Self-union Reactions and Nuclear Substitution by Anions in Some Ring Homologues of Quinoxaline.

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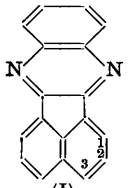
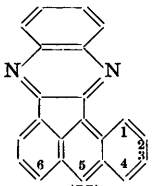
Acenaphtho[1,2-*b*]quinoxaline (I) affords a small amount of the 3-hydroxy-derivative on being heated with potassium hydroxide. Aceanthra[1,2-*b*]quinoxaline (II) does not exhibit a similar reaction. Both (I) and (II) undergo self-union to derivatives of perylene on being heated with potassium hydroxide. The relation of these reactions to those of related carbonyl compounds is discussed.

The direct replacement of nuclear hydrogen in aromatic carbonyl compounds by alkyl, hydroxyl, and substituted amino-groups has been reported in several recent communications (*e.g.*, Bradley and Waller, *J.*, 1953, 3778; Bradley and Bruce, *J.*, 1954, 1894), and the present work extends the investigation to aromatic compounds containing a quinoxaline nucleus, in particular to acenaphtho[1,2-*b*]quinoxaline (I) and aceanthra[1,2-*b*]quinoxaline


(I)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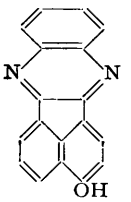
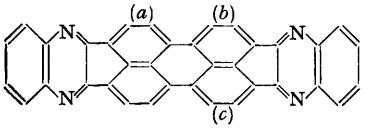

(III)

(II). Previous work has shown that numerous carbonyl derivatives of naphthalene and anthracene are directly substituted by hydroxyl ions, the substituent entering the nucleus *para* to a carbonyl group. In comparable instances the anthracene is more readily substituted than the naphthalene derivative, and it was of interest to establish whether the same properties and relations occur amongst –C=N– compounds.

Acenaphtho[1,2-*b*]quinoxaline (I) was first prepared by Ampola and Recchi (*Atti R. Accad. Lincei*, 1899, **8**, I, 209). Aceanthra[1,2-*b*]quinoxaline (II) was mentioned but not described in G.P. 602,337; but a methyl derivative was prepared by Liebermann and Zsuffa (*Ber.*, 1911, **44**, 208) from aceanthrenequinone and 3 : 4-diaminotoluene. Heating (I) with potassium hydroxide and potassium acetate at 240—250° gave a deep red product (A) in small yield and an even smaller amount of a phenol, identified as the 3-hydroxy-derivative (III), which was also derived by the hydrolysis of 3-bromoacenaphtho[1,2-*b*]quinoxaline (III; Br for OH), prepared from 3-bromoacenaphthaquinone and *o*-phenylenediamine.

The red compound (A) was also obtained by the action of alkalis on 3-bromoacenaphtho-[1,2-*b*]quinoxaline, which indicates the constitution (IV). The formation of a perylene from a naphthalene derivative on treatment with alkalis is a well-established reaction. It


(IV)

occurs, *e.g.*, in the formation of violanthrone from *meso*benzanthrone and potassium hydroxide at 240°, and of *iso*violanthrone from 3-chloro*meso*benzanthrone and alcoholic potassium hydroxide at 140—160°. Heating 3-bromoacenaphtho[1,2-*b*]quinoxaline with piperidine gave the 3-piperidino-derivative.

Liebermann and Kardos's observation (*Ber.*, 1914, **47**, 1203) that aceanthrenequinone is

readily hydroxylated by hot 10% aqueous potassium hydroxide was confirmed, but aceanthra[1,2-*b*]quinoxaline behaved quite otherwise. Aqueous 10% potassium hydroxide was without effect. Potassium hydroxide and sodium acetate at 235—240° gave a deep blue, alkali-insoluble, high-melting compound which was considered to be homogeneous because, after purification, no further separation occurred on successive extractions with solvents and sublimation. The same compound resulted by the action of ethanolic potassium hydroxide at 125° on both aceanthra[1,2-*b*]quinoxaline and its 5-bromo-derivative. These reactions indicate that the blue derivative is a dibenzo-derivative of (IV) having additional rings at (*a*) and (*b*), or (*a*) and (*c*). (According to G.P. 602,337 heating aceanthra[1,2-*b*]quinoxaline with an alkali hydroxide in alcohol at 150—160° affords a green vat dye of unknown structure.) The action of alkali hydroxides on (II) gave no 5-hydroxyaceanthra[1,2-*b*]quinoxaline, which was synthesised for identification from Liebermann and Kardos's hydroxyaceanthraquinone (*loc. cit.*) and *o*-phenylenediamine.

The main result of the present investigation is that whilst acenaphtho[1,2-*b*]quinoxaline (I) and aceanthra[1,2-*b*]quinoxaline (II) undergo self-union with ease to form derivatives of perylene, nuclear hydroxylation occurs with difficulty in the case of (I) and not at all with (II). The two quinoxalines exhibit a much lower degree of nuclear reactivity towards alkali hydroxides than 1 : 8-naphthalimide and aceanthraquinone, and the capacity for hydroxylation is affected more than self-union. That self-union is a more general property of cyclic aromatic ketones and related compounds than capacity for nuclear substitution by anions and other bases accords with the results of Bradley and Bruce (*loc. cit.*) who observed that both *N*-methyl derivatives of 1 : 9-pyrazoloanthrone showed self-coupling, but that nuclear substitution occurred only in one of the isomers. In this case, too, the importance of self-union increased with rise in temperature.

Piperidine and aceanthraquinone gave an adduct which was readily dissociated into its components on being heated with acids and for this reason probably contained piperidine combined with one of the carbonyl groups.

Experimental

Acenaphtho[1,2-b]*quinoxaline*.—Prepared by Ampola and Recchi's method (*loc. cit.*) this was obtained as colourless needles, m. p. 241° (lit., m. p. 234°) (Found : C, 85·1; H, 4·0; N, 10·9. Calc. for $C_{18}H_{10}N_2$: C, 85·0; H, 4·0; N, 11·0%); light absorption in " AnalaR " concentrated sulphuric acid, max. at 295 ($10^{-4}\varepsilon$ 1·4), 362 ($10^{-4}\varepsilon$ 5·69), and 430 mμ ($10^{-4}\varepsilon$ 1·93). The pale yellow solution in pyridine remained unchanged on the addition of methanolic potassium hydroxide. It was insoluble in alkaline sodium dithionite; on the addition of pyridine the suspension became greener and yielded a colourless aqueous layer and a pale yellowish-green pyridine layer.

3-*Bromoacenaphtho*[1,2-b]*quinoxaline*.—Prepared from 3-bromoacenaphthaquinone and *o*-phenylenediamine this derivative formed colourless needles, m. p. 276—277° (Found : C, 64·5; H, 2·4; N, 8·3; Br, 24·5. Calc. for $C_{18}H_9N_2Br$: C, 64·8; H, 2·7; N, 8·4; Br, 24·2%); light absorption in " AnalaR " concentrated sulphuric acid, max. at 376 ($10^{-4}\varepsilon$ 5·8) and 440 mμ ($10^{-4}\varepsilon$ 2·0). Guha (*J.*, 1931, 583), and Rule and Thompson (*J.*, 1937, 1761), record m. p. 272°.

3-*Hydroxyacenaphtho*[1,2-b]*quinoxaline*.—(*a*) The above 3-bromo-derivative (2 g.) was added to potassium hydroxide (10 g.) and amyl alcohol (75 c.c.) heated in an oil-bath at 150—160°. Dissolution was complete in 1 hr. and refluxing was continued for 13·5 hr. longer. The orange solution, filtered hot, gave acenaphtho[1,2-*b*]quinoxaline (0·95 g.), m. p. 237—238° (Found : C, 84·5; H, 3·8; N, 11·3. Calc. for $C_{18}H_{10}N_2$: C, 85·0; H, 4·0; N, 11·0%), on being cooled. The mother-liquor was distilled in steam, the product which separated was extracted with hot 2% sodium hydroxide solution, and the combined alkaline solutions were acidified. A yellow precipitate formed, and this became red on the addition of an excess of acid. Purification from alcohol gave 3-*hydroxyacenaphtho*[1,2-b]*quinoxaline* (0·05 g.), m. p. 256—260° (decomp.) (Found : C, 79·3; H, 3·8; N, 10·3. $C_{18}H_{10}ON_2$ requires C, 79·9; H, 3·7; N, 10·3%), as a bright yellow solid; light absorption in 95% EtOH, max. at 250 ($10^{-4}\varepsilon$ 3·74) and 330 mμ ($10^{-4}\varepsilon$ 3·4). It dissolved in cold 5% sodium carbonate solution and in warm 5% potassium hydrogen carbonate solution with a blue fluorescence. The solution in concentrated sulphuric acid was

emerald-green. The pale yellow solution in pyridine became orange on the addition of methanolic potassium hydroxide. Addition of diazotised *p*-nitroaniline to a solution in aqueous alkali gave a red azo-derivative.

(*b*) A small amount of the same 3-hydroxy-derivative, identified by comparison of the light absorption spectrum in 95% alcohol with that of authentic material, was obtained by the addition of acenaphtho[1,2-*b*]quinoxaline (7 g.) to potassium hydroxide (50 g.) and potassium acetate (4 g.) at 220° during 15 min., the melt being subsequently heated at 235—245° and stirred for 1·75 hr. Much of the quinoxaline reactant sublimed during the experiment. Extracted with dilute alkali the product afforded a residue (A) and an orange solution which gave a red precipitate on the addition of diazotised *p*-nitroaniline.

Di(cyclo*penta*[b]*quinoxalino*)[1,2,3-cd, 1′,2′,3′-lm]*perylene* (IV) *from Acenaphtho*[1,2-b]*quinoxaline*.—The alkali-insoluble material (A), obtained by the addition of the product of experiment (*b*) (above) to water (200 c.c.), was continuously extracted with alcohol, then glacial acetic acid, chlorobenzene, and finally trichlorobenzene. Each of the last two extracts gave a deep red microcrystalline solid (0·05 g., in all), and this was dissolved in concentrated sulphuric acid. On the addition of sufficient water to give 80% sulphuric acid a brown sulphate separated. This was collected, washed with 80% sulphuric acid, then added to water. A deep red solid separated (Found : N, 10·8. $C_{36}H_{16}N_4$ requires N, 11·1%). The *perylene* derivative dissolved in " AnalaR " concentrated sulphuric acid forming a brownish-red solution; light absorption of material crystallised from trichlorobenzene and then sublimed at 450°/0·4 mm., max. at 485 ($10^{-4}\varepsilon$ 13·6), 540 ($10^{-4}\varepsilon$ 2·82), and 585 mμ ($10^{-4}\varepsilon$ 4·44). It was insoluble in alkaline sodium dithionite, but on the addition of pyridine a deep emerald-green colour was formed in the organic layer. On being exposed to air the green solution rapidly afforded a red precipitate. The pale pink solution in pyridine was unaffected by the addition of methanolic potassium hydroxide.

Di(cyclo*penta*[b]*quinoxalino*)[1,2,3-cd, 1′,2′,3′-lm]*perylene* (IV) *and Acenaphtho*[1,2-b]*quinoxaline from* 3-*Bromoacenaphtho*[1,2-b]*quinoxaline*.—(*a*) 3-Bromoacenaphtho[1,2-*b*]quinoxaline was recovered unaltered after being refluxed with methanolic potassium hydroxide on the water-bath for 8 hr. or with sodium *tert*.-butoxide or potassium hydroxide in *tert*.-butanol. (*b*) Potassium hydroxide (10 g.), ethanol (10 g.), and 3-bromoacenaphtho[1,2-*b*]quinoxaline stirred and heated under reflux at 130° for 1·5 hr. gave acenaphtho[1,2-*b*]quinoxaline, m. p. 240°. (*c*) Potassium hydroxide (25 g.), ethanol (9 g.), and 3-bromoacenaphtho[1,2-*b*]quinoxaline (3 g.) at 165—170° for 2 hr. gave acenaphtho[1,2-*b*]quinoxaline, the above perylene derivative, and unchanged reactant. Amyl-alcoholic potassium hydroxide under reflux gave the same result. (*d*) 3-Bromoacenaphtho[1,2-*b*]quinoxaline (3 g.), potassium hydroxide (30 g.), and anhydrous sodium acetate (4 g.), heated at 235—240° for 1 hr. and then added to water (200 c.c.), afforded a deep brownish-red insoluble portion (2·65 g.), of which 1·2 g. remained after extraction with chlorobenzene. This was further extracted with mixed cresols; a deep red residue (0·08 g.) remained, and from the solution there crystallised a red solid (0·15 g.). Steam-distillation of the cresols mother-liquor afforded an additional 0·8 g. of red material, and this was crystallised from trichlorobenzene (10 parts) and cresols (1 part). The purified product was identified as the perylene derivative, and the remaining red fractions also showed almost identical light absorption in " AnalaR " concentrated sulphuric acid.

3-*Piperidinoacenaphtho*[1,2-b]*quinoxaline*.—The finely powdered 3-bromo-derivative (1 g.) was refluxed for 19 hr. with piperidine (12 g.). The resulting green-fluorescent, yellow-orange solution was added to water, the suspension which formed was heated to boiling, then cooled. Finally, the precipitate (1·05 g.) was crystallised from alcohol. 3-*Piperidinoacenaphtho*[1,2-b]-*quinoxaline* forms bright yellow needles, m. p. 159° (Found : C, 81·7; H, 5·7; N, 12·4. $C_{21}H_{19}N_3$ requires C, 81·9; H, 5·6; N, 12·4%). It dissolved in concentrated sulphuric acid and in pyridine with a yellow colour; the pyridine solution was unchanged on the addition of methanolic potassium hydroxide.

5-*Bromoaceanthra*[1,2-b]*quinoxaline*.—*N*-Bromosuccinimide (2·2 g.) was added to a refluxing solution of aceanthra[1,2-*b*]quinoxaline (2 g.) in " AnalaR " carbon tetrachloride, previously dried over calcium chloride. After 4 hr. the suspension was filtered, and the filtrate concentrated to 100 c.c. and then cooled overnight. Deep orange crystals (2·8 g.) separated. The powdered product was extracted for a short time with two portions of boiling glacial acetic acid (400 c.c., 200 c.c.). The residue (1 g.) crystallised from chlorobenzene as bright yellow needles (0·9 g.), m. p. 283° (Found : C, 68·8; H, 2·8; N, 7·5; Br, 21·2. $C_{22}H_{11}N_2Br$ requires C, 68·9; H, 2·9; N, 7·3; Br, 20·9%); light absorption in " AnalaR " concentrated sulphuric acid, max. at 279 ($10^{-4}\varepsilon$ 5·74), 325 ($10^{-4}\varepsilon$ 1·915), 360 ($10^{-4}\varepsilon$ 2·07), and 435 mμ ($10^{-4}\varepsilon$ 3·14).

An additional quantity of the *bromo*-derivative (0·3 g.; m. p. 280—283°) was obtained from the second acetic acid extract.

The same compound, m. p. 282·5° (Found: C, 68·3; H, 3·2; N, 7·5; Br, 20·8%), was obtained by refluxing acenaphtho[1,2-*b*]quinoxaline (0·5 g.) and bromine (0·3 g.) in nitrobenzene (50 c.c.) for 1·25 hr.

Action of Ethanolic Potassium Hydroxide.—Formation of a dibenzo-derivative of (IV). The above 5-bromo-derivative (0·9 g.) was stirred and heated for 2 hr. at 125° with a paste of potassium hydroxide (10 g.) and ethanol (10 c.c.). The deep grass-green product was added to water (150 c.c.), and the resulting suspension was aerated, then filtered. The filtrate was wine-red; on acidification it gave a deep purple precipitate which resembled 5-hydroxyaceanthra[1,2-*b*]quinoxaline but was too small in amount to be identified completely. The residue, after further extraction with hot 5% potassium hydroxide, was collected, washed, dried (0·75 g.), and extracted with chlorobenzene. The extract afforded a deep blue solid *product* (B) (0·1 g.), and this was further extracted with trichlorobenzene for a short time, collected (0·07 g.), and finally crystallised from trichlorobenzene (Found: N, 9·0. $C_{44}H_{20}N_4$ requires N, 9·3%); light absorption in "AnalaR" concentrated sulphuric acid: max. at 465 ($10^{-4}\varepsilon$ 4·83), 610 ($10^{-4}\varepsilon$ 2·66), and 840 mμ ($10^{-4}\varepsilon$ 2·78).

5-*Hydroxyaceanthra*[1,2-b]*quinoxaline.*—This resulted when the hydroxyaceanthrenequinone (0·35 g.) (Found: C, 77·6; H, 3·1. Calc. for $C_{16}H_8O_3$: C, 77·4; H, 3·3%) of Liebermann and Kardos (*loc. cit.*), dissolved in ethanol (80 c.c.), was heated with *o*-phenylenediamine (0·16 g.) in ethanol (10 c.c.). A cherry-red colour rapidly developed, and after being kept overnight the solution afforded deep purple crystals (0·32 g.). After collection, drying, and recrystallisation from ethanol, the compound melted indefinitely at ca. 320°; light absorption in "AnalaR" concentrated sulphuric acid, max. at 281 ($10^{-4}\varepsilon$ 3·99), 300 ($10^{-4}\varepsilon$ 2·54), 425 ($10^{-4}\varepsilon$ 2·42), and 535 mμ ($10^{-4}\varepsilon$ 1·39). 5-Hydroxyaceanthra[1,2-*b*]quinoxaline dissolved in 5% aqueous potassium hydroxide, sodium carbonate, or warm potassium hydrogen carbonate, with a deep pink colour. It was insoluble in dilute hydrochloric acid; in concentrated sulphuric acid the solution was pale red with a slight yellow fluorescence, and a purple precipitate was formed on the addition of water. In pyridine the solution was orange-red with a red fluorescence, and, on the further addition of methanolic potassium hydroxide, bluish pink. It was unaffected by aqueous alkaline sodium dithionite.

Action of Potassium Hydroxide on Aceanthra[1,2-b]*quinoxaline.*—(*a*) Unlike aceanthraquinone the derived quinoxaline was unaffected by refluxing for 8 hr. with 10% aqueous potassium hydroxide. (*b*) Finely powdered aceanthra[1,2-*b*]quinoxaline (7·5 g.) was stirred and heated for 1·5 hr. at 235—240° with potassium hydroxide (80 g.) and anhydrous sodium acetate (8 g.). After addition to water and aeration the resulting suspension was filtered. Deep blue alkali-insoluble material (7·5 g.) was separated from the wine-red filtrate and then extracted continuously with glacial acetic acid. The residue (4·7 g.) was further extracted with trichlorobenzene containing a small volume of mixed cresols. A deep blue solid (1·8 g.) separated from the cooled, filtered solution. The residue (2·4 g.) was extracted similarly; it afforded deep blue material (0·85 g.) on being cooled. The residue (1·4 g.) was deep blue. All three fractions of the blue material gave a single deep blue band on being sublimed at 450°/0·4 mm. Further purification of the 0·85-g. fraction from trichlorobenzene gave deep blue crystals with a metallic lustre which did not melt below 450° (Found: C, 87·8, 87·2; H, 3·6, 3·0; N, 9·0, 9·6. Calc. for $C_{44}H_{20}N_4$: C, 87·4; H, 3·3; N, 9·3%); light absorption in "AnalaR" concentrated sulphuric acid, max. at 465 ($10^{-4}\varepsilon$ 5·44), 610 (indefinite), and 840 mμ ($10^{-4}\varepsilon$ 3·08). This product dissolved in concentrated sulphuric acid with a deep olive-green colour; a bright green precipitate formed on the addition of water. It gave a blue solution in pyridine, rendered pale green on the addition of methanolic potassium hydroxide. It was unaffected by 5% aqueous potassium hydroxide or by alkaline sodium dithionite, but on the addition of a small volume of pyridine to the last a deep green solution resulted. In these reactions it was identical with the perylene derivative (B) (above).

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