Synthesis of Some Hexahydroazocino[4,3-*b*]indoles, a Tetra- and Two Hexahydropyrrolo[1′,2′:1,2]pyrrolo[3,4-*b*]indoles, and a Tetrahydropyrrolo[2′,1′:5,1]imidazo[3,4-*a*]indole. Crystal Structure Determination of 1,2,3,4-Tetrahydro-2-Phenoxycarbonyl-7-phenylsulphonylazocino[4,3-*b*]indol-6 (5*H*)-one

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Hexahydroazocino[4,3-*b*]indoles (**2a-c**) have been synthesised from 1-phenylsulphonylindole by introducing the appropriate side chain at C-2, *via* lithiation, and then intramolecular Mannich cyclisation. From (**2c**), 1,2,3,4-tetrahydro-2-phenoxycarbonyl-7-phenylsulphonylazocino[4,3-*b*]indol-6(5*H*)-one (**2e**) was then prepared and its structure determined by the *X*-ray method; the benzyl group in (**2c**) was also replaced with other urethane groups. Cleavage of the urethanes gave either a pyrrolo[1′2′:1,2]pyrrolo[3,4-*b*]indole or a 3-formyl-2-(4,5-dihydropyrrol-2-yl)indole. Reaction of 2-indol-2-ylpyrrolidine with formaldehyde in methanolic methoxide produced a pyrrolo-[2′,1′:5,1]imidazo[3,4-*a*]indole.

In our quest [1] for a synthesis of the indole alkaloid apparicine [2] (**1**) we came to consider the use of an intermediate of the form (**2**; R^2 = O) onto which it would be the plan to graft [3] the carbons required for the fourth ring and ethylidene side chain of the apparicine skeleton. Partly because of anticipated N/C:O transannular interaction [4] in a system such as (**2**; R = O) and partly because of precedent [5] it was also relevant to consider the synthesis and utility of an intermediate of the form (**3**) in which it would be the plan to cleave selectively one of the indolylic C–N bonds [5] to enter the structural series (**2**). In the event the syntheses of these two structural types became intertwined. No example of these ring systems has been previously reported.

Results

Condensation of 1-phenylsulphonylindol-2-yl-lithium [6] with 1-benzoylpyrrolidin-2-one [7] gave the oxo-amide (**4a**), vigorous alkaline hydrolysis of which yielded the imine (**5a**), as a result of intramolecular dehydration after cleavage of the two N-substituents. Borohydride reduction of (**5a**) proceeded straightforwardly to give the amine (**6a**).

In simple terms the conversion of (**6a**) into a tetracycle (**3a**) would require an intramolecular Mannich reaction. However, consideration of the intermediate (**6b**) which would have to be involved in an acid-catalysed Mannich process reveals that the required closure would be an unfavoured 5 *endo trig* process.[8] It was not surprising then that treatment of (**6a**) with formalin in acetic acid, even at high dilution, produced only complex amorphous mixtures, shown to be dimers by mass spectrometry.

Treatment of (**6a**) with formaldehyde in methanolic sodium methoxide on the other hand did lead to a tetracyclic species in which, also, a methoxymethyl group had been incorporated. The product did not give signals for either an indolic NH or an indolic β-proton suggesting that the product had structure (**3b**), though simple analysis of the spectroscopic data could not distinguish this from its isomer (**7**) resulting from cyclisation at the indolic nitrogen.

In order to differentiate between structures (**3b**) and (**7**) a detailed n.m.r. study was performed at 300 MHz using spin-decoupling and measurements of spin lattice relaxation times (T_1) and transient nuclear Overhauser enhancements (n.O.e.).[9]

Table 1. ^{1}H N.m.r. chemical shifts and spin-lattice relaxation times for (**7**), *ca.* 10 mg cm^{-3} solution in [$^2H_6$]-acetone at 25 °C

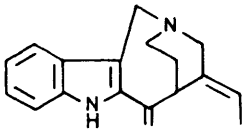
Proton	δ	T_1/s[a]
1	2.21 2.48	~2.4
2	1.95 2.01	~2.4
3	2.86 3.36	~2.4
5	5.08	2.4
7	7.37	10.6
8	7.20	8.4
9	7.14	8.8
10	7.68	10.8
11b	4.78	~6
OCH_2	4.71	3.5
OCH_3	3.41	~6

[a] Error ±5% except those qualified by the ~ symbol where error is ±20%.

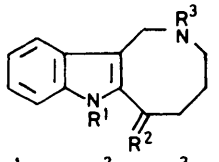
A degassed solution of *ca.* 10 mg cm^{-3} in [$^2H_6$]acetone was employed.

At 300 MHz, the ^{1}H n.m.r. spectrum is well-resolved, and from the arguments described below, it proved possible to assign the locations of each observed resonance, though not to assign individual protons within the three non-equivalent methylene pairs at C-1, C-2, and C-3. The structure was shown to be (**7**). The chemical shifts and T_1 values are given in Table 1. It is noteworthy that T_1 covers a wide range from 2.4 to 10.8 s indicating that intramolecular dipole-dipole interactions are the major relaxation source. Thus the T_1's and n.O.e.s are structurally significant.

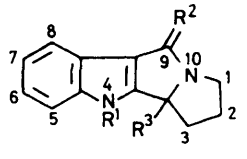
The assignment of the aliphatic protons in the C-3, C-2, C-1, C-11b fragment was established by spin-decoupling, starting from the unequivocal assignment of 11b-H to a doublet of doublets at δ 4.78, with coupling constants of 5 and 8 Hz. The aromatic protons were assigned by analogy with the model compound *N*-methylindole, in which the protons of the benzene ring ABCD system were found to resonate at δ

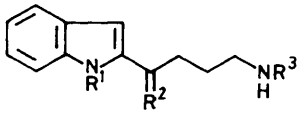


(1)



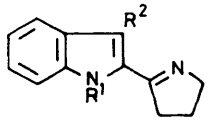
(2)	R^1	R^2	R^3
a;	H	H,OH	CH_2Ph
b;	H	O	CH_2Ph
c;	SO_2Ph	O	CH_2Ph
d;	SO_2Ph	O	CO_2CH_2Ph
e;	SO_2Ph	O	CO_2Ph
f;	SO_2Ph	O	CO_2CH_2-fluoren-9-yl
g;	SO_2Ph	O	$CO_2CH_2CCl_3$
h;	SO_2Ph	O	H

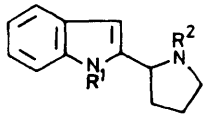




(3)	R^1	R^2	R^3
a;	H	H_2	H
b;	CH_2OCH_3	H_2	H
c;	SO_2Ph	H_2	OH
d;	SO_2Ph	H_2	O.CO.OR
e;	SO_2Ph	O	H
f;	SO_2Ph	H_2	H

(4)	R^1	R^2	R^3
a;	SO_2Ph	O	COPh
b;	H	H,OH	CH_2Ph





(5)	R^1	R^2
a;	H	H
b;	CH_2Ph	H
c;	H	CHO

(6)	R^1	R^2
a;	H	H
b;	H	$^+CH_2$
c;	CH_2Ph	H
d;	CH_2Ph	CH_2OMe

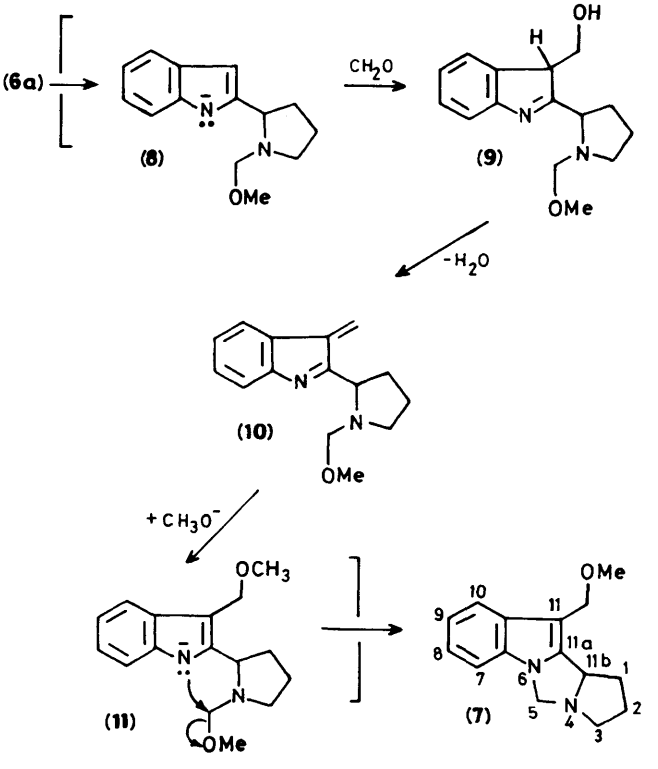
7.51 and 7.69 (doublets) and 7.17 and 7.29 (triplets). Saturation of the *N*-methyl signal produced an n.O.e. of *ca.* 12% of the doublet at δ 7.51, thus giving the assignment of 11a-H. The remaining assignments followed from spin-decoupling. The chemical shifts of the benzene ring protons in (7) are very close to those of the corresponding protons in *N*-methylindole. As further support for our assignment, the chemical shifts follow the same order as those of the benzene ring protons in the indole moiety of apparicine.[9]

The remaining unassigned peaks were two methylene singlets at δ 4.71 and 5.08. Because the latter had a T_1 similar to those of the 1-, 2-, and 3-CH_2 protons, it was assigned to a framework methylene. In contrast, the T_1 of the former was some 50% longer, indicating greater mobility, and this peak was therefore assigned to the substituent methoxymethyl methylene. To distinguish between (**3b**) and (**7**), the transient n.O.e.'s of the 10-H and 7-H signals were monitored following selective inversion of these methylenes. Inversion of the framework methylene at δ 5.08 produced a maximum enhancement of 3% of 7-H only, whereas inversion of the side-group CH_2 at δ 4.71 produced a maximum enhancement of 6% of 10-H only, thus verifying the structure (**7**).

One may reasonably view the cyclisation as a 5 *exo tet* process involving displacement of methoxy[10] from an N_b–CH_2–OMe unit. Since, from the stereochemical view point, there is no difference between attack at nitrogen and at the indole β-carbon, it seemed hopeful that if the former could be temporarily blocked, closure would be forced to take the desired course.

Selective N_a-benzylation of (**5a**) gave (**5b**) and reduction as before then produced (**6c**). Unfortunately reaction of (**6c**) with formaldehyde in methanolic sodium methoxide yielded only the *N*-methoxymethyl derivative (**6d**). A subsequent attempt to catalyse the closure of (**6d**) with acid led trivially to de-*N*-methoxymethylation.

We interpret these results as meaning that the ring closure producing (**7**) must involve an anionic indole moiety and further, that in the light of the failure of (**6c**) to *C*-methoxymethylate, the sequence of events must involve C-substitution first and thus intermediates such as (**8**)—(**11**) (Scheme 1).



Scheme 1.

Having failed by these means to produce a tetracycle (**3**), we turned to the prospect of synthesising hexahydroazocinoindole (**2**). Lithium aluminium hydride reduction of the oxo-amide (**4a**) resulted in cleavage of the indole *N*-substituent and also

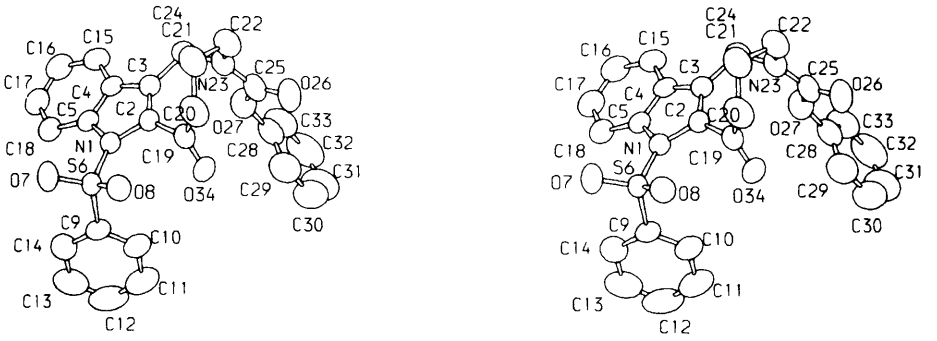
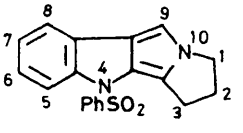


Figure 1. Stereoscopic drawing of 1,2,3,4-tetrahydro-2-phenoxycarbonyl-7-phenylsulphonylazocino[4,3-*b*]indol-6 (5*H*)-one (**2e**)

reduction of ketone and amide groups producing (**4b**). This proved to be a viable substrate for intramolecular Mannich cyclisation, best conducted at high dilution, and resulting in the tricycle (**2a**) in good yield. Manganese dioxide oxidation of the indolylic secondary alcohol and phase-transfer catalysed *N*-phenylsulphonylation then produced in turn (**2b**) and (**2c**). A moderate yield in the manganese dioxide oxidation could not be improved upon by the use of other oxidants such as chromium trioxide–pyridine, chromic acid, or pyridinium chlorochromate.

All attempts to remove the *N*-benzyl group from (**2b**) or (**2c**) to produce the corresponding secondary amine were unsuccessful. However, the benzyl group *could* be removed but at the expense of replacing[11] it with a urethane group, it being hoped that the latter would be more readily removed. To this end the urethanes (**2d**—**g**) were obtained by reaction of the benzylamine with the chloroformates, in the presence of potassium hydrogen carbonate for (**2d**, **f**, **g**).

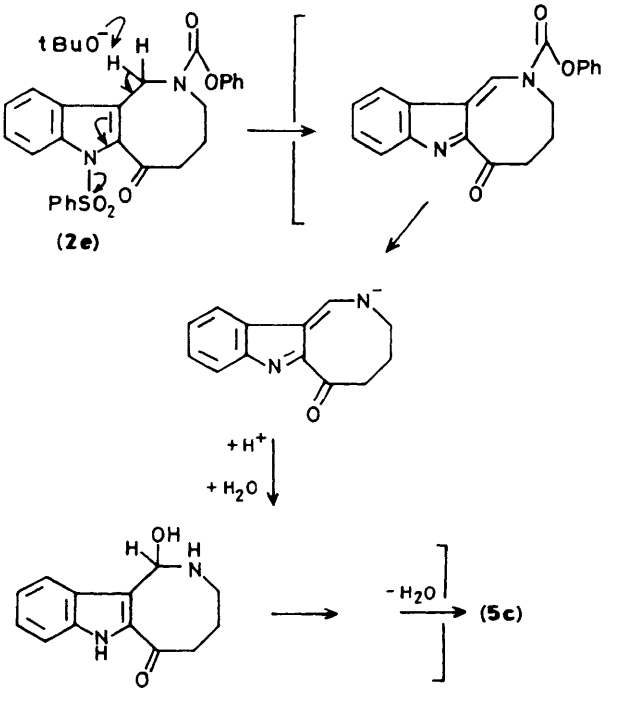
Although the various urethanes were cleaved by the methods appropriate to each, in no instance could the product of straightforward removal [*i.e.* (**2h**) or a tetracyclic form (**3c**)] be obtained. For example hydrogen bromide in acetic acid converted the benzyl urethane (**2d**) into the pyrrole (**12**); this change can be interpreted as involving firstly removal of the protecting group, then transannular N/C=O addition, generating (**3c**) followed by acid-catalysed dehydration. Based on this rationalisation it seemed possible that a better chance of preventing the aromatisation of an intermediate, such as (**3c**), would be available in a base-cleavable urethane. However cleavage of the phenylurethane (**2e**) with methyl-lithium–lithium bromide[12] or dilute aqueous sodium hydroxide, or sodium hydride, or of the fluoren-9-ylmethylurethane (**2f**) with piperidine gave the same pyrrole (**12**) in yields of 74, 26, 85, and 69% respectively, the first method being the choice for the preparation of (**12**).[13]



(12)

The persistent appearance of tetracyclic products (see also later) led us to question the structures (**2d**—**g**) assigned to the urethanes. The possibility existed that these *N*-benzyl-cleavage products had resulted from attack not at nitrogen but at carbonyl oxygen with concomitant N/C:O transannular interraction and thus had isomeric structures (**3d**). Indeed routine ^{13}C n.m.r. spectra of (**2e**) and (**2g**) showed only one carbonyl carbon signal, consistent with structures (**3d**). However a high resolution spectrum of (**2e**) did show two signals, in the carbonyl carbon region, separated by 0.061 p.p.m. A further puzzle was the absence, for (**2d**) and (**2g**), of i.r. carbonyl stretching in the region (1 640—1 690 cm^{-1}) anticipated for an α-acyl-indole [*cf.* 1 645 and 1 690 cm^{-1} for (**2b**) and (**2c**) respectively]. In the light of these doubts further confirmation for structures (**2d**—**g**) was sought. A suitable crystal of the phenylurethane (**2e**) was subjected to *X*-ray crystallographic analysis. The hexahydroazocinoindole structure (**2e**) was revealed and is shown in the stereoscopic drawing (Figure 1). One may note that the torsion angle between the indole α-carbonyl group and the plane of the pyrrole ring is 68°; this must substantially decrease the conjugation between the aromatic nucleus and the carbonyl group and this provides an explanation for the anomalous i.r. stretching frequency of the indole-α-acyl carbonyl group in this compound and the other three urethanes.

Cleavage of the phenylurethane (**2e**) with alkoxide in alcohol, best with potassium t-butoxide in t-butyl alcohol, produced an unexpected product (**5c**) of a different type. The structure was confirmed by independent synthesis of (**5c**) by Vilsmeier formylation of (**5a**). We rationalise the formation of (**5c**) from (**2e**) as involving base-catalysed elimination of benzenesulphinic

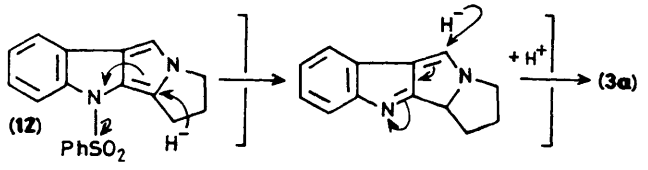


Scheme 2.

acid,[14] probably before cleavage of the urethane, and that hydration during work-up, carbinolamine cleavage and intramolecular imine formation complete the process (Scheme 2).

Cleavage of the trichloroethylurethane (**2g**) with zinc in acetic acid produced two products when air was not excluded but only one of these when the reaction was conducted after degassing and under nitrogen. The air oxidation product, the lactam (**3e**) could be converted into the product (**3f**), obtained in 94% yield in the absence of oxygen, by reduction with di-isobutylaluminium hydride.

Finally, an attempt was made to remove the phenylsulphonyl group from the pyrrole (**12**) with the aim of examining the position of tautomeric equilibrium in the expected pyrrole or its hydration product. However, after 4 h under reflux in concentrated methanolic sodium hydroxide no reaction had occurred. Lithium aluminium hydride in refluxing tetrahydrofuran not only cleaved the N-substituent but also reduced the molecule producing (**3a**). This reduction may follow the course suggested in Scheme 3.



Scheme 3.

Experimental

4-*Benzamido*-1-(1-*phenylsulphonylindol*-2-*yl*)*butan*-1-*one* (**4a**).—A solution of butyl-lithium (1.55M in hexane; 26 ml, 40 mmol) was added to a stirred solution of 1-phenylsulphonylindole[6] (10.0 g, 40 mmol) in dry tetrahydrofuran (THF) (180 ml) under nitrogen and at −75 °C. The solution was allowed to warm to room temperature during 1 h and then cooled to −75 °C when a solution of 1-benzoylpyrrolidin-2-one[7] (7.56 g, 40 mmol) in THF was added rapidly. After being warmed to room temperature during 1.5 h and stirred for a further 1.5 h the mixture was poured into saturated brine (400 ml) containing hydrochloric acid (2M; 50 ml) and extracted with ethyl acetate. The dried extract was evaporated to give an oil which was crystallised from ethyl acetate to give the *oxo-amide* (**4a**) (12.49 g, 28 mmol, 72%), m.p. 146—147 °C, $\lambda_{max.}$(EtOH) 242sh, 268sh, 275sh, and 292sh nm (log ε 3.85, 3.65, 3.68, and 3.72); $\nu_{max.}$(Nujol) 3 380m, 1 680s, and 1 660s cm^{-1}; δ($CDCl_3$) 7.3—8.2 (14 H, m, ArH), 7.1 (1 H, s, indolyl 3-H), 6.9 (1 H, s, NH), 3.65 (2 H, m, CH_2N), 3.2 (2 H, t, *J* 7 Hz, $CH_2C{=}O$), and 2.15 (2 H, m, $CH_2CH_2CH_2$); *m/z* 446 (M^+, 0.8%), 325 (3), 305 (5), 284 (2), 184 (50), 105 (100), and 77 (33) (Found: C, 66.8; H, 5.0; N, 6.1; S, 7.2. $C_{25}H_{22}N_2O_4S{\cdot}0.1\ 25H_2O$ requires C, 66.9; H, 5.0; N, 6.2; S, 7.2%).

4,5-*Dihydro*-2-*indol*-2-*yl*-3H-*pyrrole* (**5a**).—The oxo amide (**4a**) (9.99 g, 22 mmol) was hydrolysed in ethanol (150 ml) and water 10 ml) with potassium hydroxide (25 g) at reflux for 48 h. The solvent was evaporated and the residue partitioned between water and ether to give the crude crystalline product, which was recrystallised from methanol to give the *imine* (**5a**) (3.03 g, 16 mmol, 74%), m.p. 163—164 °C, $\lambda_{max.}$(EtOH) 232sh and 303 nm (log ε 4.17 and 4.20); $\lambda_{max.}$(EtOH–H^+) 215, 267, 281, and 289 nm (log ε 4.50, 3.88, 3.83, and 3.62); $\nu_{max.}$($CHCl_3$) 3 460s, and 1 660s cm^{-1}; δ($CDCl_3$) 11.40 (1 H, br s, NH), 7.66 (1 H, d, *J* 7 Hz, ArH), 7.36 (1 H, d, *J* 7 Hz), 7.25 (1 H, t, *J* 7 Hz, ArH), 7.21 (1 H, t, *J* 7 Hz, ArH), 6.82 (1 H, s, indolyl 3-H), 4.09 (2 H, t, *J* 5 Hz, NCH_2), 3.00 (2 H, t, *J* 5 Hz, CH_2 C=N), and 2.06 (2 H, quintet, *J* 5 Hz, $CH_2CH_2CH_2$); *m/z* 184 (M^+, 100%), 183 (95), 156 (25), 130 (20), and 115 (10) (Found: C, 77.3; H, 6.4; N, 14.9. $C_{12}H_{12}N_2{\cdot}0.125H_2O$ requires C, 77.3; H, 6.6; N, 15.0%).

2-*Indol*-2-*ylpyrrolidine* (**6a**).—Sodium borohydride (*ca.* 3 g) was gradually added with stirring to a solution of the imine (**5a**) (0.50 g, 2.7 mmol) in absolute ethanol (50 ml) over 72 h. The mixture was evaporated and the residue treated with hydrochloric acid (2M; 70 ml); the resulting solution was made basic with potassium carbonate and the product extracted with ether to give an oil which afforded the *pyrrolidine* (**6a**) (0.50 g, 2.7 mmol, 100%) as crystals on trituration with ether, m.p. 102—103 °C (from 1,1,1-trichloroethane), $\lambda_{max.}$(EtOH) 219, 271, 282sh, and 289 nm (log ε 4.47, 3.86, 3.86, and 3.73); $\nu_{max.}$(Nujol) 3 320s cm^{-1}; δ($CDCl_3$) 9.29 (1 H, br s, NH), 7.57 (1 H, d, *J* 8 Hz, ArH), 7.30 (1 H, d, *J* 8 Hz, ArH), 7.10 (2 H, m, ArH), 6.31 (1 H, s, indolyl 3-H), 4.36 (1 H, t, *J* 6 Hz, NCH), 3.06 (2 H, m, NCH_2), 2.12 (1 H, br s, NH), and 1.88 (4 H, m, CH_2CH_2); *m/z* 186 (M^+, 100%), 158 (40), 143 (20), 130 (35), and 117 (15) (Found: C, 77.3; H, 7.4; N, 15.2. $C_{12}H_{14}N_2$ requires C, 77.4; H, 7.6; N, 15.0%).

1,2,3,11b-*Tetrahydro*-11-*methoxymethyl*-5H-*pyrrolo*[2′,1′:5,1]*imidazo*[3,4-a]*indole* (**7**).—The pyrrolidine (**6a**) (49 mg, 0.26 mmol) was treated with paraformaldehyde (17 mg, 0.57 mmol) in methanolic sodium methoxide (3M; 4 ml) at reflux for 0.5 h. Water (10 ml) was added and the resultant precipitate filtered off. The latter was subjected to preparative t.l.c. on silica eluting with toluene–triethylamine (2:1) to give the *tetracycle* (**7**) (19 mg, 0.079 mmol, 30%) as a sintered foam, $\lambda_{max.}$(EtOH) 222, 275, 283, and 290 nm; for details of n.m.r. data see Table 1; *m/z* 242 (M^+, 45%), 211 (100), 197 (12), and 183 (30) (Found: *M* by mass spectrometry 242.1422. $C_{15}H_{18}N_2O$ requires *M* 242.1419).

2-(1-*Benzylindol*-2-*yl*)-4,5-*dihydro*-3H-*pyrrole* (**5b**).—To a vigorously stirred two-phase system of a solution of the imine (**5a**) (0.103 g, 0.56 mmol) in THF (10 ml) and aqueous sodium hydroxide (50%; 5 ml) containing a little tetrabutylammonium hydroxide, was added benzyl bromide (0.19 g, 1.1 mmol) in THF (5 ml) during 20 min. After a further 0.5 h the phases were separated, the aqueous phase was re-extracted with ethyl acetate and the combined organic extracts were washed with brine, dried, and evaporated to give the *title compound* (**5b**) (0.12 g, 0.45 mmol, 80%), m.p. 128—132 °C (from ethanol), $\lambda_{max.}$(EtOH) 223sh, 235s and 298 nm (log ε 4.23, 4.16, and 4.23), $\lambda_{max.}$(EtOH–H^+) 242 and 340 nm (log ε 4.00 and 4.30); $\nu_{max.}$(Nujol) 1 615m cm^{-1}; δ($CDCl_3$) 7.71 (1 H, d, *J* 7 Hz, ArH), 7.08—7.40 (8 H, m, ArH), 6.96 (1 H, s, indolyl 3-H), 6.16 (2 H, s, CH_2Ph), 4.08 (2 H, t, *J* 5 Hz, CH_2N), 3.05 (2 H, t, *J* 5 Hz, $CH_2C{=}N$), and 1.94 (2 H, quintet, *J* 5 Hz, $CH_2CH_2CH_2$); *m/z* 274 (M^+, 100%), 197 (83), and 91 (48) (Found: C, 83.3; H, 6.7; N, 10.1. $C_{19}H_{18}N_2$ requires C, 83.2; H, 6.6; N, 10.2%).

2-(1-*Benzylindol*-2-*yl*)*pyrrolidine* (**6c**).—To a stirred solution of the imine (**5b**) (0.50 g, 1.82 mmol) in ethanol (20 ml) was added an excess of sodium borohydride (*ca.* 3 g) over 48 h. The mixture was evaporated and the residue treated with hydrochloric acid (2M; 30 ml) and then made basic with potassium carbonate; the product was then extracted with ether and worked up to give the *pyrrolidine* (**6c**) (0.50 g, 1.81 mmol, 98%) as an oil, $\lambda_{max.}$(EtOH) 228, 270sh, 276, 283, and 291 nm; $\nu_{max.}$($CHCl_3$) 3 300 s cm^{-1}; δ($CDCl_3$) 7.64 (1 H, d, *J* 7 Hz, ArH), 6.90—7.35 (8 H, m, ArH), 6.57 (1 H, s, indolyl 3-H), 5.54 (2 H, q, *J* 19 Hz, NCH_2Ph), 4.22 (1 H, t, *J* 5 Hz, CHN), 2.96—3.14 (2 H, m, CH_2N), 2.82 (1 H, s, NH), and 1.93 (4 H, m, CH_2CH_2); *m/z* 276 (M^+, 67%), 218 (75), 157 (51), and 91 (100) (Found: *M* by mass spectrometry, 276.1626. $C_{19}H_{20}N_2$ requires *M*, 276.1624).

2-(1-*Benzylindol*-2-*yl*)-1-*methoxymethylpyrrolidine* (**6d**).—A solution of the amine (**6c**) (0.077 g, 0.28 mmol) and

paraformaldehyde in methanolic sodium methoxide (11M; 5 ml) was refluxed for 36 h. The mixture was poured onto ice and the methanol removed under reduced pressure. The resulting precipitate was filtered off to give the *methoxymethylamine* (**6d**) (0.062 g, 0.194 mmol, 70%) as pale green crystals, m.p. 61—66 °C, $\lambda_{max.}$(EtOH) 230sh, 276, 284, and 293 nm; δ($CDCl_3$) 6.80—7.70 (9 H, m, ArH), 6.57 (1 H, s, indolyl 3-H), 5.49 (2 H, s, NCH_2Ph), 4.30 (1 H, m, CHN), 4.13 (2 H, d, *J* 2 Hz, $MeOCH_2N$), 3.20 (3 H, s, MeO), 3.05—3.30 (2 H, m, CH_2N), and 1.88 (4 H, m, CH_2CH_2); *m/z* 320 (M^+, 36%), 288 (40), 260 (24), 233 (26), 218 (33), 197 (29), and 91 (100) (Found: *M* by mass spectrometry, 320.1889. $C_{21}H_{24}N_2O$ requires *M*, 320.1889).

4-*Benzylamino*-1-*indol*-2-*ylbutan*-1-*ol* (**4b**).—The oxo-amide (**4a**) (12 g, 26.9 mmol) in dry THF (500 ml) was reduced with lithium aluminium hydride (5 g) at reflux for 12 h. To the cooled solution saturated aqueous sodium sulphate was added until the suspended solid turned from grey to white. The mixture was filtered at the pump, the solid being washed thoroughly with ethyl acetate. The dried filtrate was evaporated to give an oil which was dissolved in chloroform and the solution washed with aqueous sodium carbonate; evaporation of the chloroform, gave a partially crystalline mass, which was recrystallised from ethyl acetate to afford the *alcohol* (**4b**) (5 g, 17.0 mmol, 63%), m.p. 126—128 °C, $\lambda_{max.}$(EtOH) 231, 275sh, 285, and 293sh nm (log ε 3.94, 3.18, 3.21, and 3.13); $\nu_{max.}$($CHCl_3$) 3 460 s cm^{-1}; δ($CDCl_3$) 8.65 (1 H, br s, NH), 7.55 (1 H, m, ArH), 7.0—7.3 (8 H, m, ArH), 6.24 (1 H, s, indolyl 3-H), 4.9 (1 H, m, CHO), 4.2 (2 H, br s, NH and OH), 3.75 (2 H, s, NCH_2Ph), 2.75 (2 H, m, CH_2N), 2.1 (2 H, m, CH_2CHO), and 1.8 (2 H, m, $CH_2CH_2CH_2$); *m/z* 294 (M^+, 3%), 276 (15), 143 (20), 130 (20), and 91 (100) (Found: C, 77.0; H, 7.6; N, 9.2. $C_{19}H_{22}N_2O{\cdot}0.125H_2O$ requires C, 77.0; H, 7.5; N, 9.5%).

2-*Benzyl*-1,2,3,4,5,6-*hexahydroazocino*[4,3-b]*indol*-6-*ol* (**2a**).—A mixture of the alcohol (**4b**) (1 g, 3.4 mmol), formalin (40%, 9 ml), and glacial acetic acid (9 ml) in glyme (500 ml) was set aside at room temperature for 20 min; it was then concentrated to *ca.* 20 ml by evaporation under reduced pressure. Saturated aqueous sodium carbonate (100 ml) was added and the product extracted into ether to give the *azocinoindole* (**2a**) (1.02 g, 3.3 mmol, 96%) as an oil, $\lambda_{max.}$(EtOH) 232, 272sh, 287, and 290 nm; $\nu_{max.}$($CHCl_3$) 3 465m cm^{-1}; δ($CDCl_3$) 8.1 (1 H, br s, NH), 7.0—7.4 (9 H, m, ArH), 4.8 (1 H, m, CHO), 3.89 (2 H, q, *J* 16 Hz, indolyl-CH_2N), 3.82 (2 H, q, *J* 13 Hz, NCH_2Ph), 2.5—2.9 (2 H, m, NCH_2), and 1.6—1.9 (4 H, m, CH_2CH_2); *m/z* 306 (M^+, 15%), 288 (20), 215 (4), 197 (15), 173 (85), 130 (35), and 91 (100) (Found: *M* by mass spectrometry, 306.1733. $C_{20}H_{22}N_2O$ requires *M*, 366.1732).

2-*Benzyl*-1,2,3,4-*tetrahexahydroazocino*[4,3-b]*indol*-6 (5H)-*one* (**2b**).—The alcohol (**2a**) (5.3 g, 17.3 mmol) was oxidised by stirring with manganese dioxide [15] (10 g) in dry chloroform (2 l) at room temperature for 48 h. Further portions of manganese dioxide (5 g) were added at 12 h intervals. The mixture was filtered and the filtrate evaporated to give a brown crystalline mass (3.9 g), recrystallisation of which from ethanol gave the *ketone* (**2b**) (2.8 g, 9.2 mmol, 53%) as white crystals, m.p. 173—174 °C, $\lambda_{max.}$(EtOH) 236 and 314 nm (log ε 4.06 and 4.22); $\nu_{max.}$($CHCl_3$) 3 450m and 1 645s cm^{-1}; δ($CDCl_3$) 9.1 (1 H, br s, NH), 7.2—7.5 (9 H, m, ArH), 4.4 (2 H, s, indolyl-CH_2N) 3.65 (2 H, s, NCH_2Ph), 3.1 (2 H, t, *J* 7 Hz, NCH_2), 2.6 (2 H, m, $CH_2C{=}O$), and 2.1 (2 H, m, $CH_2CH_2CH_2$); δ_C($CDCl_3$) 194.04 (s), 139.60 (s), 136.31 (s), 134.70 (s), 128.85 (d), 128.55 (d), 127.24 (d), 126.43 (s), 121.24 (d), 120.65 (d), 116.92 (s), 112.09 (d), 60.94 (t), 50.70 (t), 47.48 (t), 40.45 (t), and 23.66 (t); *m/z* 304 (M^+, 45%), 213 (43), 185 (30), 157 (40), 130 (40), and 91 (100) (Found: C, 78.9; H, 6.5; N, 9.3. $C_{20}H_{20}N_2O$ requires C, 78.9; H, 6.6; N, 9.2%).

2-*Benzyl*-1,2,3,4-*tetrahydro*-7-*phenylsulphonylazocino*-[4,3-b]*indol*-6 (5 H)-*one* (**2c**).—Benzenesulphonyl chloride (0.1 ml) in benzene (0.5 ml) was added dropwise to a vigorously stirred two-phase system of a solution of the ketone (**2b**) (100 mg, 0.33 mmol) in benzene (30 ml) and aqueous sodium hydroxide (50%; 5 ml) containing a little tetrabutylammonium hydroxide. The solution was stirred for 1 h after which the organic phase was separated, washed with water, and passed through a short column of silica. Evaporation of the eluate gave an oil (0.161 g) which was crystallised from 95% ethanol to give the *phenylsulphonyl ketone* (**2c**) (0.12 g, 0.27 mmol, 82%), m.p. 171—173 °C, $\lambda_{max.}$(EtOH) 217, 242, 268sh, 275sh, and 292sh nm; $\nu_{max.}$($CHCl_3$) 1 640s cm^{-1}; δ ($CDCl_3$) 8.0—8.4 (2 H, m, ArH), 7.2—7.7 (12 H, m, ArH), 3.85 (4 H, s, indolyl-CH_2N and NCH_2Ph), 2.70—2.95 (4 H, m, $CH_2CH_2CH_2$), and 2.1 (2 H, m, $CHCH_2CH_2$); *m/z* 444 (M^+, 1%), 353 (15), 303 (60), 174 (25), 156 (25), 91 (100), and 77 (30) (Found: C, 70.4; H, 5.4; N, 6.4; S, 7.2. $C_{26}H_{24}N_2O_3S$ requires C, 70.3; H, 5.4; N, 6.3; S, 7.1%).

General Method for Preparation of Urethanes (**2d—g**) *Exemplified by the Preparation of* (**2g**).—A dry chloroform solution of the ketone (**2c**) (0.20 g, 0.46 mmol), and 1,1,1-trichloroethyl chloroformate (0.2 g), with anhydrous potassium hydrogen carbonate (0.8 g) in suspension, was heated at reflux for 8 h. At 12 h intervals more chloroformate (0.2 g) was added. The cooled reaction mixture was washed with water and the dried organic phase evaporated to give an oil which was purified by chromatography over silica, with ethyl acetate–toluene (1:1) as eluant to give the urethane (**2g**) (0.18 g, 0.34 mmol, 74%), as a gum, $\lambda_{max.}$(EtOH) 220sh, 242sh, 260sh, 267sh, 275sh, and 292sh nm; $\nu_{max.}$($CHCl_3$) 1 720s cm^{-1}; δ($CDCl_3$) 8.18 (2 H, m, ArH), 7.3—7.75 (6 H, m, ArH), 4.62 and 4.79 (2 H, 2 × s, indolyl-CH_2N), 4.75 and 4.76 (2 H, 2 × s, CCl_3CH_2), 3.81 (2 H, 2 × t, *J* 6 Hz, NCH_2), 3.02 (2 H, m, $CH_2C{=}O$), and 2.3 (2 H, m, $CHCH_2CH_2$); *m/z* 528 and 530 (M^+, 4 and 4%), 387, 389, 391, and 393 (100, 95, 31, and 4), 257 (22), and 184 (22) (Found: *M* by mass spectrometry 528.0078. $C_{22}H_{19}Cl_3N_2O_5S$ (3 × ^{35}Cl) requires *M*, 528.0080). The *benzylurethane* (**2d**) was obtained as an oil (42%), $\lambda_{max.}$(EtOH) 242 sh, 268sh, 275sh, and 292sh nm; $\nu_{max.}$($CHCl_3$) 1 700s cm^{-1}; δ($CDCl_3$) 7.9—8.3 (2 H, m, ArH), 7.1—7.7 (12 H, m, ArH), 5.2 (2 H, s, OCH_2Ph), 4.65 (2 H, s, indolyl-CH_2N), 3.8 (2 H, m, CH_2N), 3.0 (2 H, m, $CH_2C{=}O$), and 2.75 (2 H, m, $CH_2CH_2CH_2$); *m/z* 488 (M^+, 6%), 397 (90), 353 (17), 347 (100), 212 (20), 184 (20), 91 (100), and 77 (42) (Found: *M* by mass spectrometry 488.1403. $C_{27}H_{24}N_2O_5S$ requires *M* 488.1406). The *phenylurethane* (**2e**) was obtained as a crystalline solid (56%), m.p. 175—177 °C (from methanol–water), $\lambda_{max.}$(EtOH) 220, 240sh, 265sh, and 290sh nm (log ε 4.18, 3.86, 3.79, and 3.63); $\nu_{max.}$($CHCl_3$) 1 715s and 1 680s cm^{-1}; δ($CDCl_3$) 7.8—8.2 (4 H, m, ArH), 6.8—7.6 (10 H, m, ArH), 4.7 (2 H, q, *J* 10 Hz, indolyl-CH_2N), 3.75 (2 H, m, NCH_2), 2.95 (2 H, m, $CH_2C{=}O$), and 2.25 (2 H, m, $CHCH_2CH_2$); *m/z* 474 (M^+, 2%), 380 (20), 352 (12), 333 (25), 270 (21), 240 (25), 211 (30), 184 (25), 156 (75), 128 (45), 94 (35), and 77 (100) (Found: C, 65.6; H, 4.6; H, 5.6. $C_{26}H_{22}N_2O_5S$ requires C, 65.8; H, 4.6; N, 5.9%). The *Fluoren*-9-*ylmethylurethane* (**2f**) was obtained as a crystalline solid (81%), m.p. 195—200 °C, $\lambda_{max.}$(EtOH) 222, 257sh, 264sh, 267, 274sh, 290, and 301 nm (log ε 4.47, 4.36, 4.37, 4.40, 4.29, 4.19, 3.99, and 3.96); $\nu_{max.}$(Nujol) 1 700s and 1 675w cm^{-1}; δ[$(CD_3)_2SO$] 8.00—6.5 (17 H, m, ArH), 4.61 and 4.66 (2 H, 2 × s, indolyl-CH_2), 4.32—3.95 (3 H, m, CH_2CH), 3.5 and 3.65 (2 H, 2 × br s, CH_2N), 2.68 and 2.81 (2 H, 2 × br s, $CH_2C{=}O$), and 2.05 and 2.21 (2 H, 2 × br s, $CH_2CH_2CH_2$); *m/z* 576 (M^+, 2%), 435 (4), 398 (3), 354 (4), 336 (6), 257 (63), 195 (37), 179 (56),

Table 2. Atom co-ordinates for 1,2,3,4-tetrahydro-2-phenoxycarbonyl-7-phenylsulphonylazocino[4,3-*b*]indol-6 (5*H*)-one (**2e**)

Atom	*x/a*	*y/b*	*z/c*
N(1)	0.347 2(2)	−0.174 8(3)	0.294 8(2)
C(2)	0.286 2(2)	−0.099 1(3)	0.318 7(2)
C(3)	0.217 6(3)	−0.178 0(4)	0.316 9(3)
C(4)	0.233 2(3)	−0.307 7(3)	0.290 9(2)
C(5)	0.313 0(3)	−0.304 5(3)	0.277 5(2)
S(6)	0.449 2(1)	−0.126 2(1)	0.300 8(1)
O(7)	0.513 3(2)	−0.231 3(3)	0.339 6(2)
O(8)	0.468 4(2)	−0.002 6(3)	0.347 4(2)
C(9)	0.427 0(3)	−0.104 4(4)	0.182 3(2)
C(10)	0.378 2(3)	0.002 8(4)	0.136 7(3)
C(11)	0.362 9(4)	0.022 6(5)	0.045 2(3)
C(12)	0.397 5(5)	−0.064 3(6)	0.004 6(4)
C(13)	0.445 6(5)	−0.170 3(7)	0.051 3(4)
C(14)	0.462 5(4)	−0.195 1(5)	0.142 9(4)
C(15)	0.185 3(3)	−0.426 2(4)	0.280 1(3)
C(16)	0.219 6(4)	−0.536 8(4)	0.257 5(3)
C(17)	0.299 3(4)	−0.530 8(4)	0.243 2(3)
C(18)	0.347 9(3)	−0.416 3(4)	0.252 6(3)
C(19)	0.295 5(2)	0.047 1(4)	0.333 2(3)
C(20)	0.326 5(3)	0.099 3(5)	0.430 4(3)
C(21)	0.285 0(3)	0.032 9(5)	0.487 4(3)
C(22)	0.180 1(3)	0.049 7(5)	0.447 4(3)
N(23)	0.132 3(2)	0.000 5(3)	0.351 6(2)
C(24)	0.137 0(3)	−0.139 6(4)	0.336 6(3)
C(25)	0.085 6(3)	0.086 1(4)	0.281 9(3)
O(26)	0.075 6(2)	0.201 9(3)	0.290 5(2)
O(27)	0.050 4(2)	0.022 6(3)	0.197 9(2)
C(28)	0.004 4(3)	0.097 1(5)	0.116 1(3)
C(29)	0.045 2(3)	0.202 4(6)	0.097 3(4)
C(30)	−0.002 7(5)	0.270 2(7)	0.013 8(4)
C(31)	−0.087 3(5)	0.230 4(9)	−0.048 0(4)
C(32)	−0.127 3(4)	0.123 2(9)	−0.031 0(4)
C(33)	−0.081 7(3)	0.055 5(6)	0.052 8(4)
O(34)	0.280 1(2)	0.119 1(3)	0.267 4(2)

and 178 (100) (Found: C, 70.8; H, 5.0; N, 4.8; S, 5.6. $C_{34}H_{28}N_2O_5S$ requires C, 70.8; H, 4.9; N, 4.9; S, 5.6%).

X-Ray Structure Determination of 1,2,3,4 *Tetrahydro-2-phenoxycarbonyl-7-phenylsulphonylazocino*[4,3-b]*indol-6* (5H)-*one* (**2e**).—*Crystal data.* $C_{26}H_{22}N_2O_5S$, M = 474, monoclinic, a = 15.954(2), b = 10.175(1), c = 15.986(3) Å; β = 116.47(1)°; U = 2 323 Å^3, Z = 4, ρ_c = 1.35, μ(Mo-K_α) = 1.96 cm^{-1}, space group $P2_1/c$ (No. 14), 2 599 unique reflexions with $F > 3\sigma(F)$, R = 5.91%.

The crystals were colourless and prismatic and extended in the direction of the c axis. Intensity data were collected from a specimen of dimensions 0.19 × 0.23 × 0.45 mm out to θ = 25° on an Enraf Nonius CAD-4 computer-controlled Kappa axis single-crystal diffractometer. No absorption correction was applied as μ R < 0.09. Standard reflexion monitoring showed no crystal deterioration.

Application of the MULTAN-80 suite of programs revealed 26 of the non-hydrogen atoms and a difference Fourier synthesis the remaining 8. The 34-atom model was refined to R = 14% before allowance of anisotropic motion with location of hydrogen atoms at calculated positions. All atomic positions and temperature factors (isotropic for hydrogen) were then refined until the final R = 5.91%. A final difference Fourier synthesis showed no features >0.1 electrons. The weighting scheme $w^{-1} = (1.76 - 0.15F + 0.006F^2)$ was used to obtain a uniform distribution of $w \times \Delta F^2$ over the F range.

A stereoscopic drawing of the molecule is shown in Figure 1, the positional co-ordinates for non-hydrogen atoms are given in Table 2, and Tables 3, 4, and 5 list selected bond lengths, bond angles, and torsional angles in (**2e**). Full listings of the bond

Table 3. Bond distances (Å) for (**2e**) with estimated standard deviations in parentheses

C(5)–N(1)	1.408(4)	S(6)–N(1)	1.662(3)
N(1)–C(2)	1.420(4)	N(23)–C(25)	1.347(5)
C(2)–C(3)	1.349(5)	C(2)–C(19)	1.503(5)
C(3)–C(4)	1.438(5)	C(19)–C(20)	1.503(6)
C(4)–C(5)	1.383(5)	C(20)–C(21)	1.504(7)
C(4)–C(15)	1.397(5)	C(21)–C(22)	1.512(7)
C(15)–C(16)	1.368(6)	C(22)–N(23)	1.463(6)
C(16)–C(17)	1.390(7)	N(23)–C(24)	1.452(5)
C(17)–C(18)	1.370(6)	C(24)–C(3)	1.505(6)
C(18)–C(5)	1.399(5)	C(19)–O(34)	1.213(5)

Numbering of atoms is given in Figure 1.

Table 4. Bond angles (°) for (**2e**) with estimated standard deviations in parentheses

N(1)–C(2)–C(3)	108.6(3)	C(2)–N(1)–S(6)	126.4(2)
C(2)–C(3)–C(4)	108.0(3)	C(5)–N(1)–S(6)	125.0(2)
C(3)–C(4)–C(5)	108.3(3)	C(3)–C(2)–C(19)	128.0(3)
C(4)–C(5)–N(1)	107.1(3)	C(2)–C(19)–C(20)	118.3(4)
C(5)–N(1)–C(2)	108.0(3)	C(19)–C(20)–C(21)	115.9(4)
C(4)–C(15)–C(16)	118.8(4)	C(20)–C(21)–C(22)	113.3(4)
C(15)–C(16)–C(17)	120.7(4)	C(21)–C(22)–N(23)	111.5(4)
C(16)–C(17)–C(18)	122.2(4)	C(22)–N(23)–C(24)	117.9(4)
C(17)–C(18)–C(5)	116.5(4)	N(23)–C(24)–C(3)	113.6(3)
C(18)–C(5)–C(4)	122.4(3)	C(24)–C(3)–C(2)	127.1(4)
C(5)–C(4)–C(15)	119.4(4)	C(2)–C(19)–O(34)	119.8(3)
C(3)–C(4)–C(15)	132.3(4)	C(20)–C(19)–O(34)	121.9(4)
N(1)–C(5)–C(18)	130.5(4)	C(22)–N(23)–C(25)	118.9(4)
C(4)–C(3)–C(24)	125.0(3)	C(24)–N(23)–C(25)	123.3(4)
N(1)–C(2)–C(19)	123.1(3)		

Numbering of atoms is given in Figure 1.

Table 5. Torsion angles for (**2e**)

N(1)–C(2)–C(3)–C(4)	0
C(2)–C(3)–C(4)–C(5)	0
C(3)–C(4)–C(5)–N(1)	0
C(4)–C(5)–N(1)–C(2)	0
C(5)–N(1)–C(2)–C(3)	0
C(4)–C(15)–C(16)–C(17)	−2
C(15)–C(16)–C(17)–C(18)	1
C(16)–C(17)–C(18)–C(5)	0
C(17)–C(18)–C(5)–C(4)	−1
C(18)–C(5)–C(4)–C(15)	0
C(5)–C(4)–C(15)–C(16)	1
C(2)–C(19)–C(20)–C(21)	−41
C(19)–C(20)–C(21)–C(22)	−64
C(20)–C(21)–C(22)–N(23)	57
C(21)–C(22)–N(23)–C(24)	66
C(22)–N(23)–C(24)–C(3)	−92
N(23)–C(24)–C(3)–C(2)	5
C(24)–C(3)–C(2)–C(19)	−5
C(3)–C(2)–C(19)–C(20)	76
C(18)–C(5)–N(1)–S(6)	−7
C(19)–C(2)–N(1)–S(6)	14
C(22)–N(23)–C(25)–O(27)	177
N(23)–C(25)–O(27)–C(28)	−176
C(25)–O(27)–C(28)–C(29)	54
C(19)–C(2)–N(1)–C(5)	−174
O(34)–C(19)–C(2)–N(1)	68

Numbering of atoms is given in Figure 1.

lengths, bond angles and torsional angles, the positional co-ordinates for the hydrogen atoms, and the thermal parameters are available on request from the Cambridge Crystallographic Data Centre.*

1,2,3,4-*Tetrahydro*-4-*phenylsulphonylpyrrolo*[1′,2′:1,2]-*pyrrolo*[3,4-b]*indole* (**12**).—(*a*) The benzylurethane (**2d**) (0.073 g, 0.15 mmol) was treated with a solution of hydrogen bromide in acetic acid (10%; 1 ml) at room temperature for 3 h. An excess of saturated aqueous sodium carbonate was added and the product extracted with ethyl acetate to give, after preparative t.l.c. on silica with chloroform as eluant, the *pyrrole* (**12**) (0.015 g, 0.04 mmol, 29%). (*b*) The phenylurethane (**2e**) (0.054 g, 0.114 mmol) in THF (5 ml) was treated with aqueous sodium hydroxide (2%; 5 ml) at reflux under nitrogen for 6 h. The solvent was evaporated and water (15 ml) was added to the residue; the product was then extracted with ether and the extract worked up to give a brown oil (20 mg) which was purified as in (*a*) to afford the pyrrole (**12**) (0.01 g, 0.03 mmol, 26%). (*c*) To sodium hydride (5 mg) in THF (1 ml) was added the phenylurethane (**2d**) (2.5 mg, 0.005 mmol) in THF (1 ml). After 0.5 h at room temperature work-up as in (*b*) above gave the pyrrole (**12**) (1.5 mg, 0.004 mmol, 80%). (*d*) A suspension of the fluorenylmethylurethane (**2f**) (9.5 mg, 0.016 mmol) in dry piperidine (3 ml) was stirred at room temperature under nitrogen (1.5 h). The mixture was poured into water and the product extracted with ethyl acetate to give, after column chromatography over silica, with toluene–ethyl acetate (4:1) as eluant, the pyrrole (**12**) (3.7 mg, 0.01 mmol, 69%). (*e*) A solution of methyl-lithium–lithium bromide complex in ether (1.2M; 0.2 ml, 0.23 mmol) was added dropwise to a stirred solution of the phenylurethane (**2e**) (0.02 g, 0.04 mmol) in dry THF (5 ml) at 0 °C under nitrogen. After a further 2.5 h at 0 °C the mixture was allowed to reach room temperature when saturated aqueous ammonium chloride (5 ml) was added. Extraction with dichloromethane and purification as in (*d*) gave the pyrrole (**12**) (11 mg, 0.03 mmol, 74%), m.p. 185—188 °C (from toluene), $\lambda_{max.}$(EtOH) 224, 249sh, 257sh, 265, 272sh, and 310 nm (log ε 4.34, 4.12, 4.24, 4.28, 4.15, and 3.74); δ($CDCl_3$) 8.08 (1 H, d, *J* 7 Hz, ArH), 7.74 (2 H, d, *J* 7 Hz, ArH), 7.2—7.52 (5 H, m, ArH), 6.80 (1 H, s, NCH=C), 4.11 (2 H, t, *J* 7 Hz, CH_2N), 3.24 (2 H, t, *J* 7 Hz, C=CCH_2), and 2.6 (2 H, quintet, $CH_2CH_2CH_2$); *m/z* 336 (M^+, 23), 195 (100), 167 (8), 140 (4), and 77 (30) (Found: C, 68.0; H, 4.8; N, 8.4. $C_{19}H_{16}N_2O_2S$ requires C, 67.8; H, 4.8; N, 8.33%).

2-(3-*Formylindol*-2-*yl*)-4,5-*dihydro*-3H-*pyrrole* (**5c**).—(*a*) A solution of the phenylurethane (0.04 g, 0.09 mmol) in t-butyl alcohol was treated with potassium t-butoxide (0.04 g) at reflux for 5 h. The mixture was then poured into water (5 ml) and concentrated under reduced pressure before extraction of the product with ethyl acetate. Re-extraction of the ethyl acetate layer with dilute hydrochloric acid, followed by basification of the aqueous acidic extract and extraction with ethyl acetate gave the *aldehyde* (**5c**) (0.014 g, 0.07 mmol, 73%). (*b*) Freshly distilled phosphorus oxychloride (2.0 ml, 22 mmol) was added dropwise with stirring to dry dimethylformamide (DMF) (2.5 ml) at 14 °C. The mixture was allowed to come to room temperature, then the imine (**5a**) (250 mg, 1.4 mmol) in DMF (2.5 ml) was added. After 3 h at 40—50 °C the mixture was poured onto ice, made basic with sodium hydroxide (6 g), and then heated at reflux for 0.5 h. The cooled solution was extracted with chloroform to give a semi-crystalline residue (298 mg) which was recrystallised from THF to give the aldehyde (**5c**) (85 mg, 0.4 mmol, 30%), m.p. 200—202 °C, $\lambda_{max.}$(EtOH) 223, 253, 325, and 350sh nm (log ε 4.37, 4.36, 4.12, and 3.91); $\lambda_{max.}$(EtOH–H^+) 278, 258, 270sh, and 355 nm (log ε 4.25, 4.17, 4.06, and 4.22); $\lambda_{max.}$(EtOH–OH^-) 235, 277, 345sh, and 352 nm (log ε 4.3, 4.46, 4.10, and 4.10); $\nu_{max.}$(Nujol) 3 350m, 1 650s, and 1 620s cm^{-1}; δ[$(CD_3)_2SO$] 12.35 (1 H, br s, NH), 10.55 (1 H, s, CHO), 9.24 (1 H, d, *J* 7 Hz, ArH), 7.54 (1 H, d, *J* 7 Hz, ArH), 7.32 (1 H, t, *J* 7 Hz, ArH), 7.24 (1 H, t, *J* 7 Hz, ArH), 4.04 (2 H, t, *J* 7 Hz, NCH_2), 3.10 (2 H, t, *J* 7 Hz, CH_2C=N), and 2.00 (2 H, quintet, *J* 7 Hz, $CH_2CH_2CH_2$); *m/z* 212 (M^+, 55%), 184 (95), 183 (100), 156 (60), 142 (30), and 129 (20) (Found: C, 73.0; H, 5.7; N, 13.1. $C_{13}H_{12}N_2O$ requires C, 73.6; H, 5.7; N, 13.2%).

1,2,3,3a,4,9-*Hexahydro*-4-*phenylsulphonylpyrrolo*[1′,2′:1,2]*pyrrolo*[3,4-b]*indol*-9 (4H)-*one* (**3e**) *and* 1,2,3,3a,4,9-*Hexahydro*-4-*phenylsulphonylpyrrolo*[1′,2′:1,2]*pyrrolo*[3,4-b]-*indole* (**3f**).—(*a*) To a stirred solution of the trichloroethyl-urethane (**2g**) (0.026 g, 0.05 mmol) in acetic acid (2 ml) was added zinc dust (*ca.* 0.1 g) over 5 h. The reaction mixture was filtered through Celite and the solvent removed under reduced pressure. The residue was partitioned between ethyl acetate and aqueous sodium hydrogen carbonate. Evaporation of the organic solvent gave a residue which was purified by preparative t.l.c. with toluene–ethyl acetate–triethylamine (10:10:1) as eluant, to give, in order of increasing polarity, starting material (3.5 mg, 0.007 mmol, 13%), the *lactam* (**3e**) (3 mg, 0.009 mmol, 18%) as a gum, $\lambda_{max.}$(EtOH) 216, 240sh, 268sh, 275sh, and 291sh nm; $\nu_{max.}$($CHCl_3$) 1 720s cm^{-1}; δ($CDCl_3$) 8.05 (1 H, d, *J* 7 Hz, ArH), 8.0 (2 H, d, *J* 8 Hz, ArH), 7.95 (1 H, d, *J* 7 Hz, ArH), 7.71 (1 H, t, *J* 8 Hz, ArH), 7.58 (2 H, t, *J* 8 Hz, ArH), 7.42 (2 H, m, ArH), 5.05 (1 H, m, CHN), 3.44—3.69 (2 H, m, CH_2N), and 2.46—2.68 (2 H, m, CH_2); *m/z* 352 (M^+, 24%), 211 (100), and 183 (36) (Found: *M*, by mass spectrometry, 352.0871. $C_{19}H_{16}N_2O_3S$ requires *M*, 352.0870), and the *amine* (**3f**) (4.5 mg, 0.01 mmol, 27%) as a gum, $\lambda_{max.}$(EtOH) 220, 253, and 290sh nm; δ($CDCl_3$) 8.01 (1 H, d, *J* 8 Hz, ArH), 7.82 (2 H, d, *J* 8 Hz, ArH), 7.5 (1 H, t, *J* 8 Hz, ArH), 7.4 (2 H, t, *J* 8 Hz, ArH), 7.1—7.35 (3 H, m, ArH), 4.93 (1 H, br s, CHN), 5.65 and 6.30 (2 H, q, *J* 14 Hz, *J* 2 Hz further splitting on the 6.30 signal, indolyl–CH_2N), 2.92—3.28 (2 H, m, CH_2N), 2.44—1.88 (4 H, m, CH_2CH_2); *m/z* 338 (M^+, 22%), 197 (100), and 169 (33) (Found: *M* by mass spectrometry 338.1088. $C_{19}H_{18}N_2O_2S$ requires *M* 338.1088). (*b*) To a thoroughly degassed and stirred solution of the trichloroethyl-urethane (**2g**) (20 mg, 0.04 mmol) in acetic acid (5 ml) under nitrogen was added an excess of zinc dust over 48 h. Following the work-up procedure described in (*a*) gave only the amine (**3f**) (12 mg, 0.04 mmol, 94%). (*c*) A solution of lactam (**3e**) (4 mg, 0.011 mmol) at −78 °C under nitrogen in dry toluene (2 ml) was treated with a solution of di-isobutylaluminium hydride in toluene (1.2M, 0.1 ml). After 3 h at −78 °C the solution was allowed to warm to room temperature overnight. It was then diluted with cold methanol and evaporated under reduced pressure to give a residue which was extracted with ethyl acetate to afford the amine (**3f**) (2.8 mg, 0.008 mmol, 73%), effectively pure by t.l.c. analysis.

1,2,3,3a,4,9-*Hexahydropyrrolo*[1′,2′:1,2]*pyrrolo*[3,4-b]-*indole* (**3a**).—To a stirred solution of pyrrole (**12**) (12 mg, 0.034 mmol) in THF (5 ml) at 0—5 °C under nitrogen was added an excess of lithium aluminium hydride over 6 h. The mixture was left at room temperature overnight, then poured on to ice and the product extracted using ethyl acetate. Purification by preparative t.l.c. over silica with toluene–ethyl acetate–methanol (2:2:1 plus 4% triethylamine) as eluant, gave the *indole* (**3a**) (6 mg, 0.029 mmol, 84%) as a gum, $\lambda_{max.}$(EtOH) 228, 270, 280sh, and 287 nm; δ($CDCl_3$) 10.14 (1 H, br s, NH), 7.37 (1 H, d, *J* 8 Hz, ArH), 7.24 (1 H, m, ArH), 7.13 (1 H, t, *J* 8 Hz, ArH), 7.1 (1 H, t, *J* 8 Hz, ArH), 5.37 (1 H, br s, CHN), 3.97 and 4.78 (2 H, q, *J* 12 Hz,

* For details of Supplementary Publications see Instructions for Authors (1987), para. 5.6.3. *J. Chem. Soc., Perkin Trans. 1*, 1987, Issue 1.

indolyl–CH_2N), 2.94—3.63 (2 H, m, CH_2N), and 1.92—2.46 (4 H, m, CH_2CH_2); *m/z* 198 (M^+, 80%), 169 (100), 156 (24), and 115 (10) (Found: *M*, by mass spectrometry 198.1157. $C_{13}H_{14}N_2$ requires *M*, 198.1157).

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