A Convenient Synthesis of 2,4-Diarylthietanes by Reductive Cyclization of *O,O*-Diethyl *S*-(1,3-Diaryl-3-oxopropyl) Phosphorodithioates

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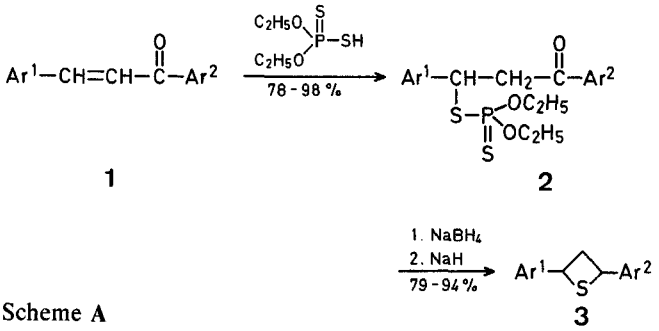
In general, the chemistry of four-membered heterocycles has been less extensively studied than that of other heterocycles such as the three- or five-membered ones. We have previously reported the preparation of 1,3-dithietane derivatives starting from dithiocarbamates[1]. We now report a new, two-step, general method for the preparation of 2,4-diarylthietane derivatives (**3**) starting from chalcones (**1**). The synthetic sequence is outlined in Scheme **A**.



Scheme **A**

Thus, *O,O*-diethyl hydrogen phosphorodithioate reacted with chalcones **1** in benzene at 50–60 °C within 3 h to give the corresponding Michael adducts **2**, *O,O*-diethyl *S*-(1,3-diaryl-3-

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Table. *O,O*-Diethyl *S*-(1,3-Diaryl-3-oxopropyl) Phosphorodithioates **2** and 2,4-Diarylthietanes **3**

Compound No.	Ar^1	Ar^2	Yield[a] [%]	m.p. [°C] (solvent)	Molecular formula[b]	^{1}H-N.M.R. (CCl_4) δ [ppm]
2a	C_6H_5	C_6H_5	88	35–36° (n-C_6H_{14}/C_2H_5OH)	$C_{19}H_{23}O_3PS_2$ (394.5)	1.12, 1.35 (dt, J=7 Hz, 6H); 3.5–4.3 (m, 6H); 4.7–5.1 (m, 1H); 7.1–7.4 (m, 8H); 7.8–7.9 (m, 2H)
2b	4-Cl—C_6H_4	C_6H_5	78	72.5–74° (n-C_6H_{14})	$C_{19}H_{22}ClO_3PS_2$ (428.9)	1.16, 1.30 (dt, J=8 Hz, 6H); 3.5–4.3 (m, 6H); 4.7–5.1 (m, 1H); 7.3–7.5 (m, 7H); 7.8–8.0 (m, 2H)
2c	4-H_3CO—C_6H_4	C_6H_5	98	81.5–82° (n-C_6H_{14})	$C_{20}H_{25}O_4PS_2$ (424.5)	1.17, 1.33 (dt, J=8 Hz, 6H); 3.75 (s, 3H); 3.5–4.2 (m, 6H); 4.7–5.2 (m, 1H); 6.71 (d, J=9 Hz, 2H); 7.35 (d, J=9 Hz, 2H); 7.4–7.5 (m, 3H); 7.8–7.9 (m, 2H)
2d	4-Cl—C_6H_4	4-Cl—C_6H_4	86	74–75.5° (n-C_6H_{14})	$C_{19}H_{21}Cl_2O_3PS_2$ (463.4)	1.20, 1.33 (dt, J=7 Hz, 6H); 3.6–4.4 (m, 6H); 4.7–5.2 (m, 1H); 7.3–7.5 (m, 6H); 7.8–8.0 (m, 2H)
2e	4-Cl—C_6H_4	4-H_3CO—C_6H_4	88	46–47° (n-C_6H_{14}/C_2H_5OH)	$C_{20}H_{24}ClO_4PS_2$ (459.0)	1.17, 1.28 (dt, J=7 Hz, 6H); 3.87 (s, 3H); 3.5–4.4 (m, 6H); 4.8–5.1 (m, 1H); 6.97 (d, J=9 Hz, 2H); 7.2–7.5 (m, 4H); 7.95 (d, J=9 Hz, 2H)[c]
2f	4-H_3CO—C_6H_4	4-H_3CO—C_6H_4	90	51–52° (n-C_6H_{14})	$C_{21}H_{27}O_5PS_2$ (454.5)	1.15, 1.33 (dt, J=7 Hz, 6H); 3.77 (s, 3H); 3.85 (s, 3H); 3.4–4.2 (m, 6H); 4.7–5.1 (m, 1H); 6.67 (d, J=9 Hz, 2H); 6.83 (d, J=9 Hz, 2H); 7.2–7.4 (m, 2H); 7.87 (d, J=9 Hz, 2H)
3a	C_6H_5	C_6H_5	79	56–57° (n-C_6H_{14})	$C_{15}H_{14}S$ (226.3)	3.0–3.4 (m, 2H); 4.6–4.9 (m, 2H); 7.3–7.6 (m, 10H)
3b	4-Cl—C_6H_4	C_6H_5	92	76.5–78° (n-C_6H_{14})	$C_{15}H_{13}ClS$ (260.8)	3.0–3.4 (m, 2H); 4.6–4.9 (m, 2H); 7.1–7.7 (m, 9H)
3c	4-H_3CO—C_6H_4	C_6H_5	93	39–40° (n-C_6H_{14})	$C_{16}H_{16}OS$ (256.4)	3.0–3.4 (m, 2H); 3.75 (s, 3H); 4.6–4.9 (m, 2H); 6.6–6.9 (m, 2H); 7.2–7.5 (m, 7H)
3d	4-Cl—C_6H_4	4-Cl—C_6H_4	88	110–111° (n-C_6H_{14})	$C_{15}H_{12}Cl_2S$ (295.2)	3.0–4.5 (m, 2H); 4.6–4.9 (m, 2H); 7.5–7.6 (m, 8H)[c]
3e	4-Cl—C_6H_4	4-H_3CO—C_6H_4	94	106–107° (n-C_6H_{14})	$C_{16}H_{15}ClOS$ (290.8)	3.2–3.4 (m, 2H); 3.82 (s, 3H); 4.6–4.9 (m, 2H); 6.8–7.0 (m, 2H); 7.2–7.6 (m, 6H)
3f	4-H_3CO—C_6H_4	4-H_3CO—C_6H_4	94	82.5–84° (n-C_6H_{14})	$C_{17}H_{18}O_2S$ (286.4)	3.1–3.7 (m, 2H); 3.87 (s, 6H); 4.7–5.0 (m, 2H); 6.9–7.0 (m, 4H); 7.5–7.6 (m, 4H)

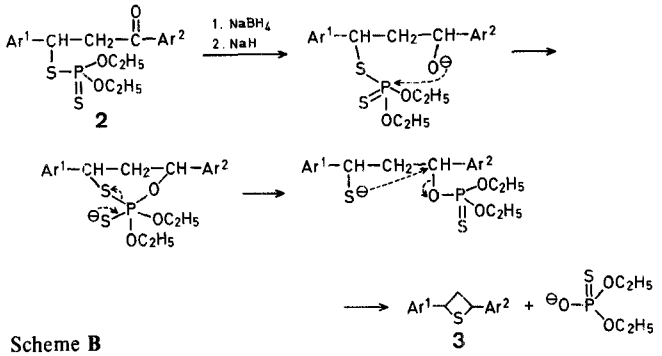
[a] Yields of isolated products.

[b] Satisfactory microanalyses obtained: C ±0.40, H ±0.19.

[c] In $CDCl_3$ solution.

oxopropyl) phosphorodithioates in good yield (Table)[2]. Conventional reduction of adducts **2** with sodium borohydride afforded the corresponding alcohols in addition to the small amount of thietane derivatives **3**. Thus, the adduct **2** was reduced with sodium borohydride in *t*-butanol followed by treatment with sodium hydride in the same vessel to produce the corresponding thietanes **3** in 79–94% yield (Table).

Formation of thietanes is best explained by the intramolecular attack of alkoxide ion on the phosphorus atom (Scheme **B**). This assumption is supported by the exclusive formation of thietanes by the addition of a base, such as sodium hydride, to facilitate the alkoxide ion formation.



Scheme **B**

2,4-Diarylthietanes **3** obtained here are a mixture of *trans* and *cis* isomers. For example, the *trans/cis* isomer ratio of **3a** is estimated to be 75/25 by N.M.R. analysis[3].

In general, thietanes have been hitherto prepared by the cyclization of 1,3-haloalkanes with sodium sulfide, or cyclization of 3-haloalkyl mercaptans with a base[4]. The present method seems to have an advantage over these classical procedures due to the wide availability of the starting chalcones and simple operations under mild conditions.

O,O-Diethyl S-(1,3-Diaryl-3-oxopropyl) Phosphorodithioates 2; General Procedure:

To a solution of chalcone **1** (20 mmol) in dry benzene (50 ml) is added a solution of *O,O*-diethyl hydrogen phosphorodithioate (3.72 g, 20 mmol) in dry benzene (5 ml) at room temperature. The mixture is stirred at 50–60 °C for 3 h under nitrogen. The mixture is washed with 10% aqueous sodium hydrogen carbonate solution (1 × 30 ml) followed by water (2 × 30 ml), and extracted with ether (3 × 50 ml). The extract is dried with magnesium sulfate and evaporated to give the adduct **2**, which is recrystallized from a suitable solvent.

2,4-Diarylthietanes 3; General Procedure:

A mixture of the adduct **2** (5 mmol) and sodium borohydride (190 mg, 5 mmol) in dry *t*-butanol (~20 ml) is stirred at room temperature for 3 h, then at 60 °C for 1 h under nitrogen. Sodium hydride (120 mg, 5 mmol) is added to the above mixture at room temperature. Stirring is continued for 4 h, then at 60 °C for 1 h. Water (30 ml) is added, the mixture is extracted with ether (3 × 50 ml), and dried with magnesium sulfate. The crude product **3** is recrystallized from *n*-hexane.

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[1] Y. Ueno, Y. Masuyama, M. Okawara, *Tetrahedron Lett.* **1974**, 2577.

[2] E. I. Hoegberg, *U. S. Patent* 2632020, American Cyanamid Co. (1953); *C. A.* **48**, 2759 (1954).

[3] R. M. Dodson, E. H. Jancis, G. Klose, *J. Org. Chem.* **35**, 2520 (1970).

[4] M. Sander, *Chem. Rev.* **66**, 341 (1966).