462. *Synthesis of* 1,2,3,4-*Tetrahydro*-3-*oxocarbazole and Indolo*[3,2-b]*carbazole.*

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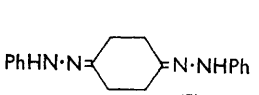
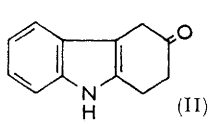
Treatment of cyclohexane-1,4-dione bisphenylhydrazone with acid gives 1,2,3,4-tetrahydro-3-oxocarbazole and indolo[3,2-*b*]carbazole. Acid treatment of indole-2-aldehyde gives a coloured material which on reduction gives indolo[3,2-*b*]carbazole.

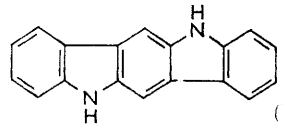
Fischer indolisation of the phenylhydrazones of cyclohexane-1,2- and -1,3-dione has been studied by several groups of workers.[1] We have now examined similar reactions of the 1,4-dione. With phenylhydrazine, cyclohexane-1,4-dione gave only a bisphenylhydrazone (I), and all attempts to prepare a mono-derivative were unsuccessful. Treatment of the bisphenylhydrazone (I) with hot dilute sulphuric acid gave a brick-red solid which we were unable to purify by recrystallisation. On heating the material at 170° in a high vacuum a white crystalline sublimate was obtained. Microanalysis indicated the formula $C_{12}H_{11}NO$, the ultraviolet spectrum was that of a simple indole, and the infrared spectrum disclosed the presence of a carbonyl group. This product was therefore 1,2,3,4-tetrahydro-3-oxocarbazole (II), which was further characterised by the formation of a picrate. The yield was, however, very poor (*ca.* 12%) and variations in the experimental conditions failed to improve on this. On raising the temperature to 310°, a second (pale yellow) crystalline sublimate was obtained in higher yield. Its complex ultraviolet spectrum indicated an



(I)



(II)



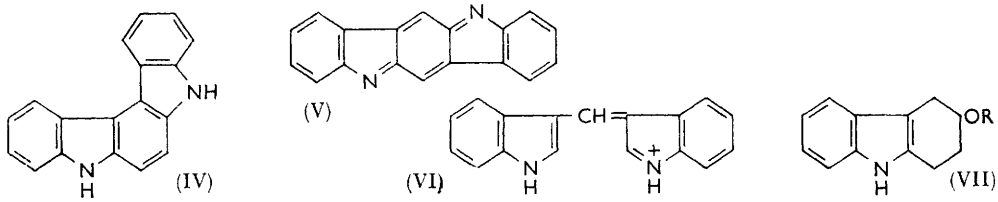
(III)

aromatic polycyclic system, and microanalysis suggested a probable formula $C_{18}H_{12-14}N$. At this stage of our work a paper by Grotta, Riggle, and Bearse [2] appeared, in which the synthesis of indolo[3,2-*b*]carbazole (III) by the vapour-phase dehydrogenation of *NN'*-diphenyl-*p*-phenylenediamine was described. A specimen of their product was identical with ours (ultraviolet and infrared spectra). Plainly, this compound is formed by a double indolisation of the bisphenylhydrazone (I) followed by dehydrogenation, possibly during the high-temperature sublimation.

[1] Coffey, *Rec. Trav. chim.*, 1923, **42**, 528; Bloink and Pausacker, *J.*, 1950, 1328; Clemo and Felton, *J.*, 1951, 700; Bhide, Tikotkar, and Tilak, *Chem. and Ind.*, 1957, 363; Mann and Willcox, *J.*, 1958, 1525.
[2] Grotta, Riggle, and Bearse, *J. Org. Chem.*, 1961, **26**, 1509.

The cyclisation could theoretically take place in two alternative directions, leading either to indolo[3,2-*b*]carbazole or indolo[2,3-*c*]carbazole (IV) and a similar ambiguity is possible in the synthesis described by Grotta *et al.* These authors describe the reduction of urorosein, obtained by the action of acid on indole-3-aldehyde and formulated in their paper after Fearon and Boggust [3] as dehydroindolo[3,2-*b*]carbazole (V), to give the indolocarbazole (III), thus justifying the linear structure allotted. However, the correct structure for urorosein has been shown [4] to be (VI) not (V), and, as would be expected from this formulation, we have been unable to repeat the reduction of urorosein to the indolocarbazole as reported by Grotta *et al.* Thus, although it is clear that our synthesis and that of the American workers give the same indolocarbazole, there is no evidence as to whether this is the linear or angular isomer.

In order to clear up this point, we have examined the action of acid on indole-2-aldehyde. This reaction leads rapidly to the formation of an insoluble very dark material which is not a salt. Unfortunately, its solubility properties precluded purification, but, on reduction, a moderate yield of indolocarbazole, identical with that prepared earlier, was obtained. It therefore seems that the dark material is the dehydro-compound (V), and its formation by self-condensation of indole-2-aldehyde is mechanistically plausible. Since there is no feasible route by which this self-condensation could lead to the skeleton of indolo[2,3-*c*]carbazole, we regard the linear structure (III) as now proved.



Since the yield of the keto-compound (II) was so low, we attempted an alternative synthesis. The phenylhydrazone of 4-benzoyloxycyclohexanone cyclised readily to give 3-benzoyloxy-1,2,3,4-tetrahydrocarbazole (VII; R = Bz) in good yield, and alkaline hydrolysis gave the hydroxy-compound (VII; R = H). However, attempted oxidation of this to the keto-compound with a wide variety of reagents was, surprisingly, unsuccessful.

Experimental

Fischer Indolisation of Cyclohexane-1,4-dione Bisphenylhydrazone.—Cyclohexane-1,4-dione bisphenylhydrazone [5] (2·5 g.) was added to a mixture of sulphuric acid (25 ml.) and water (25 ml.), and the whole was heated at 100° on a steam-bath for 1·5 hr. After cooling, water (100 ml.) was added and the brick-red precipitate (1·5 g.) was collected and thoroughly washed with water. This product (1 g.) was sublimed at $1·5 \times 10^{-4}$ mm., initially at 170°. A white crystalline sublimate (140 mg.) was obtained of 1,2,3,4-*tetrahydro*-3-*oxocarbazole* (II), m. p. 148—150° (Found: C, 78·4; H, 5·8; N, 7·6. $C_{12}H_{11}NO$ requires C, 77·9; H, 6·0; N, 7·6%); $\lambda_{max.}$ (in ethanol) 222, 282, 289 mμ (ε 32,680, 7192, 6118), λ_{infl} 252—254 mμ (ε 4419); $\nu_{max.}$ 1703s cm.$^{-1}$. The *picrate* formed red-brown needles from ethanol, m. p. 192—194° (Found: C, 52·5; H, 3·2; N, 13·0. $C_{18}H_{14}N_4O_8$ requires C, 52·2; H, 3·4; N, 13·5%).

On raising the temperature to 310°, a further (pale yellow) crystalline sublimate (300 mg.) was obtained, of indolo[3,2-*b*]carbazole, m. p. >400° (Found: C, 83·6; H, 5·3; N, 11·0. Calc. for $C_{18}H_{12}N_2$: C, 84·4; H, 4·7; N, 10·9%); $\lambda_{max.}$ (in dioxan) 250, 261, 273, 321, 335, 379, 400 mμ (ε 24,800, 25,000, 37,100, 25,900, 48,500, 3840, 4420), λ_{infl} 230, 245, 329, 364 mμ (ε 23,600, 24,100, 28,700, 3070). This spectrum was identical with that of a sample of indolo[3,2-*b*]-carbazole kindly provided by Dr. H. M. Grotta; the infrared spectra [2] were also identical.

Indolo[3,2-*b*]*carbazole from Indole-2-aldehyde.*—A solution of indole-2-aldehyde (0·4 g.) in

[3] Fearon and Boggust, *Biochem. J.*, 1950, **46**, 62.
[4] Harley-Mason and Bu'Lock, *Biochem. J.*, 1952, **51**, 430.
[5] Baeyer and Noyes, *Ber.*, 1889, **22**, 2168.

ethanol (5 ml.) was added to hot 6N-hydrochloric acid (25 ml.) and the mixture was heated at 100° for 1 hr. The initial bright red colour slowly changed to deep green, and a dark green-black amorphous solid slowly separated. After cooling, the solid (0·35 g.) was collected and thoroughly washed with water. This material, which was chlorine-free and did not melt below 400°, was probably crude dehydroindolo[3,2-*b*]carbazole (V); unfortunately its low solubility precluded purification.

The crude product (0·28 g.) was added to a mixture of 6N-hydrochloric acid (30 ml.) and acetic acid (5 ml.). Amalgamated zinc (4 g.) was added, and the mixture boiled under reflux for 24 hr. The colour changed slowly from deep maroon to pale yellow-brown. The aqueous solution was decanted from the zinc residue, concentrated to small bulk, and diluted with water, giving a yellow precipitate which on sublimation at 300°/1·6 × 10^{-4} mm. gave indolo-[3,2-*b*]carbazole, identical with that obtained before. Direct sublimation of the zinc residue gave a further quantity (total yield 0·1 g., 35%).

1,2,3,4-*Tetrahydro*-3-*hydroxycarbazole*.—To a solution of 4-benzoyloxycyclohexanone [6] (11 g.) in hot acetic acid (75 ml.), phenylhydrazine (5·71 g.) was added, and the mixture refluxed for 10 min. 3-*Benzoyloxy*-1,2,3,4-*tetrahydrocarbazole* (7·4 g., 52%) separated on cooling and formed plates, m. p. 196—198° (from ethanol) (Found: C, 79·05; H, 6·1; N, 4·5. $C_{19}H_{17}NO_2$ requires C, 78·4; H, 5·8; N, 4·8%).

To a hot solution of the above compound (0·9 g.) in ethanol, N-sodium hydroxide (18 ml.) was added and the mixture refluxed for 45 min. Most of the ethanol was removed under a vacuum, and addition of water then precipitated 1,2,3,4-*tetrahydro*-3-*hydroxycarbazole* which formed needles, m. p. 152—154° (from aqueous ethanol) (Found: C, 77·1; H, 7·1; N, 7·5. $C_{12}H_{13}NO$ requires C, 77·0; H, 6·95; N, 7·5%); $\lambda_{max.}$ (in ethanol) 227, 283, 289 mμ (ε 37,000, 7950, 6730).

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[6] Jones and Sondheimer, *J.*, 1949, 615.