Chemistry of Sulphines. Part XVI.¹ Aliphatic Sulphines from Non-enethiolisable Thietones and their Cycloaddition Reactions with Diazoalkanes

By B. Zwanenburg, A. Wagenaar, L. Thijs, and J. Strating, Department of Organic Chemistry of the University at Nijmegen, Toernooiveld, Nijmegen, and Department of Organic Chemistry of the University at Groningen, Zernikepla, Groningen, The Netherlands

Reprinted from
JOURNAL
OF
THE CHEMICAL SOCIETY
PERKIN TRANSACTIONS I
1973
Chemistry of Sulphines. Part XVI.¹ Aliphatic Sulphines from Non-enethiolisable Thioketones and their Cycloaddition Reactions with Diazooalkanes

By B. Zwanenburg,* A. Wagenaar, L. Thijs, and J. Strating, Department of Organic Chemistry of the University at Nijmegen, Toernooiveld, Nijmegen, and Department of Organic Chemistry of the University at Groningen, Zernikelaan, Groningen, The Netherlands

Oxidation with peroxy-acid of the non-enethiolisable thioketones adamantane-thione, 2,2,4,4-tetramethyl-3-thioxo-cyclobutanone and 2,2,4,4-tetramethyl-3-thioxo-cyclobutanone S-oxide gives the corresponding sulphines in high yields. Cycloaddition reactions of these sulphines with 2-diazopropane lead to \( \Delta^1 \)-1,3,4-thiadiazoline S-oxides; from diazomethane and 2,2,4,4-tetramethyl-3-thioxo-cyclobutanone S-oxide an episulphoxide was isolated.

Several types of sulphines (thione S-oxides) can conveniently be synthesised by peroxy-acid oxidation of the corresponding thiocarbonyl compounds.² Aliphatic sulphines have not been prepared hitherto by this oxidation method, presumably because of the limited stability³ of the parent thiones. Thioacetone S-oxide has been reported⁴ as a transient intermediate during the dehydrohalogenation of propane-2-sulphinyl chloride.

With the aim of studying the chemical and spectroscopic properties of aliphatic sulphines, we selected three aliphatic thioketones, (I)–(III), which show no tendency towards enethiolisation or di-, tri-, or polymerisation at ordinary temperatures, and which therefore would probably be oxidisable to sulphines. Indeed, adamantane-thione⁵ (I) smoothly reacted with \( m \)-chloroperbenzoic acid (MCPBA) in ether at 5° to give the stable aliphatic sulphine (IV) (75%). The product showed the characteristic \( \geq C=S=O \) i.r. absorption at 1070 cm\(^{-1}\), its u.v. spectrum (hexane) exhibited a maximum at 270 nm (\( \varepsilon \) 9555), and its n.m.r. spectrum (CCl\(_4\)) revealed, besides a broad absorption at \( \delta \) 2-00 (12H), broad one-proton singlets at \( \delta \) 2-87 and 4-02 p.p.m. The separation of 68 Hz between the latter two signals shows the difference between the deshielding properties of the two sides of the bent sulphine system unperturbed by other anisotropic effects.⁶

⁷ E. U. Elam and H. E. Davis, J. Org. Chem., 1967, 32, 1562. This compound was supplied by Dr. J. A. Boerma (Groningen).
oxidised by MCPBA (1.0 equiv.) in ether at 0° to give the aliphatic sulphine (V) in 80% yield. The n.m.r. spectrum (CCl₄) showed the expected singlets for the two types of methyl protons at δ 1.48 and 1.63 p.p.m. The characteristic i.r. absorptions (CCl₄) were observed at 1785 (C=O) and 1065 cm⁻¹ (CSO).

On treatment of the dithione (III) with MCPBA in ether at 0° a rapid discharge of the red coloration was observed. A crystalline substance isolated in 86% yield consisted of a mixture of anti- and syn-bis-sulphines (VIA and b). The n.m.r. spectrum (CDCl₃) showed the four methyl groups of the anti-isomer (VIA) as one singlet at δ 1.84 and those of the syn-compound as two singlets at δ 1.71 and 1.98 p.p.m. According to the n.m.r. spectrum the anti-syn ratio varied from 9 : 1 to 4 : 1 depending on the conditions of the oxidation. Despite several attempts, separation of these isomers was not achieved. Isomerisation (syn to anti) took place readily on warming a solution of the mixture. The anti-isomer could then be obtained as a single compound.

The aliphatic sulphines (IV)−(VI) are reasonably stable at room temperature, in spite of the lack of conjugative stabilisation (cf. ref. 2a). Their cycloaddition reactions offer a unique possibility for the preparation of heterocyclic compounds. We have studied reactions with diazomethane and 2-diazopropane, particularly to compare the results with those obtained recently for the parent thiones. 

Adamantanethione S-oxide (IV) reacted with 2-diazopropane at −10° to give a 1 : 1 adduct to which structure (VII) was assigned on the basis of elemental analysis and the following spectral data: λ max (KBr) 1404s (S=O) and 1570m (N=N) cm⁻¹; δ (CDCl₃; −30°) 1.50 (s, Me), 1.88 (s, Me), 2.70−3.20 (1H, m), and 1.80−2.70 p.p.m. (13H, m). The alternative mode of addition which would lead to a 1,2,3-thiadiazoline S-oxide is ruled out, because then the N=N i.r. absorption would be expected at a lower wavenumber. Moreover, the position of the methyl n.m.r. signals agrees well with those of 2,2,5,5-tetramethylcyclobutanone-spiro-1,3,4-thiadiazoline S-oxide [δ (CCl₄) 1.47 and 1.70 p.p.m.] prepared via an independent route.*

As observed previously, diazomethane reacts much more slowly with sulphines than 2-diazopropane. With compound (IV) and diazomethane no reaction took place. However, adamantanethione (I) does react with diazomethane: Krapcho et al. report two different modes of addition, viz., via an adamantanethione S-oxide (IX) was isolated (29%). The structure became evident from elemental analysis and spectra. The i.r. spectrum (Nujol) showed absorption at 3060 cm⁻¹ (C=H) indicative of the three-membered ring system, strong bands in the S=O region at 1015, 1060, and 1085 cm⁻¹, and no absorption in the N=N region (1500−1600 cm⁻¹). N.m.r. signals were observed at δ 0.94, 1.30, 1.44, and 1.68 (each s, Me) and 2.44 and 2.80 p.p.m. (AB pattern, J 8.0 Hz, CH₃). Apparently, the initially formed five-membered ring loses nitrogen easily to give the episulphoxide. This behaviour of the primary cycloadduct is similar to that of the thiadiazoline derived from the parent thione (II) and diazomethane, which also readily loses nitrogen, to give an episulphide.

The bis-sulphine (VI), as a mixture of isomers, reacted with 2-diazopropane in an analogous way to (V), to give a mixture of isomeric dispiro-compounds (Xa and b, with one form predominating) containing two 1,3,4-thiadiazoline S-oxide units (yield 66%). The product composition changed according to the anti-syn ratio of the starting material. When pure anti-sulphine (VIA) was used, a mixture of compounds was still obtained, in which the same main product dominated. If we assume a stereospecific† cycloaddition reaction the anti-sulphine (VIA) would give a mixture of trans-(Xa) and trans-(Xb) bis-sulphoxide. If we also consider that the approach of diazopropane to the two sulphine functions occurs from opposite sides of the thiadiazoline units, the anti- isomer would be expected to have the thiadiazoline group correctly oriented for nucleophilic attack on the diazomethane; accordingly, the cis- adduct would be expected to be the major product.

To our surprise the reaction of compound (V) with diazomethane did not lead to a thiadiazoline S-oxide; instead a tetramethylcyclobutanone-spiro-thiiran S-oxide (IX) was isolated (29%). The structure became evident from elemental analysis and spectra. The i.r. spectrum (Nujol) showed absorption at 3060 cm⁻¹ (C=H) indicative of the three-membered ring system, strong bands in the S=O region at 1015, 1060, and 1085 cm⁻¹, and no absorption in the N=N region (1500−1600 cm⁻¹). N.m.r. signals were observed at δ 0.94, 1.30, 1.44, and 1.68 (each s, Me) and 2.44 and 2.80 p.p.m. (AB pattern, J 8.0 Hz, CH₃). Apparently, the initially formed five-membered ring loses nitrogen easily to give the episulphoxide. This behaviour of the primary cycloadduct is similar to that of the thiadiazoline derived from the parent thione (II) and diazomethane, which also readily loses nitrogen, to give an episulphide.

The bis-sulphine (VI), as a mixture of isomers, reacted with 2-diazopropane in an analogous way to (V), to give a mixture of isomeric dispiro-compounds (Xa and b, with one form predominating) containing two 1,3,4-thiadiazoline S-oxide units (yield 66%). The product composition changed according to the anti-syn ratio of the starting material. When pure anti-sulphine (VIA) was used, a mixture of compounds was still obtained, in which the same main product dominated. If we assume a stereospecific† cycloaddition reaction the anti-sulphine (VIA) would give a mixture of trans-(Xa) and trans-(Xb) bis-sulphoxide. If we also consider that the approach of diazopropane to the two sulphine functions occurs from opposite sides of the thiadiazoline units, the anti- isomer would be expected to have the thiadiazoline group correctly oriented for nucleophilic attack on the diazomethane; accordingly, the cis- adduct would be expected to be the major product.

† Other types of sulphines indeed show stereospecific cycloaddition reactions with diazo-compounds (B. Zwanenburg and A. Wagenaar, in preparation).
molecule, the main product most likely would be trans-
(XA). Attempts to separate the mixture of products or to gain more definite information about the geometry of the constituents, failed.

Diazomethane reacted very sluggishly with the bis-sulphine (VI), yielding a small amount of a mixture of products to which bis-spiro-thiuran S-oxide structures were tentatively assigned. This behaviour of the sulphine (VI) is in line with that observed for the parent dithione (III) and the respective diazo-compounds.

EXPERIMENTAL

M.p.s were determined with a Kofer hot-stage apparatus. Combustion analyses were performed in the Micro-Analytical Department of the University at Groningen under the supervision of Mr. W. M. Hazenberg. I.r. spectra were recorded on a Perkin-Elmer 125 or 257 grating spectrometer; n.m.r. spectra were recorded with a Varian A60 spectrometer (tetramethylsilane as internal standard).

Adamanlanthane S-Oxide (IV).—MCPBA (600 mg, 3 mmol) in ether (10 ml) was added gradually to a stirred iced-cooled solution of adamanlanthane 4 (500 mg, 3 mmol) in ether (15 ml). Rapid discharge of the pink colour took place. The mixture was washed with aqueous sodium hydrogen sulphite, saturated sodium hydrogen carbonate solution, and water, dried (Na2SO4), and evaporated to leave a white solid (530 mg). Crystallisation from light petroleum (b.p. 60—80°) at —20° gave the sulphine (IV) (410 mg, 75%), m.p. 130° (sublimes) (Found: C, 65-8, 66%; m.p. 120—121° for 2-0—2-5 h, isomerisation (according to the n.m.r. spectra) to almost exclusively the anti-isomer took place. Upon cooling the anti-isomer crystallised; m.p. 145—147° (decomp.). λmax (hexane) 271 nm (ε 17,180), vmax (KBr) 1040 and 1120 cm⁻¹.

5,6-Dimethyladamanlane-2-spiro-2'-Δ¹'-1',3',4'-thiadiazoline S-Oxide (VII).—The sulphine (IV) (182 mg, 1 mmol) dissolved in pentane (5 ml) and ether (1 ml) was treated with 2-diazo propane 13 (1 equiv.) at —10°. The mixture was left overnight at —20°; crystals of the product (70 mg) had then appeared. Work-up of the mother liquor gave a further 128 mg (total yield 78-5%), m.p. 115° (decomp.) (Found: C, 61-7; 61-6; H, 8-05; 7-9; N, 11-3; 11-3; S, 12-9; 12-8. C13H16N3O2S requires C, 61-85; H, 8-0; N, 11-1; S, 12-7%; for spectra see Discussion section.

2',3',4',5,5'-Hexamethyl-Δ¹-1,3,4-thiadiazoline-2-spiro-
cyclobutan-3'-one S-Oxide (VIII).—In the same manner as described for (VII), the sulphine (V) (344 mg) was treated with 2-diazopropane. 13 After 2 weeks at —20° the crystalline product was collected (300 mg, 87%), m.p. 107° (decomp.) (Found: C, 54-45, 54-6; H, 7-45, 7-6; N, 11-5, 11-5; S, 19-1, 19-15. C11H14N2O2S requires C, 54-5; H, 7-6; N, 19-6; S, 19-5%); for spectra, see Discussion section. This mono-oxo compound was converted into the SS-dioxide by treatment with MCPBA (1-05 equiv.) in dichloromethane-ether (2 : 5) at 20°. After 1 week the mixture was worked up by thick-layer chromatography on silica (development with dichloromethane-ether, 2 : 1). The sulphine crystallised from light petroleum (b.p. 60—80°) at —20° (yield 26%); m.p. 60—61° (correct CHNS analysis for C8H12O2S, vmax (KBr) 1785 (CO), 1512 (N=N), and 980 cm⁻¹ (C=S) cm⁻¹; for spectra see Discussion section.

2,2,4,4-Tetramethyl-3-thioxocyclobutanone S-Oxide (V).— MCPBA (1-0 g, 5 mmol) in dry ether (25 ml) was added dropwise to a stirred solution of 2,2,4,4-tetramethyl-3-thioxocyclobutanone (II) in ether (50 ml) at 0°. The orange-red colour disappeared. m-Chlorobenzoic acid was removed as described for the sulphine (IV). The residual oil was dissolved in pentane (5 ml); cooling overnight at —20° gave the white crystalline sulphine (V) (534 mg), m.p. 135—137° (Found: C, 48-7; 48-8; H, 6-5, 6-6; S, 18-3, 18-3%). Crystallisation from petroleum (b.p. 60—80°) at —20° gave the white crystalline sulphine (V) (534 mg), m.p. 135—137° (Found: C, 48-7; 48-8; H, 6-5, 6-6; S, 18-3, 18-3%). Crystallisation from petroleum (b.p. 60—80°) at —20° gave the white crystalline sulphine (V) (534 mg), m.p. 135—137° (Found: C, 48-7; 48-8; H, 6-5, 6-6; S, 18-3, 18-3%). Crystallisation from petroleum (b.p. 60—80°) at —20° gave the white crystalline sulphine (V) (534 mg), m.p. 135—137° (Found: C, 48-7; 48-8; H, 6-5, 6-6; S, 18-3, 18-3%). Crystallisation from petroleum (b.p. 60—80°) at —20° gave the white crystalline sulphine (V) (534 mg), m.p. 135—137° (Found: C, 48-7; 48-8; H, 6-5, 6-6; S, 18-3, 18-3%). Crystallisation from petroleum (b.p. 60—80°) at —20° gave the white crystalline sulphine (V) (534 mg), m.p. 135—137° (Found: C, 48-7; 48-8; H, 6-5, 6-6; S, 18-3, 18-3%). Crystallisation from petroleum (b.p. 60—80°) at —20° gave the white crystalline sulphine (V) (534 mg), m.p. 135—137° (Found: C, 48-7; 48-8; H, 6-5, 6-6; S, 18-3, 18-3%). Crystallisation from petroleum (b.p. 60—80°) at —20° gave the white crystalline sulphine (V) (534 mg), m.p. 135—137° (Found: C, 48-7; 48-8; H, 6-5, 6-6; S, 18-3, 18-3%).