Intramolecular radical substitution reactions: a novel approach to fused [1,2-*a*]indoles

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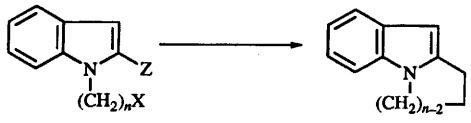
A new approach to fused [1,2-*a*]indoles 25, 26 and 27 is described; the synthesis is based on a novel intramolecular radical cyclization reaction involving ipso-substitution using sulfone, sulfide and sulfoxide substituted indoles. Some more general aspects of scope and limitation of the process are presented including vinyl and aryl radical cyclizations of 29 and 30; investigations using substituted indoline and aniline derivatives 35 and 37 are also discussed.

Introduction

The indole nucleus is ubiquitous in a wide range of natural products and indole alkaloids have proven to be attractive synthetic targets. In addition to their use in biological investigations they can also serve as useful vehicles for the development of new strategies and tactics for synthesis.[1] Although numerous advances have been made, the preparation of functionalised indoles still represents a significant synthetic challenge. As part of our interest in the development of new synthetic methods for the preparation of indole alkaloids, we were attracted to the possibility of developing a free-radical ipso-substitution reaction (Scheme 1).



Scheme 1

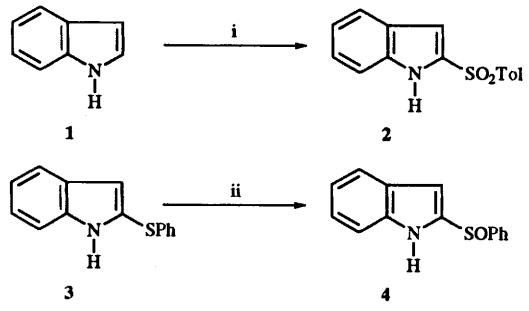
A number of reports have illustrated the viability of preparing functionalised indoles *via* radical cyclization methodology;[2] however in general the use of radical ipso-substitution reactions has received little attention.[3,4] We were interested in identifying the types of group which would participate in such a process as we felt that this might be useful for the development of new reactions for use in synthesis.[5]

Results and discussion

Precursors

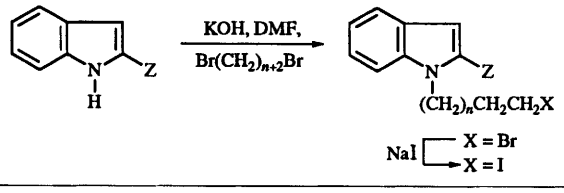
We decided to prepare and utilize sulfur-substituted indoles in the proposed substitution reaction and used two methods for the introduction of sulfur at the 2-position of indole.[6] In order to introduce the sulfone moiety we elected to use the excellent one-pot procedure developed by Katritzky and co-workers.[7] We were able to prepare gram quantities of 2-[4-(methylphenyl)-sulfonyl]indole **2** using this approach, as shown in Scheme 2. Although the yields were moderate (33–45%) the brevity of the procedure made it the most practicable approach to this compound. The phenylsulfinyl substituted indole **4** was prepared by oxidation of 2-phenylsulfanyl substituted indole **3** which was prepared by acid catalysed rearrangement of 3-phenylsulfanylindole.[8]

The desired cyclization precursors were prepared in moderate yields from **2**, **3** and **4**, by *N*-alkylation using the appropriate



Scheme 2 *Reagents and conditions:* i, ref. 7, toluene-*p*-sulfonyl fluoride, 35–45%; ii, oxone, THF–MeOH–H_2O, 50–64% (Tol = 4-MeC_6H_4)

Table 1 Preparation of *N*-halogenoalkyl substituted indol-2-yl aryl sulfides, sulfoxides and sulfones



Entry	Z[a]	*n*	Br (%)	I (%)
1	SO_2Tol	1	**5** (51)	**9** (81)
2	SO_2Tol	2	**6** (60)	**10** (68)
3	SO_2Tol	3	**7** (74)	**11** (78)
4	SO_2Tol	4	**8** (50)	**12** (89)
5	SPh	1	**13** (41)	**16** (77)
6	SPh	2	**14** (65)	**17** (75)
7	SPh	3	**15** (61)	**18** (63)
8	SOPh	1	**19** (64)	**22** (64)
9	SOPh	2	**20** (69)	**23** (54)
10	SOPh	3	**21** (53)	**24** (96)

[a] Tol = 4-MeC_6H_4.

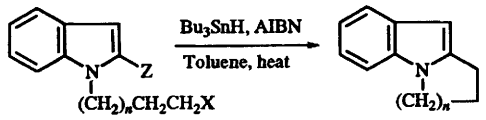
dibromoalkane,[9] followed by S_N2 displacement with sodium iodide in acetone as shown in Table 1.

Alkyl radical cyclizations

The results from the cyclization experiments are presented in Table 2.

Initially we found that treatment of bromide precursors **5** and **6** with tributyltin hydride (TBTH) under radical conditions led to moderate yields of products **25**[2a] and **26**[10] (40–60%);

Table 2 Radical cyclization of indol-2-yl aryl sulfides, sulfoxides and sulfones



Entry	Precursor	Z[a]	X	*n*	Product (%)
1	**5**	SO_2Tol	Br	1	**25** (75)
2	**6**	SO_2Tol	Br	2	**26** (84)
3	**7**	SO_2Tol	Br	3	**27** (17)
4	**9**	SO_2Tol	I	1	**25** (71)
5	**10**	SO_2Tol	I	2	**26** (71)
6	**11**	SO_2Tol	I	3	**27** (33)
7	**12**	SO_2Tol	I	4	**28** (0)
8	**16**	SPh	I	1	**25** (25)
9	**17**	SPh	I	2	**26** (51)
10	**18**	SPh	I	3	**27** (0)
11	**22**	SOPh	I	1	**25** (46)
12	**23**	SOPh	I	2	**26** (53)
13	**24**	SOPh	I	3	**27** (34)

[a] Tol = 4-MeC_6H_4.

however under the optimised conditions and with rigorously purified precursors, we were able to obtain yields of 70–85%. As expected the iodides also underwent smooth cyclization to provide the products **25** and **26**. It is interesting to compare the yields from the cyclization of bromide **7** and iodide **11** leading to **27**;[10] the improvement in yield using **11** illustrates the superior nature of the iodides as precursors for these cyclizations. The success of this cyclization, albeit in modest yield, is particularly gratifying as the formation of seven-membered rings *via* radical cyclization methodology is relatively uncommon. In attempting to extend the scope of the process we examined cyclization of **12** which, perhaps unsurprisingly, led to none of the desired product **28** and resulted in a complex mixture comprising reduction and desulfonylation products.

The cyclizations using sulfinyl substituted indoles were attempted under similar conditions and were moderately successful. In each case cyclization products **25**–**27** were obtained (entries 11,12 and 13), but the yields of these reactions were less satisfactory than those obtained with the corresponding sulfones, although the yield obtained for cyclization of **24** was similar to the corresponding sulfone **11** (entries 13 and 6). Cyclization of the sulfide precursors proceeded in poor to moderate yields and we were never able to identify any of the desired product **27** from the reaction of **18** (entry 10).

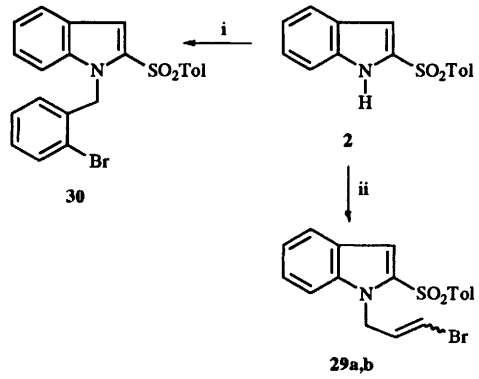
It would appear that the sulfone and sulfoxide precursors participate more effectively in this type of reaction than the sulfides. It is tempting to speculate that this behaviour is a reflection of a slower rate of cyclization of a nucleophilic alkyl radical with the relatively electron rich π-system. From a practical viewpoint the sulfones are the precursors of choice as they are easier to prepare and undergo cyclization in generally good yields.

On an experimental note we have found that potassium fluoride[11] is a useful aid for the separation of organotin by-products, if ethyl acetate, as opposed to diethyl ether, is used as solvent in the work-up procedure described in the experimental section.

Sulfone substituted indoles: vinyl and aryl radical cyclizations

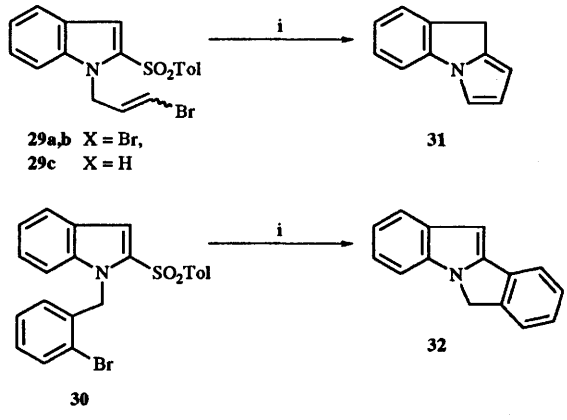
We were interested in determining the ability of vinyl and aryl radicals to participate in this ipso-substitution process. *N*-alkylation of 2-[(4-methylphenyl)sulfonyl]indole **2** with either 2-bromobenzyl bromide or 1,3-dibromoprop-1-ene led to the cyclization precursors **29a/b** and **30** in 68 and 86% yields respectively (Scheme 3).

When we subjected **29a/b** to the cyclization conditions we



Scheme 3 *Reagents and conditions:* i, *o*-$BrC_6H_4CH_2Br$, KOH, DMF, 68%; ii, 1,3-dibromopropene, KOH, DMF, 86%

obtained the desired product **31**,[12] presumably *via* 1,5-sigmatropic rearrangement of the initially formed product, and reduction product **29c** as an inseparable mixture (29% yield, 1 : 1 mixture by ^1H NMR); the ratio of products was not improved using the $NaCNBH_3$–Bu_3SnCl conditions. The aryl halide precursor **30** also underwent cyclization to give the desired product **32**[13] in 31% yield (Scheme 4).

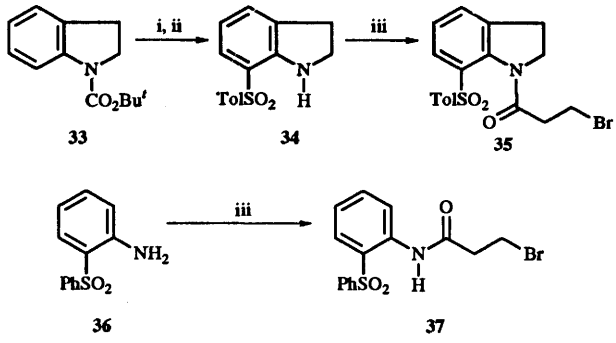


Scheme 4 *Reagents and conditions:* i, Bu_3SnH, AIBN, toluene, reflux

Thus it would appear that the vinyl and aryl radical cyclizations are viable but are low yielding and at present unlikely to offer a useful alternative to existing procedures for the synthesis of fused indoles of this type.

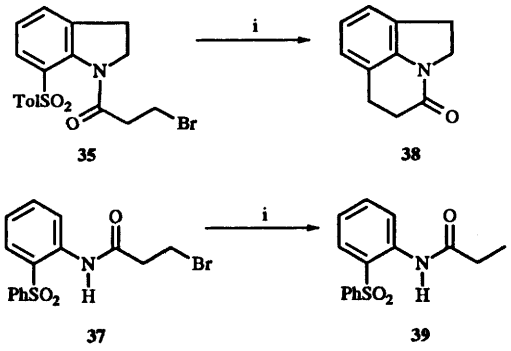
Sulfone substituted indolines and anilines

It was appealing to extend the study to investigate the generality of this type of radical cyclization methodology. We therefore prepared **35** by standard manipulations of an intermediate 7-sulfone substituted indoline **34**, which was itself prepared *via* regioselective lithiation of *N*-Boc-indoline **33**.[14] Sulfone **37** was readily prepared by acylation of commercially available **36** (Scheme 5).



Scheme 5 *Reagents and conditions:* i, Bu^sLi, TMEDA, Et_2O, −78 °C, $TolSO_2F$, 40%; ii, HCl(aq), THF, 50–60 °C, 70%; iii, $BrCH_2CH_2COCl$, DMAP, Et_3N, 42–77%

We were very pleased to find that treatment of **35** with TBTH furnished the tricycle **38**[15] in 57% yield (Scheme 6). However



Scheme 6 *Reagents and conditions:* i, Bu_3SnH, AIBN, toluene, reflux

attempted cyclization of sulfone **37** furnished an inseparable mixture of reduced product **39** and starting sulfone **37** with none of the desired cyclization product isolated (Scheme 6). The sensitivity of radical cyclizations of amides to substituent effects is well documented[16] and it may be that similar conformational effects are operating here and thus inhibiting cyclization.

Conclusion

We have developed a new approach to fused [1,2-*a*]indoles based on a novel radical ipso-substitution reaction. We have shown that sulfone, sulfinyl and sulfanyl substituted indoles can all participate in this type of reaction although it is clear that from a synthetic viewpoint optimal results are obtained using sulfone precursors. From a more general perspective, radical ipso-substitution reactions of this type may offer some interesting synthetic opportunities for the preparation of substituted/fused aromatic systems. We have some indications, for example, that it is possible to extend the methodology from simple heterocyclic aromatics, such as indoles, to carbocyclic aromatic systems, although the anomalous behaviour between the sulfone substituted indoline and aniline indicate that some limitations currently exist.

Experimental

Glassware used in the reactions was oven dried for at least 24 h or flame dried. All reactions were carried out under a positive atmosphere of argon or nitrogen unless otherwise stated. All solvents used in the reactions were dry: THF and diethyl ether were freshly distilled from sodium–benzophenone; dichloromethane, *N*,*N*-dimethylformamide (DMF) and toluene were distilled from calcium hydride. Petrol refers to light petroleum (bp 40–60 °C). All reagents were used as purchased or were purified using standard methods. 'Standard' or 'usual work-up' involved addition of water, extraction with six portions of diethyl ether (25 cm^3 per mmol) and drying with potassium carbonate. The reaction mixture was filtered and the organic solvent removed *in vacuo*. The potassium fluoride 'work-up' involved removing the solvent *in vacuo* and addition of water (0.125 cm^3), ethyl acetate (3 cm^3) and potassium fluoride (150 mg) to the crude mixture and stirring overnight. Potassium carbonate was then added, the mixture filtered and the solvent removed *in vacuo*. This procedure was then repeated with stirring for 2 h. Proton NMR spectra were recorded at 360 MHz, carbon spectra were recorded at 125 MHz in $CDCl_3$, unless otherwise stated. Chemical shifts are reported downfield in parts per million using residual $CHCl_3$ as internal reference and *J* values are given in Hz. Melting points are uncorrected. Analytical thin layer chromatography was performed using pre-coated glass-backed plates and visualised by ultra-violet light, potassium permanganate or iodine as appropriate. Silica-gel chromatography was carried out using flash silica (mesh 230–400) and under slight pressure.

2-[(4-Methylphenyl)sulfonyl]-1*H*-indole 2

Butyllithium (1.6 mol dm^{-3}; 7.0 cm^3, 11.2 mmol) was added dropwise to a solution of indole **1** (1.27 g, 10.8 mmol) in THF (40 cm^3) at −78 °C. After 30 min, CO_2(g) was passed through the deep orange solution for 10 min. The resultant pale yellow solution was allowed to stand for 10 min and the solvent evaporated at 0 °C (1 mmHg). The dry crystalline material was dissolved in THF (40 cm^3) and cooled to −78 °C. *tert*-Butyllithium (1.7 mol dm^{-3}; 11.0 cm^3, 18.7 mmol) was then added dropwise to the solution and the dark yellow solution was stirred for 20 min. Toluene-*p*-sulfonyl fluoride (1.91 g, 11.0 mmol) in THF (8.0 cm^3) was then added to the solution at −78 °C to give a burgundy-coloured solution. After 1 h at −78 °C, the solution was allowed to warm to room temperature. The reaction was stirred at ambient temperature for 2 h (TLC, petrol–diethyl ether, 2:1). The work-up involved pouring the solution onto an iced brine solution and then extraction as detailed in the general procedure. Purification (SiO_2, petrol–diethyl ether, 20:1 to 3:1, then CH_2Cl_2) gave the title compound **2** as a white solid (1.04 g, 35%), mp 196–197 °C (hexane–diethyl ether) (Found: C, 66.5; H, 4.8; N, 5.2; S, 11.7. $C_{15}H_{13}NO_2S$ requires C, 66.40; H, 4.83; N, 5.16; S, 11.82%); R_f (SiO_2, petrol–diethyl ether, 2:1) 0.29; ν_{max}(film)/cm^{-1} 3333, 2055, 1618, 1513, 1494, 1347, 1305, 1266, 1155, 1099, 1019, 949, 896 and 817; δ_H($CDCl_3$) 8.82 (1 H, br s), 7.89 (2 H, d, *J* 8.4), 7.67 (1 H, d, *J* 8.2), 7.42 (2 H, d, *J* 8.2), 7.34 (1 H, d, *J* 6.8), 7.20–7.14 (3 H, m) and 2.40 (3 H, s); δ_C($CDCl_3$) 144.5, 138.6, 137.2, 134.5, 130.0, 127.3, 127.1, 126.0, 122.6, 121.5, 112.4, 108.9 and 21.57 (Found: *M*, 271.0667. Calc. for $C_{15}H_{13}NO_2S$: *M*, 271.0667).

1-(*tert*-Butoxycarbonyl)-7-[(4-methylphenyl)sulfonyl]indoline

To a stirred solution of 1-(*tert*-butoxycarbonyl)indoline[14] (4.27 mmol) in diethyl ether (5 cm^3) and *N*,*N*,*N*′,*N*′-tetramethylethylenediamine (10.6 mmol) at −78 °C was added *sec*-butyllithium (6.37 mmol) and the reaction mixture stirred at − 78 °C for 190 min. Toluene-*p*-sulfonyl fluoride (5.14 mmol) in diethyl ether (1.5 cm^3) was added dropwise and the reaction stirred at −78 °C for 30 min and then allowed to warm to room temperature. Water (10 cm^3) was added and the aqueous layer was extracted with CH_2Cl_2, dried and the solvent removed *in vacuo* to give the crude product. Purification (SiO_2, petrol–ethyl acetate, 4:1) gave the title compound as a white solid (639.6 mg, 40%), mp 137–138 °C; R_f (SiO_2, petrol–ethyl acetate, 3:1) 0.3; ν_{max}(film)/cm^{-1} 2932, 1718, 1600, 1449, 1435, 1371, 1320, 1160 and 662; δ_H($CDCl_3$) 7.83–7.81 (2 H, d, *J* 8.3), 7.66–7.64 (1 H, d, *J* 8.2), 7.35–7.33 (1 H, d, *J* 7.3), 7.28 (2 H, d, *J* 7.9), 7.1–7.05 (1 H, t, *J* 7.7), 4.16–4.12 (2 H, t, *J* 7.9), 3.0 (2 H, t, *J* 7.7), 2.4 (3 H, s) and 1.54 (9 H, s); δ_C($CDCl_3$) 154.0, 147.7, 141.3, 139.2, 136.8, 130.5, 129.5, 129.0, 128.7, 127.5, 123.9, 82, 51.2, 29.0, 28.2 and 21.5 (Found: *M*, 373.1348. Calc. for $C_{20}H_{23}NO_4S$: *M*, 373.1348).

7-[(4-Methylphenyl)sulfonyl]indoline 34

To a stirred solution of 1-(*tert*-butoxycarbonyl)-7-[(4-methylphenyl)sulfonyl]indoline (201 mg, 0.538 mmol) in THF (2 cm^3) at 40–50 °C was added aqueous hydrochloric acid (6.27 mmol) and the solution concentrated *in vacuo* at 40–50 °C. The residue was redissolved in THF (3 cm^3) and then neutralised with methanolic KOH solution. The solvent was removed *in vacuo* to give the crude product. Purification (SiO_2, petrol–ethyl acetate, 5:1) gave the title compound **34** as a white solid (102 mg, 70%), mp 135–136 °C; R_f (SiO_2, petrol–ethyl acetate, 3:1) 0.4; ν_{max}(film)/cm^{-1} 3417, 2960, 2928, 2876, 1609, 1585, 1490, 1465, 1156, 1133 and 1059; δ_H($CDCl_3$) 7.84–7.82 (2 H, d, *J* 8.3), 7.45–7.43 (1 H, dd, *J* 8.13 and 0.9), 7.29–7.27 (2 H, d, *J* 8.13), 7.17 (1

H, dd, *J* 7.1 and 1.2), 6.66–6.62 (1 H, t, *J* 8), 5.7 (1 H, br s), 3.53–3.48 (2 H, t, *J* 8.6), 3.05–3.0 (2 H, t, *J* 8.6) and 2.4 (3 H, s); $\delta_C(CDCl_3)$ 150.6, 143.7, 139.4, 132.1, 129.6, 129.1, 126.7, 126.3, 118.6, 117.3, 47.1, 28.6 and 21.5 (Found: *M*, 273.0823. Calc. for $C_{15}H_{15}NO_2S$: *M*, 273.0823).

2-(Phenylsulfinyl)-1*H*-indole 4

A solution of Oxone™ (0.45 g, 0.732 mmol) in THF–methanol (4 cm^3, 1:1) was added to a solution of 2-phenylsulfanylindole **3** (163.0 mg, 0.724 mmol) at 0 °C in THF–methanol (4 cm^3, 1:1). The reaction mixture was stirred for 10 min at 0 °C (TLC, petrol–diethyl ether, 1:1). After the standard work-up, purification of the crude mixture by silica gel chromatography (SiO_2, petrol–diethyl ether, 5:1, 3:1, 2:1, 1:1) gave the title compound **4** as a white solid (111.0 mg, 64%), mp 139–140 °C; R_f (SiO_2, petrol–diethyl ether, 1:1) 0.32; ν_{max}(film)/cm^{-1} 3436, 2903, 2106, 1642, 1620, 1504, 1416, 1345, 1231 and 1032; $\delta_H(CDCl_3)$ 9.78 (1 H, br s), 7.71–7.68 (2 H, m), 7.63 (1 H, d, *J* 7.4), 7.49–7.44 (3 H, m), 7.39 (1 H, d, *J* 8.2), 7.28–7.25 (1 H, m), 7.15–7.09 (1 H, m) and 6.92 (1 H, d, *J* 0.78); $\delta_C(CDCl_3)$ 140.7, 137.8, 136.4, 131.1, 129.3, 127.0, 124.7, 121.7, 120.8, 112.2 and 106.8 (Found: *M*, 242.0643. Calc. for $C_{14}H_{11}NOS$: *M*, 242.0640).

General procedure: preparation of 2-substituted *N*-bromoalkylindoles

Powdered KOH was added to a stirred solution of 2-substituted indole and dibromoalkane in DMF (6 cm^3 per mmol). The reaction was stirred at ambient temperature (TLC analysis) and after the standard work-up the crude product was purified by silica gel chromatography to give the product.

1-(3-Bromopropyl)-2-[(4-methylphenyl)sulfonyl]-1*H*-indole 5. Compound **5** was prepared in 51% yield according to the general procedure from compound **2** (0.56 mmol), KOH (0.7 mmol) and 1,3-dibromopropane (1.7 mmol). Purification (SiO_2, petrol–CH_2Cl_2, 50:1, 20:1, 10:1, 5:1, 2:1) gave the title compound **5** as a white solid, mp 119–121 °C (hexane–diethyl ether) (Found: C, 55.0; H, 4.6; Br, 20.2; N, 3.5; S, 8.2. $C_{18}H_{18}BrNO_2S$ requires C, 55.24; H, 4.64; Br, 20.18; N, 3.58; S, 8.18%); R_f (SiO_2, petrol–diethyl ether, 2:1) 0.42; ν_{max}(film)/cm^{-1} 2957, 2923, 1597, 1505, 1473, 1445, 1351, 1320, 1292, 1214, 1153, 1097, 1080, 1018, 977, 901, 814 and 753; $\delta_H(CDCl_3)$ 7.85 (2 H, d, *J* 8.4), 7.71 (1 H, d, *J* 8.02), 7.44–7.37 (2 H, m), 7.34–7.31 (2 H, m), 7.22–7.16 (2 H, m), 4.44 (2 H, t, *J* 7.81), 3.40 (2 H, t, *J* 6.25), 2.40 (3 H, s) and 2.22 (2 H, p, *J* 7.04); $\delta_C(CDCl_3)$ 144.7, 138.9, 138.3, 134.9, 130.0, 127.8, 127.7, 125.9, 123.0, 121.4, 111.3, 110.5, 43.5, 32.8, 30.3 and 21.6 (Found: *M*, 391.0242. Calc. for $C_{18}H_{18}BrNO_2S$: *M*, 391.0242).

1-(3-Bromopropyl)-2-(phenylsulfinyl)-1*H*-indole 19. Compound **19** was prepared in 64% yield according to the general procedure from compound **4** (0.98 mmol), KOH (1.27 mmol) and 1,3-dibromopropane (2.94 mmol). Purification (SiO_2, petrol–diethyl ether, 3:1, 2:1) gave the title compound **19** as an oil; R_f (SiO_2, petrol–diethyl ether, 2:1) 0.28; ν_{max}(film)/cm^{-1} 2930, 2853, 1811, 1612, 1581, 1445, 1349, 1312, 1176 and 1043; $\delta_H(CDCl_3)$ 7.69–7.58 (2 H, m), 7.57–7.27 (6 H, m), 7.21–7.14 (1 H, m), 6.94 (1 H, d, *J* 0.78), 4.46–4.19 (2 H, m), 3.36–3.25 (2 H, m), 2.35–2.19 (1 H, m) and 1.92–1.67 (1 H, m); $\delta_C(CDCl_3)$ 142.4, 139.2, 136.7, 130.8, 129.3, 126.0, 125.1, 125.0, 122.4, 120.9, 110.1, 110.0, 43.07, 32.34 and 30.38 (Found: *M*, 361.0136. Calc. for $C_{17}H_{16}BrNOS$: *M*, 361.0136).

1-(3-Bromopropyl)-2-(phenylsulfanyl)-1*H*-indole 13. Compound **13** was prepared in 41% yield according to the general procedure from compound **3** (1.0 mmol), KOH (1.27 mmol) and 1,3-dibromopropane (3.0 mmol). Purification (SiO_2, petrol–CH_2Cl_2, 25:1, 20:1) gave **13** as an oil; R_f (SiO_2, petrol–ether, 25:1) 0.5; ν_{max}(film)/cm^{-1} 2941, 1803, 1703, 1582, 1440, 1354, 1313, 1256, 1180 and 1157; $\delta_H(CDCl_3)$ 7.65 (1 H, d, *J* 5.86), 7.44 (1 H, dd, *J* 8.4, 0.98), 7.31–7.28 (2 H, m), 7.26–7.16 (3 H, m), 7.15–7.07 (2 H, m), 6.95 (1 H, d, *J* 0.78), 4.33 (2 H, t, *J* 7.04), 3.31 (2 H, t, *J* 6.45) and 2.21 (2 H, m); $\delta_C(CDCl_3)$ 138.2, 136.8, 129.2, 127.5, 127.0, 126.7, 126.1, 123.2, 121.0, 120.2, 112.7, 110.0, 42.2, 33.1 and 30.3 (Found: *M*, 346.0271. Calc. for $C_{17}H_{16}BrNS$: *M*, 346.0265).

1-(4-Bromobutyl)-2-[(4-methylphenyl)sulfonyl]-1*H*-indole 6. Compound **6** was prepared in 60% yield according to the general procedure from compound **2** (0.56 mmol), KOH (0.56 mmol) and 1,4-dibromobutane (1.7 mmol). Purification (SiO_2, petrol–CH_2Cl_2: 20:1 to 2:1) gave the title compound **6** as a white solid, mp 133–135 °C (hexane–diethyl ether) (Found: C, 56.1; H, 5.0; Br, 19.4; N, 3.4; S, 7.8. $C_{19}H_{20}BrNO_2S$ requires C, 56.29; H, 4.98; Br, 19.48; N, 3.46; S, 7.89%); R_f (SiO_2, petrol–diethyl ether, 2:1) 0.31; ν_{max}(film)/cm^{-1} 2959, 2352, 1580, 1465, 1442, 1391, 1318, 1154 and 1096; $\delta_H(CDCl_3)$ 7.85 (2 H, d, *J* 8.4), 7.83 (1 H, d, *J* 8.21), 7.40–7.31 (3 H, m), 7.22–7.16 (3 H, m), 4.36 (2 H, t, *J* 7.82), 3.35 (2 H, t, *J* 6.45), 2.41 (3 H, s) and 1.87–1.70 (4 H, m); $\delta_C(CDCl_3)$ 144.6, 142.2, 138.4, 134.8, 130.0, 127.6, 125.7, 125.4, 123.0, 121.2, 111.1, 110.6, 43.98, 32.70, 29.84, 28.60 and 21.58 (Found: *M*, 405.0398. Calc. for $C_{19}H_{20}BrNO_2S$: *M*, 405.0398).

1-(4-Bromobutyl)-2-(phenylsulfinyl)-1*H*-indole 20. Compound **20** was prepared in 69% yield according to the general procedure from compound **4** (0.62 mmol), KOH (0.775 mmol) and 1,4-dibromobutane (2.33 mmol). Purification (SiO_2, petrol–diethyl ether, 3:1, 2:1, 1:1) gave the title compound **20** as an oil; R_f (SiO_2, petrol–diethyl ether, 2:1) 0.28; ν_{max}(film)/cm^{-1} 2928, 2861, 1724, 1601, 1582, 1445, 1349, 1130 and 1043; $\delta_H(CDCl_3)$ 7.68 (2 H, d, *J* 7.98), 7.64–7.62 (3 H, m), 7.55–7.50 (1 H, m), 7.34–7.27 (2 H, d, *J* 5.88), 7.20–7.17 (1 H, m), 6.94 (1 H, s), 4.37–4.26 (1 H, m), 4.21–4.16 (1 H, m), 3.31–3.27 (2 H, dt, *J* 6.45), 1.86–1.75 (2 H, m) and 1.33–1.26 (2 H, m); $\delta_C(CDCl_3)$ 142.7, 139.0, 136.7, 130.7, 129.2, 126.1, 125.0, 125.0, 122.4, 120.8, 110.1, 109.6, 43.8, 32.8, 29.9 and 28.2 (Found: *M*, 375.0300. Calc. for $C_{18}H_{18}BrNOS$: *M*, 375.0300).

1-(4-Bromobutyl)-2-(phenylsulfanyl)-1*H*-indole 14. Compound **14** was prepared in 65% yield according to the general procedure from compound **3** (0.28 mmol), KOH (0.35 mmol) and 1,4-dibromobutane (0.84 mmol). Purification (SiO_2, petrol–diethyl ether, 2:1, 1:1) gave the title compound **14** as an oil; R_f (SiO_2, petrol–diethyl ether, 25:1) 0.5; ν_{max}(film)/cm^{-1} 2932, 1806, 1724, 1582, 1440, 1352, 1313, 1219, 1024 and 1000; $\delta_H(CDCl_3)$ 7.66 (1 H, d, *J* 7.81), 7.35 (1 H, d, *J* 7.03), 7.30 (2 H, dd, *J* 6.65, 1.18), 7.24–7.16 (3 H, m), 7.16–7.11 (1 H, m), 7.10–7.01 (1 H, m), 6.94 (1 H, d, *J* 0.78), 4.21 (2 H, t, *J* 7), 3.29 (2 H, t, *J* 6.25) and 1.83–1.72 (4 H, m); $\delta_C(CDCl_3)$ 138.0, 137.0, 129.1, 127.5, 126.8, 126.7, 126.0, 123.1, 121.0, 120.0, 112.4, 110.0, 42.83, 32.89, 29.95 and 28.70 (Found: *M*, 360.0417. Calc. for $C_{18}H_{18}BrNS$: *M*, 360.0422).

1-(5-Bromopentyl)-2-[(4-methylphenyl)sulfonyl]-1*H*-indole 7. Compound **7** was prepared in 74% yield according to the general procedure from compound **2** (0.4 mmol), KOH (0.5 mmol) and 1,5-dibromopentane (1.2 mmol). Purification (SiO_2, petrol–CH_2Cl_2, 5:1, 2:1, 1.5:1) gave the title compound **7** as a white solid, mp 115–116 °C (hexane–diethyl ether) (Found: C, 57.0; H, 5.3; Br, 19.2; N, 3.2; S, 7.7. $C_{20}H_{22}BrNO_2S$ requires C, 57.14; H, 5.28; Br, 19.01; N, 3.33; S, 7.62%); R_f (SiO_2, petrol–diethyl ether, 2:1) 0.31; ν_{max}(film)/cm^{-1} 2959, 2873, 1728, 1580, 1465, 1381, 1319, 1288, 1154 and 1097; $\delta_H(CDCl_3)$ 7.83 (2 H, d, *J* 8.4), 7.70 (1 H, d, *J* 8.21), 7.37–7.31 (3 H, m), 7.19–7.13 (3 H, m), 4.29 (2 H, t, *J* 8.21), 3.35 (2 H, t, *J* 6.65), 2.40 (3 H, s), 1.82–1.71 (2 H, m) and 1.59–1.35 (4 H, m); $\delta_C(CDCl_3)$ 144.5, 138.7, 138.5, 134.8, 130.0, 127.7, 125.6, 125.4, 122.9, 121.1, 110.9, 110.5, 44.6, 33.2, 32.2, 29.0, 25.4 and 21.6 (Found: *M*, 419.0555. Calc. for $C_{20}H_{22}BrNO_2S$: *M*, 419.0554).

1-(5-Bromopentyl)-2-(phenylsulfinyl)-1*H*-indole 21. Compound **21** was prepared in 53% yield according to the general procedure from compound **4** (0.78 mmol), KOH (0.98 mmol) and 1,5-dibromopentane (2.37 mmol). Purification (SiO_2, petrol–diethyl ether, 2:1, 1:1) gave the title compound **21** as a white solid, mp 98–100 °C (petrol–diethyl ether), R_f (SiO_2,

petrol–diethyl ether, 2:1) 0.28; ν_{max}(film)/cm^{-1} 2935, 2859, 1727, 1609, 1582, 1448, 1346, 1227, 1139 and 1040; δ_H($CDCl_3$) 7.66 (2 H, d, *J* 8.04), 7.66–7.63 (3 H, m), 7.55–7.50 (1 H, m), 7.36–7.27 (2 H, m), 7.19–7.15 (1 H, m), 6.93 (1 H, s), 4.34–4.25 (1 H, m), 4.17–4.08 (1 H, m), 3.36 (2 H, t, *J* 6.7), 1.76–1.59 (4 H, m) and 1.39–1.26 (2 H, m); δ_C($CDCl_3$) 142.7, 139.0, 136.8, 130.6, 129.2, 126.1, 125.0, 124.9, 122.4, 120.7, 110.1, 109.4, 44.5, 33.4, 32.2, 28.6 and 25.4 (Found: *M*, 389.0449. Calc. for $C_{19}H_{20}BrNOS$: *M*, 389.0449).

1-(5-Bromopentyl)-2-(phenylsulfanyl)-1*H*-indole 15. Compound **15** was prepared in 61% yield according to the general procedure from compound **3** (0.50 mmol), KOH (0.63 mmol) and 1,5-dibromopentane (1.52 mmol). Purification (SiO_2, petrol–CH_2Cl_2, 50:1, 30:1, 25:1, 20:1) gave the title compound **15** as an oil; R_f (SiO_2, petrol–diethyl ether, 25:1) 0.5; ν_{max}(film)/cm^{-1} 2932, 1728, 1612, 1582, 1440, 1352, 1215, 1024 and 1013; δ_H($CDCl_3$) 7.65 (1 H, d, *J* 7.82), 7.33 (1 H, d, *J* 7.62), 7.29 (2 H, dd, *J* 6.64, 1.17), 7.25–7.16 (3 H, m), 7.15–7.13 (1 H, m), 7.11–7.06 (1 H, m), 6.93 (1 H, d, *J* 0.59), 4.18 (2 H, t, *J* 7.53), 3.28 (2 H, t, *J* 6.84), 1.78–1.68 (2 H, m), 1.66–1.51 (2 H, m) and 1.43–1.30 (2 H, m); δ_C($CDCl_3$) 138.0, 137.0, 129.1, 127.4, 126.9, 126.7, 126.0, 123.0, 121.0, 119.9, 112.3, 110.0, 43.5, 33.3, 32.3, 29.2 and 25.5 (Found: *M*, 373.0500. Calc. for $C_{19}H_{20}BrNS$: *M*, 373.0500).

1-(6-Bromohexyl)-2-[(4-methylphenyl)sulfonyl]-1*H*-indole 8. Compound **8** was prepared in 50% yield according to the general procedure from compound **2** (0.6 mmol), KOH (0.74 mmol) and 1,6-dibromohexane (1.8 mmol). Purification (SiO_2, petrol–CH_2Cl_2, 5:1, 2:1, 1.5:1) gave the title compound **8** as a white solid, mp 69–71 °C (hexane–diethyl ether) (Found: C, 58.1; H, 5.5; Br, 18.2; N, 3.2; S, 7.2. $C_{21}H_{24}BrNO_2S$ requires C, 58.06; H, 5.57; Br, 18.40; N, 3.22; S, 7.38%); R_f (SiO_2, petrol–diethyl ether, 2:1) 0.42; ν_{max}(film)/cm^{-1} 2935, 1725, 1613, 1597, 1470, 1319, 1237, 1154, 1095, 1017 and 842; δ_H($CDCl_3$) 7.85 (2 H, d, *J* 8.6), 7.71 (1 H, d, *J* 8.2), 7.35–7.28 (2 H, m), 7.21–7.15 (4 H, m), 4.30 (2 H, t, *J* 8.21), 3.40 (2 H, t, *J* 6.64), 2.42 (3 H, s), 1.81 (2 H, p, *J* 7.61), 1.57–1.50 (2 H, m) and 1.38–1.22 (4 H, m); δ_C($CDCl_3$) 144.5, 138.7, 138.5, 134.8, 129.9, 127.7, 125.6, 125.4, 122.9, 121.1, 110.9, 110.6, 44.8, 33.6, 32.5, 29.7, 27.7, 25.9 and 21.6 (Found: *M*, 433.0711. Calc. for $C_{21}H_{24}BrNO_2S$: *M*, 433.0707).

(*E*)/(*Z*)-1-(3-Bromoprop-2-enyl)-2-[(4-methylphenyl)sulfonyl]-1*H*-indole 29a/b. Compounds **29a/b** were prepared in 86% yield (*E*:*Z*, 45:55) according to the general procedure from compound **2** (1.1 mmol), KOH (3.4 mmol) and 1,3-dibromopropene (3.33 mmol). Purification (SiO_2, petrol–diethyl ether, 50:1, 20:1, 6:1, 2:1) gave the title compound **29a/b**, mp 70–73 °C (hexane–diethyl ether) (Found: C, 55.4; H, 4.05; Br, 20.5; N, 3.55; S, 8.2. $C_{18}H_{16}BrNO_2S$ requires C, 55.39; H, 4.13; Br, 20.47; N, 3.59; S, 8.22%) (Found: *M*, 389.0085. Calc. for $C_{18}H_{16}BrNO_2S$: *M*, 389.0086); ν_{max}(film)/cm^{-1} 2926, 2305, 1598, 1494, 1455, 1320, 1289, 1154, 1018 and 969. Further purification by preparative TLC furnished the individual isomers; **29a** (*E*): R_f (SiO_2, petrol–diethyl ether, 2:1) 0.31; δ_H($CDCl_3$) 7.74 (2 H, d, *J* 8.6), 7.66 (1 H, d, *J* 7.81), 7.30–7.27 (1 H, m), 7.25 (2 H, d, *J* 7.81), 7.18–7.11 (3 H, m), 5.94–5.84 (1 H, m, *J* 13.67), 5.61–5.55 (1 H, m, *J* 13.68), 5.04 (2 H, dd, *J* 5.86 and 1.96) and 2.34 (3 H, s); δ_C($CDCl_3$) 145.8, 139.7, 136.3, 133.2, 130.0, 127.9, 126.2, 125.5, 123.1, 121.7, 111.5, 110.6, 108.5, 45.7, 26.0 and 21.6. **29b** (*Z*): R_f (SiO_2, petrol–diethyl ether, 2:1) 0.42; δ_H($CDCl_3$) 7.74 (2 H, d, *J* 8.6), 7.65 (1 H, d, *J* 7.81), 7.29–7.27 (1 H, m), 7.26 (2 H, d, *J* 7.81), 7.18–7.11 (3 H, m), 6.19–6.16 (1 H, m, *J* 7.42), 5.83–5.80 (1 H, m, *J* 7.03), 5.04 (2 H, dd, *J* 5.86 and 1.95) and 2.34 (3 H, s); δ_C($CDCl_3$) 144.7, 138.9, 138.2, 134.9, 130.0, 127.8, 126.0, 125.4, 122.9, 121.5, 111.3, 110.9, 109.7, 44.4, 25.7 and 21.6.

1-(*o*-Bromobenzyl)-2-[(4-methylphenyl)sulfonyl]-1*H*-indole 30. Compound **30** was prepared in 68% yield according to the general procedure from compound **2** (0.37 mmol), KOH (0.93 mmol) and 2-bromobenzyl bromide (1.11 mmol). Purification (SiO_2, petrol–diethyl ether 100:0, 50:1, 20:1, 6:1, 3:1) gave the title compound **30** as a white solid, mp 150–152 °C; R_f (SiO_2, petrol–diethyl ether 2:1) 0.42 (Found: C, 60.0; H, 4.3; Br, 18.2; N, 2.9; S, 7.3. $C_{22}H_{18}BrNO_2S$ requires C, 60.00; H, 4.12; Br, 18.15; N, 3.18; S, 7.28%); ν_{max}(film)/cm^{-1} 2980, 2933, 1597, 1519, 1475, 1325, 1153, 1090 and 1019; δ_H($CDCl_3$) 7.80 (1 H, d, *J* 7.91), 7.68 (2 H, d, *J* 7.55), 7.56 (1 H, s), 7.51 (1 H, d, *J* 7.95), 7.30–7.22 (2 H, m), 7.11 (1 H, d, *J* 8.33), 7.02 (2 H, d, *J* 7.9), 6.95 (1 H, t, *J* 7.81), 6.67 (1 H, t, *J* 7.80), 5.7 (1 H, d, *J* 7.3), 5.6 (2 H, s) and 2.04 (3 H, s); δ_C($CDCl_3$) 144.2, 139.2, 137.3, 135.9, 135.4, 132.2, 129.7, 129.6, 128.1, 127.8, 127.3, 126.6, 126.1, 123.0, 121.6, 121.3, 111.1, 110.8, 48.0 and 21.4 (Found: *M*, 439.0242. Calc. for $C_{22}H_{18}BrNO_2S$: *M*, 439.0242).

General procedure: *N*-acylation

To a stirred solution of the amine, *N*,*N*-dimethylaminopyridine (DMAP) and distilled Et_3N in DMF at 0 °C was added 3-bromopropionyl bromide and the reaction allowed to warm to room temperature. Addition of water, extraction with CH_2Cl_2, drying and evaporation *in vacuo* gave the crude product which was purified to give the product.

***N*-(3-Bromopropionyl)-7-[(4-methylphenyl)sulfonyl]indoline 35.** Compound **35** was prepared in 77% yield according to the general procedure from compound **34** (0.63 mmol), DMF (1.8 cm^3), DMAP (0.15 mmol), Et_3N (0.76 mmol) and 3-bromopropionyl bromide (2.7 mmol). Purification (SiO_2, petrol–diethyl ether 1:1, 1:2, 1:3, 1:4) gave the title compound **35** as a cream solid, mp 155–156 °C; R_f (SiO_2, petrol–ethyl acetate, 1:3) 0.7; ν_{max}(film)/cm^{-1} 2929, 1681, 1598, 1441, 1433, 1391, 1304, 1130, 1082, 813 and 666; δ_H($CDCl_3$) 7.81 (2 H, d, *J* 8.3), 7.72 (1 H, d, *J* 8), 7.42 (1 H, dd, *J* 8 and 1), 7.29 (2 H, d, *J* 8), 7.19 (1 H, t, *J* 7.7), 4.23 (2 H, br t), 3.73 (2 H, t, *J* 7), 3.18 (2 H, t, *J* 6.9), 3.07 (2 H, t) and 2.41 (3 H, s); δ_C($CDCl_3$) 143.6, 140.2, 139.0, 137.4, 131.6, 129.5, 129.2, 127.5, 125.3, 51.1, 38.6, 29.6, 27.6 and 21.6 (Found: *M*, 407.0191. Calc. for $C_{18}H_{18}BrNO_3S$: *M*, 407.0191).

s-*trans*/s-*cis*-*N*-(3-Bromopropionyl)-2-(phenylsulfonyl)aniline 37. Compound **37** was prepared in 42% yield according to the general procedure from compound **36** (0.99 mmol), DMF (2 cm^3), DMAP (0.203 mmol), Et_3N (1.08 mmol) and 3-bromopropionyl chloride (3.2 mmol). Purification (SiO_2, petrol–ethyl acetate, 10:1, 5:1) gave the title compound **37** as an oil; R_f (SiO_2, petrol–ethyl acetate, 1:1) 0.7; ν_{max}(film)/cm^{-1} 3359, 1704, 1589, 1530, 1467, 1439, 1369, 1311, 1292, 1150, 1092, 1024, 1000, 925, 592 and 569; δ_H($CDCl_3$) 9.78 (1 H, br s), 8.44 (1 H, d, *J* 8.3), 8.04 (1 H, d, *J* 8.1), 7.88 (2 H, d, *J* 7.2), 7.60 (2 H, m), 7.51 (2 H, dt, *J* 7.2 and 1.3), 7.26 (1 H, dt, *J* 7.7 and 1.1), 3.88 (0.8 H, t, *J* 6.2), 3.7 (1.2 H, t, *J* 6.4), 3.03 (1.2 H, t, *J* 6.4) and 2.9 (0.8 H, t, *J* 6.2); δ_C($CDCl_3$) 167.8, 167.6, 140.8, 136.6, 135.1, 133.8, 129.7, 129.4, 127.7, 126.9, 124.4, 122.8, 41.0, 40.9, 39.4 and 26.3 (Found: *M*, 366.9878. Calc. for $C_{15}H_{14}BrNO_3S$: *M*, 366.9878).

General procedure: preparation of 2-substituted *N*-iodoalkylindoles

A solution of *N*-bromoalkylindole in acetone (10 cm^3 mmol^{-1}) was added dropwise to a solution of NaI in acetone. The reaction was stirred at ambient temperature overnight and after the standard work-up the crude product was purified by recrystallisation or silica gel chromatography.

1-(3-Iodopropyl)-2-[(4-methylphenyl)sulfonyl]-1*H*-indole 9. Compound **9** was prepared in 81% yield according to the general procedure from compound **5** (0.26 mmol) and NaI (0.33 mmol) in acetone (2.2 cm^3), as a white solid, mp 110–111 °C (hexane–diethyl ether) (Found C, 49.1; H, 4.0; N, 3.2; S, 7.3. $C_{18}H_{18}INO_2S$ requires C, 49.21; H, 4.13; N, 3.19; S, 7.30%); R_f (SiO_2, petrol–diethyl ether, 2:1) 0.42; ν_{max}(film)/cm^{-1} 2930, 2849, 2359, 1595, 1506, 1474, 1443, 1319, 1292, 1154 and 1096; δ_H($CDCl_3$) 7.86 (2 H, d, *J* 8.4), 7.71 (1 H, d, *J* 8.01), 7.40–7.37 (2 H, m), 7.34 (1 H, d, *J* 6.45), 7.22–7.16 (3 H, m), 4.37 (2 H, t, *J*

7.62), 3.15 (2 H, t, *J* 6.84), 2.42 (3 H, s) and 2.04 (2 H, p, *J* 7.62); $\delta_C(CDCl_3)$ 144.7, 138.8, 138.3, 134.9, 130.0, 127.8, 127.7, 125.9, 123.0, 121.4, 111.3, 110.5, 45.6, 33.3, 21.6 and 4.17 (Found: *M*, 439.0105. Calc. for $C_{18}H_{18}INO_2S$: *M*, 439.0103).

1-(3-Iodopropyl)-2-(phenylsulfinyl)-1*H*-indole 22. Compound **22** was prepared in 64% yield according to the general procedure from compound **19** (0.46 mmol) and NaI (0.57 mmol) in acetone (1.6 cm^3). Purification (SiO_2, petrol–diethyl ether 3:1, 2:1, 1:1) gave the title compound **22** as an oil. The product was repurified by HPLC (r/p, acetonitrile/water:ammonium acetate); R_f (SiO_2, petrol–diethyl ether, 2:1) 0.28; ν_{max}(film)/cm^{-1} 2930, 2852, 1723, 1612, 1581, 1444, 1312, 1139, 1217 and 1042; $\delta_H(CDCl_3)$ 7.69 (2 H, d, *J* 8.0), 7.65–7.62 (3 H, m), 7.55–7.52 (1 H, m), 7.42–7.36 (2 H, m), 7.21–7.17 (1 H, m), 6.93 (1 H, s), 4.40–4.24 (2 H, m), 3.18–3.14 (2 H, m), 2.23–2.18 (1 H, m) and 1.80–1.68 (1 H, m); $\delta_C(CDCl_3)$ 142.4, 139.1, 136.7, 130.8, 129.3, 126.0, 125.1, 125.0, 122.4, 120.9, 110.1, 109.5, 45.1, 32.9 and 2.0 (Found: *M*, 409.005. Calc. for $C_{17}H_{16}INOS$: *M*, 409.006).

1-(3-Iodopropyl)-2-(phenylsulfanyl)-1*H*-indole 16. Compound **16** was prepared in 77% yield, according to the general procedure from compound **13** (0.27 mmol) and NaI (0.34 mmol) in acetone (1.5 cm^3). Purification (SiO_2, petrol–CH_2Cl_2, 50:1, 20:1, 12:1) gave the title compound **16** as an oil; R_f (SiO_2, petrol–diethyl ether, 25:1) 0.5; ν_{max}(film)/cm^{-1} 2935, 1771, 1582, 1441, 1353, 1313, 1243, 1173 and 1024; $\delta_H(CDCl_3)$ 7.64 (1 H, d, *J* 8.01), 7.42 (1 H, d, *J* 8.01), 7.31–7.25 (2 H, m), 7.23–7.18 (3 H, m), 7.16–7.08 (2 H, m), 7.08 (1 H, d, *J* 1.17), 4.26–4.21 (2 H, t, *J* 6), 3.03 (2 H, t, *J* 6.9) and 2.16 (2 H, p, *J* 6); $\delta_C(CDCl_3)$ 138.1, 136.8, 129.2, 127.5, 126.9, 126.7, 126.1, 123.2, 121.0, 120.1, 112.7, 110.0, 44.2, 33.8 and 2.2 (Found: *M*, 393.0048. Calc. for $C_{17}H_{16}INS$: *M*, 393.0048).

1-(4-Iodobutyl)-2-[(4-methylphenyl)sulfonyl]-1*H*-indole 10. Compound **10** was prepared in 68% yield according to the general procedure from compound **6** (0.33 mmol) and NaI (0.42 mmol) in acetone (2.2 cm^3), as a white solid, mp 141–143 °C (petrol–diethyl ether) (Found: C, 49.75; H, 4.4; I, 28.05; N, 3.0; S, 6.45. $C_{19}H_{20}INO_2S$ requires C, 50.33; H, 4.45; I, 28.01; N, 3.09; S, 7.06%); R_f (SiO_2, petrol–diethyl ether, 2:1) 0.31; ν_{max}(film)/cm^{-1} 2957, 1719, 1598, 1509, 1442, 1329, 1291, 1152 and 1096; $\delta_H(CDCl_3)$ 7.88 (2 H, d, *J* 8.5), 7.75 (1 H, d, *J* 8), 7.37–7.29 (3 H, m), 7.23–7.16 (3 H, m), 4.34 (2 H, t, *J* 7.81), 3.16 (2 H, t, *J* 6.65), 2.45 (3 H, s) and 1.81–1.78 (4 H, m); $\delta_C(CDCl_3)$ 144.6, 138.7, 138.5, 134.8, 130.0, 127.7, 125.7, 125.5, 123.0, 121.2, 111.1, 110.6, 43.8, 30.9, 30.6, 21.6 and 5.3 (Found: *M*, 453.0260. Calc. for $C_{19}H_{20}INO_2S$: *M*, 453.0260).

1-(4-Iodobutyl)-2-(phenylsulfinyl)-1*H*-indole 23. Compound **23** was prepared in 54% yield according to the general procedure from compound **20** (0.59 mmol) and NaI (0.76 mmol) in acetone (2.0 cm^3). Purification (SiO_2, petrol–diethyl ether, 2:1, 1:1) gave the title compound **23** as a white solid, mp 74–76 °C (petrol–diethyl ether); R_f (SiO_2, petrol–diethyl ether, 2:1) 0.28; ν_{max}(film)/cm^{-1} 2929, 2869, 1724, 1612, 1582, 1444, 1312, 1212, 1112 and 1043; $\delta_H(CDCl_3)$ 7.68 (2 H, d, *J* 8.01), 7.65–7.62 (3 H, m), 7.55–7.51 (1 H, m), 7.37–7.27 (2 H, m), 7.20–7.17 (1 H, m), 6.93 (1 H, s), 4.32–4.12 (2 H, m), 3.11–3.00 (2 H, m), 1.82–1.69 (2 H, m) and 1.33–1.22 (2 H, m); $\delta_C(CDCl_3)$ 142.6, 139.0, 136.7, 130.7, 129.2, 126.1, 125.0, 122.4, 120.8, 110.1, 109.5, 43.5, 30.6, 30.4 and 5.4 (Found: *M*, 423.0154. Calc. for $C_{18}H_{18}INOS$: *M*, 423.0154).

1-(4-Iodobutyl)-2-(phenylsulfanyl)-1*H*-indole 17. Compound **17** was prepared in 75% yield according to the general procedure from compound **14** (0.139 mmol) and NaI (0.18 mmol) in acetone (1.7 cm^3). Purification (SiO_2, petrol–CH_2Cl_2, 50:1, 20:1, 10:1) gave the title compound **17** as an oil; R_f (SiO_2, petrol–diethyl ether, 25:1) 0.5; ν_{max}(film)/cm^{-1} 2927, 1582, 1452, 1352, 1313, 1232, 1080, 1024 and 1000; $\delta_H(CDCl_3)$ 7.66 (1 H, d, *J* 7.82), 7.35 (1 H, d, *J* 7.81), 7.30 (2 H, d, *J* 6.74), 7.27–7.15 (3 H, m), 7.15–7.11 (1 H, m), 7.09–7.05 (1 H, m), 6.94 (1 H, d, *J* 0.59), 4.21–4.15 (2 H, m), 3.07–3.02 (2 H, m) and 1.79–1.70 (4 H, m); $\delta_C(CDCl_3)$ 137.9, 137.0, 129.1, 127.4, 126.7, 126.6, 126.0, 123.0, 121.0, 120.0, 112.4, 110.0, 42.5, 30.9, 30.6 and 5.7 (Found: *M*, 407.0205. Calc. for $C_{18}H_{18}INS$: *M*, 407.0205).

1-(5-Iodopentyl)-2-[(4-methylphenyl)sulfonyl]-1*H*-indole 11. Compound **11** was prepared in 78% yield according to the general procedure from compound **7** (0.22 mmol) and NaI (0.28 mmol) in acetone (2.2 cm^3), as a white solid, mp 110–112 °C (hexane–diethyl ether) (Found: C, 51.6; H, 4.8; I, 27.1; N, 3.0; S, 6.8. $C_{20}H_{22}INO_2S$ requires C, 51.40; H, 4.74; I, 27.15; N, 3.00; S, 6.86%); R_f (SiO_2, petrol–diethyl ether, 2:1) 0.29; ν_{max}(cm^{-1}) 2931, 2863, 1735, 1597, 1444, 1319, 1152 and 1095; $\delta_H(CDCl_3)$ 7.85 (2 H, d, *J* 8.4), 7.71 (1 H, d, *J* 8.01), 7.39–7.31 (2 H, m), 7.21–7.15 (4 H, m), 4.29 (2 H, t, *J* 8.01), 3.15 (2 H, t, *J* 7.03), 2.42 (3 H, s), 1.80 (2 H, p, *J* 7.23) and 1.55–1.35 (4 H, m); $\delta_C(CDCl_3)$ 144.5, 138.7, 138.4, 134.7, 130.0, 127.7, 125.6, 125.4, 123.0, 121.1, 110.9, 110.5, 44.6, 32.9, 28.8, 27.7, 21.6 and 6.3 (Found: *M*, 467.0418. Calc. for $C_{20}H_{22}INO_2S$: *M*, 467.0416).

1-(5-Iodopentyl)-2-(phenylsulfinyl)-1*H*-indole 24. Compound **24** was prepared in 96% yield according to the general procedure from compound **21** (0.21 mmol) and NaI (0.27 mmol) in acetone (2.5 cm^3). Purification, (SiO_2, petrol–diethyl ether, 2:1, 1:1) gave the title compound **24** as a white solid, mp 91–93 °C (petrol–diethyl ether); R_f (SiO_2, petrol–diethyl ether, 2:1) 0.28; ν_{max}(film)/cm^{-1} 2927, 2855, 1724, 1612, 1581, 1444, 1348, 1086 and 1044; $\delta_H(CDCl_3)$ 7.68 (2 H, d, *J* 8.03), 7.66–7.63 (3 H, m), 7.55–7.50 (1 H, m), 7.34–7.27 (2 H, m), 7.19–7.15 (1 H, m), 6.94 (1 H, d, *J* 0.39), 4.34–4.23 (1 H, m), 4.16–4.07 (1 H, m), 3.14 (2 H, t, *J* 6.92), 1.76–1.67 (2 H, m), 1.37–1.27 (2 H, m) and 1.15–0.89 (2 H, m); $\delta_C(CDCl_3)$ 142.7, 139.0, 136.7, 130.6, 129.2, 126.1, 125.0, 124.9, 122.4, 120.7, 110.1, 109.4, 44.4, 32.8, 28.4, 27.7 and 6.4 (Found: *M*, 437.0310. Calc. for $C_{19}H_{20}INOS$: *M*, 437.0310).

1-(5-Iodopentyl)-2-(phenylsulfanyl)-1*H*-indole 18. Compound **18** was prepared in 63% yield according to the general procedure from compound **15** (0.77 mmol) and NaI (0.97 mmol) in acetone (3.0 cm^3). Purification, (SiO_2, petrol–CH_2Cl_2, 5:1) gave the title compound **18** as an oil; R_f (SiO_2, petrol–diethyl ether, 25:1) 0.5; ν_{max}(film)/cm^{-1} 2927, 1771, 1582, 1452, 1352, 1313, 1277, 1081, 1024 and 1000; $\delta_H(CDCl_3)$ 7.70 (1 H, d, *J* 7.7), 7.35–7.11 (8 H, m), 6.97 (1 H, d, *J* 0.59), 4.18 (2 H, t, *J* 7.52), 3.12 (2 H, t, *J* 7.03), 1.76–1.65 (2 H, m), 1.62–1.54 (2 H, quintet, *J* 8.01) and 1.43–1.25 (2 H, m); $\delta_C(CDCl_3)$ 137.9, 137.0, 129.1, 127.4, 126.8, 126.7, 126.0, 122.9, 121.0, 119.9, 112.3, 110.0, 43.4, 32.9, 28.9, 27.8 and 6.3 (Found: *M*, 421.0363. Calc. for $C_{19}H_{20}INS$: *M*, 421.0361).

1-(6-Iodohexyl)-2-[(4-methylphenyl)sulfonyl]-1*H*-indole 12. Compound **12** was prepared in 89% yield according to the general procedure from compound **8** (0.22 mmol) and NaI (0.39 mmol) in acetone (1.7 cm^3) as a white solid, mp 81–83 °C (petrol–diethyl ether) (Found: C, 52.3; H, 5.0; I, 26.1; N, 2.95; S, 6.55. $C_{21}H_{24}NIO_2S$ requires C, 52.40; H, 5.03; I, 26.36; N, 2.91; S, 6.66%); R_f (SiO_2, petrol–diethyl ether, 2:1) 0.42; ν_{max}(film)/cm^{-1} 2930, 2857, 1728, 1595, 1504, 1443, 1318, 1184, 1152, 1095 and 900; $\delta_H(CDCl_3)$ 7.85 (2 H, d, *J* 8.4), 7.71 (1 H, d, *J* 8.01), 7.38–7.27 (2 H, m), 7.21–7.15 (4 H, m), 4.29 (2 H, t, *J* 8.01), 3.18 (2 H, t, *J* 7.03), 2.42 (3 H, s), 1.8 (2 H, p, *J* 7.03), 1.57–1.50 (2 H, m) and 1.38–1.25 (4 H, m); $\delta_C(CDCl_3)$ 144.5, 138.7, 138.5, 134.8, 130.0, 127.7, 125.6, 125.4, 123.0, 121.1, 111.0, 110.6, 44.6, 32.9, 32.2, 28.8, 27.7, 21.6 and 6.2 (Found: *M*, 481.0577. Calc. for $C_{21}H_{24}INO_2S$: *M*, 481.0573).

General procedure: radical cyclizations

A solution of Bu_3SnH and AIBN in toluene was added to a solution of cyclization precursor in toluene at reflux. After the addition was complete the solution was stirred at reflux until the reaction was deemed complete (TLC analysis). The reaction mixture was allowed to cool to room temperature and after the 'KF work-up' purification was carried out using silica-gel chromatography.

2,3-Dihydro-1*H*-pyrrolo[1,2-*a*]indole 25. Compound **25** was prepared in 75% yield according to the general procedure from sulfone **5** (0.2 mmol) in toluene (4.0 cm^3), Bu_3SnH (0.48 mmol) and AIBN (0.04 mmol) in toluene (10 cm^3), 5 min addition, 2 h reflux.

Compound **25** was prepared in 71% yield according to the general procedure from sulfone **9** (0.073 mmol) in toluene (1.5 cm^3), Bu_3SnH (0.15 mmol) and AIBN (0.073 mmol) in toluene (2 cm^3), 15 min addition, 3 h reflux.

Compound **25** was prepared in 46% yield according to the general procedure from sulfoxide **22** (0.087 mmol) in toluene (4.5 cm^3), Bu_3SnH (0.18 mmol) and AIBN (0.018 mmol) in toluene (9.5 cm^3), 4 h addition.

Compound **25** was prepared in 25% yield according to the general procedure from sulfide **16** (0.17 mmol) in toluene (8.5 cm^3), Bu_3SnH (0.37 mmol) and AIBN (0.034 mmol) in toluene (20 cm^3), 4.5 h addition.

Purification (SiO_2, petrol–diethyl ether, 100:0, 75:1, 50:1, then 20:1) gave the title compound **25** as a white solid, mp 79–81 °C (lit.,[2] 79–80 °C); R_f (SiO_2, petrol–diethyl ether, 75:1) 0.25; ν_{max}(film)/cm^{-1} 2931, 1728, 1593, 1455, 1374, 1338, 1220, 1149, 1121 and 1041; δ_H($CDCl_3$) 7.56 (1 H, dd, *J* 6.65 and 1.56), 7.25–7.22 (1 H, m), 7.14–7.05 (2 H, m), 6.16 (1 H, d, *J* 0.98), 4.09 (2 H, t, *J* 7.03), 3.05–3.00 (2 H, m) and 2.63–2.60 (2 H, quintet, *J* 7.6); δ_C($CDCl_3$) 144.5, 133.3, 132.7, 120.3, 120.1, 119.1, 109.3, 92.3, 43.6, 27.9 and 24.3 (Found: *M*, 157.0891. Calc. for $C_{11}H_{11}N$: *M*, 157.0891).

6,7,8,9-Tetrahydropyrido[1,2-*a*]indole 26. Compound **26** was prepared in 84% yield according to the general procedure from sulfone **6** (0.185 mmol) in toluene (4.0 cm^3), Bu_3SnH (0.44 mmol) and AIBN (0.037 mmol) in toluene (9.5 cm^3), 5 min addition, 2 h reflux.

Compound **26** was prepared in 71% yield according to the general procedure from sulfone **10** (0.099 mmol) in toluene (3.0 cm^3), Bu_3SnH (0.20 mmol) and AIBN (0.099 mmol) in toluene (3.0 cm^3), 15 min addition, 2.5 h reflux.

Compound **26** was prepared in 53% yield according to the general procedure from sulfoxide **23** (0.062 mmol) in toluene (3.5 cm^3), Bu_3SnH (0.15 mmol) and AIBN (0.014 mmol) in toluene (8.0 cm^3), 4 h addition, 2 h reflux.

Compound **26** was prepared in 51% yield according to the general procedure from sulfide **17** (0.086 mmol) in toluene (2.0 cm^3), Bu_3SnH (0.22 mmol) and AIBN (0.0171 mmol) in toluene (11 cm^3), 4 h addition.

Purification (SiO_2, petrol–diethyl ether, 50:1) gave the title compound **26** as a white solid, mp 53–54 °C (lit.,[2] 52 °C); R_f (SiO_2, petrol–diethyl ether, 20:1) 0.25; ν_{max}(film)/cm^{-1} 2931, 1867, 1728, 1580, 1477, 1455, 1364, 1133, 1073 and 1012; δ_H($CDCl_3$) 7.53 (1 H, dd, *J* 6.83 and 1.60), 7.28–7.22 (1 H, m), 7.16–7.04 (2 H, m), 6.18 (1 H, d, *J* 0.78), 4.08 (2 H, t, *J* 6.25), 3.01 (2 H, t, *J* 6.45), 2.12–2.05 (2 H, m) and 2.04–1.90 (2 H, m); δ_C($CDCl_3$) 137.1, 136.3, 128.2, 120.1, 119.6, 108.5, 97.5, 42.3, 24.3, 23.5 and 21.5 (Found: *M*, 171.1048. Calc. for $C_{12}H_{13}N$: *M*, 171.1048).

7,8,9,10-Tetrahydro-6*H*-azepino[1,2-*a*]indole 27. Compound **27** was prepared in 33% yield according to the general procedure from sulfone **11** (0.133 mmol) in toluene (3.0 cm^3), Bu_3SnH (0.33 mmol) and AIBN (0.133 mmol) in toluene (4.1 cm^3), 5 h addition. Purification (SiO_2, petrol–diethyl ether, 100:0, 99:1, 50:1, 20:1, and then preparative TLC, petrol–diethyl ether, 20:1) gave the title compound **27** as a white solid.

Compound **27** was prepared in 34% yield according to the general procedure from sulfoxide **24** (0.079 mmol) in toluene (4 cm^3), Bu_3SnH (0.15 mmol) and AIBN (0.014 mmol) in toluene (8 cm^3), 4 h addition. Purification (SiO_2, petrol–diethyl ether, 100:0, 99:1, 50:1, 20:1, and then preparative TLC, petrol–diethyl ether 20:1), gave **27** as a white solid, mp 85–89 °C (lit.,[2] 87 °C); R_f (SiO_2, petrol–diethyl ether, 0.4); ν_{max}(film)/cm^{-1} 2967, 2931, 1728, 1592, 1478, 1462, 1325, 1201, 1081 and 1015; δ_H($CDCl_3$) 7.54 (1 H, d, *J* 7.04), 7.29–7.21 (1 H, m), 7.17–7.02 (2 H, m), 6.25 (1 H, d, *J* 0.78), 4.18–4.15 (2 H, m), 2.93–2.89 (2 H, m) and 1.86–1.67 (6 H, m); δ_C($CDCl_3$) 143.2, 136.9, 127.9, 120.3, 119.8, 118.9, 108.5, 99.04, 44.60, 31.10, 29.49, 28.76 and 28.17 (Found: *M*, 185.1024. Calc. for $C_{13}H_{15}N$: *M*, 185.1024).

9*H*-Pyrrolo[1,2,*a*]indole 31. Compound **31** was prepared according to the general procedure from compound **29a/b** (0.303 mmol) in toluene (7.0 cm^3), Bu_3SnH (0.33 mmol) and AIBN (0.06 mmol) in toluene (7.0 cm^3), 5 min addition, reflux 5 h. Chromatography (SiO_2, petrol–diethyl ether 100:0, 85:1) gave the title compound **31** and compound **29c** as a mixture (ratio, 55:45), yield of **31** estimated at 29%; R_f (SiO_2, hexane–diethyl ether, 85:1) 0.43; ^1H NMR data of **31/29c** were consistent with the literature data[13] for **31**; δ_H($CDCl_3$) 7.42–7.09 (9 H, m), 6.53 (1 H, dd, *J* 3.92 and 2.27), 6.42 (1 H, dt, *J* 3.1), 6.15–6.0 (1 H, m), 6.0–5.97 (1 H, m), 5.24–5.14 (2 H, m), 4.79–4.74 (2 H, m) and 3.86 (2 H, s); δ_C($CDCl_3$) of **31** 135.0, 127.5, 125.9, 123.1, 113.2, 109.8, 109.7, 101.7, 99.11, 99.10 and 29.1.

6*H*-Isoindolo[2,1-*a*]indole 32. Compound **32** was prepared in 31% yield according to the general procedure from compound **30** (0.15 mmol) in toluene (4.0 cm^3), Bu_3SnH (0.17 mmol) and AIBN (0.0304 mmol) in toluene (3.5 cm^3), 5 min addition, 5 h reflux. Purification (SiO_2, petrol–diethyl ether 100:0, 50:1, 30:1), gave the title compound **32** as a white solid, mp 209–211 °C; R_f (hexane–diethyl ether, 30:1) 0.29; ν_{max}(film)/cm^{-1} 3421, 2923, 1654, 1541, 1506, 1470, 1439, 1096 and 1015; δ_H($CDCl_3$) 7.74–7.66 (2 H, m), 7.48–7.41 (1 H, m), 7.42–7.32 (3 H, m), 7.21–7.19 (2 H, m), 6.64 (1 H, d, *J* 0.7) and 5.1 (2 H, s); δ_C($CDCl_3$) 143.9, 141.7, 133.9, 133.0, 132.7, 128.1, 127.0, 123.5, 121.7, 121.5, 120.9, 119.6, 109.2, 91.2 and 48.4 (Found: *M*, 205.0888. Calc. for $C_{15}H_{11}N$: *M*, 205.0891).

1,2,5,6-Tetrahydro-4*H*-pyrrolo[3,2,1-*ij*]quinolin-4-one 38. Compound **38** was prepared in 57% yield according to the general procedure from compound **35** (0.491 mmol) in toluene (16.2 cm^3), Bu_3SnH (0.754 mmol) and AIBN (0.1 mmol) in toluene (24.5 cm^3), 3.5 h addition. Purification (SiO_2, petrol–CH_2Cl_2, 1:2, then Et_2O) gave the title compound **38** as a white solid, mp 112–113 °C; R_f (SiO_2, petrol–ethyl acetate, 1:1) 0.3; ν_{max}(film)/cm^{-1} 2960, 2858, 1672, 1632, 1598, 1484, 1440, 1361, 1204 and 1074; δ_H($CDCl_3$) 7.08 (1 H, d, *J* 7), 7.0 (1 H, d, *J* 6.9), 6.93 (1 H, t, *J* 7.4), 4.08 (2 H, t, *J* 8.3), 3.19 (2 H, t, *J* 8.45), 2.97 (2 H, t, *J* 7.8) and 2.69 (2 H, t, *J* 7.7); δ_C($CDCl_3$) 167.6, 141.3, 128.9, 125.3, 123.2, 123.2, 120.2, 45.1, 31.6, 27.7 and 24.4 (Found: *M*, 173.0841. Calc. for $C_{11}H_{11}NO$: *M*, 173.08405).

Attempted cyclization of *N*-(3-bromopropionyl)-2-(phenylsulfonyl)aniline 37

To a stirred solution of bromide **37** (99.0 mg, 0.027 mmol) in toluene (10.2 cm^3) at reflux was added a solution of Bu_3SnH (132 mg, 0.45 mmol) and AIBN (11.5 mg, 0.07 mmol) in toluene (15 cm^3) at reflux over 3.5 h. The reaction was stirred at reflux for a further 3 h, allowed to cool to room temperature and the solvent removed *in vacuo*. Purification was carried out by silica gel chromatography (petrol–ethyl acetate, 6:1) to give an inseparable mixture containing the product **39** and starting bromide **37** (ratio 2:1, determined by integration). Selected ^1H NMR data, δ_H($CDCl_3$) 9.59 (1 H, br s), 2.49–2.42 (2 H, q, *J* 7.5) and 1.25 (3 H, t, *J* 6). Aromatic signals largely unchanged from starting bromide **37**.

Acknowledgements

We gratefully acknowledge financial assistance from the SERC/EPSRC (GR/H26673) and the Royal Society. We also thank the SERC/EPSRC and the Wellcome Foundation, Beckenham for generous support of our programme under the CASE scheme. We wish to express our gratitude to Professor C. J. Moody for enlightening discussions.

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Paper 5/05799J
Received 1*st September* 1995
Accepted 13*th October* 1995