Accordingly, an experiment was carried out with aluminum iodide under conditions like those used with the ethylaluminum iodides, and again 2-dibenzofurancarboxylic acid was isolated. This finding is not without some interest in connection with Friedel–Crafts reactions which also involve the 2-position of dibenzofuran, and in connection with mercuration in the 4-position by mercuric acetate.[4a]

The ethylaluminum iodides do effect a halogen-metal interconversion reaction with 4-iododibenzofuran to give, on carbonation, 4-dibenzofurancarboxylic acid

$$IC_{12}H_7O + C_2H_5AlI_2 \xrightarrow[{[H_2O]}]{[CO_2]} (HOOC)C_{12}H_7O$$

However, they do not give a corresponding reaction with *o*-bromophenol, which does undergo a halogen–metal interconversion with the more reactive ethylmagnesium bromide.

Experimental

Triethylaluminum and Dibenzofuran.—A benzene solution of 25 g. (0.15 mole) of dibenzofuran was added to triethylaluminum prepared in 35% yield by heating a mixture of 10 g. (0.039 mole) of diethylmercury and 3.78 g. (0.14 g. atom) of aluminum chips at 150° for six hours. After removal of the benzene by distillation, the mixture was heated for 24 hours at 145–150°. Benzene was then added to the cooled residue and carbon dioxide was passed in to a negative color test.[4b] The yield of recovered dibenzofuran was 89.5%.

Ethylaluminum Iodides, and Aluminum Iodide, with Dibenzofuran.—A mixture of 0.3 mole of ethylaluminum iodides[5] and 16.8 g. (0.1 mole) of dibenzofuran was heated in a sealed tube (dry nitrogen atmosphere) at 210° for seventy-two hours. To the cooled mixture was added 50 cc. of benzene, and after carbonation at reflux temperature with carbon dioxide, there was isolated 0.25 g. (1.1% yield) of 2-dibenzofurancarboxylic acid. The identity of the product was established both by comparison with an authentic specimen of the 2-acid, and by conversion to the known methyl 2-dibenzofurancarboxylate by diazomethane.

From a corresponding reaction in which anhydrous aluminum iodide was used in place of the ethylaluminum iodides, the yield of 2-dibenzofurancarboxylic acid was 1.4%, and 15.5 g. or 92% of the dibenzofuran was recovered.

Ethylmagnesium Bromide and Dibenzofuran.—To a filtered ether solution of ethylmagnesium bromide (prepared from 0.4 mole of ethyl bromide) was added 16.8 g. (0.1 mole) of dibenzofuran in 50 cc. of ether. Subsequent to removal of the ether, by distillation, the mixture was heated for six hours at 165°. The cooled reaction product was dissolved in 300 cc. of ether, and then carbonated in a customary manner by Dry Ice. The yield of 4-dibenzofurancarboxylic acid was 1.05 g. (5%). Identification was completed by conversion to the methyl ester by means of diazomethane.

Ethylaluminum Iodides and 4-Iododibenzofuran.—After removal of benzene from a solution of 0.3 mole of ethylaluminum iodides and 29.2 g. (0.1 mole) of 4-iododibenzofuran, the mixture was heated for twenty-four hours at 145°. Benzene was added to the cooled residue, and carbonation was effected by passing carbon dioxide into the hot solution. The yield of crude 4-dibenzofurancarboxylic acid was 3.19 g. (15%), and identification was completed in the usual way. No experiment was made to determine whether heating for an extended period at a more elevated temperature might induce any rearrangement of the C–Al grouping from the 4-position to the 2-position.

Ethylaluminum Iodides and Ethylmagnesium Bromide with *o*-Bromophenol.—Subsequent to the removal of benzene from a mixture of 0.2 mole of ethylaluminum iodides and 8.3 g. (0.05 mole) of *o*-bromophenol, the residue was heated for five hours at 120°. Then carbon dioxide was added to a hot benzene solution of the reaction mixture until a negative color test was obtained. The recovery of *o*-bromophenol was 88%, and no dibenzofurancarboxylic acid was isolated.

To an ether solution of ethylmagnesium bromide (prepared from 0.2 mole of ethyl bromide) was added 7.5 g. (0.043 mole) of *o*-bromophenol in 50 cc. of ether. Subsequent to removal of the ether by distillation, the mixture was heated for two hours at 120°. The cooled mixture was taken up in ether, and this solution was carbonated by Dry Ice to yield 2.7 g. (45%) of salicylic acid and 3.8 g. (51%) of crude *o*-bromophenol. It is to be noted that in this experiment some residual ether was probably contained in the mixture, whereas in the corresponding experiment with the ethylaluminum iodides no ether was present. However, halogen–metal interconversion was effected in the ether-free mixture of ethylaluminum iodides and 4-iododibenzofuran.

DEPARTMENT OF CHEMISTRY
IOWA STATE COLLEGE
AMES, IOWA

RECEIVED MARCH 19, 1945

---

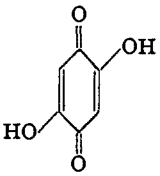
[4] (a) Gilman and Young, THIS JOURNAL, **56**, 1415 (1934); (b) Gilman and Schulze, *ibid.*, **47**, 2002 (1925).

[5] Grignard and Jenkins, *Bull. soc. chim.*, [4] **37**, 1376 (1925).

The Preparation of 2,5-Dihydroxyquinone

BY REUBEN G. JONES AND H. A. SHONLE

The synthesis of a series of compounds required 2,5-dihydroxyquinone (I) as an intermediate.



(I)

This quinone has generally been prepared by the hydrolysis of a 2,5-diaminoquinone,[1] diiminoresorcinol,[2] 2-hydroxy-5-anilinoquinone and related compounds.[3] Unfortunately, however, diiminoresorcinol and the 2,5-diaminoquinones must be obtained by tedious syntheses.

Recently Brecht and Rogers[4] have reported the formation of 2,5-dihydroxyquinone by the oxidation of salicylic acid in 25% sodium hydroxide solution by the addition of hydrogen peroxide in small portions at three-day intervals. While the oxidation of sodium salicylate required as long as fifty-four days, high yields of 2,5-dihydroxyquinone were obtained. These authors also stated that 2,5-dihydroxyquinone was obtained by the hydrogen peroxide oxidation of

---

[1] (a) Mylius, *Ber.*, **18**, 463 (1885); (b) Kehrmann, *ibid.*, **23**, 897, 1264 (1890); (c) Kehrmann and Prager, *ibid.*, **40**, 1234 (1907).

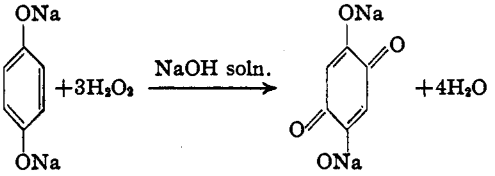
[2] Nietzki and Schmidt, *ibid.*, **21**, 2374 (1888).

[3] Kehrman and Bahatrian, *ibid.*, **31**, 2399 (1898).

[4] Brecht and Rogers, *J. Am. Pharm. Assoc.*, **29**, 178 (1940).

m-hydroxybenzoic acid, *p*-hydroxybenzoic acid, phenol, catechol, resorcinol and hydroquinone.

It has now been found that good yields of 2,5-dihydroxyquinone can be obtained by rapidly oxidizing hydroquinone in concentrated sodium hydroxide solution with 30% hydrogen peroxide. The reaction appears to be represented by the equation:



The red-orange crystalline disodium salt, which precipitated from the sodium hydroxide solution during the reaction, liberates 2,5-dihydroxyquinone upon treatment with acid.

Two factors which greatly influenced the yields of 2,5-dihydroxyquinone were the reaction temperature and the concentration of the sodium hydroxide solution. The reaction, which was exothermic, proceeded extremely slowly below 25°, but in the temperature range of 40 to 60° the oxidation could be completed in about two hours to give 59 to 62% yields of the desired product. At temperatures of 85 to 95° the reaction was vigorous, resulting in a 35% yield of 2,5-dihydroxyquinone.[5]

From a series of reactions carried out at 40–50° it was found that the yield of 2,5-dihydroxyquinone was directly proportional to the concentration of the sodium hydroxide. Thus in 50 and 65% sodium hydroxide solution the yields were 70 and 80%, respectively. When the sodium hydroxide concentration was 20%, only 14% of the 2,5-dihydroxyquinone was obtained while none was obtained with a 15% sodium hydroxide concentration.[6]

The ability of sodium hydroxide to depress the solubility of the disodium salt of 2,5-dihydroxyquinone probably accounts for the increased yields of 2,5-dihydroxyquinone in highly concentrated sodium hydroxide solutions since the disodium salt is almost completely precipitated and thus removed from the action of the hydrogen peroxide. In 15% sodium hydroxide solution the disodium salt appears to be sufficiently soluble that the hydrogen peroxide completely oxidizes it to other products.

In preliminary experiments, solutions of phenol, salicylic acid, resorcinol, catechol, and quinone in 36% sodium hydroxide solution were treated with hydrogen peroxide. After one week, a small yield of the disodium salt of 2,5-dihydroxyquinone was obtained from phenol and salicylic acid. Resorcinol reacted very slowly at room temperature, but no recognizable products were isolated. On the other hand, both catechol and quinone reacted vigorously at or below room temperature giving dark brown solutions which were not further investigated.

Experimental

A specific example is given which will illustrate the general procedure.

A 500-cc. three-necked flask was provided with a dropping funnel, a thermometer and a heavy glass stirrer. In the flask was placed 200 g. of 50% sodium hydroxide solution (2.5 mole) and 27.5 g. (0.25 mole) of hydroquinone. This mixture was well stirred while 100-cc. of 27% hydrogen peroxide (0.88 mole) was added dropwise from the dropping funnel. As soon as the temperature of the reaction reached 45°, the flask was surrounded with an ice-bath and the rate of addition of the hydrogen peroxide was adjusted so that the temperature was maintained between 45 and 50°. About thirty minutes was required for the addition. Stirring was continued for one and one-half hours. The ice-bath was removed, but the temperature was watched closely and kept below 50° by occasional cooling. The reaction mixture now consisted of a thick paste of the red-orange sodium salt of 2,5-dihydroxyquinone. It was worked up in either of the two following ways:

(1) An equal volume of 95% alcohol was added to the mixture, and, after stirring well, the sodium salt was collected on an asbestos mat in a large Büchner funnel. The solid was washed on the filter with two 100-cc. portions of 95% alcohol and then dissolved in the smallest possible volume (1 to 2 liters) of water at 70°. The resulting cherry-red solution was filtered and acidified with concentrated hydrochloric acid to precipitate the yellow crystalline 2,5-dihydroxyquinone which was collected after the mixture had been cooled to room temperature.

(2) The entire reaction mixture was stirred into 500 g. of cracked ice and acidified with a mixture of 225 cc. of 36% hydrochloric acid and 300 g. of ice. The resulting yellow precipitate of 2,5-dihydroxyquinone was collected and washed by suspension in 200 cc. of ice water.

The yield of pure 2,5-dihydroxyquinone (m. p. 212–14° dec.) dried in vacuum over calcium chloride, was 23 to 25 g. (66 to 70%).

THE LILLY RESEARCH LABORATORIES
ELI LILLY AND COMPANY
INDIANAPOLIS INDIANA
RECEIVED JANUARY 29, 1945

[5] In these reactions 0.30 mole of hydroquinone in 330 cc. of 36% sodium hydroxide solution was treated with 120 cc. (1.05 moles) of 27% hydrogen peroxide.

[6] The ratio of reactants was 1.0 mole of 27% hydrogen peroxide, 0.3 mole of hydroquinone and 4.2 moles of sodium hydroxide. The initial concentration of sodium hydroxide was varied by varying the quantity of water used.

A Nomogram for Acetate Buffers[1]

BY WILLIAM C. BOYD

In the preparation and study of proteins, particularly plasma proteins,[2] acetate buffers of known *p*H and ionic strength have proved of the greatest usefulness. The preparation of such buffers is possible from the use of the charts of Green,[3] which were in turn based on data obtained by Cohn, Heyroth and Menkin.[4] It has been found, however, that there is another form in which it is more convenient to use this information.

[1] This work was carried out under contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Harvard University.

[2] E. J. Cohn, *et al.*, *J. Clin, Invest.*, **23**, No. 4 (1944).

[3] A. A. Green, THIS JOURNAL, **55**, 2331 (1933).

[4] E. J. Cohn, F. F. Heyroth and M. F. Menkin, *ibid.*, **50**, 696 (1928).