LXXVI.—*The Chlorination and Bromination of 4-Aminodiphenyl.*

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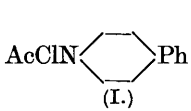
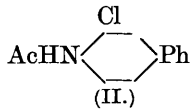
THE action of chlorine or bromine on 4-aminodiphenyl and on its acetyl derivative appears to have been investigated in only one instance, where it was shown that, by direct bromination of 4-acetylaminodiphenyl, 4′-bromo-4-acetylaminodiphenyl resulted (Hübner, *Annalen*, 1881, **209**, 339). Other halogen derivatives, however, have been prepared from benzidine and from tolidine by an adaptation of the Sandmeyer reaction (Taüber, *Ber.*, 1894, **27**, 2627; Gelmo, *Ber.*, 1906, **39**, 4175); the structure of these compounds necessarily follows from their method of preparation.

The present investigation had as its objects the preparation of the *N*-halogen derivatives and their conversion into ring-substituted products; and the direct introduction of chlorine or bromine into the molecule of 4-aminodiphenyl or 4-acetylaminodiphenyl.

It was found that a stable *N*-chloro-4-acetylaminodiphenyl (I) could be obtained from which 3-chloro-4-acetylaminodiphenyl (II) resulted; the latter compound again could be converted into a *N*-chloro-derivative which was unstable, lost chlorine, and from which a ring-substituted product could not be obtained. The corresponding *N*-bromo-4-acetylaminodiphenyl could be prepared only in an impure state, it lost bromine with ease, and the original acetyl derivative was not recovered.



(I.)



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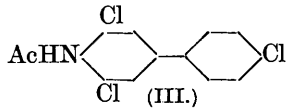

(III.)

The chlorination of the free base was attempted under various conditions, but only deeply coloured and tarry products were obtained. In contrast to this, the acetylated base could be substituted readily with the formation of 3-chloro-4-acetylaminodiphenyl, and on further chlorination 3 : 5 : 4′-trichloro-4-acetylaminodiphenyl (III) was obtained. It was found impossible to introduce more than these three atoms of chlorine into the molecule and obtain a product capable of being separated into individual compounds.

The bromination of the free base proceeded smoothly, yielding 3 : 5-dibromo-4-aminodiphenyl, and under altered conditions the latter compound could be further brominated to give 3 : 5 : 4′-tribromo-4-aminodiphenyl. Higher bromination products appear

to be formed; but from the mixture of substances produced it has been found impossible, so far, to isolate individual compounds. The acetyl derivative of the base on bromination yielded either 4′-bromo-4-aminodiphenyl or its acetyl derivative and a small quantity of a dibrominated product which has been shown to be 3 : 4′-dibromo-4-acetylaminodiphenyl. Bromination at a higher temperature yielded 3 : 5 : 4′-tribromo-4-aminodiphenyl.

The orientation of substituents in the nuclei of diphenyl is of a complex nature; thus whilst 4-aminodiphenyl and its acetyl derivative on chlorination or nitration yield a product substituted in the position adjacent to the amino-group, yet when the substituent in the 4-position is varied as widely as the halogens, the nitro-group and the carboxyl group the entering substituent goes to the 4′-position.

As the direct substitution of only 2- and 4-monosubstituted diphenyl derivatives has been investigated, it is impossible to put forward more than tentative suggestions. The following assumptions appear to be necessary :

(*a*) The usual directive influence is to be ascribed to all the simple groups.

(*b*) The phenyl group and the group C_6H_4X (where X may be an ortho-para or meta-directing group) have a strong ortho-para-directive influence.

(*c*) The amino-, hydroxy-, and derived groups promote substitution in the same nucleus.

Thus it appears that the position taken up by a substituent depends on the velocity with which substitution can be effected. This is in agreement with the experimental evidence that ortho-para-directing groups, and in particular the amino- or hydroxy-group, render substitution easy, whereas meta-directing groups tend to make substitution a comparatively slow process.

Alternatively, it might be suggested that substitution only occurs in the nucleus containing the directing group when this group is capable of being itself substituted and then undergoing a rearrangement which transfers the substituent to the ring. This would be in accord with the behaviour of amino- and hydroxy-groups.

The behaviour of 4-acetylaminodiphenyl on monobromination is very striking, since it appears to be the only known case among the substitution products of 4-amino- or 4-hydroxy-diphenyl in which the first substituent enters the 4′-position; this result is still more unexpected, since 4-aminodiphenyl itself gives rise to a normal sequence of substitution products.

This abnormal behaviour might be ascribed to (*a*) a mechanism for this bromination different from that involved in all other cases, or (*b*) steric influences. Three alternative mechanisms appear

possible: (1) the formation of a *N*-halogen compound followed by an *intra*molecular change; (2) the formation of a *N*-halogen compound followed by an *inter*molecular change; and (3) the direct interaction of the halogen and the aminodiphenyl molecules. Since *N*-bromo-4-acetylaminodiphenyl cannot be converted into a ring-substituted product, mechanism (1) cannot be the mechanism involved; since the corresponding *N*-chloro-compound can be thus transformed and since direct chlorination yields the same product, any one of the three mechanisms may be involved.

To ascribe the difference in behaviour to a steric factor would imply that by acetylation of the base the velocity of interaction of bromine with the more reactive hydrogen atoms in the 3- and 5-positions is decreased to such an extent that the less reactive hydrogen atom in the 4′-position is substituted almost exclusively.

It is the intention of the authors to complete a study of the chlorination and bromination of 2-aminodiphenyl and to extend the work to a consideration of 3-nitro- and 3-amino-diphenyl.

EXPERIMENTAL.

4-Aminodiphenyl was prepared by nitrating diphenyl by Ludens's method (*Ber.*, 1875, **8**, 871) and reducing the product by Schlenk's method (*Annalen*, 1909, **368**, 303).

N-*Chloro*-4-*acetylaminodiphenyl*.—To a suspension of 10·6 g. of 4-acetylaminodiphenyl in a solution of 13 g. of sodium bicarbonate in 200 c.c. of water, 150 c.c. of *N*-sodium hypochlorite were added during 2 hours. The product was collected after 12 hours, washed with water, dried, and extracted with light petroleum (b. p. 40—60°), in which 4-acetylaminodiphenyl is insoluble. The *chloroamine* crystallised from carbon tetrachloride in colourless needles, m. p. 129·5° (Found: Cl, 14·3. $C_{14}H_{12}ONCl$ requires Cl, 14·4%).

3-*Chloro*-4-*acetylaminodiphenyl*.—(a) *Conversion of the chloroamine*. To a hot solution of 5 g. of the chloroamine in 100 c.c. of spirit and 2—3 c.c. of glacial acetic acid, sufficient water was added to start precipitation. The product separated on cooling, and crystallised from dilute alcohol in needles, m. p. 147°.

(b) *Direct chlorination of* 4-*acetylaminodiphenyl*. Chlorine was passed into a 2% solution of the acetylamine in glacial acetic acid, cooled in ice-water, until the theoretical gain in weight was obtained. The product, which was precipitated with water, contained higher chlorination products (Found: Cl, 14·7. $C_{14}H_{12}ONCl$ requires Cl, 14·4%).

3-*Chloro*-4-*aminodiphenyl hydrochloride* was obtained on hydrolysis of the acetyl derivative with 10% alcoholic hydrochloric acid. The

salt separated from the solution, on cooling, in long needles, m. p. 217° (decomp.) (Found : HCl, 15·1. $C_{12}H_{10}NCl$,HCl requires HCl, 15·2%).

3-*Chloro*-4-*aminodiphenyl* was precipitated from the solution of the hydrochloride by dilute ammonia. It crystallised from dilute alcohol in needles, m. p. 71° (Found : Cl, 17·2. $C_{12}H_{10}NCl$ requires Cl, 17·4%).

3 : 4-*Dichlorodiphenyl*, obtained from the amine by the usual methods, was a faintly yellow oil, b. p. 195—200°/15 mm., which solidified to a pale yellow, crystalline mass, m. p. 46° (Found : Cl, 30·8. $C_{12}H_8Cl_2$ requires Cl, 31·8%). On oxidation of this crude product with chromic anhydride in glacial acetic acid solution, 3 : 4-dichlorobenzoic acid was obtained (m. p. 200°).

3-*Chloro*-4-*acetylchloroaminodiphenyl*.—The chloroamine was prepared in the manner described for 4-acetylchloroaminodiphenyl. It was a white powder soluble in non-aqueous solvents; it could not be obtained pure owing to the ease with which it lost chlorine. Several attempts were made, under various conditions, to bring about a rearrangement, but in each case chlorine was evolved and 3-chloro-4-acetylaminodiphenyl was obtained.

3 : 5 : 4′-*Trichloro*-4-*acetylaminodiphenyl*.—Chlorine and carbon dioxide were passed slowly into a 5% solution of 4-acetylaminodiphenyl, the temperature being kept as low as possible. Excess chlorine was removed with a current of air, and the solution diluted with water until precipitation commenced. The product crystallised from acetone in needles, m. p. 236° (Found : Cl, 33·6. $C_{14}H_{10}ONCl_3$ requires Cl, 33·8%).

3 : 5 : 4′-*Trichloro*-4-*aminodiphenyl*.—The acetyl derivative was hydrolysed with alcoholic hydrochloric acid; the *amine*, which separated from the solution in long needles, was recrystallised from alcohol; m. p. 128° (Found : Cl, 38·9. $C_{12}H_8NCl_3$ requires Cl, 39·05%). On oxidation with chromic anhydride in glacial acetic acid solution, *p*-chlorobenzoic acid was obtained (m. p. 235°).

N-*Bromo*-4-*acetylaminodiphenyl* was obtained as was the corresponding chloro-compound. It was a pale yellow powder, easily soluble in non-aqueous solvents, and lost bromine very easily. As it could not be obtained pure, it was not further investigated.

4′-*Bromo*-4-*aminodiphenyl*.—To a well-cooled 10% solution of 4-acetylaminodiphenyl in glacial acetic acid was added slightly more than 1 mol. of bromine. After 24 hours, on pouring into water, a mixture of brominated products was obtained which, by fractional crystallisation from dilute acetic acid, was separated into a more soluble monobromo-derivative and a less easily soluble dibromo-derivative. The former was 4′-bromo-4-aminodiphenyl and not its

acetyl derivative (compare Hübner, *loc. cit.*). It crystallised from dilute acetic acid in long needles, m. p. 145° (Found : Br. 32·2. $C_{12}H_{10}NBr$ requires Br, 32·1%). On oxidation with chromic anhydride in glacial acetic acid solution, *p*-bromobenzoic acid was obtained (m. p. 251°).

3 : 4′-*Dibromo*-4-*acetylaminodiphenyl*.—The less soluble dibromo-derivative crystallised from acetone in colourless needles, m. p. 197° (Found : Br, 43·25. $C_{14}H_{11}ONBr_2$ requires Br, 43·4%). The acetyl derivative was hydrolysed with alcoholic hydrobromic acid. The free base was not purified and analysed, as only a very small quantity was available; but was converted directly into a tribromo-derivative by bromination in glacial acetic acid solution. The product was crystallised from acetone and then from dilute acetic acid; it had m. p. 148°, alone or mixed with 3 : 5 : 4′-tribromo-4-aminodiphenyl. The original acetyl derivative was not identical with 3 : 5-dibromo-4-acetylaminodiphenyl, whence it follows that the acetyl derivative must have the bromine atoms in the 3- and 4′-positions.

3 : 5-*Dibromo*-4-*aminodiphenyl*.—The calculated quantity of a 10% solution of bromine in glacial acetic acid was added to a cold glacial acetic acid solution of 4-aminodiphenyl. The yellow precipitate was filtered off and washed with dilute sodium carbonate solution. It crystallised from alcohol in colourless needles, m. p. 119° (Found : C, 44·1; H, 2·9; Br, 48·8. $C_{12}H_9NBr_2$ requires C, 44·05; H, 2·8; Br, 48·9%).

3 : 5-*Dibromo*-4-*acetylaminodiphenyl* was prepared by heating the base with acetic anhydride in glacial acetic acid solution. After crystallising from alcohol, it melted at 162° (Found : Br, 43·45. $C_{14}H_{11}ONBr_2$ requires Br, 43·4%).

3 : 5-*Dibromodiphenyl*, obtained from the base by elimination of the amino-group in the usual manner, was a pale yellow oil, b. p. 208°/15 mm., m. p. 15° (Found : Br, 51·3. $C_{12}H_8Br_2$ requires Br, 51·3%). On oxidation with chromic anhydride in glacial acetic acid solution in a sealed tube at 200° 3 : 5-dibromobenzoic acid was obtained (m. p. 212°).

3 : 5 : 4′-*Tribromo*-4-*aminodiphenyl*.—Bromine (1 mol.) was added to a boiling solution of 3 : 5-dibromo-4-aminodiphenyl in glacial acetic acid, and the mixture refluxed until the colour of the bromine had disappeared (usually about 45 minutes). The product precipitated by addition of water crystallised from dilute acetone in white needles, m. p. 149°. The same substance was obtained by direct bromination of 4-acetylaminodiphenyl in boiling glacial acetic acid (Found : C, 35·4; H, 2·0; Br, 59·0. $C_{12}H_8NBr_3$ requires C, 35·4; H, 2·2; Br, 59·0%). On oxidation with chromic anhydride

in glacial acetic acid solution *p*-bromobenzoic acid was obtained (m. p. 251°).

The *acetyl* derivative crystallised from acetone in white needles, m. p. 256° (Found : Br, 53·5. $C_{14}H_{10}ONBr_3$ requires Br, 53·6%).

All m. p.'s recorded in this paper have been corrected, and where necessary the identity of a substituted benzoic acid was established by the " mixed m. p. " method.

The authors wish to express their thanks to Dr. H. McCombie for the interest he has taken in the work. One of them (W. A. W.) is indebted to the Master and Fellows of Gonville and Caius College for a studentship which enabled him to collaborate in this work.

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CAMBRIDGE. [*Received, November 25th*, 1925.]