SHORT PAPER

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Hypervalent iodine in synthesis 80: one pot preparation of Se-(β-oxoalkyl) O,O-dialkyl selenophospates by reaction of ketones, [hydroxy (tosyloxy) iodo]benzene, and potassium O,O-dialkyl selenophosphates†

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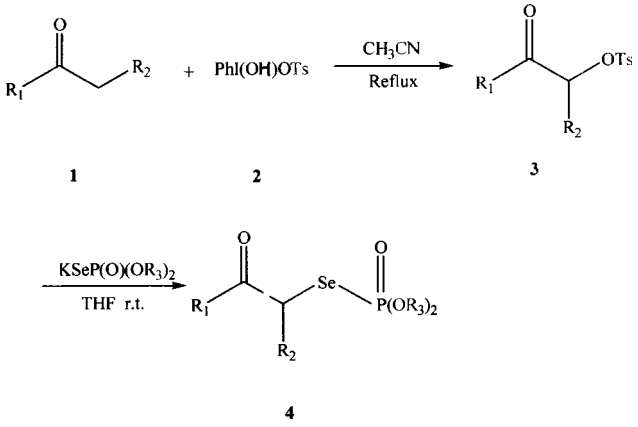
One pot reactions of ketones, [hydroxy(tosyloxy)iodo]benzene and potassium O,O-dialkyl selenophosphates lead to the formation of the corresponding Se-(β-oxoalkyl) O,O-dialkyl selenophosphates under mild conditions and in good yield.

Keywords: hypervalent iodine; se-(β-oxoalkyl) O,O-dialkyl selenophosphates

Se-(β-oxoalkyl) O,O-dialkyl selenophosphates have been reported to be key intermediates for the highly stereoselective conversion of ketones into *Z*-olefins.[1] In addition, the esters of O,O-dialkyl selenophosphoric acid are of marked interest in biochemistry.[2] But little attention has been given to their synthesis. To our knowledge, there is only one method available for the synthesis[1,3] of Se-(β-oxoalkyl) O,O-dialkyl selenophosphates, which involves the reaction of the silyl enol ethers of ketones with trialkyl selenophosphonium salts, $(RO)_3P^+SeCl\ SO_2Cl^-$, in dichloromethane at –78°C. It is obvious that the method has some disadvantages, such as using an inaccessible and toxic reagent and strict reaction conditions.

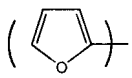
There is considerable current interest and research activity in hypervalent iodine compounds.[4] It has been demonstrated that [hydroxy(tosyloxy)iodo] benzene (HTIB, **2**) is a versatile reagent in organic synthesis and the reaction of HTIB with ketones leading to tosyloxylketones is especially useful. This reaction followed by treatment with appropriate nucleophilies *in situ* offers a variety of valuable synthetic methods. It promoted us to examine the α-tosyoxylation of ketones with HTIB followed by treatment with readily available potassium O, O-dialkyl selenophosphates. Such a reaction would provide a new, effective method for the synthesis of Se- (β-oxoalkyl) O, O-dialkyl selenophosphates.

We found that the α-tosyloxylation of ketones with HTIB, followed by treatment with potassium O, O-dialkyl selenophosphates gave Se- (β-oxoalkyl) O, O-dialkyl selenophosphates in one-pot (Scheme 1). The results are summarised in Table 1.



Scheme 1

Table 1 Synthesis of Se- (β-oxoalkyl) O, O-dialkyl selenophosphates (**4**)

	R_1	R_2	R_3	Yield[a] (%)		HPLC Purity
4a	Me	H	Et	60	Oil	99.77%
4b	Et	Me	Et	75	Oil[3]	99.76%
4c	Ph	H	Et	63	Oil	99.74%
4d	*p*-ClPh	H	Et	66	Oil	99.78%
4e	Ph	Me	Et	55	Oil[3]	99.73%
4f	Ph	Ph	Et	40	Oil[3]	99.77%
4g	Ph	H	Me	65	Oil	99.72%
4h	*p*-ClPh	H	Me	67	Oil	99.69%
4i	Ph	Me	Me	56	Oil	99.71%
4j		H	Et	45	Oil	99.78%

[a]Isolated yield based on ketone.

The products were characterised by microanalyses, ^{1}H-NMR, IR and mass spectral data. The microanalyses and ^{1}H-NMR spectra were consistent with the proposed structures. In the infrared there were two characteristic intense absorptions centred in the ν=1720–1669 cm^{-1} and o=1263–1240 cm^{-1} regions due to the >C=O and P=O stretching frequencies respectively.

The reaction was found to be general and applicable to aliphatic or aromatic ketones. However, this method was not suitable for unsymmetrical aliphatic ketones, since the α-tosyoxylation is poorly regioselective in regioselectivity for these ketones.

In conclusion, we have provided a new, effective one-pot procedure for the synthesis of Se- (β-oxoalkyl) O, O-dialkyl selenophosphates. It has some advantages over previous methods, such as simple procedure, mild reaction conditions and good yields.

Experimental

IR spectra were recorded on PE-683 Infrared Spectrophotometer. ^{1}H-NMR spectra were recorded on PMK-60 Spectrometer using CCl_4 as the solvent with TMS as an internal standard. MS was recorded on HP-5989B Mass Spectrometer. Elemental analysis was performed on a Carlo Zrba EA 1106 instrument. Purity was determined by HPLC on Schimadzu LC-6A.

Typical procedure for synthesis of potassium O, O-diethyl selenophosphate: Potassium (0.2 mole) was dissolved in 60 ml alcohol (the alcohol corresponding to the dialkyl phosphate to be pre-

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pared), and a slight excess of diethyl hydrogen phosphite, and 60 ml ether were added. Selenium was added in portions. The reaction took place vigorously with boiling of the ether, the end being indicated through a rapid change of phenol-phthalein to colourless. Excess of selenium was filtered off. The potassium O, O-diethyl selenophosphate (45.9 g) was isolated by evaporation of alcohol-ether *in vacuo*.

*Typical procedure for synthesis of Se-(β-oxo-β-phenylethyl) O,O-diethyl selenophosphate (***4c***):* Acetophenone (0.12 g, 1 mmol) and HTIB (0.392 g, 1 mmol) were added successively with efficient stirring to acetonitrile (5 ml). The reaction mixture was refluxed for 40 min, then concentrated under reduced pressure. The residue was treated under N_2 atmosphere with potassium O, O-diethyl selenophosphates (0.38 g, 1.5 mmol) in THF (10 ml) at room temperature. After 20 min, the reaction mixture was poured into water (20 ml) and extracted with ether (3 × 10 ml). The combined organic phase was dried with anhydrous maganesium sulfate, filtered and evaporated under reduced pressure. The crude product was purified by preparative TLC (ether/petroleum ether = 3:1) to obtain **4c** (0.21 g, HPLC purity: 99.74%, 63% yield) as an oil.

Spectroscopic data

4a: IR (cm^{-1}) 1720 (C=O), 1255 (P=O). ^{1}H-NMR, ppm: δ 1.20–1.50 (m, 6H, OCH_2CH_3), 2.04 (s, 3H, CH_3CO), 2.36 (s, 2H, CH_2Se), 3.56–4.46 (m, 4H, OCH_2CH_3). MS *m/z* 273 (M^+,0.97), 274 (0.38). Elemental analysis for $C_7H_{15}O_4PSe$: Calculated C, 30.78 H, 5.54 Found C, 30.68 H, 5.60.

4b: IR (cm^{-1}) 1710 (C=O), 1250 (P=O). ^{1}H-NMR, ppm: δ 0.90–1.58 (m, 3H + 6H + 3H, CH_3CH_2CO, OCH_2CH_3, CH_3CHSe), 2.40–2.75 (q, 2H, CH_3CH_2CO), 3.65–4.35 (m, 4H + 1H, OCH_2CH_3, CH_3CHSe). MS *m/z* 301 (M^+, 0.81), 302 (0.44). Elemental analysis for $C_9H_{19}O_4PSe$: Calculated C, 35.89 H, 6.36 Found C, 35.94 H, 6.43.

4c: IR (cm^{-1}) 1675 (C=O), 1263 (P=O). ^{1}H-NMR, ppm: δ 1.15–1.40 (m, 6H, OCH_2CH_3), 3.40–4.41 (m, 4H + 2H, OCH_2CH_3, CH_2Se), 7.11-8.05 (m, $5H_{arom}$). MS *m/z* 336 (M^+, 0.99), 337 (0.76). Elemental analysis for $C_{12}H_{17}O_4PSe$: Calculated C, 43.00 H, 5.11 Found C, 42.94 H, 5.19.

4d: IR (cm^{-1}) 1677 (C=O), 1250 (P=O). ^{1}H-NMR, ppm: δ 1.20–1.40 (m, 6H, OCH_2CH_3), 3.80–4.30 (m, 4H + 2H, OCH_2CH_3, CH_2Se), 7.35-8.06 (q, $4H_{arom}$). MS, 370 (1.78), 371 (1.66). Elemental analysis for $C_{12}H_{16}ClO_4PSe$: Calculated C, 38.99 H, 4.36 Found C, 39.10 H, 4.29.

4e: IR (cm^{-1}) 1678 (C=O), 1240 (P=O). ^{1}H-NMR, ppm: δ 1.07–1.43 (m, 6H, OCH_2CH_3) 1.77 (d, 3H, CH_3CHSe) 3.63–4.33 (m, 4H, OCH_2CH_3), 4.67–5.27 (m, 1H, CH_3CHSe), 7.27–8.12 (m, $5H_{arom}$). MS *m/z* 349 (M^+,1.78), 350 (1.66). Elemental analysis for $C_{13}H_{19}O_4PSe$: Calculated C, 44.71 H, 5.48 Found C, 44.80 H, 5.43.

4f: IR (cm^{-1}) 1680 (C=O), 1250 (P=O). ^{1}H-NMR, ppm: δ 0.95-1.35 (m, 6H, OCH_2CH_3), 3.45-4.15 (m, 4H, OCH_2CH_3), 6.20 (d, 1H, $CHSe$), 7.25–8.15 (m , $10H_{arom}$). MS *m/z* 411 (M^+, 1.78), 412 (0.95). Elemental analysis for $C_{18}H_{21}O_4PSe$: Calculated C, 52.56 H, 5.15 Found C, 52.64 H, 5.20.

4g: IR ($cm^{-1)}$ 1675 (C=O), 1255 (P=O). ^{1}H-NMR, ppm: δ 3.70 (d, 6H, OCH_3), 4.30 (d, 2H, CH_2Se), 7.40–8.10 (m, $5H_{arom}$). MS *m/z* 307 (M^+, 0.63), 308 (0.78), 309 (1.08). Elemental analysis for $C_{10}H_{13}O_4PSe$: Calculated C, 39.10 H, 4.27 Found C, 39.15 H, 4.19.

4h: IR (cm^{-1}) 1676 (C=O), 1260 (P=O). ^{1}H-NMR, ppm: δ 3.75 (d, 6H, OCH_3), 4.39 (d, 2H, CH_2Se), 7.40–8.10. MS *m/z* 342 (M^+,0.43), 343 (0.48). Elemental analysis for $C_{10}H_{12}ClO_4PSe$: Calculated C, 35.6 H, 3.54 Found C, 35.10 H, 3.61.

4i: IR (cm^{-1}) 1679 (C=O), 1245 (P=O).^{1}H-NMR, ppm: δ 1.73 (d, 3H, CH_3), 3.40–3.77 (m, 6H, OCH_3), 4.77–5.23 (m, 1H, CH_3CHSe), 7.30-8.07(m, $5H_{arom}$). MS *m/z* 321 (M^+, 0.54), 322 (1.27), 323 (1.01), 324 (0.34). Elemental analysis for $C_{11}H_{15}O_4PSe$: Calculated C, 41.14 H, 4.71 Found C, 41.22 H, 4.65.

4j: IR (cm^{-1}) 1669 (C=O),1245 (P=O). ^{1}H-NMR, ppm: δ 1.20–1.43 (m, 6H, OCH_2CH_3), 3.83–4.20 (m, 4H + 2H, OCH_2CH_3, CH_2Se), 6.55–7.60 (m, 3H). MS *m/z* 324 (M^+, 2.15), 326 (3.50), 327 (3.32). Elemental Analysis for $C_{10}H_{15}O_5PSe$: Calculated C, 36.94 H, 4.65 Found C, 37.03 H, 4.71.

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References

1 (a) A. Skowronska and P. Dybowski, *Phosphorus, Sulfur and Silicon*, 1990, **49**, 275; (b) A. Skowronska and P. Dybowski, *Heteroatom Chemistry*, 1991, 55; (c) P. Dybowski and A. Skowronska, *Tetrahedron Lett*., 1991, **32**, 4385.
2 (a) T.C. Stadtman, *BioFactors*, 1994, **4**, 181; (b) T.C. Stadtman, E. Veres and I.Y. Kim, *Phosphate Microorg.*, 1994, 109.
3 P. Dybowski, E. Krawczyk and A. Skowronska, *Synthesis*, 1992, 601.
4 (a) T.J. Kitamura, *Synth. Org. Chem. Jpn.*, 1995, **53**, 893; (b) P.J. Stang, V.V. Zhdankin, *Chem. Rev*., 1996, **46**, 1123; (c) T. Kitamura, Y. Fujiwara, *Org. Prep. Proced. Int.* 1997, **29**, 409; (d) T. Wirth and U.H. Hirt, *Synth.* 1999, **8**, 1271.