

## Tautomeric Cyclic Thiones

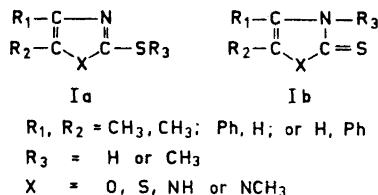
### Part III.\* Preparation of *N*- and *S*-Methyl Derivatives of Some Azoline-2-thiones

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A series of oxazoline-, thiazoline- and imidazoline-2-(3)-thiones with methyl or phenyl groups in positions 4 and 5 has been prepared, together with the corresponding *N*- and *S*-methyl derivatives.

For an investigation of the spectra and thione-thiol equilibria in a series of azoline-2-thiones (see following paper)\*\*\* it was necessary to prepare *N*- and *S*-methyl derivatives, in which the  $\pi$ -electronic structures of the thione and thiol forms were fixed. The compounds to be prepared were all possible combinations of the following substituents and ring hetero atoms in the thiol (Ia) and thione form (Ib). When each tautomeric mixture is counted as one, a



total of thirty different combinations is obtained, all of which have been prepared. The order of the substituents and the numbering of the compounds follow from Table 1.

\* Part II. *Acta Chem. Scand.* **20** (1966) 57.

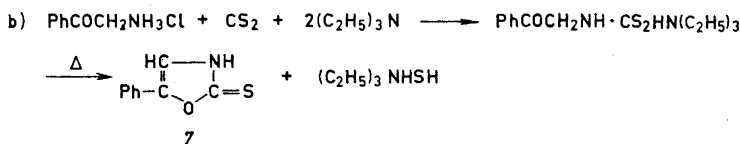
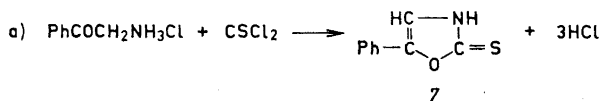
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\*\*\* Part IV. *Acta Chem. Scand.* **23** (1969) 2888.

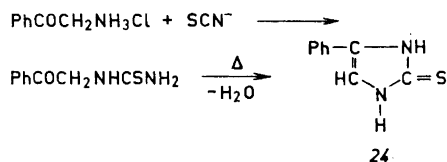
Table 1. Numbering of the compounds.

R <sub>1</sub> , R <sub>2</sub> , R <sub>3</sub> X	CH <sub>3</sub> , CH <sub>3</sub> , H	CH <sub>3</sub> , CH <sub>3</sub> , CH <sub>3</sub>		Ph, H, H	Ph, H, CH <sub>3</sub>		H, Ph, H	H, Ph, CH <sub>3</sub>	
		Ia	Ib		Ia	Ib		Ia	Ib
O	1	2	3	4	5	6	7	8	9
S	10	11	12	13	14	15	16	17	18
NH	19	20	21	24	25	26	24	25	27
NCH <sub>3</sub>	21	22	23	27	28	30	26	29	30

*Free acids.* Most of these were already known or were prepared by modifications of methods previously used for similar compounds. Some new methods have also been elaborated. Thus, 5-phenyloxazoline-2(3)-thione (7), which has not been previously described, was prepared from phenacylammonium chloride by methods a) and b):

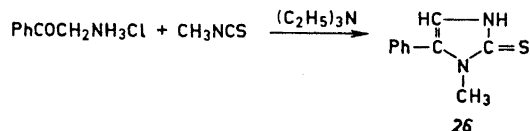


4,5-Dimethylimidazoline-2(3)-thione (21) was obtained by heating a mixture of acetoin and ammonium rhodanide to 120°. 4(5)-Phenylimidazoline-2(3)-thione (24) has previously<sup>1,2</sup> been prepared by reaction between phenacylammonium chloride and potassium rhodanide. When we repeated this reaction, we isolated an intermediate, which was not reported by the previous authors, *viz.* *N*-phenacylthiourea:

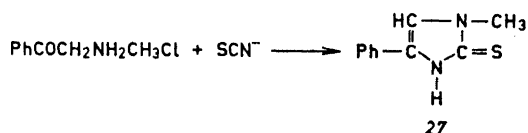


The structure of the intermediate was demonstrated by elementary analysis and by its IR spectrum, which showed a strong carbonyl band at 1687 cm<sup>-1</sup> and a thiourea band<sup>3</sup> at 1587 cm<sup>-1</sup>. 1-Methyl-5-phenylimidazoline-2(3)-thione

(26) was prepared by reaction between phenacylamine and methyl isothiocyanate:

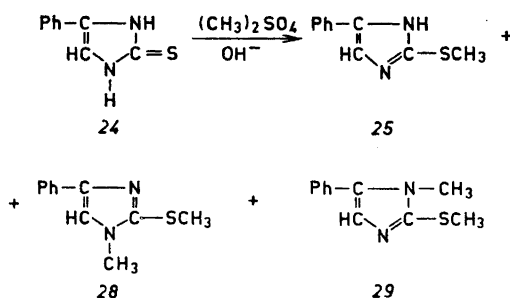


and the 1-methyl-4-phenyl analog (27) by reaction between phenacylmethylammonium chloride and ammonium rhodanide:



*S-Methyl derivatives.* These were generally prepared by reaction between the anions of the free acids and methyl iodide or dimethyl sulphate. In some cases reaction between the free acids and diazomethane was also employed.

When 4(5)-phenylimidazoline-2(3)-thione (24) was methylated in alkaline medium a mixture of 2-methylthio-4(5)-phenylimidazole (25), 1-methyl-2-methylthio-4-phenylimidazole (28), and 1-methyl-2-methylthio-5-phenylimidazole (29) was formed:

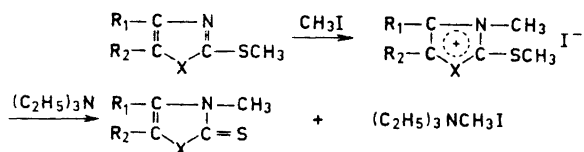


Of these 25 was isolated from the aqueous solution as a slightly soluble hydrochloride, whereas 28, which constituted the major part of the remaining mixture, was isolated as a picrate after distillation. The presence of 29 in the mixture was demonstrated by the NMR spectrum, and it was prepared in an unambiguous way by methylation of 1-methyl-5-phenylimidazoline-2(3)-thione (26).

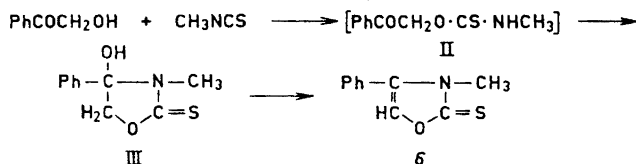
The assignment of structures 28 and 29 was further strengthened by the observation that the NMR signal of the phenyl group in 28 was a complex multiplet, whereas in 29 it was a singlet. This is in agreement with the observa-

tion of Tensmeyer and Ainsworth<sup>4</sup> that 1-phenylpyrazoles give phenyl multiplets except when the phenyl group is turned out of coplanarity by a substituent in position 5.

*N-Methyl derivatives.* Direct *N*-methylation with diazomethane was only achieved in one case, *viz.* with 5-phenyl-oxazoline-2(3)-thione (7), and the product contained the *N*- and *S*-methyl derivatives in the ratio 1:17. A more general method was found in quaternisation of the *S*-methyl derivatives with methyl iodide followed by reaction of the resulting methiodides with a tertiary amine at elevated temperatures or by heating above the melting point:

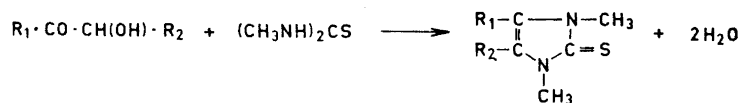


In some cases *N*-methyl derivatives were prepared by cyclisation of open-chain methylamino compounds. Thus  $\omega$ -hydroxyacetophenone and methyl isothiocyanate reacted in pyridine to give 4-hydroxy-3-methyl-4-phenyl-oxazolidine-2-thione (III), probably with a thioncarbamate (II) as an intermediate. The oxazolidine was dehydrated to the desired 3-methyl-4-phenyl-oxazoline-2(3)-thione (6) by boiling ethanolic hydrochloric acid:



The structure III was demonstrated by the IR spectrum, which showed an OH band at 3200  $\text{cm}^{-1}$ , by the NMR spectrum, which showed the expected signals and an AB spectrum for the  $\text{CH}_2$  group ( $\tau_A=5.18$ ,  $\tau_B=5.43$ ;  $J_{AB}=10.5$  Hz), and by elementary analysis.

*N*-Monosubstituted imidazoline-2-thiones have previously been prepared by Kochergin<sup>5</sup> from  $\alpha$ -hydroxyketones and *N*-alkylthioureas, which were refluxed together in 1-hexanol with a water separator. This method has now been used for the preparation of 1,3-dimethylimidazoline-2(3)-thiones from acylolins and *N,N'*-dimethylthiourea:



The NMR spectra of compounds 1–30 will be discussed elsewhere.

## EXPERIMENTAL

*4,5-Dimethyl-oxazoline-2(3)-thione (1)* was prepared according to Willems and Vandenberghe<sup>6</sup> and also in the following way: 4,5-Dimethyl-oxazoline-2(3)-one<sup>7</sup> (11.3 g) was refluxed with phosphorus oxychloride (35 ml) for 1 h. After cooling, the mixture was poured onto ice and neutralized with sodium carbonate. The product was extracted with ether and distilled, b.p.<sub>10</sub> 42–46°. GLC showed only one product (6.2 g, 49 % yield),  $n_D^{20}$  1.4602, which according to analysis consisted of 2-chloro-4,5-dimethyl-oxazole. (Found: C 46.5; H 4.96; N 10.6; O 12.0. C<sub>5</sub>H<sub>6</sub>ClNO (131.56) requires C 45.7; H 4.60; N 10.6; O 12.0).

This compound (4.6 g) and thiourea (3 g) were refluxed in ethanol (50 ml) for 2 h. The solution was evaporated to dryness, and the isothiuronium salt was decomposed with 2 N sodium hydroxide (20 ml). On acidification with 5 N HCl (10 ml) a crystalline precipitate was formed (3.2 g, 71 % yield), which crystallized from toluene-heptane as colourless prisms, m.p. 135–137° (lit.<sup>6</sup> 137°).

*2-Methylthio-4,5-dimethyl-oxazole (2)*. a) Dimethyl-oxazoline-thione (1, 9 g) was refluxed with methyl iodide (20 g) in N NaOH (100 ml) and ethanol (500 ml) for 1 h. After evaporation and extraction with ether the product was distilled, b.p.<sub>3</sub> 54–55°, and gave a pale yellow oil (3.7 g, 37 % yield), which according to analysis had the desired composition. (Found: C 50.1; H 6.23; N 9.91; S 22.4. C<sub>6</sub>H<sub>8</sub>NOS (143.21) requires C 50.3; H 6.33; N 9.78; S 22.4).

b) Dimethyl-oxazoline-thione (1, 3.3 g) was added to a solution of diazomethane (1.6 g) in ether (150 ml). When the evolution of gas had ceased, the solution was evaporated, and the oily residue was purified by chromatography on alumina. Chloroform eluted a pale yellow oil (3.2 g, 90 % yield), identical with the above product according to IR spectrum.

*3,4,5-Trimethyl-oxazoline-2(3)-thione (3)*. The above methylthio-oxazole (1.5 g) was refluxed with methyl iodide (10 ml) for 3 days. On cooling, the desired methiodide crystallized (1.9 g, 66 % yield), m.p. 129–130°, and was used without further purification. Since heating above the m.p. and refluxing with pyridine proved insufficient to effect demethylation, the methiodide was refluxed for one day with triethylamine (10 ml). After filtration and cooling the solution deposited white needles (0.42 g, 28 % yield), m.p. 76–77.5° after recrystallisation from toluene-heptane. (Found: C 50.0; H 6.26; N 9.75; S 22.4. The calculated percentages are as for 2).

*4-Phenyl-oxazoline-2(3)-thione (4)* was prepared according to Ref. 6.

*2-Methylthio-4-phenyl-oxazole (5)* was obtained in 80 % yield when 4 was methylated with methyl iodide in 80 % aqueous ethanolic sodium hydroxide. Colourless oil, b.p.<sub>2</sub> 124–125°, lit.<sup>8</sup> b.p.<sub>3</sub> 141°.

*3-Methyl-4-phenyl-oxazoline-2(3)-thione (6)*. *ω*-Hydroxyacetophenone (13.6 g) and methyl isothiocyanate (11 g) were refluxed in pyridine (200 ml) for 16 h. After evaporation the product was subjected to chromatography on silica, and ether-chloroform eluted a solid product (8 g, 38 % yield), which was recrystallized from toluene-heptane and from chloroform-toluene-petroleum ether to yield colourless prisms of *3-methyl-4-hydroxy-4-phenyl-oxazolidine-2-thione* (III), m.p. 131–132°. (Found: C 56.5; H 5.23; N 6.74; S 15.4. C<sub>10</sub>H<sub>11</sub>NO<sub>2</sub>S (209.70) requires C 57.4; H 5.30; N 6.69; S 15.3). This product (2.1 g) was refluxed for 30 min in 2.5 N hydrochloric acid in 50 % aqueous ethanol (80 ml), water (50 ml) was added, and on cooling 6 separated as colourless needles (1.7 g, 89 % yield), m.p. 100–101° after recrystallisation from toluene-heptane. (Found: C 62.7; H 4.69; N 7.47; S 16.9. C<sub>10</sub>H<sub>9</sub>NOS (191.26) requires C 62.8; H 4.74; N 7.32; S 16.8).

*5-Phenyl-oxazoline-2(3)-thione (7)*. a) Phenacylammonium chloride<sup>9</sup> (8 g) and thio-carbonyl chloride (4.5 ml) were refluxed in dry toluene (50 ml) for 19 h. A solid product separated on cooling and was purified by dissolution in N sodium hydroxide and reprecipitation with acid followed by recrystallisation from ethanol. Final yield 1.8 g (20 %), m.p. 230–232°. (Found: C 61.0; H 3.84; N 7.90; S 18.2. C<sub>9</sub>H<sub>7</sub>NOS (177.23) requires C 61.0; H 3.98; N 7.90; S 18.1).

b) Phenacylammonium chloride (15.7 g) and carbon disulphide (15.2 g) were stirred in ethanol (100 ml), and triethylamine (16 ml) was added dropwise during 30 min. A solution was obtained, and after 1 h the same quantity of triethylamine was added. A precipitate was formed, the amount of which increased upon addition of water (100 ml).

The product (23 g, 80 % yield), m.p. 100° (decomp.) consisted according to IR and NMR spectra of triethylammonium *N*-phenacyldithiocarbamate. The dithiocarbamic acid was prepared by acidification of an aqueous solution of the salt. (Found: C 53.6; H 4.16; N 6.83; S 29.5.  $C_9H_9NOS_2$  (211.31) requires C 51.2; H 4.29; N 6.63; S 30.4). The salt (16 g) was refluxed in water for 15 min. Part of the product, 7, separated on cooling and part on acidification. The combined products crystallized from butanol as pale yellow prisms (6 g, 41 % yield), m.p. 230–232°, according to IR spectrum identical with the product obtained by method a).

*2-Methylthio-5-phenyl-oxazole* (8) was obtained in 75 % yield on methylation of 7 with methyl iodide in ethanolic sodium hydroxide. The product crystallized from petroleum ether (40–60°) as pale yellow prisms, m.p. 54–54.5°. (Found: 62.7; H 4.65; N 7.42; S 16.8.  $C_{10}H_9NOS$  (191.26) requires C 62.8; H 4.74; N 7.32; S 16.8).

*3-Methyl-5-phenyl-oxazoline-2(3)-thione* (9). a) The methiodide of 8 was obtained in 84 % yield by refluxing the base in a large excess of methyl iodide for 5 days. When heated above the m.p. (99–99.5°) it lost methyl iodide and gave 9 in 57 % yield after two recrystallizations from toluene-heptane and one from ethanol, m.p. 140–141°. (Found: C 63.0; H 4.72; N 7.20; S 16.5. The calculated percentages are as for 8).

b) Solid 7 (1.6 g) was added to a solution of diazomethane (0.9 g) in ether (50 ml). After evaporation the residue was extracted with hot petroleum ether (b.p. 40–60°) This left an undissolved residue (0.1 g, 6 % yield), that crystallized from toluene-heptane as colourless prisms, m.p. 139–140°, and consisted according to IR spectrum of 9. Evaporation of the petroleum ether solution gave 8 (1.65 g, 85 % yield).

*4,5-Dimethyl-thiazoline-2(3)-thione* (10). Ammonium dithiocarbamate (30 g) was dissolved in 50 % aqueous ethanol (200 ml), cooled to –20°, and 3-chlorobutan-2-one (27 g) was added with vigorous stirring. The mixture was kept at –20° for 1 h, was then allowed to warm up to 20° and was finally refluxed for 15 min. After cooling to 0° a solid product separated (19 g, 53 % yield), which was purified first by precipitation with acid from a solution in *N* sodium hydroxide and then by recrystallization from toluene. Colourless prisms, m.p. 164–165° (lit.<sup>10</sup> 152–153°) were obtained. (Found: C 41.2; H 4.64; N 9.60; S 44.3.  $C_6H_7NS_2$  (145.25) requires C 41.3; H 4.86; N 9.64; S 44.2).

*4,5-Dimethyl-2-methylthio-thiazole* (11) was prepared by method a) for the oxazole analog and was obtained in 71 % yield as a colourless liquid, b.p.<sub>3</sub> 70–72°. (Found: C 45.3; H 5.97; N 8.68; S 40.0.  $C_8H_9NS_2$  (159.28) requires C 45.3; H 5.70; N 8.78; S 40.3).

*3,4,5-Trimethyl-thiazoline-2(3)-thione* (12). The methylthio derivative 11 was quaternised with methyl iodide as the oxazole analog and gave a 90 % yield of the iodide, m.p. 130–132°. This product (4 g) was refluxed with pyridine (65 ml) for 1 h, the solvent was evaporated, the residue was extracted with water and ether, and the ether phase was dried and evaporated. The residue crystallized from toluene-heptane as colourless prisms (1.7 g, 80 % yield), m.p. 103–103.5°. (Found: C 44.5; H 5.37; N 8.69; S 40.3. The calculated percentages are as for 11).

*4-Phenyl-thiazoline-2(3)-thione* (13) was prepared according to Miolati.<sup>11</sup> M.p. 174–176°, lit.<sup>11</sup> 168°.

*2-Methylthio-4-phenylthiazole* (14) was prepared in the usual way and was obtained in 80 % yield as colourless crystals, b.p.<sub>1</sub> 140–147°, m.p. 32–33° (lit.<sup>12</sup> 24°) after recrystallization from heptane. (Found: C 57.1; H 4.27; N 7.01; S 31.0.  $C_{10}H_9NS_2$  (207.32) requires C 57.9; H 4.38; N 6.76; S 30.9).

*3-Methyl-4-phenyl-thiazoline-2(3)-thione* (15). Quaternisation of 14 was effected by refluxing with excess methyl iodide in ethanol for three days. The methiodide was obtained in 59 % yield, m.p. 128–130°, and was demethylated in 58 % yield by refluxing in pyridine for 2 h. Pale yellow prisms were obtained on recrystallisation from toluene-heptane, m.p. 128.5–129° (lit.<sup>13</sup> 127–128°). (Found: C 58.0; H 4.49; N 6.76; S 30.9. The calculated percentages are as for 14).

*5-Phenyl-thiazoline-2(3)-thione* (16). Ammonium dithiocarbamate (19 g) was dissolved in 60 % aqueous ethanol (25 ml), and  $\alpha$ -bromophenylacetaldehyde<sup>14</sup> (30 g) was added dropwise with stirring at –10°. The solution was kept at –10° for 30 min, allowed to warm up, and was then refluxed for 30 min. After cooling a brown, crystalline precipitate formed, which was purified by precipitation with acid from an alkaline solution. This product (20 g, 69 % yield) crystallized from toluene as pale yellow prisms, m.p. 197–200°. (Found: C 55.7; H 3.55; N 7.20; S 33.6.  $C_9H_7NS_2$  (193.30) requires C 55.9; H 3.55; N 7.25; S 33.2).

*2-Methylthio-5-phenyl-thiazole* (17) was obtained from 16 in the usual way. The product crystallized from heptane as colourless prisms (37 % yield) m.p. 32–33°, without distillation. (Found: C 57.1; H 4.27; N 7.01; S 31.0.  $C_{10}H_7NS_2$  (207.32) requires C 57.9; H 4.38; N 6.76; S 30.9). The same compound was obtained in 93 % yield by methylation of 16 with diazomethane.

*3-Methyl-5-phenyl-thiazoline-2(3)-thione* (18). Quaternisation of 17 in the usual way gave the methiodide in 78 % yield, m.p. 125–127°, which was demethylated in boiling pyridine. The product (63 % yield) crystallized from toluene-heptane as pale yellow prisms, m.p. 159–159.5°. (Found: C 57.3; H 4.49; N 6.87; S 30.9. The calculated percentages are as for 17).

*4,5-Dimethyl-imidazoline-2(3)-thione* (19). An intimate mixture of acetoin (26.3 g) and ammonium rhodanide (22.8 g) was kept at 120° until the evolution of water had ceased and was then rapidly heated to 170° and allowed to cool. Recrystallisation of the solid residue from a large amount of ethanol gave pure 19 (16.5 g, 43 % yield), m.p. > 300°. The purity and identity of the product was checked by comparison of its IR spectrum with that of authentic 19, prepared according to Künne,<sup>15</sup> and also by its NMR spectrum.

*4,5-Dimethyl-2-methylthio-imidazole* (20) was prepared in the same way as the previous methylthio derivatives (yield 63 %). After two recrystallisations from toluene-heptane and one from chloroform followed by vacuum sublimation at 1 mm and 120° the product had m.p. 149.5–150°. (Found: C 50.9; H 6.88; N 19.5; S 22.6.  $C_8H_{10}N_2S$  (142.22) requires C 50.7; H 7.09; N 19.7; S 22.5).

*1,4,5-Trimethyl-imidazoline-2(3)-thione* (21). Acetoin (9.8 g) and *N*-methylthiourea (9 g) were refluxed in 1-hexanol (50 ml) for 6 h. After evaporation to one third of the original volume the solution was cooled. A solid product was formed (2.6 g, 18 % yield), which crystallized from ethanol as colourless prisms, m.p. 214–217°. (Found: C 50.8; H 7.23; N 19.7; S 22.5. The calculated percentages are as for 20).

*1,4,5-Trimethyl-2-methylthio-imidazole* (22). Dimethyl sulphate (7.7 g) was added dropwise with stirring to a solution of 20 (7.1 g) in ethanol (100 ml). The mixture was refluxed for 4 h, and after cooling the methosulphate of 20 was precipitated as an oil by the addition of anhydrous ether (500 ml). The supernatant liquid was decanted, the oil was dissolved in water (25 ml) and the solution was made alkaline with *N* sodium hydroxide. The product was extracted with chloroform and distilled at 0.5 mm and 72–75° to give a colourless liquid, which crystallized at –30° but melted at room temperature. (Found: C 52.9; H 7.77; N 17.3; S 20.1.  $C_7H_{12}N_2S$  (156.25) requires C 53.8; H 7.74; N 17.9; S 20.5).

*1,3,4,5-Tetramethyl-imidazoline-2(3)-thione* (23). Acetoin (8.8 g) and *N,N'*-dimethylthiourea (10.4 g) were refluxed in 1-hexanol (100 ml) for 20 h. The solvent was distilled off at reduced pressure, and the residue crystallized from 50 % aqueous ethanol to give colourless prisms (5 g, 35 % yield), m.p. 148–149° after vacuum sublimation. (Found: C 53.6; H 7.61; N 18.0; S 20.8. The calculated percentages are as for 22).

*4(5)-Phenyl-imidazoline-2(3)-thione* (24). a) Phenacylammonium chloride (20 g) and potassium rhodanide (20 g) were refluxed in water (100 ml) for 30 min. After cooling the solution was brought to pH 6 by the addition of sodium acetate, and a grey powder (15 g, 66 % yield) separated, which crystallized from 1-butanol as pale yellow prisms, m.p. 124–126°, and consisted of *N*-phenacylthiourea according to analysis and IR spectrum. (Found: C 55.2; H 5.06; N 14.5; S 16.3.  $C_9H_{10}N_2OS$  (194.26) requires C 55.7; H 5.19; N 14.4; S 16.5). This compound was heated to 170° for some minutes, and the solid residue was purified by precipitation by acid from an alkaline solution, followed by recrystallisation from 50 % aqueous ethanol. Yield 40 %, m.p. 264° (lit.<sup>2</sup> 267.5°). (Found: C 60.9; H 4.69; N 15.9; S 18.2.  $C_9H_8N_2S$  (176.23) requires C 61.3; H 4.57; N 15.9; S 18.2).

b) An intimate mixture of phenacylammonium chloride (34.3 g) and ammonium rhodanide (15.2 g) was heated to 190° until the formation of water had ceased. The solid residue was purified as above and gave colourless prisms (18 g, 52 % yield), identical in m.p. and IR spectrum with the product obtained in the previous experiment.

*2-Methylthio-4(5)-phenyl-imidazole* (25). Dimethyl sulphate (36 g) was added dropwise with stirring to a solution of 24 (35.5 g) in *N* NaOH (500 ml). After 2 h the solution was decanted from a separated oil, and the water phase on acidification (5 *N* HCl) deposited a crystalline product (10 g), consisting of the hydrochloride of 25. When this was suspended

in water (60 ml) and thoroughly stirred with sodium carbonate (6 g), the free base was obtained as colourless prisms, m.p. 134–136° after recrystallisation from toluene. (Found: C 62.7; H 5.25; N 14.5; S 16.6.  $C_{10}H_{10}N_2S$  (190.27) requires C 63.1; H 5.30; N 14.7; S 16.8).

*1-Methyl-2-methylthio-4-phenyl-imidazole* (28). The oil, which was formed in the previous experiment, was dissolved in chloroform. The chloroform solution was extracted with water, dried, and distilled. A colourless oil (10.2 g) was obtained at 1 mm and 170–180°. NMR spectrum showed the presence of (28) and (29) in the proportion 4.5:1. This distillate (8 g) and picric acid (9 g) were dissolved in hot ethanol (250 ml). On cooling, a picrate separated which was recrystallized twice from ethanol (9.8 g, 63 % yield), m.p. 200–203°.

The picric acid was removed from the picrate by repeated extractions with N sodium hydroxide, first from chloroform and then from ether solutions, and on evaporation the latter gave a solid residue, which crystallized from toluene-petroleum ether as colourless prisms, m.p. 33–35° (2.9 g, 61 % yield based on picrate, 10 % based on the initial amount of 24). (Found: C 64.7; H 5.99; N 13.9; S 15.9.  $C_{11}H_{12}N_2S$  (204.30) requires C 64.7; H 5.92; N 13.7; S 15.7).

*1-Methyl-5-phenyl-imidazoline-2(3)-thione* (26). Triethylamine (14.2 ml) was added dropwise with stirring to a mixture of phenacylammonium chloride (17.1 g) and methyl isothiocyanate (8 g) in ethanol (200 ml). The mixture was slowly heated to boiling and was refluxed for 1 h. The solution was evaporated almost to dryness, and the residue on treatment with water (50 ml) gave a solid product (17 g), which according to its IR spectrum consisted of a mixture of 26 and a compound with a carbonyl frequency at 1685  $cm^{-1}$ , possibly *N*-methyl-*N'*-phenacylthiourea. Pure 26 (10 g, 53 % yield), m.p. 178–179°, was obtained by dissolving the crude product in N sodium hydroxide, precipitating with hydrochloric acid, and recrystallizing from 25 % aqueous ethanol. (Found: C 62.8; H 5.20; N 15.0; S 16.9.  $C_{10}H_{10}N_2S$  (190.27) C 63.1; H 5.30; N 14.7; S 16.7).

*1-Methyl-4-phenyl-imidazoline-2(3)-thione* (27). Methylphenacylammonium chloride<sup>18</sup> (4.6 g) and ammonium rhodanide (10 g) were refluxed in 0.05 N HCl (25 ml) for 24 h. After cooling, a solid product was obtained, which crystallized from 50 % aqueous ethanol as colourless prisms (3.9 g, 83 % yield), m.p. 207–209°. (Found: C 62.6; H 5.30; N 14.3; S 16.9. The calculated percentages are as for 26).

*1-Methyl-2-methylthio-5-phenyl-imidazole* (29) was formed when 26 was methylated with methyl iodide in alkaline solution in the usual way. The crude product (67 % yield) crystallized from heptane as colourless prisms, m.p. 86–88°, unchanged on vacuum sublimation. (Found: C 64.9; H 5.96; N 13.7; S 15.7.  $C_{11}H_{12}N_2S$  (204.30) requires C 64.7; H 5.92; N 13.8; S 15.7). A picrate was prepared as with 28, m.p. 153–154°.

*1,3-Dimethyl-4(5)-phenyl-imidazoline-2(3)-thione* (30).  $\omega$ -Hydroxyacetophenone (136 g) and *N,N'*-dimethylthiourea (104 g) were refluxed in 1-hexanol (500 ml) with a water separator for 3 h, after which time 38 ml of water had separated. On cooling, a crystalline product was formed (90 g, 44 % yield), which gave colourless prisms, m.p. 126–127°, when recrystallized from a small amount of ethanol. (Found: C 63.9; H 6.03; N 14.0; S 15.9. The calculated percentages are the same as for 29).

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## REFERENCES

1. Grant, R. L. and Pyman, F. L. *J. Chem. Soc.* **119** (1921) 1893.
2. Clemo, G. R., Holmes, T. and Leitch, G. C. *J. Chem. Soc.* **1938** 753.
3. Jensen, K. A. and Nielsen, P. H. *Acta Chem. Scand.* **20** (1966) 597.
4. Tensmeyer, L. G. and Ainsworth, C. J. *Org. Chem.* **31** (1966) 1878.
5. Kochergin, P. M. *J. Gen. Chem. USSR* **31** (1961) 1010.
6. Willems, J. F. and Vandenberghe, A. *Bull. Soc. Chim. Belges* **70** (1961) 745.
7. De Stevens, G. *J. Org. Chem.* **23** (1958) 1572.
8. Sych, E. D. and Belaya, Z. N. *Zh. Obshch. Khim.* **33** (1963) 1507.
9. Mannich, C. and Hahn, F. L. *Ber.* **44** (1911) 1542.



10. Sankyo, Co. Ltd. Jap. Pat. 25,676; *Chem. Abstr.* **60** (1964) 5509.
11. Miolati, A. *Gazz. Chim. Ital.* **23** (1893) 1575.
12. Knott, E. B. *J. Chem. Soc.* **1947** 1656.
13. Hünig, S. and Lampe, W. *J. prakt. Chem.* **8** (1959) 264.
14. Yanovskaya, L. A. and Terent'ev, A. P. *Zh. Obshch. Khim.* **22** (1952) 1598.
15. Künne, H. B. *Ber.* **28** (1895) 2036.
16. Breitschneider, H. *Oesterr. Akad. Wiss. Math. Naturw. Kl. Sitzber. Abt. II b* **159** (1950) 372.

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