470. *Benzo*[c]*cinnolines. The Nitration of Benzo*[c]*cinnoline and its* N*-Oxide.*

By J. W. Barton and M. A. Cockett.

Nitration of benzo[*c*]cinnoline in sulphuric acid gives a mixture of 1- and 4-nitrobenzo[*c*]cinnolines. Nitration of benzo[*c*]cinnoline 5-oxide in the same medium gives a mixture of 1- and 4-nitrobenzo[*c*]cinnoline 6(or 5)-oxides, but with nitric acid alone the main product is 2-nitrobenzo[*c*]cinnoline 6-oxide. Three of the four mononitrobenzo[*c*]cinnolines have been synthesised unambiguously from biphenyl derivatives, and the four monoaminobenzo[*c*]cinnolines have been characterised.

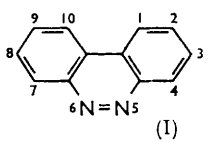
Although electrophilic substitution in benzo[*c*]cinnoline (I) has been studied theoretically, experimental verification has not yet been forthcoming. The molecular-orbital treatments of the neutral molecule by Pullman [1] and by Longuet-Higgins and Coulson [2] suggested that the 1- and the 3-position would be most active towards electrophilic reagents. A more recent treatment by Dewar and Maitlis,[3] with allowance for protonation during nitration in sulphuric acid, gave essentially the same order of reactivity, *i.e.*, $1 > 3 > 4 > 2$.

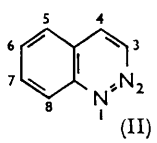
Smith and Ruby [4] nitrated benzo[*c*]cinnoline with a mixture of nitric and sulphuric acids below 30° and obtained 1-nitrobenzo[*c*]cinnoline together with an isomer thought to be 3-nitro-compound. Their result is now confirmed, although rather surprisingly the other isomer is shown to be the 4-nitro-compound, as has been mentioned in a recent paper by Corbett and Holt [5] on the bromination of benzo[*c*]cinnoline. This is in keeping with the observation that 1,10-dimethylbenzo[*c*]cinnoline can be nitrated in the 4- and the 7-position.[6] Arcos, Arcos, and Miller [7] nitrated benzo[*c*]cinnoline with one equivalent of nitric acid in sulphuric acid at 80° and reported the production of another isomer, "*y*-nitrobenzo[*c*]cinnoline," m. p. 141—142°. However, repetition of this work has shown isomer "*y*" to be a mixture of 1- and 4-nitrobenzo[*c*]cinnoline as obtained by Smith and Ruby.

This nitration pattern corresponds to that of cinnoline (II), which is nitrated in the 5- and the 8-position under similar conditions.[8] In no case was 3-nitrobenzo[*c*]cinnoline isolated.

[1] Pullman, *Rev. sci.*, 1948, **86**, 219.
[2] Longuet-Higgins and Coulson, *J.*, 1949, 971.
[3] Dewar and Maitlis, *J.*, 1957, 2521.
[4] Smith and Ruby, *J. Amer. Chem. Soc.*, 1954, **76**, 5807.
[5] Corbett and Holt, *J.*, 1961, 5029.
[6] Theilacker and Baxmann, *Annalen*, 1953, **581**, 117.
[7] Arcos, Arcos, and Miller, *J. Org. Chem.*, 1956, **21**, 651.
[8] Morley, *J.*, 1951, 1971; Alford and Schofield, *J.*, 1953, 609.

1-Nitrobenzo[*c*]cinnoline being known, the other three mononitro-compounds required for reference were synthesised from 2,2′-diaminobiphenyl. Nitration in sulphuric acid solution gave a fair yield of 2,2′-diamino-4-nitrobiphenyl (IV; R = R″ = H, R′ = NO_2), the position of the nitro-group being confirmed by the formation of 4-nitrobiphenyl together with 3-nitrobenzo[*c*]cinnoline (V; R = R″ = H, R′ = NO_2) when the bis-diazonium chloride of the diamine was reduced with hypophosphorous acid. Attempts


(I)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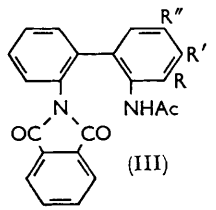
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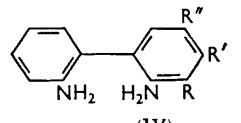
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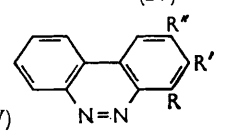
(V)

to prepare the mononitro-derivative of 2,2′-diacetamidobiphenyl gave only mixtures of starting material with 2,2′-diacetamido-5,5′-dinitrobiphenyl; this parallels the nitration of 2,2′-dibromobiphenyl.[9] However, it was found that 2-acetamido-2′-phthalimidobiphenyl, in which the activation due to one amino-group is largely suppressed, underwent nitration in a mixture of acetic acid and acetic anhydride to give a mixture of 2-acetamido-3-nitro- and 2-acetamido-5-nitro-2′-phthalimidobiphenyl (III; R = NO_2, R′ = R″ = H) and (III; R = R′ = H, R″ = NO_2). Hydrolysis gave the corresponding diamines (IV; R = NO_2, R′ = R″ = H) and (IV; R = R′ = H, R″ = NO_2) which both gave 3-nitrobiphenyl together with 4- and 2-nitrobenzo[*c*]cinnolines (V; R = NO_2, R′ = R″ = H) and (V; R = R′ = H, R″ = NO_2) when the bisdiazonium salts were reduced. The lower-melting of the two diamines was identified as 2,2′-diamino-3-nitrobiphenyl, by diazotisation and treatment with potassium iodide which gave a mixture of 3-nitrobiphenylylene-2,2′-iodonium iodide and 2,2′-di-iodo-3-nitrobiphenyl. These two compounds were identical with those produced by the oxidation and cyclisation of 2-iodo-3-nitrobiphenyl, a compound of known structure.[10] The diamines were converted into the corresponding nitrobenzo[*c*]cinnolines by oxidation with phenyl iodosodiacetate in benzene,[11] this method giving better yields than did reduction of the bisdiazonium salts. Since the completion of this work, excellent results have been obtained by using sodium perborate in acetic acid for such oxidations.[12]

Previous work on the nitration of benzo[*c*]cinnoline 5-oxide has given conflicting results. King and King [13] nitrated benzo[*c*]cinnoline 5-oxide in fuming nitric acid at 90° and obtained what they considered to be a mixture of 2- and 3-nitrobenzo[*c*]cinnoline 6-oxides, although, as a result of dipole moment studies by Calderbank and Le Fèvre,[14] they withdrew their conclusions regarding the structures. Repetition of this work by Arcos, Arcos, and Miller [7] gave what was thought to be a dinitrobenzo[*c*]cinnoline dioxide. We found that considerable decomposition occurred under the conditions specified by King and King, but that benzo[*c*]cinnoline 5-oxide was nitrated by fuming nitric acid below 40° to give 2-nitrobenzo[*c*]cinnoline 6-oxide together with small amounts of 2-nitrobenzo[*c*]cinnoline 5,6-dioxide. The monoxide corresponded to the 2-nitro-compound described by King and King, but under these conditions no other isomer was isolated. The orientation of the nitro-group in both the mono- and the di-oxide was demonstrated by reduction

[9] Baker, McOmie, Preston, and Rogers, *J.*, 1960, 414.
[10] Sako, *Bull. Chem. Soc. Japan*, 1934, **9**, 55.
[11] Pausacker, *J.*, 1953, 1989.
[12] Corbett and Holt, *J.*, 1961, 3695.
[13] King and King, *J.*, 1945, 824.
[14] Calderbank and Le Fèvre, *J.*, 1951, 649.

with stannous chloride which gave 2-aminobenzo[*c*]cinnoline, identical with that produced by the reduction of 2-nitrobenzo[*c*]cinnoline. The mononitro-derivative was shown to be the 6-oxide in the following way. Reduction with hydrazine hydrate and Raney nickel gave the rather unstable highly fluorescent 2-aminobenzo[*c*]cinnoline 6-oxide which was converted into 2-bromobenzo[*c*]cinnoline 6-oxide by the Sandmeyer reaction. The latter compound gave 2-bromobenzo[*c*]cinnoline on reduction with stannous chloride and was identical with a sample prepared from 2-acetamido-2′-nitrobiphenyl by bromination, hydrolysis, and reaction of the resulting 2-amino-5-bromo-2′-nitrobiphenyl with base, a method similar to that of Corbett and Holt [5] being used.

Arcos, Arcos, and Miller [7] also nitrated benzo[*c*]cinnoline 5-oxide with one equivalent of nitric acid in sulphuric acid at 80° and obtained an isomer, " *x*-nitrobenzo[*c*]cinnoline oxide," m. p. 208—210°. We find this to be a mixture of a 1-nitrobenzo[*c*]cinnoline oxide, m. p. 247—248°, and a 4-nitrobenzo[*c*]cinnoline oxide, m. p. 259—260°. Both compounds have been obtained by oxidation of the corresponding nitrobenzo[*c*]cinnolines with hydrogen peroxide and on reduction they gave 1- and 4-aminobenzo[*c*]cinnoline, respectively.

Thus the nitration pattern of benzo[*c*]cinnoline 5-oxide in sulphuric acid is similar to that of benzo[*c*]cinnoline. The change of orientation in the absence of sulphuric acid may be due to a lesser degree of protonation of the substrate, or, more likely, to attack by a different species, possibly a nitrous acid-catalysed nitration.[15]

The four monoaminobenzo[*c*]cinnolines have been fully characterised for the first time and their ultraviolet spectra recorded in ethanol. The variation of the spectra with pH and the ionisation constants of the compounds will be discussed in a later paper. The conversion of 2-aminobenzo[*c*]cinnoline into 2-bromobenzo[*c*]cinnoline is described; attempts to carry out the same reaction on the 4-amino-compound have failed, although 4-iodobenzo[*c*]cinnoline can be obtained from it in the usual manner.

Experimental

Benzo[*c*]cinnoline was prepared from 2,2′-dinitrobiphenyl [16] by the method of Moore and Furst [17] (average yield 70%).

Nitration of Benzo[c]*cinnoline.*—A solution of benzo[*c*]cinnoline (8 g.) in concentrated sulphuric acid (100 ml.) was stirred whilst nitric acid (3 ml.; *d* 1·4) in concentrated sulphuric acid (30 ml.) was added dropwise. The solution was heated at 80—90° with occasional swirling for 2 hr., cooled, and poured on ice. The product gave the sparingly soluble 4-nitrobenzo[*c*]-cinnoline [from benzene] as yellow leaflets, m. p. and mixed m. p. 237—238° (Found: C, 64·4; H, 3·2. Calc. for $C_{12}H_7N_3O_2$: C, 64·0; H, 3·1%). The benzene solution was concentrated and chromatographed on alumina (35 × 5 cm.) with benzene as eluent, giving 1-nitro-benzo[*c*]cinnoline as yellow needles (5·6 g., 56%), m. p. 162—163° (from ethanol) (Found: C, 63·7; H, 3·2%). A second slow-moving band gave more 4-nitrobenzo[*c*]cinnoline (total yield 1·5 g., 15%). The two compounds were identical with those obtained by the method of Smith and Ruby.[4]

2,2′-*Diamino*-4-*nitrobiphenyl.*—2,2′-Diaminobiphenyl (18·4 g.) in concentrated sulphuric acid (150 ml.) was stirred at 0—5° whilst nitric acid (7 ml., *d* 1·5) in concentrated sulphuric acid (30 ml.) was added dropwise. The solution was stirred at this temperature for 2 hr. and then poured on ice. It was neutralised until oily droplets started to separate, and then filtered and basified. The red oil, collected by ether extraction, was fractionated and gave a fore-run of starting material (6·1 g.) and 2,2′-*diamino*-4-*nitrobiphenyl* (6·0 g.), b. p. 190—200°/0·35 mm., as orange-red plates, m. p. 89—90° (from ethanol) (Found: C, 62·95; H, 5·1; N, 18·2. $C_{12}H_{11}N_3O_2$ requires C, 62·9; H, 4·8; N, 18·3%). The *diacetyl* derivative formed yellow prisms, m. p. 174·5—176° (from aqueous ethanol) (Found: C, 61·0; H, 4·8; N, 13·7. $C_{16}H_{15}N_3O_4$ requires C, 61·4; H, 4·8; N, 13·4%).

[15] de la Mare and Ridd, " Aromatic Substitution," Butterworths, London, 1959, p. 99.
[16] Kornblum and Kendall, *J. Amer. Chem. Soc.*, 1952, **74**, 5782.
[17] Moore and Furst, *J. Org. Chem.*, 1958, **23**, 1504.

3-*Nitrobenzo*[c]*cinnoline*.—(*a*) 2,2′-Diamino-4-nitrobiphenyl (5 g.) in concentrated hydrochloric acid (20 ml.) and water (20 ml.) was diazotised at 0—5° with sodium nitrite (3·2 g.) in a little water. The solution was treated with 50% hypophosphorous acid (35 ml.; pre-cooled to 0°), stirred for 1 hr., and cooled in the refrigerator for 24 hr. After a further 48 hr. at room temperature the solution was diluted and the solid collected. Extraction with concentrated hydrochloric acid–water (2 : 1) and re-precipitation by dilution gave 3-*nitrobenzo*[c]*cinnoline*, yellow leaflets (1·1 g., 22%), m. p. 255—257° (from benzene). Further crystallisation gave material, m. p. 258—259° (Found: C, 63·9; H, 3·1; N, 18·5. $C_{12}H_7N_3O_2$ requires C, 64·0; H, 3·1; N, 18·7%). Prolonged steam distillation of the acid-insoluble material gave 4-nitrobiphenyl (1·2 g., 27·5%), m. p. and mixed m. p. 113—114°.

(*b*) 2,2′-Diamino-4-nitrobiphenyl (1·15 g.) in dry benzene (100 ml.) was treated with phenyl iodosodiacetate (3·2 g.) and kept for 2 days at room temperature. The filtered solution was washed with 5% sodium carbonate solution, dried, and concentrated. Chromatography on alumina with benzene as eluent gave 3-nitrobenzo[*c*]cinnoline (0·78 g., 69·5%), m. p. 258—259°.

2-Acetamido-2′-phthalimidobiphenyl was prepared by Sako's method.[18] It formed prisms, m. p. 163—164° (from ethanol), not 145° as previously reported.

Nitration of 2-Acetamido-2′-phthalimidobiphenyl.—The compound (20 g.) in acetic acid (15 ml.) and acetic anhydride (12 ml.) was stirred at 20—25° during the dropwise addition of nitric acid (5 ml.; *d* 1·5) in acetic acid (4 ml.). After 3 hr. the reaction mixture was poured into water, and the solid collected. Two crystallisations from benzene gave 2-*acetamido*-5-*nitro*-2′-*phthalimidobiphenyl* (10 g., 44·5%), pale yellow plates, m. p. 268—270° (Found: C, 65·9; H, 3·9; N, 10·9. $C_{22}H_{15}N_3O_5$ requires C, 65·9; H, 3·9; N, 10·5%). Evaporation of the mother-liquor and crystallisation of the residue from ethanol gave crude 2-acetamido-3-nitro-2′-phthalimidobiphenyl (7·9 g., 35%) as pale yellow microcrystals, m. p. 210—217°. Crystallisation from various solvents failed to improve the melting range and the material was hydrolysed without further purification.

2,2′-*Diamino*-5-*nitrobiphenyl*.—2-Acetamido-5-nitro-2′-phthalimidobiphenyl (10 g.) and hydrazine hydrate (2·5 ml.) in ethanol (100 ml.) were refluxed for 30 min. The resulting paste was refluxed with concentrated hydrochloric acid (100 ml.) for 4 hr. The solution was diluted with water (200 ml.), cooled, and filtered. Neutralisation with ammonia gave a yellow oil which solidified (5·7 g.). Crystallisation from aqueous ethanol gave 2,2′-*diamino*-5-*nitrobiphenyl* as yellow needles, m. p. 128—129° (Found: C, 63·1; H, 5·0; N, 18·5. $C_{12}H_{11}N_3O_2$ requires C, 62·9; H, 4·8; N, 18·3%).

2-*Nitrobenzo*[c]*cinnoline*.—(*a*) By method (*a*) above, 2,2′-diamino-5-nitrobiphenyl (2 g.) gave 2-*nitrobenzo*[c]*cinnoline* (0·85 g., 43%) as yellow needles, m. p. 269—270° (from ethanol) (Found: C, 64·1; H, 3·2; N, 18·6. $C_{12}H_7N_3O_2$ requires C, 64·0; H, 3·1; N, 18·7%). The acid-insoluble portion was chromatographed on alumina in benzene, giving 3-nitrobiphenyl (0·3 g., 18%), m. p. 58—60°.

(*b*) Method (*b*) above, applied to 2,2′-diamino-5-nitrobiphenyl (1·15 g.), gave 2-nitrobenzo[*c*]cinnoline (0·53 g., 47%), m. p. 269—270°, from ethanol.

2,2′-*Diamino*-3-*nitrobiphenyl*.—Hydrolysis of the crude acyl derivative, m. p. 210—217°/(1 g.), by the method used for the 5-nitro-isomer gave the *diamine* as yellow needles (0·5 g., 88%), m. p. 96—98° (from aqueous ethanol). Further crystallisation gave material with m. p. 99—100° (Found: C, 62·7; H, 4·8; N, 18·1. $C_{12}H_{11}N_3O_2$ requires C, 62·9; H, 4·8; N, 18·3%).

4-*Nitrobenzo*[c]*cinnoline*.—(*a*) By method (*a*) above, 2,2′-diamino-3-nitrobiphenyl (1 g.) gave 4-nitrobenzo[*c*]cinnoline (0·15 g., 15%), m. p. and mixed m. p. with a sample from the nitration of benzo[*c*]cinnoline, 237—238°. Chromatography of the acid-insoluble material on alumina in benzene gave 3-nitrobiphenyl (0·33 g., 41%) together with a trace of what was presumed to be 1-nitrocarbazole, m. p. 188—189° (lit.,[19] m. p. 185—187°).

(*b*) Method (*b*) above, applied to 2,2′-diamino-3-nitrobiphenyl (1·15 g.), gave 4-nitrobenzo[*c*]-cinnoline (0·41 g., 37%), m. p. 236—238°.

3-*Nitrobiphenylylene*-2,2′-*iodonium Iodide and* 2,2′-*Di-iodo*-3-*nitrobiphenyl*.—(*a*) (cf. Sandin and his co-workers [20]) 2-Iodo-3-nitrobiphenyl [9] (5 g.) in acetic anhydride (10 ml.) was added to a solution of peracetic acid [from 30% hydrogen peroxide (5 ml.) and acetic anhydride (20 ml.)]. After 24 hr. the solution was stirred at 0° and treated with concentrated sulphuric acid (5 ml.)

[18] Sako, *Mem. Coll. Eng., Kyushu Imp. Univ.*, 1932, **6**, 307 (*Chem. Abs.*, 1932, **26**, 3248).
[19] Barclay and Campbell, *J.*, 1945, 530.
[20] Collette, McGreer, Crawford, Chubb, and Sandin, *J. Amer. Chem. Soc.*, 1956, **78**, 3819.

dropwise. After a further 6 hr. the solution was diluted. The resulting suspension was shaken with benzene and filtered, the solid and the aqueous layer being taken up in boiling water (1 l.). Treatment with sodium pyrosulphite (*ca.* 0·5 g.) followed by excess of potassium iodide gave 3-nitrobiphenylylene-2,2′-iodonium iodide as a lemon-yellow powder (6·5 g., 95%), m. p. 184—186° (decomp.) after trituration with methanol. The residue from the benzene extract gave starting material (0·1 g.). The iodonium iodide (1 g.) was gently heated until decomposition started. On cooling, 2,2′-*di-iodo*-3-*nitrobiphenyl* was extracted with acetone and crystallised from methanol (0·86 g., 86%). After recrystallisation it formed yellow plates, m. p. 107—108° (Found: C, 32·1; H, 1·7; N, 2·9. $C_{12}H_7I_2NO_3$ requires C, 31·9; H, 1·55; N, 3·1%).

(*b*) 2,2′-Diamino-3-nitrobiphenyl (0·5 g.) was diazotised, as in the preparation of 4-nitrobenzo[*c*]cinnoline, and treated with a cold concentrated solution of potassium iodide (2 g.). The solution was allowed to warm to room temperature, stirred for 1 hr., and then warmed on the water-bath until the evolution of nitrogen ceased. On cooling, the resulting suspension was treated with sodium pyrosulphite, stirred with benzene (25 ml.), and filtered. The solid was triturated with hot methanol leaving 3-nitrobiphenylylene-2,2′-iodonium iodide (0·35 g., 35·5%), m. p. 181—184° (decomp.). The benzene layer was concentrated and chromatographed on alumina giving 2,2′-di-iodo-3-nitrobiphenyl as yellow plates from methanol (0·2 g., 20%), m. p. and mixed m. p. with a sample prepared by method (*a*), 107—108°.

Nitration of Benzo[c]*cinnoline* 5-*Oxide*.—(*a*) The oxide (19·6 g.) was added in portions during 20 min. to stirred nitric acid (150 ml.; *d* 1·5), the temperature being kept below 40°. After a further 1 hr. the solution was poured into water. The precipitate was crystallised from *NN*-dimethylformamide giving 2-nitrobenzo[*c*]cinnoline 6-oxide (16·6 g., 69%). Recrystallisation from acetic acid gave yellow needles, m. p. 274—276° (decomp.) (lit.,[13] 269°). The mother-liquor was diluted and the precipitate crystallised successively from aqueous *NN*-dimethylformamide and acetic acid giving 2-*nitrobenzo*[c]*cinnoline* 5,6-*dioxide* as yellow needles (3·5 g., 13·5%), m. p. 258—259° (Found: C, 56·1; H, 2·7. $C_{12}H_7N_3O_4$ requires C, 56·1; H, 2·7%).

(*b*) A solution of the oxide in concentrated sulphuric acid (120 ml.) was stirred whilst nitric acid (3·9 ml.; *d* 1·42) in concentrated sulphuric acid (45 ml.) was added dropwise. The solution was heated at 70—80° with occasional swirling for 2 hr., cooled, and poured on ice. The precipitate was extracted with benzene (Soxhlet) for 48 hr., during which time 4-*nitrobenzo*[c]*cinnoline* 6(*or* 5)-*oxide* (3·8 g., 26%), m. p. 258—260°, crystallised from the extract. It crystallised from acetic acid as pale yellow plates, m. p. 259—260° (Found: C, 59·3; H, 2·9; N, 17·4. $C_{12}H_7N_3O_3$ requires C, 59·8; H, 2·9; N, 17·4%). The benzene extract was evaporated and the residue crystallised from acetic acid giving 1-*nitrobenzo*[c]*cinnoline* 6(*or* 5)-*oxide* (6·4 g., 43%), m. p. 234—240°, finally raised to 247—248° (Found: C, 60·0; H, 3·1; N, 17·3%).

1-*Nitrobenzo*[c]*cinnoline* 5- *and* 6-*Oxides*.—A suspension of 1-nitrobenzo[*c*]cinnoline (8 g.) in acetic acid (60 ml.) was kept at 80° for 7 hr. with 30% hydrogen peroxide (6 ml.). On cooling, the solid was collected and fractionally crystallised from benzene, giving two monoxides, one (4·4 g.), m. p. 245—247°, and a more soluble one (3·0 g.), m. p. 217—220°. The former crystallised from acetic acid as pale yellow prisms, m. p. and mixed m. p. with a sample from the nitration of benzo[*c*]cinnoline 5-oxide by method (*b*) 247—248°. The more soluble *oxide* was recrystallised from benzene giving pale yellow needles, m. p. 226—227° (Found: C, 59·6; H, 3·1; N, 17·5%).

Oxidation of 4-*Nitrobenzo*[c]*cinnoline*.—4-Nitrobenzo[*c*]cinnoline (0·5 g.) was oxidised by the method used in the previous experiment. The product was crystallised from a large volume of benzene, giving pale yellow plates (0·35 g.), m. p. 240—245°. Further crystallisation gave 4-nitrobenzo[*c*]cinnoline 6(or 5)-oxide (0·3 g.), m. p. and mixed m. p. with a sample from the nitration of benzo[*c*]cinnoline 5-oxide by method (*b*) above, 258—260°. The mother-liquor gave a mixture which was not further investigated.

Reduction of Nitrobenzo[c]*cinnolines and Nitrobenzo*[c]*cinnoline Oxides*.—The nitro-compound (2 g.), stannous chloride dihydrate (10 g.) (for 2-nitrobenzo[*c*]cinnoline 5,6-dioxide the amount of stannous chloride was increased to 15 g.), concentrated hydrochloric acid (15 ml.), and ethanol (15 ml.) were heated on the water-bath for 30 min. The cooled solution was made basic with sodium hydroxide and cooled to 0°. The amine was collected and recrystallised from aqueous ethanol (yields varied from 68% to 90%).

1-*Aminobenzo*[c]*cinnoline*.—Orange needles, m. p. 167—168° (lit.,[4] m. p. 167°), $\lambda_{max.}$ (in ethanol) 224, 297·5, 403 mμ (log ε 4·43, 4·33, 3·42, respectively). The colour in 2N-hydrochloric acid was red-violet. The *acetyl* derivative was obtained as yellow needles, m. p. 257—258°, from ethanol (Found: C, 70·6; H, 4·8. $C_{14}H_{11}N_3O$ requires C, 70·9; H, 4·65%).

2-*Aminobenzo*[c]*cinnoline*.—This formed pale yellow needles, m. p. 244—245° (lit.,[13] m. p. 243°), showing a weak green fluorescence in ethanolic solution, $\lambda_{max.}$ (in ethanol) 251, 307·5, 386 mμ (log ε 4·71, 3·86, 4·25, respectively). The acetyl derivative formed yellow needles, m. p. 239—240°, from ethanol (lit.,[13] m. p. 233°) (Found: C, 70·9; H, 4·9%).

3-*Aminobenzo*[c]*cinnoline*.—This was prepared by the reduction of 3-nitrobenzo[*c*]cinnoline and also by the reduction of 2,2,4′-trinitrobiphenyl [21] with hydrazine and Raney nickel, as in the preparation of benzo[*c*]cinnoline [17] (yield 59%). It formed orange needles, m. p. 162—163° (lit.,[7] m. p. 163—165°), $\lambda_{max.}$ (in ethanol) 245, 272, 420 mμ (log ε 4·29, 4·72, 3·36, respectively). The colour in 2N-hydrochloric acid was red-violet. The *acetyl* derivative was obtained as pale yellow needles, m. p. 296—297°, from ethanol (Found: C, 71·0; H, 4·6%).

4-*Aminobenzo*[c]*cinnoline*.—This formed deep golden needles, m. p. 206—207° (lit.,[4] m. p. 198—200°), $\lambda_{max.}$ (in ethanol) 240, 268, 301, 331, 433 mμ (log ε 4·58, 3·95, 4·24, 3·62, 3·71, respectively). The colour in 2N-hydrochloric acid was deep blue. The *acetyl* derivative was obtained as yellow needles, m. p. 194—195°, from ethanol (Found: C, 71·0; H, 4·55%).

2-*Aminobenzo*[c]*cinnoline* 6-*Oxide*.—Powdered 2-nitrobenzo[*c*]cinnoline 6-oxide (1·3 g.), in hot ethanol (100 ml.), was treated with hydrazine hydrate (1 ml.) followed by Raney nickel in small portions. When the initial reaction subsided the solution was refluxed for 30 min., filtered, and diluted at the boiling point, giving 2-aminobenzo[*c*]cinnoline 6-oxide as deep orange needles. Recrystallisation from benzene–methanol gave material (0·78 g., 68%), m. p. 213—215° (decomp.), but there was some loss due to the formation of brown amorphous material. Solutions of the oxide in ethanol exhibited a vivid green fluorescence. It was characterised as the *acetyl* derivative, pale yellow needles (from ethanol), m. p. 278—280° (decomp.) (Found: C, 66·9; H, 4·6; N, 16·6. $C_{14}H_{11}N_3O_2$ requires C, 66·5; H, 4·35; N, 16·6%).

2-*Bromobenzo*[c]*cinnoline* 6-*Oxide*.—2-Aminobenzo[*c*]cinnoline 6-oxide (2 g.) in 47% hydrobromic acid (8 ml.) and water (20 ml.) was diazotised at 0—5° with sodium nitrite (0·7 g.) in water (6 ml.). The resulting solution was added to cuprous bromide (10 g.) in 47% hydrobromic acid (20 ml.) at 0°. After 10 min. the solution was warmed on the water-bath until the evolution of nitrogen ceased, diluted, cooled, and filtered. The solid was stirred with ammonia (*d* 0·88)–water (1 : 1) then crystallised from benzene–methanol and aqueous acetic acid giving 2-bromobenzo[*c*]cinnoline 6-oxide (1·2 g., 46%), m. p. and mixed m. p. with a sample prepared by a method similar to that of Corbett and Holt [5] who give m. p. 248°, 249—250°.

2-*Bromobenzo*[c]*cinnoline*.—(*a*) 2-Aminobenzo[*c*]cinnoline (1·95 g.) was diazotised and treated with cuprous bromide by the method used in the previous experiment. After warming until the evolution of nitrogen ceased, the solution was diluted, neutralised with ammonia, and the product collected by benzene extraction, giving 2-bromobenzo[*c*]cinnoline as dull yellow needles from ethanol (0·5 g., 19%), m. p. 221—222° (lit.,[5] m. p. 220°) (Found: C, 56·0; H, 2·6; N, 11·0. Calc. for $C_{12}H_7BrN_2$: C, 55·6; H, 2·7; N, 10·8%), $\lambda_{max.}$ (in ethanol) 255, 314, 352 mμ (log ε 4·67, 4·03, 3·29, respectively).

(*b*) 2,2′-Diamino-5-bromobiphenyl was obtained in 62% overall yield by the bromination of 2,2′-diacetamidobiphenyl and subsequent hydrolysis.[22] It formed needles, m. p. 113—115° (from aqueous ethanol) (lit.,[22] m. p. 109—115° on crude material). The diamine (8 g.) in concentrated sulphuric acid (16 ml.) and water (40 ml.) was diazotised at 0—5° with sodium nitrite (4·25 g.) in water (15 ml.). After the addition of 50% hypophosphorous acid (50 ml.; pre-cooled to 0°), the solution was allowed to warm to room temperature, kept for 24 hr., then heated on the water-bath until the evolution of nitrogen ceased. The solution was diluted, neutralised with ammonia, and extracted with benzene. The extract was adsorbed on alumina and eluted with benzene giving a trace of 3-bromobiphenyl followed by 3-bromocarbazole (0·9 g., 12%), greenish leaflets from aqueous ethanol, m. p. 199—200° (lit.,[19] m. p. 201°) [*N*-acetyl derivative, needles (from ethanol), m. p. 129—130° (lit.,[23] m. p. 127°)]. Further elution with benzene–chloroform (4 : 1) gave 2-bromobenzo[*c*]cinnoline (3·4 g., 43%), m. p. 221—222° (from ethanol).

[21] Gull and Turner, *J.*, 1929, 491.
[22] Murakami and Moritani, *J. Chem. Soc. Japan*, 1949, **70**, 236.
[23] Tucker, *J.*, 1924, **125**, 1144.

(*c*) Oxidation of the diamine (1·3 g.) by the method (*b*) used for the preparation of 3-nitrobenzo[*c*]cinnoline gave 2-bromobenzo[*c*]cinnoline (0·7 g., 55%), m. p. 215—217°.

4-*Iodobenzo*[c]*cinnoline*.—4-Aminobenzo[*c*]cinnoline (0·5 g.) in concentrated hydrochloric acid (2 ml.) and water (5 ml.) was diazotised at 0—5° with sodium nitrite (0·175 g.) in water (1·5 ml.). After 10 min., potassium iodide (1 g.) in water (2·5 ml.) was added and the mixture was allowed to warm to room temperature and treated with sodium pyrosulphite. The product was crystallised from aqueous ethanol and sublimed *in vacuo* at 140—150°/14 mm., giving 4-*iodobenzo*[c]*cinnoline* as yellow needles (0·35 g., 44·5%), m. p. 190·5—191·5° (Found: C, 47·1; H, 2·4; N, 9·4. $C_{12}H_7IN_2$ requires C, 47·1; H, 2·3; N, 9·15%).

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