83. *Experiments on the Preparation of Indolocarbazoles. Part VI.* Compounds from Two of the Amino-1-phenylbenzotriazoles.*

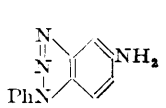
By A. R. Katritzky and S. G. P. Plant.

5-Amino-1-phenyl- and 1-*p*-aminophenyl-benzotriazole have been converted into a number of substances from which indolocarbazoles could theoretically be formed by a combination of a known carbazole synthesis with the Graebe–Ullmann reaction. Although some of these gave triazolo(5′ : 4′-3 : 4)carbazoles, the complete synthesis of an indolocarbazole along these lines has not been effected.

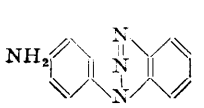
Many carbazole derivatives have been obtained by the Graebe–Ullmann reaction (*Annalen*, 1896, **291**, 16), involving the elimination of nitrogen from the appropriate 1-phenylbenzotriazole. There are other well-known carbazole syntheses which also require an aromatic primary amine as starting material. It seemed possible, therefore, that indolocarbazoles would result from amino-1-phenylbenzotriazoles by suitable combinations of these syn-

* Part V, *J.*, 1953, 116.

thetical processes. With this end in view a study has been made of several derivatives of the comparatively readily accessible 5-amino-1-phenylbenzotriazole (I) and 1-*p*-aminophenylbenzotriazole (II).



(I)



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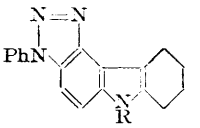

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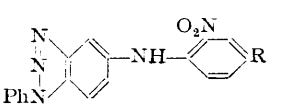
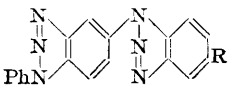


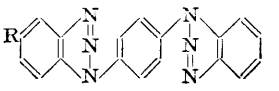
(IV)

Tetrahydrocarbazoles have been prepared by applying the Fischer indole synthesis to phenylhydrazines and *cyclo*hexanone, and it was hoped to extend this method, but the requisite hydrazine could not be obtained from either of the bases (I and II) by the usual processes.

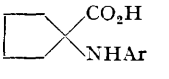
From the base (I) the substituted 5-anilino-1-phenylbenzotriazoles (IV; R = NO_2, CN, Ac, and Cl) were prepared, although the yield of one of them (IV; R = Cl) was very small, and the first three were converted into the bistriazoles (V; R = NO_2, CN, and Ac). The compound (V; R = CN) has already been prepared by an alternative route by Coker, Plant, and Turner (*J.*, 1951, 110) who were unable to effect transformation into a cyano-



(V)



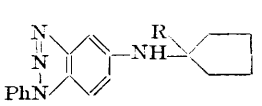
(VI)



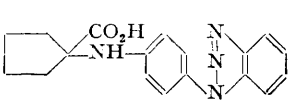
(VII)

indolocarbazole by a double Graebe–Ullmann reaction. The larger quantity of the substance now available has made it possible to study this process in more detail, as well as with the compound (V; R = Ac), albeit unsuccessfully. The compound (V; R = NO_2), obtained in less satisfactory yields, was, in consequence, not further examined because the presence of a nitro-group is known to affect the Graebe–Ullmann reaction adversely (Preston, Tucker, and Cameron, *J.*, 1942, 500). The isomeric bistriazoles (VI; R = CN and Ac) were prepared similarly from the base (II), but, since the overall yields were small and this type of bistriazole has already been examined by Clifton and Plant (*J.*, 1951, 461), they were not further studied.

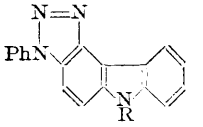
In contrast to the synthesis of carbazoles from (VII) (Plant and Facer, *J.*, 1925, **127**, 2037; Oakeshott and Plant, *J.*, 1926, 1210; 1927, 484), alkali fusion of the acids (VIII; R = CO_2H) and (IX) and the amide (VIII; R = $CO{\cdot}NH_2$) failed to give the expected carbazoles or indolocarbazoles.



(VIII)



(IX)



(X)

In an extension of a known method for the preparation of tetrahydrocarbazoles (D.R.-P. 374,098; *Chem. Zentr.*, 1923, IV, 724; Campbell and McCall, *J.*, 1950, 2870), the base (I) reacted with 2-chloro*cyclo*hexanone to give a product for which there are two possible structures, but on theoretical grounds and from analogy with related reactions (see, *e.g.*, Tomlinson, *J.*, 1951, 809; Hall and Plant, Part V) it must be regarded as 5 : 6 : 7 : 8-tetrahydro-1′-phenyltriazolo(5′ : 4′-3 : 4)carbazole (III; R = H). It was hoped that a Graebe–Ullmann reaction would occur during the dehydrogenation of this substance with palladium–charcoal above 300°, but the products were unsatisfactory. Under some conditions carbazole appeared to be formed, and it is significant that Tomlinson (*loc. cit.*) observed that carbazole resulted from the dehydrogenation of products obtained by applying a double Fischer indole synthesis to bis*cyclo*hexanone *p*-phenylenedihydrazone. Conversion into 1′-phenyltriazolo(5′ : 4′-3 : 4)carbazole (X; R = H) was effected with chloranil in boiling xylene (cf. Barclay and Campbell, *J.*, 1945, 530), but all attempts to convert this

into indolo(2′ : 3′-3 : 4)carbazole have failed. Nothing pure could be isolated in attempts to condense the base (II) with 2-chloro*cyclo*hexanone.

The degree of success which attends Graebe–Ullmann reactions varies widely among closely related substances. With this in mind the benzylidene derivative of the base (I) was reduced to 5-benzylamino-1-phenylbenzotriazole, the nitrosamine from which was converted directly into 9-benzyl-5 : 6 : 7 : 8-tetrahydro-1′-phenyltriazolo(5′ : 4′-3 : 4)carbazole (III; R = Ph·CH_2) by reduction with zinc in warm acetic acid in the presence of *cyclo*hexanone, but attempts to effect dehydrogenation to the compound (X; R = Ph·CH_2) and a Graebe–Ullmann change have not succeeded. The nitrosamine from 1-*p*-benzylaminophenylbenzotriazole, from the base (II), did not give a tetrahydrocarbazole derivative under similar conditions, no doubt because even at 15—20° zinc and acetic acid reduced it to the original benzylamino-compound in good yield.

Experimental

2 : 4′-*Dinitrodiphenylamine*.—The following method was found to be more convenient than any in the literature for the preparation of this compound in substantial amounts. A mixture of *p*-nitroaniline (90 g.), *o*-chloronitrobenzene (75 g.), potassium carbonate (75 g.), copper powder (3 g.), and potassium iodide (3 g.) was rapidly heated to 200°. After the vigorous reaction had subsided, the temperature was raised to 215° for 3 minutes, and the whole poured into a large enamelled dish and broken up while still warm. The solid was agitated with a hot mixture of dilute hydrochloric acid and ethanol, and the dried residue extracted with boiling toluene (5 l.), from which 2 : 4′-dinitrodiphenylamine (92 g.) separated on cooling; recrystallisation from glacial acetic acid gave brick red needles, m. p. 219—220°.

Substituted 5-Anilino-1-phenylbenzotriazoles (IV).—After a mixture of 5-amino-1-phenylbenzotriazole, m. p. 158° (5 g., prepared by a method essentially the same as that of Beretta, *Gazzetta*, 1925, **55**, 788), 1-chloro-2 : 4-dinitrobenzene (5·5 g.), and anhydrous sodium acetate (5 g.) had been heated on a steam-bath for 2 hours, the whole extracted with dilute hydrochloric acid, and the dried residue crystallised from acetic acid, 5-(2 : 4-dinitroanilino)-1-phenylbenzotriazole (6·2 g.) was obtained in orange needles, m. p. 229—230° (Found: C, 57·0; H, 3·6. Calc. for $C_{18}H_{12}O_4N_6$: C, 57·4; H, 3·2%). The substance is evidently the same as that (m. p. 228°) prepared by Manjunath (*J. Indian Chem. Soc.*, 1927, **4**, 271) and called "1-*p*-2′ : 4′-dinitroanilinophenylbenzotriazole." In early preparations 5-amino-1-phenylbenzotriazole was obtained in an unstable polymorphic form, m. p. 128°.

The following were similarly prepared: 5-(4-*cyano*-2-*nitroanilino*)-1-*phenylbenzotriazole* (from 4-chloro-3-nitrobenzonitrile; reaction time, 4½ hours), orange-red needles (yield, 58%), m. p. 200° (rapid heating; on slow heating it changed to a yellow form, m. p. 209°) (from acetic acid, after purification by adsorption from benzene on alumina) (Found: C, 63·6; H, 3·4. $C_{19}H_{12}O_2N_6$ requires C, 64·0; H, 3·4%); and 5-(4-*acetyl*-2-*nitroanilino*)-1-*phenylbenzotriazole* (from 4-bromo-3-nitroacetophenone with the addition of copper powder; reaction temperature, 170° for 1 hour), orange crystals (yield, 30%), m. p. 205° (from toluene, after adsorption from benzene on alumina) (Found: C, 64·0; H, 4·0. $C_{20}H_{15}O_3N_5$ requires C, 64·3; H, 4·0%).

After a mixture of 5-amino-1-phenylbenzotriazole (6 g.), 2 : 5-dichloronitrobenzene (5·1 g.), potassium carbonate (3 g.), and amyl alcohol (30 c.c.) with small amounts of potassium iodide and copper powder had been refluxed for 5 hours and the solvent removed in steam, 5-(4-*chloro*-2-*nitroanilino*)-1-*phenylbenzotriazole* (0·08 g.) was isolated from the residue by adsorption from benzene on alumina, and obtained from toluene in scarlet needles, m. p. 201—202° (Found: C, 59·4; H, 3·5. $C_{18}H_{12}O_2N_5Cl$ requires C, 59·1; H, 3·3%).

Substituted 5-(Benzotriazol-1-yl)-1-phenylbenzotriazoles (V).—After crystalline sodium sulphide (1 g.) in water (1 c.c.) had been added to 5-(2 : 4-dinitroanilino)-1-phenylbenzotriazole (1 g.) in boiling ethanol (30 c.c.), the whole was boiled for 5 minutes and filtered. The solid which separated from the filtrate on cooling was immediately treated in boiling ethanol first with aqueous sodium nitrite (0·5 c.c. of 50%) and then with concentrated hydrochloric acid (1 c.c.). When the precipitate was crystallised from acetic acid, 5-(5-*nitrobenzotriazol*-1-*yl*)-1-*phenylbenzotriazole* (0·05 g.) separated in colourless prisms, m. p. 314° (Found: C, 59·9; H, 3·2. $C_{18}H_{11}O_2N_7$ requires C, 60·5; H, 3·1%).

Sodium hydrosulphite (dithionite) (12 g.) was gradually added to a boiling solution of 5-(4-cyano-2-nitroanilino)-1-phenylbenzotriazole (4 g.) in acetic acid (100 c.c.), and the whole boiled for 5 minutes. The hot mixture was filtered under suction, and sodium nitrite (1·2 g.) in water (2·5 c.c.) added dropwise to the boiling filtrate. The 5-(5-cyanobenzotriazol-1-yl)-1-

phenylbenzotriazole (3·5 g.) which separated on cooling was obtained from acetic acid in colourless prisms, m. p. 311°, identical (mixed m. p.) with the substance prepared by Coker, Plant, and Turner (*loc. cit.*) by another route. Prepared like the cyano-compound, 5-(5-*acetylbenzotriazol*-1-*yl*)-1-*phenylbenzotriazole* (yield, 60%) crystallised from acetic acid in pale yellow prisms, m. p. 295° (Found: N, 23·6. $C_{20}H_{14}ON_6$ requires N, 23·7%).

Substituted 1-p-*Anilinophenylbenzotriazoles*.—A mixture of 1-*p*-aminophenylbenzotriazole (1 g.; prepared from 2 : 4′-dinitrodiphenylamine; cf. Nietzki and Baur, *Ber.*, 1895, **28**, 2977), 1-chloro-2 : 4-dinitrobenzene (1·1 g.), and anhydrous sodium acetate (1 g.) was heated for an hour on the steam-bath. After the whole had been ground with ethanol–dilute hydrochloric acid, the residue was twice recrystallised from acetic acid, and 1-p-(2 : 4-*dinitroanilino*)*phenylbenzotriazole* (0·9 g.) obtained in orange needles, m. p. 248° (Found: C, 58·1; H, 3·3%).

The following were similarly prepared: 1-p-(4-*cyano*-2-*nitroanilino*)*phenylbenzotriazole* (from 4-chloro-3-nitrobenzonitrile, with potassium carbonate and a little copper powder instead of sodium acetate; reaction time, 3½ hours), orange prisms (yield, 23%), m. p. 246° (from acetic acid) (Found: C, 63·9; H, 3·5%), and 1-p-(4-*acetyl*-2-*nitroanilino*)*phenylbenzotriazole* (from 4-bromo-3-nitroacetophenone with copper powder; reaction temperature, 180° for 1 hour), yellow prisms (yield, 22%), m. p. 225—227° (from ethanol, after adsorption from benzene on alumina) (Found: C, 64·2; H, 3·8%).

Substituted 1-p-(*Benzotriazol*-1-*yl*)*phenylbenzotriazoles* (VI).—Prepared as described above for the isomeric compounds 1-p-(5-*cyanobenzotriazol*-1-*yl*)*phenylbenzotriazole* (yield, 38%) separated from nitrobenzene in colourless prisms, m. p. above 360°, containing solvent of crystallisation (Found: C, 64·8; H, 3·3. $C_{19}H_{11}N_7,C_6H_5O_2N$ requires C, 65·2; H, 3·5%), and 1-p-(5-*acetylbenzotriazol*-1-*yl*)*phenylbenzotriazole* (yield, 70%) from acetic acid in orange prisms, m. p. 269—271° (Found: N, 23·9%).

5-(1-*Carboxy*cyclo*pentylamino*)-1-*phenylbenzotriazole* (VIII; R = CO_2H) *and* 1-p-(1-*Carboxy*-cyclo*pentylamino*)*phenylbenzotriazole* (IX).—When *cyclo*pentanone (2·25 g.) was gradually added to a solution of 5-amino-1-phenylbenzotriazole (5 g.) in acetic acid (25 c.c.) which had been treated with potassium cyanide (2 g.) in water (5 c.c.), and the whole then kept at 40—45° for 6 hours, 5-(1-*cyano*cyclo*pentylamino*)-1-*phenylbenzotriazole* (6·5 g.), colourless plates, m. p. 139° (from ethanol), separated (Found: C, 71·0; H, 5·8. $C_{18}H_{17}N_5$ requires C, 71·3; H, 5·6%). On being refluxed with concentrated hydrochloric acid for 5 hours it was converted back to 5-amino-1-phenylbenzotriazole. After a solution of the cyano-compound (6·5 g.) in concentrated sulphuric acid (65 c.c.) had been left at room temperature for 2 days and then poured on ice, the addition of ammonia in the cold precipitated 5-(1-*carbamyl*cyclo*pentylamino*)-1-*phenylbenzotriazole* (6 g.), colourless prisms, m. p. 228° (from amyl alcohol) (Found: C, 66·9; H, 6·0; N, 22·2. $C_{18}H_{19}ON_5$ requires C, 67·3; H, 5·9; N, 21·8%). In early experiments a more soluble, unstable polymorphic form of the amide was obtained from aqueous ethanol in colourless prisms, m. p. 210°. The amide (5·3 g.) was refluxed for 6 hours with concentrated hydrochloric acid (53 c.c.), the whole evaporated to dryness, the residue dissolved in aqueous sodium hydroxide, and the filtered solution acidified with acetic acid. The precipitated 5-(1-*carboxy*-cyclo*pentylamino*)-1-*phenylbenzotriazole* (1·9 g.) separated from aqueous ethanol in colourless needles, m. p. 227—228° (Found: C, 67·2; H, 5·4; N, 17·6. $C_{18}H_{18}O_2N_4$ requires C, 67·1; H, 5·6; N, 17·4%).

The following were prepared from 1-*p*-aminophenylbenzotriazole as for the isomers just described: 1-p-(1-*cyano*cyclo*pentylamino*)*phenylbenzotriazole* (yield, 70%; reaction time, 15 hours), pale brown prisms, m. p. 165° (from ethanol; prolonged boiling with the solvent regenerated the original amine) (Found: C, 71·6; H, 6·1%), 1-p-(1-*carbamyl*cyclo*pentylamino*)-*phenylbenzotriazole* (yield almost quantitative), colourless needles, m. p. 204° (from aqueous ethanol) (Found: C, 67·2; H, 5·9%), and 1-p-(1-*carboxy*cyclo*pentylamino*)*phenylbenzotriazole* (yield almost quantitative; reaction time, 1 hour), practically colourless prisms, m. p. 232—233° (decomp.) (from aqueous ethanol) (Found: C, 66·9; H, 5·7%).

1′-*Phenyltriazolo*(5′ : 4′-3 : 4)*carbazole* (X; R = H).—A mixture of 5-amino-1-phenylbenzotriazole (12 g.) and 2-chloro*cyclo*hexanone (3·8 g.) was rapidly heated to 160°, and, after the vigorous reaction had subsided, the whole was cooled a little and extracted with hot dilute hydrochloric acid. Original amine (4·5 g.) was recovered from the extract, while the residue gave 5 : 6 : 7 : 8-*tetrahydro*-1′-*phenyltriazolo*(5′ : 4′-3 : 4)*carbazole* (5·1 g.) in colourless prisms, m. p. 222°, on crystallisation from aqueous ethanol (Found: C, 75·0; H, 5·6. $C_{18}H_{16}N_4$ requires C, 75·0; H, 5·6%). A mixture of the tetrahydro-compound (5·1 g.), chloranil (8·7 g.), and xylene (170 c.c.) was refluxed for 24 hours, then filtered whilst hot, and the solid which separated on cooling extracted with aqueous sodium hydroxide. After the residual 1′-*phenyl*-

triazolo(5′ : 4′-3 : 4)*carbazole* (2 g.) had been purified by adsorption from benzene on alumina, it crystallised from benzene in colourless plates, m. p. 252° (Found : C, 76·2; H, 4·6. $C_{16}H_{12}N_4$ requires C, 76·1; H, 4·2%).

5-N-*Nitrosobenzylamino*-1-*phenylbenzotriazole and* 1-p-N-*Nitrosobenzylaminophenylbenzotriazole*. —5-Benzylideneamino-1-phenylbenzotriazole, prepared by heating 5-amino-1-phenylbenzotriazole (5 g.) with benzaldehyde (2·8 g.) on the steam-bath for ½ hour, crystallised from ethanol in colourless plates (5·4 g.), m. p. 139° [Fries (*Annalen*, 1927, **454**, 153) gives m. p. 137°] (Found : C, 76·2; H, 4·6. Calc. for $C_{19}H_{14}N_4$: C, 76·5; H, 4·7%). After this compound (5·4 g.) in dioxan (120 c.c.) had been shaken for 2 hours with hydrogen in the presence of palladium–strontium carbonate at atmospheric temperature and pressure, and the solution filtered, removal of the solvent left 5-*benzylamino*-1-*phenylbenzotriazole* (5·4 g.), colourless needles, m. p. 111° (from aqueous ethanol) (Found : C, 75·8; H, 5·0. $C_{19}H_{16}N_4$ requires C, 76·0; H, 5·3%). Addition of a slight excess of aqueous sodium nitrite to the benzylamino-compound (5·4 g.) in acetic acid (70 c.c.) in the cold, and dilution with water, precipitated 5-N-*nitrosobenzylamino*-1-*phenylbenzotriazole* (5·4 g.), colourless prisms, m. p. 141° (from ethanol) (Found : C, 69·4; H, 4·8. $C_{19}H_{15}ON_5$ requires C, 69·3; H, 4·6%).

The following were prepared similarly from 1-*p*-aminophenylbenzotriazole : 1-p-*benzylideneaminophenylbenzotriazole* (yield, 75%), pale brown prisms, m. p. 143—145° (from ethanol) (Found : C, 76·9; H, 5·1%); 1-*p*-benzylaminophenylbenzotriazole (almost quantitative yield), a viscous syrup, which gave a *hydrochloride*, colourless plates, m. p. 223° (from ethanol–dilute hydrochloric acid) (Found : C, 67·8; H, 5·3. $C_{19}H_{17}N_4Cl$ requires C, 67·8; H, 5·1%); and 1-p-N-*nitrosobenzylaminophenylbenzotriazole* (yield, 80%), pale yellow needles, m. p. 155° (from ethanol) (Found : C, 69·4; H, 4·4%).

9-*Benzyl*-5 : 6 : 7 : 8-*tetrahydro*-1′-*phenyltriazolo*(5′ : 4′-3 : 4)*carbazole* (III; R = Ph·CH_2).— Zinc dust (6·8 g.) was gradually added during ¼ hour, with stirring, to a suspension of 5-*N*-nitrosobenzylamino-1-phenylbenzotriazole (4 g.) in a mixture of acetic acid (40 c.c.), water (12 c.c.), and *cyclo*hexanone (4 c.c.) at 55°. When the temperature was then slowly raised to 90° and kept there for 5 minutes, 9-*benzyl*-5 : 6 : 7 : 8-*tetrahydro*-1′-*phenyltriazolo*(5′ : 4′-3 : 4)*carbazole*, colourless needles (2·2 g.), m. p. 172° (from amyl alcohol), separated (Found : C, 79·2; H, 5·7. $C_{25}H_{22}N_4$ requires C, 79·4; H, 5·8%).

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