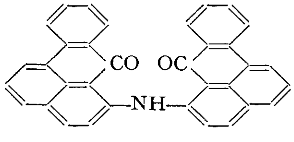
573. *Replacement of Substituents in Derivatives of* meso*Benzanthrone.*

By William Bradley.

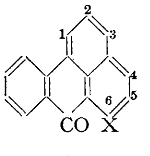
The ability of *meso*benzanthrone to undergo self-condensation is associated with the ready transmission of the effect of the carbonyl group through the component naphthalene nucleus. A further example of the effect is found in the replacement, by other amines, of amino-, alkylamino-, dialkylamino-, aralkylamino-, and arylamino-groups attached to position 6 of *meso*benzanthrone. The mechanism of the replacement reaction is discussed.

The intermediate formation of the 4-*meso*benzanthronyl anion during the conversion of *meso*benzanthrone into 4 : 4′-di*meso*benzanthronyl implies that the electron-attracting effect of the carbonyl group is very readily transmitted through the *meso*benzanthrone nucleus. This accords with the development of an intense orange-red colour when *meso*benzanthrone is dissolved in concentrated sulphuric acid (Bally and Scholl, *Ber.*, 1911, **44**, 1665), with the occurrence of deeply coloured alkali derivatives of 3-, 4-, and 6-acylamino*meso*benzanthrones (*J. Soc. Dyers Col.*, 1942, **58**, 2), with the mobility of halogen substituents attached to position 6 of *meso*benzanthrone (Bradley and Jadhav, *J.*, 1948, 1746), and the ready hydrolysis of 6-amino*meso*benzanthrone (Bradley, *ibid.*, p. 1175). 6 : 6′-Di*meso*benzanthronylamine (I) forms an alkali derivative and is very easily hydrolysed by alkalies to form a mixture of 6-hydroxy*meso*benzanthrone (II; X = OH) and 6-amino*meso*benzanthrone (II; $X = NH_2$) (*J.*, 1948, 1175). In these respects it resembles an acid imide, of which it may be regarded as a vinylogue (Fuson, *Chem. Reviews*, 1935, **16**, 1). Similarly it decomposes when heated with 2-phenylethylamine, yielding 6-2′-phenylethylamino*meso*benzanthrone (II; $X = NH{\cdot}CH_2{\cdot}CH_2Ph$).

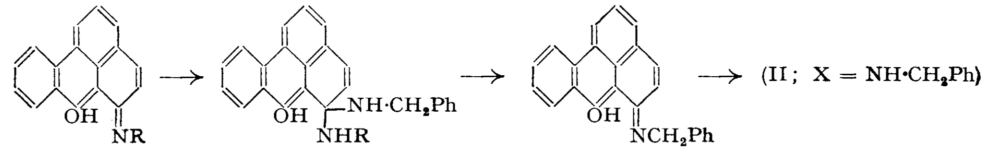
(I.)



(II.)

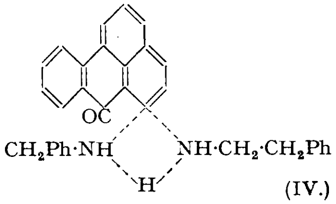


An investigation of the scope of this and similar reactions has shown that amino-, alkylamino-, dialkylamino-, aralkylamino-, and arylamino-substituents in *meso*benzanthrone are all replaceable by amines under appropriate conditions. Generally the replacement of aromatic substituents by amines occurs the more easily the more stable are the substituents in the form of anions. Amino- and substituted amino-groups are among the more difficult to replace and the numerous examples recorded in the present communication emphasize the considerable degree to which the effect of the carbonyl group is carried through the naphthalene component of the *meso*benzanthrone nucleus. Heating 6-amino*meso*benzanthrone with benzylamine yields 6-*benzylamino*meso*benzanthrone* (II; X = NH·CH_2Ph) identical with the product obtained by heating 6-iodo*meso*benzanthrone (Bradley and Jadhav, *J.*, 1948, 1622) with benzylamine. The same product is obtained by treating benzylamine with 6-methylamino-, 6-anilino-, 6-*N*-methylanilino-, and 6-*morpholino*-meso*benzanthrone.* Similarly, heating with 2-phenylethylamine transforms 6-*p*-chloroanilino*meso*benzanthrone into 6-2′-phenylethylamino*meso*benzanthrone identical with the compound obtained by treating 6-iodo*meso*benzanthrone with 2-phenylethylamine.



(III.)

The easy replacement of a morpholino- or *N*-methylanilino-substituent which occurs when 6-morpholino- or 6-*N*-methylanilino-*meso*benzanthrone is heated with benzylamine indicates that in these instances the reaction consists of a simple displacement of the substituent. In other cases addition of benzylamine or 2-phenylethylamine may occur to a modified form of the *meso*benzanthrone derivative (III), but it is unlikely that this mechanism is involved because all of the replacements occur under approximately the same conditions. It would be expected that the replacement reaction would occur the more readily the more strongly basic the displacing amine. This has been shown by the superiority of benzylamine in comparison with aniline when these amines are used at their boiling points. The replacement reaction is reversible. Heating with 2-phenylethylamine transforms 6-benzylamino*meso*benzanthrone into 6-2′-phenylethylamino*meso*benzanthrone, and the reverse change is brought about by heating 6-2′-phenylethylamino*meso*benzanthrone with benzylamine. If, as appears probable, the replacement reaction consists in the direct displacement of the substituent an intermediate stage represented by (IV) must be involved :



(IV.)

In other experiments 6-benzylamino*meso*benzanthrone was hydrolysed to 6-hydroxy*meso*-benzanthrone (Bradley and Jadhav, *J.*, 1937, 1791) and formed again by heating the hydroxy-derivative and its boroacetate with benzylamine. In parallel experiments 6-2′-phenylethylamino*meso*benzanthrone was hydrolysed to 6-hydroxy*meso*benzanthrone, and the former was regenerated by heating the boroacetate of 6-hydroxy*meso*benzanthrone with 2-phenylethylamine.

EXPERIMENTAL.

6-*Benzylamino*meso*benzanthrone.*—(*a*) 6-Iodo*meso*benzanthrone (Bradley and Jadhav, *J.*, 1948, 1625) (1 g.) was heated under reflux with benzylamine (5 c.c.) during 5 hours. The product crystallised on cooling. It was stirred with 50 c.c. of 20% hydrochloric acid, and the yellow crystalline residue was collected, washed with water, and recrystallised from acetic acid and then from alcohol in which it was sparingly soluble. 6-*Benzylamino*meso*benzanthrone* forms yellow rods, m. p. 192—192·5° (Found : C, 85·7; H, 5·0; N, 4·2. $C_{24}H_{17}ON$ requires C, 85·9; H, 5·1; N, 4·2%). It dissolves in concentrated sulphuric acid with a cherry-red colour. Its yellow solution in pyridine shows no change in colour when amyl-alcoholic potassium hydroxide is added.

(*b*) 6-Hydroxy*meso*benzanthrone boroacetate (4·5 g.) was added to 15 c.c. of benzylamine. A mildly exothermic reaction ensued. The suspension was heated under reflux. It rapidly formed a deep-brownish-yellow solution, and after 1 hour this was cooled and added to dilute hydrochloric acid. The undissolved material was collected, washed with water, and dissolved in benzene, the solution passed through a short column of alumina, and the adsorbed product eluted by means of benzene and recovered by evaporating the eluate. Finally it was recrystallised from alcohol. The product had m. p. 191—192° (Found : C, 85·7; H, 5·2; N, 4·6%).

(*c*) A solution containing 0·4 g. of 6-hydroxy*meso*benzanthrone in 4 c.c. of benzylamine was heated under reflux during 3 hours. The cooled product was added to excess of 20% hydrochloric acid, and the acid solution was filtered and basified with ammonia. The precipitated yellow solid, collected and recrystallised from alcohol, had m. p. 191—192°. The acid-insoluble portion of the product was extracted by means of benzene, and the benzene solution washed with water, dried, and then chromatographed on a short column of alumina. The least strongly adsorbed fraction of the product formed a yellow band, and this was eluted by means of benzene and recovered as a yellow solid on evaporating the eluate. Recrystallisation from alcohol gave yellow rods, m. p. 191—192° (Found: C, 85·5; H, 5·3; N, 4·3%). Yield, 0·02 g. The m. p. was not depressed on mixing the substance with 6-benzylamino*meso*benzanthrone prepared by heating 6-amino*meso*benzanthrone with benzylamine.

6-*Morpholino*meso*benzanthrone*.—A solution containing 0·29 g. of 6-iodo*meso*benzanthrone in 3 c.c. of morpholine was heated under reflux during 4 hours. The deep-orange product was added to dilute hydrochloric acid, and the yellow precipitate which formed was dissolved by heating the mixture with concentrated hydrochloric acid. The filtered orange-yellow solution gave a precipitate of the crude base when water was added. The precipitate was collected, washed by water, and recrystallised from alcohol. 6-*Morpholino*meso*benzanthrone* forms orange-yellow prisms, m. p. 170—171° (Found: C, 80·0; H, 5·1; N, 4·6. $C_{21}H_{17}O_2N$ requires C, 80·0; H, 5·4; N, 4·4%). It dissolves in concentrated sulphuric acid with a cherry-red colour, but its solution in pyridine does not undergo any change in colour on addition of a few drops of amyl-alcoholic potassium hydroxide.

Hydrolysis. 6-Morpholino*meso*benzanthrone (0·05 g.) was heated under reflux during 3 hours with a solution of potassium hydroxide (0·4 g.) in amyl alcohol (9 c.c.). The product was added to water, the amyl alcohol evaporated, and the residual yellow solid collected. Recrystallisation from benzene gave 6-hydroxy*meso*benzanthrone, m. p. 176—177°.

6-2′-*Phenylethylamino*meso*benzanthrone*.—(*a*) A solution containing 6-iodo*meso*benzanthrone (0·3 g.) in 5 c.c. of 2-phenylethylamine was heated at the b. p. during 4 hours. The product crystallised on cooling. It was stirred with dilute hydrochloric acid, and the insoluble material collected and crystallised from ethyl alcohol in which it was sparingly soluble. The purified material was dissolved in benzene, the solution chromatographed on alumina, and the 6-2′-*phenylethylamino*meso*benzanthrone* washed through the column by means of benzene. The evaporated eluate gave a residue which was again crystallised from alcohol. The base crystallised in canary-yellow needles, m. p. 154—155° (Found: C, 85·4; H, 5·5; N, 4·1. $C_{25}H_{19}ON$ requires C, 85·9; H, 5·5; N, 4·0%). The colour of its solution in concentrated sulphuric acid was cherry-red. The yellow colour of its solution in pyridine was not affected by addition of amyl-alcoholic potassium hydroxide.

(*b*) 6-Hydroxy*meso*benzanthrone boroacetate (4·5 g.) was added to 14 c.c. of 2-phenylethylamine. A mildly exothermic reaction occurred. The suspension dissolved readily on warming, and after heating under reflux during 1·25 hours the product was isolated by cooling, adding the mixture to dilute hydrochloric acid, and collecting the precipitate. After recrystallisation from alcohol, 1·1 g. of yellow needles were obtained, having m. p. 155° (Found: C, 85·4; H, 5·6; N, 4·4%). Mixing it with 6-2′-phenylethylamino*meso*benzanthrone prepared from 6-iodo*meso*benzanthrone and 2-phenylethylamine did not alter the m. p.

Hydrolysis. A solution containing 1 g. of 6-2′-phenylethylamino*meso*benzanthrone in 15 c.c. of amyl alcohol was heated under reflux with 1 g. of potassium hydroxide. A yellow crystalline product separated quickly from the dark brownish-yellow solution. After 1·5 hours 20 c.c. of alcohol was added and the product kept overnight. The crystalline precipitate was collected, washed in turn with alcohol, water, dilute hydrochloric acid, and finally with water, and then dried. The crystals had m. p. 150° (crude), and m. p. 155° (recrystallised from alcohol), not depressed on mixing with 6-2′-phenylethylamino*meso*benzanthrone after recrystallisation from alcohol. The original mother-liquor was evaporated to expel alcohol. Crystals separated and these were collected and recrystallised from alcohol (Found: C, 82·9; H, 4·2. Calc. for $C_{17}H_{10}O$: C, 82·9; H, 4·1%). The m. p. was 176°, not depressed by admixture with 6-hydroxy*meso*benzanthrone.

Benzylamine and 6-*Amino*meso*benzanthrone*.—A solution containing 6-amino*meso*benzanthrone (0·5 g.) in benzylamine (5 c.c.) was heated at the b. p. for 5 hours. The cooled product was mixed with 10% hydrochloric acid (100 c.c.), and the yellow precipitate dissolved in benzene. The benzene solution was washed with water, dried (Na_2SO_4), and chromatographed on alumina (B.D.H. for chromatographic analysis). The main portion of the product was easily removed from the column by means of benzene. Evaporation of the eluate and crystallisation of the residue from alcohol gave yellow needles, m. p. 192—192·5° (Found: C, 85·6; H, 5·0; N, 4·1. Calc. for $C_{24}H_{17}ON$: C, 85·9; H, 5·1; N, 4·2%), unaltered by admixture with 6-benzylamino*meso*benzanthrone prepared from 6-iodo*meso*benzanthrone and benzylamine.

After the benzylamine derivative had been removed from the column, repeated washing with benzene removed unchanged 6-amino*meso*benzanthrone, m. p. 186° (Found: C, 82·9; H, 4·5; N, 6·0. Calc. for $C_{17}H_{11}ON$: C, 83·2; H, 4·5; N, 5·7%).

Benzylamine and 6-*Methylamino*meso*benzanthrone*.—A solution containing 0·1 g. of 6-methylamino*meso*benzanthrone in 3 c.c. of benzylamine was heated under reflux during 6 hours and the product isolated by cooling, acidification, extraction with benzene, and chromatography on alumina. The main portion of the product was obtained in the form of yellow rods, m. p. 185° (Found: C, 85·5; H, 5·2; N, 4·1. Calc. for $C_{24}H_{17}ON$: C, 85·9; H, 5·1; N, 4·2%), consisting of slightly impure 6-benzylamino*meso*benzanthrone.

Benzylamine and 6-*Anilino*meso*benzanthrone*.—A solution of 6-anilino*meso*benzanthrone (0·04 g.) in benzylamine (2·5 c.c.) was heated under reflux for 6 hours. The initial deep-brown colour of the solution became paler. Alcohol was added and then dilute acetic acid, and the yellow precipitate was crystallised from alcohol. It formed yellow rods, m. p. 184—185°, which consisted essentially of 6-benzylamino*meso*benzanthrone (Found: C, 85·4; H, 5·0. Calc. for $C_{24}H_{17}ON$: C, 85·9; H, 5·1%).

A similar product, m. p. 184°, was obtained when 6-*N*-methylanilino*meso*benzanthrone (0·02 g.) was heated with benzylamine (2 c.c.) and the product isolated by adding it to dilute hydrochloric acid, extraction with benzene, and chromatography on alumina. On the other hand, when 6-β-naphthylamino*meso*benzanthrone (0·1 g.) was heated under reflux with benzylamine (2 c.c.) during 4 hours the crude product, m. p. 160—162°, contained a considerable proportion of unchanged naphthylamino*meso*benzanthrone.

Benzylamine and 6-*Morpholino*meso*benzanthrone.*—A solution of 6-morpholino*meso*benzanthrone (0·03 g.) in 3 c.c. of benzylamine was heated under reflux during 5 hours. The cooled product was added to dilute acetic acid, and the yellow precipitate extracted by means of benzene. The benzene extracts were washed with water, dried (Na_2SO_4), concentrated, and then chromatographed on alumina. The main fraction was weakly adsorbed and easily eluted by means of benzene. The evaporated eluate gave canary-yellow crystals, m. p. 188—189°, and these recrystallised from alcohol had m. p. 191—192° (Found: C, 86·3; H, 5·2; N, 4·2. Calc. for $C_{24}H_{17}ON$: C, 85·9; H, 5·1; N, 4·2%), not depressed by mixing them with 6-benzylamino*meso*benzanthrone prepared from 6-iodo*meso*benzanthrone and benzylamine.

Benzylamine and 6-2′-*Phenylethylamino*meso*benzanthrone.*—6-2′-Phenylethylamino*meso*benzanthrone (0·6 g.) was heated under reflux with benzylamine (10 c.c.) during 24 hours. The product was isolated by addition of water and then excess of dilute hydrochloric acid, and filtering off the yellow crystalline precipitate. Recrystallisation from alcohol gave yellow rods, m. p. 190—191° (Found: C, 86·0; H, 5·1; N, 4·3. Calc. for $C_{24}H_{17}ON$: C, 85·9; H, 5·1; N, 4·2%).

2-*Phenylethylamine and* 6-p-*Chloroanilino*meso*benzanthrone.*—A solution containing 0·1 g. of 6-*p*-chloroanilino*meso*benzanthrone in 4 c.c. of 2-phenylethylamine was heated under reflux during 6 hours. The product was isolated by cooling, pouring into dilute hydrochloric acid, and dissolving the precipitate in benzene. The benzene extract, washed with water, dried (Na_2SO_4), and concentrated, was chromatographed on alumina. The least easily adsorbed fraction was eluted by means of benzene, recovered by evaporating the eluate, and recrystallised from alcohol. It formed yellow needles, m. p. 155—156° (Found: C, 85·2; H, 5·5; N, 3·9. Calc. for $C_{25}H_{19}ON$: C, 85·9; H, 5·5; N, 4·0%), not depressed on mixing them with 6-2′-phenylethylamino*meso*benzanthrone prepared by heating 2-phenylethylamine with 6-iodo*meso*benzanthrone.

2-*Phenylethylamine and* 6 : 6′-*Di*meso*benzanthronylamine.*—A suspension containing 0·3 g. of 6 : 6′-di*meso*benzanthronylamine in 4 c.c. of 2-phenylethylamine was heated under reflux during 1·75 hours, then cooled, and added to excess of 10% hydrochloric acid. The brown precipitate which separated was almost completely soluble in a small volume of glacial acetic acid. The filtered solution was added to water, the suspension made alkaline, and the precipitate extracted by means of benzene. After being washed with water, dried (Na_2SO_4), and concentrated, the solution was chromatographed on alumina. The least readily adsorbed material formed an orange band, and when this had been eluted the main product followed as a yellow band. The eluted yellow band gave yellow crystals which separated from ethyl alcohol in needles, m. p. 155—156° (Found: C, 86·1; H, 4·6; N, 4·2. Calc. for $C_{25}H_{19}ON$: C, 85·9; H, 5·5; N, 4·0%). The m. p. was not depressed by admixture with 6-2′-phenylethylamino*meso*benzanthrone prepared from 6-iodo*meso*benzanthrone.

2-*Phenylethylamine and* 6-*Benzylamino*meso*benzanthrone.*—A solution containing 0·7 g. of 6-benzylamino*meso*benzanthrone in 10 c.c. of 2-phenylethylamine was heated under reflux during 24 hours. The cooled product was mixed with excess of 10% hydrochloric acid, and the almost black precipitate collected after being kept overnight. Extraction by means of hot alcohol (40 c.c.) left a bright yellow residue which was then separated and dissolved in a further portion of hot alcohol. Crystals, m. p. 154—155°, separated readily from the second solution, and these had the same m. p. after further recrystallisation from alcohol (Found: C, 86·0; H, 5·3; N, 4·3. Calc. for $C_{25}H_{19}ON$: C, 85·9; H, 5·5; N, 4·0%).

Morpholine and 6-*Substituted-amino*meso*benzanthrones.*—There was no evidence of any considerable formation of 6-morpholino*meso*benzanthrone when morpholine (5 c.c.) was heated under reflux with 6-benzylamino*meso*benzanthrone (0·025 g.) during 5 hours, or when morpholine (3 c.c.) was heated under reflux during 7 hours with 6-β-naphthylamino*meso*benzanthrone (0·02 g.). In the latter instance the product was isolated by pouring into excess of dilute hydrochloric acid, and the precipitate dissolved in benzene and chromatographed on alumina. The adsorbed material, eluted by means of benzene, recovered by evaporating off the solvent, and crystallised from alcohol, afforded orange-red needles, m. p. 189—190° (Found: C, 86·9; H, 4·7; N, 4·0. Calc. for $C_{27}H_{17}ON$: C, 87·3; H, 4·6; N, 3·8%).

Aniline and 6-*Benzylamino*meso*benzanthrone.*—The product, m. p. 188—189°, isolated after boiling 6-benzylamino*meso*benzanthrone (0·15 g.) under reflux with 7 c.c. of aniline during 6 hours was unchanged 6-benzylamino*meso*benzanthrone.

Piperidine and 6-*Hydroxy*meso*benzanthrone Boroacetate.*—There was an immediate exothermic reaction when 6-hydroxy*meso*benzanthrone boroacetate (2·8 g.) was shaken with piperidine (10 c.c.) which had been dried over potassium hydroxide. The deep-golden-brown solution was kept overnight and then added to dilute hydrochloric acid. The precipitate was collected, dried, and recrystallised from benzene. It formed yellow slender prisms, m. p. 175—176° (Found: C, 82·5; H, 4·2. Calc. for $C_{17}H_{10}O_2$: C, 82·9; H, 4·1%) (yield, 1·5 g.), identical with 6-hydroxy*meso*benzanthrone.

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