH), 4.02 (2H, t, J_{HH} 6 Hz, CH₂OCO), 7.30 - 7.95 (10H, m, Ph₂PO), ν_{max} 3390 (OH), 1730 - 1700 (broad CO), 1440 (P-Ph), and 1180 cm⁻¹ (P=O), m/e 444 (M^+ , 0.5%), 215 (Ph₂POCH₂⁺, 64), 201 (Ph₂PO⁺, 100), (Found M^+ , 444.2063. C₂₅H₃₃O₅P requires M^+ , 444.2065). The ester (10) may be converted into the hydroxyketone, (9; R=H, n=7), by acid hydrolysis in methanol.

2-Diphenylphosphinoyl-8-hydroxyoctan-3-one, (9, R = Me, n = 7). — Using the same method as for (9, R=H, n=5), ethyldiphenylphosphine oxide (2.3 g), BuLi (7.3 ml), and ϵ -caprolactone (1.25 g) gave, after column chromatography (eluted with EtOAc), the hydroxyketone, (9, R = Me, n = 7) (2.96 g, 86%) as a viscous oil, R_F 0.12 (EtOAc), δ (CDCl₃) 1.05 - 1.65 (9H, m, (CH₂)₃ and PCHMe), 1.54 [2h, t, J_{HH} 8 Hz,

$\text{COCH}_2(\text{CH}_2)_3$], 3.40 (1H, broad s, OH), 3.50 (2H, t, $J_{\text{HH}} = 8$ Hz, CH_2OH), 3.72 (1H, dq, $J_{\text{HH}} = 8$ Hz, $J_{\text{PH}} = 15$ Hz, PCHMe), 7.30 – 7.95 (10 H, m, Ph_2PO), ν_{max} 3350 (OH), 1700 (C=O), 1440 (P-Ph), and 1180 cm^{-1} (P=O), m/e 344 (M^+ , 0.8%), 326 ($M - \text{H}_2\text{O}$, 0.9), 201 (Ph_2PO^+ , 100). (Found: M^+ , 344.1528. $\text{C}_{20}\text{H}_{25}\text{O}_3\text{P}$ requires M^+ , 344.1541).

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