Reactions with Arenesulphonyl Azides of Some Indoles with Oxygen- and Nitrogen-containing Substituents

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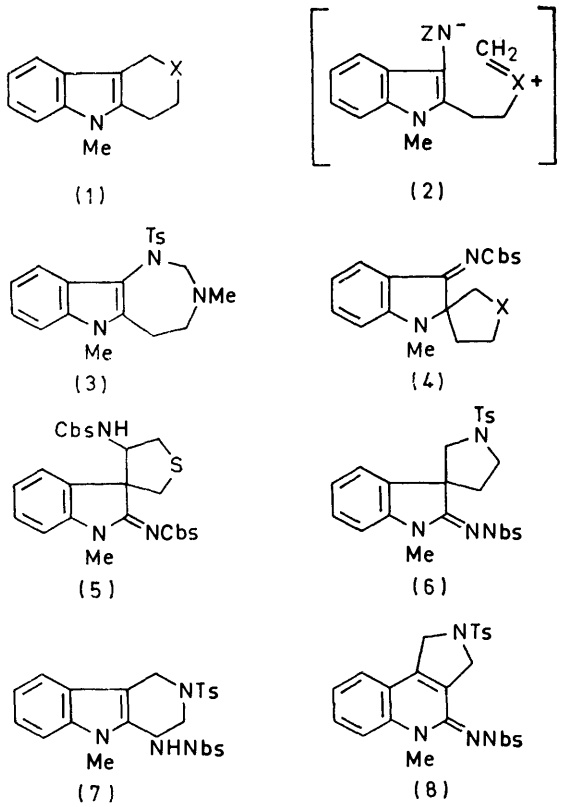
Treatment of 2,3,4,5-tetrahydro-5-methyl-2-tosyl-1*H*-pyrido[4,3-*b*]indole with *p*-nitrobenzenesulphonyl azide affords 1-methyl-2-*p*-nitrophenylsulphonylimino-1'-tosylindoline-3-spiro-3'-pyrrolidine in moderate yield: 1,3,4,5-tetrahydro-5-methylpyrano[3,4-*b*]indole reacts with *p*-chlorobenzenesulphonyl azide to form 3-*p*-chlorophenylsulphonylimino-1-methylindoline-2-spiro-3'-tetrahydrofuran. The reaction of methyl 1,3-dimethylindole-2-carboxylate with *p*-nitrobenzenesulphonyl azide involves migration of the methoxycarbonyl group.

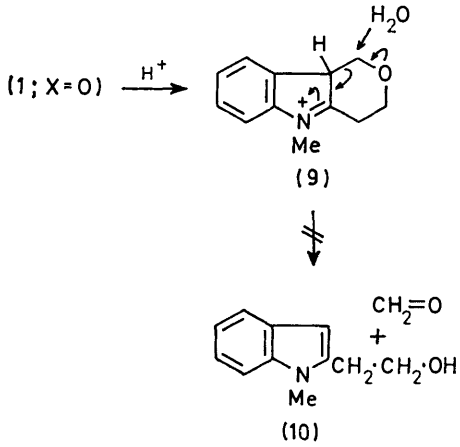
From the reaction of methyl 1,3-dimethylindol-2-ylacetate with azides derivatives containing the 2-methyleneindoline nucleus have been isolated.

We have reported [1] that the γ-carboline (1; X = NMe) reacts smoothly with tosyl azide to form the ring-enlarged compound (3), and we suggested that the formation of (3) occurs *via* the intermediate (2; X = NMe, Z = Ts). In contrast the sulphur analogue (1; X = S) [2] formed mainly tars when treated with arenesulphonyl azides; the only crystalline materials isolated, in small quantities, were the orange-coloured spiran (4; X = S) and the 1 : 2 adduct (5). This work has now been extended by an examination of the reactions of compound (1; X = NTs) with azides, since formation of an intermediate such as (2; X = NTs) appeared unlikely.



The γ-carboline (1; X = NTs) was far less reactive than (1; X = NMe) and it did not react with *p*-chlorobenzenesulphonyl (Cbs) azide. However, boiling the compound in ethanol with *p*-nitrobenzenesulphonyl (Nbs) azide afforded a small quantity of crystalline material to which we assign structure (6); the n.m.r. and u.v. spectral data eliminated structures of types (3), (4), (7), and (8).[3]

This series has now been completed by an examination of the oxygen analogue (1; X = O). Although complex pyrano[4,3-*b*]indoles are known,[4] there appears to be no reference in the literature to the parent compound. Tetrahydropyran-4-one [5] formed a crystalline phenylhydrazone but all (fifteen) attempts to cyclise it to the corresponding indole with acid or thermally [6] gave black amorphous material. However, the *N*-methylated compound (1; X = O) was obtained, in poor yield, by treatment of tetrahydropyran-4-one with *N*-methyl-*N*-phenylhydrazine followed by acid-catalysed cyclisation



under very mild conditions. This indole is unstable and so it was treated with Cbs azide in chloroform at room temperature, to give the yellow fluorescent spiran

[1] A. S. Bailey, A. G. Holton, and J. F. Seager, *J.C.S. Perkin I*, 1972, 1003.
[2] A. S. Bailey, P. A. Hill, and J. F. Seager, *J.C.S. Perkin I*, 1974, 967.
[3] A. S. Bailey, R. Scattergood, and W. A. Warr, *J. Chem. Soc.* (C), 1971, 2479.
[4] H. Behringer and H. Weissauer, *Chem. Ber.*, 1952, **85**, 743.
[5] R. Artenzen, Y. T. Yan Kui, and C. B. Reese, *Synthesis*, 1975, **8**, 509.
[6] R. J. Sundberg, 'The Chemistry of Indoles,' Academic Press, New York, 1970, pp. 142—164.

(4; X = O) in 89% yield. This is by far the largest yield of this type of spiran obtained with any indole.

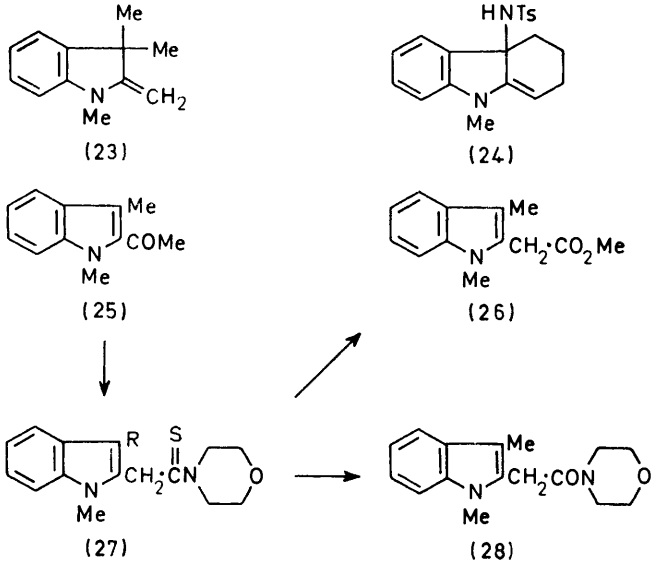
All attempts to rearrange the spiran either thermally or with trifluoroacetic acid [3] gave dark-coloured decomposition products. These results indicate that structures of type (2) are not formed when X = O, S, or NTs, and that the most favoured reactions involve ring contraction to spirans.

As reported above we were unable to obtain the simple indole (1; X = O, NH replacing NMe) and the *N*-methyl derivative (1; X = O) is far less stable to acid than the X = S or NMe analogues. When compound (1; X = O) is warmed to 80 °C with M-sulphuric acid a purple polymeric solid rapidly separates. Protonation of (1; X = NMe) would occur on the aliphatic nitrogen atom, but an indole such as (1; X = O) might be expected to undergo protonation at the β-position of the indole nucleus [7] to form the ion (9), which would then decompose to form *N*-methylisotryptophol (10) and formaldehyde.[8] A sample of the indole (1; X = O) was mixed with dilute sulphuric acid and a stream of nitrogen bubbled through the mixture; the mixture was then slowly distilled and the vapours were passed through aqueous 2,4-dinitrophenylhydrazine hydrochloride. No formaldehyde was detected, and the mechanism of the breakdown of (1; X = O) with acid remains obscure.

Barnes [9] had observed that the oxime (11; R = Me) reacted with Cbs azide to form the isoxazolo-derivative (13) by attack of the OH group of the oxime in the intermediate (12) on C(3) of the indole nucleus. In order to examine the generality of this cyclisation the oxime (11; R = CH_2Ph) has been prepared. This oxime reacted smoothly with Cbs azide; however the product was not the isoxazole (13; R = CH_2Ph) but the fluorescent imine (14); this is the first time this type of structure has been obtained which does not contain a spiran ring of type (4). It appears that in the intermediate (12) the large benzyl group (R = CH_2Ph) prevents attack at C(3) of the indole nucleus, hence the intermediate (15) is formed and in (15) there is no hydrogen atom in the group attached to C(2) which may be lost to form a

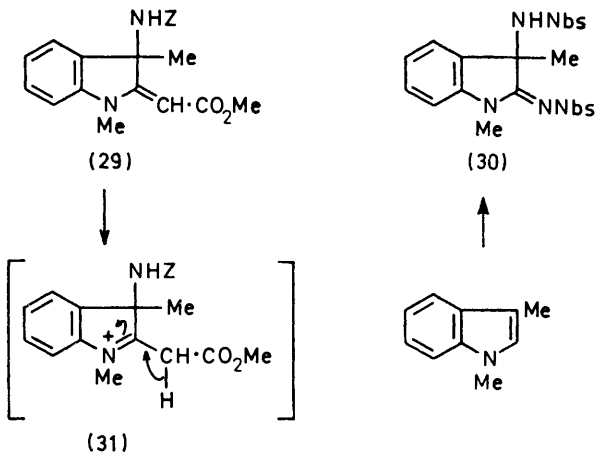
[7] Ref. 6, pp. 3—6.
[8] Ref. 6, pp. 39—56; E. Leete, *J. Amer. Chem. Soc.*, 1959, **81**, 023.
[9] A. S. Bailey, C. J. Barnes, and P. A. Wilkinson, *J.C.S. Perkin I*, 1974, 1321.

methyleneindoline structure.[3] In order to determine whether formation of the imine (14) was a particular feature of the benzyl group at C(3) in (11), compound (16) was prepared; on treatment with Cbs azide it formed the 2 : 1 adduct (17) *via* the intermediate (18), behaviour similar to that of 1,2,3-trimethylindole.[3] We have reported [9] that 2-acylindoles do not react with



azides; the methyl ester (20) has now been prepared in order to study its reactions. 1,3-Dimethylindole did not react with trichloroacetyl chloride under conditions which are successful with pyrroles [10] but the indole reacted smoothly with trifluoroacetic anhydride to form the ketone (19). Methanolysis of (19) gave (20) but the yields were erratic and it was more convenient to hydrolyse (19) to the corresponding acid and to esterify the latter [a photochemical synthesis of compounds of type (20) has subsequently been reported [11]]. This ester slowly reacted with *p*-nitrobenzenesulphonyl azide to form a compound to which we ascribe structure (21), by a process involving migration of the methoxycarbonyl group; the alternative structure (22) was rejected since it contains the same chromophore as compounds (4) and (14) and would be expected to have a characteristic u.v. spectrum and to fluoresce in solution.[3]

In order to explain the formation of many of the products obtained by the reactions of various indoles with azides [2,3,12] the formation of methyleneindoline intermediates [*cf.* (18)] has been suggested. Although the reaction of the Fischer base (23) [3] with azides has been examined, and compound (24) has been prepared and its reactions with azides have been studied,[13] no methyleneindoline has been isolated directly from the reaction of an indole with an azide. We, therefore, prepared methyl 1,3-dimethylindol-2-ylacetate (26) to study its reactions with azides. The first attempt involved treatment of the ketone (25) [9] with thallium nitrate,[14] a reaction used successfully on acetylpyrroles.[15] Under a variety of conditions black amorphous materials were obtained and none of the desired product. However the Willgerodt reaction afforded the thiomorpholide (27; R = Me) in satisfactory yield, but methanolysis with methanol–HCl failed to produce the ester (26) although the reaction was successful with the related compound (27; R = H).[16] Compound (27; R = Me) was methylated [17] and the methiodide boiled with methanol. This, however, afforded the amide (28) and not the desired ester. The thiomorpholide was, therefore, hydrolysed and the free acid immediately esterified with diazomethane affording (26). The ester (26) was boiled in chloroform solution with Cbs azide affording a 1 : 1 adduct to which we ascribe structure (29; Z = Cbs); the n.m.r spectrum contains a singlet at τ 5.29 (=C*H*·CO_2Me) and the u.v. spectrum is very similar to that of the alkaloid pseudovincadifformine.[18] A similar compound (29; Z = Nbs) was obtained using *p*-nitrobenzenesulphonyl azide in chloroform. Huisgen [19] has shown that αβ-unsaturated esters react more slowly with azides than do simple olefins; hence (29), formed *via* (31), is sufficiently unreactive to allow isolation. When compound (26) was heated with Nbs azide in propan-1-ol the 2 : 1 adduct



(30) was isolated, the side-chain being lost from (29) (*cf.* the reactions of enamino-ketones with azides [20]).

[10] J. W. Harbuck and H. Rapoport, *J. Org. Chem.*, 1972, **37**, 3618.
[11] A. G. Schultz and W. K. Hagmann, *J.C.S. Chem. Comm.*, 1976, 726.
[12] A. S. Bailey and P. A. Wilkinson, *J.C.S. Perkin I*, 1976, 481; G. A. Bahadur, A. S. Bailey, and P. A. Baldry, *ibid.*, 1977, 1619.
[13] A. S. Bailey, A. J. Buckley, and J. F. Seager, *J.C.S. Perkin I*, 1973, 1809.
[14] A. McKillop and E. C. Taylor, *Endeavour*, 1976, **35**, 88; E. C. Taylor, R. L. Robey, K.-T. Liu, B. Favre, H. T. Bozimo, R. A. Conley, C.-S. Chiang, A. McKillop, and M. E. Ford, *J. Amer. Chem. Soc.*, 1976, **98**, 3037.
[15] G. W. Kenner, J. Rimmer, K. M. Smith, and J. F. Unsworth, *J.C.S. Perkin I*, 1977, 332.
[16] C. F. Jones, D. A. Taylor, and D. P. Bowyer, *Tetrahedron*, 1974, **30**, 957.
[17] R. Gompper and W. Elser, *Annalen*, 1969, **725**, 64.
[18] J. P. Kutney, R. T. Brown, E. Piers, and J. R. Hadfield, *J. Amer. Chem. Soc.*, 1970, **92**, 1708.
[19] R. Huisgen, G. Szeimies, and L. Möbius, *Chem. Ber.*, 1966, **99**, 475; 1967, **100**, 2494.
[20] R. Fusco, G. Bianchetti, D. Pocar, and R. Ugo, *Chem. Ber.*, 1963, **96**, 802; P. D. Croce and R. Stradi, *Tetrahedron*, 1977, **33**, 865.

Compound (30) was identical with the product obtained from 1,3-dimethylindole with Nbs azide in the presence of pyridine.[21] The isolation of compounds of structure (29) provides valuable evidence for the mechanism we have suggested for the reactions of indoles with azides.

EXPERIMENTAL

General details and instruments used have been reported.[22] U.v. spectra were determined for solutions in ethanol and n.m.r. spectra for solutions in $CDCl_3$; i.r. spectra were recorded for Nujol mulls.

1-*Methyl*-2-p-*nitrophenylsulphonylimino*-1'-*tosylindoline*-3-*spirocyclo*-3'-*pyrrolidine* (6).—*N*-Tosylpiperidone (m.p. 129—131°; lit.,[23] 128—131°) (2.8 g) and phenylhydrazine (1.2 g) were mixed in ethanol (15 ml) and warmed for 2 min. Sulphuric acid (M; 15 ml) was added and the solution boiled (30 min; prolonged boiling yields tar). Next day 2,3,4,5-*tetrahydro*-2-*tosyl*-1H-*pyrido*[4,3-b]*indole* was collected (80%) and recrystallised (MeOH); m.p. 196.5—198.5° (Found: C, 66.3; H, 5.5; N, 8.6; S, 10.0. $C_{18}H_{21}N_3O_2S$ requires C, 66.3; H, 5.5; N, 8.6; S, 9.8%); $\lambda_{max.}$ 225, 273, and 289 nm (ε 44 300, 6 730, and 5 330); $\nu_{max.}$ 3 400 cm^{-1}; τ 2.10 (1 H, NH), 2.25 (2 H, d, *J* 8 Hz), 2.5—3.0 (6 H, m), 5.62 [2 H, s, C(1)H_2], 6.59 [2 H, t, *J* 6 Hz, C(3)H_2], 7.16 [2 H, t, *J* 6 Hz, C(4)H_2], and 7.59 (3 H, s, ArMe). This indole did not react with *p*-chlorobenzenesulphonyl azide (90 h, boiling EtOH). *N*-Tosylpiperidone (2.84 g) and *N*-methyl-*N*-phenylhydrazine (1.38 g) were dissolved in EtOH (15 ml); the solution was boiled (1 min) and 15 min later sulphuric acid (M; 17 ml) was added. The solution was boiled for 20 min; next day the solid was collected and recrystallised (EtOH). 2,3,4,5-*Tetrahydro*-5-*methyl*-2-*tosyl*-1H-*pyrido*[4,3-b]*indole* (1; X = NTs) formed needles, m.p. 172.5—174.5° (56%) (Found: C, 66.9; H, 5.9; N, 8.2. $C_{19}H_{20}N_2O_2S$ requires C, 67.1; H, 5.9; N, 8.2%); $\lambda_{max.}$ 228, 273sh, 283, and 292 nm (ε 60 400, 8 200, 8 700, and 7 600); τ 2.2—3.0 (8 H, m), 5.62 [2 H, s, C(1)H_2], 6.38—6.55 [5 H, m, C(3)H_2, NMe], 7.20 [2 H, t, *J* 8 Hz, C(4)H_2], and 7.61 (3 H, ArMe). This indole was recovered after boiling for 16 h with TsN_3 in MeOH. The indole (62 mg) was boiled (70 h) with *p*-nitrobenzenesulphonyl azide (42 mg) in EtOH (3 ml). On cooling the *spiro-compound* (6) separated (34%); it formed small prisms from EtOH containing solvent of crystallisation, m.p. 165—168° (Found: C, 55.1; H, 5.0; N, 9.2; S, 10.5. $C_{25}H_{24}N_4O_6S_2 \cdot C_2H_6O$ requires C, 55.3; H, 5.0; N, 9.6; S, 10.9%); $\lambda_{max.}$ 224 and 270 nm (ε 54 500 and 18 500); $\nu_{max.}$ 1 530(C=N) and 3 400 cm^{-1} (OH) (after crystallisation from PhH the band at 3 400 was absent); τ 1.82 (2 H, d, *J* 9 Hz), 2.05—2.45 (4 H, m), 2.66—2.95 (4 H, m), 3.0—3.4 (2 H, m), 3.28 (1 H, s, OH, exchanged with D_2O), 5.25 [2 H, s, C(2')H_2], 6.30 (3 H, s, NMe), 6.40—6.66 [4 H, m, C(5')H_2, and $HOCH_2$-CH_3], 6.85—6.71 [2 H, m, C(4')H_2], 7.62 (3 H, s, ArMe), and 9.87 (3 H, t, *J* 8 Hz, $HOCH_2CH_3$); *m/e* 540 (M^+, 0.30%), 198 (88%), 182 (85), 181 (49), 171 (33), 123 (57), and 91 (100).

1,3,4,5-*Tetrahydro*-5-*methylpyrano*[4,3-b]*indole* (1; X = O).—Phenylhydrazine (5.4 g) was mixed with tetrahydropyran-4-one [5] (5.04 g) and MeOH (3 ml) was added. Next day the solid was collected and recrystallised from MeOH (yield 6.33 g); m.p. 60—63°. The compound slowly darkened and no analysis was attempted; $\nu_{max.}$ 3 370 cm^{-1}; τ 2.7—3.3 (6 H, m, Ar and NH), 6.10—6.35 (2 H, m), and 7.4—7.7 (2 H, m). All attempts to cyclise this hydrazone failed. *N*-Methyl-*N*-phenylhydrazine (4.05 g) and tetrahydropyran-4-one (3.3 g) were mixed and acetic acid (1 drop) was added. The mixture was heated (90 °C) for 20 min and MeOH (3 ml) was added. Next day sulphuric acid (M; 15 ml) was added and the mixture shaken; after 30 min the solid was collected, washed with water, and recrystallised from ethanol (yield 17%). The *indole* (1; X = O) formed plates, m.p. 83.5—85° (Found: C, 77.0; H, 7.0; N, 7.5. $C_{12}H_{13}NO$ requires C, 76.8; H, 7.1; N, 7.5%); $\lambda_{max.}$ 227, 283, and 290sh nm (ε 43 600, 9 000, and 8 200); τ 2.55—3.0 (4 H, m), 5.09 [2 H, s, C(1)H_2], 5.92 [2 H, t, *J* 7 Hz, C(3)H_2], 6.37 (3 H, s, NMe), and 7.19 [2 H, t, br, *J* 7 Hz, C(4)H_2]; *m/e* 187 (M^+, 100%), 186 (42), 159 (13; *m** 135), 157 (77), 143 (10), and 142 (12; *m** 107).

3-p-*Chlorophenylsulphonylimino*-1-*methylindoline*-2-*spiro*-3'-*tetrahydrofuran* (4; X = O).—The indole (1; X = O) (2.6 g) and Cbs azide (3.0 g) were dissolved in chloroform (20 ml) and kept at room temperature for 190 h. The chloroform was removed and the residue recrystallised from MeOH. The *spiro-compound* formed orange-yellow needles (4.66 g), m.p. 196—197° (Found: C, 57.4; H, 4.6; Cl, 9.3; N, 7.3; S, 8.7. $C_{18}H_{17}ClN_2O_3S$ requires C, 57.4; H, 4.5; Cl, 9.4; N, 7.4; S, 8.5%); $\lambda_{max.}$ 208, 228, 281, and 468 nm (ε 32 000, 23 600, 5 050, and 3 500); $\nu_{max.}$ 1 620 cm^{-1}; τ 1.52 [1 H, d, *J* 8 Hz, C(4)H], 2.02 (2 H, d, *J* 9 Hz), 2.65 (3 H, m), 3.1—3.4 (2 H, m), 5.68—6.35 [4 H, m, C(2')H_2 and C(5')H_2], 6.9 (3 H, s, NMe), and 7.62—7.83 [2 H, m, C(4')H_2]; *m/e* 376 (M^+, 10%), 201 (*M* — Cbs, 100%), 173 (201 — C_2H_4, 33%; *m** 149), 171 (201 — CH_2O, 53%), and 111 (17%). All attempts to rearrange this compound either thermally or by treatment with CF_3CO_2H failed.

2-*Acetyl*-2-*benzyl*-3-p-*chlorophenylsulphonylimino*-1-*methylindoline Oxime* (14).—3-Benzylindole [24] was methylated (Me_2SO–NaH–MeI) forming 3-benzyl-1-methylindole.[21,25] 3-Benzyl-1-methylindole (5.3 g) was dissolved in Ac_2O (5 ml) and HOAc (25 ml). To the ice-cold mixture was added (drop-wise with stirring) BF_3–Et_2O (5.5 ml) followed by dry Et_2O (50 ml). After 15 h at room temp. Et_2O (50 ml) was added, followed by Na_2CO_3 (50 ml; 2M). The ethereal layer was washed and dried ($MgSO_4$), the solvent removed, and the product recrystallised from petroleum (b.p. 60—80 °C). 2-*Acetyl*-3-*benzyl*-1-*methylindole* formed tiny prisms, m.p. 64—65.5° (57%) (Found: C, 82.1; H, 6.5; N, 5.3. $C_{18}H_{17}NO$ requires C, 81.7; H, 6.5; N, 5.5%); $\lambda_{max.}$ 209, 240, and 309 nm (ε 25 000, 15 500, and 16 100); $\nu_{max.}$ 1 610 and 1 660 cm^{-1}; τ 2.35—2.95 (9 H, m, Ar), 5.52 (2 H, s), 6.02 (3 H, s, NMe), and 7.48 (3 H, s, CMe); *m/e* 263 (M^+, 100%), 248 (45%), 220 (58), 186 (18), and 172 (32). The *oxime* (11; R = CH_2Ph) (prepared in pyridine) formed needles, m.p. 113—116° (from MeOH) (Found: C, 77.6; H, 6.6; N, 10.0. $C_{18}H_{18}N_2O$ requires C, 77.7; H, 6.5; N, 10.1%); *m/e* 278 (M^+, 32%), and 261 (100%). This oxime (0.49 g) and Cbs azide (0.42 g) were dissolved in ethyl propionate (5 ml) and the mixture heated (100 °C, 48 h). The solvent was removed, the residue chromatographed (silica; PhH–EtOAc, 9 : 1), and the product recrystallised from propan-1-ol (yield 0.71 g). The oxime (0.67 g) was

[21] A. S. Bailey, A. J. Buckley, and W. A. Warr, *J.C.S. Perkin I*, 1972, 1626.
[22] A. S. Bailey, T. Morris, and Z. Rashid, *J.C.S. Perkin I*, 1975, 420.
[23] W. N. Speckamp, J. Dijkink, A. W. J. D. Dekkers, and H. O. Huisman, *Tetrahedron*, 1971, **27**, 3151.
[24] E. F. Pratt and L. W. Botimer, *J. Amer. Chem. Soc.*, 1957, **79**, 5248.
[25] S. Pietra and G. Tacconi, *Gazzetta*, 1959, **89**, 2304.

heated (100 °C; 48 h) in Pr^{n}OH (5 ml) with CbsN$_3$ (0.69 g). On cooling the product separated (0.67 g). The *imine* (14) formed orange-coloured prisms, m.p. 215—217° (Found: C, 61.8; H, 5.2; N, 8.8. $C_{24}H_{22}ClN_3O_2S$ requires C, 61.7; H, 4.8; N, 9.0%); $\lambda_{max.}$ 230, 290, and 473 nm (ε 32 000, 10 700, and 11 000); $\nu_{max.}$ 1 615 (C=N) and 2 950 cm^{-1} (OH); τ 1.74 [1 H, d, *J* 8 Hz, C(4)H], 2.0 (2 H, d, *J* 8 Hz), 2.5—3.6 (10 H, m), 2.26 (1 H, s, OH, exchanged with D_2O), 6.56 (2 H, s, CH_2Ph), 6.97 (3 H, s, NMe), and 8.42 (3 H, s, CMe); in $(CD_3)_2SO$ solution the CH_2Ph signal formed a pair of doublets τ 6.45 and 6.72 (*J* 15 Hz); *m/e* 467 (M^+, 6%), 376 (68%), 292 (18), 235 (65), 201 (100), and 91 (36).

3-Benzyl-3-p-chlorophenylsulphonylamino-2-p-chlorophenylsulphonylimino-1-methylindoline (17).—3-Benzyl-2-methylindole [26] was methylated to form 3-benzyl-1,2-dimethylindole.[26] This indole (1.1 g) was heated (50 °C; 36 h) with Cbs azide (1.1 g). The resulting solid was chromatographed affording the *indoline* (17), recrystallisation from propan-1-ol gave prisms, m.p. 200—202° (0.5 g) (Found: C, 55.8; H, 4.0; Cl, 12.0; N, 6.8; S, 10.6. $C_{28}H_{23}Cl_2N_3O_4S_2$ requires C, 55.7; H, 3.9; Cl, 11.7; N, 7.0; S, 10.7%); $\lambda_{max.}$ 226, 289, and 305 nm (ε 34 900, 12 400, and 9 100); $\nu_{max.}$ 1 585, 1 630, and 3 280 cm^{-1}; τ 1.95 (2 H, d, *J* 8 Hz), 2.32 (1 H, s, NH, exchanged with D_2O), 2.50 (2 H, d, *J* 8 Hz), 2.9—3.6 (13 H, m, Ar), 6.10 (1 H, d, *J* 13 Hz), 6.65 (1 H, d, *J* 13 Hz), and 7.12 (3 H, s, NMe); *m/e* 599 (M^+, 4%), 508 (100%), 268 (48), 175 (29), and 111 (48).

Methyl 1,3-Dimethylindole-2-carboxylate (20).—Trifluoroacetic anhydride (4 ml) in ether (8 ml) was added dropwise to a stirred ice-cold solution of 1,3-dimethylindole (2 g) in ether (5 ml). After 24 h (room temp.) the solution was poured into water; the ethereal layer was washed (aqueous sodium carbonate), dried, and evaporated. The residue was triturated with light petroleum and the resulting solid recrystallised from MeOH. *1,3-Dimethyl-2-trifluoroacetylindole* (19) formed yellow plates, m.p. 69—70° (2.2 g) (Found: C, 59.9; H, 4.2; N, 5.8. $C_{12}H_{10}F_3NO$ requires C, 59.8; H, 4.2; N, 5.8%); $\lambda_{max.}$ 208, 245, and 330 nm (ε 23 000, 12 400, and 24 000); $\nu_{max.}$ (CCl_4) 1 620 and 1 678 cm^{-1}; τ 2.3—3.0 (4 H, m, Ar), 6.08 (3 H, s, NMe), and 7.38 (3 H, s, CMe); *m/e* 241 (M^+, 83%) and 172 (100%). This ketone (1 g) was dissolved in MeOH (11 ml) containing sodium methoxide [from sodium (0.2 g)] and the solution boiled for 48 h. Water was then added and the solid which separated was collected and recrystallised (MeOH). The *ester* (0.66 g) formed rods, m.p. 76—77° (Found: C, 70.9; H, 6.3; N, 7.0. $C_{12}H_{13}NO_2$ requires C, 70.9; H, 6.4; N, 6.9%); $\nu_{max.}$ 1 615 and 1 705 cm^{-1}; τ 2.3—3.0 (4 H, m), 6.0 (3 H, s, OMe), 6.05 (3 H, s, NMe), and 7.4 (3 H, s, CMe); *m/e* 230 (M^+, 100%), 188 (70%), and 144 (39). The yields by this method were variable. The ketone (1 g) was boiled for 1 h with NaOH (1 g) in EtOH–H_2O (10 ml; 1 : 1). The solution was diluted with water and extracted with ether, and the aqueous phase was acidified. The solid which separated was extracted into ether; the solvent was removed and the residue recrystallised (EtOH) yielding needles (0.73 g), m.p. 216—218° (lit.,[27] 213°); *m/e* 189 (M^+, 100%), 156 (58%), and 144 (45). This acid was then esterified (CH_2N_2) affording (20).

Methyl 1,3-Dimethyl-2-p-nitrophenylsulphonyliminoindoline-3-carboxylate (21).—The indole (20) (0.2 g) and NbsN$_3$ (0.24 g) were heated in pyridine (80 °C; 4 weeks). Benzene was then added and the solution washed with dilute hydrochloric acid. The solvent was removed and the solid was recrystallised (MeOH) giving needles (0.1 g), m.p. 182—185° (Found: S, 7.9. $C_{18}H_{17}N_3O_6S$ requires S, 7.9%); $\nu_{max.}$ ($CHCl_3$) 1 570, 1 610, 1 625, 1 705, and 1 745 cm^{-1}; τ 1.75 (2 H, d, *J* 8 Hz), 1.85 (2 H, d, *J* 8 Hz), 2.5—3.0 (4 H, m), 6.30 (3 H, s, OMe), 6.60 (3 H, s, NMe), and 8.0 (3 H, s, CMe); *m/e* 403 (M^+, 43%), 217 (35%), 158 (100), and 145 (54).

Methyl 1,3-Dimethylindol-2-ylacetate (26).—2-Acetyl-1,3-dimethylindole [9] (6 g), sulphur (2 g), and morpholine (10 ml) were heated under reflux (oil-bath; 160 °C; 18 h). The excess of morpholine was removed *in vacuo*, the residue triturated with EtOAc, and the product recrystallised from propan-1-ol. The *thiomorpholide* (27) formed pale yellow needles, m.p. 224—227° (6 g) (Found: C, 66.8; H, 6.9; N, 9.6; S, 10.8. $C_{16}H_{20}N_2OS$ requires C, 66.8; H, 6.9; N, 9.7; S, 11.1%); $\nu_{max.}$ 1 560, 1 610, and 1 650 cm^{-1}; τ 2.4—3.1 (4 H, m, Ar), 5.6—5.8 (4 H, m, OCH_2), 5.72 (2 H, s, $-CH_2{\cdot}C{=}S$), 6.4—6.8 (4 H, m, NCH_2), 6.31 (3 H, s, NMe), and 7.76 (3 H, s, CMe); *m/e* 288 (M^+, 37%), 158 (100%), and 144 (30). The thioamide (1 g) was boiled (4 h) in CH_2Cl_2 (20 ml) with MeI (4 ml). The solvent was removed and the *methiodide* recrystallised (MeCN) forming yellow needles (1.3 g), m.p. 227—228° (Found: C, 47.5; H, 5.4; I, 29.4; N, 6.6. $C_{17}H_{23}IN_2OS$ requires C, 47.4; H, 5.4; I, 29.5; N, 6.5%). The methiodide (1 g) was boiled (3 h) in MeOH (30 ml). The solution was concentrated yielding *1,3-dimethylindol-2-ylacetomorpholide* (28) (0.48 g), needles (MeOH), m.p. 235—238° (Found: C, 70.4; H, 7.4; N, 10.2. $C_{16}H_{20}N_2O_2$ requires C, 70.6; H, 7.4; N, 10.3%); $\nu_{max.}$ 1 650 cm^{-1}; τ 2.4—3.0 (4 H, m, Ar), 6.20 (2 H, s, $CH_2{\cdot}CO$), 6.32 (3 H, s, NMe), 6.3—6.6 (8 H, m), and 7.70 (3 H, s, CMe); *m/e* 272 (M^+, 33%) and 158 (100%). The thiomorpholide (27) (10.8 g) was boiled under reflux with KOH (43 g) in water (60 ml) and EtOH (380 ml). After 3 h the solid had dissolved and the bulk of the EtOH was removed *in vacuo*. The aqueous solution was cooled in ice and acidified with ice-cold aqueous HCl. The solid which separated was collected and immediately esterified (CH_2N_2). The *ester* (26) formed needles, m.p. 66—68° [from petroleum (b.p. 60—80 °C)] (yield 5.4 g) (Found: C, 71.8; H, 6.9; N, 6.6. $C_{13}H_{15}NO_2$ requires C, 71.9; H, 6.9; N, 6.5%); $\nu_{max.}$ 1 730 cm^{-1}; τ 2.4—3.1 (4 H, m), 6.23 (2 H, s), 6.33 (6 H, s, OMe and NMe), and 7.71 (3 H, s, CMe); *m/e* 217 (M^+, 85%), 158 (100%), and 143 (13). Since the OMe and NMe signals coincided, a sample of the ester was reduced with LiAlH$_4$ in ether yielding *2-(1,3-dimethylindol-2-yl)ethanol*, cubes, m.p. 92—93° (from PhH) (82%) (Found: C, 76.0; H, 8.0; N, 7.4. $C_{12}H_{15}NO$ requires C, 76.3; H, 7.9; N, 7.4%); $\nu_{max.}$ 3 350br cm^{-1}; τ 2.4—3.0 (4 H, m), 6.25 (2 H, t, *J* 8 Hz, OCH_2), 6.33 (3 H, s, NMe), 7.00 (2 H, t, *J* 8 Hz, CH_2), 7.73 (3 H, s, CMe), and 8.4 (1 H, s, OH); *m/e* 189 (M^+, 34%), 158 (100%), and 144 (4).

Reactions of Methyl 1,3-Dimethylindol-2-ylacetate with Azides.—The ester (26) (0.4 g) was boiled (2 days) in chloroform (5 ml) with Cbs azide (0.4 g); the solvent was removed and MeOH added. The solid which separated was collected and recrystallised from propan-1-ol. *Methyl 3-p-chlorophenylsulphonylamino-1,3-dimethylindolin-2-ylidene acetate*

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(29; Z = Cbs) formed pale yellow prisms (0.23 g), m.p. 165—168° (Found: C, 55.9; H, 4.6; Cl, 8.8; N, 7.0; S. 7.7, $C_{19}H_{19}ClN_2O_4S$ requires C, 56.1; H, 4.7; Cl, 8.7; N, 6.9; S, 7.9%); $\lambda_{max.}$ 233, 301, and 336 nm (ε 18 000, 11 200, and 11 200); $\nu_{max.}$ 1 580, 1 660, and 3 160 cm^{-1}; τ 1.63 (1 H, s, NH, exchanged with D_2O), 2.6—3.5 (8 H, m, Ar), 5.29 (1 H, s, =CH·CO), 6.29 (3 H, s, OMe), 7.07 (3 H, s, NMe), and 8.28 (3 H, s, CMe); *m/e* 406 (M^+, 63%), 216 (85%), 184 (100), and 111 (13). The ester (0.5 g) was boiled (24 h) with *p*-nitrobenzenesulphonyl azide (1.0 g) in chloroform solution. The usual work-up gave *methyl* 1,3-*dimethyl*-3-p-*nitrophenylsulphonylaminoindoline*-2-*ylideneacetate* (29; Z = Nbs), orange-coloured prisms, m.p. 198—201° (from Pr^nOH) (0.83 g) (Found: C, 54.4; H, 4.7; N, 10.0; S, 7.4. $C_{19}H_{19}N_3O_6S$ requires C, 54.7; H, 4.6; N, 10.1; S, 7.8%); $\lambda_{max.}$ 234, 298, and 336 nm (ε 22 000, 16 100, and 14 800); $\nu_{max.}$ 1 590, 1 670, and 3 100br cm^{-1}; τ 1.45 (1 H, NH, exchanged with D_2O), 1.5—3.2 (8 H, m, Ar), 5.18 (1 H, s), 6.23 (3 H, s), 6.96 (3 H, s), and 8.23 (3 H, s); *m/e* 417 (M^+, 40%), 216 (46%), 186 (100), 184 (75), and 122 (66).

The ester (26) (0.4 g) and Nbs azide (1.0 g) were dissolved in Pr^nOH (5 ml) and heated (100 °C; 3 days). On cooling a solid separated; this crystallised from 2-methoxyethanol as minute prisms, m.p. 294—297° (0.57 g), identical (m.p., i.r., n.m.r.) with material obtained as follows. 1,3-Dimethylindole (2 g) and *p*-nitrobenzenesulphonyl azide (8 g) were dissolved in pyridine (10 ml). After 3 days the pyridine was removed and MeOH added. The product was recrystallised from 2-methoxyethanol (yield 4.7 g). 1.3-*Dimethyl*-3-p-*nitrophenylsulphonylamino*-2-p-*nitrophenylsulphonyliminoindoline* (30) had m.p. 295—297° (Found: C, 48.5; H, 3.5; N, 12.8; S, 11.9. $C_{22}H_{19}N_5S_2O_8$ requires C, 48.4; H, 3.5; N, 12.8; S, 11.7%); $\lambda_{max.}$ 210, 270, and 295sh (ε 23 100, 19 600, and 9 000); $\nu_{max.}$ 1 610, 1 630, and 3 300 cm^{-1}; τ[$(CD_3)_2SO$] 0.63 (1 H, NH, exchanged with D_2O), 1.5—3.5 (12 H, m, Ar), 6.62 (3 H, s, NMe), and 8.22 (3 H, s, CMe); *m/e* 545 (M^+, 55%), 359 (44%), 173 (100), 159 (40), 158 (42), and 132 (48).

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