The Synthesis of Potential Insecticides. Part II.† Carbamic Esters of 4-Alkylthiopyrazolones

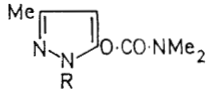
By I. T. Kay,* D. J. Lovejoy, and (in part) S. Glue, Imperial Chemical Industries Limited, Plant Protection Ltd., Jealott's Hill Research Station, Bracknell, Berkshire

By use of 2-(alkylthio)acetoacetic esters, for which an improved synthesis is described, a series of 4-alkylthio-2-pyrazolin-5-ones has been prepared and these have been converted into their methyl- and dimethyl-carbamic esters. In an alternative approach to these esters, methylthio-groups were introduced directly into the 4-position of certain 4-unsubstituted pyrazol-5-yl carbamates by reaction with methanesulphenyl chloride. Oxidation of the 4-alkylthiopyrazol-5-yl carbamates gave good yields of the corresponding sulphoxides and sulphones.

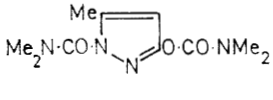
CARBAMIC esters of aromatic and heteroaromatic systems frequently possess insecticidal activity; this is known [1] to be a result of their ability to inhibit acetylcholinesterase, probably by the transfer of the carbamoyl group to an active site of the enzyme.

Recently Metcalf [2] has discussed cholinesterase inhibitors which show systematic insecticidal activity, and has related the presence of alkylthio-substituents in these compounds, and their ability to undergo oxidation *in vivo* to the corresponding sulphoxides and sulphones, to 'delay factors' in their endometatoxic systemic properties.

Of the heteroaromatic carbamates, the pyrazol-5-yl carbamates,[3] *e.g.* Isolan (I; R = Pr^i), Pyrolan (I; R = Ph), and Dimetilan (II), show particularly strong insecticidal activity, and a recent paper [4] describing the chemistry and insecticidal properties of this group prompts us to record our findings for 4-alkylthio-2-pyrazolin-5-ones and their carbamic esters.



(I)

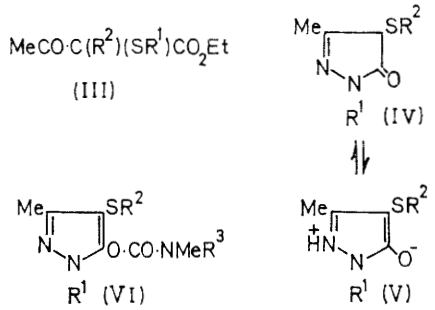


(II)

Two synthetic routes to the 4-alkylthiopyrazol-5-yl-carbamates were examined. The first of these was the usual synthesis of 2-pyrazolin-5-ones by the treatment of the appropriately substituted β-keto-ester with hydrazine. Initial attempts to prepare ethyl 2-(methylthio)acetoacetate (III; R^1 = Me, R^2 = H) required for this route were unpromising. The reaction [5] of methanesulphenyl chloride with ethyl acetoacetate, gave, in our hands, only complex mixtures containing traces of ethyl 2-(methylthio)acetoacetate. However, the reaction of ethyl 2-chloroacetoacetate with methanesulphenyl chloride, generated *in situ* from the reaction of dimethyl disulphide with sulphuryl chloride,[5] at −40°, afforded ethyl 2-chloro-2-(methylthio)acetoacetate (III; R^1 = Me, R^2 = Cl) (78%), and reduction of this ester with zinc dust in aqueous acetic acid at −5° gave ethyl 2-(methylthio)acetoacetate (III; R^1 = Me, R^2 = H) (54%).

This process was extended, though in poorer yield, to the preparation of the ethylthio-ester (III; R^1 = Et, R^2 = Cl), previously obtained [6] by the reaction of ethanesulphenyl chloride and ethyl 2-diazoacetoacetate; this in turn gave (III; R^1 = Et, R^2 = H) on reduction with zinc.

The reaction of hydrazine, or monosubstituted hydrazines, with the alkylthio-esters (III; R^1 = Me and Et, R^2 = H) gave the required 4-alkylthio-2-pyrazolin-5-ones (IV) in good yields. The i.r. spectra (Nujol) of the pyrazolones all contained strong bands between 2400 and 2700 cm.$^{-1}$, previously ascribed [7] to contributions of the zwitterionic form (V).



The reaction of the 4-alkylthio-2-pyrazolin-5-ones (IV) with dimethylcarbamoyl chloride in hot pyridine, or with methyl isocyanate in chloroform containing a trace of triethylamine, gave the anticipated carbamic esters (VI; R^3 = Me or H respectively), usually as stable, low-melting crystalline solids. Although pyrazolones may behave as ambident nucleophiles towards acylating agents,[8] the carbamate structures (VI) were assigned to these products on the basis of strong C=O absorption at 1725—1740 cm.$^{-1}$ and strong C·O·C absorption between 1150 and 1250 cm.$^{-1}$.

The dimethylcarbamoyl groups of the esters (VI; R^3 = Me) gave rise to double peaks in the n.m.r. spectra. This is a well known feature of dimethylcarbamic esters

† Part I, I. T. Kay and N. Punja, *J. Chem. Soc.* (*C*), 1968, 3011.

[1] For a review, see R. L. Metcalf and T. R. Fukuto, *J. Agric. Food Chem.*, 1965, **13**, 220.
[2] R. L. Metcalf, *Agrochimica*, 1967, **11**, 105.
[3] H. Gysin, *Chimia* (*Switz.*), 1954, **8**, 205.
[4] K. Gubler, A. Margot, and H. Gysin, *J. Sci. Food Agric.*, Supplementary Issue, Symposium on Pesticidal Carbamates, London, 1968.
[5] H. Brintzinger and M. Langheck, *Chem. Ber.*, 1954, **87**, 325.
[6] F. Weygand, H.-J. Bestmann, and H. Fritsche, *Chem. Ber.*, 1960, **93**, 2340.
[7] G. De Stevens, A. Halamandaris, P. Wenk, and L. Dorfman, *J. Amer. Chem. Soc.*, 1959, **81**, 6292.
[8] A. Weissberger and H. D. Porter, *J. Amer. Chem. Soc.*, 1943, **65**, 1495.

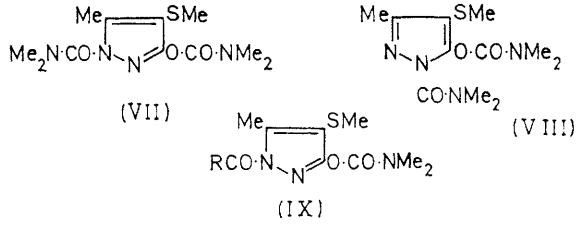
and has been ascribed [9] to hindered rotation about the C–N bond.

Among the carbamates thus prepared were the 4-methylthio-analogues of Isolan (VI; $R^1 = Pr^i$, $R^2 = R^3 = Me$), and Pyrolan (VI; $R^1 = Ph$, $R^2 = R^3 = Me$).

An alternative approach to the synthesis of the 4-alkylthiopyrazolones (IV) by the direct introduction of alkylthio-groups into 4-unsubstituted 2-pyrazolin-5-ones was unsuccessful. Although 4-arylthiopyrazolones have been prepared by the reaction of 4-unsubstituted pyrazolones with diaryl disulphides at elevated temperatures,[10] attempts to extend this method by the use of dimethyl disulphide and 1,3-dimethyl-2-pyrazolin-5-one gave only starting materials. Further attempts to introduce a methylthio-group by the reaction of methanesulphenyl chloride and 1,3-dimethyl-2-pyrazolin-5-one, either itself or as its sodium salt (*cf.* ref. 11) gave only water-soluble products which were not examined further.

However, in contrast, the 4-unsubstituted pyrazol-5-yl dimethylcarbamates (I; R = Me and Ph) reacted smoothly with methanesulphenyl chloride at 0° to give good yields of the 4-methylthiopyrazol-5-yl dimethylcarbamates (VI; $R^2 = R^3 = Me$, $R^1 = Me$ or Ph respectively). Attempts to extend this method to the preparation of the 1-unsubstituted carbamate (VI; $R^1 = H$, $R^2 = R^3 = Me$) led only to the recovery of the starting carbamate (I; $R^1 = H$).

Prolonged treatment of the 1-unsubstituted pyrazol-5-yl dimethylcarbamate (VI; $R^1 = H$, $R^2 = R^3 = Me$) with dimethylcarbamoyl chloride in the presence of potassium carbonate, gave a separable mixture of *N*-carbamoylated esters (VII) and (VIII) (cf. ref. 5). Their structures were assigned on the basis of the chemical shifts of the ring methyl protons. In the case of the 1-dimethylcarbamoylpyrazol-3-yl carbamate (VII), the 5-methyl protons gave rise to a signal at τ 7·5, owing to deshielding by the neighbouring carbonyl group. The 3-methyl protons of the isomer (VIII) gave a signal at τ 7·7, and the 3-methyl protons of the starting ester (VI; $R^1 = H$, $R^2 = R^3 = Me$) a signal at τ 7·76.



Acylation of (VI; $R^1 = H$, $R^2 = R^3 = Me$) with hot acid anhydrides in the presence of a trace of sulphuric acid, in contrast, gave rise to single products which were assigned the 1-acylpyrazol-3-yl carbamate structures (IX; R = Me, Et, or Pr^i), since again the 5-methyl signals were shifted downfield to τ 7·35.

Oxidation of the 4-methylthiopyrazol-5-yl dimethylcarbamates (VI; $R^2 = R^3 = Me$, $R^1 = Me$ or Ph) with potassium permanganate in aqueous acetic acid and with the calculated quantity of hydrogen peroxide in glacial acetic acid gave good yields of their corresponding sulphones and sulphoxides respectively.

Several of the 4-alkylthiopyrazol-5-yl dimethylcarbamates gave a good control of the green pea aphid, *Acyrthosiphon*, on broad bean plants by a systemic action when present in the soil at concentrations of about 30 p.p.m.

EXPERIMENTAL

Light petroleum refers to the fraction b.p. 80—120° unless otherwise stated. N.m.r. spectra were determined for deuteriochlorform solutions, with tetramethylsilane as an internal reference.

Ethyl 2-Chloro-2-(methylthio)acetoacetate (III; $R^1 = Me$, $R^2 = Cl$).—To a solution of dimethyl disulphide (85·5 g., 0·91 mole) in anhydrous tetrachloroethane (600 ml.) at −40°, was added sulphuryl chloride (152 g., 0·91 mole), dropwise with stirring. The mixture was then allowed to warm to −5° with stirring; it was then cooled to −40°, and ethyl 2-chloroacetoacetate (300 g., 1·82 mole) was added dropwise with stirring. The mixture was then kept at room temperature overnight.

Evaporation under reduced pressure, followed by distillation of the residual oil *via* a Vigreux column (24 cm.) gave the *product* (196·5 g., 78%) as a pale yellow oil, b.p. 120—122°/11 mm., n_D^{19} 1·4838 (Found: C, 39·8; H, 5·1; Cl, 16·6; S, 15·4. $C_7H_{11}ClO_3S$ requires C, 39·9; H, 5·25; Cl, 16·85; S, 15·4%), $\nu_{max.}$ 1740s and 1240s cm.$^{-1}$, τ 5·65 (2H, q, *J* 7 c./sec.), 7·64 (3H, s), 7·87 (3H, s), and 8·58 (3H, t, *J* 7 c./sec.).

Ethyl 2-Chloro-2-(ethylthio)acetoacetate (III; $R^1 = Et$, $R^2 = Cl$).—Prepared similarly by use of diethyl disulphide, the product (48%) had b.p. 129—132°/12 mm., n_D^{24} 1·4804 (Found: C, 42·7; H, 5·8; Cl, 16·4; S, 13·9. Calc. for $C_8H_{13}ClO_3S$: C, 42·75; H, 5·85; Cl, 15·8; S, 14·25%).

Ethyl 2-(Methylthio)acetoacetate (III; $R^1 = Me$, $R^2 = H$).—To a vigorously stirred suspension of zinc dust (247 g.) in a mixture of acetic acid (630 ml.) and water (420 ml.) maintained at −5°, was added ethyl 2-chloro-2-(methylthio)acetoacetate dropwise during *ca.* 30 min. Very efficient cooling of the exothermic reaction is necessary during this addition. As the temperature increases, an increasing proportion of ethyl acetoacetate is formed. The mixture was then stirred for a further 10 min., and the excess of zinc dust was removed. The filtrate was diluted with water (1·5 l.) and then extracted with chloroform (3 × 300 ml.). The combined extracts were washed with water (500 ml.) and with a saturated solution of sodium hydrogen carbonate (250 ml.), and then dried ($MgSO_4$). Removal of the chloroform followed by distillation of the residual oil *via* a Vigreux column (24 cm.) gave the product (110 g., 54%) as a colourless oil, b.p. 97—100°/11 mm., n_D^{24} 1·4840 (lit.,[5] b.p. 140°/14 mm.) (Found: C, 47·75; H, 6·6; S, 17·8. Calc. for $C_7H_{12}O_3S$: C, 47·7; H, 6·85; S, 18·2%), $\nu_{max.}$ *ca.* 2900w,vbr, 1720s,br, 1600s,br, and 1240s cm.$^{-1}$. The n.m.r. spectrum showed the compound to be a mixture of keto and enol forms: τ −3·65 (s, enol proton, rapidly exchangeable), 5·67 and 5·72 (2H, two

[9] E. Lustig, W. R. Benson, and N. Duy, *J. Org. Chem.*, 1967, **32**, 851.

[10] C. Angelini and A. Martani, *Ann. Chim.* (*Italy*), 1955, **45**, 156.

[11] E. A. Gray, R. M. Hulley, and B. K. Snell, *J. Chem. Soc.* (*C*), to be published.

superimposed quartets, J 7 c./sec.), 5·9 (s, this together with the enol proton ≡ 1H), 7·64 (3H, s), 7·86 (3H, s), and 8·64 and 8·7 (3H, two superimposed triplets, J 7 c./sec.).

Ethyl 2-(*Ethylthio*)*acetoacetate* (III; R^1 = Et, R^2 = H).—This *compound* (40%), prepared similarly, had b.p. 107°/13 mm., n_D^{22} 1·4810 (Found: C, 50·6; H, 7·1; S, 17·2. $C_8H_{14}O_3S$ requires C, 50·5; H, 7·4; S, 16·85%).

3-*Methyl*-4-*methylthio*-2-*pyrazolin*-5-*one* (IV; R^1 = H, R^2 = Me).—To a solution of ethyl 2-(methylthio)acetoacetate (3·52 g., 0·02 mole) in ethanol (20 ml.) was added hydrazine hydrate (1·1 g., 0·022 mole). Following the exothermic reaction, the mixture was kept at room temperature for 1 hr. The product was then separated and washed with ethanol, and gave colourless *plates* (2·5 g., 87%), m.p. 265° (decomp.) (from aqueous dimethylformamide) (Found: C, 41·8; H, 5·7; N, 19·3; S, 22·2. $C_5H_8N_2OS$ requires C, 41·65; H, 5·6; N, 19·45; S, 22·2%).

1,3-*Dimethyl*-4-*methylthio*-2-*pyrazolin*-5-*one* (IV; R^1 = R^2 = Me).—A mixture of ethyl 2-(methylthio)acetoacetate (3·52 g., 0·02 mole) and methylhydrazine (1·1 g., 0·022 mole) in ethanol (12 ml.) was heated under reflux for 30 min. Removal of ethanol left a pale yellow oil which solidified upon trituration with light petroleum and gave the *product* (2·7 g., 86%) as colourless prisms, m.p. 127—128° (from acetone) (Found: C, 45·9; H, 6·1; N, 17·6; S, 19·8. $C_6H_{10}N_2OS$ requires C, 45·6; H, 6·35; N, 17·7; S, 20·25%), τ −3·78 (1H, s), 6·2 (3H, s), 7·68 (3H, s), and 7·9 (3H, s).

4-*Ethylthio*-1,3-*dimethyl*-2-*pyrazolin*-5-*one* (IV; R^1 = Me, R^2 = Et).—Prepared similarly from ethyl 2-(ethylthio)-acetoacetate, the product (82%) formed colourless *prisms* (from ethyl acetate–light petroleum), m.p. 76° (Found: C, 48·5; H, 6·8; N, 16·3; S, 18·6. $C_7H_{12}N_2OS$ requires C, 48·8; H, 7·0; N, 16·25; S, 18·6%), τ −3·7 (1H, s), 6·4 (3H, s), 7·5 and 7·7 (5H, q, J 7 c./sec., superimposed on a singlet), 8·88 (3H, t, J 7 c./sec.).

1-(2-*Cyanoethyl*)-3-*methyl*-4-*methylthio*-2-*pyrazolin*-5-*one* (IV; R^1 = $CH_2{\cdot}CH_2{\cdot}CN$, R^2 = Me).—Prepared similarly from ethyl 2-(methylthio)acetoacetate and (2-cyanoethyl)-hydrazine, the *product* (80%) had m.p. 168—170° (decomp.) (from ethanol) (Found: C, 48·5; H, 5·5; N, 21·7; S, 16·5. $C_8H_{11}N_3OS$ requires C, 48·7; H, 5·6; N, 21·3; S, 16·25%).

3-*Methyl*-4-*methylthio*-1-*phenyl*-2-*pyrazolin*-5-*one* (IV; R^1 = Ph, R^2 = Me).—Prepared similarly, the *product* (87%) formed colourless prisms, m.p. 155—156° (from ethyl methyl ketone) (Found: C, 59·3; H, 5·6; N, 12·4; S, 15·0. $C_{11}H_{12}N_2OS$ requires C, 59·7; H, 5·5; N, 12·7; S, 14·55%).

1-*Isopropyl*-3-*methyl*-4-*methylthio*-2-*pyrazolin*-5-*one* (IV; R^1 = Pr^i, R^2 = Me).—To a solution of sodium hydroxide (2·4 g., 0·06 mole) in water (10 ml.) was added isopropylhydrazine oxalate [12] (4·92 g., 0·03 mole), followed by ethyl 2-(methylthio)acetoacetate (5·28 g., 0·03 mole) in ethanol (25 ml.), and the mixture was heated on a steam-bath for 1·5 hr. The ethanol was evaporated off and water (50 ml.) was added to the residue; the *product* separated and yielded colourless prisms (5·1 g., 89%), m.p. 164° (from ethyl methyl ketone) (Found: C, 51·4; H, 7·6; N, 15·0; S, 16·8. $C_8H_{14}ON_2S$ requires C, 51·55; H, 7·55; N, 15·05; S, 17·2%).

Pyrazol-5-*yl Carbamates*.—Procedure (a) for 1,3-dimethyl-4-methylthiopyrazol-5-yl dimethylcarbamate illustrates the general method used to obtain pyrazol-5-yl dimethylcarbamates.

1,3-*Dimethyl*-4-*methylthiopyrazol*-5-*yl Dimethylcarbamate* (VI; R^1 = R^2 = R^3 = Me).—(*a*) A mixture of 1,3-dimethyl-4-methylthio-2-pyrazolin-5-one (2·0 g., 0·012 mole) and dimethylcarbamoyl chloride (2·0 g., 0·018 mole) in anhydrous pyridine (10 ml.) was heated on a steam-bath for 45 min. Water (50 ml.) was added to the cooled mixture and the product was extracted into ether (3 × 50 ml.). The combined extracts were dried ($MgSO_4$) and evaporated to leave a pale yellow oil, which slowly solidified and gave colourless *prisms* (2·3 g., 79%), m.p. 66—67° (from light petroleum) (Found: C, 47·0; H, 6·6; N, 18·4; S, 13·7. $C_9H_{15}N_3O_2S$ requires C, 47·2; H, 6·6; N, 18·35; S, 13·95%), $\nu_{max.}$ (Nujol) 1735s and 1150s cm.$^{-1}$, τ 6·4 (3H, s), 6·85 and 6·98 (6H, two singlets of equal intensity, Me_2N), 7·75 (3H, s), and 7·88 (3H, s).

(*b*) To a stirred solution of dimethyl disulphide (2·1 g., 0·022 mole) in anhydrous dichloromethane (30 ml.) at −20°, was added sulphuryl chloride (3·0 g., 0·022 mole) dropwise during *ca.* 15 min. The solution was then allowed to warm to room temperature and added during *ca.* 30 min. to a solution of 1,3-dimethylpyrazol-5-yl dimethylcarbamate [13] (8·0 g., 0·044 mole) in anhydrous dichloromethane (20 ml.) maintained at 0°. The mixture was left overnight at room temperature, then poured slowly with stirring into a saturated solution of sodium hydrogen carbonate in water (200 ml.). The organic layer was separated, dried ($MgSO_4$), and evaporated to give a pale yellow oil which solidified upon trituration with light petroleum. Crystallisation from light petroleum gave the *product* (7·0 g., 74%), m.p. 66—67°, identical (mixed m.p. and i.r. and n.m.r. spectra) with the product from (*a*).

3-*Methyl*-4-*methylthiopyrazol*-5-*yl Dimethylcarbamate* (VI; R^1 = H, R^2 = R^3 = Me).—The *compound* (75%) had m.p. 87° (from ether–light petroleum) (Found: C, 44·7; H, 6·4; N, 19·9; S, 14·5. $C_8H_{13}N_3O_2S$ requires C, 44·65; H, 6·1; N, 19·55; S, 14·5%), $\nu_{max.}$ (Nujol) 3030m, 3080m, 3170m, 1735s, and 1150s cm.$^{-1}$, τ −3·25br (1H, s), 6·88 and 6·98 (6H, two singlets of equal intensity, Me_2N) 7·76 (3H, s), and 7·85 (3H, s).

3-*Methyl*-4-*methylthio*-1-*phenylpyrazol*-5-*yl Dimethylcarbamate* (VI; R^1 = Ph, R^2 = R^3 = Me).—(*a*) Prepared by the reaction of 3-methyl-4-methylthio-1-phenyl-2-pyrazolin-5-one with dimethylcarbamoyl chloride in pyridine, the *compound* (71%) had m.p. 75—76° (from light petroleum) (Found: C, 57·8; H, 5·85; N, 14·3; S, 10·5. $C_{14}H_{17}N_3O_2S$ requires C, 57·8; H, 5·9; N, 14·45; S, 11·0%).

(*b*) The product (84%) obtained from the reaction of 3-methyl-1-phenylpyrazol-5-yl dimethylcarbamate [13] and methanesulphenyl chloride in dichloromethane had m.p. and mixed m.p. with product of (*a*) 75—76° (from light petroleum).

1-*Isopropyl*-3-*methyl*-4-*methylthiopyrazol*-5-*yl Dimethylcarbamate* (VI; R^1 = Pr^i, R^2 = R^3 = Me).—The *compound*, obtained as an almost colourless oil which could not be induced to crystallise, had n_D^{25} 1·5082 (Found: C, 51·2; H, 7·7; N, 16·3; S, 12·3. $C_{11}H_{19}N_3O_2S$ requires C, 51·35; H, 7·4; N, 16·35; S, 12·5%), τ 5·65 (1H, m, J 6 c./sec.), 6·86 and 6·98 (6H, two singlets of equal intensity), 7·73 (3H, s), 7·86 (3H, s), and 8·57 (6H, d, J 6 c./sec.).

4-*Ethylthio*-1,3-*dimethylpyrazol*-5-*yl Dimethylcarbamate* (VI; R^1 = R^3 = Me, R^2 = Et).—The *compound*, obtained as an almost colourless oil which could not be induced to crystallise, had n_D^{27} 1·5125 (Found: C, 49·5; H, 7·0; N, 17·6; S, 13·0. $C_{10}H_{17}N_3O_2S$ requires C, 49·4; H, 7·05; N, 17·3; S, 13·2%).

1,3-*Dimethyl*-4-*methylthiopyrazol*-5-*yl Methylcarbamate*

[12] G. Gever and K. Hayes, *J. Org. Chem.*, 1949, **14**, 813.
[13] B.P. 681,376/1952.

(VI; $R^1 = R^2 = Me$, $R^3 = H$).—To a solution of 1,3-dimethyl-4-methylthio-2-pyrazolin-5-one (1 g.) in anhydrous chloroform (10 ml.) containing triethylamine (3 drops), was added methyl isocyanate (1 ml.), and the mixture was kept at room temperature for 3 hr. Removal of the solvent and crystallisation of the residue from carbon tetrachloride gave the *product* as colourless prisms (1·1 g., 81%), m.p. 107—108° (Found: C, 44·7; H, 6·4; N, 19·3; S, 14·6. $C_8H_{13}N_3O_2S$ requires C, 44·7; H, 6·1; N, 19·6; S, 14·9%), $\nu_{max.}$ (Nujol) 3220m, 1750s, and 1250s cm.$^{-1}$, τ 3·85br (1H, s), 6·36 (3H, s), 7·1 (3H, d, J 5 c./sec.), 7·72 (3H, s), and 7·85 (3H, s).

3-*Methyl*-4-*methylthio*-1-*phenylpyrazol*-5-*yl Methylcarbamate* (VI; $R^1 = Ph$, $R^2 = Me$, $R^3 = H$).—Formed in a similar manner, the *product* (68%) had m.p. 100—101° (from carbon tetrachloride) (Found: C, 56·5; H, 5·4; N, 15·0; S, 11·2. $C_{13}H_{15}N_3O_2S$ requires C, 56·3; H, 5·45; N, 15·15; S, 11·55%).

Reaction of Dimethylcarbamoyl Chloride with 3-*Methyl*-4-*methylthiopyrazol*-5-*yl Dimethylcarbamate*.—A mixture of 3-methyl-4-methylthiopyrazol-5-yl dimethylcarbamate (3 g.), dimethylcarbamoyl chloride (3 g.), and anhydrous potassium carbonate (2 g.) in anhydrous benzene (50 ml.) was heated under reflux with stirring for 18 hr. Separation of the inorganic salts followed by removal of the solvent from the filtrate afforded a light brown oil which solidified on trituration with light petroleum (b.p. 40—60°). T.l.c. (ethyl acetate–silica) showed this to consist of two compounds. Three crystallisations from light petroleum afforded 1-*dimethylcarbamoyl*-3-*methyl*-4-*methylthiopyrazol*-5-*yl dimethylcarbamate* (VIII) (1·2 g.) as colourless needles, m.p. 103—104° (Found: C, 45·9; H, 6·1; N, 19·4; S, 11·2. $C_{11}H_{18}N_4O_3S$ requires C, 46·15; H, 6·35; N, 19·6; S, 11·2%), $\nu_{max.}$ (Nujol) 1725s, 1690s, 1550m, 1370s, and 1140s cm.$^{-1}$, τ 6·9 (12H, superimposed singlet and doublet 2 × Me_2N), 7·7 (3H, s), and 7·8 (3H, s).

Evaporation of the mother liquors, followed by repeated crystallisation of the residue from n-hexane gave the other isomer, 1-*dimethylcarbamoyl*-5-*methyl*-4-*methylthiopyrazol*-3-*yl dimethylcarbamate* (VII) (500 mg.) as colourless prisms, m.p. 77—78° (Found: C, 45·9; H, 6·35; N, 20·1; S, 10·7. $C_{11}H_{18}N_4O_3S$ requires C, 46·15; H, 6·35; N, 19·6; S, 11·2%), $\nu_{max.}$ (Nujol) 1735s, 1680s, 1540w, 1370s, and 1140s cm.$^{-1}$, τ 6·9 (12H, superimposed singlet and doublet) 7·5 (3H, s), and 7·8 (3H, s).

1-*Acetyl*-5-*methyl*-4-*methylthiopyrazol*-3-*yl Dimethylcarbamate* (IX; R = Me).—3-Methyl-4-methylthiopyrazol-5-yl dimethylcarbamate (3 g.) in acetic anhydride (10 ml.) containing concentrated sulphuric acid (3 drops) was heated on a steam-bath for 2 hr. The solution was cooled and poured, slowly and with stirring, into a saturated solution of sodium hydrogen carbonate in water (70 ml.). When effervescence ceased, the oily product was extracted into chloroform (50 ml.), and the extract was dried ($MgSO_4$) and evaporated, to leave a pale yellow oil which slowly solidified. The *product* gave colourless prisms (2·7 g., 75%), m.p. 77—78° (from light petroleum) (Found: C, 46·9; H, 6·0; N, 16·3; S, 12·0. $C_{10}H_{15}N_3O_3S$ requires C, 46·7; H, 5·9; N, 16·35; S, 12·5%), $\nu_{max.}$ (Nujol) 1740s, 1720s, 1650w, 1320s, and 1150s cm.$^{-1}$, τ 6·87 and 6·98 (6H, two singlets, Me_2N), 7·35 (3H, s), 7·4 (3H, s), and 7·8 (3H, s).

5-*Methyl*-4-*methylthio*-1-*propionylpyrazol*-3-*yl Dimethylcarbamate* (IX; R = Et).—Prepared similarly, the *product* (82%) had m.p. 83—84° [from light petroleum (b.p. 60—80°)] (Found: C, 49·0; H, 6·15; N, 15·3; S, 11·9. $C_{11}H_{17}N_3O_3S$ requires C, 48·7; H, 6·3; N, 15·5; S, 11·85%), τ 6·9 (8H, superimposed quartet and doublet), 7·35 (3H, s), 7·8 (3H, s), and 8·8 (3H, t, J 7 c./sec.).

5-*Methyl*-1-(2-*methylpropionyl*)-4-*methylthiopyrazol*-3-*yl Dimethylcarbamate* (IX; R = Pr^i).—The *product* (85%), crystallised from light petroleum (b.p. 40—60°) at −60°, m.p. 71—72° (Found: C, 50·6; H, 6·85; N, 14·5; S, 10·9. $C_{12}H_{19}N_3O_3S$ requires C, 50·6; H, 6·7; N, 14·75; S, 11·25%), τ 6·18 (1H, m, J 7 c./sec.), 6·85 and 6·95 (6H, two singlets), 7·35 (3H, s), 7·8 (3H, s), and 8·85 (6H, d, J 7 c./sec.).

1,3-*Dimethyl*-4-*methylsulphinylpyrazol*-5-*yl Dimethylcarbamate*.—To a solution of 1,3-dimethyl-4-methylthiopyrazol-5-yl dimethylcarbamate (3·0 g., 0·013 mole) in glacial acetic acid (10 ml.) was added hydrogen peroxide (100 vols.; 1·5 ml.) dropwise and with stirring during 1 hr. at 20°. The mixture was then kept at room temperature overnight, poured into water (100 ml.), and neutralised with an excess of solid sodium hydrogen carbonate. It was extracted with chloroform (3 × 25 ml.), and the combined extracts were dried ($MgSO_4$) and evaporated to leave a pale yellow oil which slowly solidified. The *product* (2·2 g., 68%) gave colourless prisms, m.p. 93—94° (from benzene–light petroleum) (Found: C, 44·1; H, 6·25; N, 16·9; S, 13·1. $C_9H_{15}N_3O_3S$ requires C, 44·1; H, 6·1; N, 17·15; S, 13·05%), $\nu_{max.}$ (Nujol) 1750s, 1150s, and 1035s cm.$^{-1}$, τ 6·4 (3H, s), 6·88 and 7·0 (6H, two singlets, Me_2N), 7·14 (3H, s), and 7·61 (3H, s).

3-*Methyl*-4-*methylsulphinyl*-1-*phenylpyrazol*-5-*yl Dimethylcarbamate*.—Prepared similarly by oxidation of 3-methyl-4-methylthio-1-phenylpyrazol-5-yl dimethylcarbamate, the *product* (78%) had m.p. 107—108° (from carbon tetrachloride) (Found: C, 55·0; H, 5·6; N, 13·9. $C_{14}H_{17}N_3O_3S$ requires C, 54·8; H, 5·6; N, 13·7%).

1,3-*Dimethyl*-4-*methylsulphonylpyrazol*-5-*yl Dimethylcarbamate*.—To a solution of 1,3-dimethyl-4-methylthiopyrazol-5-yl dimethylcarbamate (3·0 g., 0·013 mole) in glacial acetic acid (18 ml.) maintained at 20° by water-bath cooling, was added with stirring a solution of potassium permanganate (2·7 g., 0·017 mole) in water (50 ml.) during 1 hr. Sulphur dioxide was then passed into the solution until it became colourless; it was then poured into water (150 ml.), neutralised with an excess of solid sodium hydrogen carbonate, and extracted with chloroform (3 × 25 ml.). The combined extracts were dried ($MgSO_4$) and evaporated, and the residue gave the *product* (2·85 g., 83%) as colourless prisms, m.p. 139—140° (from benzene–light petroleum) (Found: C, 41·6; H, 5·68; N, 16·2. $C_9H_{15}N_3O_4S$ requires C, 41·4; H, 5·75; N, 16·1%), $\nu_{max.}$ (Nujol) 1755s, 1300s, and 1140s cm.$^{-1}$, τ 6·37 (3H, s), 6·9 and 7·0 (6H, two singlets, Me_2N), 7·0 (3H, s), and 7·65 (3H, s).

3-*Methyl*-4-*methylsulphonyl*-1-*phenylpyrazol*-5-*yl Dimethylcarbamate*.—Prepared by similar oxidation of 3-methyl-4-methylthio-1-phenylpyrazol-5-yl dimethylcarbamate with potassium permanganate, the *product* (85%) had m.p. 134—135° (from ethanol) (Found: C, 51·8; H, 5·35; N, 13·1. $C_{14}H_{17}N_3O_4S$ requires C, 52·0; H, 5·25; N, 13·05%).

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