

CCLXXIV.—*Orientation Effects in the Diphenyl Series.**Part III. The Mononitro-4 : 4'-dihalogenodiphenyls and Some Allied Compounds.*

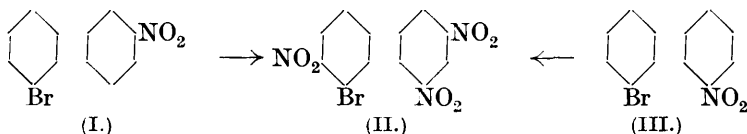
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IN Part I of this series (this vol., p. 476) it was concluded that the product of mononitration of 4 : 4'-dibromodiphenyl (Lellmann, *Ber.*, 1882, **15**, 2837) was the 2-nitro-derivative, and further investigation of this compound therefore seemed desirable. We have attempted to prepare it by other methods, as follows: (1) from 2-nitrobenzidine, using the perbromide method of Griess-Saunders, (2) from 2-nitrodiphenyl by direct bromination, and (3) from 4-bromo-4'-aminodiphenyl (see Experimental).

2-Nitrobenzidine, under the conditions of a perbromide displacement, gave, not 4 : 4'-dibromo-2-nitrodiphenyl, but a substance which we regard as 3' : 4' : 4'-tribromo-2-nitrodiphenyl.

2-Nitrodiphenyl, when brominated in the cold in presence of ferric chloride, readily gave 4-bromo-2'-nitrodiphenyl (I), obtained by Schultz, Schmidt, and Strasser (*Annalen*, 1881, **207**, 311) from 2'-nitro-4-aminodiphenyl. The bromonitro-compound could not, however, be further brominated to give Lellmann's compound (above).

4-Bromo-2'-nitrodiphenyl nitrated readily to give 4-bromo-2' : 3 : 4'-trinitrodiphenyl (II), whose constitution is established (a) by its conversion by piperidine into 2' : 3 : 4'-trinitro-4-piperidinodiphenyl, and (b) by its formation also by the nitration of 4-bromo-4'-nitrodiphenyl (III).

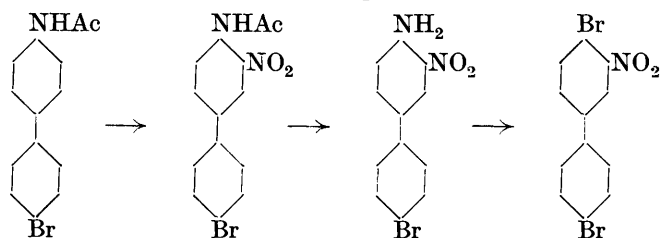


The restricted nitration of 4 : 4'-dibromodiphenyl was accordingly studied afresh, and a satisfactory method has been found (see Experimental) for the preparation of the 2-nitro-derivative, avoiding the extravagant conditions described by Lellmann.

By the restricted nitration of 4 : 4'-dichlorodiphenyl under similar conditions, 4 : 4'-dichloro-2-nitrodiphenyl was obtained. Its constitution follows from its inertness towards piperidine.

It was now necessary to prepare 4 : 4'-dibromo-3-nitrodiphenyl in order to discover whether this, like its isomeride, would be quantita-

tively nitrated to give the 2 : 3'-dinitro-compound. The following scheme denotes the reactions which gave the desired result :



4-Nitrodiphenyl brominated readily in glacial acetic acid at 100° to give 4-bromo-4'-nitrodiphenyl (III). The nitration of 4-bromo-4'-acetaminodiphenyl gave the 3'-nitro-compound, whose constitution was proved by its conversion into a 4 : 4'-dibromonitrodiphenyl, m. p. 101—102°, which reacted with piperidine, depressed the m. p. of 4 : 4'-dibromo-2-nitrodiphenyl, and is evidently the desired 4 : 4'-*dibromo-3-nitrodiphenyl*. The identity of Lellmann's compound is thus, incidentally, set beyond all doubt.

Nitration of 4 : 4'-dibromo-3-nitrodiphenyl gave 4 : 4'-dibromo-2 : 3'-dinitrodiphenyl, together with a second substance (probably the 3 : 3'-dinitro-compound) from which it could not be separated. When the crude nitration product was heated with piperidine, there resulted a mixture of piperidino-derivatives, from which pure 4-bromo-4'-piperidino-2 : 3'-dinitrodiphenyl (Dennett and Turner, Part I, *loc. cit.*) was isolated. Thus, whilst 4 : 4'-dibromo-2 : 3'-dinitrodiphenyl is formed *quantitatively* by the nitration of the 2-nitro-derivative, it is accompanied by an isomeride when prepared by the nitration of the 3-nitro-compound. Further, 4 : 4'-dichloro-2-nitrodiphenyl is the first substance formed during the conversion of 4 : 4'-dichlorodiphenyl into its 2 : 3'-dinitro-derivative.

In our earlier attempts to prepare 4 : 4'-dibromo-3-nitrodiphenyl, it was hoped to make use of 3-nitrobenzidine. Koller (*Ber.*, 1904, **37**, 2880) described the preparation of this substance, m. p. 190°, by the nitration of monophthalylbenzidine,\* and hydrolysis of the resulting mononitro-compound. We carefully followed Koller's directions

\* Other allied experiments have shown that monophthalylbenzidine does not possess the structure assumed by Koller (*loc. cit.*) and by Kauffer (*Annalen*, 1907, **351**, 151), but contains instead a free amino-radical, and therefore a phthalylamino-group. The formation of 2-nitrobenzidine mentioned above is not surprising, since the "amino-sulphate" group has a pronounced meta-orienting influence, and the phthalylamino-group is known not to exhibit any appreciable ortho-para orienting effect when other substituents are present (Cain and Micklethwait, *J.*, 1914, **105**, 1442; Brady, Quick, and Welling, *J.*, 1925, **127**, 2264). An investigation of the structures of other "Kauffer compounds" is now in progress.

for nitration on six different occasions. Each time, the bulk of the product was 2-nitrobenzidine, and no isomeric nitrobenzidine having the properties mentioned by Koller was isolated.

Since the nitration of diacetylbenzidine in excess of nitric acid gives 3 : 3'-dinitrodiacetylbenzidine (Strakosch, *Ber.*, 1872, **5**, 236; Cain, Coulthard, and Micklethwait, *J.*, 1912, **101**, 2298; Le Fèvre and Turner, this vol., p. 1759), it might seem that the mononitration of diacetylbenzidine would yield 3-nitrodiacetylbenzidine. This has been investigated, but, owing to the highly insoluble nature of diacetylbenzidine, we were compelled to use concentrated sulphuric acid as a solvent. Only impure 2-nitrobenzidine was isolated. A similar meta-directing influence on the part of an acetylaminogroup under these conditions was noted by Koller (*Ber.*, 1903, **36**, 410), the nitration of *p*-acetylaminophenyloxamic acid in concentrated sulphuric acid giving 4-acetylamino-2-nitrophenyloxamic acid.

In Parts I and II of this series, reference was made to the action of reagents other than piperidine on dihalogenodinitrodiphenyls. Some *phenoxy*-, *amino*-, *anilino*-, *methylanilino*-, and *piperazino*-derivatives of 2 : 3'- and 3 : 3'-dinitrohalogenodiphenyls are now described.

#### EXPERIMENTAL.

*Perbromide Displacement on 2-Nitrobenzidine.*—The nitrobenzidine was diazotised in sulphuric acid, and the solution treated with bromine dissolved in hydrobromic acid. The perbromide separated as an oil, which slowly became an orange solid. This was washed, pressed, and boiled with glacial acetic acid until bromine evolution ceased. The resulting solution, on cooling, became a magma of crystals, which were washed with spirit and once recrystallised from glacial acetic acid, 3 : 4 : 4'-tribromo-2'-nitrodiphenyl (?) being obtained in needles, m. p. 195—196° (Found : N, 3.6; Br, 55.2; *M*, in camphor by Rast's method, 450.  $C_{12}H_6O_2NBr_3$  requires N, 3.2; Br, 55.0%; *M*, 436). The molecular weight was determined in order to distinguish the compound from the other possible product, a hexabromodinitrobenzerythrene (requiring N, 3.2; Br, 55.1%; *M*, 870).

*Bromination of 2-Nitrodiphenyl.*—A mixture of 22.5 g. of the nitrocompound, 8 c.c. of bromine, 1 g. of ferric chloride, and 25 c.c. of water was well stirred, and then left over-night. After removal of the excess of bromine by means of sodium carbonate, followed by crystallisation from alcohol, 4-bromo-2'-nitrodiphenyl was obtained in good yield. Attempts to brominate the product further, by means of bromine and ferric chloride, either in the cold or at high temperatures under pressure, were unsuccessful.

*Nitration of 4-Bromo-2'-nitrodiphenyl.*—This substance was dissolved in nitric acid (*d* 1.5; 7 parts by wt.) at the ordinary temperature. After 2 minutes, the solution was rapidly diluted, the product collected, and crystallised from glacial acetic acid. 4-Bromo-2' : 3 : 4'-trinitrodiphenyl was thus obtained as cream-coloured needles, m. p. 176—177°, sparingly soluble in alcohol (Found : Br, 21.8.  $C_{12}H_6O_6N_3Br$  requires Br, 21.7%).

When the last-named compound was warmed for 1 minute with excess of piperidine, it was converted into 2' : 3 : 4'-trinitro-4-piperidinodiphenyl, which crystallised from glacial acetic acid in scarlet plates, m. p. 144—145° (Found : N, 15.3.  $C_{17}H_{16}O_6N_4$  requires N, 15.0%).

*Nitration of 4-Bromo-4'-nitrodiphenyl.*—This substance was nitrated by the method used for the 2'-nitro-compound, and gave 4-bromo-2' : 3 : 4'-trinitrodiphenyl, identical with the specimen obtained from 4-bromo-2'-nitrodiphenyl. Identity was further confirmed by means of the piperidino-derivatives.

*4-Bromo-2'-nitro-4'-aminodiphenyl.*—When 4-bromo-4'-aminodiphenyl (see below) was nitrated in excess of concentrated sulphuric acid a product was obtained which could not be crystallised. It was therefore converted into the acetyl derivative, which melted at about 151°. Hydrolysis gave the amino-compound as a yellow solid, m. p. about 180°. This could not be purified further, and a perbromide displacement gave a gummy product from which no chemical individual was isolated.

*Restricted Nitration of 4 : 4'-Dibromodiphenyl.*—To a solution of the dibromo-compound (10 g.) in a mixture of 100 c.c. of acetic acid and 100 c.c. of acetic anhydride at 85—90°, 5 g. of potassium nitrate in 30 c.c. of concentrated sulphuric acid were added slowly. After being heated for a further 20 minutes, the solution was cooled, the dibromodiphenyl that separated (1.7 g.) was removed, and the residue diluted with water. The resulting precipitate melted at 110—115° after drying, and at 124° after four crystallisations from alcohol. One further crystallisation from light petroleum (b. p. 80—100°) and then two crystallisations from alcohol failed to raise the m. p.\* (Particular care was taken in purifying this substance because of its indefinite crystalline appearance.)

*Restricted Nitration of 4 : 4'-Dichlorodiphenyl.*—A well-stirred

\* Nitration by this method gave 2 g. (22% yield) of the pure material. The process described by Lellmann affords a product which is very difficult to purify. About 500 g. of fuming nitric acid are required for the preparation of a gram or so of the pure nitro-compound. As Lellmann says : "Da das Dibromdiphenyl in Eisessig schwer löslich ist, so ist die Ausbeute an Mononitrodibromdiphenyl eine geringe." We are unable to account for the m. p. (127°) recorded by Lellmann.

solution of 5.6 g. of dichlorodiphenyl in 100 c.c. of glacial acetic acid and 10 c.c. of acetic anhydride was slowly treated at 90° with a solution of 3.5 g. of potassium nitrate in a little sulphuric acid, and thereafter the temperature was kept at 100° for  $\frac{1}{2}$  hour. On cooling, 2 g. of unchanged dichlorodiphenyl separated. The solution was diluted, and the resulting bright yellow solid (3 g.) dissolved in a little hot alcohol. On cooling, the yellow nitro-compound and the white dichloro-compound separated together, and this occurred after three further crystallisations. Three subsequent crystallisations from alcohol, in which the boiling solution was allowed to cool partially, followed by two crystallisations from carbon tetrachloride, gave 4 : 4'-dichloro-2-nitrodiphenyl as yellow needles, m. p. 102° (Found: Cl, 26.3.  $C_{12}H_7O_2NCl_2$  requires Cl, 26.5%). The nitro-compound was unaffected by piperidine, and was not accompanied, in its formation, by any isomeride.

4-Bromo-4'-nitrodiphenyl.—A mixture of 4-nitrodiphenyl (45 g.), glacial acetic acid (90 c.c.), and bromine (22.3 c.c.) was heated at 100° for 3.5 hours (longer heating diminished the yield), cooled, and filtered. The resulting solid crystallised from about 300 c.c. of glacial acetic acid in slightly brown needles, m. p. 170—172° (yield, 80%). The product was sufficiently pure for use in the next stage (compare Schultz, *Annalen*, 1874, 174, 218).

4-Bromo-4'-amino- and 4-Bromo-4'-acetylamino-diphenyl.—A boiling solution of 50 g. of the bromonitro-compound in 400 c.c. of alcohol was treated slowly with a solution of 180 g. of stannous chloride crystals in 200 c.c. of concentrated hydrochloric acid. Heating was then continued for an hour (bath at 100°). On cooling, plates separated. These were stirred with excess of alkali and the resulting amino-compound was collected and crystallised from alcohol. Thus obtained, it melted at 142—143° (Gelmo, *Ber.*, 1906, 39, 4175, gives 145° corr.). 30 G. were boiled for 2 hours with a mixture of 75 c.c. of acetic acid and 40 c.c. of acetic anhydride; after the usual procedure, 33 g. of 4-bromo-4'-acetylamino-diphenyl were obtained (see Gelmo, *loc. cit.*).

4-Bromo-3'-nitro-4'-acetylamino-diphenyl.—A solution of the preceding acetyl compound (32 g.) in a mixture of 400 c.c. of glacial acetic acid, 160 c.c. of acetic anhydride, and 160 c.c. of concentrated sulphuric acid was kept at 0° and treated with 12 g. of potassium nitrate. After 12 hours the solution was warmed to 50° for 20 minutes, cooled and poured on to ice. The light yellow powder, so obtained, after two crystallisations from acetic acid, gave plates, m. p. 199—200° (Found: Br, 24.2.  $C_{14}H_{11}O_3N_2Br$  requires Br, 23.9%).

4-Bromo-3'-nitro-4'-aminodiphenyl.—The preceding compound

was heated for 30 minutes at 140° with a mixture of equal volumes of concentrated sulphuric acid and water. The solution was cooled, basified with ammonia and the precipitate collected. It did not crystallise well from any of the common solvents, but was obtained pure by solution in *o*-dichlorobenzene and partial precipitation with light petroleum, forming brown needles, m. p. 174—175° (Found : Br, 27.1.  $C_{12}H_9O_2N_2Br$  requires Br, 26.9%).

4 : 4'-Dibromo-3-nitrodiphenyl.—The preceding amine was dissolved in concentrated sulphuric acid (10 parts), and ice added until a precipitate just began to form. Solid sodium nitrite (1 mol.) and, at intervals, ice were added. The filtered solution, when treated with a mixture of bromine and hydrobromic acid, gave the *perbromide* as a reddish-orange, crystalline precipitate. This was boiled with acetic acid, and the resulting solution diluted; the dibromo-compound which separated crystallised from alcohol in cream-coloured plates, m. p. 101—102° (Found : Br, 44.9; *M*, in camphor by Rast's method, 352.  $C_{12}H_7O_2NBr_2$  requires Br, 44.8%; *M*, 357.  $C_{24}H_{12}O_4N_2Br_4$ , the corresponding tetrabromodinitrobenzerythrene, requires Br, 44.9%; *M*, 712).

4-Bromo-3'-nitro-4'-piperidinodiphenyl, readily obtained by heating the dibromo-compound with piperidine, separated from alcohol in bright yellow plates, m. p. 85° (Found : Br, 26.7.  $C_{17}H_{17}O_2N_2Br$  requires Br, 26.9%).

Nitration of 4 : 4'-Dibromo-3-nitrodiphenyl.—This substance was warmed with excess of nitric acid (*d* 1.5) for 1 minute, the solution rapidly diluted, and the yellow precipitate dried. It had m. p. 110—125° and could not be purified by crystallisation. Extraction with benzene, however, left a solid, m. p. 190—200° alone or 210—215° when mixed with 4 : 4'-dibromo-3 : 3'-dinitrodiphenyl, with which it is probably identical. The latter substance would appear to be the only possible dibromodinitrodiphenyl (melting above 200°) that could be formed in the above circumstances.

The crude nitration mixture was boiled with excess of piperidine. The gummy product became solid after repeated washing with hot water and was then recrystallised four times from alcohol. The yellow crystals so obtained melted at 135°. A mixture with an authentic specimen of 4-bromo-2 : 3'-dinitro-4'-piperidinodiphenyl melted at 135—136°.

Nitration of Monophthalylbenzidine.—Monophthalylbenzidine was prepared and nitrated exactly as described by Koller (*loc. cit.*). The nitration product was hydrolysed either with cold ammonia as recommended by Koller or by heating with 60% sulphuric acid for 20 minutes at 140°. In the former case a mixture was produced the separation of which was difficult, but in the latter case, when the

acid solution was cooled, impure 2-nitrobenzidine sulphate crystallised, a partial separation being thus effected. It was found best, however, to liberate the mixture of free bases, dissolve them in excess of hydrochloric acid, filter the solution from the yellowish-brown sludge, and precipitate the bases fractionally with ammonia. Repeated applications of this process led to separation into two main fractions, m. p. about 127° and m. p. about 200°, respectively. The former, after repeated crystallisation, gave pure 2-nitrobenzidine, whilst the latter could not be purified, but was probably impure 2 : 3'-dinitrobenzidine, formed by the nitration of 2-nitrophthalylbenzidine.

*Nitration of Diacetylbenzidine.*—A solution of 36 g. of diacetylbenzidine in 120 c.c. of concentrated sulphuric acid was cooled to -3° to -5° and slowly nitrated with 12 g. of potassium nitrate dissolved in 30 c.c. of concentrated sulphuric acid. After being stirred for 10 minutes, the mixture was diluted with water, and the resulting yellow precipitate washed with boiling alcohol, and hydrolysed at once with excess of 60% sulphuric acid at 140° for 20 minutes. After cooling, dilution and basification, a reddish-brown product was obtained from which only 2-nitrobenzidine could be isolated. Variation of the conditions of nitration produced no essential difference in the result.

*Displacement Products from 4 : 4'-Dichloro- and 4 : 4'-Dibromo-2 : 3'-dinitrodiphenyls.*—The anilino-, methylanilino-, and piperazino-derivatives described below were formed by gently boiling a solution of the halogen compound concerned with about 10 parts of the appropriate base for 5 minutes. On cooling, the base hydrochloride or hydrobromide crystallised. The magma was stirred with dilute hydrochloric acid to remove excess of amine, the product washed with water, and recrystallised from a suitable solvent.

*4-Bromo-2 : 3'-dinitro-4'-anilinodiphenyl* crystallises from glacial acetic acid in spherical aggregates of orange microscopic needles, m. p. 151° (Found : Br, 19.1.  $C_{18}H_{12}O_4N_3Br$  requires Br, 19.3%).

*4-Chloro-2 : 3'-dinitro-4'-anilinodiphenyl* separates from dilute acetic acid in orange-yellow, microscopic needles, m. p. 129—130° (Found : Cl, 9.5.  $C_{18}H_{12}O_4N_3Cl$  requires Cl, 9.6%).

*4-Bromo-2 : 3'-dinitro-4'-methylanilinodiphenyl* separates from alcohol in yellow plates, m. p. 142—143° (Found : Br, 9.4.  $C_{19}H_{14}O_4N_3Br$  requires Br, 9.8%).

*4-Chloro-2 : 3'-dinitro-4'-methylanilinodiphenyl* crystallises from alcohol in golden-yellow, rectangular platelets, m. p. 134° (Found : Cl, 9.2.  $C_{19}H_{14}O_4N_3Cl$  requires Cl, 9.3%).

*4-Bromo-2 : 3'-dinitro-4'-phenoxydiphenyl.*—To the hot solution

produced by mixing 3 g. of potassium hydroxide, 1 c.c. of water, and 20 g. of phenol, 2 g. of 4 : 4'-dibromo-2 : 3'-dinitrodiphenyl were added, and the whole was boiled for a few minutes. After cooling and treatment with water, a yellow powder was obtained which crystallised from glacial acetic acid in pale yellowish-green, hairy needles, m. p. 124—125° (Found : Br, 19.1.  $C_{18}H_{11}O_5N_2Br$  requires Br, 19.3%).

4-Chloro-2 : 3'-dinitro-4'-phenoxydiphenyl, prepared like the bromo-compound, crystallises from glacial acetic acid in pale greenish-yellow, hairy needles, m. p. 113° (Found : Cl, 9.6.  $C_{18}H_{11}O_5N_2Cl$  requires Cl, 9.6%).

4-Bromo-2 : 3'-dinitro-4'-piperazindiphenyl was obtained by heating 3 g. of dibromodinitrodiphenyl with 3.5 g. of piperazine for 2 minutes. The product, obtained on dilution with water, crystallised from *o*-dichlorobenzene in yellow, microscopic plates, m. p. above 250° (Found : Br, 19.1.  $C_{16}H_{15}O_4N_4Br$  requires Br, 19.6%).

4-Chloro-2 : 3'-dinitro-4'-piperazindiphenyl, prepared similarly, separates from alcohol as a yellowish-orange, amorphous powder, which blackens above 200° and does not melt at 250° (Found : Cl, 9.2.  $C_{16}H_{15}O_4N_4Cl$  requires Cl, 9.8%).

Similarly, when the dihalogeno-2 : 3'-dinitro-compounds were heated with aqueous-alcoholic ammonia at 140—160° for 8 hours under pressure, the following compounds were obtained : 4-Chloro-2 : 3'-dinitro-4'-aminodiphenyl, long, orange needles, from alcohol, m. p. 218—219° (Found : Cl, 12.0.  $C_{12}H_8O_4N_3Cl$  requires 12.1%), and 4-bromo-2 : 3'-dinitro-4'-aminodiphenyl, yellow needles, m. p. 219° (Found : Br, 23.8.  $C_2H_8O_4N_3Br$  requires 23.7%).

*Displacement Products from 4 : 4'-Dibromo-3 : 3'-dinitrodiphenyl.*—Bases reacted with this substance to give products which were much less soluble than the corresponding substances obtained from the 2 : 3'-compound.

3 : 3'-Dinitro-4 : 4'-dianilinodiphenyl separates from pyridine in reddish-brown, microscopic needles, m. p. 242° (Found : N, 13.8.  $C_{24}H_{18}O_4N_4$  requires N, 13.1%).

3 : 3'-Dinitro-4 : 4'-dimethylanilinodiphenyl is sparingly soluble in acetic acid, and crystallises from pyridine in light brown, rectangular plates, m. p. 250° (Found : N, 12.8.  $C_{26}H_{22}O_4N_4$  requires N, 12.3%). (All three methylanilino-derivatives have the same crystalline appearance under the microscope.)

3 : 3'-Dinitro-4 : 4'-diphenoxydiphenyl.—In the preparation of this substance a reddish-brown tar containing diphenols results if water is present. Potassium hydroxide (5 g.) was dissolved in 30 c.c. of molten phenol, and 2 g. of the dibromodinitro-compound were added. The mixture was boiled for 5 minutes, cooled somewhat,



and diluted first with alcohol, and then with water. The greenish-yellow precipitate, after being twice crystallised from glacial acetic acid, became a yellow, microcrystalline powder, m. p. 139—140° (Found : N, 6.8.  $C_{24}H_{16}O_6N_2$  requires N, 6.5%).

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