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NEW PHOTOCHEMISTRY OF CYCLIC DIENES - THE REACTION BETWEEN 10H-AZEPINO[1,2-a]INDOLES AND METHANOL

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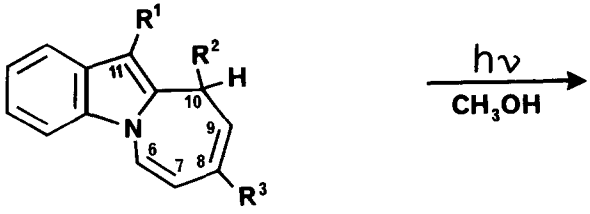
Abstract. Photochemical reaction of methanol with 10H-azepino[1,2-a]indoles gives three types of product derived from addition of methanol to the diene system; one of the products has undergone a skeletal rearrangement.

Photochemical reactions of cycloheptadienes,[1] and cycloheptatrienes,[2] and of their benzologues[3] have been the subject of many studies; numerous rearrangements and electrocyclic reactions are known to occur. Unlike the arylbutadienes[4] the cyclic dienes and trienes do not add methanol when irradiated in this solvent. The 10H-azepino[1,2-a]indoles (1)-(4), available in quantity by intramolecular nitrene insertions, gave no identifiable products when irradiated in benzene or THF, but provided a number of novel photoproducts when irradiated in methanol.

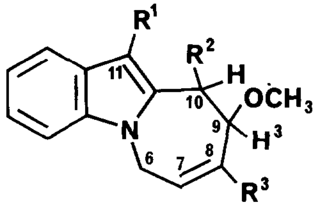
When the parent compound (1) (1g.) was irradiated in AR methanol (500 ml) with an Hanovia medium pressure lamp (Pyrex sleeve) the absorption maximum at 315 nm decreased, disappearing after 8 h. Better yields of products were obtained by stopping the irradiation after 5 to 6 h., some starting material being recovered. Chromatography on alumina (100 g., activity 4), in petrol gave in a typical run, starting material (∿100 mgm), and four products. One, obtained in small amounts was a dimer, m.p. >230° (30 mgm, 3%), of undetermined structure. The other three were isomers, $C_{14}H_{15}NO$, in order of elution from the column (A), (B) and (C). All represent, formally, the addition of one molecule of methanol to the azepino-indole (1). The major product was (C), obtained almost pure as the latest fractions from the column, recrystallized from petrol, m.p. 96-97° (Found: C.78.75; H, 7.05; N, 6.45. $C_{14}H_{15}NO$ requires C, 78.85; H, 7.1; N, 6.55%)(0.25 g., 24% on unresolved starting material). Yields of up to 57% of compound (C) have been obtained. The ^1H n.m.r. spectrum (C_6D_6) showed four aromatic protons, an indole β-hydrogen at δ6.32, and a methoxyl signal at δ3.08. Multiplets at δ3.05 (2H), 3.69 (1H), 3.95 (2H), 5.47 (1H), and 5.74 (1H) were shown by decoupling to be due to the sequence -$\overset{\alpha}{C}H_2$CH=CHCH(OCH_3)CH_2-; the chemical shifts of the methylene signals indicated that $\overset{\alpha}{C}H_2$ was attached to the indole nitrogen, and the photoproduct (A) is the dihydro-8-methoxyazepinoindole (5). The assignment of signals was confirmed by the isolation of similar photoproducts (6)-(8) from azepinoindoles (2)-(4); for example the photoproduct (8) showed in the ^{1}H n.m.r. spectrum only one alkene signal, and the corresponding simplification of the signals due to H7 and H9. The other photoproducts (B) and (C) could only be obtained pure by p.l.c. (10% ethyl acetate in petrol) with some loss. Yields are estimated from the n.m.r. spectrum of the mixture before p.l.c.

Compound B (98 mg., 9.5%), was distilled, b.p. $90^{\circ}/4x10^{-5}$ mm (bulb tube), m.p. 38-40° (Found: C, 78.9; H, 7.1; N, 6.6;). The ^{1}H n.m.r. spectrum showed four aromatic protons, all upfield of benzene, and no indole proton; these observations suggested an indoline structure. Other signals were at δ1.2 (1H, q of d, J5.2, 6.7, 11.2 Hz), 2.26 (1H, t of d, J9.4, 11.2, 11.2 Hz), 2.98 (1H, m), 3.2 (3H, s, OCH_3), 3.37 (d of d, J5.2, 9.4 Hz), 3.6 (2H, m), 5.38 (q of t, J1.9, 4.0, 10.1 Hz), and 5.6 p.p.m. (1H, m, J1.8, 10.1, x Hz). Decoupling experiments showed the sequence $CH_2CH{=}CHCHCH^A(H^B)$-CH^C and H^C was shown to be the original H11, being absent in the photoproducts from azepinoindoles (2) and (3). The ^{13}C n.m.r. spectrum showed signals at δ30.6(t, C10), 38.5 (d, C9), 40.4 (d, C11) 41.2 (t, C6), 48.7 (q, OCH_3), 91.9 (s, C9a), and 8 aromatic and alkene signals. (off-resonance multiplicities in parenthesis). The best fit for these spectra is the cyclobutane (9); assignments were again confirmed by examination of the substituted derivatives (10)-(12).

The third isomer, (C) was the least stable and could be purified only wastefully on p.l.c. plates. Distillation of the material recovered from p.l.c. gave pure (C), b.p. $120^{\circ}/2x10^{-3}$ mm Hg. (Found: C, 78.7; H, 7.1; N, 6.55%). Yield estimated by n.m.r. on the fractions after chromatography on alumina was 50 mgm (4.8%). From the ^{1}H n.m.r. spectrum (C_6D_6) compound (C) was clearly an indole (β-proton at δ6.22) with one aromatic proton considerably deshielded, and the methoxyl group absorption appeared at δ2.8. The other signals were at δ1.95-2.15 (2H, m), 2.55-2.75 (H^A, d of t (subsplit), J14.2, 3.8, 1.0 Hz), 3.27-3.6 (H^B, d of q, subsplit, J14.2, 6.3, 10.4, 1 Hz), 5.5-5.9 (3H, m). Irradiation of the indole proton removed the minor coupling of H^B thus establishing that this proton adjoins the indole ring. H^A is thus the other proton at C10, and since both are coupled to the 2H multiplet at δ2.0 and this in turn to the multiplet at δ5.5, the sequence <u>indole</u> -$CH_2CH_2CH{=}CHCH(OCH_3)$- is established, and



(1) $R^1 = R^2 = R^3 = {}^1H$
(2) $R^1 = R^2 = {}^2H ; R^3 = {}^1H$
(3) $R^1 = R^2 = {}^1H ; R^3 = CH_3$
(4) $R^1 = CH_3 ; R^2 = R^3 = {}^1H$



(5) $R^1 = R^2 = R^3 = {}^1H$
(6) $R^1 = R^2 = {}^2H ; R^3 = {}^1H$
(7) $R^1 = R^2 = {}^1H ; R^3 = CH_3$
(8) $R^1 = CH_3 ; R^2 = R^3 = {}^1H$

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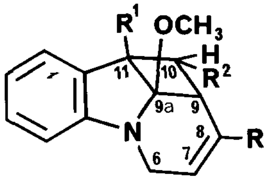

(9) $R^1 = R^2 = R^3 = {}^1H$
(10) $R^1 = R^2 = {}^2H ; R^3 = {}^1H$
(11) $R^1 = R^2 = {}^1H ; R^3 = CH_3$
(12) $R^1 = CH_3 ; R^2 = R^3 = {}^1H$

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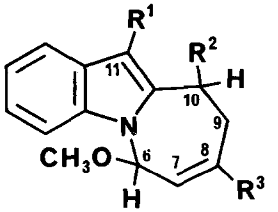
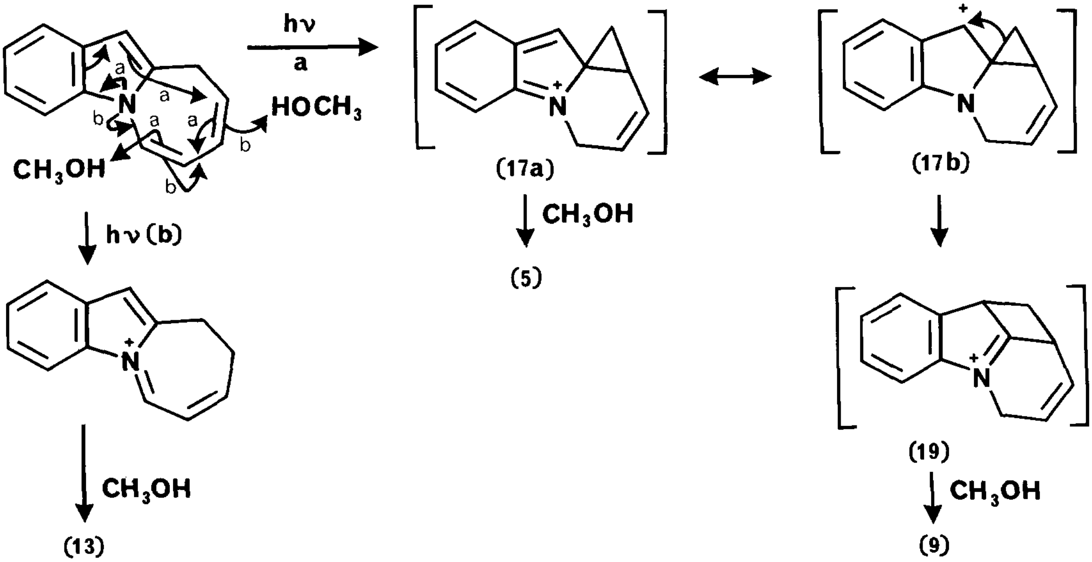


(13) $R^1 = R^2 = R^3 = {}^1H$
(14) $R^1 = R^2 = {}^2H ; R^3 = {}^1H$
(15) $R^1 = R^2 = {}^1H ; R^3 = CH_3$
(16) $R^1 = CH_3 ; R^2 = R^3 = {}^1H$

SCHEME



compound (C) has formula (13). In the case of compound (16), the signals for H9 was simplified to a doublet of doublets, H6 and H7 were coincidental, giving a 2H singlet, and the 1 Hz subsplitting on H^A was removed.

The mechanism of the photochemical reaction, and its scope, are still under study. Two charged intermediates (17) and (18) could account for all three addition products (SCHEME). The crucial stage for the production of the cyclobutane is a Wagner-Meerwein rearrangement of (17b), generating the stabilized carbocation (19).

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