



The derivatives *IIIa–III d* and *IVa–IVd* were finally prepared from ketones *I* and *II* either by reaction with methoxy- and ethoxycarbonylmethylenetriphenylphosphoranes⁵ under catalysis of benzoic acid⁶ or by reaction with diethyl monoethylaminocarbonylmethanephosphonate⁷ or diethyl diethylaminocarbonylmethanephosphonate^{8–10}.

EXPERIMENTAL

Column chromatography was performed on the Pitra¹¹ silica gel produced by Service Laboratories of this Institute (particle size 60–120 μ unless stated otherwise; extracted before use with 1 : 1 chloroform–methanol; activated at 120°C for 24 h; partially deactivated by the addition of 12% water). Thin-layer chromatography was carried out on silica gel G (Merck). Purity of substances and the isomeric ratio was determined by gas chromatography on a Pye Argon Chromatograph apparatus with ionisation detection (⁹⁰Sr) in columns packed with 10% LAC-6R-860 on Chromosorb W, 15% QF-1 on Chromosorb W, or 3% SE-30 on HMDS Gaschrom P. Mass spectra were measured on a A.E.I. MS 902 apparatus combined with a Model 64 Pye Series 104 gas chromatograph. The IR spectra were taken in tetrachloromethane on a UR 10 apparatus (Carl Zeiss, Jena).

Methyl 3,7-Dimethyl-4-thiooctanoate

3-Methylbutanethiol (30.60 g; 293.6 mmol) was treated with 40% methanolic Triton B (0.5 ml) and then dropwise with stirring under argon with freshly distilled methyl crotonate (36.79 g; 367.5 mmol) over 150 min at temperature below 30°C. The whole mixture was stirred at room temperature for 6 h, kept overnight, diluted with light petroleum, washed, dried over anhydrous magnesium sulfate, and distilled to afford 55.78 g (93%) of the title methyl ester, b.p. 121.5 to 123.0°C/14 Torr. For C₁₀H₂₀O₂S (204.3) calculated: 58.78% C, 9.87% H, 15.69% S; found: 58.80% C, 10.19% H, 15.87% S. IR spectrum (cm⁻¹): 1743, 1437, 1170.

Methyl 3,6-Dimethyl-4-thiooctanoate

The title compound (b.p. 110.6–112.6°C/8 Torr) was prepared analogously in 41.42 g (86%) yield from 2-methylbutanethiol (24.50 g; 235.1 mmol) and methyl crotonate (31.95 g; 319.1 mmol). For C₁₀H₂₀O₂S (204.3) calculated: 58.78% C, 9.87% H, 15.69% S; found: 58.81% C, 9.83% H, 15.50% S.

3,7-Dimethyl-4-thiaoctanol

Ethereal lithium aluminum hydride prepared by refluxing 6.32 g (166.6 mmol) of LiAlH_4 in ether (250 ml) for 30 min and cooling down, was treated dropwise under stirring at room temperature with methyl 3,7-dimethyl-4-thiaoctanoate (56.75 g; 277.7 mmol) in ether (50 ml) over 150 min. The whole mixture was refluxed for 2 h, cooled down, and decomposed¹² by the successive dropwise addition of water (6.32 ml), 15% aqueous sodium hydroxide (6.32 ml), and water (18.96 ml). The salts were filtered off and washed with ether. The ethereal filtrate and washings were dried over anhydrous magnesium sulfate and distilled to afford 45.56 g (93%) of the title compound, b.p. 129–132.5°C/12 Torr. For $\text{C}_9\text{H}_{20}\text{OS}$ (176.3) calculated: 61.31% C, 11.44% H, 18.18% S; found: 61.70% C, 11.22% H, 18.13% S.

3,6-Dimethyl-4-thiaoctanol

The title alcohol was prepared analogously to the preceding compound from methyl 3,6-dimethyl-4-thiaoctanoate (42.25 g; 206.8 mmol) by reduction with lithium aluminum hydride (4.94 g; 130.2 mmol). B.p. 123–127°C/8.5 Torr. Yield, 34.59 g (95%). For $\text{C}_9\text{H}_{20}\text{OS}$ (176.3) calculated: 61.31% C, 11.44% H, 18.18% S; found: 61.61% C, 11.47% H, 18.05% S.

1-Bromo-3,7-dimethyl-4-thiaoctane

3,7-Dimethyl-4-thiaoctanol (38.43 g; 218 mmol) and triphenylphosphine (62.88 g; 240 mmol) were successively dissolved under argon in dimethylformamide (218 ml) and the solution was treated dropwise under stirring over 40 min with bromine (38.32 g; 240 mmol) in such a manner that the temperature did not exceed 40°C. The whole mixture was stirred at room temperature for 1 h, distilled under diminished pressure, the distillate (up to the boiling point of 102.5°C/12.5 Torr) poured into water, and extracted with light petroleum. The extract was washed, dried over anhydrous magnesium sulfate, and distilled to afford 46.46 g (83%) of the title bromide, b.p. 118–122°C/12 Torr. For $\text{C}_9\text{H}_{19}\text{BrS}$ (239.2) calculated: 45.18% C, 8.01% H, 33.41% Br, 13.40% S; found: 45.58% C, 8.07% H, 32.80% Br, 13.41% S.

1-Bromo-3,6-dimethyl-4-thiaoctane

Analogously to the preceding preparation, 3,6-dimethyl-4-thiaoctanol (34.97 g; 198.3 mmol), triphenylphosphine (57.22 g; 218.2 mmol), and bromine (34.87 g; 218.2 mmol) yielded 39.71 g (84%) of the title bromide, b.p. 114.5–119.5°C/8.5 Torr. For $\text{C}_9\text{H}_{19}\text{BrS}$ (239.2) calculated: 45.18% C, 8.01% H, 33.41% Br, 13.40% S; found: 45.86% C, 8.11% H, 32.62% Br, 13.56% S.

6,10-Dimethyl-7-thia-2-undecanone (I)

Ethyl acetoacetate (30.18 g; 231.9 mmol) was added dropwise with stirring in the atmosphere of argon over 15 min into ethanolic sodium ethoxide prepared from sodium (5.33 g; 231.9 milligramatom) and ethanol (100 ml). The mixture was kept at room temperature for 10 min and then treated with 1-bromo-3,7-dimethyl-4-thiaoctane (50.44 g; 210.8 mmol) over 90 min. The stirring was continued at room temperature for 2 h and at 90°C for 8 h. The mixture was then kept overnight, heated to 90°C, and treated dropwise over 1 h with 10% aqueous sodium hydroxide (360 ml). The stirring at 90°C was continued for 4 h, the mixture cooled down, diluted with water, and extracted with light petroleum. The extract was washed, dried over anhydrous magnesium sulfate, and distilled under diminished pressure through a Vigreux column to afford 21.64 g (47%) of the

ketone *I*, b.p. 78.5°C/0.01 Torr to 78°C/0.008 Torr. For $C_{12}H_{24}O_2S$ (216.4) calculated: 66.61% C, 11.18% H, 14.82% S; found: 66.65% C, 11.34% H, 15.07% S. IR spectrum (cm^{-1}): 1718, 1360.

6,9-Dimethyl-7-thia-2-undecanone (*II*)

Analogously to preparation of compound *I*, 1-bromo-3,6-dimethyl-4-thiooctane (41.74 g; 174.5 mmol), ethyl acetoacetate (26.11 g; 200.7 mmol), and sodium (4.41 g; 191.9 milligramatom) in ethanol (90 ml) yielded 21.76 g (58%) of ketone *II*, b.p. 74–76°C/0.006 Torr. As shown by gas chromatography and mass spectrometry, the product was contaminated with the starting bromide. The specimen for elemental analysis was therefore chromatographed on silica gel in light petroleum–ether (93 : 7). For $C_{12}H_{24}O_2S$ (216.4) calculated: 66.61% C, 11.18% H, 14.82% S; found: 66.56% C, 11.14% H, 14.52% S.

Preparation of Compounds *IIIa*, *IIIb*, *IVa*, and *IVb*

The ketones *I* or *II* (2.16 g; 10 mmol) along with methoxy- or ethoxycarbonylmethylenetriphenylphosphoranes (5.02 g and 5.22 g, resp.; 15 mmol) and benzoic acid (0.99 g) were dissolved in benzene (30 ml), the solution refluxed under argon for 24 h, and treated with additional phosphorane (1.67 g and 1.74 g, resp.; 5 mmol), benzoic acid (0.33 g), and benzene (10 ml). The reflux was continued until the starting compounds *I* and *II* disappeared or until the composition of the mixture was constant (15–32 h), as determined by thin-layer chromatography. The benzene was evaporated under diminished pressure, the residue taken into light petroleum, the solution washed, dried over anhydrous magnesium sulfate, evaporated, and the residue chromatographed on silica gel (130–135 g) in light petroleum–ether (95 : 5 to 97 : 3). Content of fractions was checked by thin-layer chromatography. Identical fractions were pooled, evaporated, and the residues distilled from a Hickman flask packed with glass wool.

Methyl 3,7,11-trimethyl-8-thia-2-dodecenoate (*IIIa*). Yield, 1.02 g (37%) of ester *IIIa*, boiling at the bath temperature of 158–166°C and at 10 Torr. For $C_{15}H_{28}O_2S$ (272.4) calculated: 66.12% C, 10.36% H, 11.77% S; found: 66.75% C, 10.07% H, 11.70% S. Mass spectrum: 2 isomers with an identical spectrum, M^+ 272, and identical fragmentation. IR spectrum (cm^{-1}): 1721, 1650, 1438, 1226, 1151. In addition to the product *IIIa*, there was recovered 0.43 g of the starting *I*.

Methyl 3,7,10-trimethyl-8-thia-2-dodecenoate (*IVa*) Two portions were obtained differing in the ratio of isomers. Distillation yielded 1.59 g (63%) of fraction 1 boiling at the bath temperature of 122–132°C and at 0.006 Torr, and 0.20 g (8%) of fraction 2 boiling at the bath temperature of 110–120°C and at 0.006 Torr. Overall yield, 1.79 g (71%). For $C_{15}H_{28}O_2S$ (272.4) calculated: 66.12% C, 10.36% H, 11.77% S; found: 66.53% C, 10.31% H, 12.15% S. IR spectrum (cm^{-1}): 1723, 1437, 1226, 1152.

Ethyl 3,7,11-trimethyl-8-thia-2-dodecenoate (*IIIb*). Distillation yielded 1.97 g (69%) of ester *IIIb*, boiling at the bath temperature of 125–130°C and at 0.005 Torr. For $C_{16}H_{30}O_2S$ (286.5) calculated: 67.08% C, 10.56% H, 11.19% S; found: 67.28% C, 10.32% H, 11.46% S. IR spectrum (cm^{-1}): 1715, 1649, 1223, 1148.

Ethyl 3,7,10-trimethyl-8-thia-2-dodecenoate (*IVb*). Two portions were obtained differing in the ratio of isomers. Distillation yielded 1.64 g (62%) of fraction 1 boiling at the bath temperature of 122–127°C and at 0.006 Torr, and 0.31 g (12%) of fraction 2 boiling at the bath temperature of 125–130°C and at 0.006 Torr. Overall yield, 1.95 g (74%). For $C_{16}H_{30}O_2S$ (286.5) calculated:

67.08% C, 10.56% H, 11.19% S; found: 66.99% C, 10.39% H, 11.54% S. IR spectrum (cm^{-1}): 1718, 1650, 1225, 1150.

N-Monoethylamide of 3,7,11-Trimethyl-8-thia-2-dodecenoic Acid (*IIIc*)

Into a solution of diethyl monoethylaminocarbonylmethanephosphonate (2.69 g; 12 mmol) in dimethylformamide (20 ml) there was added dropwise over 10 min with stirring in an atmosphere of argon ethanolic sodium ethoxide prepared from sodium (0.28 g; 12 milligramatom) and ethanol (6 ml). The mixture was stirred at room temperature for 1 h and then treated dropwise over 10 min with the ketone *I* (2.16 g; 10 mmol). The whole mixture was stirred at room temperature for 6 h and at 75–80°C for 7 h, cooled down, poured into water, and extracted with light petroleum. The extract was washed, dried over anhydrous magnesium sulfate, evaporated, and the residue chromatographed on silica gel (110 g) in light petroleum–acetone (9 : 1) into three fractions differing in the spot position (thin-layer chromatography in 4 : 1 light petroleum–acetone). These fractions were separately distilled from a Hickman flask packed with glass wool to afford 1.115 g (39%) of fraction *IIIc*₁ boiling at the bath temperature of 140–150°C and at 0.004 Torr, 0.640 g (22%) of fraction *IIIc*₂ boiling at the bath temperature of 140–150°C and at 0.004 Torr, and 0.735 g (26%) of fraction *IIIc*₃ boiling at the bath temperature of 150 to 167°C and at 0.004 Torr (overall yield, 2.490 g *i.e.* 87%). For C₁₆H₃₁NOS (285.5) calculated: 67.31% C, 10.95% H, 4.91% N, 11.23% S; found (*IIIc*₁): 67.11% C, 10.86% H, 5.03% N, 11.50% S; found (*IIIc*₂): 67.26% C, 11.01% H, 4.94% N, 11.40% S; found (*IIIc*₃): 67.26% C, 10.97% H, 4.93% N, 11.09% S. IR spectrum (cm^{-1}): 3450, 3420, 1668, 1640 (*IIIc*₁ and *IIIc*₂); 3450, 3420, 1675, 1668, 1640 (*IIIc*₃).

N,N-Diethylamide of 3,7,11-Trimethyl-8-thia-2-dodecenoic Acid (*IIIId*)

The title compound *IIIId* was prepared analogously to the amide *IIIc* from the ketone *I* (2.16 g; 10 mmol), diethyl diethylaminocarbonylmethanephosphonate (2.76 g; 11 mmol), and ethanolic sodium ethoxide obtained from sodium (0.25 g; 11 milligramatom) and ethanol (5 ml). Chromatography on silica gel (220 g) in light petroleum–acetone (95 : 5) afforded three fractions differing in the position of the thin-layer-chromatographic spot (in 9 : 1 light petroleum–acetone), namely, 0.38 g (14%) of fraction *IIIId*₁ boiling at the bath temperature of 125–135°C and at 0.004 Torr, 1.05 g (39%) of fraction *IIIId*₂ boiling at the bath temperature of 135–145°C and at 0.004 Torr, and 0.92 g (35%) of fraction *IIIId*₃ boiling at the bath temperature of 135–145° and at 0.004 Torr (overall yield, 2.35 g *i.e.* 88%). For C₁₈H₃₅NOS (313.5) calculated: 68.95% C, 11.25% H, 4.47% N, 10.23% S; found (*IIIId*₁): 68.65% C, 11.27% H, 4.47% N, 10.46% S; found (*IIIId*₂): 68.76% C, 11.30% H, 4.42% N, 10.33% S; found (*IIIId*₃): 69.31% C, 11.36% H, 4.04% N, 10.64% S. IR spectrum (cm^{-1}): 1648, 1629 with small differences in the fingerprint region of compounds *IIIId*₁–*IIIId*₃.

N-Monoethylamide of 3,7,10-Trimethyl-8-thia-2-dodecenoic Acid (*IVc*)

Into a suspension of sodium hydride (content, 70%; 0.377 g; 11 mmol) in peroxide-free 1,2-dimethoxyethane (20 ml) there was added dropwise over 10 min with stirring and under argon diethyl monoethylaminocarbonylmethanephosphonate (2.79 g; 12.5 mmol) and the mixture was stirred at room temperature for 1 h. The ketone *II* (2.16 g; 10 mmol) was then added dropwise and the stirring continued at room temperature for 1 h and at 60°C for 4 h. The reaction mixture was processed analogously to preparation of compound *IIIc*. Chromatography of the crude residue on silica gel (220 g) in light petroleum–acetone (92 : 8) afforded four fractions

differing in the position of the thin-layer chromatographic spots (in 4 : 1 light petroleum-acetone): 0.48 g (17%) of fraction *IVc*₁ boiling at the bath temperature of 154–170°C and at 0.008 Torr, 0.09 g (3%) of fraction *IVc*₂ boiling at the bath temperature of 157–170°C and at 0.008 Torr, 1.43 g (50%) of fraction *IVc*₃ boiling at the bath temperature of 160–170°C and at 0.008 Torr, and 0.15 g (5%) of fraction *IVc*₄ boiling at the bath temperature of 163–172°C and at 0.008 Torr (overall yield, 2.15 *i.e.* 75%). For C₁₆H₃₁NOS (285.5) calculated: 67.31% C, 10.95% H, 4.91% N, 11.23% S; found: 67.18% C, 11.08% H, 5.09% N, 11.61% S. Infrared spectrum (cm⁻¹): 3400, 1669, 1640, 1549, 1535, 1512, 1504 with small differences in the fingerprint region of particular compounds *IVc*₁–*IVc*₄.

N,N-Diethylamide of 3,7,10-Trimethyl-8-thia-2-dodecenoic Acid (*IVd*)

The title *IVd* was prepared analogously to compound *IVc* from the ketone *II* (2.16 g; 10 mmol), diethyl diethylaminocarbonylmethanephosphonate (3.02 g; 12 mmol), and sodium hydride (0.377 g; 11 mmol; content, 70%). Chromatography on silica gel (230 g; particle size, 30–60 μ) in light petroleum-acetone (95 : 5) afforded three fractions differing in their thin-layer chromatographic *R_f* value, namely, 0.71 g (23%) of fraction *IVd*₁ boiling at the bath temperature of 146 to 160°C and at 0.008 Torr, 0.19 g (6%) of fraction *IVd*₂ boiling at the bath temperature of 151 to 160°C and at 0.007 Torr, and 2.64 g (55%) of fraction *IVd*₃ boiling at the bath temperature of 155–165°C and at 0.007 Torr (overall yield, 2.64 g *i.e.* 84%). For C₁₈H₃₅NOS (313.5) calculated: 68.95% C, 11.25% H, 4.47% N, 10.23% S; found: 69.25% C, 11.40% H, 4.36% N, 10.63% S. IR spectrum (cm⁻¹): 1650, 1630 with small differences in the fingerprint region of the particular compounds *IVd*₁–*IVd*₃.

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