

## Some Novel Transformations in Indole Chemistry

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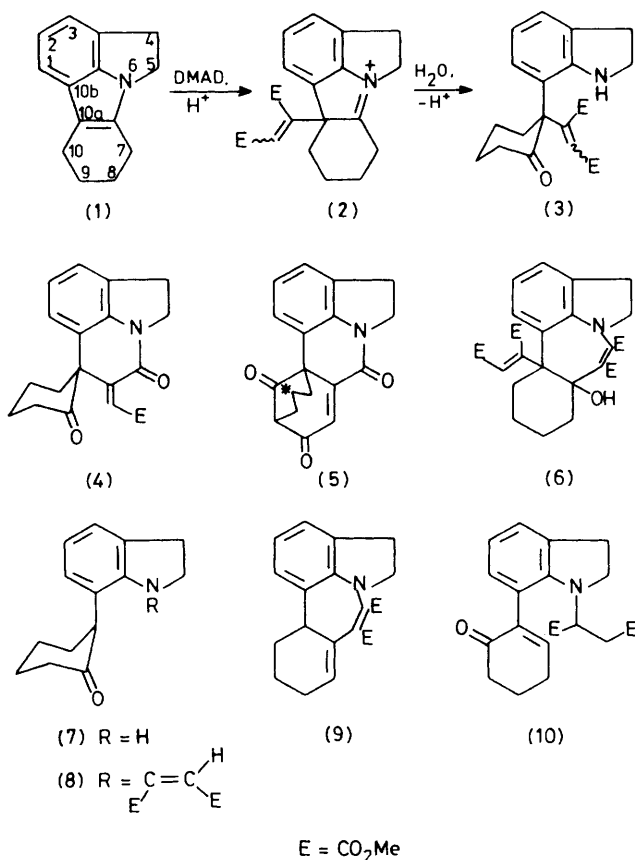
**Summary** 4,5,7,8,9,10-Hexahydropyrrolo[3,2,1-*jk*]carbazole with dimethyl acetylenedicarboxylate in wet acetic acid gave two pyrido[3,2,1-*hi*]indoles and two azepino[3,2,1-*hi*]indoles; one pyrido- and one azepino-indole were identified by X-ray crystallography and the other compounds by  $^1\text{H}$  and  $^{13}\text{C}$  n.m.r. spectral comparisons.

MANY products from indoles and dimethyl acetylenedicarboxylate (DMAD) contain either the original indole ring<sup>1</sup> or an azepine system.<sup>2</sup> The latter arises from enaminic addition of the acetylene to the 2,3-double bond followed by rupture of the resulting 4-membered ring. The possibility of obtaining different types of reaction from strained indoles, such as (1),<sup>3</sup> was attractive and our first experiments are now described.

The pyrrolocarbazole (1) with DMAD in wet acetic acid gave a mixture of (4), (5), (6), and (9) which were isolated by t.l.c. The trione (5) and the azepine (9) were identified by X-ray crystallography,<sup>4</sup> and the structures of (4) and (6) were deduced mainly from comparisons of their  $^1\text{H}$  and  $^{13}\text{C}$  n.m.r. spectra with those of (5) and (9) and other compounds. One of the methylene carbon atoms of (5) appears at higher field ( $\delta$  16.7 p.p.m.) than any of the methylene carbon atoms of cyclohexanone,<sup>5</sup> and this resonance has been assigned to

the asterisked carbon atom as the bonds to it from adjacent carbon atoms are shorter than normal.<sup>6</sup>

The  $^1\text{H}$  n.m.r. spectrum of (4) showed resonances for one OMe group and one olefinic proton ( $\delta$  6.12) while the  $^{13}\text{C}$  n.m.r. spectrum showed as main features one quaternary  $sp^3$  C (58.1 p.p.m.), 6  $\times$   $\text{CH}_2$ , normal CONH (159.5 p.p.m.),  $\text{CO}_2\text{Me}$  (167.6 p.p.m.), and CO (ketone) (207.8 p.p.m.) carbon atoms. The olefinic proton of (5) appeared at lower field than that of (4), with the aromatic protons ( $\delta$  6.9—7.65), as expected of the different stereochemistry with respect to the amide carbonyl. The  $^{13}\text{C}$  resonance of (5) for one of the ketone groups (197.5 and 203.6 p.p.m.) corresponds to that of (4) while the CONH resonance (157.1 p.p.m.) is so similar that it excludes a 7-membered ring containing this group as Dreiding models show for this case that the conformation of the carbonyl group must be such that normal amidic resonance would be very severely inhibited. The presence of the hydroxy-group in (6) is clear from the i.r. and  $^1\text{H}$  n.m.r. spectra, and from the rapid exchange effected by  $\text{D}_2\text{O}$ . The  $^{13}\text{C}$  n.m.r. spectrum for (6) showed as main features 4 normal field  $\text{CO}_2\text{CH}_3$  resonances, 6  $\text{CH}_2$  groups, and 2 quaternary  $sp^3$  C atoms (57.5 and 76.2 p.p.m.). The higher field of these quaternary atoms corresponds to those of (4) and (5) (55.7 p.p.m.) while the  $sp^3$  C-H resonance for (9) is at higher field (51.5 p.p.m.) as



anticipated. The resonance at 76.2 p.p.m. is compatible with the attachment of the oxygen atom to this  $sp^3$  carbon atom.<sup>7</sup>

The proposed intermediate (3), which has not been detected experimentally although structurally similar compounds have been isolated from (1) with tosyl azide,<sup>8</sup> does not arise through an initial ring opening of (1) to (7) since 2-phenylcyclohexanone showed no reaction with DMAD in wet acetic acid after 3 months and (7) itself gives only (9) under these conditions. Intermediate (3) must be formed from an initial electrophilic attack by DMAD at position 10a of (1), giving (2) which undergoes hydrolytic ring fission. If the ester groups are *cis* then amide formation to (4) can occur, while if they are *trans* the double cyclisation to (5) is understandable. Michael addition of DMAD to the nitrogen atom of (3) and attack by the resulting enamine at the ketonic carbonyl function could lead to (6).

The ketone (7) was obtained in 92% yield by warming (1) in 6M aqueous sulphuric acid for a few minutes. With DMAD in acetic acid (9) was formed from (7) in 90% yield, no other adducts being detected. Use of dichloromethane as solvent gave an uncrystallisable gum which was identified as the *cis*-ester (8) from its mass and  $^1H$  n.m.r. spectra. This gum with acetic acid gave (9) (77%) which suggests that the original reaction could proceed by (1)  $\rightarrow$  (7)  $\rightarrow$  (8)  $\rightarrow$  (9). A particularly interesting reaction of (8) is its ready conversion into (10) on refluxing in acetonitrile, which must be a consequence of the proximity of the enamine system and the cyclohexanone ring.

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