CLI.—*The Bromination of 2-Nitro- and 2-Acetamidodiphenyl Ether.*

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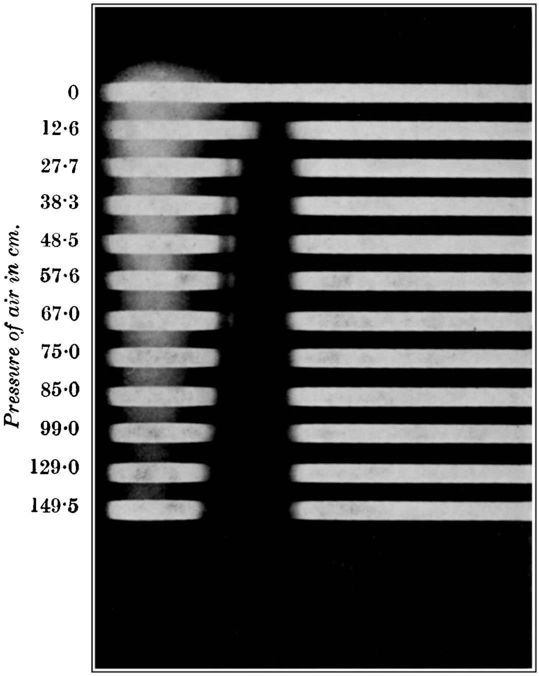
The bromination of 2-nitrodiphenyl ether proceeded in three stages : 4-*bromo*-2′-*nitrodiphenyl ether* was formed in acetic acid solution, 2 : 4-*dibromo*-2′-*nitrodiphenyl ether* by the action of dry bromine in diffused light, and 2 : 4 : 4′-*tribromo*-2′-*nitrodiphenyl ether* (I) by the action of dry bromine in bright sunlight. Similarly, 2-*bromo*-2′-*nitro*-, 4-*bromo*-2-*nitro*-, and 5-*bromo*-2-*nitro-diphenyl ethers* when brominated in acetic acid solution yielded dibromo-derivatives in which the entering bromine atom occupies the 4-position in the non-nitrated nucleus. The action of dry bromine on 2 : 4-dibromo- and 4 : 4′-*dibromo*-2′-*nitrodiphenyl ethers* was to yield 2 : 4 : 4′-tribromo-2′-nitrodiphenyl ether; and 4 : 5′-*dibromo*-2′-*nitrodiphenyl ether* yielded 2 : 4 : 4′ : 5′-*tetrabromo*-2′-*nitrodiphenyl ether*.

The bromination of 2-acetamidodiphenyl ether in acetic acid solution gave 5-*bromo*-2-*acetamidodiphenyl ether* as the sole product; a second bromine atom could, however, be introduced under the same conditions to give 4 : 5′-*dibromo*-2′-*acetamidodiphenyl ether*.

FIG. 1.



Iodine vapour at various air pressures at 90°.

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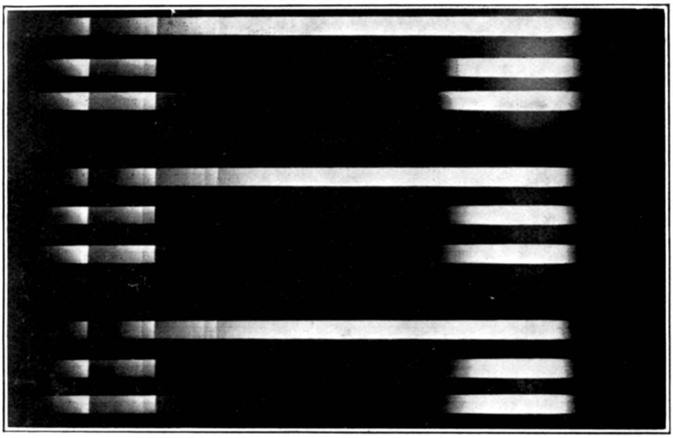
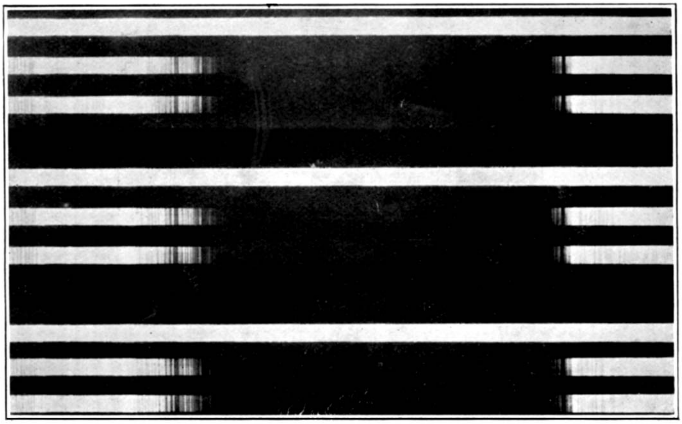
FIG. 2.



Bromine in a vacuum and in air at 15°.

Reference spectrum and three sets of exposures.

FIG. 3.

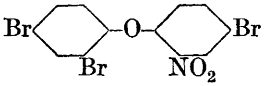


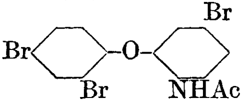
Chlorine in a vacuum and in air.

Reference spectrum and three sets of exposures.

The direct introduction of a third bromine atom into the molecule was not attempted. Further it was found that 2-, 4-, and 4′-*bromo-2′-acetamidodiphenyl ethers* were also brominated in the 5′-position; 4 : 4′-*dibromo-* and 2 : 4 : 4′-*tribromo-2′-acetamidodiphenyl ethers* behaved in the same manner. Under similar conditions it was found that 2 : 5′-*dibromo-2′-acetamidodiphenyl ether* was converted into 2 : 4 : 5′-*tribromo-2′-acetamidodiphenyl ether* (II).

(I.)





(II.)

The structures of the monobromo-2-nitro- and 2 : 4-dibromo- and 4 : 4′-dibromo-2′-nitro-diphenyl ethers were established by the condensation of appropriately substituted *o*-halogenonitrobenzenes with sodium or potassium halogenophenoxide. The reduction of the nitro-compound to the base and subsequent acetylation also determines the structure of the corresponding bromoacetamidodiphenyl ethers. Since both 2 : 4- and 4 : 4′-dibromo-2′-nitrodiphenyl ethers yield the same tribromo-compound, it must have the constitution 2 : 4 : 4′-tribromo-2′-nitrodiphenyl ether, and the structure of the acetamido-derivative also follows. The further bromination of 5-bromo-2-nitrodiphenyl ether, reduction and acetylation yielded a product identical with that obtained by the further bromination of 4-bromo-2′-acetamidodiphenyl ether and thus established the structure of 4 : 5′-dibromo-2′-nitrodiphenyl ether and of the corresponding acetamido-derivative. The orientation of the bromine atoms in 2 : 4 : 4′ : 5′-tetrabromo-2′-nitrodiphenyl ether and of the acetyl derivative of the derived base was fixed by brominating 2 : 4 : 4′-tribromo-2′-acetamidodiphenyl ether and proving that the product was identical with that obtained by introducing three bromine atoms into the molecule of 5-bromo-2-nitrodiphenyl ether and reducing and acetylating the product.

The results show that the bromination of 2-nitro- or of a monobromo-2-nitro-diphenyl ether proceeds in stages until the 2 : 4-positions in the non-nitrated and the 4-position in the nitrated nucleus are substituted; a definite sequence is followed and substitution in the nitrated nucleus does not take place until the other two positions are substituted. The introduction of the third bromine atom into the 4-position in the nitrated nucleus as the sole product to be isolated was unexpected and thus in the case of both 2- and 4-nitrodiphenyl ethers there seems to be a marked steric factor which limits substitution in the positions adjacent to the oxygen linkage. A marked difference is shown between the behaviour of 2- and 4-acetamidodiphenyl ethers on bromination;

whereas 2-acetamidodiphenyl ether yielded as the sole product a compound substituted in the same nucleus as the acetamido-group, 4-acetamidodiphenyl ether yielded a single product substituted in the opposite nucleus. Further, a dibromo-derivative of 4-acetamidodiphenyl ether was obtained only with great difficulty, yet 2-acetamidodiphenyl ether yielded a dibromo-derivative with the greatest ease. The loading of the 2-acetamidodiphenyl ether molecule with bromine atoms did not appear in any way to hinder substitution in the 5-position in the same nucleus as the acetamido-group. Two factors would seem to influence the positions taken by the bromine atoms; first, the strong directive effect of the acetamido-group, which exceeds that of any other group in the molecules considered, and secondly a strong steric factor, which would almost seem to inhibit substitution in the positions ortho to the acetamido-group.

Certain substituted derivatives of 2-aminodiphenyl ether have been converted into the corresponding diphenylene oxides. It is proposed to extend the work along these lines.

EXPERIMENTAL.

2-Nitrodiphenyl ether was prepared by heating, at 160° for 12 hours, a mixture of 2 parts of *o*-chloronitrobenzene and 1 part of sodium phenoxide in the presence of copper powder. The product was distilled in steam to remove excess *o*-chloronitrobenzene and the residue was taken up in ether, washed with dilute soda solution and water, dried, and distilled under diminished pressure.

2-*Bromo*-2′-*nitrodiphenyl ether* was obtained when *o*-chloronitrobenzene was condensed with potassium *o*-bromophenoxide. It distilled at 250°/20 mm., and separated from methyl alcohol in faintly yellow prisms, m. p. 54° (Found : Br, 27·35. $C_{12}H_8O_3NBr$ requires Br, 27·2%).

4-*Bromo*-2-*nitrodiphenyl ether* was prepared by the condensation of 2 : 5-dibromonitrobenzene with potassium phenoxide. Excess 2 : 5-dibromonitrobenzene was removed by prolonged distillation with steam. The product was a light yellow oil, b. p. 210°/15 mm. (Found : Br, 27·4. $C_{12}H_8O_3NBr$ requires Br, 27·2%).

4-*Bromo*-2′-*nitrodiphenyl ether* was obtained when 2-nitrodiphenyl ether was treated, in carbon tetrachloride or acetic acid solution, with a slight excess of bromine as a 10% solution. The reaction was completed by warming the mixture on a water-bath for 30 minutes and then pouring it into a dilute solution of sodium sulphite. It separated from methyl alcohol in faintly yellow needles, m. p. 72° (Found : Br, 27·05. $C_{12}H_8O_3NBr$ requires Br, 27·2%). The same product was obtained when *o*-chloronitrobenzene was condensed with potassium *p*-bromophenoxide.

5-*Bromo-2-nitrodiphenyl Ether*.—2 : 4-Dibromonitrobenzene (1·1 mols.) was condensed with sodium phenoxide (1 mol.), in the presence of phenol and copper powder, at 150° for 18 hours. The compound, extracted in the usual manner, crystallised from methyl alcohol in yellow plates, m. p. 108° (Found : Br, 26·95. $C_{12}H_8O_3NBr$ requires Br, 27·2%).

2 : 4-*Dibromo-2′-nitrodiphenyl ether* was obtained when 2-nitro- or 4-bromo-2′-nitrodiphenyl ether was treated with an excess of dry bromine, and the solution kept until it solidified. The product was warmed with a dilute solution of sodium sulphite and crystallised from methyl alcohol. 2 : 4-Dibromo-2′-nitrodiphenyl ether separated from light petroleum (b. p. 40—60°) in small yellow needles, m. p. 80°. The condensation of *o*-chloronitrobenzene with potassium 2 : 4-dibromophenoxide, at 200° for 24 hours, yielded the same product (Found : Br, 43·0. $C_{12}H_7O_3NBr_2$ requires Br, 42·9%).

4 : 4′-*Dibromo-2-nitrodiphenyl ether* was prepared by treating 4-bromo-2-nitrodiphenyl ether with a slight excess of bromine in acetic acid solution. It separated from methyl alcohol in pale yellow needles, m. p. 94° (Found : Br, 42·9. $C_{12}H_7O_3NBr_2$ requires Br, 42·9%). The same product was obtained when 2 : 5-dibromonitrobenzene was condensed with potassium *p*-bromophenoxide.

4 : 5′-*Dibromo-2′-nitrodiphenyl ether* was obtained when 5-bromo-2-nitrodiphenyl ether was treated with a slight excess of bromine in acetic acid solution. It crystallised from methyl alcohol in yellow plates, m. p. 99° (Found : Br, 42·8. $C_{12}H_7O_3NBr_2$ requires Br, 42·9%).

2 : 4 : 4′-*Tribromo-2′-nitrodiphenyl ether* was obtained when 2-nitro-, 4-bromo-2′-nitro-, 4-bromo-2-nitro-, or 2 : 4-dibromo-2′-nitro-diphenyl ether was dissolved in dry bromine, and the solution kept in sunlight until a solid mass was formed. Excess bromine was removed with dilute aqueous sodium sulphite, and the product crystallised from acetic acid. It separated from methyl alcohol in pale yellow prisms, m. p. 102° (Found : C, 31·65; H, 1·5; Br, 53·3. $C_{12}H_6O_3NBr_3$ requires C, 31·85; H, 1·35; Br, 53·1%).

2 : 4 : 4′ : 5′-*Tetrabromo-2′-nitrodiphenyl ether* was prepared by dissolving 5-bromo-2-nitrodiphenyl ether in excess of dry bromine and keeping the solution in sunlight until a solid mass was obtained. It crystallised from ethyl alcohol or acetic acid in yellow needles, m. p. 170° (Found : Br, 59·95. $C_{12}H_5O_3NBr_4$ requires Br, 60·2%).

2-*Acetamidodiphenyl Ether*.—2-Nitrodiphenyl ether was reduced with stannous chloride in ethereal hydrogen chloride solution by refluxing for 3 hours. The ether was removed and the base was liberated with 30% sodium hydroxide solution, taken up in ether, and distilled under diminished pressure. 2-Aminodiphenyl ether was obtained as a light yellow oil, b. p. 173°/20 mm., m. p. 44°. It was acetylated with acetic acid (4 parts) and acetic anhydride (1 part) by refluxing for 20 hours. On pouring the solution into water an oil was obtained which solidified slowly. The acetyl derivative crystallised from dilute methyl alcohol or light petroleum (b. p. 60—80°) in prisms, m. p. 81°.

2-*Bromo-2′-acetamidodiphenyl Ether*.—2-Bromo-2′-nitrodiphenyl ether was reduced with stannous chloride in ethereal hydrogen chloride solution, and the base extracted in the usual manner. 2-*Bromo-2′-aminodiphenyl ether* crystallised from light petroleum (b. p. 40—60°) in clustered needles, m. p. 60° (Found : Br, 30·3. $C_{12}H_{10}ONBr$ requires Br, 30·3%). The base was acetylated by refluxing it for 2 days with acetic anhydride (1 part) and acetic acid (10 parts); the *product* crystallised from methyl alcohol or light petroleum (b. p. 60—80°) in needles, m. p. 95° (Found : Br, 26·3. $C_{14}H_{12}O_2NBr$ requires Br, 26·1%).

2-*Bromo-2′-diacetamidodiphenyl ether* was obtained when 2-bromo-2′-aminodiphenyl ether was refluxed with a mixture of acetic anhydride (1 part) and acetic acid (3 parts) for 36 hours. It separated from methyl alcohol or light petroleum in heavy prisms, m. p. 105° (Found : Br, 23·1. $C_{16}H_{14}O_3NBr$ requires Br, 23·0%).

4-*Bromo-2-aminodiphenyl Ether*.—4-Bromo-2-nitrodiphenyl ether was reduced in the usual manner. The *base* distilled at 222°/15 mm. and the light yellow oil slowly solidified; it separated from light petroleum in clustered needles, m. p. 54° (Found : Br, 30·3. $C_{12}H_{10}ONBr$ requires Br, 30·3%). Acetylation of the base was attempted under various conditions, but the product was invariably a thick oil which would neither solidify nor crystallise from any of the usual solvents.

4-*Bromo-2′-aminodiphenyl ether* was obtained, by the reduction of 4-bromo-2′-nitrodiphenyl ether in the usual manner, as a light yellow oil, b. p. 211°/15 mm. (Found : Br, 30·5. $C_{12}H_{10}ONBr$ requires Br, 30·3%). The *acetyl* derivative was obtained by refluxing the base with a mixture of acetic anhydride and acetic acid; it separated from methyl alcohol in prisms, m. p. 106° (Found : Br, 25·95. $C_{14}H_{12}O_2NBr$ requires Br, 26·1%).

5-*Bromo-2-acetamidodiphenyl Ether*.—2-Acetamidodiphenyl ether was brominated in acetic acid solution in the presence of fused sodium acetate, or 5-bromo-2-nitrodiphenyl ether was reduced and the base acetylated. The *acetyl* derivative separated from methyl alcohol in prisms, m. p. 146° (Found : Br, 25·95. $C_{14}H_{12}O_2NBr$ requires Br, 26·1%).

5-*Bromo-2-aminodiphenyl ether* was obtained by the reduction of the nitro-compound or by refluxing the acetyl derivative with ethyl-alcoholic hydrochloric acid for 4 hours. It separated from light petroleum (b. p. 40—60°) in plates, m. p. 46° (Found: Br, 30·15. $C_{12}H_{10}ONBr$ requires Br, 30·3%). The *hydrochloride* crystallised from a solution of the base in dilute hydrochloric acid in needles, m. p. 186° (Found: HCl, 12·15. $C_{12}H_{10}ONBr,HCl$ requires HCl, 12·15%).

2 : 4-Dibromo-2′-aminodiphenyl ether was prepared by reducing the corresponding nitro-compound in the usual manner and was liberated as a thick yellow oil which did not solidify. It was purified by conversion into the *hydrochloride*, which separated from dilute hydrochloric acid solution in plates, m. p. 180° (Found: HCl, 9·5. $C_{12}H_9ONBr_2,HCl$ requires HCl, 9·6%). The base was acetylated with a mixture of acetic acid and anhydride; the *acetyl* derivative crystallised from light petroleum (b. p. 60—80°) in needles, m. p. 117° (Found: Br, 41·3. $C_{14}H_{11}O_2NBr_2$ requires Br, 41·5%).

2 : 5′-*Dibromo-2′-acetamidodiphenyl Ether*.—2-Bromo-2′-acetamidodiphenyl ether was treated with a slight excess of bromine in acetic acid solution in the presence of fused sodium acetate. It separated from light petroleum (b. p. 80—100°) in clustered needles, m. p. 112° (Found: Br, 41·5. $C_{14}H_{11}O_2NBr_2$ requires Br, 41·5%).

4 : 4′-*Dibromo-2′-aminodiphenyl ether* was prepared by the reduction of 4 : 4′-dibromo-2′-nitrodiphenyl ether and obtained as an oil, b. p. 240°/15 mm., which slowly solidified and then crystallised from methyl alcohol in needles, m. p. 70° (Found: Br, 46·5. $C_{12}H_9ONBr_2$ requires Br, 46·65%). The *acetyl* derivative, prepared in the usual manner, separated from methyl alcohol or benzene in needles, m. p. 142° (Found: Br, 41·35. $C_{14}H_{11}O_2NBr_2$ requires Br, 41·55%).

4 : 5′-*Dibromo-2′-acetamidodiphenyl ether* was obtained when 4 : 5′-dibromo-2′-nitrodiphenyl ether was reduced and the base acetylated; or when 4-bromo-2′-acetamidodiphenyl ether was brominated in acetic acid solution in the presence of fused sodium acetate. It crystallised from methyl alcohol in needles, m. p. 144° (Found: Br, 41·55. $C_{14}H_{11}O_2NBr_2$ requires Br, 41·55%). 4 : 5′-*Dibromo-2′-aminodiphenyl ether* was prepared by refluxing the acetyl derivative with alcoholic hydrochloric acid for 3 hours; it separated from methyl alcohol in needles, m. p. 82° (Found: Br, 46·4. $C_{12}H_9ONBr_2$ requires Br, 46·65%). The *hydrochloride* separated from dilute hydrochloric acid solution in needles, m. p. 202° (Found: HCl, 9·65. $C_{12}H_9ONBr_2,HCl$ requires HCl, 9·6%).

2 : 4 : 4′-*Tribromo-2′-aminodiphenyl ether*, obtained by the reduc-

tion of 2 : 4 : 4′-tribromo-2′-nitrodiphenyl ether with stannous chloride in ethereal hydrogen chloride solution, separated from methyl alcohol or light petroleum in rosetted needles, m. p. 83° (Found: Br, 57·1. $C_{12}H_8ONBr_3$ requires Br, 56·9%). It was acetylated in the usual manner and the *acetyl* derivative separated from methyl alcohol in needles, m. p. 127° (Found: Br, 51·65. $C_{14}H_{10}O_2NBr_3$ requires Br, 51·7%).

2 : 4 : 5′-*Tribromo-2′-acetamidodiphenyl ether* was obtained when 2 : 4- or 2 : 5′-dibromo-2′-acetamidodiphenyl ether was treated with bromine in acetic acid solution in the presence of fused sodium acetate. It separated from methyl alcohol in needles, m. p. 147° (Found: Br, 51·7. $C_{14}H_{10}O_2NBr_3$ requires Br, 51·7%).

4 : 4′ : 5′-*Tribromo-2′-acetamidodiphenyl ether* was obtained from 4 : 4′-dibromo-2′-acetamidodiphenyl ether by bromination in the usual manner; and also from 5-bromo-2-acetamidodiphenyl ether by bromination in acetic acid solution on the water-bath. It crystallised from methyl alcohol in needles, m. p. 167° (Found: Br, 51·6. $C_{14}H_{10}O_2NBr_3$ requires Br, 51·7%). 4 : 4′ : 5′-*Tribromo-2′-aminodiphenyl ether*, obtained by deacetylation in alcoholic hydrochloric acid solution, crystallised from methyl alcohol or light petroleum in needles, m. p. 120° (Found: Br, 56·7. $C_{12}H_8ONBr_3$ requires Br, 56·85%). The *hydrochloride* of the base separated from methyl-alcoholic hydrochloric acid solution in needles, m. p. 222° (Found: HCl, 7·7. $C_{12}H_8ONBr_3,HCl$ requires HCl, 7·9%).

2 : 4 : 4′ : 5′-*Tetrabromo-2′-acetamidodiphenyl ether* was prepared by treating 2 : 4 : 4′-tribromo-2′-acetamidodiphenyl ether with excess of bromine in acetic acid solution in the presence of fused sodium acetate; after standing in the sunlight and warming to 70°, a partly brominated product was obtained, from which the unchanged tribromo-compound was separated by refluxing with light petroleum. The residue crystallised from ethyl alcohol in needles, m. p. 210° (Found: Br, 58·9. $C_{14}H_9O_2NBr_4$ requires Br, 58·9%). The same product was obtained when 2 : 4 : 4′ : 5′-tetrabromo-2′-nitrodiphenyl ether was reduced and the base acetylated in the usual manner.

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