Further Examination of the Reaction between Hexahydro-*N*-methylcyclohept[*b*]indole and Arenesulphonyl Azides

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The reaction between 5,6,7,8,9,10-hexahydro-5-methylcyclohept[*b*]indole and tosyl azide in carbon tetrachloride solution yields 2,3,4,5,6,7-hexahydro-1-methyl-7-*p*-tolylsulphonylamino-12-*p*-tolylsulphonylimino-2,7-methano-1*H*-1-benzazonine. The compound to which this structure was previously assigned is now considered to be a derivative of octahydro-*N*-methylcyclohept[*b*]indole. *p*-Chlorobenzenesulphonyl azide also yields a 1*H*-benzazonine. The reactions of this compound have been examined and a comparison has been made with the reactions of 6-*p*-chlorophenylsulphonylamino-5-*p*-chlorophenylsulphonylimino-1,2,5,6-tetrahydro-4,6-butano-4*H*-pyrrolo-[3,2,1-*ij*]quinoline.

We have reported [1] that the reaction between 5,6,7,8,9,10-hexahydro-5-methylcyclohept[*b*]indole (I) and tosyl azide (TsN_3) afforded four products, (II; Z = Ts), (III; Z = Ts), (IV; Z = Ts), and a compound to which we assigned structure (V; Z = Ts). This reaction was run in four polar solvents (methanol, acetic acid, pyridine, and pyridine–sodium hydroxide); and since we have recently observed [2] that the products obtained from the reaction between tosyl azide and 1,4-dihydro-1-methylquinoline-4-carbonitrile differ according to whether a polar or a non-polar solvent is used, we examined the reaction of (I) with TsN_3 in carbon tetrachloride solution. Our results require revision of one of the structures assigned earlier.[1]

Tosyl azide reacted smoothly with compound (I) in carbon tetrachloride solution yielding a yellow crystalline compound, $C_{28}H_{31}N_3O_4S_2$, to which we assign structure (V; Z = Ts). This new compound is different from the material isolated earlier [1] to which we had ascribed this structure [formula (IX) in ref. 1] and we now reformulate this material as (VII; Z = Ts). These structures are based on a comparison of spectroscopic data (see Table 1) of compounds (V) and (VII) with those of compound (VIII),[3] whose structure has been confirmed by *X*-ray crystallographic analysis.[4]

With compound (V) available in quantity it was decided to examine its reactions in detail to establish the relationship, if any, amongst compounds (V), (VII), and (IV) and to compare the reactions of (V) with those of (IX) to see the influence of the $-[CH_2]_2-$ bridge. The physical data of (IX) [5] support this structure rather than the alternative structure corresponding to compound (VII). Compound (V; Z = Ts) gave a clear melt from which compound (IV; Z = Ts) was isolated in high yield. In contrast (IX; Z = Ts) yields a black tar on melting. Further, a sample of (VII; Z = Ts) afforded

[1] A. S. Bailey and J. F. Seager, *J.C.S. Perkin I*, 1974, 763.
[2] A. S. Bailey, T. Morris, and Z. Rashid, *J.C.S. Perkin I*, 1975, 420.
[3] A. S. Bailey, R. Scattergood, and W. A. Warr, *J. Chem. Soc.* (*C*), 1971, 2479.
[4] T. S. Cameron, C. K. Prout, B. Denton, R. Spagna, and E. White, *J.C.S. Perkin II*, 1975, 176.
[5] A. S. Bailey, P. A. Hill, and J. F. Seager, *J.C.S. Perkin I*, 1974, 967.

(IV; Z = Ts) on melting. Compound (V; Z = Ts) was stable in boiling ethyl acetate but on boiling a solution of the compound in ethyl propionate (b.p. 99°) the compound rearranged, t.l.c. showing that (VII; Z = Ts) was the major product. Column chromatography of the material gave an impure specimen of (VII; Z = Ts) and the n.m.r. spectrum showed that the minor impurity was the product (IV; Z = Ts) obtained by elimination of $TsNH_2$ from (VII; Z = Ts) on the column. Finally compound (VII; Z = Ts) was dissolved in trifluoroacetic acid (TFA) and the n.m.r. spectrum of the solution recorded as quickly as possible. The spectrum was consistent with the presence of a mixture of (IV; Z = Ts) and toluene-*p*-sulphonamide; compound (IV; Z = Ts) was isolated in high yield.

TABLE 1

N.m.r. (τ values) and i.r. (cm^{-1}) data

(V)	(VII)	(VIII)	Assignment
2.05	2.13	2.05	Low-field half of Ts signal
2.6—3.7	2.7—4.2	2.5—3.6	Aromatic
4.38	3.4	4.38	NH (exchanged in D_2O)
4.75	5.52	4.76	NMe·C*H*
7.10	7.20	7.10	NMe
7.58, 7.67	7.50, 7.63	7.54, 7.64	Tosyl Me
7.9—9.2	6.63, 7.7—8.6		8 H, m, $[CH_2]_4$
3 300	3 295	3 330	NH
1 640	1 600	1 638	C=NTs

From the reaction between *p*-chlorobenzenesulphonyl azide ($CbsN_3$) and compound (I) in carbon tetrachloride solution two products were isolated, the minor product being (III; Z = Cbs) and the major (V; Z = Cbs) (*ca.* 40% yield), the physical data supporting structure (V) rather than (VII). At its m.p. compound (V; Z = Cbs) re-arranged, forming (IV; Z = Cbs); boiling (V; Z = Cbs) in ethyl propionate gave a mixture containing (VII; Z = Cbs) as the major [τ 3.8—4.2 (high-field aromatic m) and 5.45 (1 H, d, *J* 8 Hz, NMe·C*H*)] and (IV; Z = Cbs) as the minor component. The n.m.r. spectrum of a solution of (V; Z = Cbs) in TFA contained three NMe signals (τ 6.02, 6.17, and 6.29); after 90 min the spectrum contained only one NMe signal (6.02), rearrangement to (IV; Z = Cbs) being complete. The reaction of (IX; Z = Cbs) with TFA is completely different;[5] the ion (X) being formed.

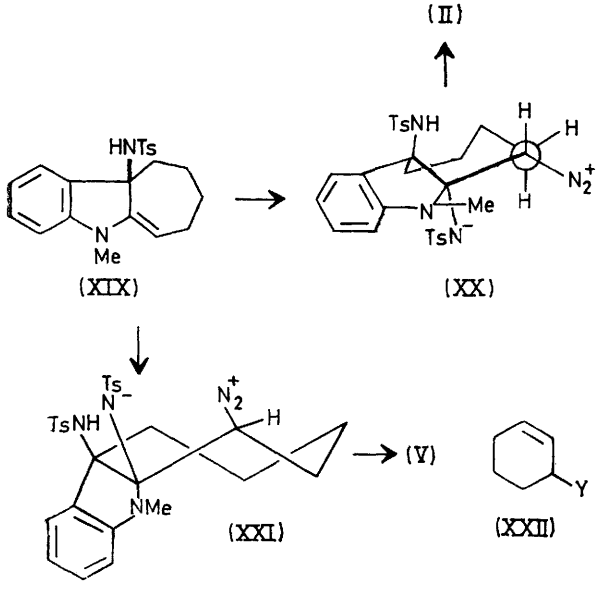
When compound (IX; Z = Cbs) is boiled[5] with alkali, the pyrroloacridine (XI) is formed; but under these conditions compound (V; Z = Cbs) gave (t.l.c.) a complex mixture. However compound (V; Z = Cbs)

was hydrolysed smoothly in aqueous pyridine, affording a ketone for which two structures (XII) and (XIII) were considered. Treatment of the ketone with TFA afforded compound (IV; Z = Cbs), supporting structure (XII) since (XIII) would be expected to lose $CbsNH_2$, forming (XIV). Boiling compound (XII) with alkali afforded the yellow fluorescent compound (XV) with characteristic [5] u.v. spectrum. It was expected that dehydration of this compound with polyphosphoric acid would yield the known [1,6] acridone (XVII); however the product was the cycloheptindolone (XIV),[1] presumably obtained by dehydration of the hydroxy-ketone (XVIII). In contrast compound (XI) forms (XVI) on dehydration.[5]

It appears that in the reactions of the *N*-methyl compounds [(V) and (XII)] rearrangements tend to favour formation of the indole structures whereas in those of the bridged compounds of type (IX), acridine (XVI) or phenanthridine (X) structures are preferred [5] rather than pyrroloindole structures containing two fused five-membered rings.

The most interesting feature of the chemistry of compound (II; Z = Ts) is the reluctance of the molecule to undergo base-catalysed elimination of toluene-*p*-sulphonamide to form (VI).[1] In contrast the homologue of (II) with the alicyclic ring seven-membered undergoes elimination rapidly.[1] We suggested that the stereochemistry at the ring junction of (II) was *cis* as shown.

The formation of compounds (II) and (V) shows clearly the effect of polar and non-polar solvents on the course



of the reaction between indoles and azides. We believe that (XIX) is the common intermediate in these reactions (*cf.* the reaction of *N*-methyltetrahydrocarbazole with tosyl azide).[7] In pyridine solution hydrogen bonding between the solvent and the TsNH group in (XIX) directs the attack onto the opposite side of the molecule from the TsNH group yielding (XX), which rearranges with loss of nitrogen to form compound (II) of stereochemistry shown.[8] However, in carbon tetrachloride solution ' bonding ' of the azide to the TsNH group in (XIX) causes attack to occur at the olefinic bond on the same side as the TsNH group, leading to (XXI) and hence to (V). These observations parallel those of Henbest [9] on the reaction of peroxy-acids with cyclohexenes of type (XXII), bonding between the substituent and the peroxy-acid leading to *cis*-epoxidation.

The structure of compound (II) has been confirmed by *X*-ray crystallographic analysis.[10]

EXPERIMENTAL

Instruments used have been described.[2] U.v. spectra were measured for solutions in ethanol, i.r. spectra for Nujol mulls, and n.m.r. spectra for solutions in $CDCl_3$ unless otherwise stated.

2,3,4,5,6,7-Hexahydro-1-methyl-7-p-tolylsulphonylamino-12-p-tolylsulphonylimino-2,7-methano-1H-1-benzazonine (V; Z = Ts).—Hexahydro-5-methylcyclohept[*b*]indole (1 g) was dissolved in carbon tetrachloride (20 ml; purified over alumina) containing tosyl azide (2 g). After 2 days the solid was collected and recrystallised from acetonitrile. The *compound* (0.92 g) formed bright yellow cubes, m.p. 165—166° (Found: C, 63.1; H, 5.9; N, 7.9. $C_{28}H_{31}N_3O_4S_2$ requires C, 62.8; H, 5.8; N, 7.8%); $\lambda_{max.}$ 215, 228sh, 252sh, and 306 nm (ε 37 000, 30 000, 14 500, and 2 700); M^+ not detected, *m/e* 366 (*M* — $TsNH_2$, 16%), 211 (*M* — $TsNH_2$ — Ts, 100%), and 169 (211 — H — MeCN, 53%, *m** 135.1). A solution of compound (V; Z = Ts) (0.4 g) in ethyl propionate (2 ml) was boiled for 10 h and the solvent removed yielding 5,5a,6,7,8,9,10,10a-octahydro-5-methyl-10a-*p*-tolylsulphonylamino-10-*p*-tolylsulphonyliminocyclohept[*b*]indole (VII; Z = Ts), identical (t.l.c. and i.r.) with a sample obtained [1] earlier. Chromatography (silica; benzene–ethyl acetate) gave a mixture containing (n.m.r.) *ca.* 18% of (IV; Z = Ts).

5,6,7,8,9,10-Hexahydro-5-methyl-10-p-tolylsulphonyliminocyclohept[b]indole (IV; Z = Ts).—(*a*) Compound (V; Z = Ts) (0.50 g) was heated (170 °C) for 5 min and the melt recrystallised from ethanol (yield 0.30 g, 82%); (*b*) compound (VII; Z = Ts) (150 mg) was melted, affording (IV; Z = Ts) (80 mg); (*c*) compound (VII; Z = Ts) (50 mg) was dissolved in TFA (1 ml), and after 1 h the solvent was removed giving (IV; Z = Ts) (31 mg). All three samples were identical with an authentic [1] sample (i.r., n.m.r., and u.v.); τ (TFA) 1.9—2.7 (8 H, m, ArH), 6.03 (3 H, s, NMe), 6.5—6.9 (3 H, m), 7.48 (3 H, s, tosyl Me), and 7.8—8.3 (5 H, m).

7-p-Chlorophenylsulphonylamino-12-p-chlorophenylsulphonylimino-2,3,4,5,6,7-hexahydro-1-methyl-2,7-methano-1H-1-benzazonine (V; Z = Cbs).—The indole (I) (1 g) was treated with $CbsN_3$ (1.6 g) in carbon tetrachloride (20 ml). After 2 days the solid was collected. The *compound* formed yellow prisms (0.91 g), m.p. 155—161° (decomp.) (from acetonitrile) (Found: C, 54.4; H, 4.4; N, 7.5; S, 11.3. $C_{26}H_{25}Cl_2N_3O_4S_2$ requires C, 54.1; H, 4.3; N, 7.3; S, 11.1%); $\lambda_{max.}$ (MeCN) 232 and 350 nm (ε 46 200 and 4 800); $\nu_{max.}$

[6] R. A. Reed, *J. Chem. Soc.*, 1944, 425.
[7] A. S. Bailey, A. J. Buckley, and J. F. Seager, *J.C.S. Perkin I*, 1973, 1809.
[8] *Cf.* T. S. Stevens and W. E. Watts, ' Selected Molecular Rearrangements,' Van Nostrand, London, 1973, p. 26.
[9] H. B. Henbest and R. A. L. Wilson, *J. Chem. Soc.*, 1957, 1958; *cf.* O. Hoshino, H. Hara, M. Ogawa, and B. Umezawa, *J.C.S. Chem. Comm.*, 1975, 306.
[10] J. M. Peach, unpublished work.

1 640 (C=N) and 3 280 (NH) cm^{-1}; τ 2.00 (2 H, d, *J* 8 Hz), 2.50 (2 H, d, *J* 8 Hz), 2.7—3.7 (8 H, m, ArH), 4.42 (1 H, s, NH, exchanged in D_2O), 4.55 (1 H, s), 7.04 (3 H, s, NMe), and 7.5—9.1 (8 H, m); no mass spectral peaks above *m/e* 191 ($CbsNH_2$). On a 2 g scale the yield of pure material was 49%. From the acetonitrile mother liquors 2′-p-*chlorophenylsulphonylamino*-2-p-*chlorophenylsulphonylimino*-1-*methylindoline*-3-*spirocyclohexane* (III; Z = Cbs) (0.29 g) was isolated. The compound formed fine prisms (from propan-1-ol), m.p. 193—195° (Found: C, 54.0; H, 4.3; N, 7.1; S, 10.8. $C_{26}H_{25}Cl_2N_3O_4S_2$ requires C, 54.1; H, 4.3; N, 7.3; S, 11.1%); $\lambda_{max.}$ 224 and 283 nm (ε 36 000 and 17 700); $\nu_{max.}$ 1 580 and 3 260 cm^{-1}; τ 2.00 (2 H, d, *J* 8 Hz), 2.3—3.1 (10 H, m), 6.3—6.4 (1 H, m, NH, exchanged in D_2O), 6.68 (3 H, s, NMe), 7.45 (1 H, m), and 8.1—8.5 (7 H, m); *m/e* 577 (*M*, 16%), 402 (*M* — Cbs, 24%), 386 (*M* — $CbsNH_2$, 12%), 211 (402 — $CbsNH_2$, 40%), 199 (402 — $CbsN{=}CH_2$, 34%), 191 ($CbsNH_2$, 100%), 185 (402 — $CbsN{=}CH{\cdot}CH_3$, 28%), 175 (Cbs, 98%), and 159 (14%) (*cf.* the fragmentation patterns of similar compounds [1,3]).

10-p-*Chlorophenylsulphonylimino*-5,6,7,8,9,10-*hexahydro*-5-*methylcyclohept*[b]*indole* (IV; Z = Cbs).—(*a*) Compound (V; Z = Cbs) was heated at 170 °C for 5 min (yield of purified material 80%); (*b*) (V; Z = Cbs) was dissolved in TFA and the solution worked up after 2 h (yield 84%). The *product* formed needles, m.p. 222—223° (from ethanol) (Found: C, 62.5; H, 5.0; N, 7.3. $C_{20}H_{19}ClN_2O_2S$ requires C, 62.3; H, 4.9; N, 7.2%); $\lambda_{max.}$ 217, 263, 275sh, and 348 nm (ε 36 000, 10 800, 9 650, and 22 200); $\nu_{max.}$ 1 580 cm^{-1}; τ 1.95 (3 H, m), 2.4—2.9 (5 H, m), 6.30 (3 H, s, NMe), 6.55 (2 H, m), 7.00 (2 H, m), and 7.9—8.4 (4 H, m); *m/e* 386 (*M*, 43%), 322 (*M* — SO_2, 6%), 211 (*M* — Cbs, 100%), and 169 (211 — MeCN — H, 56%).

7-p-*Chlorophenylsulphonylamino*-2,3,4,5,6,7-*hexahydro*-1-*methyl*-2,7-*methano*-1H-1-*benzazonin*-12-*one* (XII).—Compound (V; Z = Cbs) (1 g) was dissolved in pyridine (5 ml) containing water (1 ml). After 2 days the solvent was removed *in vacuo*; benzene was then added and evaporated to remove water; methanol was then added to the residue and the solid collected. Recrystallisation from ethyl acetate–petroleum (b.p. 60—80°) (1 : 1) gave the *ketone*, needles, m.p. 208—209° (0.49 g) (Found: C, 59.4; H, 5.3; N, 6.8; S, 8.2 $C_{20}H_{21}ClN_2O_3S$ requires C, 59.4; H, 5.2; N, 6.9; S, 7.9%); $\lambda_{max.}$ 233, 253sh, and 304 nm (ε 17 200, 11 300, and 2 100); $\nu_{max.}$ 1 730 and 3 250 cm^{-1}; τ 2.3—3.3 (8 H, m, ArH), 4.22 (1 H, s, NH, exchanged in D_2O), 6.25 [1 H, t, *J* 5 Hz, C(2)H], 7.12 (3 H, s, NMe), and 7.6—9.3 (8 H, m); *m/e* 404 (*M*, 60%), 229 (*M* — Cbs, 70%), 214 (*M* — CbsNH, 24%), 201 (229 — CO, 48%), and 186 (214 — CO, 100%). A solution of the ketone (100 mg) in TFA (1 ml) was kept at room temperature for 4 weeks. The solvent was removed and methanol added; the solid so obtained (65 mg) was identical (t.l.c., u.v., and i.r.) with an authentic specimen [1] of compound (IV; Z = Cbs).

1,2,3,4,4a,9a-*Hexahydro*-9a-*hydroxy*-10-*methylacridin*-9(10H)-*one* (XV).—The ketone (XII) (1 g) was boiled for 20 h in ethanol (20 ml) containing sodium hydroxide solution (2M; 20 ml). The solution was diluted with water (250 ml) and neutralised (2M-HCl). The solid which separated was collected and recrystallised from a little methanol to give bright yellow fluorescent *prisms* (0.34 g), m.p. 137—138° (Found: C, 72.8; H, 7.3; N, 6.3. $C_{14}H_{17}NO_2$ requires C, 72.7; H, 7.4; N, 6.1%); $\lambda_{max.}$ 236, 264, and 403 nm (ε 26 000, 7 500, and 4 600); $\nu_{max.}$ 1 640 and 3 420 cm^{-1}; τ 2.1 (1 H, dd, *J* 8 and 1 Hz), 2.5—3.3 (3 H, m), 6.60 (1 H, OH, exchanged in D_2O), 6.5—6.65 (1 H, m, N·CH), 6.99 (3 H, s, NMe), and 7.7—8.6 (8 H, m); *m/e* 321 (*M*, 74%), 203 (*M* — CO, 42%, *m** 178.2), 186 (203 — OH, 10%), 160 (*M* — C_4H_7O, 100%), and 147 (16%). A solution of compound (XV) (150 mg) in polyphosphoric acid (2 g) was heated for 2 min at 150 °C and poured onto ice. The solution was neutralised with sodium hydroxide solution (2M) and the solid which separated was collected and recrystallised from ethanol to give material (110 mg) identical (m.p., t.l.c., u.v., and i.r.) with compound (XIV).[1]

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