

## Synthesis and Photochemical Rearrangement of 1-Allyl-1,8-dihydropyrrolo[2,3-*b*]indoles

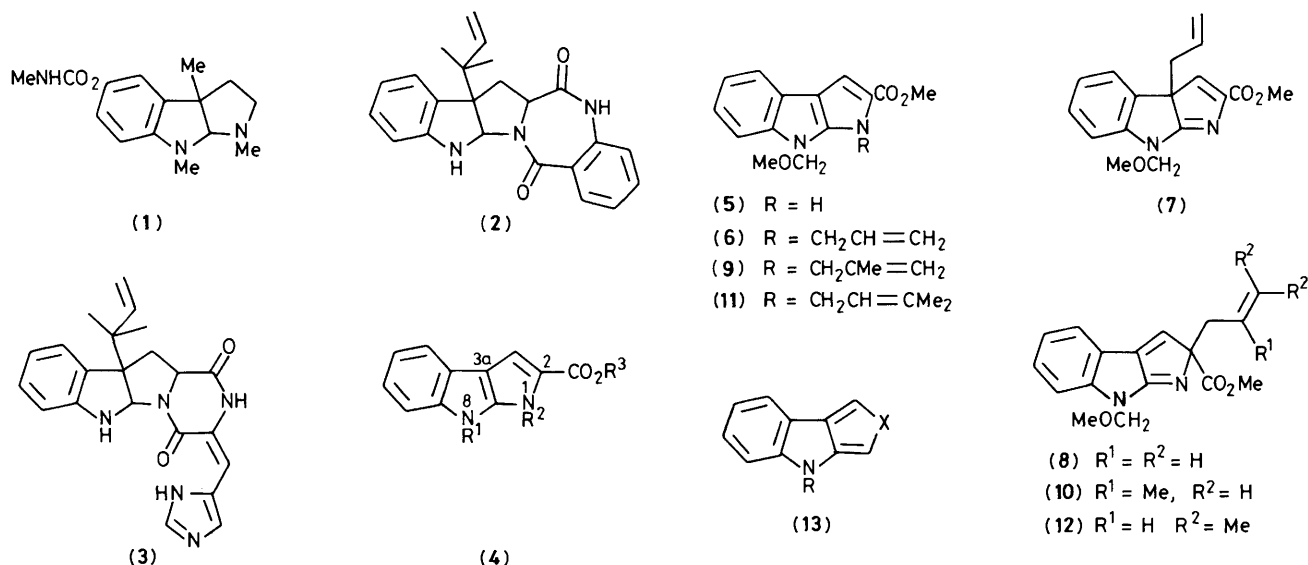
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The 1,8-dihydropyrrolo[2,3-*b*]indole ring system, readily prepared in three steps from indole-3-carbaldehyde, behaves as an isolated pyrrole in that its 1-allyl derivatives (**6**), (**9**), and (**11**) undergo photochemical rearrangement to the 2*H*-isomers (**8**), (**10**), and (**12**) respectively.

Although the pyrrolo[2,3-*b*]indole ring system occurs in nature at the hexahydro level in alkaloids such as physostigmine (**1**),<sup>1</sup> aszonalenin (**2**),<sup>2</sup> and the structurally related neurotoxin, roquefortine (**3**),<sup>3</sup> little is known about the less saturated versions of this ring system. With a view to developing routes to these latter two alkaloids, we have been

interested in the 1,8-dihydro derivatives (**4**)<sup>4</sup> on the grounds that they offer considerable scope for the introduction of the substituent at C-3a and for the annelation of the fourth ring between N-1 and the carbonyl at C-2. We now report a concise route to, and some chemistry of, this unexplored ring system.



The requisite monoprotected methyl 1,8-dihydro-pyrrolo[2,3-*b*]indole-2-carboxylate (**5**), m.p. 214–218 °C (decomp.) was prepared in three steps from indole-3-carbaldehyde *via* *N*-alkylation (86%), followed by condensation with methyl azidoacetate<sup>5</sup> to give methyl 2-azido-3-(1-methoxymethylindol-3-yl)propenoate [60% (83% based on consumed aldehyde)], which on heating in toluene (1.5 h) cyclised to (**5**) (70%) with loss of nitrogen.

Attention was then turned to the introduction of an allyl substituent at C-3a, and to this end the transfer of allyl groups from nitrogen to carbon was investigated. Accordingly, reaction of the pyrroloindole (**5**) with sodium hydride in dimethylformamide followed by allyl bromide gave the required *N*-allyl derivative (**6**) (71%), together with a minor by-product (13%). Although the *N*-allyl compound (**6**) was recovered after heating in decalin for 24 h, it was rapidly converted into another compound by irradiation in cyclohexane at 300 nm for 40 min.† This major product (62%) m.p. 87–89 °C, an isomer of the starting material, was shown to be identical to the minor product formed in the allylation reaction. That the allyl group had migrated from nitrogen to carbon was immediately clear from the <sup>1</sup>H n.m.r. spectrum which showed that the signal for the CH<sub>2</sub>CH=CH<sub>2</sub> had moved upfield from δ 5.40 to 2.93, and from the <sup>13</sup>C n.m.r. spectrum which contained an additional quaternary sp<sup>3</sup> carbon resonance at δ 92.95. These data are consistent with both the required 3a-allyl isomer (**7**) and the 2-allyl isomer (**8**). However, the presence of an ester carbonyl (1730 cm<sup>-1</sup> in the i.r. spectrum) suggested that the product was in fact the 2-isomer (**8**), and this assignment was confirmed by an *X*-ray crystallographic study.‡

The *N*-methallyl (**9**), and *N*-prenyl (**11**) derivatives underwent similar photochemical rearrangement to give the 2*H*-pyrroloindoles (**10**) and (**12**) respectively, the prenyl derivative migrating without allylic inversion. The fact that these *N*-1 allyl derivatives rearrange exclusively to the 2*H*-isomers suggests that the 1,8-dihydropyrrolo[2,3-*b*]indole behaves as an isolated pyrrole, since *N*-allylpyrroles are known to undergo photochemical rearrangement to 2*H*-pyrroles.<sup>6</sup> On

the other hand, if the system showed any indole-like character the formation of 3a-allyl isomer (**7**) was expected, especially since another 2-allyl hetero atom indole, 2-allyl-2-thio-1,3-dimethylindole is reported to undergo facile thermal rearrangement with transfer of the allyl group from the heteroatom to the 3-position.<sup>7</sup>

The rearranged pyrroloindoles (**8**), (**10**), and (**12**) are examples of indole 2,3-quinone methide imines,<sup>8</sup> and as such are related to indole 2,3-quinone dimethanes. There is considerable current interest in indole 2,3-quinone dimethanes,<sup>9</sup> and cyclic derivatives (**13**; X = NR<sup>1</sup>,<sup>10</sup> X = O,<sup>11</sup> X = S, Se<sup>12</sup>), analogous to the 2*H*-pyrroloindoles described herein, have recently been reported.

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† A small amount (11%) of compound (**5**) was also formed by photochemical cleavage of the allyl group.

‡ Determined by Dr. D. J. Williams of this department.