b. p. 80–82°. For the triethoxy compound, 77 g. (1.1 moles of methyl vinyl ketone containing a trace of hydroquinone, 148 g. (1.00 mole) of ethyl orthoformate, 115 g. (2.50 moles) of absolute ethanol, and 0.1 g. of hydrogen chloride dissolved in 8 ml. of absolute ethanol were mixed in a 500-ml. erlenmeyer flask and allowed to stand, tightly stoppered, for seven days. After heating under reflux for fifteen minutes, the mixture was neutralized with 28% aqueous ammonia, dried over anhydrous magnesium sulfate, and fractionally distilled through a ten-inch helix-packed column to yield 137.5 g. (66% based on methyl vinyl ketone) of 1,3,3-triethoxybutane, b. p. 79–82° (15 mm.); n^{20}_{D} 1.4137 (lit.,[23] 1.4148).

Summary

1. The use of excess aqueous ammonia in the Chichibabin synthesis of pyridines gives better yields of single products than does the use of aldehyde–ammonias or vapor-phase condensation.

2. An important limitation of the Chichibabin synthesis of pyridines from methyl or methylene ketones and aldehydes or α,β-unsaturated carbonyl compounds is the reversible nature of the aldol condensation under the conditions of the reaction. Proper choice of substituents is necessary for formation of single products in satisfactory yields.

3. The condensation of two molecules of a methyl aryl ketone with a substituted aryl aldehyde and aqueous ammonia occurs so as to form a pyridine with the substituted aromatic nucleus on the γ-position of the pyridine.

4. Protection of simple aldehydes or α,β-unsaturated carbonyl compounds by formation of their acetals or similar derivatives gives increased yields of pyridines in the Chichibabin synthesis.

URBANA, ILLINOIS RECEIVED JANUARY 14, 1949

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[23] Dykstra, THIS JOURNAL, **57**, 2255 (1935).

[CONTRIBUTION FROM THE WM. H. CHANDLER CHEMISTRY LABORATORY, LEHIGH UNIVERSITY]

Studies in the Diphenylacetic Acid Series. I. Nitro and Amino Acids[1]

BY I. MOYER HUNSBERGER[2] AND E. D. AMSTUTZ

In view of the reported[3] high anti-tubercular activity of 1,1,1-trichloro-2-bis-*p*-aminophenylethane, it was felt that an examination of the preparation, properties and anti-bacterial effectiveness of 4,4′-diaminodiphenylacetic acid (XII) and its derivatives might bring to light new substances of value in the treatment of tuberculosis.

The only recorded synthesis of 4,4′-diaminodiphenylacetic acid[4] (XII) employs the condensation of aniline with dichloroacetic acid (or glyoxylic acid diacetate) with subsequent rearrangement of the dianilinoacetic acid which is presumably formed as an intermediate. Since this method formed the subject of considerable controversy and the structure of the product was never conclusively proved, it appeared that such a proof of structure must necessarily precede any use of the method for preparative purposes. The present paper reports the synthesis of the above diamino acid by an unambiguous route (see Reaction Sequence) and substantiates the work of Heller, at least in those respects pertinent to our interest.

It appeared at the outset that the best approach would be through the unknown 4,4′-dinitrodiphenylacetic acid (IX). Symons and Zincke[5] obtained mainly resinous acidic material from the nitration of diphenylacetic acid (I) using nitric acid (sp. gr. 1.5). However, they also isolated a small amount of unidentified neutral material melting at 180°, which was believed to be a nitrated benzophenone. The literature since 1874 is devoid of any further reference to the nitration of I. By nitrating ethyl diphenylacetate with red fuming nitric acid at −18° Werner[6] produced ethyl bis-(2,4-dinitrophenyl)-acetate in good yield.

In the present investigation diphenylacetic acid (I) was nitrated with white fuming nitric acid at 30° almost exactly according to the method recently used for nitrating the similarly constituted 1,1,1-trichloro-2,2-diphenylethane.[3] The crude resinous product undoubtedly consisted of a mixture of nitro compounds, but two recrystallizations from glacial acetic acid yielded *ca.* 7% of pure 3,4′-dinitrodiphenylacetic acid (II) as a white crystalline powder, m. p. 180.5–183.5°. The configuration of II was established by decarboxylation to 3,4′-dinitrodiphenylmethane (III) and by oxidation to 3,4′-dinitrobenzophenone (IV). The latter was reduced to 3,4′-diaminobenzophenone (V), acetylation of which produced 3,4′diacetamidobenzophenone (VI). Esterification of II with methanol and hydrogen chloride afforded methyl 3,4′-dinitrodiphenylacetate.

The formation of the 3,4′-dinitro acid (II) is somewhat unexpected since nitration of 1,1,1-trichloro-2,2-diphenylethane affords 1,1,1-trichloro-2,2-bis-(*p*-nitrophenyl)-ethane[3,7] in good yield. Although it is possible that II is not the main product formed, no other pure substance has been isolated thus far.

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[1] Abstracted, in part, from a thesis presented by I. Moyer Hunsberger to the Graduate Faculty of Lehigh University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[2] American Chemical Society Predoctoral Fellow, 1946–1948. Present address: Department of Chemistry, University of Illinois, Urbana, Illinois.

[3] Kirkwood and Phillips, THIS JOURNAL, **69**, 934 (1947).

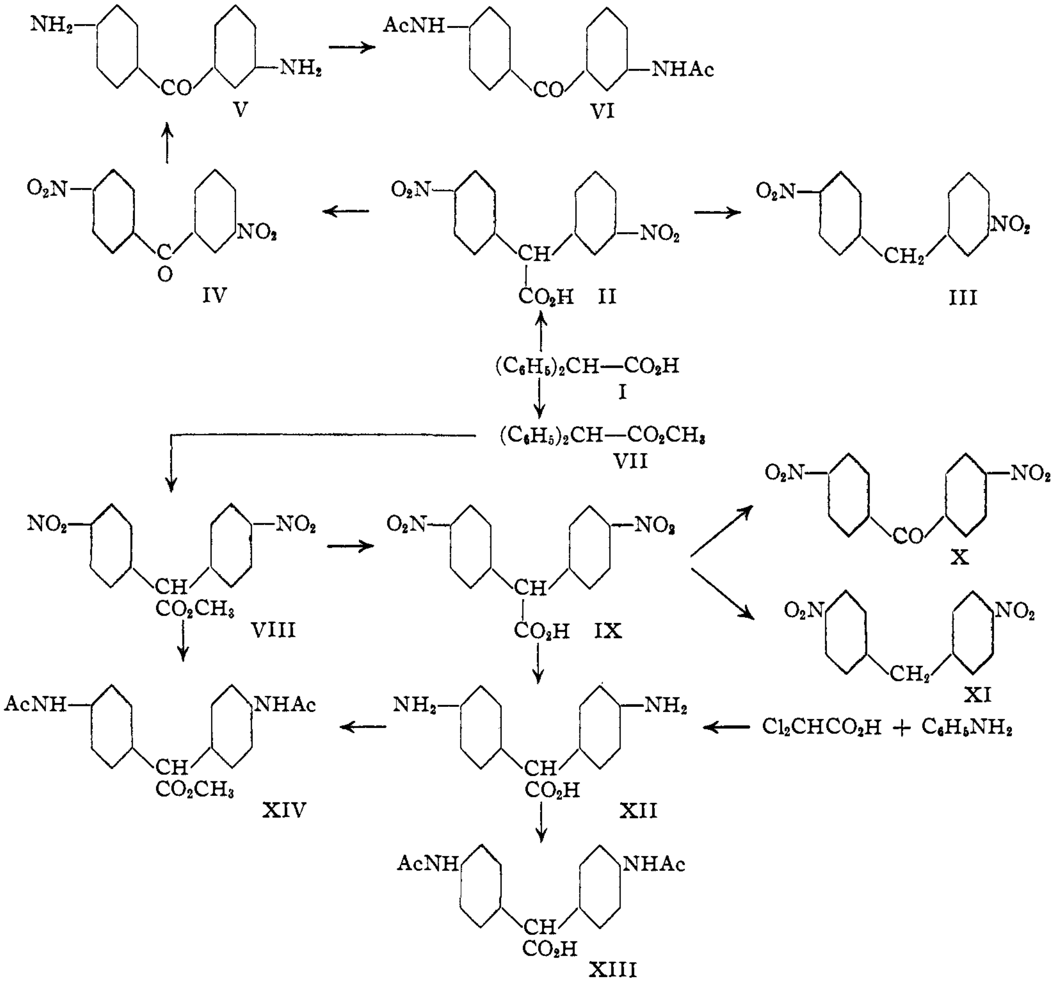
[4] Heller, *Ann.*, **332**, 247 (1904); **358**, 349 (1908); **375**, 261 (1910); *Ber.*, **41**, 4264 (1908); compare Ostromisslensky *ibid.*, **41**, 3019, 3029 (1908).

[5] Symons and Zincke, *Ann.*, **171**, 117 (1874).

[6] Werner, *Ber.*, **39**, 1278 (1906).

[7] Haskelberg and Lavie, *ibid.*, **69**, 2267 (1947).

REACTION SEQUENCE



The nitration of methyl diphenylacetate (VII) next was investigated under conditions identical with the above. Although a gummy crude product again was obtained, several recrystallizations from glacial acetic acid permitted the isolation of methyl 4,4′-dinitrodiphenylacetate (VIII) in 25% yield. The nitrated ester (VIII) crystallized more readily than the nitrated acid (II). Hydrolysis of VIII with boiling aqueous acetic acid containing a small amount of sulfuric acid afforded a high yield of the desired 4,4′-dinitrodiphenylacetic acid (IX), the structure of which was established by oxidation to 4,4′-dinitrobenzophenone (X). All attempts to oxidize pure VIII resulted in gummy products which gradually hardened to solids of wide melting ranges. The acid (IX) from the hydrolysis exhibited a considerable melting range, and this was difficult to eliminate until it was observed that considerable decarboxylation occurred during recrystallization. The 4,4′-dinitrodiphenylmethane (XI) thus formed was isolated and identified. It is believed that its ease of decarboxylation caused the 4,4′-dinitro acid (IX) to melt lower than its less symmetrical 3,4′-isomer (II), for melting and decarboxylation apparently occurred simultaneously. The sharpest melting range for any fraction obtained was 168.5–171.5°.

After this experience with the 4,4′-dinitro acid it seemed to us entirely possible that in the nitration of diphenylacetic acid (IX) is actually produced, perhaps as a major product, but that it was so largely decomposed in the various recrystallizations from acetic acid that were required as to escape our notice.

Although catalytic reductions in several solvents were attempted the most satisfactory conversion of IX to XII was obtained by the use of stannous chloride in acetic acid clarified with dry hydrochloric acid. The amine double salt which precipitated was decomposed with aqueous sodium bicarbonate. Acidification by means of acetic acid precipitated the free amino acid. The pure compound, obtained by recrystallization from nitromethane followed by conversion to the poorly soluble sodium salt, was proved, by the method of mixed melting points, to be identical with a sample of acid prepared by Heller's method. Added confirmation of the structure of Heller's acid was obtained by a comparison of the diacetyl derivatives and the diacetyl derivatives of the methyl esters of acids prepared by the two methods.

Reduction of methyl 4,4′-dinitrodiphenylacetate (VIII) was accomplished catalytically and with stannous chloride, but the product was obtained only as an oil and was, therefore, immediately converted into its diacetyl derivative. The same compound was prepared from Heller's acid by esterification with methanolic hydrogen chloride and subsequent acetylation with acetic anhydride. Mixed melting points showed no depression.

The methyl esters of both II and IX gave intense blue colors in excess alcoholic alkali and became colorless on acidification. This behavior parallels the indicator properties of ethyl bis-(2,4-dinitrophenyl)-acetate[8] and the similar colors reported for analogous compounds by others.[9-11]

Many other routes to IX were explored, but all proved unsuccessful. Attempted hydrolyses of 1,1,1-trichloro-2,2-bis-(*p*-nitrophenyl)-ethane[3,7] under a variety of conditions produced either the corresponding ethylene or unidentified products. Methods designed for condensing *p*-bromonitrobenzene both with the sodio derivative of diethyl malonate[12] and the potassium derivative of ethyl *p*-nitrophenylacetate yielded unidentified, highly colored solids. One substance, m. p. 232–235°, sublimed to form *p*-nitrobenzoic acid, which was identified by the method of mixed melting points.

Some of the diphenylacetic acid (I) used in this work was prepared in good yield from 1,1,1-trichloro-2,2-diphenylethane according to Grummitt's method for hydrolyzing DDT.[13] However, the former proved much more resistant to hydrolysis than DDT. On the other hand, Grummitt's procedure proved too strenuous for the efficient hydrolysis of 1,1,1-trichloro-2,2-bis-(*p*-bromophenyl)-ethane and 1,1,1-trichloro-2,2-bis-(*p*-iodophenyl)-ethane, since the corresponding dihalodiphenylmethanes were isolated in 39 and 69% yields, respectively, and the corresponding dihalodiphenylacetic acids in small (27%) and negligible yields, respectively. When allowed to proceed for only three hours the hydrolysis of the diiodotrichloroethane afforded a small amount of the hitherto unknown 4,4′-diiododiphenylacetic acid.[14]

The 4,4′-dihalodiphenylacetic acids were prepared as possible intermediates in the synthesis of 4,4′-diaminodiphenylacetic acid.

Experimental[15]

Diphenylacetic Acid (I).—(a) Reduction[16] of benzilic acid afforded I, m. p. 145.6–146.6° (after recrystallization from a large amount of water).

(b) Hydrolysis of 1,1,1-trichloro-2,2-diphenylethane according to directions for DDT[13] produced 17% of I, m. p. 142.5–144°, and *ca.* 80% of the corresponding ethylene, m. p. 76.5–80°. When the hydrolysis was continued for twenty-seven hours, 42.5 g. (0.149 mole) of the trichloro compound yielded 17.1 g. of I, m. p. 141–144°, plus 12 g. of the ethylene,[17] hydrolysis of which for another twenty hours produced an additional 7.3 g. of I (total yield, 77%). After recrystallization as above the acid melted at 145–146°.

3,4′-Dinitrodiphenylacetic Acid (II).—Over a seventy-five minute period 13.5 g. (0.0637 mole) of powdered I was added to 135 g. of well-stirred white fuming nitric acid (sp. gr. 1.5) at 30°. After four hours at room temperature the solution was poured on 75 g. of crushed ice. The resultant gum was removed and heated with four separate changes of hot water, the aqueous layer being decanted each time. The crude product was thoroughly vacuum-dried over caustic and dissolved in 7–8 ml. of boiling glacial acetic acid. After cooling spontaneously to room temperature the viscous solution was seeded[18] and set aside. After some days the fine white crystals were removed by filtration,[19] washed with fresh acetic, then with chloroform and dried as before; the product, m. p. 170–177°, weighed 2.86 g. (15%). A second recrystallization proceeded overnight without seeding to yield 1.41 g. (7.4%) of pure II as a fine white crystalline powder, m. p. 180.5–183.5°. This material was insoluble in water, fairly soluble in methanol, and readily soluble in acetone; it completely dissolved in 10% sodium bicarbonate solution and was reprecipitated unchanged on acidification.

Anal. Calcd. for $C_{14}H_{10}O_6N_2$: N, 9.27; neut. equiv., 302. Found: N, 8.87, 8.78; neut. equiv., 306.[20]

The acetic acid liquors from a series of nitrations were diluted separately with methanol. On cooling, significant amounts of unidentified neutral white solids (melting range, 150–159°) were obtained, the purest fraction melting at 157.5–159° (uncor.). Since these materials gave the same blue color in alkali observed for the esters of II and IX, one fraction (m. p. 154–158°) was subjected to hydrolysis. However, the starting material was recovered almost quantitatively.

3,4′-Dinitrobenzophenone (IV).—A solution of 0.40 g. (0.0013 mole) of II and 0.80 g. (0.0080 mole) of chromium trioxide in 10 ml. of glacial acetic acid was refluxed for thirteen hours and poured into water. The solid product 0.34 g. m. p., 162–167° (uncor.) was recrystallized twice from glacial acetic acid to yield 0.25 g. (71%) of pure IV, m. p. 171.6–172.6° (literature: 172°,[21] 175°[22]), plus 0.01 g. of unidentified material, m. p. *ca.* 148–151°.

3,4′-Diaminobenzophenone (V).—The above ketone (IV) (0.23 g., 0.00085 mole) was reduced[22,23] with stannous chloride dihydrate and hydrogen chloride in acetic

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[8] Fehnel and Amstutz, *Ind. Eng. Chem., Anal. Ed.*, **16**, 53 (1944).

[9] Maxwell, *Ber.*, **12**, 1764 (1879).

[10] Richter, *ibid.*, **21**, 2470 (1888).

[11] Canback, *Svensk. Kem. Tid.*, **58**, 101 (1946).

[12] Compare Borsche, Stackmann, and Makaroff-Semljanski, *Ber.*, **49**, 2222 (1916).

[13] Grummitt, Buck and Egan, *Org. Syn.*, **26**, 21 (1946).

[14] Chattaway and Muir, *J. Chem. Soc.*, 701 (1934), first prepared 1,1,1-trichloro-2,2-bis-(*p*-iodophenyl)-ethane but offered no proof of structure. The structures of this compound and of the diiododiphenylacetic acid are established by our isolation of the known 4,4′-diiododiphenylmethane *cf.* Nastukoff and Scheljagin, *J. prakt. Chem.*, [N. F.] **119**, 303 (1928).

[15] All melting points are corrected unless specified otherwise.

[16] Marvel, Hager and Caudle, "Org. Syn.," Coll. Vol. I, Second Edition, p. 224 (1941).

[17] Others (Sheibley and Prutton, THIS JOURNAL, **62**, 840 (1940); Fritsch and Feldmann, *Ann.*, **306**, 72 (1899); Elbs and Forster, *J. prakt. Chem.*, N. F., **39**, 298 (1889)) have noted the resistance to hydrolysis offered by this compound.

[18] A preliminary experiment had yielded a small amount of impure II, m. p. 171–177°, from a two-months old solution of the crude nitration product in glacial acetic acid.

[19] Best performed under conditions of low humidity.

[20] The titration, performed in 30% methanol using a Beckmann *p*H meter, required over six hours, long intervals being necessary for attainment of equilibrium after adding each portion of base. The end-point occurred at *p*H 6.94. From a 0.2020-g. sample 0.19 g. was recovered unchanged on acidification.

[21] Staedel, *Ann.*, **283**, 164 (1894).

[22] Gattermann and Rudt, *Ber.*, **27**, 2293 (1894).

[23] Montagne, *ibid.*, **49**, 2271 (1916).

acid solution by refluxing for two hours. An aqueous solution of the tin complex was rendered alkaline and the resulting precipitate extracted with boiling ethanol. The needles (0.10 g.) obtained from the ethanol were extracted with boiling benzene, from which 0.05 g. (30%) of pure V was obtained as faintly yellowish crystals, m. p. 123–124° (literature: 121–122°,[22] 125–126°,[21] 131–132°[24]).

3,4′-Diacetamidobenzophenone (VI).—Acetylation[25] of 0.040 g. (0.0002 mole) of V required one hour at 50° and yielded 0.044 g. (80%) of the crude VI, m. p. 210–215°. Crystallization from ethanol afforded pure VI as a colorless powder, m. p. 221–222° (literature, 218°[22]).

3,4′-Dinitrodiphenylmethane (III).—In a test-tube immersed in an oil-bath at 185–205°, 0.30 g. (0.0010 mole) of II was heated until gas evolution ceased. After cooling, the dark solid was broken up under a 10% solution of sodium bicarbonate. The insoluble material (0.24 g.) was recrystallized from ethanol to yield 0.13 g. (50%) of III as a pale solid, m. p. 90–93.5° (unchanged by subsequent recrystallization; literature: 94°,[26] 101–102°,[27] 103–104°.[22]

Methyl 3,4′-Dinitrodiphenylacetate.—For seventy minutes dry hydrogen chloride was introduced into a solution of 0.174 g. (0.000576 mole) of II in a little absolute methanol. The mixture was diluted with two portions of water, and two gummy fractions [total weight, 0.132 g. (73%)] of crude ester were collected which hardened on standing and melted at 79–95° and 90–94°. The combined fractions were recrystallized (charcoal) from aqueous methanol to yield the pure ester, m. p. 91.5–94.8°; mixed m. p. with III (m. p. 90–93.5°), 65.71°.

Anal. Calcd. for $C_{15}H_{12}O_6N_2$: N, 8.86. Found: N, 9.09.[28]

Methyl 4,4′-Dinitrodiphenylacetate (VIII).—In a typical preparation 7.0 g. (0.031 mole) of VII was nitrated by the same procedure used in nitrating I. The semicrystalline crude product readily crystallized from a few ml. of glacial acetic acid to yield 6.94 g. of white solid, m. p. 75–136°. Two more recrystallizations from successively larger portions of acetic acid afforded 2.43 g. (25%) of VIII as fine white crystals, m. p. 162–164.5°. Recrystallization of a small amount of this material from a large volume of ethanol yielded pure VIII as almost transparent crystals, m. p. 165.5–166.7°.

Anal. Calcd. for $C_{15}H_{12}O_6N_2$: N, 8.86. Found: N, 8.88.[28]

The combined acetic acid liquors from the above recrystallizations were concentrated at reduced pressure to a viscous oil which slowly solidified. Three recrystallizations from acetic acid produced 0.37 g. of unidentified white solid, m. p. 110.5–113.5°, an attempted hydrolysis of which produced no acidic material.

4,4′-Dinitrodiphenylacetic Acid (IX).—(a) A solution of 0.304 g. (0.000962 mole) of VIII in *ca.* 8 ml. of acetic acid containing four drops of concentrated sulfuric acid and just enough water to avoid turbidity at the b. p. was refluxed for five and one-half hours. Most of the solvent was removed at reduced pressure and water and sodium bicarbonate were added. Acidification of the filtered alkaline solution caused the separation of a sticky precipitate which gradually hardened to yield 0.229 g. (79%) of acidic material, m. p. *ca.* 155–171°.

Anal. Calcd. for $C_{14}H_{10}O_6N_2$: neut. equiv., 302. Found: neut. equiv., 313.[29]

Acidification of the solution from the neutral equivalent determination afforded acid melting at 153–165° (with bubbling). Recrystallization from a small amount of glacial acetic acid yielded white crystals, m. p. 168.5–171° (with bubbling); mixed m. p. with authentic II, 152–171°.

(b) A solution containing 1.05 g. (0.00332 mole) of VIII was hydrolyzed as above to yield 0.87 g. (87%) of acid, m. p. 151–161° (with bubbling). Recrystallization from *ca.* 10 ml. of 50% ethanol afforded 0.66 g. of IX, m. p. 159–166.5° (with bubbling). Recrystallization from 95% ethanol yielded (besides the fractions described below) 0.029 g. of neutral white crystals (A), m. p. 180–188°, which were recrystallized from glacial acetic acid to produce pure 4,4′-dinitrodiphenylmethane (XI), m. p. 188.6–189.4°; mixed m. p. with authentic XI[30] (m. p. 186.2–188.2°), 187.8–189.2°), 187.8–189.4°; mixed m. p. with authentic 4,4′-dinitrobenzophenone[31] (X), < 150°.

Successive dilutions of the liquor from (a) yielded two fractions of acid (IX) which were in turn fractionated with ethanol and acetic acid. The decarboxylation accompanying each recrystallization rendered it necessary to perform the final purification by solution in sodium bicarbonate and reprecipitation with acid. In this way 0.12 g. of pure IX was obtained as white crystals, m. p. 166.4–169.6° (with bubbling).

Anal. Calcd. for $C_{14}H_{10}O_6N_2$: N, 9.27. Found N, 9.04.[28] It seems certain that more pure IX could have been obtained had its ease of decarboxylation been discovered earlier.

When the amount of sulfuric acid in the hydrolysis mixture was decreased and the refluxing period maintained the same, the yield of IX was reduced greatly, but the product melted at 160.4–163° (with bubbling) without recrystallization.

4,4′-Dinitrobenzophenone (X).—Oxidation of 0.033 g. (0.00011 mole) of IX (m. p. 168.5–171.5°) by the same procedure used on II yielded 0.017 g. (57%) of neutral white crystals, m. p. 189.6–190.6° without recrystallization; mixed m. p. with authentic X[31] (m. p. 189.4–190.6°), 189.6–190.8°.

1,1,1-Trichloro-2,2-bis-(*p*-nitrophenyl)-ethane.—Duplication of Kirkwood and Phillips' preparation[8] of this compound proved impossible in our hands until initiation of the following modified procedure.[32] The nitration mixture was poured on such a small quantity of crushed ice that the resultant mixture became quite hot. The aqueous acid was decanted and the crude product washed (decantation) thrice with hot water and thoroughly dried. Several recrystallizations[19] from the minimum amount of glacial acetic acid yielded the pure dinitroethane, m. p. 167.8–168.4°; literature: 166–167° (uncor.),[3] 169°.[7] The first recrystallization required seeding and overnight standing, but subsequent recrystallizations proceeded rapidly.

4,4′-Diaminodiphenylacetic Acid (XII).—The well-stirred solution of 1 g. (0.003 mole) of unrecrystallized IX in 30 ml. of glacial acetic acid (containing 4.6 g. (0.02 mole) stannous chloride dihydrate and saturated with hydrogen chloride) was heated for two hours at 70°. After standing for some hours the complex was removed and worked up as usual. The free acid was purified by recrystallization from nitromethane and by precipitation of the sodium salt with strong alkali, after which it (*ca.* 0.15 g.)[33] melted at 194.5–197° with shrinking at 189°. Heller's acid, purified in the same manner melted at 195–

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[24] Baeyer, *Ann.*, **354**, 177 (1907).

[25] Method of Lumière and Barbier, *Bull. soc. chim.*, [3] **33**, 783 (1905), as described in Fieser, "Experiments in Organic Chemistry," second edition, D. C. Heath and Co., Boston, Mass., 1941, p. 165.

[26] Becker, *Ber.*, **15**, 2090 (1882).

[27] Staedel, *Ann.*, **283**, 149 (1894).

[28] Analysis hy Dr. Carl Tiedcke.

[29] This titration, performed on a 0.2191-g. sample as in the case of II, required thirteen and one-half hours. The *p*H at the end-point was 6.46.

[30] Prepared by nitration of diphenylmethane according to Staedel,[27] who gave a m. p. of 183°.

[31] Prepared by oxidation of synthetic XI with chromium trioxide as in the oxidation of II.

[32] Dr. S. Kirkwood, in a private communication, suggested this modification and graciously supplied a sample of the nitrated ethane for seed. The authors are grateful for this assistance, especially since an almost identical procedure enabled the isolation of both II and VIII.

[33] Recrystallization from toluene, as suggested by Heller, affords practically colorless acid but requires exceedingly large quantities of solvent. Isolation of the sodium salt always reduces the yield considerably but is more practical.

197° and a mixture of the two at 196°–198° with softening at 189°.

Methyl 4,4'-Diacetamidodiphenylacetate (XIV).—A. From the nitro ester (VIII). Hydrogenation and acetylation of the nitro-ester was accomplished by shaking for several hours (initial temperature of 75°) a solution of 0.80 g. (0.0025 mole) of the nitro compound in about 140 ml. of glacial acetic acid and 1 ml. of acetic anhydride under 40 lb. of hydrogen pressure in the presence of 0.2 g. of platinum on carbon catalyst. Filtration and evaporation of the solvent yielded 0.84 g. (98%) of light brown crystalline amide which, on heating, shrank at about 240° and finally melted at 275°. Recrystallization several times from acetic acid yielded pure white product which melted at 284–286° (on the block).

Anal. Calcd. for $C_{19}H_{20}O_4N_2$: N, 8.24. Found: N, 8.08.

B. **From Heller's Acid.**—Esterification of Heller's acid with methanol and dry hydrogen chloride yielded an oil which failed to crystallize. Acetylation of the oil afforded an excellent yield of white crystals melting at 284–287° and showing no depression (284–286°) when mixed with material from procedure A (above).

4,4'-Dibromodiphenylacetic Acid.—When 6.0 g. (0.014 mole) of 1,1,1-trichloro-2,2-bis-(*p*-bromophenyl)-ethane was hydrolyzed according to Grummitt,[13] 1.4 g. (27%) of fairly pure acid resulted. Recrystallization from ethanol afforded the pure acid, m. p. 188–189.2° (literature, 187–188°[34]). The material insoluble in the hydrolysis mixture was recrystallized from ethanol to yield 1.78 g. (39%) of pure 4,4'-dibromodiphenylmethane, m. p. 62–63.8° (literature, 64°[35]).

4,4'-Diiododiphenylacetic Acid.—(a) Hydrolysis of 3.00 g. (0.0056 mole) of 1,1,1-trichloro-2,2-bis-(*p*-iodophenyl)-ethane (m. p. 175.2–176.6°),[36] according to Grummitt[13] produced 1.63 g. (69%) of fairly pure 4,4'-diiododiphenylmethane, m. p. 87.5–93°, as the insoluble product. Recrystallization from 50 ml. of ethanol afforded 1.18 g. of the pure methane, m. p. 91.6–93° (literature: 92–93°,[37] 93–93.5°[38]). Acidification of the alkaline filtrate from the hydrolysis yielded 0.42 g. of crude acidic material which was not purified.

(b) Hydrolysis of 4.3 g. (0.0080 mole) of the ethane for three hours produced 1.81 g. of insoluble material. Acidification of the alkaline filtrate as before caused the formation of a white emulsion which on standing one month in a refrigerator gradually deposited 0.43 g. (12%) of brownish solid, m. p. 176–186°. Recrystallization (charcoal) from aqueous ethanol left 0.20 g. of pure acid as a fine white powder, m. p. 192.5–195.5° (uncor.).

Anal. Calcd. for $C_{14}H_{10}O_2I_2$: I, 54.70; neut. equiv., 464. Found: I, 54.88[28]; neut. equiv., 458.

Summary

Nitration of diphenylacetic acid (I) has produced as the major isolable substance the 3,4'-dinitrodiphenylacetic acid (II), while nitration under similar conditions of the corresponding methyl ester, VII, afforded the 4,4'dinitro isomer, VIII. Acid hydrolysis of VIII yielded the corresponding acid, IX. The structures of II and IX have been proved by degradations to previously known materials while reduction of IX to the diamino acid produced a material identical with that prepared by Heller from dichloroacetic acid and aniline. The identity of the two has been further confirmed by the preparation of derivatives.

The method used for hydrolyzing DDT was modified and extended with varying degrees of success to the preparation of diphenylacetic acid (I) and its 4,4'-dibromo and 4,4'-diiodo derivatives.

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[34] Biltz, *Ber.*, **43**, 1815 (1910).

[35] Goldthwaite, *Am. Chem. J.*, **30**, 447 (1903).

[36] Chattaway and Muir (ref. 14) listed 172°.

[37] Nastukoff and Scheljagin (ref. 14).

[38] Menon, *Quart. J. Indian Chem. Soc.*, **4**, 437 (1927).

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY AND CHEMICAL ENGINEERING OF THE UNIVERSITY OF WASHINGTON]

The Aromatic Elimination Reaction. I. Mechanism of the Decarboxylation of Mesitoic Acid

BY W. M. SCHUBERT

The decarboxylation of mesitoic acid[1] and other hindered aromatic acids[2] in solutions of strong acids appears to be a manifestation of a general aromatic elimination reaction. Probably occurring by a similar mechanism are such reactions as desulfonation, the cleavage of hindered aromatic ketones in boiling sirupy phosphoric acid,[1,3] the reverse Fries rearrangement[4] and similar acyl wanderings, and migrations of the sulfonic acid group. A profound influence is exerted on these reactions by bulky substituents *ortho* to the group being eliminated. Thus the decarboxylation of alkylbenzoic acids in boiling sirupy phosphoric acid occurred only when two alkyl substituents were substituted *ortho* to the carboxyl group.[1] Acyl cleavage requires the presence of at least one *ortho* alkyl group,[1] and in the reverse Fries rearrangement the presence of an alkyl substituent *ortho* to the wandering acyl group is necessary.[4] Similarly, the desulfonation reaction is enhanced considerably by the presence of *ortho* methyl substituents.[5]

These acid-catalyzed reactions appeared to be, on the surface at least, the reverse of aromatic electrophilic substitution. It appeared also that resonance inhibition is involved. With a view toward elucidating the mechanism of these processes, a kinetic study was made of the decarboxylation of mesitoic acid in strong sulfuric acid solution. Of all the aromatic elimination reactions,

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[1] Klages, *Ber.*, **32**, 1549 (1899).

[2] Buning, *Rec. trav. chim.*, **40**, 327 (1921).

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