Antifertility Agents: Synthesis of Yuehchukene Analogues: 6β-(Indol-3-yl)-9,12-dimethyl-6,7,10,11-tetrahydro-7,11-methano-5*H*-[*b*]indole and 6β-(Indol-3-yl)-9,12-dimethyl-6,7,8,11-tetrahydro-7,11-methano-5*H*-cyclo-oct[*b*]indole

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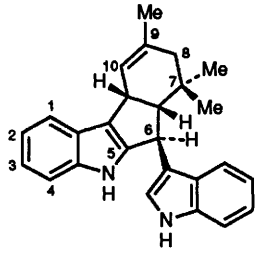
Diels–Alder reactions between (E)-3-(3-methylbuta-1,3-dienyl)-1-tosylindole (**3**) and β-substituted acrylic acid derivatives are described. Reaction of (**3**) with maleic anhydride afforded the adduct (**14**). The latter compound in the presence of aluminium trichloride underwent intramolecular acylation with rearrangement to give 9-methyl-6-oxo-5-tosyl-6,7,8,11-tetrahydro-7,11-methano-5*H*-cyclo-oct[*b*]indole-12-carboxylic acid (**16**) and its double bond isomer (**17**) possessing a skeleton with a close resemblance to that of yuehchukene (**1**), an antifertility agent. Compounds (**16**) and (**17**) were stereoselectively converted into the title compounds (**28**) and (**29**). The structures of two precursors, (**24**) and (**25**), of compounds (**28**) and (**29**) have been determined by X-ray crystallography.

In 1985 we reported the isolation of a new bis-indole alkaloid which showed strong anti-implantation activity and it is becoming a promising fertility-regulating agent.[1,2] The structure of the alkaloid, yuehchukene (YCK), was determined to be (**1**) by X-ray crystallographic analysis.[3] The biological activity of YCK has established it as an important new lead compound for antifertility agents. That fact, coupled with its novel skeletal framework, has stimulated interest in its synthesis.[4–6]

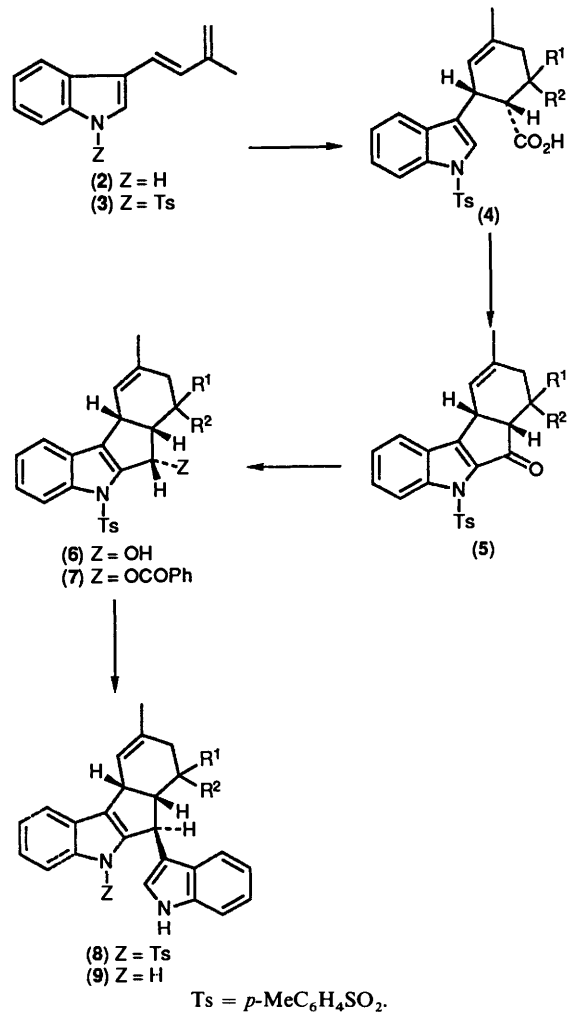


(**1**) YCK

Our laboratory provided the first synthesis of YCK (**1**) by acid dimerization of the 3-dehydroprenylindole (**2**).[4] Since then we have synthesized by the same strategy a few yuehchukene analogues by employing substituted 3-dehydroprenylindole.[7] However, this dimerization strategy cannot provide other analogues, involving, for example, variation of substituents in the cyclohexenyl ring. Therefore we started an investigation into a more general synthetic approach to YCK which would provide access to yuehchukene analogues with possible variation of substituent at C-6, C-7, and C-9.

One attractive route (Scheme 1) which we had investigated was based on the intermolecular Diels–Alder reaction for the conversion of the diene (**3**) into (**4**) followed by intramolecular acylation to obtain the key tetracyclic intermediate (**5**). Stereoselective transformation of the ketone (**5**) to the α-benzoate (**7**) *via* the alcohol (**6**), followed by S_N2 displacement of the benzoate with the indol-3-yl group and removal of the N-protection in (**8**) to give the bis-indole (**9**) was then possible.

In our initial study we successfully synthesized by this route 7,7-dinoryuehchukene (**10**).[8] Our preliminary bioassay indicated that the gem-dimethyl group at C-7 plays a significant role in the biological activity.

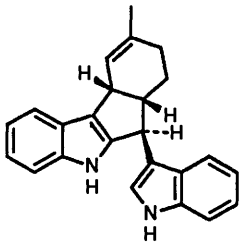


(**2**) Z = H
(**3**) Z = Ts
(**4**)
(**5**)
(**6**) Z = OH
(**7**) Z = OCOPh
(**8**) Z = Ts
(**9**) Z = H

Ts = *p*-$MeC_6H_4SO_2$.

Scheme 1.

In order to carry out further studies on the effect of the substituents at C-7 on the biological activity, it was decided to secure a number of YCK analogues with a variety of substituent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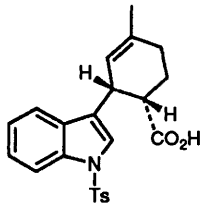
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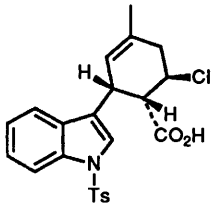
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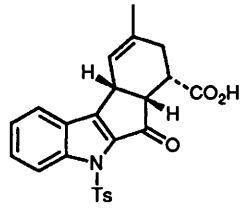
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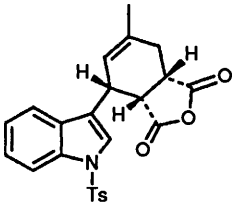
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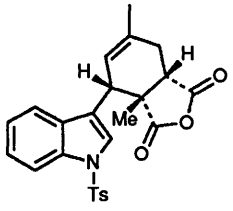
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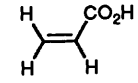
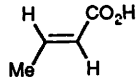
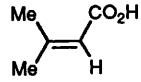
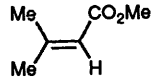
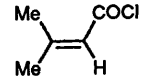
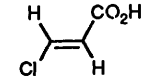
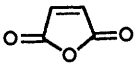
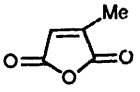
Table 1. Diels–Alder reactions of the diene (3).

Entry	Dienophile	Product	% Yield
1		(11)	80
2		—	—
3		—	—
4		—	—
5		—	—
6		(12)	10
7		(14)	100
8		(15)	80

at C-7 by the same synthetic approach. Thus our immediate target was to synthesize the key tetracyclic intermediate (**5**) with different R groups. To this end we subjected the diene (**3**) to reaction with β-mono- and β,β-di-substituted acrylic acids.

The results of the reaction between the diene (**3**) and substituted acrylic acids are shown in Table 1. While acrylic acid itself (entry 1) gave a satisfactory yield of the Diels–Alder adduct, β-methylacrylic and (entry 2), β,β-dimethylacrylic acid (entry 3), its ester (entry 4), or its acid chloride (entry 5) did not give any desirable adduct under thermal or Lewis acid-catalysed ($ZnCl_2$, Et_2AlCl) conditions. Under mild thermal conditions (< 120 °C in a sealed tube) where the diene (**3**) could survive, no reaction was observed. Under more vigorous conditions (> 120 °C, prolonged treatment) or in the presence of $AlCl_3$ catalyst, only intractable complicated products were obtained. Presumably the diene (**3**) polymerized under these conditions.

The Diels–Alder reaction exhibits a large negative volume of activation together with a large negative volume of reaction.[9] Thus, the use of high pressure to promote intermolecular Diels–Alder reactions has been relatively well explored.[10] However, attempts to induce Diels–Alder reaction of the diene (**3**) with β,β-dimethylacrylic acid under high pressure[11] (10 kbar, at 40 °C) were unsuccessful, the starting materials being recovered unchanged.

The lanthanide, $Yb(fod)_3$ (fod = 6,6,7,7,8,8,8-heptafluoro-2,2-dimethyloctane-3,5-dionato), has been reported to be a useful catalyst for promoting Diels–Alder reactions with acid-labile components which fail to react under thermal or Lewis acid-catalysed condition.[12] However, this catalyst offered no improvement in our system. The failure of the Diels–Alder reaction could be attributed to the steric effect of the β-methyl group in the dienophile.

Trans-β-Chloroacrylic acid (entry 6) gave the desired adduct (**12**) when the reaction was carried out in water–benzene (1:1).[13] albeit in 10% yield.

It was quite clear at this stage that direct introduction of R groups at C-7 by intermolecular Diels–Alder reaction of the diene (**3**) with β-substituted or β,β-disubstituted acrylic acids was not feasible.

On the other hand, the tetracyclic keto-acid (**13**) which we envisaged would be obtainable by intramolecular acylation of the anhydride (**14**) at C-2 of the indole would serve as an alternative key intermediate. The presence of the carboxy group at C-7 provides a handle to introduce different R groups and itself can be readily modified to another R group. When the diene (**3**) was exposed to maleic anhydride in benzene at room temperature, adduct (**14**) was obtained in quantitative yield (entry 7).

We have also treated the diene (**3**) with citraconic anhydride (entry 8) in refluxing benzene and obtained a single adduct (80%). Decoupling experiments established that 10a-H (YCK numbering) was not coupled to any proton other than the olefinic one (10-H) and led to the structure (**15**) which is the undesired *ortho*-adduct.

Treatment of the anhydride (**14**) with aluminium trichloride afforded in 80% yield two keto-acids in a ratio of 3:2 (from NMR integration) which were barely separated by column chromatography. The two keto-acids were very similar in all spectroscopic data. The ketone carbonyl group showed an IR absorption at 1 678 cm^{-1} which is considerable lower than the expected value of 1 702 cm^{-1} as shown by the tetracycle (**5**; R^1 = R^2 = H) indicating that a 5-membered cyclic ketone was not formed.[8] These two keto-acids were proved to possess the isomeric structures (**16**) and (**17**) by X-ray crystal structure analyses of their benzoate derivatives (**24**) (Figure 1) and (**25**) (Figure 2) prepared respectively by sequential lithium aluminium hydride reduction of the keto-acids (**16**) and (**17**), monotosylation of the diols (**18**) and (**19**), sodium iodide–zinc

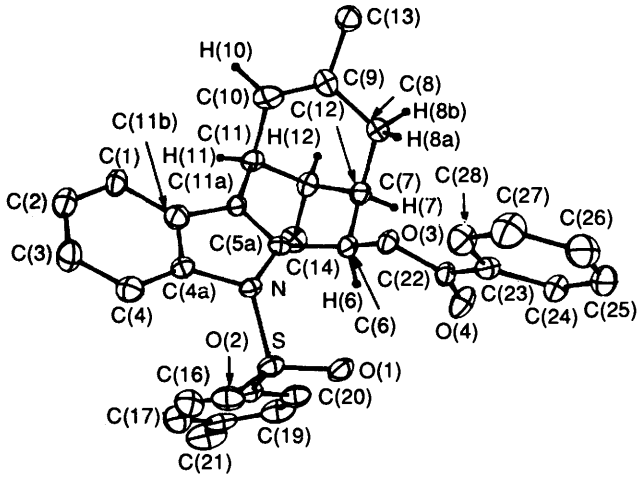


Figure 1. X-Ray structures of the benzoate (**24**).*

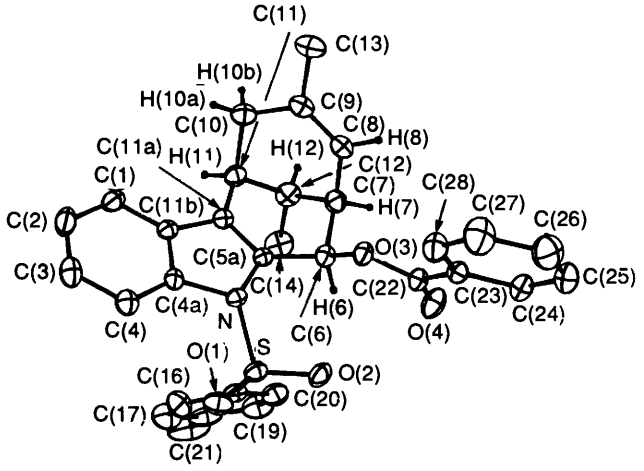
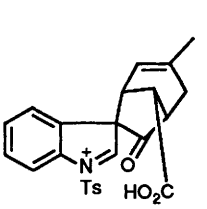
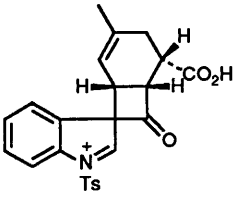


Figure 2. X-Ray structure of the benzoate (**25**).*



(**30**)



(**31**)

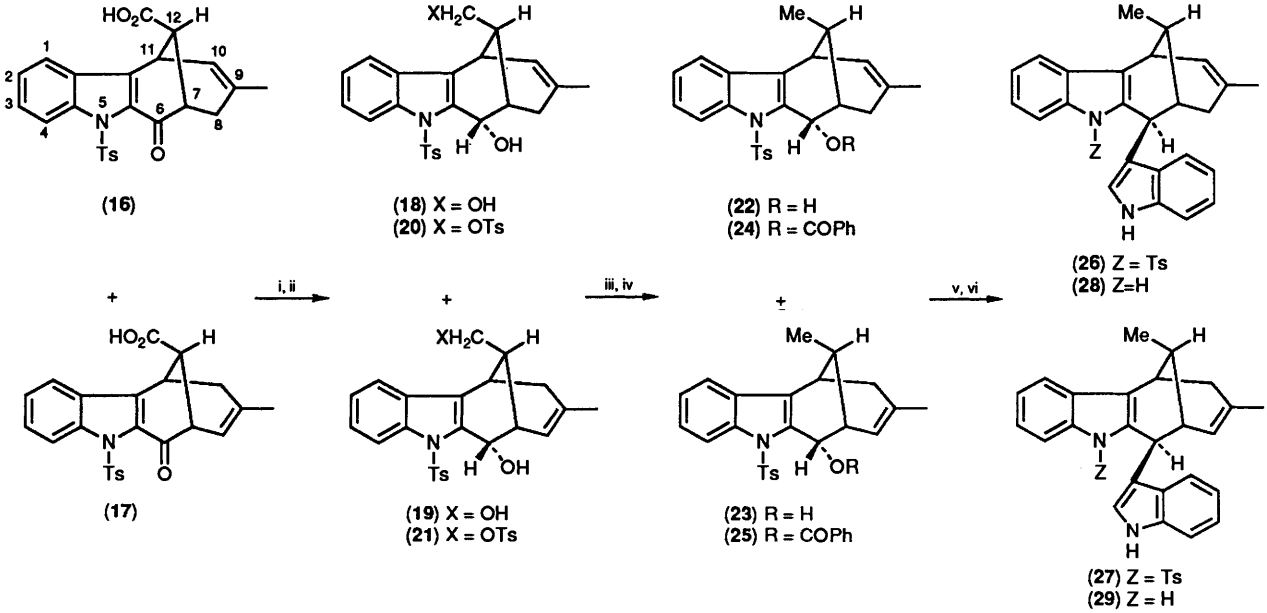
reduction of the tosylates (**20**) and (**21**), and benzoylation of the alcohols (**22**) and (**23**) (Scheme 2).

Clearly, the keto-acids (**16**) and (**17**) were formed from the initial intramolecular electrophilic substitution of indole at C-3 giving rise to the spiro intermediate (**30**), followed by a Wagner–Meerwein-type rearrangement of the 3,3-disubstituted indolene together with or without the isomerization of the isolated double bond. The fact that no desired keto-acid (**13**) was detected reflected the fact that the pathway to the four-membered ring spiro intermediate (**31**) was energetically unfavourable.[14]

The conformations corresponding to the minimum energy of YCK (**1**) and its analogues (**28**) generated from calculations using the Macro Model[15] molecular modelling system (Figures 3 and 4) revealed that the two indole moieties and these molecules are orientated at similar inclinations of 19 and 15° respectively. Therefore, it would be interesting to see if such molecules exhibited biological activity similar to that of YCK. Thus we decided to complete the present synthesis by introducing an indol-3-yl group at C-6. The benzoate (**24**) obtained from (**16**) was elaborated into the bis-indole (**28**) by alkylation with indolyl Grignard reagent, followed by detosylation with sodium amalgam in methanol in the presence of disodium hydrogen phosphate buffer.[16]

Likewise, the isomeric benzoate (**25**) was transformed into the bis-indole (**29**) by a similar sequence.

The biological activity of compounds (**28**), (**29**), and other YCK analogues will be reported elsewhere.



Scheme 2. *Reagents:* i, $LiAlH_4$; ii, TsCl, pyridine, $CHCl_3$; iii, NaI, Zn, HMPA; iv, PhCOCl, DMAP, Et_3N; v, indol-3-yl-MgCl, benzene; vi, Na–Hg, Na_2HPO_4, MeOH.

* All aromatic and methyl hydrogen atoms have been omitted for clarity.

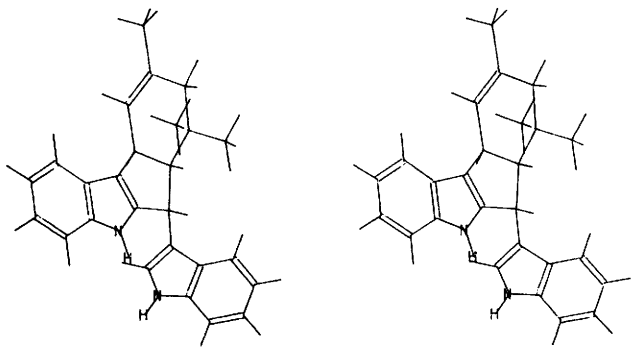


Figure 3. Stereoscopic graphic representation of the calculated geometry for yuehchukene (**1**).

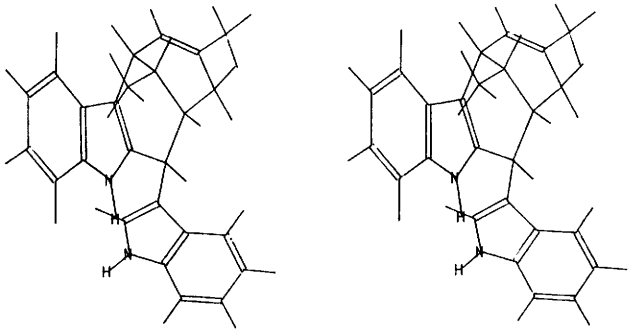


Figure 4. Stereoscopic graphic representation of the calculated geometry for compound (**28**).

Experimental

M.p.s were measured on a Reichert Kofler-hot-stage apparatus and are uncorrected. IR spectra were recorded on a Perkin-Elmer 577 spectrophotometer and calibrated with styrene. NMR spectra were recorded on a JEOL FX-90Q and Bruker WM-400 spectrometer in deuteriochloroform unless otherwise stated with tetramethylsilane as internal standard. Mass spectra were recorded on a Hitachi RMS-4 and VG 70-70F high resolution mass spectrometers. UV spectra were recorded on a Shimdazu UV240 spectrophotometer. TLC was performed using Merck pre-coated silica gel F-254 plates (thickness 0.25 mm). Flash chromatography was carried out with Kieselgel 60 (Merck) as the stationary phase.[17] Analytical HPLC was performed on a Beckmann Model 331 HPLC System with a Model 163 variable wavelength UV–VIS detector. Preparative HPLC was carried out on a Waters Prep LC/System 500A apparatus with a differential refractive index detector. Organic extracts were dried over anhydrous sodium sulphate and evaporated at aspirator pressure using a rotary evaporator. Ether refers to diethyl ether and light petroleum refers to the fraction with b.p. 40–60 °C which was redistilled before use. All reactions requiring anhydrous conditions were conducted in an apparatus dried in an oven at 120 °C and under a static atmosphere of dry argon or nitrogen. New compounds whose elemental compositions were established through accurate mass determination were shown to be homogeneous by spectroscopic and chromatographic methods. All compounds described are racemic.

(2S,3S)-5-*Methyl*-3-(1-*tosylindol*-3-*yl*)*cyclohex*-4-*ene*-1,2-*dicarboxylic Anhydride* (**14**).—A solution of the diene (**3**) (14 g, 41.5 mmol) and maleic anhydride (4.1 g, 41.5 mmol) in anhydrous benzene (27 ml) was stirred at room temperature for 1 h and then at 60 °C for 15 min. Removal of solvent gave the *adduct* (**14**) (17.2 g, 96%) as a colourless solid, m.p. 185–186 °C (Found: C, 66.4; H, 4.7; N, 3.2. $C_{24}H_{21}NO_5S$ requires C, 66.2; H, 4.9; N, 3.2%); λ_{max}(EtOH) 204, 214, 252, 281, and 228 nm; ν_{max}(Nujol) 1 860m, 1 783s (C=O), 1 597, 960, 910, 790, and 770 cm^{-1}; δ_H(90 MHz) 8.0–7.1 (9 H, m, ArH), 5.92 (1 H, br s, 4-H), 3.88 (1 H, br s, 3-H), 3.54 (2 H, m, 1- and 2-H), 2.51, 2.30 (2 H, 2 × m, 6-H), 2.30 (3 H, s, ArMe), and 1.89 (3 H, s, Me); δ_C (22.5 MHz), 173.7, 170.3, 144.9, 137.8, 135.1, 129.9, 127.0, 125.3, 124.9, 123.2, 119.7, 119.0, 113.8, 44.4, 40.5, 32.4, 28.5, 23.3, and 21.5; *m/z* 435 (M^+).

2,5-*Dimethyl*-3-(1-*tosylindol*-3-*yl*)*cyclohex*-4-*ene*-1,2-*dicarboxylic Anhydride* (**15**).—A solution of the diene (**3**) (2.0 g, 5.93 mmol) and citraconic anhydride (665 mg, 5.93 mmol) in benzene (4 ml) was heated under reflux. The progress of the reaction was monitored by TLC. After all the diene (**3**) had reacted (*ca.* 3 h), benzene was removed. Chromatography of the residue on silica gel with ether–light petroleum (2:3) as eluant gave the *anhydride* (**15**) (2.13 g, 80%) as a pale yellow solid, m.p. 185–186 °C (Found: C, 66.9; H, 5.3; N, 3.1. $C_{25}H_{23}NO_5S$ requires: C, 66.8; H, 5.2; N, 3.1%); λ_{max}(EtOH) 202, 213, 252, 282, and 290 nm; ν_{max}(Nujol) 1 855m, 1 790s, 1 595, 1 160, 950, 720, and 650 cm^{-1}; δ_H(400 MHz) 7.84 (1 H, d, *J* 8.0 Hz, 4′-H), 7.77 (2 H, d, *J* 8.0 Hz, 2″- and 3″-H), 7.45 (1 H, d, *J* 8.0 Hz, 7′-H), 7.18–7.30 (3 H, m, 2′-, 5′- and 6′-H), 7.25 (2 H, d, *J* 8.0 Hz, 3″- and 5″-H), 5.72 (1 H, br s, 4-H), 3.67 (1 H, d, *J* 17.5 Hz, 3-H), 3.08 (1 H, dd, *J* 2.0 and 8.5 Hz, 1-H), 2.87 (1 H, d, *J* 17.5 Hz, 6-H), 2.39 (1 H, dd, *J* 17.5 and 8.5 Hz, 6-H), 2.34 (3 H, s, ArMe), 1.92 (3 H, s, 5-Me), and 1.56 (3 H, s, 2-Me); δ_C(22.5 MHz) 174.1, 172.3, 145.0, 134.9, 134.6, 129.9, 129.5, 127.1, 126.2, 124.9, 120.0, 122.5, 120.0, 119.9, 118.5, 113.5, 49.4, 39.5, 25.8, 23.3, 23.2, and 21.5; *m/z* 449 (M^+).

6-*Chloro*-4-*methyl*-2-(1-*tosylindol*-3-*yl*)*cyclohex*-3-*enecarboxylic Acid* (**12**).—From reaction of the diene (**3**) and 3-chloropropenoic acid in benzene–water (1:1) heated under reflux, the acid (**12**) was isolated as a pale yellow solid (10%); ν_{max}(Nujol) 3 400br (OH, H-bonded), 1 720 (C=O), 1 595 (C=C), 1 105, 950, and 790 cm^{-1}; δ_H(90 MHz) 8.0–7.0 (10 H, m, ArH), 5.39 (1 H, br s, 3-H), 4.38 (1 H, m, 6-H), 3.96 (1 H, d, br, *J* 10.9 Hz, 2-H) 2.96 (1 H, t, *J* 10.9 Hz, 1-H), 2.59 (2 H, m, 5-H_2), 2.25 (3 H, s, ArMe), and 1.75 (3 H, s, 4-Me); *m/z* 443 and 445 (3:1 (M^+).

9-*Methyl*-6-*oxo*-5-*tosyl*-6,7,8,11-*tetrahydro*-7,11-*methano*-5H-*cyclo*-*oct*[b]*indole*-12-*carboxylic Acid* (**16**) *and* 9-*Methyl*-6-*oxo*-5-*tosyl*-6,7,10,11-*tetrahydro*-7,11-*methano*-5H-*cyclo*-*oct*-[b]*indole*-12-*carboxylic Acid* (**17**).—To a solution of the anhydride (**14**) (0.5 g, 24.1 mmol) in anhydrous chloroform (120 ml) was added in small portions aluminium trichloride (6.44 g, 48.2 mmol). The resulting solution was heated under gentle reflux for 15 min, water was added, and the mixture extracted with chloroform. The organic layer was washed with water and brine, dried, and evaporated to dryness to give a yellow solid (8.9 g, 85%) consisting of a 3:2 mixture of (**16**) and (**17**). This crude product was used for subsequent reaction without further purification. Chromatography of a sample of the crude product on silica gel with ether as eluant gave the *acid* (**16**) as a white solid, m.p. 109–110 °C (Found: M^+, 435.1142. $C_{24}H_{21}NO_5S$ requires *M*, 435.1140); λ_{max}(EtOH) 209 and 305 nm; ν_{max}(Nujol) 3 400 vbr (OH, H-bonded), 1 710s (C=O), 1 678s (C=O), 1 600 (C=C), 1 250, 1 070, 950, and 890 cm^{-1}; δ_H(90 MHz) 8.58 (1 H, s, br, CO_2H), 8.5–7.1 (8 H, m, ArH), 5.79 (1 H, d, *J* 6.6 Hz, 10-H), 4.01 (1 H, d, *J* 6.6 Hz, 11-H), 3.32 (1 H, m, 7-H), 3.12 (1 H, t, *J* 2.6 Hz, 12-H), 2.30 (3 H, s, ArMe), 2.30 (2 H, m, 8-H_2), and 1.46 (3 H, s, 9-Me), $J_{10,11}$ 6.6, $J_{11,12}$ 2.6, $J_{7,12}$ 2.6 Hz; δ_C (22.5 MHz) 187.2, 176.6, 144.4, 142.8, 140.8, 136.5, 134.0, 129.7, 129.2, 127.5, 125.7, 123.8, 122.9, 121.2, 116.1, 46.7, 43.4, 33.4, 30.7, 22.6, and 21.4.

12-*Hydroxymethyl*-9-*methyl*-5-*tosyl*-6,7,8,11-*tetrahydro*-7,11-*methano*-5H-*cyclo-oct*[b]*indol*-6α-*ol* (**18**) *and* 12-*Hydroxymethyl*-9-*methyl*-5-*tosyl*-6,7,10,11-*tetrahydro*-7,11-*methano*-5H-*cyclo-oct*[b]*indol*-6α-*ol* (**19**).—A mixture of the keto-acids (**16**) and (**17**) (9 g, 20.7 mmol) and lithium aluminium hydride (4 g) in dry tetrahydrofuran (80 ml) was stirred at room temperature for 1 h. Water was added and the mixture was extracted with ether. The extract was washed with brine, dried, and evaporated to give the diols (**18**) and (**19**) as a white solid (7.88 g, 90%). Chromatography of a sample of the diols on a Lobar column with ether as eluant gave first the *diol* (**18**) as a white solid, m.p. 191–192 °C (Found: C, 68.3; H, 5.9; N, 3.3. $C_{24}H_{25}NO_4S$ requires C, 68.1; H, 6.0; N, 3.3%); λ_{max}(EtOH) 222 and 257 nm; ν_{max}(Nujol) 3 560s (OH), 3 390vbr (OH, H-bonded), 1 595 (C=C), 1 070, and 780 cm^{-1}; δ_H(90 MHz) 8.1–7.1 (8 H, m, Ar-H), 5.81 (1 H, d, *J* 6.6 Hz, 10-H), 5.19 (1 H, dd, *J* 7.0 and 3.1 Hz, 6-H), 4.34 (1 H, d, *J* 3.1 Hz, OH), 3.34 (2 H, 2 × dd, CH_2OH), 3.24 (1 H, m, 11-H), 2.73 (1 H, m, 7-H), 2.25 (3 H, s, ArMe), 2.25 (1 H, m, 12-H), and 1.53 (3 H, s, 9-Me); δ_C(22.5 MHz) 145.1, 137.4, 135.2, 134.5, 129.7, 129.5, 126.9, 126.4, 125.1, 124.2, 123.7, 120.1, 119.0, 115.6, 64.0, 63.5, 44.3, 34.2, 29.9, 29.3, 22.6, and 21.5; *m/z* 423 (M^+) and 405.

Further elution afforded the *diol* (**19**) as a white solid, m.p. 203–204 °C (Found: M^+ 424.1471. $C_{24}H_{25}NO_4S$ requires *M*, 424.1470); λ_{max}(EtOH) 202, 221, and 254 nm; ν_{max}(Nujol) 3 520s (OH), 1 598 (C=C), 1 070, and 690 cm^{-1}; δ_H(90 MHz) 8.1–7.1 (8 H, m, ArH), 5.71 (1 H, d, *J* 5.7 Hz, 8-H), 5.10 (1 H, dd, *J* 6.1 and 3.5 Hz, 6-H), 4.25 (1 H, d, *J* 3.5 Hz, OH), 3.38 (2 H, 2 × dd, CH_2OH), 2.95 (2 H, m, 7- and 11-H), 2.29 (3 H, s, ArMe), 2.22 (3 H, m, 10-H_2 and 12-H), and 1.60 (3 H, s, 9-Me); δ_C(22.5 MHz) 145.1, 137.8, 136.7, 134.5, 133.9, 130.0, 129.7, 126.5, 125.0, 124.2, 123.7, 122.2, 118.9, 115.9, 66.2, 63.4, 42.9, 37.1, 36.5, 28.4, 23.2, and 21.5.

9-*Methyl*-5-*tosyl*-12-*tosyloxymethyl*-6,7,8,11-*tetrahydro*-7,11-*methane*-5H-*cyclo-oct*[b]*indol*-6α-*ol* (**20**) *and* 9-*Methyl*-5-*tosyl*-12-*tosyloxymethyl*-6,7,10,11 -*tetrahydro*-7,11-*methano*-5H-*cyclo-oct*[b]*indol*-6α-*ol* (**21**).—To a solution of the diols (**18**) and (**19**) (5.7 g, 13.5 mmol) in anhydrous chloroform (27 ml) was added toluene-*p*-sulphonyl chloride (3.08 g, 16.2 mmol) and dry pyridine (2.6 ml, 32.2 mmol). The resulting solution was stirred at room temperature. The progress of the reaction was monitored by TLC. After all the diols had reacted, the mixture was extracted with dichloromethane. The extract was washed with aqueous copper sulphate and water, dried, and evaporated to dryness. Chromatography of the residue on silica gel with ether–light petroleum (1:1) as eluant gave a white solid (5.83 g, 75%) consisting of the tosylates (**20**) and (**21**). Further chromatography of a small sample of the solid on a Lobar column with ether–light petroleum (1:1) as eluant afforded firstly the *tosylate* (**20**) as a white solid, m.p. 79–80 °C (Found: C, 64.4; H, 5.3; N, 2.4. $C_{31}H_{31}NO_6S_2$ requires C, 64.5; H, 5.4; N, 2.4%); λ_{max}(EtOH) 222 and 258 nm; ν_{max}(Nujol) 3 570s (OH), 1 596 (C=C), 935, and 785 cm^{-1}; δ_H(90 MHz) 8.1–7.1 (8 H, m, ArH), 5.73 (1 H, d, *J* 6.6 Hz, 10-H), 5.15 (1 H, d, *J* 6.6 Hz, 6-H), 3.82 (2 H, 2 × dd, CH_2OTs), 3.05 (1 H, d, *J* 6.6 Hz, 11-H), 2.73 (1 H, m, 7-H), 2.50 (1 H, m, 12-H), 2.36 (3 H, s, ArMe), 2.30 (3 H, m, ArMe), 2.30 (2 H, m, 8-H_2), and 1.532 (3 H, s, 9-Me); δ_C(22.5 MHz) 145.4, 144.8, 137.3, 135.3, 134.8, 134.2, 133.0, 129.7, 129.5, 128.9, 127.5, 126.4, 125.3, 124.1, 123.2, 118.9, 115.6, 70.7, 63.4, 40.6, 33.6, 29.4, 29.1, 22.5, and 21.6; *m/z* 577 (M^+) and 405.

Further elution afforded the tosylate (**21**) as a white solid, m.p. 159–160 °C (Found M^+, 577.1567, $C_{31}H_{31}NO_6S_2$ requires *M*, 577.156 49); λ_{max}(EtOH) 202, 221, and 254 nm; ν_{max}(Nujol) 3 550s (OH), 1 596 (C=C), 975, 815, and 770 cm^{-1}; δ_H(90 MHz) 8.1–7.1 (8 H, m, ArH), 5.65 (1 H, d, *J* 5.3 Hz, 8-H), 5.08 (1 H, dd, *J* 5.7 and 3.5 Hz, 6-H), 4.22 (1 H, d, *J* 3.5 Hz, OH), 3.83 (2 H, 2 × dd, CH_2OTs), 2.98 (2 H, m, 7- and 11-H), 2.41 (1 H, m, 12-H), 2.33 (2 H, m, 10-H_2), 2.37 (3 H, s, ArMe), 2.30 (3 H, s, ArMe), and 1.55 (3 H, s, 9-Me); δ_C(22.5 MHz) 145.3, 144.8, 137.7, 136.2, 134.0, 133.6, 133.0, 129.9, 129.8, 129.5, 127.5, 126.5, 125.2, 124.1, 122.8, 121.4, 118.8, 115.8, 70.4, 65.7, 39.2, 36.5, 35.8, 28.1, 23.0, and 21.5.

9,12-*Dimethyl*-5-*tosyl*-6,7,8,11-*tetrahydro*-7,11-*methano*-5H-*cyclo-oct*[b]*indol*-6α-*ol* (**22**) *and* 9,12-*Dimethyl*-5-*tosyl*-6,7,10,11-*tetrahydro*-7,11-*methano*-5H-*cyclo-oct*[b]*indol*-6α-*ol* (**23**).—To a solution of the tosylate mixture (**20**) and (**21**) (2.50 g, 4.3 mmol) in anhydrous hexamethylphosphoramide (HMPA) (20 ml) was added anhydrous sodium iodide (3.90 g, 26 mmol) and zinc powder (3.38 g, 52 mmol). The mixture was heated at 80–100 °C for 3 h. After cooling, dichloromethane and water were added and excess of zinc powder was filtered off. The organic layer was washed with water, dried, and evaporated to dryness. Chromatography of the residue on silica gel with ether–light petroleum (3:7) as eluant gave a white solid. Preparative HPLC separation on a silica gel cartridge with ether–light petroleum (1:9) as eluant afforded first the *alcohol* (**22**) (0.82 g, 48% based on the mixed tosylates) as a white solid, m.p. 189–190 °C (Found: C, 70.8; H, 6.1; N, 3.4; M^+, 407.1553. $C_{24}H_{25}NO_3S$ requires C, 70.7; H, 6.2; N, 3.4%; *M*, 407.1545); λ_{max}(EtOH) 203, 220, and 258 nm; ν_{max}(Nujol) 3 585 (OH), 1 593 (C=C), 1 280, 1 200, 1 050, and 940 cm^{-1}; δ_H(400 MHz) (primes refer to tosyl) 8.09 (1 H, d, *J* 8.0 Hz, 1-H), 7.56 (2 H, d, *J* 8.0 Hz, 2′- and 6′-H), 7.39 (1 H, d, *J* 8.0 Hz, 4-H), 7.25 (2 H, m, 2- and 3-H), 7.12 (2 H, d, *J* 8.0 Hz, 3′- and 5′-H), 5.81 (1 H, dq, br, *J* 6.5 and 1.5 Hz, 10-H), 5.24 (1 H, dd, *J* 6.5, 3.0 Hz, 6-H), 4.31 (1 H, d, *J* 3.0 Hz, OH), 2.97 (1 H, d, *J* 6.5 Hz, 11-H), 2.74 (1 H, d, *J* 19.0 Hz, 8-H), 2.54 (1 H, br dt, 7-H), 2.27 (1 H, m, 12-H), 2.29 (3 H, s, ArMe), 2.17 (1 H, dd, *J* 19.0 and 8.0 Hz, 8-H), 1.55 (3 H, s, 9-Me), and 0.82 (3 H, d, *J* 7.0 Hz, 12-Me), $J_{6,7}$ 6.5, $J_{7,8}$ 8.0, $J_{8,8}$ 19, and $J_{10,11}$ 6.5 Hz; δ_C(22.5 MHz) 144.9, 137.5, 134.9, 134.6, 134.5, 130.0, 129.6, 127.1, 126.4, 125.0, 124.8, 124.1, 118.9, 115.7, 63.9, 38.1, 35.6, 33.8, 30.3, 22.7, 21.5, and 16.9.

Further elution afforded the *alcohol* (**23**) (0.54 g, 32% based on the tosylate mixture) as a white solid, m.p. 172–173 °C (Found: M^+, 407.1549. $C_{24}H_{25}NO_3S$ requires *M*, 407.1545); λ_{max}(EtOH) 202, 221, and 254 nm; ν_{max}(Nujol) 3 570 (OH), 1 597 (C=C), 1 190, 1 120, 1 070, 1 040, and 680 cm^{-1}; δ_H(400 MHz) 8.11 (1 H, d, *J* 8.0 Hz, 1-H), 7.56 (2 H, d, *J* 8.0 Hz, 2′- and 6′-H), 7.35 (1 H, d, *J* 8.0 Hz, 4-H), 7.25 (2 H, m, 2- and 3-H), 7.12 (2 H, d, *J* 8.0 Hz, 3′- and 5′-H), 5.68 (1 H, d, *J* 5.5 Hz, 8-H), 5.15 (1 H, d, *J* 5.5 Hz, 6-H), 4.24 (1 H, br s, OH), 2.86 (1 H, d, *J* 5.5 Hz, 11-H), 2.74 (1 H, br s, 7-H), 2.49 (1 H, br dd, *J* 17.0 and 5.5 Hz, 10-H), 2.30 (3 H, s, ArMe), 2.14 (1 H, ddq, *J* 7.0, 3.5, and 1.75 Hz, 12-H), 2.08 (1 H, d, *J* 17.0 Hz, 10-H), 1.59 (3 H, s, 9-Me), and 0.83 (3 H, d, *J* 7.0 Hz, 12-Me); δ_C(22.5 MHz) 144.9, 137.9, 136.4, 134.4, 133.4, 130.5, 129.6, 126.4, 124.8, 124.1, 123.8, 122.28, 118.9, 115.9, 66.3, 40.0, 37.3, 34.2, 32.9, 23.2, 21.5, and 16.6.

6α-*Benzoyloxy*-9,12-*dimethyl*-5-*tosyl*-6,7,10,11-*tetrahydro*-7,11-*methano*-5H-*cyclo-oct*[b]*indole* (**25**).—To a solution of compound (**23**) (424 mg, 1.04 mmol) in chloroform was added 4-dimethylaminopyridine (DMAP) (140 mg, 1.05 mmol), triethylamine (0.16 ml, 1.05 mmol), and benzoyl chloride (0.133 ml, 1.05 mmol). The resulting solution was heated under gentle reflux for 0.5 h. The solution was cooled and dichloromethane was added. The organic layer was washed with aqueous copper sulphate, dried, and evaporated to dryness. Flash column chromatography of the residue on silica gel with ether–light petroleum (3:7) as eluant afforded the *benzoate* (**25**) (479 mg, 90%) as a white solid, m.p. 219–220 °C (Found: C, 72.5; H, 5.5; N, 2.7; M^+, 511.1787. $C_{31}H_{29}NO_4S$ requires C, 72.8; H, 5.7; N, 2.7%; *M*, 511.1789); λ_{max}(EtOH) 201, 217, and 258 nm; ν_{max}(Nujol) 1 720, 1 598, 1 255, 1 090, and 685 cm^{-1}; δ_H(90 MHz) 8.1–6.9 (13 H, m, ArH), 6.54 (1 H, d, *J* 6.1 Hz, 6-H), 5.35 (1

Table 2. Crystallographic details for (**24**) and (**25**).

	Compound (**24**)	Compound (**25**)
Formula	$C_{31}H_{29}NO_4S$	$C_{31}H_{29}NO_4S$
M_r	511.63	511.63
a/Å	9.964(2)	9.931(1)
b/Å	27.040(3)	26.824(3)
c/Å	9.974(1)	10.105(1)
β/°	105.16(1)	104.92(1)
V/Å^3	2 594(1)	2 601(1)
Space group	$P2_1/n$	$P2_1/n$
Z	4	4
D_c/g cm^{-3}	1.308	1.304
μ/cm^{-1}	1.54	1.54
Crystal colour	Colourless	Colourless
Crystal dimensions/mm	0.07 × 0.18 × 0.25	0.07 × 0.18 × 0.21
Collection range	$2\theta_{max}$ 44°; $hk \pm l$	$2\theta_{max}$ 44°; $\pm hk \pm l$
Scan mode and scan speed/° min^{-1}	ω/2θ, 0.72–5.49	ω/2θ, 0.72–5.49
Scan width/°	0.65 + 0.34 tanθ	0.60 + 0.34 tanθ
No. of reflections measured	3 502	5 803
No. of independent reflections	3 282	3 280
No. of reflections with $F_o > 3\sigma(F_o)$, m	2 034	1 830
No. of parameters refined, p	334	334
R^a	0.038	0.034
R_w^a	0.047	0.040
S^a	1.60	1.31
Residual extrema in final difference map/e Å^{-3}	−0.26; +0.19	−0.25; +0.16

[a] $R = \Sigma||F_o| - |F_c||/\Sigma|F_o|$. $R_w = [w(|F_o| - |F_c|)^2/\Sigma w|F_o|^2]^{\frac{1}{2}}$, with $w = 4F^2/[\sigma^2(F_o^2) + (0.04F_o^2)^2]$. $S = [\Sigma w|F_o| - |F_c|)^2/(m - p)]^{\frac{1}{2}}$.

H, d, *J* 5.3 Hz, 8-H), 3.0 (2 H, m, 7- and 11-H), 2.42 (2 H, br s, 10-H_2), 2.22 (3 H, s, ArMe), 2.22 (1 H, m, 12-H), 1.55 (3 H, s, 9-Me), and 0.94 (3 H, d, *J* 7.0 Hz, 12-Me); δ_C(22.5 MHz) 166.1, 144.3, 138.5, 135.5, 133.9, 132.6, 131.8, 130.6, 129.9, 129.4, 128.2, 126.3, 125.4, 125.1, 124.1, 123.8, 122.2, 118.8, 116.1, 70.0, 37.7, 36.9, 34.6, 22.7, and 23.1.

6α-*Benzoyloxy*-9,12-*dimethyl*-5-*tosyl*-6,7,8,11-*tetrahydro*-7,11-*methano*-5H-*cyclo-oct*[b]*indole* (**24**).—By the same method as in the preparation of (**25**), the reaction between compound (**22**) (680 mg, 1.67 mmol) and benzoyl chloride (0.213 ml, 1.68 mmol) with 4-dimethylaminopyridine (224 mg, 1.67 mmol) and triethylamine (0.225 ml, 1.67 mmol) produced, after chromatography, the *benzoate* (**24**) (770 mg, 90%) as a white solid, m.p. 195–196 °C (Found: C, 72.5; H, 5.5; N, 2.7%; M^+, 511.1821); ν_{max}(Nujol) 1 710 (C=O), 1 595 (C=C), 1 460, 1 390, 1 285, 1 192, 1 135, 1 055, and 985 cm^{-1}; δ_H(90 MHz) 8.2–6.95 (13 H, m, ArH), 6.67 (1 H, d, *J* 7.4 Hz, 6-H), 5.87 (1 H, br d, *J* 5.3 Hz, 10-H), 3.09 (1 H, br d, *J* 6.1 Hz, 11-H), 2.95 (1 H, m, 7-H), 2.41 (1 H, m, 12-H), 2.23 (3 H, s, ArMe), 2.23 (2 H, m, 8-H_2), 1.51 (3 H, s, 9-Me), and 0.90 (3 H, d, *J* 7.0 Hz, 12-Me); δ_C(22.5 MHz) 165.8, 144.3, 138.3, 135.9, 133.4, 132.7, 130.6, 130.4, 129.9, 129.8, 125.3, 128.3, 126.3, 125.4, 123.8, 118.9, 115.9, 68.8, 36.2, 33.7, 32.0, 22.8, 21.5, and 17.2.

6β-(*Indol*-3-*yl*)-9,12-*dimethyl*-5-*tosyl*-6,7,10,11-*tetrahydro*-7,11-*methano*-5H-*cyclo-oct*[b]*indole* (**27**).—To a suspension of magnesium turnings (22 mg, 0.92 mmol) in anhydrous ether (2 ml) was added bromoethane (0.068 ml, 0.92 mmol). After reaction had ceased, indole (107 mg, 0.92 mmol) in anhydrous benzene (2 ml) was added. The ether solvent was replaced with benzene and this freshly prepared solution of indolylmagnesium bromide in benzene was added to a suspension of the benzoate (**25**) (425 mg, 0.832 mmol) in benzene (4 ml) and the mixture was heated under reflux for 0.5 h. The mixture was then treated with aqueous ammonium chloride, extracted with ether, washed with water and brine, dried, and evaporated to dryness. Flash column chromatography on silica gel with ether–light petroleum (3:7) as eluant gave the *indole* (**27**) (295 mg, 70%) as a white solid, m.p. 219 °C (decomp.) (Found: C, 76.0; H, 5.9; N, 5.5; M^+, 506.1974. $C_{32}H_{30}N_2O_2S$ requires C, 75.9, H, 6.0; N, 5.5%; M, 506.1972); λ_{max}(EtOH) 224 and 259 nm; ν_{max}(Nujol) 3 410s (NH), 1 598 (C=C), 1 090, 950, 810, and 745 cm^{-1}; δ_H(90 MHz, C_6D_6) 8.6–6.2 (14 H, m, NH, ArH), 5.77 (1 H, d, *J* 4.8 Hz, 8-H), 5.14 (1 H, br s, 6-H), 3.27 (1 H, br s, 11-H), 2.91 (1 H, d, *J* 4.4 Hz, 7-H), 2.02 (1 H, m, 12-H), 2.09 (2 H, m, 10-H_2), 1.64 (3 H, s, ArMe), 1.45 (3 H, s, 9-Me), and 0.71 (3 H, d, *J* 7.4 Hz, 12-Me); δ_C(22.5 MHz) 143.8, 138.1, 136.4, 136.2, 135.4, 132.4, 131.2, 129.1, 127.5, 126.9, 126.3, 124.1, 123.6, 123.4, 123.2, 121.6, 119.1, 118.9, 118.8, 118.0, 116.2, 111.3, 40.3, 37.6, 37.5, 32.9, 32.8, 23.2, 21.5, and 19.2.

6β-(*Indol*-3-*yl*) -9,12-*dimethyl*-5-*tosyl*-6,7,8,11-*tetrahydro*-7,11-*methano*-5H-*cyclo-oct*[b]*indole* (**26**).—By the same procedure as in the preparation of compound (**27**), reaction of the benzoate (**24**) (600 mg, 1.17 mmol) with indolylmagnesium bromide generated *in situ* gave, after chromatography, *compound* (**26**) (475 mg, 80%) as a white solid, m.p. 218 °C (decomp.) (Found: C, 76.1, H, 5.8; N, 5.6%); ν_{max}(Nujol) 3 400, 1 598, 1 450, 1 170, 1 090, and 955 cm^{-1}; δ_H(90 MHz; C_6D_6) 8.56–6.42 (13 H, m, ArH), 6.20 (1 H, d, *J* 1.3 Hz, indole 2-H), 5.80 (1 H, br d, *J* 6.0 Hz, 10-H), 5.00 (1 H, s, 6-H), 3.03 (2 H, m, 7- and 11-H), 2.5–1.9 (3 H, m, 8-H_2 and 12-H), 1.64 (3 H, s, ArMe), 1.50 (3 H, s, 9-Me), and 0.81 (3 H, d, *J* 7.0 Hz, 12-Me); δ_C(22.5 MHz; C_6D_6) 143.36, 138.8, 136.8, 136.7, 136.4, 132.8, 131.4, 129.3, 128.4, 126.3, 124.6, 124.2, 123.1, 121.9, 120.9, 119.5, 119.1, 118.3, 116.6, 111.8, 42.3, 41.9, 39.8, 34.7, 34.3, 22.9, 20.9, and 19.3; m/z 506 (M^+).

6β-(*Indol*-3-*yl*)-9,12-*dimethyl*-6,7,10,11-*tetrahydro*-7,11-*methano*-5H-*cyclo-oct*[b]*indole* (**29**).—A mixture of compound (**27**) (250 mg, 0.49 mmol) in anhydrous tetrahydrofuran (2 ml) and methanol (4 ml), disodium hydrogen phosphate (2.5 g), and sodium amalgam (5%; 2.8 g) was stirred at room temperature. The progress of the reaction monitored by TLC. After the reaction was complete, water was added. Work-up and flash chromatography on silica gel with ether–light petroleum (1:4) as eluant gave the *title compound* (**29**) (131 mg, 75%) as a white solid, m.p. 246 °C (decomp.) (Found: M^+, 352.1942. $C_{25}H_{24}N_2$ required M, 352.1939); ν_{max}(Nujol) 3 380s (NH), 2 980 br, 1 450,

Table 3. Fractional co-ordinates for the non-hydrogen atoms in compound (**24**) with e.s.d.s in parentheses.

Atom	x/a	y/b	z/c
S	0.311 33(9)	0.456 86(3)	0.496 82(9)
O(1)	0.370 9(2)	0.435 9(1)	0.629 7(2)
O(2)	0.330 0(2)	0.507 55(9)	0.470 6(3)
O(3)	0.520 0(2)	0.350 42(9)	0.590 7(2)
O(4)	0.438 9(3)	0.329 2(1)	0.773 2(2)
N	0.374 5(3)	0.425 1(1)	0.382 3(3)
C(1)	0.318 4(4)	0.406 8(1)	0.013 7(4)
C(2)	0.324 4(4)	0.453 8(2)	−0.036 5(4)
C(3)	0.343 5(4)	0.494 5(2)	0.051 4(4)
C(4)	0.359 3(4)	0.489 5(1)	0.192 8(4)
C(4a)	0.351 9(3)	0.442 4(1)	0.242 5(3)
C(5a)	0.364 3(3)	0.372 4(1)	0.374 7(3)
C(6)	0.387 2(3)	0.338 0(1)	0.495 9(3)
C(7)	0.384 8(4)	0.283 8(1)	0.448 7(4)
C(8)	0.525 4(4)	0.263 6(2)	0.434 3(4)
C(9)	0.549 8(4)	0.266 4(2)	0.292 0(4)
C(10)	0.455 6(4)	0.284 3(1)	0.183 8(4)
C(11)	0.319 6(4)	0.304 4(1)	0.199 5(3)
C(11a)	0.336 2(3)	0.357 8(1)	0.241 4(3)
C(11b)	0.331 5(3)	0.400 7(1)	0.155 6(3)
C(12)	0.273 7(4)	0.275 3(1)	0.311 8(4)
C(13)	0.687 7(5)	0.246 6(2)	0.281 2(5)
C(14)	0.126 1(4)	0.288 0(1)	0.320 3(4)
C(15)	0.132 7(3)	0.442 7(1)	0.449 9(4)
C(16)	0.047 0(4)	0.466 1(2)	0.338 0(4)
C(17)	−0.093 6(4)	0.453 1(2)	0.298 1(4)
C(18)	−0.146 9(4)	0.416 9(2)	0.367 1(4)
C(19)	−0.057 2(4)	0.394 4(2)	0.480 0(5)
C(20)	0.082 2(4)	0.407 0(2)	0.523 1(4)
C(21)	−0.298 1(4)	0.402 5(2)	0.322 0(5)
C(22)	0.531 2(4)	0.345 4(1)	0.727 9(3)
C(23)	0.670 1(4)	0.360 3(1)	0.813 5(3)
C(24)	0.706 1(4)	0.348 5(2)	0.953 3(4)
C(25)	0.835 8(4)	0.359 4(2)	1.035 7(4)
C(26)	0.930 8(4)	0.383 1(2)	0.981 0(4)
C(27)	0.895 2(4)	0.396 3(2)	0.842 7(5)
C(28)	0.764 7(4)	0.385 0(2)	0.758 2(4)

Table 4. Fractional co-ordinates for the non-hydrogen atoms in compound (**25**) with e.s.d.s in parentheses.

Atom	x/a	y/b	z/c
S	0.307 60(9)	0.460 11(3)	0.492 09(9)
O(1)	0.364 0(2)	0.440 87(9)	0.626 1(2)
O(2)	0.328 8(2)	0.510 74(8)	0.461 2(2)
O(3)	0.517 6(2)	0.354 80(8)	0.601 9(2)
O(4)	0.438 3(3)	0.332 7(1)	0.782 5(2)
N	0.373 8(2)	0.425 76(9)	0.385 3(2)
C(1)	0.321 7(4)	0.400 8(1)	0.024 5(3)
C(2)	0.327 7(4)	0.447 1(2)	−0.030 5(4)
C(3)	0.345 5(4)	0.489 6(2)	0.050 9(4)
C(4)	0.360 4(4)	0.487 1(1)	0.190 3(4)
C(4a)	0.353 0(3)	0.440 4(1)	0.244 7(3)
C(5a)	0.363 5(3)	0.372 7(1)	0.384 8(3)
C(6)	0.386 0(3)	0.340 6(1)	0.508 6(3)
C(7)	0.394 6(4)	0.285 7(1)	0.466 1(4)
C(8)	0.534 1(4)	0.273 6(1)	0.442 2(4)
C(9)	0.558 7(4)	0.268 9(1)	0.321 2(4)
C(10)	0.447 8(4)	0.277 6(1)	0.191 4(4)
C(11)	0.316 8(4)	0.301 3(1)	0.218 1(3)
C(11a)	0.338 5(3)	0.355 3(1)	0.256 2(3)
C(11b)	0.333 5(3)	0.397 0(1)	0.165 1(3)
C(12)	0.278 8(4)	0.274 0(1)	0.336 9(4)
C(13)	0.700 4(4)	0.254 3(2)	0.302 3(5)
C(14)	0.131 6(4)	0.285 5(2)	0.349 6(4)
C(15)	0.128 8(3)	0.446 4(1)	0.443 0(3)
C(16)	0.045 3(4)	0.469 0(1)	0.329 0(4)
C(17)	−0.094 8(4)	0.456 5(2)	0.287 7(4)
C(18)	−0.151 5(4)	0.421 3(2)	0.356 2(4)
C(19)	−0.066 3(4)	0.399 3(2)	0.470 4(4)
C(20)	0.074 0(4)	0.411 8(2)	0.515 4(4)
C(21)	−0.304 5(4)	0.408 7(2)	0.305 8(5)
C(22)	0.530 2(3)	0.348 9(1)	0.736 8(3)
C(23)	0.670 4(3)	0.362 5(1)	0.818 8(3)
C(24)	0.707 3(4)	0.350 3(1)	0.956 6(3)
C(25)	0.840 0(4)	0.359 5(2)	1.036 1(4)
C(26)	0.936 5(4)	0.381 6(2)	0.980 3(4)
C(27)	0.900 9(4)	0.394 7(2)	0.843 5(4)
C(28)	0.767 4(4)	0.385 1(1)	0.762 7(4)

1 375, 1 230, 1 100, 860, 802, and 750 cm^{-1}; δ_H[90 MHz; C_6D_6–$(CD_3)_2CO$] 9.19 (1 H, br s, NH), 8.78 (1 H, br s, NH), 7.80–7.11 (8 H, m, ArH), 6.53 (1 H, s, indole 2-H), 5.91 (1 H, br d, *J* 5.7 Hz, 8-H), 4.35 (1 H, s, 6-H), 3.20 (1 H, m, 11-H), 3.02 (1 H, br s, 7-H), 2.36 (1 H, m, 12-H), 2.2 (2 H, m, 10-H_2), 1.49 (3 H, s, 9-Me), and 0.90 (3 H, d, *J* 7.4 Hz, 12-Me); δ_C[22.5 MHz; C_6D_6–$(CD_3)_2CO$] 137.7, 137.4, 133.5, 133.0, 128.4, 127.8, 123.6, 122.1, 121.2, 119.6, 119.1, 118.3, 118.1, 113.2, 111.9, 111.4, 41.3, 38.7, 36.1, 34.6, 33.1, 23.6, and 19.4.

6β-(*Indol-3-yl*)-9,12-*dimethyl*-6,7,8,11-*tetrahydro*-7,11-*methano*-5H-*cyclo-oct*[b]*indole* (**28**).—By the same procedure as in the preparation of compound (**29**), detosylation of compound (**26**) (410 mg, 0.79 mmol) gave the *title compound* (**28**) (220 mg, 77%) as a white solid, m.p. 227 °C (decomp.) (Found: M^+, 352.1935); ν_{max}(Nujol) 3 410 (NH), 3 390 (NH), 1 375, 1 230, 1 110, 880, 740, and 730 cm^{-1}; δ_H(90 MHz; C_6D_6) 7.8–6.4 (10 H, m, NH, ArH), 6.08 (2 H, m, indole 2- and 10-H), 4.10 (1 H, s, 6-H), 3.34 (1 H, br d, 11-H), 2.36 (4 H, m, 7- and 12-H, and 8-H_2), 1.57 (3 H, s, 9-Me), and 0.99 (3 H, d, *J* 7.0 Hz, 12-Me); δ_C(22.5 MHz; C_6D_6) 136.7, 136.5, 133.8, 130.3, 129.7, 127.7, 127.3, 122.5, 122.1, 121.2, 120.3, 119.9, 119.5, 119.0, 118.0, 116.2, 111.5, 110.9, 43.0, 41.3, 38.5, 35.2, 34.7, 23.3, and 18.4.

X-Ray Study of Compounds (**24**) *and* (**25**).—Intensity data were collected on an Enraf-Nonius CAD4 diffractometer with graphite-monochromated Mo-K_α radiation (λ = 0.710 73 Å). Crystal data and a summary of data collection and structure refinement are given in Table 2. Atomic scattering factors were taken from ref. 18. Calculations were carried out on a MicroVax II computer using the Structure Determination Package (SDP).[19]

Table 5. Selected torsion angles (°).

	Compound (**24**)	Compound (**25**)
H(6)–C(6)–C(7)–H(7)	−36.3(4)	−43.0(4)
H(7)–C(7)–C(12)–H(12)	−59.6(4)	−52.2(5)
H(12)–C(12)–C(11)–H(11)	−64.7(4)	−67.4(4)

The structures were solved by direct methods with MULTAN 82,[20] from which all the non-hydrogen atoms were located. Positions of the hydrogen atoms in the methyl groups were obtained from difference maps and those of other hydrogen atoms were generated geometrically (C–H = 0.95 Å). Refinement was by full-matrix least-squares. All the non-hydrogen atoms were refined anisotropically; the hydrogen atoms were not refined and were allowed to ride on their parent carbon atoms. The compounds are crystallographically isostructural. The final *R* values are given in Table 2, fractional co-ordinates in Tables 3 and 4, and selected torsion angles in Table 5. Tables of bond lengths, bond angles, and thermal parameters have been deposited at the Cambridge Crystallographic Data Centre.*

* For details, see Instructions for Authors (1990), *J. Chem. Soc., Perkin Trans. 1*, 1990, Issue 1.

Acknowledgements

This investigation received financial support from the Special Programme of Research, Development, and Research Training in Human Reproduction, World Health Organization. We thank the Croucher Foundation for a scholarship (to T. Y. C.) and Professor E. Piers and his colleagues (University of British Columbia) for 400 MHz NMR spectra.

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Paper 9/03560E
Received 21*st August* 1989
Accepted 8*th November* 1989