Diels–Alder Reactivity of Pyrano[3,4-*b*]indol-3-ones, Stable, Synthetic Equivalents of Indole-2,3-quinodimethanes

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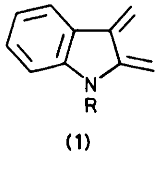
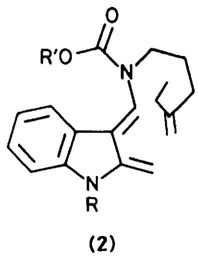
Pyrano[3,4-*b*]indol-3-ones (**5**), synthetic equivalents of indole-2,3-quinodimethanes, undergo Diels–Alder reaction with acetylenes and with benzyne to give carbazoles and benzo[*b*]carbazoles respectively.

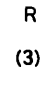
Indole-2,3-quinodimethanes (**1**) have been the subject of considerable synthetic interest in the last few years. Although not isolable, derivatives of (**1**) containing an additional nitrogen atom (*e.g.* **2**, R = $4\text{-MeOC}_6H_4SO_2$) have been elegantly employed as intramolecular Diels–Alder substrates in indole alkaloid synthesis.[1] However, intermolecular Diels–Alder reactions involving simple indole-2,3-quinodimethanes are less satisfactory owing to the lability of the compounds (**1**, R = Me and Bu^tOCO).[2] More recently attention has turned to cyclic systems as stable synthetic analogues of (**1**), and the thieno- (**3**, R = COPh, X = S), selenolo- (**3**, R = COPh, X = Se),[3] and furo-[3,4-*b*]indoles (**3**, R = SO_2Ph, X = O)[4] have been reported. The anionic 2,3-quinodimethane-like intermediate (**4**) has also been generated by treatment of the corresponding anhydride with strong base,[5] and in common with all the other approaches mentioned, requires the indole nitrogen to be protected. However, there is another approach to indole-2,3-quinodimethanes which is simpler to carry out, does not require protection of the indole nitrogen, and is based on readily available pyrano[3,4-*b*]indol-3-ones (**5**). Since the preparation and Diels–Alder reactions of these compounds were first reported by Plieninger and co-workers in 1964,[6] it is surprising that none of the recent papers refer to this work. The results reported herein extend Plieninger's original work, and demonstrate that pyrano[3,4-*b*]indol-3-ones are synthetic equivalents of indole-2,3-quinodimethanes which clearly deserve further attention.



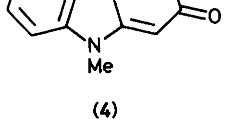
(**1**)



(**2**)

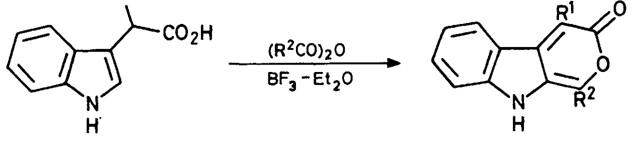


(**3**)



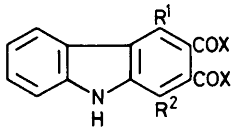
(**4**)

The pyranoindolone (**5a**) was prepared from commercially available indole-3-acetic acid by treatment with acetic anhy-



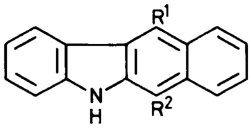
(**5**)

a; $R^1 = H, R^2 = Me$
b; $R^1 = R^2 = Me$



(6)

a; $R^1 = H, R^2 = Me, X = OMe$
b; $R^1 = H, R^2 = Me, X = Ph$
c; $R^1 = R^2 = Me, X = OMe$
d; $R^1 = R^2 = Me, X = Ph$



(7)

a; $R^1 = H, R^2 = Me$
b; $R^1 = R^2 = Me$

dride and boron trifluoride–diethyl ether exactly as previously described.[6] The dimethyl analogue (**5b**) was similarly prepared from α-methylindole-3-acetic acid, obtained by reaction of indole with lactic acid.[7] Both pyranoindolones (**5**) are stable, high melting, orange crystalline compounds.

Although the Diels–Alder reactions of (**5a**) with olefinic dienophiles are already adequately described,[6] only one addition to an acetylenic dienophile was reported, and this involved heating the pyrone (**5a**) in a large excess of dimethyl acetylenedicarboxylate (DMAD) without solvent. Therefore the preparation of carbazoles from the pyranoindolones (**5**) and acetylenes was investigated. The pyranoindolone (**5a**) reacted only slowly with DMAD in boiling toluene owing to its poor solubility. However, the Diels–Alder reaction occurred readily in boiling bromobenzene to give, with concomitant loss of carbon dioxide, the carbazole (**6a**) (81%), m.p. 184—185 °C (lit.,[6] 187 °C). Reaction of the pyrone (**5a**) with dibenzoylacetylene (DBA) gave the carbazole (**6b**) (76%). Similarly, the pyranoindolone (**5b**) underwent Diels–Alder reaction with both DMAD and DBA to give the carbazoles (**6c**) (67%) and (**6d**) (52%), respectively.

The pyrano[3,4-*b*]indol-3-ones (**5**) are also suitable diene substrates for the highly reactive dienophile benzyne. Thus, reaction of (**5a**) with benzyne (from benzenediazonium-2-carboxylate) in boiling 1,2-dichloroethane gave 6-methyl-5*H*-benzo[*b*]carbazole (**7a**) (44%), m.p. 158.5—160 °C (lit.,[8] 210—211 °C).† Similarly, the pyranoindolone (**5b**) gave 6,11-dimethyl-5*H*-benzo[*b*]carbazole (**7b**) (38%), m.p. 206.5—210 °C (lit.,[9] 211—212 °C) on reaction with benzyne. Although the yields in the Diels–Alder reactions with benzyne are only moderate, the present method constitutes the shortest route to these benzo[*b*]carbazoles (three steps from indole).

In summary, pyrano[3,4-*b*]indol-3-ones, first described twenty years ago, are useful indole-2,3-quinodimethane equivalents which offer advantages over some of the more recently reported methods.

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References

1 P. Magnus, T. Gallagher, P. Brown, and P. Pappalardo, *Acc. Chem. Res.*, 1984, **17**, 35.
2 E. R. Marinelli, *Tetrahedron Lett.*, 1982, **23**, 2745.
3 A. Shafiee and S. Sattari, *J. Heterocycl. Chem.*, 1982, **19**, 227.
4 M. G. Saulnier and G. W. Gribble, *Tetrahedron Lett.*, 1983, **24**, 5435.
5 Y. Tamura, S. Mohri, H. Maeda, T. Tsugoshi, M. Sasho, and Y. Kita, *Tetrahedron Lett.*, 1984, **25**, 309.
6 H. Plieninger, W. Müller, and K. Weinerth, *Chem. Ber.*, 1964, **97**, 667.
7 H. E. Johnson and D. G. Crosby, *J. Org. Chem.*, 1963, **28**, 1246.
8 S. Kano, E. Sugino, S. Shibuya, and S. Hibino, *J. Org. Chem.*, 1981, **46**, 2979.
9 D. A. Taylor, M. M. Baradarani, S. J. Martinez, and J. A. Joule, *J. Chem. Res.*, 1979, (*S*) 387; (*M*) 4801.

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† The data obtained for compound (**7a**) contrasts with those previously reported (ref. 8). In addition to the difference in melting point, compound (**7a**) is reported to exhibit δ ($CDCl_3$) 2.37 (3H, s) (the only n.m.r. signal quoted), and was only characterised by high resolution mass spectrometry. The present compound was fully characterised by elemental analysis and by i.r., u.v., and n.m.r. spectroscopy, which in particular shows a singlet for the 6-methyl group at δ 2.79. The structure was supported by the nuclear Overhauser effect, in which pre-irradiation of the NH caused the expected strong enhancement of the methyl signal.