8. *A Rearrangement of* o-*Aminodiphenyl Ethers. Part V.*

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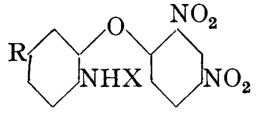
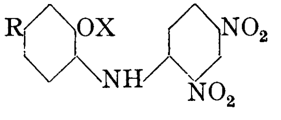
In extension of the observations recorded in Parts I to IV (J., 1934, 727; 1935, 196, 1309, 1312), an investigation of the rearrangement of 5-substituted 2′ : 4′-dinitro-2-aminodiphenyl ethers (I, R = OMe, Me, H, I, Cl; X = H) to the isomeric 4-substituted diphenylamines (II) is now reported. The behaviour of certain acyl derivatives of (I and II, X = acetyl, *o*-nitrobenzoyl) is also recorded.

(I.)





(II.)

The members of the limited series which it has proved practicable to prepare show behaviour closely analogous to that of the 4-substituted ethers (*loc. cit.*, p. 727). The rates of rearrangement in minutes under the standard conditions previously described (Part II, J., 1935, 198) are shown in the accompanying table, those of the earlier 4-series being included for comparison, and the substituents being arranged in order of decreasing negative inductive effect. In the new series, approach from either side to the optimum in the neighbourhood of R = H is much more rapid, and complete inhibition of the change under the standard conditions is reached on the one hand at R = OMe and on the other at R = Cl. This is presumably due to the stronger effect of R in the *p*- than in the *m*-position to the amino-group in inhibiting the rearrangement either by reducing the tendency of amino-hydrogen to be ejected as a proton (R = OMe) or by reducing the ability of the amino-nitrogen atom to supply the electron demand at the positive α-carbon atom in the dinitrophenyl nucleus (R = Cl). In this connection compare Part II (*loc. cit.*, p. 197) and also the generalisations of Evans and Smiles (J., 1935, 181) covering the mechanism of rearrangements of this type.

Substituent (R)	NH_2	OMe	Me	H	I	Br	Cl	CO_2H
4-Series	50	13	7	5	15	30	60	No change
5-Series	—	No change	90	5	7	—	No change	—

Decreasing $-I$ ⟶ $+I$

An additional feature shown in the new series is the highly specific nature of the effect of the catalysing solvent. Thus the simple alcohols which readily effect rearrangement of the 4-substituted ethers are without effect on those now discussed. A further instance of this specificity is provided by the 5-methyl ether in the present series, which, while it undergoes the normal rearrangement under the influence both of weak bases (aniline, pyridine) and of alkalis (aqueous caustic soda, baryta), is most readily affected by the strongly basic piperidine. In this solvent, which is without effect either on the 4-substituted ethers or on the other members of the present series, the 5-methyl ether is converted almost instantaneously into the isomeric diphenylamine. The 5-methoxy- and the 5-chloro-ether, which readily rearrange at their melting points, are nevertheless stable towards all other reagents tried.

Experimental.

2′ : 4′-*Dinitro-2-hydroxy-4-methoxydiphenylamine.*—2-Amino-5-methoxyphenol was conveniently prepared by reduction of an aqueous-alcoholic solution of benzeneazoresorcinol 4-methyl ether with sodium hyposulphite. It was isolated as the hydrochloride by treatment of the reaction mixture with hydrochloric acid.

Equimolecular amounts of the above hydrochloride and 1-chloro-2 : 4-dinitrobenzene in alcohol were heated for 6 hours under reflux in presence of anhydrous sodium acetate (4 mols.). The *product*, isolated in 60% yield by usual methods, exhibited chromoisomerism, being obtained red from alcoholic solution and brown from glacial acetic acid, m. p. 178° (Found: C, 51·4; H, 3·3. $C_{13}H_{11}O_6N_3$ requires C, 51·1; H, 3·6%).

2′ : 4′-*Dinitro-2-hydroxy-5-methoxydiphenyl Ether.*—2-Amino-5-methoxyphenol hydrochloride (1 mol., 1·2 g.) in alcohol (40 c.c.) containing potassium ethoxide (2 mols.) was cooled in ice, and chlorodinitrobenzene (1 mol.) in alcohol added. After 1 hour the insoluble yellow *ether* was purified (yield 40%) and recrystallised from benzene, forming yellow needles, m. p. 162° (Found : C, 51·3; H, 3·3. $C_{13}H_{11}O_6N_3$ requires C, 51·1; H, 3·6%). No diphenylamine was observed among the products of the reaction.

2′ : 4′-*Dinitro*-2-*hydroxy*-4-*methyldiphenylamine*.—4-Amino-*m*-cresol (3 g., from 4-nitro-*m*-cresol in aqueous caustic soda with sodium hyposulphite) in alcohol (20 c.c.) was treated with chlorodinitrobenzene (5 g.) and anhydrous sodium acetate (5 g.) for 2 hours under reflux. The *product* (80% yield), isolated by pouring the reaction mixture into cold water, crystallised from alcohol in alkali-soluble red needles, m. p. 166—167° (Found : C, 53·7; H, 4·2. $C_{13}H_{11}O_5N_3$ requires C, 54·0; H, 3·8%). The substance was also obtained by rearrangement of the isomeric diphenyl ether. The orange *acetate*, m. p. 145°, was purified from alcohol (Found : C, 54·2; H, 3·4. $C_{15}H_{13}O_6N_3$ requires C, 54·3; H, 3·9%). The o-*nitrobenzoate*, prepared in acetone solution in presence of anhydrous sodium carbonate, formed bright yellow crystals, m. p. 185°, from benzene (Found : C, 54·7; H, 3·4. $C_{20}H_{14}O_8N_4$ requires C, 54·7; H, 3·1%). This substance also resulted when 2′ : 4′-dinitro-2-amino-5-methyldiphenyl ether in warm acetone was treated with excess of *o*-nitrobenzoyl chloride.

2′ : 4′-*Dinitro*-2-*amino*-5-*methyldiphenyl Ether*.—4-Amino-*m*-cresol (6 g.) in the minimum amount of alcohol was treated with sodium ethoxide (somewhat less than 1 mol.) and added to chlorodinitrobenzene (10 g.) dissolved in alcohol (80 c.c.); the mixture was kept for 1 hour at 20°. The resulting *ether*, which separated in 45% yield, formed yellow crystals, m. p. 134°, from benzene (Found : C, 53·8; H, 4·1. $C_{13}H_{11}O_5N_3$ requires C, 54·0; H, 3·8%). The isomeric diphenylamine also was isolated from the reaction mixture. The *acetyl* derivative, formed in the cold with acetic anhydride in presence of 50% aqueous acetic acid, formed pale yellow needles, m. p. 146°, from benzene (Found : N, 12·8. $C_{15}H_{13}O_6N_3$ requires N, 12·6%). The o-*nitrobenzoyl* derivative, formed in glacial acetic acid solution with *o*-nitrobenzoyl chloride at room temperature, was a white substance, m. p. 206° (from benzene) (Found : N, 12·8. $C_{20}H_{14}O_8N_4$ requires N, 12·7%).

The parent ether rearranged rapidly to the isomeric diphenylamine in piperidine solution in the cold, and also when heated alone at 150°. The same rearrangement was effected slowly in contact with 2*N*-sodium hydroxide and with 2*N*-baryta, and also in solution in aniline and in pyridine. Alcohols, organic acids and aqueous ammonia were without effect. The above derivatives underwent similar but slower rearrangements to the corresponding derivatives of the isomeric diphenylamine, the *o*-nitrobenzoyl more slowly than the acetyl derivative; but heating of the solution in some cases effected hydrolysis of the derivative.

2′ : 4′-*Dinitro*-2-*hydroxydiphenylamine*.—The m. p. of this material, previously recorded as 199°, is 205°.

2′ : 4′-*Dinitro*-2-*aminodiphenyl Ether*.—An improved yield (80%) of this substance was obtained (cf. Part II, *loc. cit.*, p. 199) by using somewhat less than the theoretical amount of sodium ethoxide in the condensation, and by keeping the reaction mixture for only ¾ hour. The m. p. is 133°, not 123° as previously reported (*loc. cit.*).

4-*Iodo*-2′ : 4′-*dinitro*-2-*hydroxydiphenylamine*.—A paste of *m*-iodoaniline (11 g.) with sulphuric acid (20 g.) and water (50 c.c.) was diazotised at 0° with a 10% solution of sodium nitrite (4 g.). After 2 hours the filtered liquid was added slowly to a mixture of sulphuric acid and water (2 : 1) at 140°. *m*-Iodophenol distilled in quantitative yield (cf. B.P. 200,714). 3-Iodo-6-nitrophenol (Hodgson and Moore, J., 1927, 632) in boiling 50% aqueous alcohol was quantitatively reduced by sodium hyposulphite to 3-iodo-6-aminophenol. Condensation of the latter with chlorodinitrobenzene as described above yielded the *diphenylamine* (80%; red crystals, m. p. 180°, from alcohol. Found : C, 36·2. $C_{12}H_8O_5N_3I$ requires C, 35·9%). The same substance resulted on rearrangement of the isomeric diphenyl ether. The o-*nitrobenzoate*, prepared as above, was obtained as a bright yellow substance, m. p. 206°, from benzene (Found : N, 10·2. $C_{19}H_{11}O_8N_4I$ requires N, 10·1%). It was also formed when the iodoaminodiphenyl ether in warm acetone was treated with excess of *o*-nitrobenzoyl chloride.

5-*Iodo*-2′ : 4′-*dinitro*-2-*aminodiphenyl Ether*.—3-Iodo-6-aminophenol (1 g.) in absolute alcohol (20 c.c.) containing potassium ethoxide (1 mol.) was treated for 1 hour at 20° with chlorodinitrobenzene (1 mol.) in the minimum amount of alcohol. The purified insoluble *product* (50% yield) was obtained after two crystallisations from benzene in bright yellow needles, m. p. 175° (Found : C, 35·8; H, 2·2. $C_{12}H_8O_5N_3I$ requires C, 35·9; H, 1·9%). A little of the isomeric diphenylamine also was formed. The o-*nitrobenzoyl* derivative, prepared in cold acetic acid solution, was a colourless substance, m. p. 194° (from benzene) (Found : N, 10·0. $C_{19}H_{11}O_8N_4I$ requires N, 10·1%).

The parent ether rearranged at the melting point, and in both aniline and pyridine solutions, but not in aqueous alkali or in piperidine. Normal rearrangement of the *o*-nitrobenzoyl derivative took place slowly under the usual conditions.

4-*Chloro*-2′ : 4′-*dinitro*-2-*hydroxydiphenylamine*.—To *m*-chlorophenol (13 g.) in cooled glacial acetic acid (100 c.c.) was gradually added fuming nitric acid (6·3 g.) in glacial acetic acid (100 c.c.) at 0°. The material which separated when the reaction mixture was poured on ice was distilled with steam, and the volatile 3-chloro-6-nitrophenol was thus removed in 32% yield. The chloronitrophenol in 50% aqueous alcohol was smoothly reduced by gradual addition of sodium hyposulphite (*q.s.*). After removal of alcohol, the aminophenol separated in a very pure form (yield, theoretical).

Condensation of the aminophenol to the *diphenylamine* was effected as usual, the product (90% yield) being obtained in a red form from alcohol and in purple needles from benzene, both having m. p. 208°. It was also obtained during the preparation of the isomeric diphenyl ether (below) (Found : C, 46·8; H, 2·2. $C_{12}H_8O_5N_3Cl$ requires C, 46·5; H, 2·5%). The o-*nitrobenzoate* formed yellow plates, m. p. 196°, from glacial acetic acid (Found : N, 12·2. $C_{19}H_{11}O_8N_4Cl$ requires N, 12·2%).

5-*Chloro*-2′ : 4′-*dinitro*-2-*hydroxydiphenyl Ether*.—3-Chloro-6-aminophenol (3 g.) in alcohol (20 c.c.) containing potassium ethoxide (1 mol.) was treated for 1½ hours at room temperature with chlorodinitrobenzene (1 mol.) in alcohol (40 c.c.). The insoluble yellow *ether* (yield, 70—80%) was purified from alcohol and from benzene, m. p. 176° (Found : C, 46·3; H, 2·3. $C_{12}H_8O_5N_3Cl$ requires C, 46·5; H, 2·5%). The isomeric diphenylamine also was formed in small amount. The o-*nitrobenzoyl* derivative, prepared by usual methods, formed colourless prisms, m. p. 202°, from benzene (Found : N, 12·0. $C_{19}H_{11}O_8N_4Cl$ requires N, 12·2%). It also resulted when the chlorodiphenylamine in boiling acetone was treated with excess of *o*-nitrobenzoyl chloride. For similar anomalous reactions, compare Part III, *loc. cit.*, p. 1310.

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