Tetrahedron Letters,Vol.26,No.29,pp 3479-3482,1985 0040-4039/85 $3.00 + .00
Printed in Great Britain

NEW SYNTHETIC METHOD OF O,S-THIOACETALS OF FORMYLPHOSPHONATES

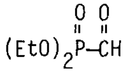
Taek Hyeon Kim and Dong Young Oh*

Department of Chemistry, Korea Advanced Institute of Science and Technology.

Seoul 131, Korea

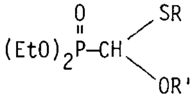
Abstract: The reaction of diethyl [(methylthio or arylthio)methyl]phosphonate with N-chlorosuccinimide (NCS) affords α-chloromethanephosphonate(5), which can be converted into a variety of O,S-thioacetals of formylphosphonates(2) by reaction with alcohols.

Phosphonate esters containing an electron-withdrawing substituent form stabilized carbanions which can effect the synthesis of certain olefins from aldehydes and ketones.[1] O,S-Thioacetals of formylphosphonates(2) which are the derivatives of the practically unknown formylphosphonate(1)[2] are the intermediates for the conversion under Wittig-Horner reaction conditions into the corresponding ketene O,S-thioacetals(3).[3] Ketene O,S-thioacetals are also valued reagents for the conversion into thioesters and amides.[4] Until now, the synthetic methods for 2 have been described by M.Mikolajczyk et al..[1b,2,5b] However their use is still hampered by low yield and reaction conditions.

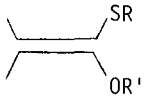


$(\mathrm{EtO})_2\overset{\mathrm{O}}{\overset{\|}{\mathrm{P}}}-\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}\mathrm{H}$

1



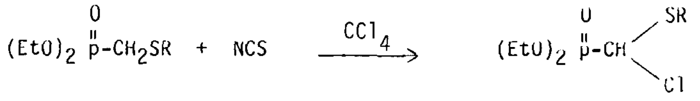
2



3

We wish to report both the preparation and reaction of diethyl [chloro(methylthio or arylthio)methyl]phosphonate(5) to develop a new general route to prepare O,S-thioacetals of formylphosponates(2) in high yields. The α-chloromethanephosphonates(5) are potential precursors of the corresponding carbanions and carbenes. Some methods now exist for the synthesis of these reagents.[5] The required phosphonats(5) were prepared quantitatively by reaction of diethyl [(methylthio or arylthio)methyl]phosphonates with N-chlorosuccinimide(NCS) in carbon tetrachloride at room temperature(eq.1). Although the best yields were generally obtained by using a 10-20% excess of NCS, it was proved to give only monochloro-substituted phosphonates(5) without dichloro-substituted phosphonates by means of the careful examination of ^{31}P NMR spectroscopy. The phosphonates(5) were obtained in better than 98% purity as a pale yellow liquid, but they were not purified by distillation.

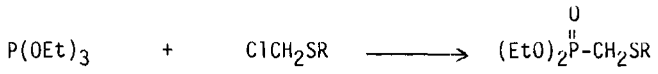
Diethyl [(methylthio or arylthio)methyl]phosphonates(4) as starting agents were prepared by Arbuzov reaction of triethyl phosphite with chloromethyl methyl(or aryl)sulfides(eq.2).[6,7]


(1)

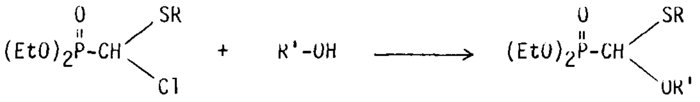
4 5

5a; R=CH_3 5b; R=C_6H_5 5c; R=4-$CH_3C_6H_4$ 5d; R=4-ClC_6H_4

A new approach to the synthesis of thioacetals(2) involves the reaction of α-chloromethane phosphonates(5) with alcohols(eq.3). The general procedure was the reaction between 5 and excess refluxing alcohols without other solvent. Using this procedure, a variety of thioacetals(2) were prepared in nearly quantitative yield without any traces of side product(Table I). The structure of all compounds prepared in the present work was confirmed by ^1H NMR, IR, ^{31}P NMR, and mass spectroscopy.[8,9]



$$P(OEt)_3 + ClCH_2SR \longrightarrow (EtO)_2\overset{O}{\overset{\|}{P}}\text{-}CH_2SR \qquad (2)$$


(3)

5 2

Table I. Preparations of O,S-Thioacetals of Formylphosphonates (2)

No	R	R'	Reaction time (h)	Yield (%)[a]	b.p. (°C/mmHg)[b]	^{31}P NMR[c] ($CDCl_3/H_3PO_4$)
2a	CH_3	CH_3	0.5	94	73- 75/0.5	+16.0
2b	CH_3	C_2H_5	1.0	96	100-101/1.0	+15.6
2c	C_6H_5	CH_3	24	95	136-138/0.5	+15.4
2d	C_6H_5	C_2H_5	36	92	152-154/0.4	+15.5
2e	4-$CH_3C_6H_4$	CH_3	2.0	95	138-140/0.5	+16.2
2f	4-$CH_3C_6H_4$	C_2H_5	3.0	93	142-145/0.4	+16.3
2g	4-ClC_6H_4	CH_3	24	86	143-145/0.5	+15.5
2h	4-ClC_6H_4	C_2H_5	36	85	150-151/0.4	+15.9

[a] Isolated yield by Kugelrohr distillation.

[b] Lit.[5b]; 2a; 64/0.1 2b; 103-105/1.5 2c; 125-128/0.05 2d; 138-142/0.02

[c] The conversion of positive ^{31}P NMR signals to low field from H_3PO_4 is used.

The general experimental procedure is as followings.

Diethyl [chloro(methylthio or arylthio)methyl]phosphonates(5) : A solution of diethyl [(methylthio or arylthio)methyl]phosphonates(4) (5 mmol) in 3 ml carbon tetrachloride was added to a suspension of 0.81 g NCS (6 mmol) in 17 ml carbon tetrachloride and the mixture was stirred for 3 h at room temperature under nitrogen. Then the insoluble materials were removed and the filtrate was concentrated. The residue was diluted with solution of 4 ml chloroform and 4 ml hexane, chilled and the precipitate so obtained filtered off. The mixture solvent was removed to give 5.

O.S-thioacetals of formylphosphonates(2) : A solution of diethyl [chloro(methylthio or arylthio)methyl]phosphonates(5) (1 mmol) in alcohol was refluxed for 0.5-36 h. After the reaction was complete, the excess alcohol was evaporated, and the product was purified by repeated Kugelrohr distillation.

References and Notes

1. (a) J. Boutagy and R. Thomas, Chem. Rev., 87(1973). (b) M. Mikolajczyk, S. Grzejszczak, A. Chefczynska, and A, Zatorski, J. Org. Chem., 44, 2967(1979).
2. M. Mikolajczyk, B. Costisella, S. Grzejszczak, and A. Zatorski, Tetrahedron Lett., 477(1976).
3. M. Mikolajczyk, S. Grzejszczak, and A. Zatorski, Tetrahedron, 3081(1978).
4. (a) A. de Groot and B. J. M. Jansen, Syn. Commun., 985(1983). (b) S. Hackett and T. Livinghoue, Tetrahedron Lett., 3539(1984).
5. (a) H. Gross and H. Seibt, J. Prakt. Chem., 312, 475(1970). (b) M. Mikolajczyk, A. Zatorski, S. Grzejszczak, B. Costisella, and W. Midura, J. Org., Chem., 2518(1978).
6. (a) N. Kreutzkamp and J. Pluhatsch, Arch. Pharm. (Weinheim, Ger.) 292, 159(1959). (b) M. Green, J. Chem. Soc., 1324(1963).
7. Another routes to these compounds are described by (a) B. A. Arbuzov and N. P. Bogonostseva, Zh. Obshch. Khim., 2419(1956). (b) Ibid., 2360(1957). (c) D. L. Comins, A. F. Jacobine, J. L. Marshall, and M. Turnbull, Synthesis, 309(1978). (d) J. G. Smith, M. S. Finck, B. D. Kontoleon, M. A. Trecoske, L. A. Giordano, and L. A. Renzulli, J. Org. Chem., 48, 1110(1983).
8. Characteristics of 5. 5a; H-NMR ($CDCl_3$) 1.48 (6H, t, OCH_2CH_3), 2.52 (3H, s, CH_3), 4.38 (4H, dq, OCH_2CH_3), 5.08 (1H, d, PCH, J=12); IR (CH_3Cl) 3010, 1260 (P=O,s), 1060-1025 cm^{-1}(vs); ^{31}P NMR ($CDCl_3/H_3PO_4$) + 14.1 5b; H-NMR ($CDCl_3$) 1.52 (6H, t, OCH_2CH_3), 4.43 (4H, dq, OCH_2CH_3), 5.40 (1H, d, PCH, J=12), 7.40-7.83 (5H, m, ArH); IR (CH_3Cl) 3030, 2990, 1260 (P=O, s), 1050-1020 cm^{-1}(vs); ^{31}P NMR ($CDCl_3/H_3PO_4$) + 14.3 5c; H-NMR ($CDCl_3$) 1.37 (6H, t, OCH_2CH_3), 2.33 (3H, s, CH_3), 5.25 (1H, d, PCH, J=13), 7.06-7.56 (4H, m, ArH); IR (CH_3Cl), 2995, 1265 (P=O, s), 1050-1020 cm^{-1}(vs); ^{31}P NMR ($CDCl_3/H_3PO_4$) + 13.6 5d; H-NMR ($CDCl_3$) 140 (6H, t, OCH_2CH_3), 4.23 (4H, dq, OCH_2CH_3), 5.39 (1H, d, PCH, J=14), 7.20-7.67 (4H, m, ArH); IR (CH_3Cl) 1260 (P=O, s), 1050-1020 cm^{-1}; ^{31}P NMR ($CDCl_3/H_3PO_4$) + 13.1
9. Characteristics of 2. 2a; H-NMR ($CDCl_3$) 1.50 (6H, t, OCH_2CH_3), 2.40 (3H, s, SCH_3), 3.63 (3H, s, OCH_3), 4.73 (4H, dq, OCH_2CH_3), 4.60 (1H, d, PCH, J=10); IR ($CHCl_3$) 3000, 1260 (P=O, s), 1090-1020 cm^{-1} (vs); Mass (m/e) 228 (M^+), 182 (Base peak), 167, 121, 91, 65,

2b; H-NMR ($CDCl_3$) 1.40 (6H, t, $CHOCH_2CH_3$), 1.50 (3H, t, $POCH_2CH_3$), 2.40 (3H, s, SCH_3), 3.53-4.00 (2H, m, $CHOCH_2CH_3$), 4.40 (4H, dq, $POCH_2CH_3$), 4.71 (1H, d, PCH, J=11); IR ($CHCl_3$) 2955, 1260 (P=O, s), 1055-1030 cm^{-1} (vs). 2c; H-NMR ($CDCl_3$) 1.50 (6H, t, OCH_2CH_3), 3.73 (3H, s, OCH_3), 4.38 (4H, dq, OCH_2CH_3), 5.10 (1H, d, PCH, J=11), 7.33-7.81 (5H, m, ArH); IR ($CHCl_3$) 3025, 1260 (P=O, s), 1075-1020 cm^{-1} (vs); Mass (m/e) 290 (M^+), 153 (Base peak), 121, 93, 65. 2d; H-NMR ($CDCl_3$) 1.30 (3H, t, $CHOCH_2CH_3$), 1.50 (6H, t, $POCH_2CH_3$), 3.53-4.00 (2H, m, $CHOCH_2CH_3$), 4.38 (4H, dq, $POCH_2CH_3$), 5.21 (1H, d, PCH, J=11), 7.33-7.81 (5H, m, ArH); IR ($CHCl_3$) 3025, 1260 (P=O, s), 1075-1020 cm^{-1} (vs). 2e; H-NMR ($CDCl_3$) 1.37 (6H, t, OCH_2CH_3), 2.40 (3H, s, $ArCH_3$), 3.63 (3H, s, OCH_3), 4.25 (4H, dq, OCH_2CH_3), 4.90 (1H, d, PCH, J=11), 7.07-7.57 (4H, m. ArH); IR ($CHCl_3$) 2990, 1260 (P=O, s), 1080-1025 cm^{-1} (vs);Mass (m/e) 304 (M^+), 167 (Bae peak), 121, 93, 65. 2f; H-NMR ($CDCl_3$) 1.33 (3H, t, $CHOCH_2CH_3$), 1.43 (6H, t, $POCH_2CH_3$), 3.53-4.10 (2H, m, $CHOCH_2CH_3$), 4.30 (4H, dq, $POCH_2CH_3$), 5.03 (1H, d, PCH, J=11), 7.10-7.63 (4H, m, ArH); IR ($CHCl_3$) 2990, 1260 (P=O, s), 1080-1025 cm^{-1} (vs). 2g; H-NMR ($CDCl_3$) 1.43 (6H, t, OCH_2CH_3) 3.67 (3H, s, OCH_3), 4.30 (4H, dq, OCH_2CH_3), 4.95 (1H, d, PCH, J=11), 7.27-7.68 (4H, m, ArH); IR ($CHCl_3$) 3030, 1260 (P=O, s), 1080-1020 cm^{-1} (vs); Mass (m/e) 324 (M^+), 326 (M^++2), 187 (Base peak), 121, 93, 65. 2h; H-NMR ($CDCl_3$) 1.31 (3H, t, $CHOCH_2CH_3$) 1.43 (6H, t, $POCH_2CH_3$), 2.43 (3H, s, $ArCH_3$), 3.57-4.00 (2H, m, $CHOCH_2CH_3$), 4.30 (4H, dq, $POCH_2CH_3$), 5.03 (1H, d, PCH, J=11), 7.27-7.67 (4H, m, ArH); IR ($CDCl_3$) 3050, 1260 (P=O, vs), 1080-1030 cm^{-1} (vs).

(Received in Japan 31 March 1985)