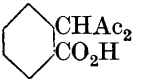
CCXLIV.—*Replacement of Halogen in* ortho*Bromobenzoic Acid.*

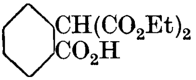
By William Robert Hardy Hurtley.

Under the catalytic influence of copper the halogen in *o*-bromobenzoic acid is much more reactive than is commonly realised. Rosenmund and Harms (*Ber.*, 1920, **53**, 2231) obtained salicylic acid by boiling an aqueous solution of sodium *o*-bromobenzoate with sodium β-naphthalenesulphonate for 4 hours with "Naturkupfer C" as catalyst, but it has now been found that in sodium acetate solution in the presence of copper acetate the conversion into salicylic acid is completed in 30 minutes. Moreover, reaction between sodium *o*-bromobenzoate and the sodium derivatives of ethyl malonate, ethyl acetoacetate, ethyl acetonedicarboxylate, acetylacetone and benzoylacetone in boiling alcohol takes place with unexpected ease, the halogen being replaced. The presence of copper-bronze or copper acetate is necessary; the latter appears to be the more vigorous catalyst, but the former gives purer products and was used where possible.

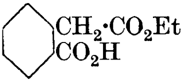
With acetylacetone and ethyl malonate the simple products of substitution (I) and (II) were isolated. The acetylacetone compound gives a red coloration with ferric chloride, is oxidised by alkaline permanganate solution to phthalic acid, and, on evaporation to dryness of its solution in ammonia, gives methyl*iso*carbostyril (m.p. 211°)



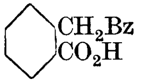
(I.)



(II.)



(III.)



(IV.)

in good yield. Homophthalic acid is obtained from the malonic ester derivative by treatment with warm 2*N*-sodium hydroxide.

From ethyl acetoacetate and ethyl acetonedicarboxylate the only product which could be isolated was, in each case, monoethyl homophthalate (III), but this was obtained in good yield. The reaction with benzoylacetone was similarly rapid and gave a good yield of halogen-free material, probably β-deoxybenzoin-*o*-carboxylic acid (IV), since oxidation produced a mixture of benzoic and phthalic acids but no acetic acid.

The sodium derivatives of certain phenols which exhibit tautomeric behaviour react with replacement of the bromine in sodium *o*-bromobenzoate. Notably with the monosodium derivative of resorcinol reaction occurs almost instantaneously in boiling aqueous solution on the addition of a little copper sulphate. An almost colourless crystalline substance is precipitated, though not in very good yield. The compound is probably the lactone of 2′ : 4′-dihydroxydiphenyl-2-carboxylic acid, since it yields fluorene on distillation with zinc dust and a methoxy-lactone and a dimethoxy-acid on methylation.

As the presence of copper in some form was essential to the success of the above reactions, it was of interest to investigate the action of copper powder alone on the bromo-acid and on its sodium salt. When a powdered mixture of *o*-bromobenzoic acid (1 mol.) and copper-bronze (2 atoms) was heated at 160°, rapid reaction occurred and a pale green powder was obtained consisting of cuprous bromide and cuprous benzoate :

$$2C_6H_4Br\cdot CO_2H + 4Cu \longrightarrow 2C_6H_5\cdot CO_2Cu + Cu_2Br_2.$$

A solution of the acid in boiling water was similarly converted by copper into benzoic acid, but diphenic acid also was obtained in about 7% yield. Good yields (43%) of diphenic acid can be obtained only by heating a powdered mixture of potassium *o*-bromobenzoate with excess of copper-bronze at 100° and stirring in a small quantity of water. Reaction then occurs instantaneously.

Ethyl *o*-bromobenzoate would readily enter into none of the above reactions (compare Anschütz and Jansen, *Ber.*, 1922, **55**, 681), nor would *p*-bromobenzoic acid or *o*-bromonitrobenzene. The non-reactivity of *p*-bromobenzoic acid is possibly explained by the insolubility of the free acid and of its sodium salt in alcohol.

EXPERIMENTAL.

Salicylic Acid.—A solution of 3 g. of sodium *o*-bromobenzoate, 6 g. of sodium acetate, and 0·5 g. of copper acetate in 60 c.c. of water was boiled under reflux for 30 minutes. When the acidified solution was cooled, salicylic acid crystallised.

*Phenylacetylacetone-*o*-carboxylic acid* (I) (3·5—4 g.) was obtained by boiling a solution of sodium (1·15 g.), *o*-bromobenzoic acid (5 g.), and acetylacetone (2·5 g.) in absolute alcohol (25 c.c.) in presence of copper bronze (0·1 g.) for 3 hours and acidifying the cooled, diluted solution. It crystallised from aqueous alcohol in colourless needles, m. p. 142° (Found : C, 65·5; H, 5·6. $C_{12}H_{12}O_4$ requires C, 65·5; H, 5·5%). Boiling aqueous alkali produced from it a poor yield of *o*-carboxybenzyl methyl ketone, m. p. 115°, which gave no coloration with ferric chloride.

Ethyl o-*Carboxyphenylmalonate* (II).—*o*-Bromobenzoic acid (5 g.) and ethyl malonate (4 g.) were added together with copper acetate (0·2 g.) to a solution of sodium (1·15 g.) in alcohol (25 c.c.). The solution was boiled for 8 hours, diluted with water, filtered, and acidified. The precipitate solidified on scratching and crystallised from benzene–ligroin in pink square plates, m. p. 102° (Found : C, 59·3; H, 5·7. $C_{14}H_{16}O_6$ requires C, 59·6; H, 5·7%).

Ethyl hydrogen homophthalate (III) was obtained by dissolving sodium (1·15 g.) in alcohol (25 c.c.), adding *o*-bromobenzoic acid (5 g.), ethyl acetoacetate (3·25 g.), and copper-bronze (0·1 g.), and boiling the solution obtained for 2—3 hours. The product, worked up as in previous preparations, separated from hot water in long colourless needles, m. p. 109° (yield, about 5 g.).

The same compound was obtained when the acetoacetic ester was replaced by ethyl acetonedicarboxylate, but the yield was not so good.

β-Deoxybenzoin-*o*-carboxylic acid (IV) was similarly obtained, benzoylacetone (4·1 g.) being used in place of ethyl acetoacetate. It crystallised from alcohol in flat needles, m. p. 168° after sintering at 145° (Gabriel, *Ber.*, 1885, **18**, 2446, gives m. p. 162—163° after sintering at 140°) (Found : C, 75·0; H, 5·2. Calc. for $C_{15}H_{12}O_3$: C, 75·0; H, 5·0%).

The *lactone* of 2′ : 4′-dihydroxydiphenyl-2-carboxylic acid was obtained by boiling a solution of *o*-bromobenzoic acid (5 g.), resorcinol (5 g.), and sodium hydroxide (2 g.) in 50 c.c. of water. On addition of 10% copper sulphate solution (2 c.c.) a crystalline precipitate (3·5 g. after washing with water) was almost immediately formed. (The use of alcohol as solvent failed to improve the yield. By carrying out the reaction in molten resorcinol the same product was obtained, and not a derivative of diphenyl ether, as would be expected, by the Ullmann reaction.) The lactone was very sparingly soluble in the common solvents and crystallised from glacial acetic acid or amyl alcohol in fine colourless needles, m. p. 232° (Found : C, 73·2; H, 4·0. $C_{13}H_8O_3$ requires C, 73·6; H, 3·8%). The solution in concentrated sulphuric acid shows a green fluorescence.

The lactone dissolved readily in 2*N*-alkali with a transitory yellow coloration. When the cold alkaline solution was shaken with methyl sulphate and acidified, an oil was obtained which gave a residue of the *lactone* of 2′-hydroxy-4′-methoxydiphenyl-2-carboxylic acid after extraction with cold 2*N*-alkali. This material crystallised from alcohol in fine colourless needles, m. p. 141° (Found : C, 74·4; H, 4·6. $C_{14}H_{10}O_3$ requires C, 74·3; H, 4·4%). The solution in concentrated sulphuric acid gives a strong green fluorescence.

Complete methylation occurred when the process was carried out at 100°. The product, which was completely soluble in cold alkali, crystallised from alcohol in colourless prisms, m. p. 150°. 2′ : 4′-*Dimethoxydiphenyl-2-carboxylic acid* is somewhat soluble in hot water. It gives no colour with cold concentrated sulphuric acid, but a green fluorescence develops on warming (Found : C, 69·8; H, 5·4; *M*, ebullioscopic in acetone, 266. $C_{15}H_{14}O_4$ requires C, 69·8; H, 5·4%; *M*, 258).

Diphenic Acid.—Dry potassium *o*-bromobenzoate prepared from 5 g. of the acid was mixed with copper-bronze (7 g.) and heated on a boiling water-bath and water (2 g.) was rapidly stirred in. The product was extracted with aqueous alkali, and the solution rendered acid. The precipitate obtained, after being dried (1·6 g.) and extracted with boiling benzene, left a residue of diphenic acid.

The author wishes to thank Professor S. Smiles, F.R.S., for his interest in the work.

KING'S COLLEGE, LONDON. [*Received, October 29th,* 1928.]