Reactions of Nucleophiles with Some *N*-Methyl-1,2,4-thiadiazolium Salts

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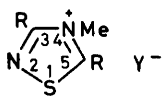
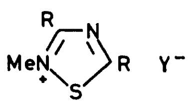
N-Methyl salts were prepared from 3,5-disubstituted 1,2,4-thiadiazoles, the position of methylation was established (N-2 or N-4), and the reactions of the salts with a variety of oxygen, sulphur, nitrogen, and carbon nucleophiles were studied. Initial attack took place either at carbon (predominantly C-5) or at sulphur (S-1), depending on the nature of the nucleophile employed.

FOLLOWING studies of the reactions of nucleophiles with 3-alkylthiazolium [1-3] and 2-alkylisothiazolium [4] salts, we have investigated the behaviour of *N*-methyl-1,2,4-thiadiazolium salts (1)—(3). These are formally related to *N*-alkylthiazolium or *N*-alkylisothiazolium salts, depending on whether methylation occurs at N-4 or N-2, respectively.

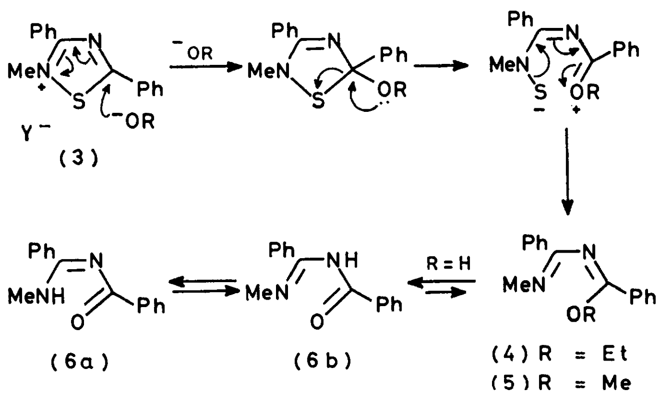


(1) R = Me
(2) R = Ph



(3) R = Ph

Methylation of Thiadiazoles.—3,5-Dimethyl-1,2,4-thiadiazole [5] has been methylated [6] in low yield with methyl iodide but the position of methylation was not established. Use of methyl fluorosulphate increased the yield considerably, and the position of methylation was established [through reaction with hydrazine (see below)] as N-4 [structure (1)]. Similar treatment of 3,5-diphenyl-1,2,4-thiadiazole [7] yielded a mixture of both *N*-methylated products, (2) and (3), in the ratio *ca.* 1 : 4. The salts (2 and 3; Y = SO_3F), were, after separation, converted by long heating in propan-2-ol into the corresponding isopropyl sulphates (2 and 3; Y = OSO_2OCHMe_2), thereby greatly increasing their solubility. The position of methylation in (2) and (3) was established through *X*-ray crystal structure determination [8] of the product of ethoxide ion attack on one of them. The shift in



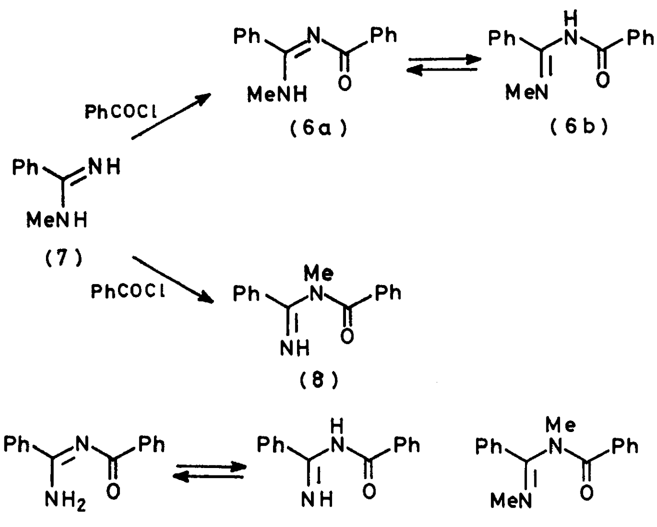
SCHEME 1

position of methylation from N-4 in (1) to predominantly N-2 in (3) presumably stems from the electronic,

[1] J. E. Downes and P. Sykes, *Chem. and Ind.*, 1959, 161.
[2] G. M. Clarke and P. Sykes, (*a*) *Chem. Comm.*, 1965, 370; (*b*) *J. Chem. Soc.* (*C*), 1967, 1269; (*c*) *ibid.*, p. 1411.
[3] Y. Gelernt and P. Sykes, *J.C.S. Perkin I*, 1974, 2610.
[4] P. Sykes and H. Ullah, (*a*) *J.C.S. Perkin I*, 1972, 2305; (*b*) *Chem. and Ind.*, 1973, 1162.
[5] J. Goerdler and H. Porrmann, *Chem. Ber.*, 1962, **95**, 627.
[6] J. Goerdler and H. Hammen, *Chem. Ber.*, 1964, **97**, 1134.
[7] A. W. Hofmann and S. Gabriel, *Ber.*, 1892, **25**, 1578.
[8] P. G. Jones and O. Kennard, *Acta Cryst.*, 1977, **B33**, 627.

and particularly steric, effects of the two bulky phenyl groups flanking N-4 in 3,5-diphenyl-1,2,4-thiadiazole.

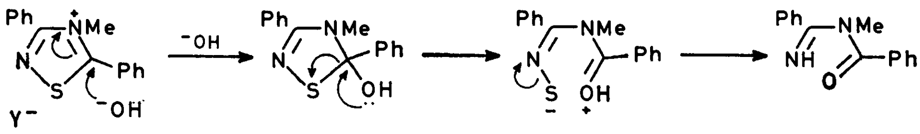
Reactions with Oxygen Nucleophiles.—The salt (3) reacted with ethoxide ion at room temperature to yield the ring-opened product (4), whose structure was determined by *X*-ray crystallographic analysis.[8] Similar treatment with methoxide ion led to the corresponding



(6a) (6b) (7) (8) (9a) (9b) (10)

methoxy-compound (5), while hydroxide ion yielded the benzoylamidine (6) as the major product; sulphur was also obtained. These products are all compatible with initial nucleophilic attack at C-5 (Scheme 1).

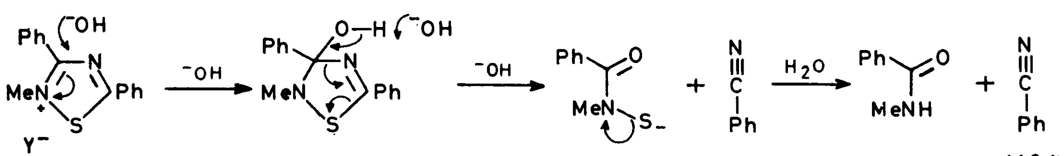
The structure (6) was established by benzoylation of



(2) (8)

SCHEME 2

N-methylbenzamidine[9] (7) and comparison of the u.v. spectra of the two isomeric benzoyl derivatives thus obtained with the u.v. spectra of *N*-benzoylbenzamidine[10] (9) and *N*-methyl-*N*-(*N*-methylbenzimidoyl)-benzamide (10). One of the two benzoyl derivatives from (7) was identical with the product obtained from the action of hydroxide ion on (3). It exhibited u.v.



(3) (11) (12) (13)

SCHEME 3

[9] F. L. Pyman, *J. Chem. Soc.*, 1923, **123**, 3359.

[10] A. W. Titherley and E. C. Hughes, *J. Chem. Soc.*, 1911, **99**, 1493.

absorption maxima at 238 and 275 nm, arising from the tautomers (6a) and (6b); behaviour paralleled by that of *N*-benzoylbenzamidine, (9a) ⇌ (9b), which absorbed at 249 and 281 nm. By contrast, the second benzoyl derivative from (7), *i.e.* (8), in which tautomeric equilibration analogous to that in (6) and (9) cannot occur, exhibited u.v. absorption at 239 nm only; behaviour paralleled by that of the similarly 'locked' structure (10), which absorbed at 244 nm only.

The second benzoyl derivative (8) was, however, identical with the product obtained from the action of hydroxide ion on the 4-methyl salt (2). This product is also compatible with initial nucleophilic attack at C-5 (Scheme 2).

Attack of hydroxide ion on (3) yielded, in addition to (6) and sulphur, *N*-methylbenzamide (12) and benzonitrile (13). These products were not obtained, under the conditions of the reaction, by the action of aqueous base on the first-formed benzoylamidine (6), thus suggesting initial nucleophilic attack at C-3 (Scheme 3), in addition to that at C-5.

No such fragmentation occurred with ethoxide or methoxide ions, suggesting the need to establish a negative charge on oxygen, *e.g.* in (11), the presence of a lone pair, as in Scheme 2, not in itself being sufficient to effect fragmentation.

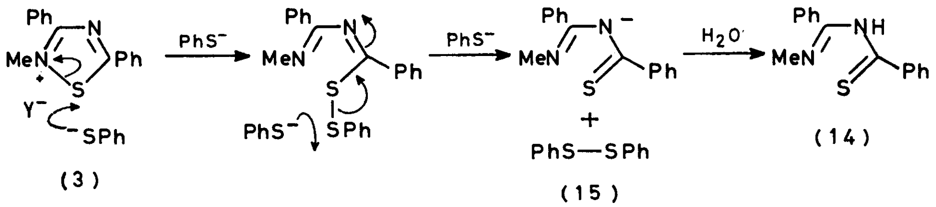
Finally, attack of hydroxide ion on (3) also yielded a small quantity of (14), the thio-analogue of (6). This product was not obtained, under the conditions of the reaction, by the action of sulphur or sulphide ion on the first-formed benzoylamidine (6), thus suggesting a small amount of initial nucleophilic attack at the sulphur atom, as occurred with sulphur nucleophiles.

Reactions with Sulphur Nucleophiles.—The salt (3) reacted with sodium sulphide, sodium thiosulphate, and sodium benzenethiolate to yield, in each case, the thiobenzoylamidine (14) as the only product derived from (3). The unlikelihood of the phenyl group being detached from the sulphur atom in the benzenethiolate anion suggests strongly that the sulphur atom in (14) is the one originally present in (3), and that initial attack by the sulphur nucleophiles is thus at the sulphur atom (Scheme 4).

Reaction with Borohydride Ion.—Initial nucleophilic attack at sulphur also occurred with borohydride ion to yield (**14**) directly, and as the only detectable product.

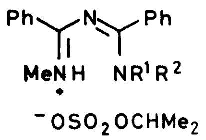
Reactions with Nitrogen Nucleophiles.—With primary

sulphur atom to yield the thiocyanate (**27**), but on attempted recrystallisation this cyclised, *via* isomerisation to the isothiocyanate, to yield the triazinethione [13] (**28**) (Scheme 6).



SCHEME 4

and secondary amines initial nucleophilic attack on (**3**) again took place at C-5 to yield analogues of (**6**), *i.e.* the salts (**16**)—(**18**). No reaction took place with tertiary

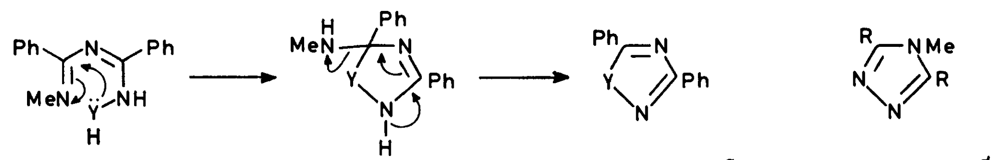


(16) R^1 = H, R^2 = Ph
(17) R^1 = H, R^2 = $PhCH_2$
(18) R^1R^2 = $[CH_2]_5$

amines. With hydrazines and hydroxylamine similar initial attack took place on (**3**), but cyclisation then occurred with elimination of the NMe group of the original ring system (Scheme 5).

By contrast, initial attack on (**3**) by the dicyanomethanide anion took place at C-5. Sulphur was eliminated but the expected product (**29**) underwent cyclisation to yield the dihydropyrimidine (**30**). Treatment of (**30**) with further dicyanomethanide anion (or use of more than one mol. equiv. of anion on the starting material) resulted in ring-opening and subsequent closure to yield the aromatised primidine (**31**) (Scheme 7). This conversion of (**30**) into (**31**) could also be effected by aqueous base.

General support for the above formulation is provided by n.m.r. spectra. The yellow compound (**30**) exhibits an NH proton exchangeable in deuterium oxide and an



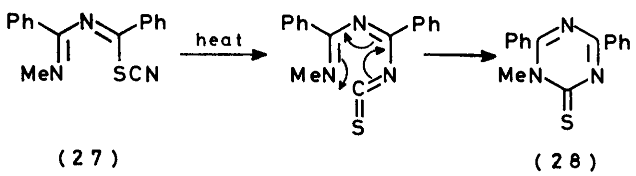
(19) Y = NH
(20) Y = NPh
(21) Y = O

(22) Y = NH [a]
(23) Y = NPh [b]
(24) Y = O [c]

(25) R = Ph [d]
(26) R = Me [e]

SCHEME 5 [a] Ref. 17. [b] Ref. 18. [c] Ref. 19. [d] Ref. 11. [e] Ref. 12

The 4-methyl salt (**2**) was much less reactive towards hydrazine than was (**3**), but in dimethyl sulphoxide yielded the *N*-methyltriazole [11] (**25**) *via* ring-opening



SCHEME 6

and subsequent closure with elimination of ammonia (Scheme 5). The *N*,3,5-trimethyl-1,2,4-thiadiazolium salt yielded similarly the 3,4,5-trimethyltriazole [12] (**26**), thereby establishing the position of original methylation as N-4 [structure (**1**)].

Reactions with Carbon Nucleophiles.—With cyanide ion initial nucleophilic attack on (**3**) took place at the

$N{\cdot}CH_3$ singlet, whereas the colourless compound (**31**) exhibits the $N{\cdot}CH_3$ signal as a doublet, which collapses to a singlet when the accompanying NH proton is exchanged in deuterium oxide. An identical rearrangement of closely similar *N*-methylpyrimidine imines has been observed previously.[14]

Conclusion.—Initial nucleophilic attack on the 2-methyl salt (**3**) follows a general pattern of attack by 'hard' nucleophiles [15] at carbon and 'soft' ones at sulphur. The carbon atom attacked is C-5 except that the 'hardest' nucleophile, hydroxide ion, attacks at C-3 also (in addition, there is a very small amount of attack by this nucleophile at sulphur). The only exception to the above pattern is the dicyanomethanide anion which might have been expected, as a 'soft' nucleophile, to attack at sulphur but which actually attacked at C-5: this may result from the cyclisation possibilities that then become available.

[11] E. Brunn, E. Funke, H. Gotthardt, and R. Huisgen, *Chem. Ber.*, 1971, **104**, 1562.

[12] (*a*) G. F. Duffin, J. D. Kendall, and H. R. J. Waddington, *Chem. and Ind.*, 1954, 1458; (*b*) R. Jacquier, M-L. Roumestant, and P. Viallefont, *Bull. Soc. chim. France*, 1967, 2630.

[13] J. Neuffer and J. Goerdler, *Chem. Ber.*, 1972, **105**, 3138.

[14] H. C. Carrington, F. H. S. Curd, and D. N. Richardson, *J. Chem. Soc.*, 1955, 1858.

[15] J. O. Edwards and R. G. Pearson, *J. Amer. Chem. Soc.*, 1962, **84**, 19.

EXPERIMENTAL

M.p.s were obtained with a Kofler hot-stage apparatus. I.r. spectra were obtained with a Perkin-Elmer 157G instrument; n.m.r. spectra with a Varian HA 100, Perkin-Elmer R12B, or Hitachi–Perkin-Elmer R24A instrument {tetramethylsilane [$CDCl_3$, $(CD_3)_2SO$, or $(CD_3)_2CO$] or 2-methylpropan-2-ol (D_2O) as internal standard}; mass spectra with an A.E.I. MS 30 instrument. T.l.c. was performed on silica gel 60 F_{254} plates (0.25 mm), and short column chromatography on Reeve Angel silica gel S13F TLC.

Methylation of Thiadiazoles.—(a) *3,5-Diphenyl-1,2,4-thiadiazole*. Methyl fluorosulphate (27.6 g, 0.24 mol) was added to 3,5-diphenyl-1,2,4-thiadiazole [7] (19.04 g, 0.08 mol) in dry carbon tetrachloride (150 ml), and the solution heated under reflux for 3 h. The separated solid was filtered off, washed with dry carbon tetrachloride, and dried under vacuum. An n.m.r. spectrum [$(CD_3)_2SO$] exhibited two methyl signals (τ 5.65 and 6.03) in the ratio 4 : 1.

Extraction with hot propan-2-ol (150 ml) yielded an insoluble residue of *4-methyl-3,5-diphenyl-1,2,4-thiadiazolium fluorosulphate* (2; Y = SO_3F) (2.4 g, 9%), m.p. 218—221° (from methanol) (Found: C, 51.0; H, 3.95; N, 7.8. $C_{15}H_{13}S_2N_2O_3F$ requires C, 51.1; H, 3.7; N, 7.9%), τ [$(CD_3)_2SO$] 2.0—2.4 (10 H, m, 2 × Ph), 6.03 (3 H, s, $^+NCH_3$); *picrate*, m.p. 174—175° (from methanol). Long refluxing of (2; Y = SO_3F) with propan-2-ol ultimately effects dissolution with the formation of the thiadiazolium isopropyl sulphate (2; Y = OSO_2OCHMe_2), m.p. 105—109° (from ethanol–ether) (Found: C, 54.7; H, 5.2; N, 7.0. $C_{18}H_{20}N_2S_2O_4$ requires C, 55.1; H, 5.1; N, 7.1%), τ ($CDCl_3$) 1.8—2.6 (10 H, m, 2 × Ph), 5.54 (1 H, septet, *J* 6 Hz, CH), 5.90 (3 H, s, $^+NCH_3$), and 8.83 (6 H, d, *J* 6 Hz, 2 × CH_3).

Concentration of the original propan-2-ol filtrate yields *2-methyl-3,5-diphenyl-1,2,4-thiadiazolium fluorosulphate* (3; Y = SO_3F) (9.7 g, 34%), m.p. 168—171° (from ethanol) (Found: C, 51.1; H, 3.95; N, 7.8. $C_{15}H_{13}N_2O_3S_2F$ requires C, 51.1; H, 3.7; N, 7.9%), τ [$(CD_3)_2SO$] 1.6—2.4 (10 H, m, 2 × Ph), 5.64 (3 H, s, $^+NCH_3$); *picrate*, m.p. 1.6—2.4 (10 H, m, 2 × Ph), 5.64 (3 H, s, $^+NCH_3$); *picrate*, m.p. 171—172° (from ethanol); *isopropyl sulphate* (3; Y = OSO_2OCHMe_2), m.p. 121—122° (from acetone–ether) (Found: C, 54.9; H, 5.2; N, 7.1. $C_{18}H_{20}N_2S_2O_4$ requires C, 55.1; H, 5.1; N, 7.1%), τ ($CDCl_3$) 1.8—2.6 (10 H, m, 2 × Ph), 5.46 (1 H, septet, *J* 6 Hz, CH), 5.50 (3 H, s, $^+NCH_3$), 8.83 (6 H, d, *J* 6 Hz, 2 × CH_3).

(b) *3,5-Dimethyl-1,2,4-thiadiazole*.[6] Similar treatment with methyl fluorosulphate at room temperature yielded *3,4,5-trimethyl-1,2,4-thiadiazolium fluorosulphate* (1; Y = SO_3F) (60%), m.p. 175—176° (decomp.) (from ethanol) (Found: C, 26.2; H, 3.95; N, 12.3. $C_5H_9FN_2S_2O_3$ requires C, 26.3; H, 3.95; N, 12.3%), τ (D_2O) 6.03 (3 H, s), 6.98 (3 H, s), and 7.24 (3 H, s); *picrate*, m.p. 119—120° (from ethanol).

Action of Oxygen Nucleophiles.—(a) *Ethoxide ion*. Sodium ethoxide (0.204 g, 3 mmol) in ethanol (3 ml) was added to 2-methyl-3,5-diphenyl-1,2,4-thiadiazolium fluorosulphate (3; Y = SO_3F) (0.352 g, 1 mmol) in ethanol (15 ml). The solution was filtered through Celite, and the solvent removed under reduced pressure to yield an oil, which t.l.c. showed to contain only one major constituent, R_F 0.4 [methanol–dichloromethane (1 : 9)]. Part was chromatographed [short column; methanol–dichloromethane (7 : 93)] to yield *ethyl* N-(N-*methylbenzimidoyl*)*benzimidate* (4) (17%) (Found: C, 76.2; H, 6.95; N, 10.1. $C_{17}H_{18}N_2O$ requires C, 76.7; N, 6.8; N, 10.5%), *m/e* 266 (M^+, 25%), τ ($CDCl_3$) 2.0—2.8 (10 H, m, 2 × Ph), 5.47 (2 H, q, *J* 7 Hz, CH_2), 6.95 (3 H, s, NCH_3), 8.44 (3 H, t, *J* 7 Hz, CH_3).

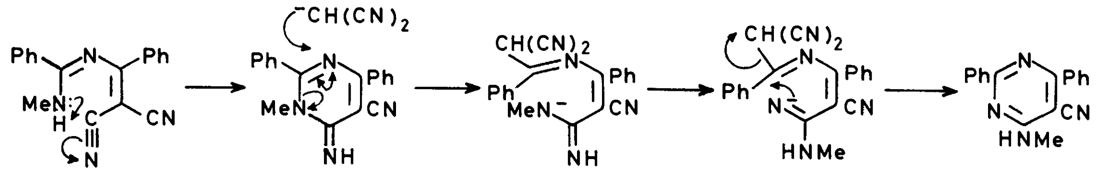
The residual oil was converted into the *picrate* (52%), m.p. 180—181° (from ethanol) (Found: C, 55.7; H, 4.3; N, 14.4. $C_{23}H_{21}N_5O_8$ requires C, 55.7; H, 4.25; N, 14.1%). A sample of this material was submitted for *X*-ray crystallographic analysis.[8]

(b) *Methoxide ion*. Similar treatment of (3; Y = SO_3F) with sodium methoxide in methanol yielded *methyl* N-(N-*methylbenzimidoyl*)*benzimidate* (5) (41%) (Found: C, 75.8; H, 6.45; N, 11.0. $C_{16}H_{16}N_2O$ requires C, 76.2; H, 6.35; N, 11.1%), *m/e* 252 (M^+, 20%), τ ($CDCl_3$) 2.0—3.0 (10 H, m, 2 × Ph), 5.97 (3 H, s, OCH_3), and 7.02 (3 H, s, NCH_3); *picrate*, m.p. 170—171° (from methanol).

(c) *Hydroxide ion*. (i) *2-Methyl-3,5-diphenyl-1,2,4-thiadiazolium isopropyl sulphate* (3; Y = OSO_2OCHMe_2). Sodium hydroxide (0.36 g, 9 mmol) in water (5 ml) was added dropwise to a stirred solution of (3; Y = OSO_2OCHMe_2) (1.176 g, 3 mmol) in water (5 ml). The mixture was extracted with chloroform; the extracts were washed with water, dried ($MgSO_4$), and evaporated under reduced pressure to yield a residue which on dilution with chloroform (3 ml) deposited sulphur (0.04 g, 44%). The orange oil obtained after removal of sulphur was chromatographed on a short column [ethyl acetate–light petroleum (b.p. 60—80 °C) (3 : 7)] to yield (i) *N*-methylbenzamide (12) (0.154 g, 38%), m.p. and mixed m.p. 80—81°; (ii) *N*-(*N*-methylbenzimidoyl)benzamide (6) (0.217 g, 30%), m.p. and mixed m.p. 136—137°; (iii) *N*-(*N*-methylbenzimidoyl)thiobenzamide (14) (0.037 g, 5%), m.p. and mixed m.p. 142—143°. High pressure liquid chromatography of the original chloroform extract also established the presence of benzonitrile (13) [retention time 5 min, 30 × 0.25 cm Bondapak-CN column; dichloromethane–hexane (1 : 19); 1.5 ml min^{-1} flow rate].

(ii) *4-Methyl-3,5-diphenyl-1,2,4-thiadiazolium fluorosulphate* (2; Y = SO_3F). Similar treatment of (2; Y = SO_3F) yielded an oil which was shown by t.l.c. to contain two main constituents [R_F 0.2 and 0.5; ethyl acetate–light petroleum (b.p. 60—80 °C) (4 : 6)]. Short column chromatography yielded *N*-benzimidoyl-*N*-methylbenzamide (8) (7%), m.p. and mixed m.p. 124—125°. The R_F 0.5 fraction is a mixture and has as yet resisted separation.

Benzoylation of N-*Methylbenzamidine*.—Benzoyl chloride



(29) (30) (31)

SCHEME 7

(0.78 g, 5.57 mmol) in dry ether (20 ml) was added over 30 min to a stirred, cooled solution of *N*-methylbenzamidine [9] (7) (1.50 g, 11.2 mmol) in dry ether (100 ml). *N*-Methylbenzamidine hydrochloride was filtered off and the solvent was removed from the filtrate under reduced pressure. T.l.c. demonstrated the presence of two major components, R_F 0.55 (i) and 0.65 (ii) [methanol–chloroform (1 : 9)]. Separation by short column chromatography yielded (i) N-(N-*methylbenzimidoyl*)*benzamide* (6) (0.13 g, 10%), m.p. 136—137° (from ethyl acetate) (Found: C, 75.4; H, 6.15; N, 11.9. $C_{15}H_{14}N_2O$ requires C, 75.6; H, 5.9; N, 11.8%), *m/e* 238 (M^+, 55%), $\lambda_{max.}$ (EtOH) 238 and 275 nm (ε 17 650 and 12 900), τ ($CDCl_3$) 1.5—3.5 (11 H, m, 2 × Ph and NH, exchangeable with D_2O) and 6.96 (3 H, s, NCH_3); and (ii) N-*benzimidoyl*-N-*methylbenzamide* (8) (0.26 g, 20%), m.p. 124—126° (from ethyl acetate) (Found: C, 75.6; H, 6.0; N, 11.7. $C_{15}H_{14}N_2O$ requires C, 75.6; H, 5.9; N, 11.8%) *m/e* 238 (M^+, 20%), $\lambda_{max.}$ (EtOH) 239 nm (ε 13 250), τ ($CDCl_3$) 2.4—3.2 (11 H, m, 2 × Ph and NH, exchangeable with D_2O) and 6.48 (3 H, s, NCH_3).

N-Benzoylbenzamidine [10] (9) had m.p. 104—105° [from light petroleum (b.p. 60—80 °C)] (lit.,[10] 98°) (Found: C, 74.9; H, 5.5; N, 12.3. Calc. for $C_{14}H_{12}N_2O$: C, 75.0; H, 5.35; N, 12.5%), $\lambda_{max.}$ (EtOH) 249 and 281 nm (ε 13 300 and 19 000).

N-*Methyl*-N-(N-*methylbenzimidoyl*)*benzamide* (10).—Benzoyl chloride (0.251 g, 1.79 mmol) was added dropwise to a stirred solution of *NN'*-dimethylbenzamidine hydrochloride [16] (0.66 g, 3.58 mmol) and sodium hydroxide (0.143 g, 3.58 mmol) in water (15 ml). After shaking (15 min) the mixture was extracted with chloroform. The extracts were washed with water, dried ($MgSO_4$), and evaporated under reduced pressure to yield an oil, which t.l.c. showed to contain one major constituent: R_F 0.4 [methanol–chloroform (1 : 99)]. Short column chromatography [methanol–chloroform (1 : 199)] yielded *N methyl*-N-(N-*methylbenzimidoyl*)*benzamide* (0.100 g, 23%), m.p. 120—121° [from light petroleum (b.p. 60—80 °C)] (Found: C, 76.1; H, 6.55; N, 10.9. $C_{16}H_{16}N_2O$ requires C, 76.2; H, 6.35; N, 11.1%), *m/e* 252 (M^+, 15%), $\lambda_{max.}$ (EtOH) 244 nm (ε 14 800), τ ($CDCl_3$) 2.0—3.0 (10 H, m, 2 × Ph), 6.77 (3 H, s), and 6.86 (3 H, s); *picrate*, m.p. 126—127° (from ethanol).

Action of Sulphur Nucleophiles.—(a) *Benzenethiolate ion*. Sodium benzenethiolate (0.132 g, 1 mmol) in ethanol (1 ml) was added to 2-methyl-3,5-diphenyl-1,2,4-thiadiazolium isopropyl sulphate (3; Y = OSO_2OCHMe_2) (0.098 g, 0.25 mmol) in ethanol (3 ml). T.l.c. showed the presence of diphenyl disulphide (15) and one other constituent only: R_F 0.5 [methanol–dichloromethane (3 : 97)]. The solvent was removed under reduced pressure, the residue partioned between water and chloroform, the chloroform extract dried ($MgSO_4$), and the solvent removed under reduced pressure. The resultant orange oil, on trituration with diethyl ether–light petroleum (b.p. 60—80 °C) (1 : 1) yielded N-(N-*methylbenzimidoyl*)*thiobenzamide* (14) as orange prisms (0.04 g, 63%), m.p. 142—143° (from ethyl acetate) (Found: C, 70.8; H, 5.7; N, 11.2. $C_{15}H_{14}N_2S$ requires C, 70.9; H, 5.5; N, 11.0%), *m/e* 254 (M^+, 85%), $\lambda_{max.}$ (EtOH) 258 and 354 nm (ε 16 900 and 5 200), τ ($CDCl_3$) 1.6—2.8 (11 H, m, 2 × Ph and NH) and 6.87 (3 H, s, NCH_3).

(b) *Sodium sulphide*. Similar reaction of (3; Y = OSO_2-$OCHMe_2$) yielded (14) (61%).

[16] S. J. Angyal and W. K. Warburton, *Austral. J. Sci. Res. (A)*, 1951, **4**, 93.

(c) *Sodium thiosulphate*. Similar reaction of (3; Y = SO_3F) yielded (14) (47%).

Action of Borohydride Ion.—Reaction of (3; Y = OSO_2-$OCHMe_2$) in methanol yielded (14) (55%).

Action of Nitrogen Nucleophiles.—(a) *Aniline*. Aniline (0.279 g, 3 mmol) in ethanol (3 ml) was added dropwise to stirred 2-methyl-3,5-diphenyl-1,2,4-thiadiazolium isopropyl sulphate (3; Y = OSO_2OCHMe_2) (0.392 g, 1 mmol) in ethanol (10 ml). Sulphur (0.029 g, 91%) was removed and the filtrate evaporated under reduced pressure to give an oil which on trituration with diethyl ether yielded N-(N-*methylbenzimidoyl*)-N'-*phenylbenzamidinium isopropyl sulphate* (16) (0.296 g, 65%), m.p. 182—183° (from ethanol–diethyl ether) (Found: C, 63.6; H, 6.1; N, 9.4. $C_{24}H_{27}$-N_3SO_4 requires C, 63.6; H, 5.95; N, 9.3%), τ ($CDCl_3$) −0.8br (1 H, s, NHPh, exchangeable with D_2O), 0 (1 H, q, $NHCH_3$, exchangeable with D_2O), 2.2—2.9 (15 H, m, 3 × Ph), 5.60 (1 H, septet, *J* 6 Hz, CH), 6.89 (3 H, d, *J* 5 Hz, NH·CH_3, collapses to singlet on exchange with D_2O), and 8.90 (6 H, d, *J* 6 Hz, 2 × CH_3).

(b) *Benzylamine*. Similar treatment of (3) with benzylamine yielded N-*benzyl*-N'-(N-*methylbenzimidoyl*)*benzamidinium isopropyl sulphate* (17) (53%), m.p. 129—131° (from ethanol–ether) (Found: C, 64.4; H, 6.2; N, 9.1. $C_{25}H_{29}$-N_3SO_4 requires C, 64.2; H, 6.2; N, 9.0%).

(c) *Piperidine*. Similar treatment of (3) with piperidine yielded N-(N-*methylbenzimidoyl*)-N'-*piperidinobenzamidinium isopropyl sulphate* (18) (65%), m.p. 155—158° (from ethanol–ether) (Found: C, 61.8; H, 7.05; N, 9.5. $C_{23}H_{31}$-N_3SO_4 requires C, 62.0; H, 7.0; N, 9.4%).

(d) *Hydrazine*. (i) 2-*Methyl*-3,5-*diphenyl*-1,2,4-*thiadiazolium isopropyl sulphate* (3; Y = OSO_2OCHMe_2). Hydrazine hydrate (0.075 g, 1.5 mmol) in ethanol (1 ml) was added dropwise to a stirred solution of (3) (0.588 g, 1.5 mmol) in ethanol (5 ml). Sulphur (0.04 g, 80%) was removed, and the filtrate evaporated under reduced pressure to yield a solid containing one major product only [t.l.c. R_F 0.4 in methanol–chloroform (3 : 97)]. Short column chromatography yielded 3,5-diphenyl-1,2,4-triazole (22) (0.253 g, 76%), m.p. 192—193° [from ethyl acetate–light petroleum (b.p. 60—80 °C)] (lit.,[17a] 190°) (Found: C, 75.9; H, 5.35; N, 18.9. Calc. for $C_{14}H_{11}N_3$: C, 76.0; H, 5.0; N, 19.0%). The n.m.r.[17b] and mass [17c] spectra were identical with those reported.

(ii) 4-*Methyl*-3,5-*diphenyl*-1,2-4-*thiadiazolium fluorosulphate* (2; Y = SO_2F). Similar treatment in dimethyl sulphoxide and pouring into water yielded 4-methyl-3,5-diphenyl-4*H*-1,2,4-triazole (25) (63%), m.p. 249—250° (vac. sublimation at 160° and 10^{-3} mmHg) (lit.,[11] 249—250°) (Found: C, 76.7; H, 5.6; N, 17.9. Calc. for $C_{15}H_{13}N_3$: C, 76.6; H, 5.5; N, 17.9%), *m/e* 235 (M^+, 90%).

(iii) 3,4,5-*Trimethyl*-1,2,4-*thiadiazolium ethyl sulphate* (1; Y = OSO_2OEt). Similar treatment in ethanol yielded 3,4,5-trimethyl-4*H*-1,2,4-triazole (26) as a trihydrate (26%), m.p. 93—94° (lit.,[12a] 94°), which on vac. sublimation (130 °C and 10^{-3} mmHg) yielded the anhydrous triazole, m.p. 175—176° (lit.,[12a] 178°), τ (CF_3CO_2D) 6.14 (3 H, s, 4-CH_3) and 7.24 (6 H, s, 3, 5-CH_3); picrate, m.p. 183—184° (lit.,[12b] 184°) (Found: C, 38.8; H, 3.65; N, 24.9. Calc. for $C_{11}H_{12}$-N_6O_7: C, 38.8; H, 3.55; N, 24.7%).

(e) *Phenylhydrazine*. Similar treatment of (3) with phenylhydrazine yielded 1,3,5-triphenyl-1,2,4-triazole (23)

[17] (*a*) K. T. Potts, *J. Chem. Soc.*, 1954, 3461; (*b*) L. A. Lee and J. W. Wheeler, *J. Org. Chem.*, 1972, **37**, 348; (*c*) K. T. Potts, R. Armbruster, and E. Houghton, *J. Heterocyclic Chem.*, 1971, **8**, 773.

(59%), m.p. 104—105° (from methanol–water) (lit.,[18] 103—104°) (Found: C, 80.9; H, 5.0; N, 14.3. Calc. for $C_{20}H_{15}N_3$: C, 80.8; H, 5.05; N, 14.1%), *m/e* 297 (M^+, 55%).

(f) *Hydroxylamine*. Similar treatment of (3) with hydroxylamine yielded 3,5-diphenyl-1,2,4-oxadiazole (24) (61%), m.p. 108—109° (from methanol) (lit.,[19] m.p. 109°) (Found: C, 75.6; H, 4.8; N, 12.6. Calc. for $C_{14}H_{10}N_2O$: C, 75.7; H, 4.5; N, 12.6%). The mass spectrum [19] was identical with that reported.

Action of Carbon Nucleophiles.—(a) *Cyanide*. Sodium cyanide (0.054 g, 1 mmol) in water (3 ml) was added dropwise to stirred 2-methyl-3,5-diphenyl-1,2,4-thiadiazolium isopropyl sulphate (3; Y = OSO_2OCHMe_2) (0.392 g, 1 mmol) in water (3 ml). The separated solid was extracted into chloroform; the extracts were washed with water, dried ($MgSO_4$), and evaporated under reduced pressure to give a red oil which, on trituration with diethyl ether, yielded S-*cyano*-N-(N-*methylbenzimidoyl*)*thiobenzimidate* (27) as red platelets (0.192 g, 69%), m.p. 105—107° (decomp.) (Found: C, 68.5; H, 4.8; N, 15.1. $C_{16}H_{13}N_3S$ requires C, 68.8; H, 4.65; N, 15.0%), *m/e* 279 (M^+, 40%), 278 ($M - 1$, 50%), 135 ($PhCNS^+$, 50%), 121 ($PhCS^+$, 100%) 118 ($PhCNCH_3^+$, 90%), 103 ($PhCN^+$, 80%), and 77 (Ph^+, 90%), $\nu_{max.}$ ($CHCl_3$) 2 220 (C≡N) and 1 650 cm^{-1} (C=N), $\lambda_{max.}$ ($CHCl_3$) 291 nm (ε 15 600), τ ($CDCl_3$) 1.8—2.8 (10 H, m, 2 × Ph) and 6.46 (3 H, s, NCH_3).

Attempted recrystallisation of (27) from ethanol yielded 1-methyl-4,6-diphenyl-1,3,5-triazine-2(1*H*)-thione (28) as yellow needles (18%), m.p. 238—239° (lit.,[13] 240°) (Found: C, 68.9; H, 4.85; N, 15.0. Calc. for $C_{16}H_{13}N_3S$: C, 68.8; H, 4.65; N, 15.0%), *m/e* 279 (M^+, 60%) and 278 ($M - 1$, 100%), $\lambda_{max.}$ ($CHCl_3$) 296 and 370 nm (ε 33 100 and 2 400), τ ($CDCl_3$) 1.4—2.7 (10 H, m, 2 × Ph) and 6.11 (3 H, s, NCH_3).

(b) *Dicyanomethanide*. The sodium salt of malononitrile (0.114 g, 1.72 mmol) in ethanol (3 ml) was added dropwise to stirred 2-methyl-3,5-diphenyl-1,2,4-thiadiazolium isopropyl sulphate (3; Y = OSO_2OCHMe_2) (0.674 g, 1.72 mmol) in ethanol (3 ml); the precipitate was collected after 3 h. T.l.c. indicated two components: R_F 0.95 (i) and 0.4 (ii) [chloroform–methanol (97 : 3)]. Short column chromatography yielded (i) sulphur (0.03 g, 55%) and (ii) 3,4-*dihydro*-4-*imino*-3-*methyl*-2,6-*diphenylpyrimidine*-5-*carbonitrile* (30) as yellow plates (0.297 g, 60%), m.p. 188—189° (from ethanol) (Found: C, 75.8; H, 4.95; N, 19.7. $C_{18}H_{14}N_4$ requires C, 75.5; H, 4.9; N, 19.6%), *m/e* 286 (M^+, 40%), $\nu_{max.}$ ($CHCl_3$) 3 300 (NH) and 2 205 cm^{-1} (C≡N), τ ($CDCl_3$) 1.9—2.7 (10 H, m, 2 × Ph), 3.84br (1 H, s, NH, exchangeable with D_2O), and 6.44 (3 H, s, NCH_3).

Repetition of the above experiment but with 5 mmol of malononitrile anion yielded 4-*methylamino*-2,6-*diphenylpyrimidine*-5-*carbonitrile* (31) (60%), m.p. 221—222° (from methanol) (Found: C, 75.5; H, 5.15; N, 20.1. $C_{18}H_{14}N_4$ requires C, 75.5; H, 4.9; N, 19.6%), *m/e* 286 (M^+, 100%) and 285 ($M - 1$, 50%), $\nu_{max.}$ ($CHCl_3$) 3 440 (NH) and 2 205 cm^{-1} (C≡N), τ ($CDCl_3$) 1.3—2.6 (10 H, m, 2 × Ph), 4.20br (1 H, m, NH, exchangeable with D_2O), and 6.73 (3 H, d, *J* 5 Hz, NCH_3, collapses to singlet in D_2O).

The imine (30) was converted into the pyrimidine (31) on treatment with malononitrile anion or with aqueous base.

We thank the S.R.C. for an 'instant award' research studentship (to S. C.).

[7/340 *Received*, 25*th February*, 1977]

[18] H. Wolchowe, *Monatsh.*, 1916, **37**, 479.
[19] J. L. Cotter. *J. Chem. Soc.*, 1964, 5491.