

proved to be unnecessary, but the product turned brown in the presence of air, at least until it had been purified by recrystallization from alcohol. As the formaldehyde was added, all of the solid material first dissolved, then an oil was formed and, finally, a crystalline solid separated. The ice-cold mixture was filtered, washed with cold water and dried; yield, almost quantitative. After recrystallization from alcohol, and drying, the substance was pure white, m. p. 190°.

*Anal.* Calcd. for  $C_{12}H_{20}O_2N_2$ : N, 12.5. Found: N, 12.5.

**2,5-Dimethylhydroquinone.**—The above material (30 g.), copper chromite (15 g.) and 250 cc. of dioxane were hydrogenated for four hours at 165° and 2500 lb. (170 atm.) pressure. The catalyst was removed by filtration and the solvent by distillation. The product, which was not volatile in steam, was treated with 500 cc. of water and

15 cc. of hydrochloric acid and the resulting mixture filtered, giving a gray residue which was recrystallized from water and also from benzene; white needles, m. p. 208°; yield, 23%. Upon oxidation with ferric chloride, 2,5-dimethylquinone, m. p. 123–124°, was formed which suffered no depression of the melting point when mixed with an authentic sample of 2,5-dimethyl-1,4-benzoquinone.

### Summary

A new method for the nuclear methylation of phenols consisting in the hydrogenolysis of the dimethylaminomethyl derivative formed by treatment with dimethylamine and formaldehyde, is reported.

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[CONTRIBUTION FROM THE CHEMISTRY DEPARTMENT OF TEMPLE UNIVERSITY]

## The Mono- and Dibromination of Certain Heteronuclear-substituted 4-Acetaminodiphenyls<sup>1</sup>

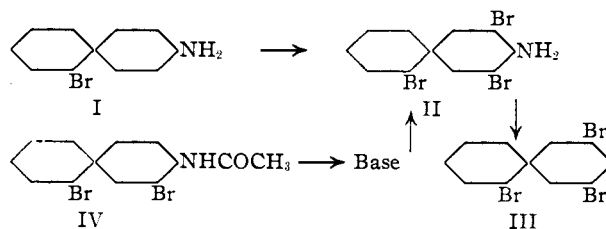
BY FRANCIS H. CASE

It has been shown that of the isomeric acetaminodiphenyls only 4-acetaminodiphenyl yields, on monobromination, any derivative substituted in the 4'-position. The present work was undertaken with the object of determining the effect of substituents in the 2'- and 3'-positions on substitution by bromine in the originally unsubstituted ring of 4-acetaminodiphenyl. For this purpose the following compounds were subjected to mono- and dibromination: 4-acetamino-2'-bromodiphenyl, 4-acetamino-2'-nitrodiphenyl, and 4-acetamino-3'-nitrodiphenyl. It was found that in no case did any bromine enter the ring already occupied by bromine or nitro groups, the resulting products being in each case 3-bromo-4-acetamino or 3,5-dibromo-4-acetamino derivatives.

In order to establish the structure of the mono- and dibromination products of 4-acetamino-2'-bromodiphenyl, the base, 4-amino-2'-bromodiphenyl<sup>4</sup> (I) was dibrominated, and the resulting product (II) deaminized. Since the tribromo product (III) thus obtained yielded on oxidation 3,5-dibromobenzoic acid, it is therefore 2,3',5'-tribromodiphenyl, and is evidently identical

with the tribromodiphenyl prepared by Bellavita<sup>3</sup> from 4-amino-2'-nitrodiphenyl. The dibromo base (II) is therefore 2',3,5-tribromo-4-aminodiphenyl.

The monobromination product (IV) of 4-acetamino-2'-bromodiphenyl was hydrolyzed to the base which on further bromination yielded II. Hence



IV is 2',3-dibromo-4-acetaminodiphenyl. The dibromination product of 2'-bromo-4-acetaminodiphenyl was found to be identical with 2',3,5-tribromo-4-acetaminodiphenyl, obtained by acetylation of II. No other dibromination product could be found.

The preparation of 2'-nitro-4-acetaminodiphenyl was accomplished most easily by the partial catalytic reduction of 2,4'-dinitrodiphenyl.

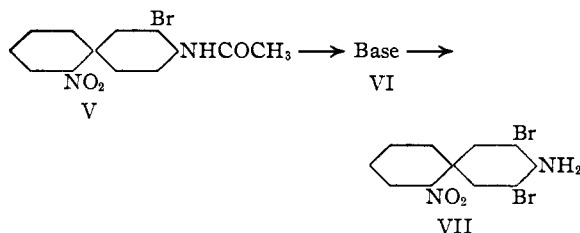
The structure of its monobromination product (V) was proved by hydrolysis to the base (VI) and bromination of the latter to yield the known 3,5-dibromo-4-amino-2'-nitrodiphenyl<sup>3</sup> (VII), obtained by the bromination of 4-amino-2'-nitro-

(1) The present investigation originated in an attempt to confirm the results of Bellavita<sup>3</sup> regarding the bromination of 2-nitro-4'-aminodiphenyl and 4-nitro-2'-aminodiphenyl. The revised results<sup>4</sup> of this author were in agreement with those obtained simultaneously by the writer.

(2) Bellavita, *Atti Congr. naz. chim. pura applicata*, 5 (1935).

(3) Bellavita, *Gazz. chim. ital.*, 67, 574 (1937).

(4) Case, *THIS JOURNAL*, 60, 424 (1938).



diphenyl; also by the fact that VI is converted by deamination into the known 2'-nitro-3-bromo-diphenyl.<sup>5</sup> The dibromination of 4-acetamino-2'-nitrodiphenyl yielded a dibromo compound identical with the product obtained by acetylating VII and a small amount of 3-bromo-4-acetamino-2'-nitrodiphenyl.

4-Amino-3'-nitrodiphenyl was first obtained by Finzi and Mangini<sup>6</sup> by the reduction of 3,4'-dinitrodiphenyl by 20% sodium bisulfite solution.

In this Laboratory the partial reduction of the dinitro compound was attempted by catalytic hydrogenation using the Adams catalyst. Due to the insolubility of the substance, dioxane was used as solvent. From the reaction products, however, no pure product could be isolated.

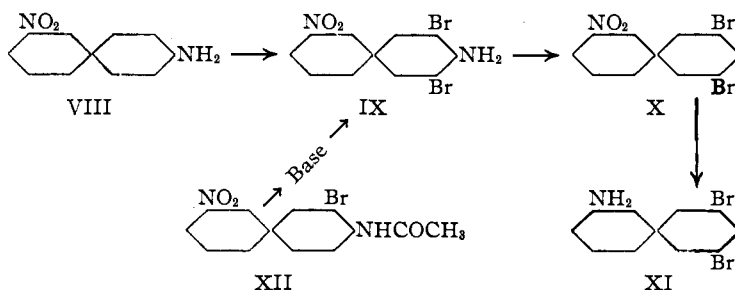
The investigation of this reduction mixture made it necessary to prepare a sample of 3-amino-4'-nitrodiphenyl. Using the directions of Blakey and Scarborough,<sup>7</sup> none could be obtained from the reaction mixture, which contained considerable dinitro product. When the concentration of the fuming nitric acid used was increased, the hitherto undescribed 4,4'-dinitro-3-acetaminodiphenyl was obtained. The structure of this product was established by deamination of its base to 4,4'-dinitrodiphenyl.

The preparation of 3-amino-4'-nitrodiphenyl was best effected by using the same procedure as that employed by Scarborough and Waters<sup>8</sup> for the preparation of 2-amino-4'-nitrodiphenyl.

It was found that 3'-nitro-4-aminodiphenyl can be prepared satisfactorily by reducing 3,4'-dinitrodiphenyl in dioxane solution by a mixture of sodium sulfide and sulfur, the success of the reaction depending on the fact that the dinitro compound is dissolved completely in the solvent.

In order to establish the structures of the mono- and disubstitution products of 4-aceta-

mino-3'-nitrodiphenyl, the corresponding base VIII was successively subjected to the stages of dibromination IX, deamination X, reduction XI, and oxidation, yielding 3,5-dibromobenzoic acid. The dibromo base, IX, is therefore 3,5-dibromo-4-amino-3'-nitrodiphenyl. The monobromination product of 4-acetamino-3'-nitrodiphenyl, XII, on hydrolysis and subsequent bromination, yields IX. Its structure is therefore 3-bromo-4-acetamino-3'-nitrodiphenyl. The



dibromination of 4-acetamino-3'-nitrodiphenyl yielded a compound identical with the acetyl derivative of 3,5-dibromo-4-amino-3'-nitrodiphenyl (IX), and a small amount of 3-bromo-4-acetamino-3'-nitrodiphenyl.

### Experimental Part

**2,3'-Dibromo-4'-acetaminodiphenyl.**—Nine grams of 2-bromo-4'-acetaminodiphenyl<sup>4</sup> and 10 g. of anhydrous sodium acetate were dissolved in 150 cc. of glacial acetic acid and treated with 6 g. of bromine. After standing overnight, the reaction mixture was poured into water, and the precipitate crystallized from methanol: yield 8 g.; m. p. 161–162°.

*Anal.* Calcd. for  $C_{14}H_{11}NOBr_2$ : Br, 43.35. Found: Br, 43.65.

**2,3'-Dibromo-4'-aminodiphenyl.**—This was obtained by hydrolysis of the above acetamino compound in alcoholic hydrogen bromide. It crystallizes from an ether-petroleum ether mixture, m. p. 69–70°.

*Anal.* Calcd. for  $C_{12}H_9NBr_2$ : Br, 48.89. Found: Br, 49.02.

On further bromination this base yielded 2,3',5'-tribromo-4'-aminodiphenyl, thus proving the position of the single bromine atom in the amino ring.

**2,3',5' - Tribromo - 4' - aminodiphenyl.**—2-Bromo-4'-aminodiphenyl (8 g.) dissolved in 80 cc. of glacial acetic acid was treated with 15.5 g. of bromine. The product, when poured into water and crystallized from alcohol, yielded 11 g. of product, m. p. 100–101°.

*Anal.* Calcd. for  $C_{12}H_6NBr_3$ : Br, 59.08. Found: Br 59.24.

**2,3',5'-Tribromo-4'-acetaminodiphenyl.**—This was obtained by acetylation, using an acetic acid-acetic anhydride mixture in presence of a little sulfuric acid. It crystallizes from ethanol, m. p. 223–224°.

(5) Leslie and Turner, *J. Chem. Soc.*, 1590 (1933).

(6) Finzi and Mangini, *Gazz. chim. ital.*, **62**, 664 (1932).

(7) Blakey and Scarborough, *J. Chem. Soc.*, 3000 (1927).

(8) Scarborough and Waters, *ibid.*, 89 (1927).

*Anal.* Calcd. for  $C_{14}H_{10}NOBr_3$ : Br, 53.53. Found: Br, 53.97.

**2,3',5'-Tribromodiphenyl.**—2,3',5'-Tribromo-4'-aminodiphenyl was deaminized by sodium nitrite in an alcoholic solution containing sulfuric acid. The tribromo compound was crystallized from methanol, m. p. 68–69°.

*Anal.* Calcd. for  $C_{12}H_7Br_3$ : Br, 61.34. Found: Br, 61.14.

On oxidation with chromic acid this product yielded 3,5-dibromobenzoic acid, thus proving the position of the bromine atoms in the amine ring of 2,3',5'-tribromo-4'-aminodiphenyl.

**Dibromination of 2-Bromo-4'-acetaminodiphenyl.**—2-Bromo-4'-acetaminodiphenyl (9 g.) and 10 g. of anhydrous sodium acetate were dissolved in 150 cc. of glacial acetic acid. The mixture was treated with 4.6 cc. of bromine and allowed to stand overnight. The same amount of bromine was again added, and the mixture heated at 80–90° for about thirty hours. After pouring into water and crystallizing from alcohol, 5.5 g. of a product was obtained, m. p. 210–211°. After repeated crystallization, less than 1 g. of material was obtained melting at 222–223°, and unchanged when mixed with 2,3',5'-tribromo-4'-acetaminodiphenyl. No other product could be identified in the reaction mixture of the dibromination of 2-bromo-4'-acetaminodiphenyl.

**2-Nitro-4'-acetaminodiphenyl.**—2,4'-Dinitrodiphenyl (73.2 g.) suspended in 400 cc. of ethanol was reduced catalytically in the presence of the Adams catalyst. The reaction was stopped after the absorption of 3 moles of hydrogen. After removal of the alcohol, the residue was acetylated by refluxing with acetic acid. The yield of crude 2-nitro-4'-acetaminodiphenyl, m. p. 148°, was 37 g., from which was obtained 27 g., m. p. 154–155°. From the first filtrate from benzene recrystallization was obtained 2 g. of 2-acetamino-4'-nitrodiphenyl, m. p. 199–200°.

**3-Bromo-4-acetamino-2'-nitrodiphenyl.**—Eight grams of 4-acetamino-2'-nitrodiphenyl and 10 g. of sodium acetate were dissolved in 200 cc. of glacial acetic acid. The mixture was treated with 6 g. of bromine. After standing overnight it was poured into water, and the residue crystallized from alcohol: yield 45 g.; m. p. 169–170°.

*Anal.* Calcd. for  $C_{14}H_{11}N_2BrO_3$ : Br, 23.85. Found: Br, 24.21.

**3-Bromo-4-amino-2'-nitrodiphenyl.**—This was obtained by hydrolysis of the above acetamino compound in alcoholic hydrogen bromide. The base crystallizes from ether-petroleum ether, m. p. 83–84°.

*Anal.* Calcd. for  $C_{12}H_9N_2O_2Br$ : Br, 27.28. Found: Br, 27.49.

On further bromination this base yielded 3,5-dibromo-4-amino-2'-nitrodiphenyl, thus proving the position of the single bromine atom.

On deamination, 3-bromo-2'-nitrodiphenyl is obtained, which melts unchanged with the product obtained by the deamination of 3-bromo-2'-nitrobenzidine,<sup>5</sup> thus establishing definitely the structure of the latter compound.

**Dibromination of 4-Acetamino-2'-nitrodiphenyl.**—Seventeen grams of 4-acetamino-2'-nitrodiphenyl and 20 g. of anhydrous sodium acetate were dissolved in 250 cc. of glacial acetic acid. Bromine (24 g.) was added, and the

mixture allowed to stand overnight. The same amount of bromine was again added and the mixture warmed on the steam-bath for about thirty hours. The mixture was then poured into water and the residue crystallized from ethanol, yielding 5 g. of a product melting at 219°. The pure dibromo product melts at 220–221°. It melts unchanged when mixed with acetylated 3,5-dibromo-4-amino-2'-nitrodiphenyl.<sup>3</sup>

*Anal.* Calcd. for  $C_{14}H_{10}N_2O_3Br_2$ : Br, 38.61. Found: Br, 38.72.

From the first alcoholic filtrate was obtained 2 g. of crude 3-bromo-4-acetamino-2'-nitrodiphenyl. No other products could be identified in the reaction mixture.

**3,4'-Dinitrodiphenyl.**—This was best obtained by the nitration of 3-nitrodiphenyl using a method similar to the one employed by Bell and Kenyon<sup>9</sup> for the nitration of 2-nitrodiphenyl.

**4-Amino-3'-nitrodiphenyl.**—Two 23-g. portions of 3,4'-dinitrodiphenyl were dissolved in 200 cc. of dioxane. This solution was treated with a mixture of 4 g. of sulfur, dissolved in 28 g. of melted hydrated sodium sulfide, and heated for nine hours at 80–90°. The two portions were now combined, the solvent removed, and the residue treated with water and filtered. The precipitate was extracted three times with boiling 1–1 acetic acid, and the extract neutralized with sodium hydroxide. The crude 3-nitro-4'-aminodiphenyl thus obtained was dried and crystallized from benzene: total yield 19 g., m. p. 124°; or 15 g., m. p. 127–128°. From the residue from the acetic acid extraction some unchanged dinitrodiphenyl could be recovered. The structure of the base was confirmed by oxidation to *m*-nitrobenzoic acid.

**4-Acetamino-3'-nitrodiphenyl.**—This compound crystallizes from methanol, m. p. 189–190°, but sinters before melting.

*Anal.* Calcd. for  $C_{14}H_{12}N_2O_3$ : C, 65.54; H, 4.72. Found: C, 65.87; H, 4.97.

**3-Bromo-4-acetamino-3'-nitrodiphenyl.**—4-Acetamino-3'-nitrodiphenyl (8.5 g.) and 10 g. of anhydrous sodium acetate were dissolved in 150 cc. of glacial acetic acid and treated with 2 cc. of bromine. After standing overnight the mixture was poured into water and the precipitate crystallized from methanol, m. p. 164–165°.

*Anal.* Calcd. for  $C_{14}H_{11}N_2BrO_3$ : Br, 23.85. Found: Br, 23.85.

**3-Bromo-4-amino-3'-nitrodiphenyl.**—This compound was obtained by the hydrolysis of the acetyl derivative in alcoholic hydrogen bromide. It crystallizes from benzene, m. p. 110–111°.

*Anal.* Calcd. for  $C_{12}H_9N_2O_2Br$ : Br, 27.28. Found: Br, 27.52.

On further bromination this base yielded 3,5-dibromo-4-amino-3'-nitrodiphenyl, thus proving the position taken by the single bromine atom.

**3,5-Dibromo-4-amino-3'-nitrodiphenyl.**—4-Amino-3'-nitrodiphenyl (7 g.), dissolved in 180 cc. of glacial acetic acid, was treated with 14 g. of bromine. After standing several hours, the paste was poured into water, filtered, dried, and crystallized from benzene: yield 5 g.; m. p. 175–176°.

(9) Bell and Kenyon, *J. Chem. Soc.*, 2705 (1926).

*Anal.* Calcd. for  $C_{12}H_8N_2O_2Br_2$ : Br, 43.00. Found: Br, 42.86.

**3,5-Dibromo-4-acetamino-3'-nitrodiphenyl.**—The corresponding base (2.5 g.) was dissolved in a mixture of 150 cc. of glacial acetic acid and 27 cc. of acetic anhydride. One cc. of sulfuric acid was added. After standing one hour the mixture was poured into water. The product was crystallized from acetone: yield 2.5 g.; m. p. 255–256°.

*Anal.* Calcd. for  $C_{14}H_{10}N_2O_3Br_2$ : Br, 38.61. Found: Br, 38.91.

**3,5-Dibromo-3'-nitrodiphenyl.**—The above base (7 g.), dissolved in 250 cc. of ethanol, was treated with 50 cc. of 1-1 sulfuric acid, and 4 g. of a saturated solution of sodium nitrite added gradually. The deaminized product was obtained by pouring the reaction mixture into water. It was crystallized from acetone: yield 3 g.; m. p. 165–166°.

*Anal.* Calcd. for  $C_{12}H_7NO_2Br_2$ : Br, 44.79. Found: Br, 44.71.

**3,5-Dibromo-3'-acetaminodiphenyl.**—Ten grams of the above dibromonitrodiphenyl was reduced by refluxing with 20 g. of stannous chloride in 200 cc. of absolute ethanol. The crude base, after removal of the alcohol, addition of excess alkali and extraction with ether, was acetylated by dissolving in glacial acetic acid-acetic anhydride mixture, and addition of a few drops of sulfuric acid. It crystallizes from benzene: yield 9.5 g.; m. p. 177–178°.

*Anal.* Calcd. for  $C_{14}H_{11}NOBr_2$ : Br, 43.35. Found: Br, 43.01.

**3,5-Dibromo-3'-aminodiphenyl.**—This was obtained by hydrolysis of the above acetamino compound in alcoholic hydrogen bromide. It crystallizes from petroleum ether, m. p. 67–68°.

*Anal.* Calcd. for  $C_{12}H_9NBr_2$ : Br, 48.89. Found: Br, 49.02.

On oxidation of this base with chromic acid, 3,5-dibromobenzoic acid was obtained, thus proving the position of the bromine atoms in the dibromo-4-amino-3'-nitrodiphenyl.

**Dibromination of 4-Acetamino-3'-nitrodiphenyl.**—A mixture of 11 g. of 4-acetamino-3'-nitrodiphenyl and 20 g. of anhydrous sodium acetate was dissolved in 170 cc. of glacial acetic acid. Bromine (4.8 cc.) was added and the reactants allowed to stand overnight. The same amount of bromine was again added and the mixture heated for forty-eight hours at 90–100°. After pouring into water

the reaction product was crystallized from acetone, yielding 6.5 g. of material melting at 200–225°. After several crystallizations, this yielded a small amount of pure 3,5-dibromo-4-acetamino-3'-nitrodiphenyl. From the first acetone filtrate was obtained 4 g. of material, m. p. 160–180°, which, after repeated crystallization, yielded the same dibromo product. From the first filtrate of this batch was obtained, by further crystallization, 4-acetamino-3-bromo-3'-nitrodiphenyl in a small amount.

**4,4'-Dinitro-3-aminodiphenyl.**—Five grams of 3-acetaminodiphenyl was added gradually with stirring to 150 cc. of fuming nitric acid (sp. gr. 1.6), keeping the temperature below  $-1^\circ$ . After one-half hour, the mixture was poured into water and the precipitate crystallized from acetone, yielding 1.5 g. of a product melting at 180°. This could not be purified completely even after repeated crystallization. The 180° product was therefore hydrolyzed by means of alcoholic hydrochloric acid to the base, which after crystallization from acetone melted at 252–253°.

*Anal.* Calcd. for  $C_{12}H_9N_3O_4$ : N, 16.22. Found: N, 16.11.

The structure of this base is based on the fact that on deamination it is converted into 4,4'-dinitrodiphenyl.

**4,4'-Dinitro-3-acetaminodiphenyl.**—This was prepared by the acetylation of the above base in an acetic acid-acetic anhydride mixture in the presence of a few drops of sulfuric acid.

*Anal.* Calcd. for  $C_{14}H_{11}N_3O_5$ : N, 13.96. Found: N, 13.90.

**4-Nitro-3'-acetaminodiphenyl.**—This could not be obtained using the method of Blakey and Scarborough.<sup>7</sup> (On hydrolysis of the reaction product, a small amount of 4,4'-dinitro-3-aminodiphenyl was isolated.) It was however obtained in 35% yield by using the directions of Scarborough and Waters<sup>8</sup> for the preparation of 2-acetamino-4'-nitrodiphenyl. On hydrolysis the base, m. p. 137–138°, was obtained, yielding on oxidation *p*-nitrobenzoic acid.

### Summary

1. The mono- and dibromination of 2'-nitro-, 3'-nitro-, and 2'-bromoacetaminodiphenyls yield, respectively, 3-bromo-4-acetamino and 3,5-dibromo-4-acetamino derivatives only.

2. The determination of the structure of these bromination products is described.

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