Mesoionic Compounds derived from Pyrazole, Isothiazole, and Isoxazole

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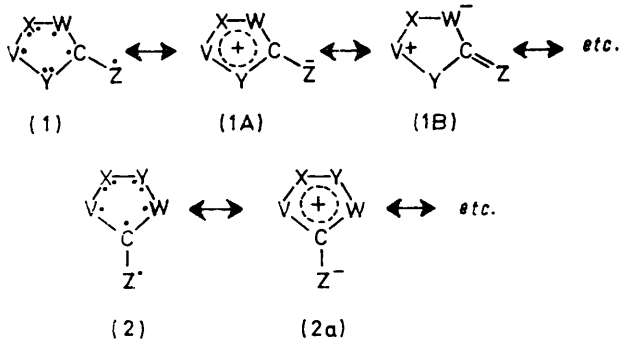
A number of novel mesoionic compounds related to dehydrodithizone (2,3-diphenyltetrazolium 5-sulphide) have been obtained by deprotonation of 2-methyl-4-methyl- (or 4-*p*-tolyl-)sulphonylamino-pyrazolium, -isothiazolium, and -isoxazolium perchlorates. The pyrazoliumsulphonamidates (9b) and (9c) rearrange to covalent amino-pyrazoles on thermolysis; a similar methyl migration occurs when 1,2-dimethyl-3,5-diphenylpyrazolium 4-oxide is heated. Attempted cycloaddition of the pyrazoliumsulphonamidates to dimethyl acetylenedicarboxylate resulted in the loss of an *N*-methyl group and formation of pyrazolylfumaric esters. Spectroscopic experiments indicate that whereas 2-methyl-3,5-diphenylisoxazolium 4-oxide (26) decomposes rapidly, the related 4-toluene-*p*-sulphonamidate (24) is stable in dilute solution.

MESOIONIC compounds containing a five-membered ring may be divided into two classes;[1] in the first, the hetero-atoms X and Y, each of which contributes two electrons, are non-adjacent [*cf.* (1)] and in the second (2) they are adjacent. Of the **144** possible systems in the first class the most familiar are the sydnones (3)[2] but many others are now known[3] and research in this field is being actively pursued, particularly since the realisation[4] that such compounds can function as 1,3-dipoles [*cf.* (1B)] in cycloaddition reactions. Much less is known about the **84** possible systems (not **144**, as stated by Bieber[1]) in the second class, although dehydrodithizone (4a),[5] the first mesoionic compound to be discovered, is of this type. The related tetrazolium oxide (4b) and benzoylimine (4c) were obtained many years ago[6] but to our knowledge the only other compounds in this group are the recently described dithiolium oxide (5)[7] and several pyrazolium

[1] T. I. Bieber, *Chem. and Ind.*, 1955, 1055.
[2] F. H. C. Stewart, *Chem. Rev.*, 1964, **64**, 129.
[3] W. Baker and W. D. Ollis, *Quart. Rev.*, 1957, **11**, 15; M. Ohta and H. Kato, in 'Nonbenzenoid Aromatics,' ed. J. P. Snyder, vol. 1, Academic Press, New York, 1969, p. 117.
[4] R. Huisgen and R. Grashey, *Angew. Chem.*, 1962, **74**, 29; R. Huisgen, H. Gotthardt, H. O. Bayer, and F. C. Schaefer, *Chem. Ber.*, 1970, **103**, 2611.
[5] E. Fischer and A. Besthorn, *Annalen*, 1882, **212**, 316.
[6] E. Bamberger, *Ber.*, 1911, **44**, 3743; E. Bamberger, R. Padova, and E. Ormerod, *Annalen*, 1926, **446**, 260.
[7] A. Schönberg and E. Frese, *Chem. Ber.*, 1970, **103**, 3885.

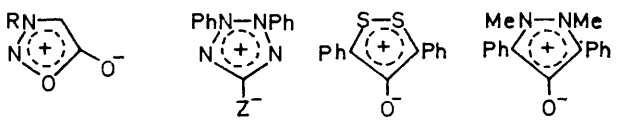
oxides, such as the dimethyldiphenyl derivative (6).[8] We now report the synthesis and chemistry of further



(1) (1A) (1B) etc.

(2) (2a) etc.

X,Y=O,S, or NR
V,W=CR or N
Z=O,S,NR or CRR'



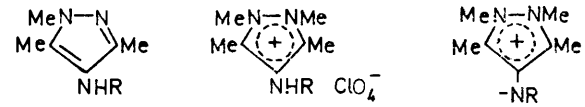
(3) (4) (5) (6)

a, Z=S
b, Z=O
c, Z=NBz

members of the dehydrodithizone family derived from pyrazole, isothiazole, and isoxazole.

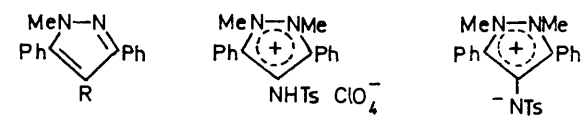
The sulphonamide (7b), obtained from 4-amino-1,3,5-trimethylpyrazole (7a) [9] and methanesulphonyl chloride, reacted with methyl fluorosulphonate in refluxing chloroform to give an oily salt which was converted into the crystalline perchlorate (8b) by treatment with perchloric acid. The n.m.r. spectrum of the salt showed that methylation had occurred on the cyclic (N^2) nitrogen atom since only three methyl singlets, corresponding respectively to the two equivalent *N*-methyl and *C*-methyl groups and the *S*-methyl substituent, were observed. Deprotonation of the perchlorate by potassium hydroxide gave the mesoionic pyrazolium sulphonamidate (9b). A similar sequence of reactions, starting with the toluene-*p*-sulphonamide (7c), yielded the analogue (9c). Condensation of isonitrosodibenzoylmethane with methylhydrazine gave the nitrosopyrazole (10a), which was reduced [9] to the amine (10b) by ethanolic hydrazine. The derived toluene-*p*-sulphonamide (10c) was converted successively into the perchlorate (11) and the pyrazolium sulphonamidate (12).

The mesoionic pyrazole derivatives (9b), (9c), and (12) are stable colourless solids. Their salt-like character is suggested by their high melting points and their insolubility in non-polar solvents. Their mass spectra indicated that they are monomeric and their i.r. and n.m.r. spectra are in accord with the assigned structures; in particular, the n.m.r. spectra show the equivalence of the *N*-methyl groups in all three compounds and that of the 3- and 5-methyl substituents in the first two. All the imines could be reconverted into the parent perchlorates by treatment with perchloric acid. Whereas the diphenylpyrazolium sulphonamidate (12) is thermally stable, the tetramethyl compounds (9b) and (9c) rearranged to the covalent sulphonamides (13a) and (13b), respectively, when boiled in benzonitrile for several hours. The structures of the products are based on their spectroscopic properties summarised in the Experimental section and, in the case of compound (13b), by an unambiguous synthesis from the sodium salt of the toluene-*p*-sulphonamide (7c) and dimethyl sulphate. The rearrangement is closely analogous to the migration of



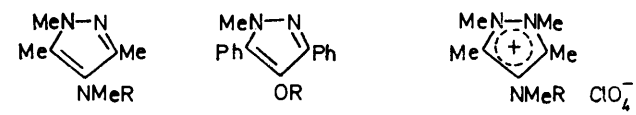
(7) (8) (9)

a; R=H
b; R=Ms*
c; R=Ts*



(10) (11) (12)

a; R=NO
b; R=NH_2
c; R=NHTs



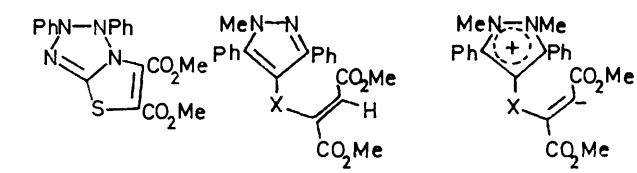
(13) (14) (15)

a; R=Ms
b; R=Ts

a; R=Me
b; R=H

a; R=Ms
b; R=Ts

* Ms=O_2SMe, Ts=$O_2S{\cdot}C_6H_4Me$-*p*



(16) (17) (18)

a; X=NTs
b; X=O

* Ms = O_2SMe, Ts = $O_2S{\cdot}C_6H_4Me$-*p*.

alkyl groups in pyrazoles from an endocyclic nitrogen atom to an exocyclic nitrogen or sulphur substituent [10]

[8] (*a*) M. J. Nye and W. P. Tang, *Tetrahedron*, 1972, **28**, 455; (*b*) M. J. Nye, M. J. O'Hare, and W. P. Tang, *J.C.S. Chem. Comm.*, 1973, 402.

[9] S. F. Torf, N. I. Kudryashova, N. V. Khromov-Borisov, and T. A. Mikhailova, *Zhur. obshchei Khim.*, 1962, **32**, 1740.

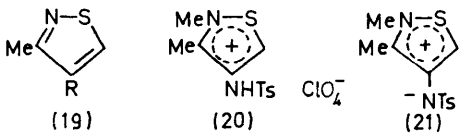
[10] A. Michaelis, A. Besson, W. Moeller, and M. Kober, *Annalen*, 1904, **331**, 197; A. Michaelis and A. Lachwitz, *Ber.*, 1910, **43**, 2106.

and has a parallel in the formation of 3-(2,4-dinitrophenoxy)pyridine from 1-(2,4-dinitrophenyl)pyridinium 3-oxide.[11] The pyrazolium oxide (6) similarly gave the rearranged ether (14a) when heated, but the yield was only 2% compared with 40—50% in the sulphonamidate rearrangements. The main product in this reaction was the 4-hydroxypyrazole (14b) (23%), resulting from thermal dealkylation, a behaviour typical of pyrazolium salts [12] which indicates the ionic character of the oxide.

The pyrazolium sulphonamidates (9b) and (9c) readily reacted with methyl fluorosulphonate to yield N^4-methylpyrazolium salts, isolated as the perchlorates (15a) and (15b), respectively; in the case of compound (12), however, methylation did not occur, possibly for steric reasons, and only the protonated salt (11) was obtained after the addition of perchloric acid.

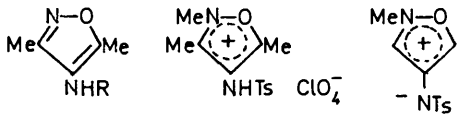
Dehydrodithizone has been reported [13] to undergo cycloaddition to a number of dipolarophiles, dimethyl acetylenedicarboxylate, for instance, yielding compound (16). We were unable to obtain analogous adducts from the attempted reactions of the pyrazolium sulphonamidates (9b), (9c), and (12) and the oxide (6) with diethyl maleate, diethyl fumarate, maleic anhydride, *N*-phenylmaleimide, or dimethyl acetylenedicarboxylate. When the acetylenic ester was heated with the sulphonamidate (12) and with the oxide (6) the demethylated products (17a) and (17b), respectively, were formed, which presumably exist in the *E*-configuration shown. The i.r. spectrum of compound (17a) exhibited ester carbonyl absorptions at 1710 and 1750 cm^{-1}, that of compound (17b) at 1715 and 1750 cm^{-1}. The n.m.r. spectrum of each product showed the presence of an olefinic proton and contained only three singlet methyl signals in the region 6—6·5 τ, indicating that one of the *N*-methyl groups had been lost. It is thought that the reactions proceed by initial formation of the adducts (18), as in the Michael addition of sodiomalonic esters to acetylenic esters,[14] followed by protonation and dealkylation of the resulting pyrazolium salts. An attempt to prepare compound (17a) by treatment of the sodium salt of the toluenesulphonamide (10c) with dimethyl acetylenedicarboxylate resulted in recovery of the starting materials.

We prepared a mesoionic isothiazole derivative, starting from 3-methylisothiazole (19a). Nitration, reduction,[15] toluene-*p*-sulphonation, and, finally, methylation gave successively compounds (19b—d) and (20). The salt was deprotonated with aqueous potassium hydroxide to yield the isothiazoliumsulphonamidate (21) as a pale yellow air-stable crystalline solid, which decomposed at its melting point and which, unlike the pyrazolium sulphonamidates, was only sparingly soluble in water or acetonitrile. It could not be methylated on the exocyclic nitrogen atom and attempted isomerisation in hot benzonitrile resulted in an intractable tar. It reacted with dimethyl acetylenedicarboxylate to give a complex mixture of at least four products, which could not be resolved by chromatography. Attempts to induce electrophilic substitution at the unsubstituted ring



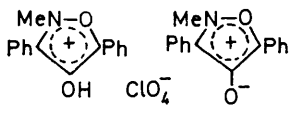
(19) (20) (21)

a; R = H
b; R = NO_2
c; R = NH_2
d; R = NHTs



(22) (23) (24)

a; R = H
b; R = Ts



(25) (26)

position with copper(II) nitrate–acetic anhydride, trifluoroacetic anhydride, or *p*-nitrobenzenediazonium fluoroborate were unsuccessful.

In the isoxazole series, the synthesis of the sulphonamidate (24) and of the oxide (26) was investigated. 4-Amino-3,5-dimethylisoxazole (22a) [16] was converted into the *p*-tolylsulphonyl derivative (22b) and thence into the salt (23), which required prolonged heating with methyl fluorosulphonate. The perchlorate was deprotonated by treatment with aqueous potassium hydroxide in acetonitrile but attempts to isolate the mesoionic sulphonimidate (24) from the resulting soution led to the formation of tars. However, the stability of the sulphonamidate in dilute solution could be demonstrated by spectroscopy (see the Table). The u.v. spectrum of a solution of the perchlorate (23) in acetonitrile

U.v. maxima of perchlorates and the corresponding mesoionic anhydro-bases

Compound	(8c)	(9c)	(11)	(12)	(20)	(21)	(23)	(24) [b]	(25) [c]
$\lambda_{max.}$/nm [a]	230	252	234	251	226, 270	221	230	250sh	233, 322

[a] In acetonitrile. [b] Spectrum of a solution of the salt after the addition of aqueous sodium hydroxide. After the addition of sodium hydroxide a band at 251 nm was observed.

had a maximum at 230 nm; after the addition of aqueous sodium hydroxide a different spectrum was observed ($\lambda_{max.}$ 250 nm), which we attribute to (24). The spec-

[11] N. Dennis, B. Ibrahim, A. R. Katritzky, and Y. Takeuchi, *J.C.S. Chem. Comm.*, 1973, 29.
[12] L. Balbiano and G. Marchetti, *Gazzetta*, 1893, **23**, 485; L. Knorr, *Ber.*, 1895, **28**, 714; K. von Auwers and W. Daniel, *J. prakt. Chem.*, 1925, **110**, 235.
[13] P. Rajagopalan and P. Penev, *Chem. Comm.*, 1971, 490.
[14] E. H. Farmer, S. C. Ghosal, and G. A. R. Kon, *J. Chem. Soc.*, 1936, 1804.
[15] A. Adams and R. Slack, *J. Chem. Soc.*, 1959, 3072.
[16] G. T. Morgan and H. Burgess, *J. Chem. Soc.*, 1921, **119**, 700.

trum of the alkaline solution did not change over 6 h and when the solution was then acidified with perchloric acid the spectrum of the original salt was reproduced with only a slight decrease (<5%) in the extinction coefficients.

Heating 4-acetoxy-3,5-diphenylisoxazole [17] with methyl fluorosulphonate and subsequent treatment with perchloric acid resulted in loss by hydrolysis of the acetyl group to form the hydroxyisoxazolium perchlorate (25). In the case of this salt, u.v. spectroscopy showed that deprotonation was irreversible. The spectrum obtained after a solution of the perchlorate had been treated with sodium hydroxide did not revert to that of the salt after acidification, even when perchloric acid was added immediately after basification. We conclude that the mesoionic oxide (26) is so unstable that the spectrum of the alkaline solution is that of its decomposition products. During the deprotonation experiments a transient yellow colour was observed which may be due to the isoxazolium oxide. Attempts to trap the oxide or the sulphonamidate (24) by carrying out the deprotonation of the corresponding salts in the presence of dimethyl acetylenedicarboxylate failed.

EXPERIMENTAL

Perchloric acid was of 72% strength; light petroleum refers to the fraction of b.p. 40—60°. I.r. spectra were determined for Nujol mulls unless stated otherwise and n.m.r. spectra were recorded at 60 MHz unless stated otherwise.

1,3,5-*Trimethyl*-4-*methylsulphonylaminopyrazole* (7b).—Methanesulphonyl chloride (7·0 g) was slowly added to an ice-cold solution of 4-amino-1,3,5-trimethylpyrazole (7a) [9] (7·0 g) in dry pyridine (70 ml). The resulting solution was stirred at room temperature for 3 h and then poured into water (300 ml). The mixture was extracted with chloroform (2 × 250 ml) and the combined extracts were washed successively with 2N-hydrochloric acid (2 × 50 ml) and water (2 × 50 ml) and then dried ($MgSO_4$). Removal of the solvent left the *product* (7b) (7·0 g, 61%), m.p. 115—117° (from ethanol), $\nu_{max.}$ (KBr) 3140, 1565w, 1500, 1320 (SO), 1150 (SO), and 970 cm^{-1}, τ ($CDCl_3$) 3·90br (NH), 6·30 (s, NMe), 7·05 (s, SMe), 7·73 (s, CMe), and 7·79 (s, CMe) (Found: C, 39·9; H, 6·95; N, 20·0. $C_7H_{13}N_3O_2S$ requires C, 39·6; H, 6·6; N, 19·8%).

1,2,3,5-*Tetramethyl*-4-*methylsulphonylaminopyrazolium Perchlorate* (8b).—A solution of the foregoing pyrazole (1·7 g) and methyl fluorosulphonate (1·0 g) in chloroform (17 ml) was heated under reflux for 1·5 h. The solvent was distilled and the residual oil was dissolved in the minimum amount of acetic acid. Addition of perchloric acid (1·5 ml), followed by ether, gave the *salt* (8b) (2·41 g, 92%), m.p. 171—174° (from acetonitrile–ether), $\nu_{max.}$ (KBr) 3200, 1160, and 1100br (ClO_4) cm^{-1}, τ ($CF_3{\cdot}CO_2H$) 5·97 (s, 2 × NMe), 6·70 (s, SMe), and 7·42 (s, 2 × CMe) (Found: C, 30·4; H, 5·1; N, 13·4. $C_8H_{16}ClN_3O_6S$ requires C, 30·2; H, 5·05; N, 13·2%).

N-(1,2,3,5-*Tetramethyl*-4-*pyrazolium*)*methanesulphonamidate* (9b).—The foregoing perchlorate (7·0 g) was added to 12·5% aqueous acetonitrile (80 ml), containing potassium hydroxide (1·56 g), and the mixture was stirred for 1 h, filtered from precipitated potassium perchlorate, and evaporated. Repeated crystallisation of the residue from acetonitrile gave the sulphonamidate (1·5 g, 31%), m.p. 229—232° (decomp.), $\nu_{max.}$ 1550, 1505, 1305, 1265, 1230, 1140, and 1105 cm^{-1}, τ (D_2O) 6·16 (s, 2 × NMe), 7·24 (s, SMe), and 7·69 (s, 2 × CMe) (Found: C, 44·0; H, 7·1; N, 19·4. $C_8H_{15}N_3O_2S$ requires C, 44·2; H, 6·9; N, 19·35%). Treatment of the sulphonamidate with perchloric acid regenerated the perchlorate (8b), identified by m.p., mixed m.p., and i.r. spectrum.

N-(1,2,3,5-*Tetramethyl*-4-*pyrazolium*)*toluene*-p-*sulphonamidate* (9c).—The solution obtained from toluene-*p*-sulphonyl chloride (14·8 g), 4-amino-1,3,5-trimethylpyrazole (10·0 g), and ice-cold pyridine (90 ml) was kept at room temperature for 3 h and then poured into water (400 ml). The resulting precipitate was filtered off and dissolved in chloroform (100 ml) and the solution was washed successively with dilute hydrochloric acid and water, and then dried. Evaporation of the chloroform gave 1,3,5-*trimethyl*-4-p-*tolylsulphonylaminopyrazole* (7c) (12·7 g, 66%), m.p. 143—144° (from ethanol), $\nu_{max.}$ 3060, 1600, 1340, 1300, and 1170 cm^{-1}, τ ($CDCl_3$) 2·6 (4H, AB, Ar), 3·88 (s, NH), 6·35 (s, NMe), 7·58 (s, CMe), 7·95 (s, CMe), and 8·38 (s, ArMe) (Found: C, 55·8; H, 6·3; N, 15·0. $C_{13}H_{17}N_3O_2S$ requires C, 55·8; H, 6·15; N, 15·05%). Methylation of this amide (12·7 g) by the method described previously gave 1,2,3,5-*tetramethyl*-4-p-*tolylsulphonylaminopyrazolium perchlorate* (8c) (15·0 g, 97%), m.p. 182—183°, $\nu_{max.}$ 3200, 1600, 1340, 1180, and 1100br cm^{-1}, τ ($CF_3{\cdot}CO_2H$) 2·45 (4H, AB, Ar), 6·08 (s, 2 × NMe), 7·51 (s, ArMe), and 7·84 (s, 2 × CMe) (Found: C, 42·7; H, 5·3; N, 10·7. $C_{14}H_{20}ClN_3O_6S$ requires C, 42·7; H, 5·15; N, 10·65%). The perchlorate (5·0 g) on treatment with 11·2% aqueous potassium hydroxide (100 ml) gave the mesoionic *sulphonamidate* (9c) (1·8 g, 74%), m.p. 233—234° (from acetonitrile), $\nu_{max.}$ 1550, 1500, 1410, 1360, 1270, 1235, 1140, 1120, and 1090 cm^{-1}, τ (D_2O) 2·70 (4H, AB, Ar), 6·30 (s, 2 × NMe), 7·68 (s, ArMe), and 8·09 (s, 2 × CMe) (Found: C, 57·6; H, 6·8; N, 14·6; S, 11·0. $C_{14}H_{19}N_3O_2S$ requires C, 57·3; H, 6·55; N, 14·3; S, 10·9%). The sulphonamidate was reconverted into the salt (8c) by the action of perchloric acid.

1-*Methyl*-4-*nitroso*-3,5-*diphenylpyrazole* (10a).—Methylhydrazine (2·6 g) was added during 15 min to a stirred ice-cold solution of isonitrosodibenzoylmethane (10·0 g) in ethanol (50 ml) and stirring and cooling were continued for 1 h. The mixture was poured into N-hydrochloric acid (400 ml) and the product extracted with dichloromethane (2 × 200 ml). The dried ($MgSO_4$) extracts were combined and evaporated, leaving a green gum which was dissolved in the minimum quantity of boiling ethanol. The *nitrosopyrazole* crystallised as green needles (6·0 g, 58%), m.p. 96—97°, $\nu_{max.}$ 1485 (NO), 1380, 1355, 1300, 890, 785, 730, and 705 cm^{-1}, τ ($CDCl_3$) 2·58 (m, 2 × Ph) and 6·23 (s, NMe) (Found: C, 72·7; H, 4·9; N, 15·9. $C_{16}H_{13}N_3O$ requires C, 73·0; H, 5·0; N, 15·95%).

4-*Amino*-1-*methyl*-3,5-*diphenylpyrazole* (10b).—A solution of the nitroso-compound (4·8 g) in 10% ethanolic hydrazine (50 ml) was boiled under reflux for 1 h and then evaporated under reduced pressure, leaving a viscous oil. Crystallisation from light petroleum gave the *aminopyrazole* (4·0 g, 88%), pale yellow, m.p. 90—91°, $\nu_{max.}$ 3400, 3320, 1615, 1590, 1565, 1440, and 1355 cm^{-1}, τ ($CDCl_3$) 2·6 (m, 2 × Ph), 6·21 (s, NMe), and 7·04br (2 × NH) (disappears with D_2O) (Found: C, 77·4; H, 6·0; N, 16·6. $C_{16}H_{15}N_3$ requires C, 77·1; H, 6·05; N, 16·35%).

[17] A. H. Blatt and W. L. Hawkins, *J. Amer. Chem. Soc.*, 1934, **56**, 2190.

1-*Methyl*-3,5-*diphenyl*-4-p-*tolylsulphonylaminopyrazole* (10c) (4·6 g, 74%), m.p. 201—202° (from ethanol), $\nu_{max.}$ 3030sh, 1600w, 1500w, 1330, 1300, and 1160 cm^{-1} (Found: C, 68·9; H, 5·5; N, 10·3. $C_{23}H_{21}N_3O_2S$ requires C, 68·45; H, 5·25; N, 10·4%), was prepared from the foregoing aminopyrazole (4·0 g) in the usual way and a sample (4·6 g) was converted by the method described previously into 1,2-*dimethyl*-3,5-*diphenyl*-4-p-*tolylsulphonylaminopyrazolium perchlorate* (11) (5·1 g, 86%), pale yellow plates (from acetonitrile–ether), m.p. 233—235° (decomp.), $\nu_{max.}$ 3230, 1600w, 1400, 1340, 1310, 1170, and 1100br cm^{-1}, τ (CD_3CN) 2·20 (s, NH) (disappears on adding D_2O), 2·70 (m, 2 × Ph and Ar), 6·20 (s, 2 × NMe), and 7·70 (s, ArMe) (Found: C, 55·7; H, 4·6; N, 8·0. $C_{24}H_{24}ClN_3O_6S$ requires C, 55·65; H, 4·7; N, 8·1%).

N-(1,2-*Dimethyl*-3,5-*diphenyl*-4-*pyrazolium*)*toluene*-p-*sulphonamidate* (12).—A solution of the preceding perchlorate (2·2 g) in acetonitrile (10 ml) was treated with 11·2% aqueous potassium hydroxide (35 ml) and, after removal of the precipitated potassium perchlorate, the solution was evaporated under reduced pressure. The residual oil was dissolved in hot water (100 ml), and the filtered solution deposited the *product* (1·6 g, 90%) on cooling, m.p. 240—242° (from acetonitrile–ether), $\nu_{max.}$ (KBr) 1600, 1520, 1460, 1390, 1360, 1310, 1240, 1140, and 1085 cm^{-1}, τ ($CDCl_3$) 3·0 (m, 2 × Ph and Ar), 6·37 (s, 2 × NMe), and 7·82 (s, ArMe). Treatment of the sulphonamidate with a mixture of acetic and perchloric acids gave the pyrazolium salt (11). The sulphonamidate was recovered after being boiled with benzonitrile for 8 h. Heating the imine with an excess of methyl fluorosulphonate at 100° for 3 h, followed by the addition of acetic and perchloric acids, gave the pyrazolium perchlorate (11).

Rearrangement of the Sulphonamidates (9b) *and* (9c).—(*a*) A solution of the methanesulphonamidate (9b) (0·4 g) in benzonitrile (20 ml) was boiled under reflux for 8 h. The solvent was removed at 0·1 mmHg and the black residue was dissolved in chloroform and chromatographed on alumina (Type H; 50 g), using chloroform–light petroleum (1 : 5) as eluant, to yield 1,3,5-*trimethyl*-4-*methyl*(*methylsulphonyl*)*aminopyrazole* (13a) (0·16 g, 40%), m.p. 131—132° (from benzene–light petroleum), $\nu_{max.}$ 1565, 1495, 1390, 1380, 1330, 1310, and 1150 cm^{-1}, τ ($CDCl_3$) 6·30 (s, N^1-Me), 6·80s (SMe), 7·08 (s, N^4-Me), and 7·75 (s, 2 × CMe) (Found: C, 44·4; H, 7·2; N, 19·3. $C_8H_{15}N_3O_2S$ requires C, 44·3; H, 6·9; N, 19·4%).

(*b*) The toluenesulphonyl analogue (9c) (1·0 g) was boiled in benzonitrile (25 ml) for 3 h; the solvent was removed under reduced pressure and the residue was dissolved in chloroform. Chromatography on alumina (Type O, 45 g) and elution with chloroform–light petroleum (1 : 3) gave 1,3,5-*trimethyl*-4-*methyl*-(p-*tolylsulphonyl*)*aminopyrazole* (13b) (0·503 g, 50%), m.p. 110—111° (from light petroleum), $\nu_{max.}$ 1600w, 1570, 1490, 1350, 1300, and 1155 cm^{-1}, τ ($CDCl_3$) 2·5 (4H, AB, Ar), 6·30 (s, N^1-Me), 6·81 (s, N^4-Me), 7·58 (s, ArMe), 7·90 (s, CMe), and 8·40 (s, CMe) (Found: C, 57·5; H, 6·6; N, 14·3. $C_{14}H_{19}N_3O_2S$ requires C, 57·3; H, 6·55; N, 14·3%). The same compound (0·2 g, 19%) was obtained by adding dimethyl sulphate (1·5 g) to a solution of the toluene-*p*-sulphonamide (7c) (1·0 g) in 2N-sodium hydroxide (25 ml), stirring the mixture at 50° for 16 h, collecting the precipitate, and recrystallising it from light petroleum.

Thermolysis of 1,2-*Dimethyl*-3,5-*diphenylpyrazolium* 4-*Oxide* (6).—A solution of the 4-oxide (0·4 g) in a mixture of xylene (10 ml) and chloroform (10 ml) was boiled under reflux for 48 h and then cooled. The precipitated brown oil was separated and subjected to p.l.c. (' GF 273 ', 1 mm, eluant 30% ethyl acetate in light petroleum) to yield 4-hydroxy-1-methyl-3,5-diphenylpyrazole (14b) (0·06 g), identified by comparison with an authentic [8a] specimen. The supernatant solution was similarly worked up, giving 4-methoxy-1-methyl-3,5-diphenylpyrazole (14a) [8a] (0·008 g, 2%), a further quantity (0·044 g) of the hydroxypyrazole (total yield 23%), and an unidentified compound (0·01 g).

Methylation of the Pyrazolium Sulphonamidates (9b) *and* (9c).—(*a*) A mixture of the sulphonamidate (9b) (0·45 g), methyl fluorosulphonate (0·29 g), and chloroform (5 ml) was kept for 1 h and then evaporated under reduced pressure. The residual oil was dissolved in acetic acid (9 ml); addition of perchloric acid (1 ml), followed by ether (8 ml), precipitated 1,2,3,5-*tetramethyl*-4-*methyl*(*methylsulphonyl*)*aminopyrazolium perchlorate* (15a) (0·5 g, 73%), m.p. 158—159° (from acetonitrile–ether), $\nu_{max.}$ 1555m, 1510, 1340, 1150, and 1100br cm^{-1}, τ ($CF_3{\cdot}CO_2H$) 5·95 (s, N^1-Me and N^2-Me), 7·46 (s, 2 × CMe), and 7·62 (s) and 7·73 (s) (SMe and N^4-Me) (Found: C, 32·5; H, 5·6; N, 12·6. $C_9H_{18}ClN_3O_6S$ requires C, 32·6; H, 5·45; N, 12·7%).

(*b*) A similar reaction, using the toluenesulphonyl analogue (9c) (0·45 g) yielded 1,2,3,5-*tetramethyl*-4-*methyl*-(p-*tolylsulphonyl*)*aminopyrazolium perchlorate* (15b) (0·35 g, 68%), m.p. 138—139° (from acetonitrile–ether), $\nu_{max.}$ 1600, 1560, 1350, 1160, and 1100br cm^{-1}, τ ($CF_3{\cdot}CO_2H$) 2·45 (4H, AB, Ar), 6·06 (s, N^1-Me and N^2-Me), 6·74 (s, N^4-Me), 7·50 (s, ArMe), and 7·81 (s, 2 × CMe) (Found: C, 44·1; H, 5·5; N, 10·3. $C_{15}H_{22}ClN_3O_6S$ requires C, 44·2; H, 5·4; N, 10·3%).

Reactions with Dimethyl Acetylenedicarboxylate.—(*a*) A mixture of the ester (0·5 g), the sulphonamidate (12) (0·5 g), and acetonitrile (25 ml) was boiled under reflux for 3 h and the solvent was then removed. The residue was dissolved in chloroform and chromatographed on alumina (Type ' H ', 45 g), using chloroform–light petroleum (1 : 4) for elution, to yield 4-(1,2-*bismethoxycarbonylvinyl*)-(p-*tolylsulphonyl*)-*amino*-1-*methyl*-3,5-*diphenylpyrazole* (17a) (0·161 g, 25%), m.p. 204—205° (from ethanol), $\nu_{max.}$ 1750, 1710, 1590, 1350, 1300w, 1210, 1170, and 1145 cm^{-1}, τ ($CDCl_3$) 2·8 (m, 2 × Ph and Ar), 4·62 (s, =CH), 6·06 (s), 6·17 (s), and 6·33 (s) (OMe, OMe, and NMe), and 7·78 (s, ArMe) (Found: C, 64·0; H, 5·1; N, 7·5; S, 6·0. $C_{29}H_{27}N_3O_6S$ requires C, 63·8; H, 4·95; N, 7·7; S, 5·9%).

(*b*) A solution of the acetylenic ester (1·68 g) and the pyrazolium oxide (6) (0·7 g) in a mixture of xylene (30 ml) and chloroform (15 ml) was boiled under reflux overnight. The solvents were removed and the residue was first chromatographed on alumina as just described, then further purified by p.l.c., and finally crystallised from ethyl acetate–light petroleum, giving 4-(1,2-*bismethoxycarbonylvinyl*)*oxy*-1-*methyl*-3,5-*diphenylpyrazole* (17b) (0·3 g, 29%), m.p. 139—140°, $\nu_{max.}$ (KBr) 3060, 1750, 1715, 1635, 1440, 1365, 1205, 1170, 1140, 780, and 700 cm^{-1}, τ ($CDCl_3$; 90 MHz) 2·56 (m, 2 × Ph), 4·78 (s, =CH), 6·12 (s), 6·16 (s), and 6·45 (s) (OMe, OMe, and NMe) (Found: C, 67·7; H, 5·35; N, 7·0. $C_{21}H_{20}N_3O_5$ requires C, 67·35; H, 5·15; N, 7·15%).

3-*Methyl*-4-p-*tolylsulphonylaminoisothiazole* (19d).—Treatment of a solution of 4-amino-3-methylisothiazole (19c) [15] (3·7 g) in ice-cold pyridine (30 ml) with toluene-*p*-sulphonyl chloride (7·5 g), followed by the usual work-up, gave the *toluenesulphonamide* (8·0 g, 93%), m.p. 138—139° (from ethanol–light petroleum), $\nu_{max.}$ 3100, 1590w, 1420, 1340, 1320, and 1160 cm^{-1} (Found: C, 49·3; H, 4·4; N, 10·5. $C_{11}H_{12}N_2O_2S_2$ requires C, 49·3; H, 4·45; N, 10·4%).

2,3-*Dimethyl*-4-p-*tolylsulphonylaminoisothiazolium Perchlorate* (20).—A solution of the foregoing amide (0·5 g) and methyl fluorosulphonate (0·25 g) in chloroform (10 ml) was boiled under reflux for 3 h. The solvent was removed and the oily residue was dissolved in acetic acid (5 ml); addition of perchloric acid (0·5 ml) precipitated the salt (0·5 g, 70%), m.p. 194—196° (decomp.) (from acetonitrile–ether), $\nu_{max.}$ (KBr) 3200, 1590, 1495, 1370, 1340, 1150, and 1100br cm^{-1}, τ ($CF_3{\cdot}CO_2H$) 1·12 (s, 5-H), 2·4 (4H, AB, Ar), 5·78 (s, NMe), 7·32 (s, 3-Me), and 7·50 (s, ArMe).

N-(2,3-*Dimethyl*-4-*isothiazolium*)*toluene*-p-*sulphonamidate* (21).—A solution of the preceding salt (2·0 g) and potassium hydroxide (0·35 g) in a mixture of water (50 ml) and acetonitrile (5 ml) was stirred for 1 h and then heated on a steam-bath for 5 min. The precipitated potassium perchlorate was filtered off and the filtrate was passed through a 20 cm column of Amberlite IR 45 ion-exchange resin in the hydroxide form. The column was washed with 50% aqueous acetonitrile (200 ml) and the combined eluates were evaporated to dryness. The residue was dissolved in boiling acetonitrile (150 ml); the filtered solution deposited the yellow *sulphonamidate* (0·6 g, 40%), m.p. 175—180° (decomp.), $\nu_{max.}$ (KBr) 3100w, 3000w, 1600w, 1540w, 1460, 1420, 1380, 1365, 1240, 1220, 1160, 1130, 1100, and 1080 cm^{-1} (Found: C, 51·0; H, 5·0; N, 9·8. $C_{12}H_{14}N_2O_2S_2$ requires C, 51·1; H, 4·95; N, 9·9%). The compound was too insoluble for a determination of its n.m.r. spectrum; its n.m.r. spectrum in trifluoroacetic acid was identical with that of its parent perchlorate (20). Treatment with an excess of methyl fluorosulphonate in refluxing chloroform, followed by addition of perchloric acid, gave the salt (20).

3,5-*Dimethyl*-4-p-*tolylsulphonylaminoisoxazole* (22b).—Reaction of 4-amino-3,5-dimethylisoxazole (22a) [16] (1·5 g) with toluene-*p*-sulphonyl chloride (2·54 g) in the usual way gave the *product* (3·2 g, 78%), m.p. 170—171° (from ethanol), $\nu_{max.}$ 3250, 1655w, 1640w, 1600, 1500, 1400, 1330, 1240, 1160, and 1095 cm^{-1}, τ ($CDCl_3$) 2·5 (4H, AB, Ar), 3·70br (NH) (exchanges with D_2O), 7·55 (s, ArMe), 7·93 (s) and 8·13 (s) (3-Me and 5-Me) (Found: C, 54·2; H, 5·25; N, 10·6. $C_{12}H_{14}N_2O_3S$ requires C, 54·1; H, 5·25; N, 10·55%).

2,3,5-*Trimethyl*-4-p-*tolylsulphonylaminoisoxazolium Perchlorate* (23).—Boiling the amide (22b) (2·0 g) and methyl fluorosulphonate (0·6 g) in chloroform (10 ml) for 30 h, followed by evaporation, addition of acetic acid (15 ml), perchloric acid (2 ml), and ether (30 ml), and cooling to −70°, gave the *perchlorate* (1·7 g, 61%), m.p. 125—128° (from acetonitrile–ether), $\nu_{max.}$ 3210, 1565, 1315, 1255, 1175, and 1100br cm^{-1}, τ ($CF_3{\cdot}CO_2H$) 2·35 (4H, AB, Ar), 5·70 (s, NMe), 7·45s (2 × CMe), and 7·70 (s, CMe) (Found: C, 40·8; H, 4·65; N, 7·3. $C_{13}H_{17}ClN_2O_7S$ requires C, 41·0; H, 4·45; N, 7·35%). Attempts to isolate the derived sulphonamidate (24) after treatment of the salt with potassium hydroxide or triethylamine were unsuccessful.

4-*Hydroxy*-2-*methyl*-3,5-*diphenylisoxazolium Perchlorate* (25).—A solution of 4-acetoxy-3,5-diphenylisoxazole [17] (5·0 g) and methyl fluorosulphonate (2·46 g) in chloroform (50 ml) was boiled under reflux for 30 h. The solvent was distilled off, the residue was dissolved in the minimum quantity of acetic acid, perchloric acid (5 ml) was added, and the solution was treated with ether to incipient cloudiness, whereupon the *isoxazolium salt* (2·4 g, 38%) crystallised. It had m.p. 182—184° (from acetonitrile–ether), $\nu_{max.}$ 3100br, 1620w, 1565w, 1515w, 1220, 1120br, 1035, 770, 715, and 690 cm^{-1}, τ ($CF_3{\cdot}CO_2H$) 2·27 (m, 2 × Ph) and 5·74 (s, NMe) (Found: C, 54·9; H, 4·1; N, 3·9. $C_{16}H_{14}ClNO_6$ requires C, 54·65; H, 4·0; N, 4·0%).

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