CLV.—*Investigations in the Diphenyl Series. Part V. Derivatives of* 4-*Amino- and* 4-*Hydroxy-diphenyl.*

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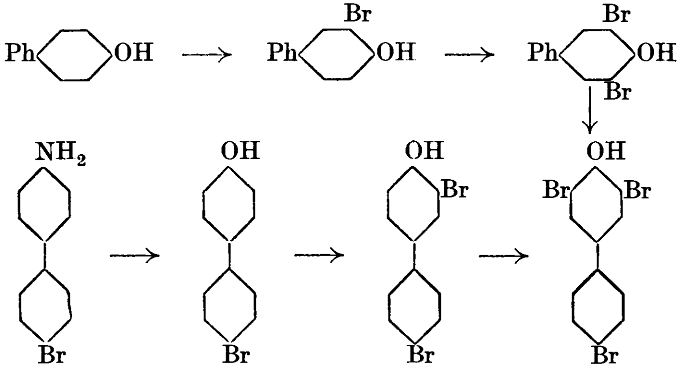
SINCE dinitro-4-methylaminodiphenyl (Bell and Kenyon, J., 1926, 2711) is resistant to acetylating agents, it was inferred that the nitro-groups are in the 3 : 5-positions. This view is substantiated by the fact that 3-nitro-4-methylaminodiphenyl is readily acetylated. 3-Nitro-4-methylaminodiphenyl, which had previously been obtained by the oxidation of 3-nitro-4-dimethylaminodiphenyl (Garciá Banús and Ferrer Tomás, *Anal. Fís. Quím.*, 1921, **19**, 293), was advantageously prepared by the hydrolysis of 3-*nitro*-4-p-*toluenesulphonmethylamidodiphenyl,* obtained by nitration of the corresponding amide. It appears that the orienting influence of the *p*-toluenesulphonmethylamido-group is very similar to that of the acetamido-group. This conclusion is supported by a comparison of the results of the nitration of *p*-toluenesulphonmethylanilide with that of acetanilide, since the ratio of *p* : *o* substitution is very approximately the same in both cases.

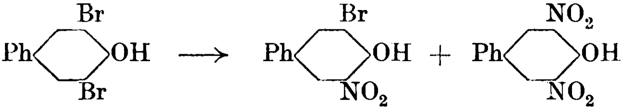
The further substitution of 3 : 4-derivatives of diphenyl is of considerable interest. On further nitration, 3-nitro-4-acetamido-(or dimethylamino-)diphenyl and 3-nitro-4-hydroxydiphenyl yield only 5-nitro-derivatives (Fichter and Sulzberger, *Ber.*, 1904, **37**, 878; Bell and Kenyon, *loc. cit.*; Garciá Banús and Guiteras, *Anal. Fís. Quím.*, 1923, **21**, 126), but 3-nitro-4-methoxydiphenyl, in addition, gives about 15% of the 4′-nitro-derivative (Bell and Kenyon, J., 1926, 3046). The somewhat surprising production of the 4′-bromo-derivative in the bromination of 4-acetamidodiphenyl (Scarborough and Waters, J., 1926, 558; Kenyon and Robinson, *ibid.*, p. 3050) suggested that the bromination of the above compounds might yield interesting results, and 3-nitro-4-acetamidodiphenyl has now been examined. The product consists mainly of the 5-bromo-derivative, together with some of the 5 : 4′-dibromo-derivative and small amounts of other products. No 4′-bromo-3-nitro-4-acetamidodiphenyl was isolated from the reaction mixture.

The bromination of 4-hydroxydiphenyl has now been shown to follow a normal course. Monobromination gives the 3-derivative, dibromination the 3 : 5-derivative, and tribromination the 3 : 5 : 4′-derivative. 4′-Bromo-4-hydroxydiphenyl was prepared from 4′-bromo-4-aminodiphenyl, and converted successively into 3 : 4′-dibromo- and 3 : 5 : 4′-tribromo-4-hydroxydiphenyl.



3 : 5-Dibromo-4-hydroxydiphenyl readily reacts with nitrous acid to give a complex mixture from which 5-bromo-3-nitro- and 3 : 5-

dinitro-4-hydroxydiphenyl have been isolated. This result is in marked contrast with that obtained by Raiford and Colbert (*J. Amer. Chem. Soc.*, 1925, **47**, 1456), who not only failed to isolate these products, but stated that the principal product is a nitrodibromophenol, m. p. 171°. Of this, we can discover no trace.



EXPERIMENTAL.

Nitration of p-*Toluenesulphonmethylanilide.*—10 G. were added to warm nitric acid (20 c.c.); vigorous reaction then occurred. The cooled mixture was filtered from an insoluble part (8·5 g.), and the filtrate poured into water. The precipitated gum (1·3 g.) crystallised from alcohol in prismatic needles, m. p. 126°, identical with *p*-toluenesulphonmethyl-2-nitroanilide (described below). The less soluble material was crystallised from alcohol, and separated into *p*-toluenesulphonmethyl-4-nitroanilide, m. p. 175—176° (identified by comparison with a specimen prepared from *p*-nitroaniline and by hydrolysis to 4-nitromonomethylaniline), and a further small crop of the 2-nitro-derivative.

p-*Toluenesulphon*-2-*nitroanilide*, prepared by the interaction of *o*-nitroaniline and *p*-toluenesulphonyl chloride in pyridine solution, crystallised from alcohol in prismatic needles, m. p. 110° (Found: C, 54·1; H, 4·2. $C_{13}H_{12}O_4N_2S$ requires C, 53·4; H, 4·1%). By methylation with methyl sulphate it gave p-*toluenesulphonmethyl*-2-*nitroanilide*, m. p. 126° (Found: C, 54·4; H, 4·5. $C_{14}H_{14}O_4N_2S$ requires C, 54·9; H, 4·6%).

Nitration of 4-p-*Toluenesulphonmethylamidodiphenyl.*—To 12·5 g., dissolved in acetic acid (125 c.c.) at 70°, was added nitric acid (*d* 1·5; 10 c.c.) in acetic acid (10 c.c.), and the whole was maintained at 70—75° for $\frac{1}{4}$ hour. On cooling, the liquid became filled with needles (11 g., m. p. 154—156°), which were filtered off and, after recrystallisation from acetic acid, had m. p. 157° (Found: C, 63·2; H, 4·9. $C_{20}H_{18}O_4N_2S$ requires C, 62·8; H, 4·7%). The filtrate, when poured into water, gave gummy material (4·5 g.). The main product of the reaction was identical with 3-*nitro*-4-p-*toluenesulphonmethylamidodiphenyl*, prepared by the methylation of 3-nitro-4-*p*-toluenesulphonamidodiphenyl.

3-*Nitro*-4-*methylaminodiphenyl.*—A solution of 3-nitro-4-*p*-toluenesulphonmethylamidodiphenyl (10 g.) in sulphuric acid (20 c.c.) was after $\frac{1}{2}$ hour poured on ice and neutralised with ammonia, and the resulting precipitate was filtered off and crystallised from alcohol. 3-Nitro-4-methylaminodiphenyl forms orange-red needles, m. p. 112°.

3-*Nitro*-4-*nitrosomethylaminodiphenyl*, prepared by the addition of a slight excess of sodium nitrite to a solution of 3-nitro-4-methylaminodiphenyl in acetic acid (10 parts), crystallised from alcohol in pale yellow needles, m. p. 87° (Found : C, 60·8; H, 4·4. $C_{13}H_{11}O_3N_3$ requires C, 60·7; H, 4·2%). Nitration converted it into 3 : 5-dinitro-4-nitrosomethylaminodiphenyl.

3-*Nitro*-4-*acetmethylamidodiphenyl*.—3-Nitro-4-methylaminodiphenyl was warmed on a water-bath with acetic anhydride, until the deep red colour of the solution faded to pale yellow. The solution was poured into water, and the gummy deposit dissolved in alcohol, from which it separated as a pale yellow, crystalline powder, m. p. 89° (Found : C, 66·8; H, 4·7. $C_{15}H_{14}O_3N_2$ requires C, 66·6; H, 5·2%).

Nitration of 4 : 4′-*Di*-p-*toluenesulphonamidodiphenyl*.—This compound (10 g.) was added slowly to nitric acid (*d* 1·4; 20 c.c.), and the mixture was diluted with acetic acid and filtered. 3 : 3′-*Dinitro*-4 : 4′-*di*-p-*toluenesulphonamidodiphenyl* crystallises from pyridine–ethyl alcohol in needles, m. p. 220° (Found : C, 53·8; H, 3·8. $C_{26}H_{22}O_8N_4S_2$ requires C, 53·6; H, 3·8%). It was hydrolysed by dissolving it in sulphuric acid (3 parts) and, after ½ hour, pouring the solution into water. Pure 3 : 3′-dinitrobenzidine, m. p. 275°, was obtained when the product was crystallised from pyridine–ethyl alcohol.

Bromination of 3-*Nitro*-4-*acetamidodiphenyl*.—To a solution of 3-nitro-4-acetamidodiphenyl (17 g.) in acetic acid (70 c.c.), bromine (11 g.) in acetic acid (5 c.c.), and ferric chloride (1 g.) were added. The mixture was heated on a water-bath for 10 hours, cooled, and filtered from a deposit (13 g.) which consisted mainly of the hydrobromides of bases produced by hydrolysis. The filtrate was poured into water; the gummy deposit (8 g.) thus obtained crystallised from alcohol in needles, m. p. 93—95° (Found : C, 50·4; H, 3·0. $C_{14}H_{11}O_3N_2Br$ requires C, 50·2; H, 3·3%). The hydrobromides were decomposed by boiling water and the mixture of amines obtained was acetylated. The acetyl derivatives were readily separated by crystallisation from alcohol into a less soluble portion, m. p. 140—150°, and a more soluble portion, m. p. 85—95°. The former, after crystallisation from carbon tetrachloride and then from alcohol, formed long, yellow needles, m. p. 153° (Found : C, 40·0; H, 2·4. $C_{14}H_{10}O_3N_2Br_2$ requires C, 40·5; H, 2·4%), whilst the latter, after repeated crystallisation, gave pure (5 ?)-*bromo*-3-*nitro*-4-*acetamidodiphenyl*, m. p. 94—95°. The compound, m. p.

153°, is probably 5 : 4′-*dibromo*-3-*nitro*-4-*acetamidodiphenyl*, since it was also obtained by the bromination of 4′-bromo-3-nitro-4-acetamidodiphenyl as follows. To a hot solution of 4′-bromo-4-acetamidodiphenyl (3 g.) in acetic acid (30 c.c.) was added nitric acid (*d* 1·5; 2 c.c.) in acetic acid (2 c.c.). After ½ hour, the mixture was allowed to cool; 4′-bromo-3-nitro-4-acetamidodiphenyl, m. p. 197—200°, then separated. This compound (2·4 g.), acetic acid (30 c.c.), bromine (1·6 g.), and ferric chloride were warmed together until hydrogen bromide ceased to be evolved. On cooling, the liquid filled with orange needles, m. p. 151—153°.

In addition to the 5- and 5 : 4′-bromo-derivatives, there was isolated a trace of a compound which crystallised from alcohol in colourless needles, m. p. 210—213° (Found : C, 45·6; H, 3·1; N, 3·8%).

4′-*Bromo*-4-*aminodiphenyl* was prepared by Le Fèvre and Turner's method (J., 1926, 2045) and characterised by means of its p-*toluenesulphonyl* derivative, which crystallised from alcohol in needles, m. p. 174° (Found : C, 57·2; H, 3·65. $C_{19}H_{16}O_2NBrS$ requires C, 56·7; H, 4·0%).

4′-*Bromo*-4-*hydroxydiphenyl*.—4′-Bromo-4-aminodiphenyl (10 g.) was dissolved in boiling dilute hydrochloric acid (700 c.c. of 1%), the solution rapidly cooled to 5—10°, and sodium nitrite (3 g.) added. After ½ hour, the solution was filtered, dilute sulphuric acid added, and steam passed in. The precipitate which formed was filtered off and extracted with boiling dilute aqueous sodium hydroxide. The extract was acidified with hydrochloric acid and the crude bromophenol precipitated was filtered off and crystallised from alcohol. 4′-*Bromo*-4-*hydroxydiphenyl* forms plates, m. p. 164—166° (Found : C, 57·6; H, 3·8. $C_{12}H_9OBr$ requires C, 57·8; H, 3·6%).

3 : 4′-*Dibromo*-4-*hydroxydiphenyl*.—To a warm solution of 4′-bromo-4-hydroxydiphenyl (10 g.) in chloroform (90 c.c.) was added bromine (6·5 g.) in chloroform (10 c.c.). The chloroform solution was evaporated to a small bulk and then diluted with light petroleum. On cooling, hard, stellate masses, m. p. 117°, were formed (Found : C, 44·2; H, 2·7. $C_{12}H_8OBr_2$ requires C, 43·9; H, 2·4%).

3 : 5 : 4′-*Tribromo*-4-*hydroxydiphenyl*, prepared as described above from 4′-bromo-4-hydroxydiphenyl (7·4 g.) and bromine (10·8 g.), crystallised from chloroform in stout needles, m. p. 159° (Found : C, 35·8; H, 1·9. $C_{12}H_7OBr_3$ requires C, 35·4; H, 1·7%).

3 : 4′-*Dibromo*-5-*nitro*-4-*hydroxydiphenyl*.—To a warm solution of 3 : 4′-dibromo-4-hydroxydiphenyl (3·2 g.) in acetic acid (20 c.c.) was added nitric acid (*d* 1·4; 0·8 c.c.) in acetic acid (10 c.c.). The

solution rapidly filled with small needles; these, after crystallisation from chloroform, had m. p. 189° (Found: C, 38·9; H, 2·0. $C_{12}H_7O_3NBr_2$ requires C, 38·6; H, 1·9%).

3-*Bromo*-4-*hydroxydiphenyl*.—To a warm solution of 4-hydroxydiphenyl (7·8 g.) in chloroform (70 c.c.) was added bromine (7·4 g.) in chloroform (10 c.c.). After partial evaporation of the chloroform, and dilution with light petroleum, the liquid filled with needles of 3-*bromo*-4-*hydroxydiphenyl*, m. p. 96° (Found: C, 57·8; H, 3·5. $C_{12}H_9OBr$ requires C, 57·8; H, 3·6%).

3 : 5-Dibromo-4-hydroxydiphenyl, obtained in quantitative yield by using 14·8 g. of bromine in the previous preparation, crystallised from chloroform–light petroleum in needles, m. p. 91—94° (Raiford gives m. p. 96°).

Oxidation of 4 g. with alkaline permanganate gave a trace of *p*-bromobenzoic acid, and we were unable to eliminate the small amount of impurity which gives rise to this acid. The dibromophenol is, however, readily characterised as its p-*toluenesulphonyl* derivative, which crystallises from acetic acid in needles, m. p. 132° (Found: C, 47·5; H, 2·6. $C_{19}H_{14}O_3Br_2S$ requires C, 47·3; H, 2·9%). Further bromination in chloroform slowly converted this dibromophenol into 3 : 5 : 4′-tribromo-4-hydroxydiphenyl (see above).

Action of Nitrous Acid on 3 : 5-*Dibromo*-4-*hydroxydiphenyl*.—Various amounts of sodium nitrite (1—2 mols.) and acetic acid were tried, and the following is a typical experiment. To a solution of the dibromophenol (10·9 g.) in acetic acid (100 c.c.), sodium nitrite (3·6 g.), dissolved in the minimum quantity of water, was added. After ¼ hour, the mixture was warmed on the steam-bath for a few minutes and then poured into water. The oily product obtained slowly solidified; after being dried, and fractionally crystallised from chloroform, it gave two pure products. The less soluble formed yellow, lustrous plates, m. p. 152° (Found: C, 55·7; H, 3·0%), identical with 3 : 5-dinitro-4-hydroxydiphenyl (Calc.: C, 55·4; H, 3·1%) prepared by the method of Garciá Banús and Guiteras (*loc. cit.*). The more soluble portion, which formed golden-yellow needles, m. p. 76°, was 5-*bromo*-3-*nitro*-4-*hydroxydiphenyl* (Found: C, 49·1; H, 3·1. $C_{12}H_8O_3NBr$ requires C, 49·0; H, 2·7%). Only gummy products were formed when 3 : 5-dibromo-4-hydroxydiphenyl was treated with nitric acid (1 mol.).

Action of Nitrous Acid on 3 : 5 : 4′-*Tribromo*-4-*hydroxydiphenyl*.—To this tribromophenol (2·2 g.) in hot acetic acid (33 c.c.) was added sodium nitrite (0·6 g.), and the solution was poured into water. The bulk of the product consisted of 5 : 4′-dibromo-3-nitro-4-hydroxydiphenyl (above).

Action of Nitric Acid on 3-*Bromo*-4-*hydroxydiphenyl*.—To this bromophenol (5·2 g.) in acetic acid (25 c.c.) was added nitric acid (1·5 c.c.) in acetic acid (10 c.c.). The reaction was completed by warming, the mixture poured into water, and the precipitated mass filtered off and fractionally crystallised from chloroform–light petroleum. It was thus separated into 3 : 5-dinitro-4-hydroxydiphenyl, 5-bromo-3-nitro-4-hydroxydiphenyl, and a small amount of 5-bromo-3 : 4′-dinitro-4-hydroxydiphenyl (see below).

3-*Bromo*-4′-*nitro*-4-*hydroxydiphenyl*.—To a suspension of 4′-nitro-4-hydroxydiphenyl (4 g.) in boiling chloroform (70 c.c.) was added bromine (3 g.) in chloroform (10 c.c.), and the resultant solution was evaporated. The residue crystallised from aqueous acetic acid as a pale yellow powder, m. p. 132° (Found: C, 49·6; H, 3·0. $C_{12}H_8O_3NBr$ requires C, 49·0; H, 2·7%).

5-*Bromo*-3 : 4′-*dinitro*-4-*hydroxydiphenyl*.—To 3-bromo-4′-nitro-4-hydroxydiphenyl (3 g.) in warm acetic acid (20 c.c.) was added nitric acid (0·8 c.c.) in acetic acid (5 c.c.). The liquid immediately filled with golden-yellow needles, which, after crystallisation from acetic acid, melted at 218° (Found: C, 42·1; H, 2·4. $C_{12}H_7O_5N_2Br$ requires C, 42·5; H, 2·1%).

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