

A Stable Analogue of Indole-2,3-quinodimethane: Synthesis and Diels–Alder Reaction of 2-Methoxycarbonyl-4-[(*p*-methoxyphenyl)sulphonyl]-2,4-dihydropyrrolo[3,4-*b*]indole

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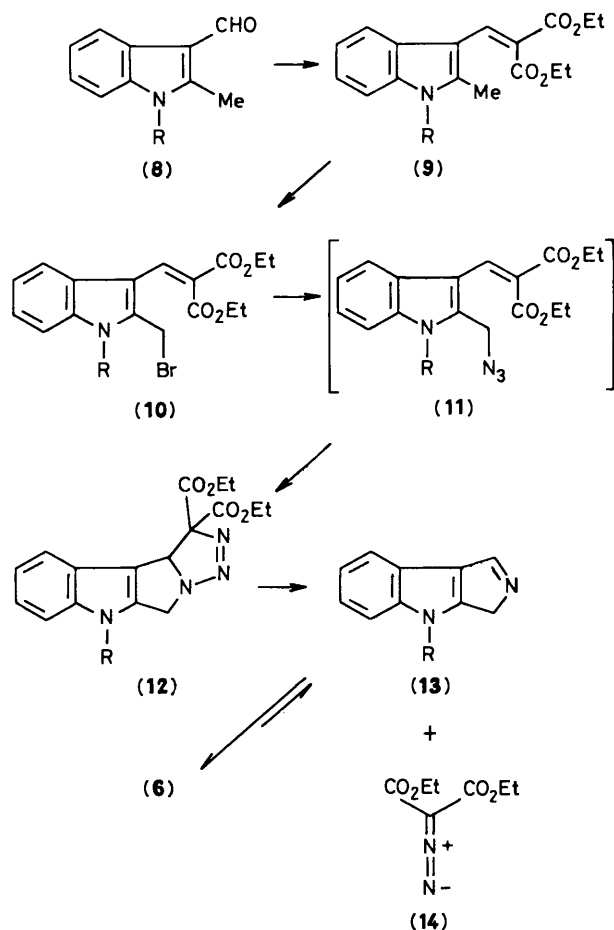
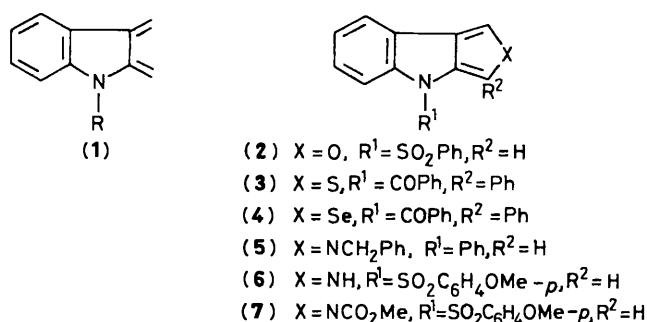
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The 2,4-dihydropyrrolo[3,4-*b*]indole ring system, readily prepared from 1-[(*p*-methoxyphenyl)sulphonyl]-2-methyl-3-formylindole, underwent Diels–Alder reaction with highly reactive dienophiles, *e.g.*, benzyne and *N*-phenylmaleimide, to give cycloadducts in excellent yields.

The preparation of stable analogues of the indole-2,3-quinodimethane system (1) is of current interest,¹ and a number of cyclic derivatives (2),¹ (3),² (4),² and (5)³ have been synthesized. However, these cyclic analogues, except the 4*H*-furo[3,4-*b*]indole (2), do not show marked diene character. In particular the pyrrolo[3,4-*b*]indole derivative (5),

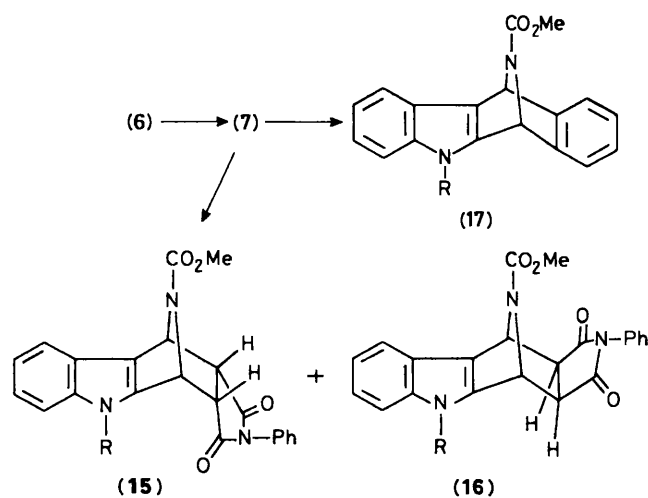
the only compound prepared containing this ring system, was not found to undergo Diels–Alder reactions.³

We now report the synthesis of the new compounds (6) and (7), which also contain the pyrrolo[3,4-*b*]indole ring system, by a novel route, namely *via* the intramolecular 1,3-dipolar cycloaddition⁴ of the azide (11) followed by 1,3-dipolar

Scheme 1. $\text{R} = \text{SO}_2\text{C}_6\text{H}_4\text{OMe}_p$

cycloreversion⁵ of the triazolone intermediate (12). We have also found that compound (7) reacted as a good diene system in Diels–Alder reactions with the highly reactive dienophiles *N*-phenylmaleimide and benzyne.

Knoevenagel condensation of the readily available formylindole (8)⁶ with diethyl malonate in benzene and piperidine gave (9) (77%) (Scheme 1). Bromination of (9) with *N*-bromosuccinimide–dibenzoyl peroxide in carbon tetrachloride afforded the bromide (10) (92%), which reacted with sodium azide in aqueous tetrahydrofuran to give the triazolone (12) (87%) directly. Presumably, displacement of Br^- from (10) by N_3^- produced the azide (11), which immediately underwent a facile intramolecular 1,3-dipolar cycloaddition reaction to give



Scheme 2

the triazolone (12). Treatment of the triazolone (12) with a catalytic amount of toluene-*p*-sulphonic acid in tetrahydrofuran at room temperature gave diethyl diazomalonate (14) (92%) and a more polar product (82%), which was characterized spectroscopically as the 2,4-dihydropyrrolo[3,4-*b*]indole (6),[†] m.p. 122–124 °C. We reasoned that acid-catalysed 1,3-dipolar cycloreversion of the triazolone (12) would give diethyl diazomalonate (14) and compound (13) which tautomerized to give the more stable (6), which is stable under nitrogen.

Attempted Diels–Alder reactions of (6) by prolonged heating with *N*-phenylmaleimide and benzyne in toluene led only to unchanged (6). On the basis of the reactivity of pyrrole derivatives as diene systems,⁷ we concluded that *N*-substituted derivatives of (6) should undergo Diels–Alder reactions. Thus, compound (6) was treated with potassium hydride and methyl chloroformate in tetrahydrofuran to give the methoxy carbonyl derivative (7),[†] m.p. 145–147 °C (95%). Compound (7) was then heated with *N*-phenylmaleimide in refluxing tetrahydrofuran, and the Diels–Alder reaction proceeded smoothly to give the *endo*- (15) (57%) and *exo*-adducts (16) (19%) (Scheme 2). Similarly, the Diels–Alder reaction of (7) with benzyne, generated from benzenediazonium-2-carboxylate, in refluxing tetrahydrofuran gave the adduct (17) (75%) in 1 h. The difference between (7) and (6) in their reactivity as dienes is in good accord with the reactivity of *N*-substituted pyrrole derivatives.⁷ It is interesting that (7) is stable even in the air. Owing to their stability and reactivity as diene systems, derivatives of the 2,4-dihydropyrrolo[3,4-*b*]indole ring systems, such as (7), have potential for use as the synthetic equivalent of indole-2,3-quinodimethanes.

[†] Compounds (6) and (7) were characterized by ¹H and ¹³C n.m.r., i.r., and mass spectroscopy, and also gave satisfactory elemental analyses: e.g. (6): ¹H n.m.r. (CDCl₃): δ 3.68 (s, 3H), 6.65 (d, 2H, *J*_{AB} 9 Hz, 6.83–6.88 (m, 1H), 6.96–7.01 (m, 1H), 7.11–7.24 (m, 2H), 7.44–7.56 (m, 1H), 7.67 (d, 2H, *J*_{AB} 9 Hz), 7.92–8.04 (m, 1H), and 8.34 (br. s, 1H); ¹³C n.m.r. (CDCl₃+CD₃SOCD₃) 54.20(q), 98.85(d), 104.94(d), 112.67(d), 113.67(d), 115.49(s), 119.12(d), 122.52(d), 123.10(d), 124.10(s), 127.15(s), 127.44(d), 129.78(s), 141.03(s), and 162.07(s); *v*_{max} (CHCl₃): 1590 and 1500 cm⁻¹; *m/z* 326 (*M*⁺, 37%), 155 (100), and 128 (28).

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References

- 1 M. G. Saulnier and W. Gribble, *Tetrahedron Lett.*, 1983, 5435, and references therein.
 - 2 A. Shafiee and S. Sattani, *J. Heterocycl. Chem.*, 1982, **19**, 227.
 - 3 W. M. Welch, *J. Org. Chem.*, 1976, **41**, 2031.
 - 4 For a related study see: C. K. Sha, S. L. Ouyang, and D. Y. Hsieh, *J. Chem. Soc., Chem. Commun.*, 1984, 492.
 - 5 G. Bianchi, C. PeMicheli, and R. Gandolfi, *Angew. Chem., Int. Ed. Engl.*, 1979, **18**, 721.
 - 6 C. Exon, T. Gallagher, and P. Magnus, *J. Am. Chem. Soc.*, 1983, **105**, 4739.
 - 7 R. M. Acheson and N. F. Elmore, *Adv. Heterocycl. Chem.* 1978, **23**, 263, and references therein; L. Mandell and W. A. Blanchard, *J. Am. Chem. Soc.*, 1957, **79**, 2343, 6198; R. Kitzing, R. Fuchs, M. Joyeux, and M. Prinzbach, *Helv. Chim. Acta*, 1968, **51**, 888; R. C. Bansol, A. W. McCulloch, and A. G. McLinnes, *Can. J. Chem.*, 1969, **47**, 2391; 1970, **48**, 1472.
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