Synthesis of Elusive 1,4-Dihydrocarbazoles *via* Intramolecular Trapping of an Indole-2,3-quinodimethane

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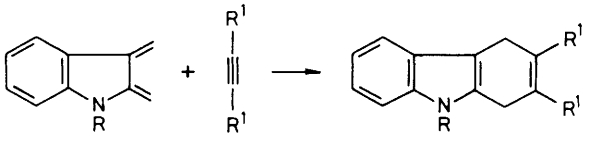
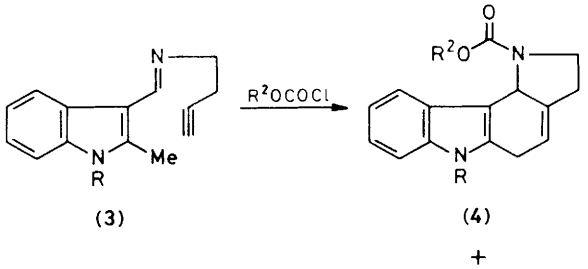
1,4-Dihydrocarbazoles are synthesized by heating 3-imino-2-methylindole derivatives with either an alkyl chloroformate or an alkynyl acid mixed anhydride.

In principle the trapping of an indole-2,3-quinodimethane (**1**) by an acetylene derivative should constitute a direct way of making the extremely rare 1,4-dihydrocarbazole system (**2**).[1] Here we report the intramolecular implementation of this idea, thus overcoming any adverse entropic and regiochemical problems. Addition of methyl chloroformate (3.0 equiv.) to a solution of the imine (**3**) in chlorobenzene, containing di-isopropylethylamine (3.0 equiv.) at 0 °C, followed by heating to 130 °C for 1 h gave the 1,4-dihydrocarbazole (**4**; R^2 = Me) [17%; n.m.r. δ 5.33(1H, br., olefinic) and 5.95(1H, br.s)] and the carbazole (**5**; R^2 = Me) (17%). Prolonged heating eventually (15 h) converted (**4**; R^2 = Me) into (**5**; R^2 = Me). Also (**4**; R^2 = Me) was not formed in any appreciable amounts at temperatures below 130 °C. (Throughout, the indole-nitrogen atom is 'protected' by *p*-$MeOC_6H_4SO_2$–, which is essential to reduce the vinylogous amidine character of the 3-imine group; N–Me does not work.) We found that treatment of (**3**) with 2-chloroethyl chloroformate, (2.0 equiv.) in benzene–di-isopropylamine (2.0 equiv.) at 80 °C for 1 h, avoided the subsequent elimination and gave the 1,4-dihydrocarbazole (**4**; R^2 = CH_2CH_2Cl) (>95% yield after chromatography over Florisil eluting with EtOAc–light petroleum). At 130 °C the carbazole (**5**; R^2 = CH_2CH_2Cl) (m.p. 127—



(1) (2)



(3) (4)

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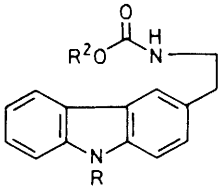

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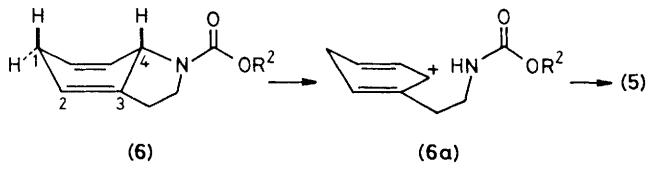
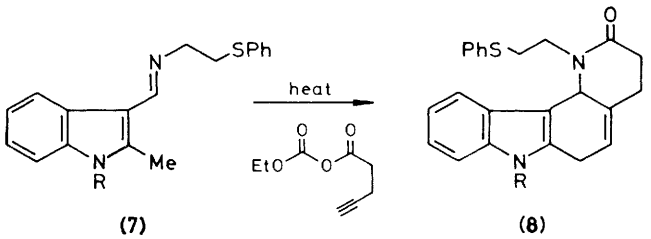
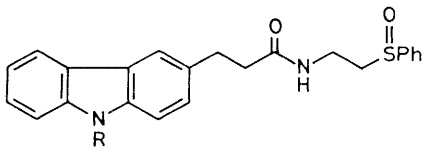


(6) (6a)



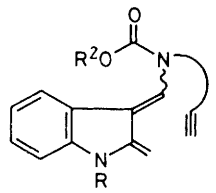
(7) (8)



(9)

129 °C) was the only product. The exclusive formation of (**4**; $R^2 = CH_2CH_2Cl$) with no aromatisation can be attributed to two facts. The carbamate group in (**4**; $R^2 = CH_2CH_2Cl$) is a bad leaving group, and the stereochemical requirements of the required 1,4-elimination are not good because the C–4–N bond is almost orthogonal to the C–2–C–3 π-system (**6**).[3] As a consequence of these orbital alignments, the thermal conversion of (**4**) into (**5**) must proceed with a relatively large activation energy. If this qualitative statement were not true then (**4**) would not exist. As a corollary, (**4**) should be extremely sensitive to electrophiles, since formation of the dienyl cation (**6a**) by protonation should readily lead to (**5**). This is indeed the case since (**4**) rapidly gives (**5**) when left in solutions that are acidic (CH_2Cl_2–*p*-$MeC_6H_4SO_3H$, 20 °C, 5 min).

Treatment of the imine (**7**) with the mixed anhydride prepared from ethyl chloroformate and pent-4-ynoic acid, in



(10)

chlorobenzene at 20 °C, followed by rapid heating to 130 °C, 2.5 h gave (**8**) (31 %, m.p. 164—165 °C; n.m.r. δ 5.32(1H,t) and 5.77(1H, s). The 1,4-dihydrocarbazole (**8**) was stable to these conditions, reflecting that it is less strained than (**4**).

Oxidation of (**8**) (*m*-chloroperbenzoic acid–CH_2Cl_2–$NaHCO_3$) gave the derived sulphoxide which rapidly aromatized to give (**9**) when treated with electrophiles (trifluoroacetic anhydride, $CPh_3^+BF_4^-$, HBr) at low temperatures, or on heating (PhCl, 130 °C, 2 min). The thermal lability of the sulphoxide is in marked contrast to the sulphide (**8**). This presumably reflects the increased electrophilic character of the amide due to the β-PhS(O) group.

These cyclizations proceed *via* an indole-2,3-quinodimethane (**10**),[2] and provide for the first time a rational synthesis of 1,4-dihydrocarbazoles.

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