131. *The Preparation and Isomerization of Some Basic Esters of OO'-Diethyl Hydrogen Phosphorothioate.*

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The preparation of *S*-2-diethylaminoethyl diethyl phosphorothiolate (II; X = NEt_2) and some of its acid addition salts have been briefly reported.[1] Details are now given for the synthesis of this compound by a variety of methods. 2-Diethylaminoethyl diethyl phosphorothionate (I; X = NEt_2) has also been characterised and evidence provided for the mechanism of its extremely ready isomerization to the corresponding thiolate (II; X = NEt_2).

Although condensation of sodium 2-diethylaminoethoxide with diethyl phosphorochloridothionate would be expected to yield the thionate ester (I; X = NEt_2), this product can only be obtained in any quantity if the reaction is controlled at low temperatures. If the reaction is effected above about 50° the product contains progressively more of the thiolate isomer (II; X = NEt_2). This substance, which shows outstanding acaricidal and insecticidal activity against some species, has been given the common name " amiton."

(I) $(EtO)_2P(=S)\cdot O\cdot CH_2\cdot CH_2\cdot X$ $\qquad$ $(EtO)_2P(=O)\cdot S\cdot CH_2\cdot CH_2\cdot X$ (II)

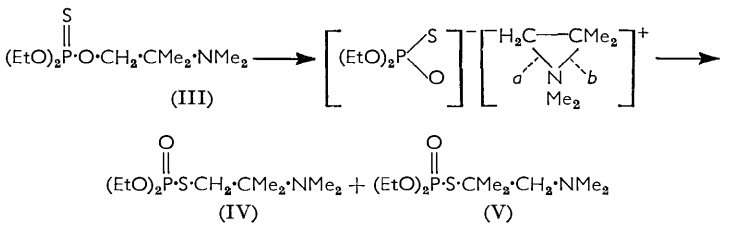
Although the thionate ester (I; X = NEt_2) can be obtained by this method it can also be prepared by the reaction between *S*-2-bromoethyl diethyl phosphorothionate (I; X = Br) and diethylamine. The free base rapidly decomposes on storage to give a white solid, which has not been further investigated, as well as the thiolate (II; X = NEt_2); heat converts it into the thiolate (II; X = NEt_2). It is, however, stabilised by conversion into a salt from which the free base is conveniently obtained, as required, by treatment with an ion-exchange resin. The purest sample of thionate obtained showed only a weak absorption at 1265 $cm.^{-1}$, characteristic of P=O stretching, measured on a sample of base freshly liberated from its hydrogen oxalate. In contrast, the infrared spectrum of the corresponding thiolate exhibited a very strong band in this region. While the thiolate shows pronounced anticholinesterase activity on a preparation of locust nerve chord *in vitro* (I 50; 1×10^{-8}M), the thionate hydrogen oxalate showed only about one-fiftieth of this activity.

In addition to the evidence provided by the infrared spectrum the structure of the thiolate (II; X = NEt_2) was determined by oxidative hydrolysis to bis-(2-diethylaminoethyl) disulphide, and by a synthesis from sodium 2-diethylaminoethyl sulphide and diethyl phosphorochloridate. It was also readily obtained by condensation of 2-diethylaminoethyl chloride with sodium diethyl phosphorothioate and by reaction between 2-diethylaminoethyl thiocyanate with sodium diethyl phosphite or triethyl phosphite.

The thionate-to-thiolate isomerization (I ⟶ II where X = NEt_2) is reminiscent of the similar isomerization (I ⟶ II where X = SEt),[2] though it occurs much more readily in the present instance. In the case of the ethylthio-compounds, Fukuto and Metcalf[3] postulated that the isomerization might occur *via* an ethylenesulphonium ion. More recently Fukuto and Stafford[4] have provided evidence in support of the similar intervention of an ethyleneiminium ion in the present instance. We have obtained further evidence supporting this mechanism on examining the isomerization of the unsymmetrically substituted phosphorothionate (III) which has given two isomeric thiolates (IV) and (V); this is readily explicable by rupture of the ethyleneiminium ion at *a* and *b* respectively.

[1] Ghosh and Newman, *Chem. and Ind.*, 1955, 118.
[2] Schrader, *Angew. Chem.*, 1952, Monograph 62.
[3] Fukuto and Metcalf, *J. Amer. Chem. Soc.*, 1954, **76**, 5103.
[4] Fukuto and Stafford, *ibid.*, 1957, **79**, 6083.

Condensation of diethyl phosphorochloridothionate with sodium 2-dimethylamino-2-methylpropoxide in benzene at room temperature gave 2-dimethylamino-2-methylpropyl diethyl phosphorothionate (III), which, by rapid working, was isolated and purified as its picrate. The free base, obtained by treatment of the picrate with an ion-exchange resin, readily decomposed. When heated for two hours in ethanol, however, it was smoothly



(III)

(IV) (V)

isomerized to a mixture of the two thiolates (IV and V), separated by fractional crystallisation of their picrates. Although the infrared spectra of both esters showed strong bands in the 1250 cm.$^{-1}$ region, attributable to P=O stretching, they differed significantly in other regions. That of (IV), corresponding to the less soluble picrate, had bands at 766 and 744 cm.$^{-1}$ not present in that of (V), which had additional bands at 1121 and 758 cm.$^{-1}$.

(VI) (VII)

Oxidative hydrolysis of the ester (IV) gave the disulphide (VI). Hydrogenolysis of both the thiolate (IV) and the disulphide (VI) by heating them with Raney nickel (W5) gave *NN*-dimethyl-t-butylamine identical with an authentic specimen obtained by methylation of t-butylamine with formic acid and formaldehyde.

Since similar degradative reactions applied to the thiolate (V) gave no readily characterisable products, the structure of this isomer was established by synthesis from 1-dimethylamino-2-methylpropane-2-thiol and diethyl phosphorochloridate. The thiol, which was obtained by reaction between 2,2-dimethylethylene sulphide and dimethylamine, gave, on oxidation with iodine, the disulphide (VII), isomeric with the disulphide (VI).

Experimental

S-2-*Diethylaminoethyl Diethyl Phosphorothiolate*.—(*A*) 2-Diethylaminoethanethiol (20 g.) was added to a suspension of finely divided sodium (2·3 g.) in dry benzene (300 c.c.), and the mixture was warmed until all the sodium dissolved. Diethyl phosphorochloridate (17·25 g.) was then slowly added and the mixture refluxed for 6 hr. in an atmosphere of nitrogen. It was then cooled and treated with water, and the benzene solution was isolated and dried (Na_2SO_4). On removal of the solvent, the residue was distilled. S-2-*Diethylaminoethyl diethyl phosphorothiolate* was obtained as an oil, b. p. 85·5°/0·05 mm., n_D^{21} 1·4743 [Found: C, 44·3; H, 8·9; N, 5·1; P, 11·9%; *M* (cryoscopy in benzene), 272·1. $C_{10}H_{24}O_3NSP$ requires C, 44·6; H, 8·9; N, 5·2; P, 11·5%; *M* 269]. The base forms salts readily, *e.g.*, a *hydrogen oxalate* (from acetone), m. p. 98—99° (Found: N, 3·8; P, 8·6; S, 8·7. $C_{12}H_{26}O_7NSP$ requires N, 3·9; P, 8·6; S, 8·7%), *toluene*-p-*sulphonate* (from ether–acetone), m. p. 105—106° (Found: N, 3·3; P, 7·0; S, 14·6. $C_{17}H_{32}O_6NS_2P$ requires N, 3·2; P, 7·0; S, 14·5%), *dihydrogen citrate* (from acetone), m. p. 94—95° (Found: N, 3·5; P, 6·8; S, 6·6. $C_{16}H_{32}O_{10}NSP$ requires N, 3·1; P, 6·7; S, 6·9%). The infrared spectrum of the base showed a strong band at 1262 cm.$^{-1}$, confirming its phosphorothiolate (P=O) structure.

(*B*) Diethyl phosphite (20·7 g.) was added to finely divided sodium (3·45 g.) under benzene (300 c.c.) and the temperature of the mixture maintained at 40—50° until all the metal dissolved. 2-Diethylaminoethyl thiocyanate (23·7 g.) was then added, and the reaction carried out at the same temperature as above for 1½ hr. in nitrogen. The product was then worked up as in method

A; it was identified by its infrared spectrum (strong band at 1262 cm.$^{-1}$) and hydrogen oxalate, m. p. and mixed m. p. 98—99°.

2-Diethylaminoethyl thiocyanate required in the above experiment was prepared as follows: 2-diethylaminoethyl chloride (18·8 g.) was added to potassium thiocyanate (13·5 g.) in acetone (160 c.c.) and stirred at the room temperature for 15 hr., a solid separating. The mixture was then filtered and the filtrate concentrated, treated with water, and extracted with ether. The ethereal extract was dried (Na_2SO_4) and after removal of ether distilled under reduced pressure. The *thiocyanate* had b. p. 117°/14 mm., n_D^{24} 1·4954 (Found: C, 53·0; H, 8·9. $C_7H_{14}N_2S$ requires C, 53·16; H, 8·86%).

(*C*) 2-Diethylaminoethyl thiocyanate (31·6 g.) was added dropwise to triethyl phosphite (33·2 g.) at 100°. The temperature rose to 107° and the addition of the thiocyanate was reguated to keep the temperature of the mixture at 107° while the temperature of the bath was 100°. The mixture was left at the room temperature overnight and then distilled under reduced pressure. The thiolate was characterised as described under (*B*).

(*D*) Sodium ethoxide (from 4·6 g. of sodium) in ethyl alcohol (100 c.c.) was gradually added to 2-diethylaminoethyl chloride hydrochloride (34·4 g.) in ethyl alcohol (200 c.c.) at 0—5°. Then the mixture was added slowly to sodium diethyl phosphorothioate, which was prepared from sodium (4·6 g.), ethyl alcohol (100 c.c.), diethyl phosphite (27·6 g.), and sulphur (6·4 g.), and refluxed for 4 hr. It was then cooled, filtered, and concentrated. The residue was dissolved in benzene, and the solution was worked up and the product characterised as given under (*B*).

The above reaction was also carried out successfully with ammonium instead of sodium diethyl phosphorothioate.

(*E*) 2-Diethylaminoethanol (35·1 g.) was gradually added to finely divided sodium (4·6 g.) under benzene (300 c.c.), and the mixture heated on the steam-bath until all the metal dissolved. It was then cooled to 30° and diethyl phosphorochloridothionate (37·7 g.) gradually added. The mixture was refluxed for 6½ hr., then cooled, and the thiolate isolated from the mixture and characterised as described under (*B*).

2-Bromoethyl Diethyl Phosphorothionate.—Diethyl phosphorochloridothionate (47·0 g.) was added at 15° ± 3° during 36 min. to a stirred mixture of ethylene bromohydrin (31·0 g.) and pyridine (19·8 g.). The mixture was stirred for 1 hr. and then left at the room temperature for 18 hr. Dry ether was then added and the pyridine hydrochloride removed. On removal of ether, the residue was distilled. *2-Bromoethyl diethyl phosphorothionate* had b. p. 84—94°/0·3—0·6 mm., n_D^{24} 1·4929 (Found: P, 11·3; Br, 28·4. $C_6H_{14}O_3BrSP$ requires P, 11·2; Br, 28·9%). The infrared spectrum of this compound showed no band in the P=O region.

2-Diethylaminoethyl Diethyl Phosphorothionate.—(i) Sliced sodium (1·15 g.) was added in portions to 2-diethylaminoethanol (33 c.c.), and the mixture heated at 80° until the sodium dissolved. The excess of alcohol was removed *in vacuo* and the residual sodium salt, in benzene (40 c.c.), was treated with diethyl phosphorochloridothionate (9·4 g.) at 20—25° during 45 min. After 5 hours' stirring at room temperature the benzene solution was washed with water (30 c.c. × 3), dried ($MgSO_4$), and filtered. A solution of oxalic acid (6·3 g.) in acetone (50 c.c.) was added to the benzene solution, and the resulting mixture evaporated *in vacuo* until separation of a crystalline oxalate started. Ether was then added and the oxalate (15 g.), m. p. 86—88°, was collected. Recrystallisation from acetone (30 c.c.) afforded plates (12·7 g.) of *2-diethylaminoethyl diethyl phosphorothionate hydrogen oxalate*, m. p. 87—88° (Found: P, 8·6. $C_{12}H_{26}O_7NSP$ requires P, 8·6%). The free base (n_D^{16} 1·4630) was unstable, rapidly darkening and forming a fine white precipitate. The infrared spectrum of the thionate base, liberated from the oxalate by means of Amberlite resin I.R.A.-400 and measured soon after preparation, showed only a weak band in the region of P=O absorption (1265 cm.$^{-1}$). Reaction of the thionate base with benzyl bromide gave *N-benzyl-N-(2-diethoxyphosphinothioyloxyethyl)-NN-diethyl ammonium bromide* (needles from acetone), m. p. 108° (decomp.) (Found: P, 6·9; Br, 18·2. $C_{17}H_{31}O_3NBrSP$ requires P, 7·0; Br, 18·2%). The infrared spectrum, determined on a mull in Nujol, showed no absorption in the region of 1250 cm.$^{-1}$.

(ii) 2-Bromoethyl diethyl phosphorothionate (14·0 g.) was added to diethylamine (18 g.), stirred for 7½ hr., and left overnight. The whole was poured into water and the mixture extracted with benzene. The benzene solution was washed with water and extracted with dilute hydrochloric acid. The aqueous acidic solution was then basified with ice-cold sodium hydroxide solution and extracted with benzene, and the product was isolated from the benzene solution after removal of solvent under reduced pressure below 40°. The base was converted into

an oxalate, m. p. and mixed m. p. 86—87°, 2-diethylaminoethyl diethyl phosphorothionate hydrogen oxalate.

Isomerization of 2-Diethylaminoethyl Diethyl Phosphorothionate.—This ester (1·0 g., n_D^{16} 1·4630; liberated from the oxalate with Amberlite resin I.R.A.-400) was refluxed for 2 hr. in ethanol (10 c.c.). The ethanol was then evaporated *in vacuo*, and the residual oil dissolved in ether (5 c.c.), filtered, and added to a solution of oxalic acid (0·5 g.) in acetone (10 c.c.). The oxalate (1·25 g.), m. p. 98—99°, which separated (as glistening plates) was, after 0·5 hr., filtered off and identified (mixed m. p.) as *S*-2-diethylaminoethyl diethyl phosphotothiolate hydrogen oxalate.

The thionate hydrogen oxalate salt was substantially unchanged after 6 hours' refluxing in ethanol or benzene.

Bis-(2-diethylaminoethyl) Disulphide Di(hydrogen Oxalate).—Bis-(2-diethylaminoethyl) disulphide (2 g.) was added to oxalic acid (2·5 g.) in acetone (20 c.c.); immediate precipitation occured. The solid was filtered off and recrystallised from ethanol, giving plates of *bis-(2-diethylaminoethyl) disulphide bis(hydrogen oxalate)*, m. p. 155° (Found: C, 43·2; H, 7·0; N, 6·2. $C_{16}H_{32}O_8N_2S_2$ requires C, 43·2; H, 7·2; N, 6·3%).

Oxidative Hydrolysis of S-2-*Diethylaminoethyl Diethyl Phosphorothiolate Hydrogen Oxalate.*—The hydrogen oxalate salt (15 g.) was treated with 10N-sodium hydroxide (10 c.c.), followed by bleach liquor (50 c.c., containing *ca.* 33% of sodium hypochlorite) below 30°. After 10 min. the temperature of the mixture rose to 40° and then dropped slowly to the room temperature. After 1 hr. it was diluted with water (100 c.c.), filtered, and extracted with benzene. The benzene extract was washed with water, dried (Na_2SO_4), and concentrated, and the oily residue (7 g.) was collected. This oil (1 c.c.) was treated with oxalic acid (0·5 g.) in acetone (5 c.c.), and the precipitated solid recrystallised from ethanol. Bis-(2-diethylaminoethyl) disulphide bis(hydrogen oxalate) was obtained as plates, m. p. and mixed m. p. 155°.

2-*Dimethylamino-2-methylpropan*-1-*ol.*—Prepared by methylation of 2-amino-2-methylpropan-1-ol, as described by Rosnati,[6] this had b. p. 159—161°, n_D^{24} 1·4451, and crystallised slightly below 20°. It gave a hydrochloride, hygroscopic needles (from methanol–ether), m. p. 252—253° (decomp.), and *picrate*, orange needles (from ethanol), m. p. 255° (decomp.) (Found: C, 41·8; H, 5·1; N, 16·1. $C_{12}H_{18}O_8N_4$ requires C, 41·6; H, 5·2; N, 16·2%).

NN-*Dimethyl-t-butylamine.*—40% Aqueous formaldehyde (83 g.) was added with cooling to t-butylamine (36·5 g.) and water (25 c.c.). 98—100% Formic acid (76 g.) was then added, and the mixture refluxed for 6 hr. Potassium hydroxide (112 g.) was added with cooling, and the oil separated, dried (KOH), and distilled, giving NN-*dimethyl-t-butylamine* (25 g.), b. p. 90—91°, n_D^{23} 1·4035 (Found: N, 13·7. Calc. for $C_6H_{15}N$: N, 13·8%) [*picrate*, yellow needles or plates (from methanol), m. p. 289° (decomp.) (Found: C, 43·7; H, 5·6; N, 16·6. $C_{12}H_{18}O_7N_4$ requires C, 43·6; H, 5·5; N, 16·9%)].

Reaction of 2-Dimethylamino-2-methylpropan-1-*ol and Diethyl Phosphorochloridothionate. Separation of the Two Isomeric Thiolates.*—A mixture of powdered sodium (18·4 g.), 2-dimethylamino-2-methylpropan-1-ol (104 g.), and benzene (750 c.c.) was refluxed until the sodium had all dissolved. After cooling, diethyl phosphorochloridothionate (151 g.) was added dropwise at 20—25°, during 45 min. The mixture was stirred at room temperature for 1 hr., refluxed for 8 hr., cooled, washed with water (2 × 100 c.c.), dried ($MgSO_4$), and evaporated under reduced pressure. The residual oil was distilled and the fraction (130 g.), b. p. 101—112°/0·25 mm., n_D^{23} 1·4720, was collected (Found: P, 11·6; S, 12·3; N, 5·1. $C_{10}H_{24}O_3NSP$ requires P, 11·5; S, 11·9; N, 5·2%).

Part (75 g.) of the product was added to a solution of picric acid (65 g.) in ethanol (1 l.), and the crystalline picrate (42 g.), m. p. 106—108°, which gradually separated was filtered off. Recrystallisation from ethanol afforded bright yellow plates of the *picrate* (A), m. p. 112—113° (Found: P, 6·1; S, 6·6; N, 11·0. $C_{16}H_{27}O_{10}N_4SP$ requires P, 6·2; S, 6·4; N, 11·2%). The mother-liquors from the first filtration were concentrated (to 250 c.c.) *in vacuo* and progressively diluted with ether to faint cloudiness during about 2 weeks. A further crop (7·2 g.) of a slightly impure picrate was thus obtained [m. p. 106—108° (previous softening), undepressed in admixture with (A)]. Evaporation *in vacuo* of the solvent from the mother-liquors of this crop left a clear golden syrup (80 g.) which solidified slowly when seeded. Part (2 g.) of this product was extracted with boiling ether (2 × 200 c.c.); golden plates of the *isomeric picrate*

[5] *Org. Synth.*, Coll. Vol. III, p. 181.
[6] Rosnati, *Gazzetta*, 1950, **80**, 663.

(B) (0·7 g.), m. p. 63—64°, separated. The m. p. was not raised by further recrystallisation (Found: P, 6·3; S, 6·2; N, 11·0%).

The pure thiolate bases were liberated from the respective picrates by using Amberlite resin I.R.A.-400, previously digested for 1 hr. with 2N-sodium hydroxide and then washed until alkali-free. The picrate, dissolved in acetone–water (1 : 3), was shaken with an excess of the resin (about five times the weight of picrate taken) until the yellow colour of the supernatant liquid disappeared and the resin assumed a deep red colour. The resin was filtered off and the filtrate, after saturation with salt, extracted several times with ether. After drying (Na_2SO_4), the ether was evaporated, and an almost quantitative yield of pure basic thiolate obtained. It was freed from traces of solvent by keeping it at 40—50°/0·07 mm. for 45 min. The *thiolate base* (A') [from picrate (A), m. p. 112—113°] had n_D^{18} 1·4760 (Found: P, 11·0; N, 4·9%). The infrared spectrum (capillary layer) showed max. at 3510, 2985, 2817, 1466, 1393, 1374, 1250s, 1166, 1099, 1047—1010s, 980—970s, 794, 766, and 744 cm.$^{-1}$. The *thiolate base* (B') [from picrate (B), m. p. 63—64°] had n_D^{19} 1·4705 (Found: P, 11·4; N, 4·8%). The infrared spectrum (capillary layer) showed max. at 3510, 2985, 2817, 1466, 1399, 1374, 1250s, 1166, 1121, 1099, 1047—1010s, 980—970s, 851, 794, and 758 cm.$^{-1}$.

Distillation of the base B' (6 g.) gave a colourless oil (3·6 g.), b. p. 87—90°/0·24 mm., n_D^{20} 1·4700 (Found: P, 11·5; N, 5·0%). The infrared spectrum was identical with that of the undistilled sample, and with picric acid it formed the picrate (B), m. p. 63—64°. No trace of the higher-melting, less soluble picrate (A) could be detected.

2-Dimethylamino-2-methylpropyl Diethyl Phosphorothionate.—Powdered sodium (2·3 g.) was dissolved in 2-dimethylamino-2-methylpropan-1-ol (13·4 g.) and benzene (100 c.c.) and treated, at room temperature, with diethyl phosphorochloridothionate (18·9 g.) as previously described. After being stirred for 1 hr. at room temperature, the solution was washed with water (30 c.c. × 2) and dried ($MgSO_4$). Treatment of one-third of this benzene solution with a solution of picric acid (6·2 g.) in benzene (50 c.c.) yielded a crystalline picrate (9·0 g.), m. p. 114—118°. Recrystallisation from ethanol (100 c.c.) afforded deep yellow needles of *2-dimethylamino-2-methylpropyl diethyl phosphorothionate picrate* (7·9 g.), m. p. 118—119° (Found: P, 6·2; N, 10·8; S, 6·4%) [a mixed m. p. of this product with the thiolate picrate (A), m. p. 112—113° showed a depression]. The free base was unstable.

Isomerization of 2-Dimethylamino-2-methylpropyl Diethyl Phosphorothionate.—The thionate picrate (5 g.) was converted into the free base (2·0 g., n_D^{19} 1·4665) by Amberlite resin I.R.A.-400, as previously described. This was then refluxed for 2 hr. in absolute ethanol (10 c.c.), then cooled, and a solution of picric acid (2 g.) in ethanol (20 c.c.) added, giving a picrate (2·35 g.), m. p. 109—110°. This was undepressed in admixture with the thiolate picrate (A), m. p. 112—113°. Concentrating the mother-liquors to 10—15 c.c. and diluting them with ether (90 c.c.) gave gradually a further amount (0·35 g.) of impure picrate, m. p. 105—108°. The mother-liquors were then evaporated *in vacuo* and the residual gum (*ca.* 1 g.) was extracted with boiling ether (50 c.c. × 3). The ether deposited plates (0·2 g.), m. p. 64—65° undepressed in admixture with the isomeric picrate (B).

Oxidative Hydrolysis of the Thiolate Ester (A').—The thiolate ester (A') (n_D^{18} 1·4760, 10 g.), dissolved in aqueous ethanol (50 c.c., 1 : 1), was treated with 40% aqueous sodium hydroxide (30 c.c.). Stirring gave an emulsion and the temperature rose during 30 min. to 35°. The temperature was kept for a further 0·5 hr. at 35—40° and iodine (5 g.) in ethanol (20 c.c.) was then added as rapidly as the colour was discharged. The mixture was stirred for a further hr. at this temperature, cooled, diluted with alkali as above (25 c.c.), and extracted with ether (25 c.c. × 4). After drying, the ether was evaporated, leaving basic material dissolved in ethanol. This solution gave a picrate (11·9 g.), m. p. 220—224° (decomp. and preliminary shrinking), which was sparingly soluble in the common organic solvents. Two recrystallisations from large volumes of Cellosolve gave mustard-coloured needles of a *basic disulphide dipicrate* (C), m. p. 252° (decomp.) [Found: C, 39·5; H, 4·7; N, 15·4; S, 8·5. $(C_{12}H_{17}O_7N_4S)_2$ requires C, 40·0; H, 4·7; N, 15·5; S, 8·9%].

This picrate (C) (5 g.) was decomposed on digestion with warm 2N-sodium hydroxide, and the free base was extracted into light petroleum (b. p. 40—60°; 30 c.c. × 4). The petroleum solution was washed once with water, dried (Na_2SO_4), and evaporated, leaving the disulphide (1·0 g.). This product, in ethanol (60 c.c.), was refluxed for 0·5 hr. with Raney nickel [5] (12 c.c. of settled suspension). After cooling, the suspension was centrifuged and decanted through Hyflo Super-cel. The clear filtrate was treated with picric acid (1·2 g.), and the precipitated

picrate (1·0 g.), m. p. 280° (decomp.), collected. Recrystallisation from Cellosolve (60 c.c.) afforded yellow needles (0·5 g.), m. p. 282—283° (decomp.), undepressed on admixture with *NN*-dimethyl-t-butylamine picrate.

Degradation of the Thiolate Ester (A') with Raney Nickel.—The thiolate ester (A'), n_D^{18} 1·4760 (5 g.), in ethanol (250 c.c.) was refluxed for 2 hr. with Raney nickel (80 c.c. of settled suspension). The nickel was then removed and the clear solution, which smelled strongly of an aliphatic amine, treated with a slight excess of picric acid. Crystalline *NN*-dimethyl-t-butylamine picrate (1·4 g.), m. p. 280° (decomp.), separated almost immediately and was recrystallised from methanol (200 c.c.) [yield 0·6 g.; m. p. and mixed m. p. 286° (decomp.)] (Found: C, 43·7; H, 5·5; N, 16·8%).

1-*Dimethylamino*-2-*methylpropane*-2-*thiol.*—2,2-Diethylethylene sulphide (9 g.) and anhydrous dimethylamine (5 g.) were heated at 100° for 2—3 hr. in a sealed tube. Distillation of the product gave 1-dimethylamino-2-methylpropane-2-thiol (9·0 g., 60%), b. p. 75—78°/95 mm., n_D^{18} 1·4538 [*picrate*, yellow flocculent needles (from ethanol), m. p. 157—158° (decomp.) (Found: C, 39·8; H, 5·0; N, 15·7; S, 9·1. $C_{12}H_{18}O_7N_4S$ requires C, 39·7; H, 5·0; N, 15·5; S, 8·9%)].

Bis-(2-*dimethylamino*-1,1-*dimethylethyl*) *Disulphide.*—1-Dimethylamino-2-methylpropane-2-thiol (1·0 g.) in ethanol (10 c.c.) was treated with ethanolic iodine until a faint yellow colour persisted. *Bis*-(2-*dimethylamino*-1,1-*dimethylethyl*) *disulphide dihydriodide* (1·9 g.), m. p. 186—189° (decomp.), which separated, was collected and recrystallised from ethanol (100 c.c.) as needles (1·6 g.), m. p. 193—194° (decomp.) [Found: C, 27·9; H, 5·8; I, 48·3. $(C_6H_{14}NS,HI)_2$ requires C, 27·7; H, 5·8; I, 48·8%]. The dihydriodide (0·5 g.) was converted into a *dipicrate* (0·6 g.), yellow needles, m. p. 174—176° (Found: C, 39·9; H, 4·8; S, 9·1%). This dipicrate was different from the disulphide dipicrate (C), *viz.*, bis-(2-dimethylamino-2-methyl)propyl disulphide dipicrate, m. p. 252° (decomp.), obtained by oxidative hydrolysis of the thiolate ester (A').

S-(2-*Dimethylamino*-1,1-*dimethylethyl*) *Diethyl Phosphorothiolate.*—1-Dimethylamino-2-methylpropane-2-thiol (7·2 g.), powdered sodium (1·15 g.), and benzene (50 c.c.) were refluxed until the sodium dissolved, then cooled. Diethyl phosphorochloridate (8·6 g.) in benzene (10 c.c.) was added, at room temperature, during 15 min. The mixture was stirred for 2 hr., washed with water, dried ($MgSO_4$), and evaporated *in vacuo* to an oil (11 g.). Part (5 g.) of this was distilled, giving S-(2-*dimethylamino*-1,1-*dimethylethyl*) *diethyl phosphorothiolate* (1·5 g.), b. p. 88—91°/0·2 mm., n_D^{18} 1·4695 (Found: P, 11·3; N, 4·9%). The infrared spectrum of this sample was identical with that of the thiolate ester (B'). The undistilled oil (1·0 g.) was treated with picric acid (0·9 g.) in ethanol (20 c.c.) and, after filtration from a little disulphide dipicrate, *S*-(2-dimethylamino-1,1-dimethylethyl) diethyl phosphorothiolate picrate (0·4 g.), m. p. 68—69°, was obtained as golden plates (from ether). This picrate was undepressed in admixture with the picrate (B).

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