

tract was dried over sodium sulfate and evaporated to dryness. The residue was dissolved in hot *n*-butyl ether. Upon cooling 0.36 g. of dihydrodeguelic acid separated which had the properties recorded for the acid obtained by catalytically reducing deguelic acid.

Summary

1. Derric and risic acids have been obtained from deguelic acid by methods analogous to those used in preparing these acids from derivatives of rotenone. This shows that in deguelin as in rotenone, derric acid constitutes one-half of the molecule.

2. Reduction of dehydrodeguelin yields dihydrodehydrodeguelin, which is identical with dehydro- β -dihydrorotenone.

3. Upon treatment with alcoholic alkali, dihydrodehydrodeguelin gives dihydrodeguelic acid. This acid is also obtained by catalytically reducing deguelic acid.

4. Dihydrodeguelic acid has been found to be identical with dehydrodihydroxy- β -dihydrorotenonic acid described by Haller.

5. These facts show that there exist structural relationships common to the entire molecule of both rotenone and deguelin.

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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF ILLINOIS]

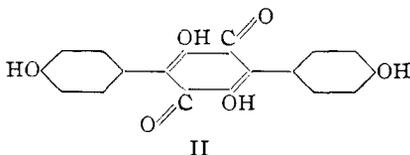
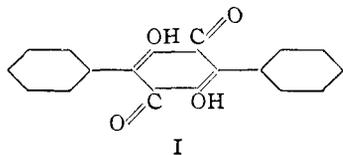
THE SYNTHESIS OF POLYPORIC ACID AND ATROMENTIN DIMETHYL ETHER

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Two of the important coloring matters found in fungi are polyporic acid (I) obtained from *Polyporus nidulans* and atromentin (II) from *Paxillus atrotomentosus*. Kögl² determined the structures of these two compounds to be derivatives of diphenylquinone.



Moreover, he synthesized each of these compounds in two ways. The first method was that devised by Fichter.³ For the polyporic acid, ethyl phenylacetate and ethyl oxalate² were condensed together with sodium;

¹ This communication is an abstract of a portion of a thesis submitted by P. R. Shildneck in partial fulfilment of the requirements for the Degree of Doctor of Philosophy in Chemistry at the University of Illinois.

² Kögl, *Ann.*, **447**, 78 (1926).

³ Fichter, *ibid.*, **361**, 363 (1908).

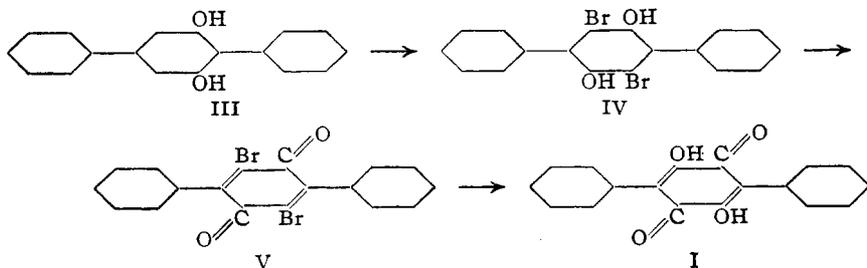
for the atromentin, ethyl *p*-methoxyphenylacetate and ethyl oxalate.⁴ Although sufficient product in each case was obtained to characterize the compounds and to form one or two derivatives, the yields were extremely poor, as they amounted only to about one per cent. of the theoretical.

Kögl used a second method of synthesis also which consisted in preparing diphenylquinone or *p*-hydroxyphenylquinone by the method of Pummerer⁵ and then in introducing methoxyls adjacent to the carbonyl groups of the quinone by heating with zinc chloride in methyl alcohol. Upon demethylation of the ethers the two natural coloring matters were obtained. Even by this procedure, however, the introduction of the methoxyl groups resulted in such low yields that these syntheses may be considered valuable only so far as the identification of structure is concerned.

During recent work on substituted diphenylquinones in connection with the stereochemistry of diphenylbenzenes, it was noticed that diaryldibromoquinones were easily hydrolyzed to the corresponding hydroxy derivatives. This procedure has now been applied to the synthesis of polyporic acid and atromentin dimethyl ether with the result that the compounds were prepared with ease in excellent yields.

Diphenylhydroquinone (III) was prepared by the general procedure of Pummerer but with such changes in detail as to increase the yield seven-fold to about 65%. This was then brominated to diphenyldibromohydroquinone (IV) and the latter oxidized to diphenyldibromoquinone (V). Upon hydrolysis of this product, the corresponding dihydroxyquinone was obtained which was polyporic acid (I). Each of the steps involved in the process just mentioned resulted in yields of 90% or better.

Acetylation of the diphenyldihydroxyquinone gave an acetyl derivative which analyzed correctly for the diacetate and agreed as to melting point with the diacetylpolyporic acid prepared by Kögl.² The corresponding diacetylhydroquinone and tetraacetate were also prepared.

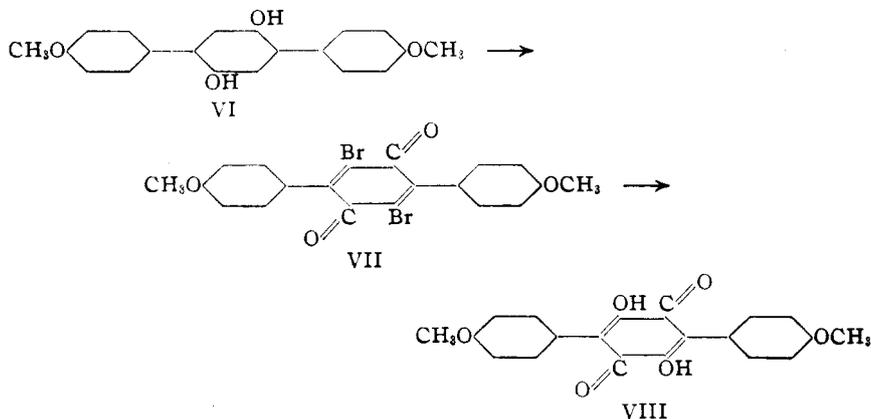


In a similar manner anisole was condensed with quinone to dianisylhydroquinone (VI). Upon treatment with bromine in glacial acetic

⁴ Kögl and Becker, *Ann.*, **465**, 251 (1928).

⁵ Pummerer and Prell, *Ber.*, **55**, 3108 (1922).

acid, bromination and oxidation took place simultaneously and di-(*p*-methoxyphenyl)-dibromoquinone (VII) was produced. This in turn was hydrolyzed with aqueous sodium hydroxide to the dimethyl ether of atromentin (VIII).



Experimental

2,5-Diphenylquinone.—To a suspension of 300 g. of finely powdered anhydrous aluminum chloride in 500 cc. of dry benzene in a 2-liter three-necked flask equipped with a mechanical stirrer, 500-cc. separatory funnel, thermometer and reflux condenser was slowly added with stirring a solution of 100 g. of pure benzoquinone in 1000 cc. of dry benzene. Heat was evolved and the rate of addition was regulated to maintain the reaction mixture at a temperature of 35–40°. The addition required two to three hours. Stirring was continued for five hours thereafter and the temperature allowed to drop to that of the room.

The reaction product was decomposed by pouring it slowly onto a mechanically-stirred mixture of 2 kg. of ice and 250 cc. of concentrated hydrochloric acid. Stirring was continued until a light brown emulsion was formed and no lumps of undecomposed material remained. The benzene was removed by steam distillation. The residual light brown solid was definitely granular and was readily separated by filtration. It was washed with hot water and air-dried. The yield of dry material was 140 g., green in color and obviously a mixture of quinones, hydroquinones and quinhydrones.

To obtain the yellow crystalline diphenylquinone, the crude reaction product was oxidized carefully in a hot glacial acetic acid solution with chromic acid, but since any excess chromic acid over that required to oxidize hydroquinones and quinhydrones in the crude product to the quinone state will rapidly oxidize the terphenyl molecule to benzoic acid, it was necessary to determine beforehand the amount of chromic acid to be used per unit weight of the crude material. This was carried out as follows.

Three 1-g. samples of the crude product were accurately weighed out and placed in 50-cc. Erlenmeyer flasks. To the first flask was added 0.100 g. of chromic acid; to the second 0.133 g. and to the third 0.150 g. To each flask was then added 25 cc. of glacial acetic acid. Each was heated to boiling for two to three minutes and filtered hot. The first filtrate was a definite mixture of yellow quinone plates and dark green quinhydrone needles; the second showed only yellow plates of the quinone at first but the dark colored quinhydrone crystallized later as a fringe around the upper edge of the solution, and the third filtrate exhibited only the yellow plates of the quinone even on long standing.

The remaining 137 g. of crude product was placed in a 5-liter round-bottomed flask with 3 liters of glacial acetic acid and 21 g. of chromic acid and rapidly heated to boiling. The solution was immediately filtered through a large fluted filter, the filtrate cooled for two to three hours under the tap and then filtered through a Büchner funnel. The mat of yellow flakes was washed first with water, then with 150 cc. of 50% ethyl alcohol. The yield of air-dried material amounted to 51 g. and it melted at 210–212° (corr.). It was pure enough to be used for further preparations. A single recrystallization from either benzene or glacial acetic acid yielded the pure substance melting constantly at 214° (corr.). An additional 7 g. of pure material was obtainable from the mother liquors, bringing the total yield up to 58 g. (72%).

2,5-Diphenylhydroquinone (II).—In a 1-liter round-bottomed flask was placed a mixture of 500 cc. of glacial acetic acid, 25 g. of diphenylquinone and 50 g. of powdered zinc. The mixture was stirred for one hour without external heating and then refluxed for thirty minutes. The solution was filtered hot and the solid material on the filter washed with two 50-cc. portions of warm glacial acetic acid, the washings being added to the filtrate. The filtrate was transferred to a 3-liter round-bottomed flask equipped with a reflux condenser and heated to boiling. Hot water was added slowly through the condenser until the white hydroquinone crystallized from the boiling solution. A few hundred cc. more of water may be slowly added if desired to complete the precipitation of the product and the filtrate then cooled. It was filtered and the product washed with hot water. The pale straw-colored air-dried material amounted to 23 g. and was sufficiently pure to be used for the next step. A single recrystallization from either chloroform or dilute ethyl alcohol yielded white needles melting constantly at 225° (corr.).

2,5-Diphenyl-3,6-dibromohydroquinone (IV).—To a 1-liter three-necked flask, equipped with a mechanical stirrer, thermometer, 125-cc. separatory funnel and outlet tube, was added 400 cc. of chloroform and 20 g. of diphenylhydroquinone. The stirrer was started and the contents of the flask cooled to 10° by external cooling. Through the separatory funnel was then added rapidly a solution of 39 g. of bromine in 50 cc. of chloroform. At first a heavy dark crystalline precipitate, presumably the quinhydrone, appeared which later dissolved to a clear orange solution. The solution was stirred for eight hours at room temperature.

The solvent was removed under reduced pressure, avoiding a temperature above 30°. The light yellow solid remaining was refluxed with 1500 cc. of 95% ethyl alcohol and 20 g. of stannous chloride until a clear pale yellow solution was obtained. Dilute hydrochloric acid (6 *N*) was added slowly to the boiling solution until needles of the white hydroquinone appeared. The solution was chilled to 0° and filtered. The mat of white needles was washed with 6 *N* hydrochloric acid, followed by hot water and then air-dried; yield, 29 g. (90%).

The product as obtained was quite pure. A single recrystallization from 95% ethyl alcohol yielded long, slender white needles melting constantly at 237° (corr.).

Anal. (Parr bomb). Calcd. for $C_{18}H_{12}O_2Br_2$: Br, 38.10. Found: Br, 38.44.

2,5-Diphenyl-3,6-dibromoquinone (V).—A mixture of 25 g. of the diphenyldibromohydroquinone, 1 liter of 95% ethyl alcohol and 15 g. of benzoquinone was refluxed for one-half hour. The mixture was cooled and filtered. The orange crystalline quinone was washed free of benzoquinone on the filter with cold alcohol and air-dried; yield, 21 g. The product crystallized from *n*-butyl alcohol in slender orange needles melting constantly at 224°.

Anal. (Parr bomb). Calcd. for $C_{18}H_{10}O_2Br_2$: Br, 38.23. Found: Br, 38.03.

2,5-Diphenyl-3,6-dihydroxyquinone (I).—A mixture of 20 g. of the diphenyldibromoquinone, 1 liter of methyl alcohol and 1 liter of 10% sodium hydroxide solution was stirred mechanically for two hours at 40–50°. The purple solution was filtered and

acidified with concentrated hydrochloric acid. One liter of water was added and the volume of solution reduced to one-half by evaporation on a hot-plate. This boiling and concentrating served to coagulate the brown precipitate material and to remove a considerable amount of alcohol, all of which aided subsequent filtration. The filtered product after washing and drying amounted to 13 g. (92%).

The product may be crystallized from toluene—1.4 g. in 630 cc. of boiling toluene yielded 1.1 g. of bronze-colored plates melting with sublimation at 305° (obs.)—or purified through the diacetate as described below.

Anal. (Crystallized from toluene.) Calcd. for $C_{18}H_{12}O_4$: C, 73.95; H, 4.14
Found: C, 73.61, 73.50; H, 4.11, 4.19.

2,5-Diphenyl-3,6-diacetoxyquinone.—A mixture of 10 g. of the dihydroxyquinone, 150 cc. of pyridine and 150 cc. of acetic anhydride was refluxed for two minutes and then poured with stirring into a mixture of 1500 cc. of water and 250 cc. of concentrated hydrochloric acid. The light yellow solid was filtered, washed and dried; yield, 11.5 g. (quantitative). A single recrystallization from benzene yielded yellow needles melting constantly at 215° (corr.).

Anal. Calcd. for $C_{22}H_{16}O_6$; C, 70.18; H, 4.29. Found: C, 70.09; H, 4.30.

Hydrolysis of the Diacetoxyquinone.—A solution of 5 g. of the diacetoxy derivative in 150 cc. of glacial acetic acid was heated to boiling under a reflux condenser. Through the condenser was added 40 cc. of 6 *N* hydrochloric acid and refluxing continued for thirty minutes. The hydroxyquinone crystallized from the boiling solution in bronze-colored flakes. If the mixture was cooled before filtering, the recovery of material was nearly quantitative—4.2 g. The product melted at 305° (obs.) with sublimation and was otherwise identical with that obtained by crystallization from toluene.

2,5-Diphenyl-3,6-diacetoxyhydroquinone.—A solution of 3.35 g. of the diacetoxyquinone and 7 g. of stannous chloride in 200 cc. of acetone was gently refluxed for ten to fifteen minutes. The original yellow solution was almost completely decolorized. Through the condenser was added 25 cc. of 6 *N* hydrochloric acid and heating continued for two to three minutes. The flask was removed, 200 cc. of 3 *N* hydrochloric acid added at once and the solution immediately cooled to 15–20°; yield of slender white needles, 3.2 g. Two crystallizations from *n*-butyl alcohol gave a white product consisting of minute needles and melting constantly at 246° (corr.).

Anal. Calcd. for $C_{22}H_{18}O_6$: C, 69.81; H, 4.80. Found: C, 70.10; H, 4.95.

2,5-Diphenyl-1,3,4,6-tetraacetoxybenzene.—Acetylation of 2 g. of the diacetoxyhydroquinone with pyridine and acetic anhydride in the usual manner gave a quantitative yield of the crude material (2.45 g.). Two crystallizations from *n*-butyl alcohol yielded minute white needles melting constantly at 267–268° (corr.).

Anal. Calcd. for $C_{26}H_{22}O_8$: C, 67.50; H, 4.80. Found: C, 67.33; H, 4.79.

2,5-Di(*p*-methoxyphenyl)-hydroquinone, VI.—The corresponding quinone was prepared from benzoquinone and anisole according to the directions of Pummerer and Prell.⁵ The hydroquinone was obtained by reduction with stannous chloride and hydrochloric acid in acetone solution.

A mixture of 20 g. of the dianisylquinone, 40 g. of stannous chloride and 600 cc. of acetone was stirred for one hour at room temperature. Heat developed, the red quinone disappeared and the resulting bluish-green solution deposited small lustrous white plates of the hydroquinone. If cooled to 0° and allowed to stand for two to three hours, the yield of practically pure product was 16–17 g. A single recrystallization from acetone containing a trace of stannous chloride and hydrochloric acid yielded a pure white product melting constantly at 210° (corr.).

2,5-Di(*p*-methoxyphenyl)-3,6-dibromoquinone, VII.—A solution of 8.5 g. of

dianisylhydroquinone in 4.5 liters of glacial acetic acid was prepared by gentle heating and stirring on the steam-bath. The warm solution was cooled to 25°. To this was added with stirring a solution of 17 g. of bromine in 100 cc. of glacial acetic over a period of one hour. The red solution was slowly stirred for forty-eight hours during which time a small crop of dark reddish-brown needles separated. (The dianisylquinone, produced by oxidation with bromine of the hydroquinone in cold glacial acetic acid solution, separates in bright red silky needles easily distinguished from the darker colored brominated product.) Stirring was then discontinued and the solution allowed to stand at 15° or a few degrees lower for three to four days. The needles were filtered off and washed with cold methyl alcohol; yield 5.7 g. Three crystallizations from glacial acetic acid, using 125 cc. per gram of substance, gave a reddish-brown product melting with decomposition constantly at 282–283° (corr.).

Anal. Calcd. for $C_{20}H_{14}O_4Br_2$: Br, 33.44; C, 50.21; H, 2.95. Found: Br, 33.75; C, 50.66; H, 3.12.

This substance crystallized unchanged in m. p. or appearance from acetic anhydride, pyridine, or a mixture of the two.

2,5-Di-(*p*-methoxyphenyl)-3,6-dihydroxyquinone (Atromentin Dimethyl Ether), VIII.—A mixture of 1.7 g. of the dibromodianisylquinone in a solution consisting of 170 cc. of methyl alcohol and 170 g. of 10% sodium hydroxide was stirred at room temperature for forty-eight hours. The dibromoquinone was nearly completely replaced by the purple sodium salt of the corresponding dihydroxyquinone. The mixture was filtered and the filtrate, being nearly colorless, was set aside. The sodium salt was separated from the unreacted starting material on the filter by pouring repeatedly over it 500 cc. of cold water. The permanganate-colored filtrate was acidified with acetic acid and heated to boiling. The brown flocculent precipitate was filtered with gentle suction and washed with hot water. It was redissolved on the filter with 500 cc. of cold 2% sodium hydroxide, reprecipitated with acetic acid, filtered, washed and dried as before; yield of air-dried material 1.0 g. (80%). Two crystallizations from toluene, using 500 cc. of toluene per gram of substance, gave minute, glistening, bronze-colored plates melting with decomposition constantly at 297–298° (corr.) and free of halogen.

Anal. Calcd. for $C_{20}H_{18}O_6$: C, 68.18; H, 4.58. Found: C, 67.65, 67.72; H, 4.66, 4.60.

2,5-Di-(*p*-(*n*)-butoxyphenyl)-quinone.—To a solution of 10.8 g. of benzoquinone and 15 g. of *n*-butyl phenyl ether in 150 cc. of dry carbon disulfide maintained at 0–5° with an ice-bath, 27 g. of anhydrous aluminum chloride was slowly added with vigorous stirring. The addition required about thirty minutes and the mixture was stirred for four hours longer. The reaction mixture was decomposed by pouring onto ice and dilute hydrochloric acid. The carbon disulfide was steam distilled out and the residual black solid material crystallized from 1 liter of *n*-butyl alcohol to which was previously added 2 g. of norite and 3 g. of benzoquinone; yield of yellow flakes, 4 g. Recrystallization from 50 cc. of toluene gave 3.2 g. of similar crystals melting constantly at 173° (corr.).

Anal. Calcd. for $C_{28}H_{28}O_4$: C, 77.18; H, 6.98. Found: C, 77.02; H, 6.99.

Summary

1. Polyporic acid and atromentin dimethyl ether have been prepared by new procedures in excellent yields.

2. Diphenylquinone from the condensation of benzene and quinone was reduced to diphenylhydroquinone. This was in turn brominated to diphenyldibromohydroquinone and the latter, after oxidation to the

corresponding quinone, was hydrolyzed to diphenyldihydroxyquinone (polyporic acid).

3. In a similar manner atromentin dimethyl ether was produced from dianisylquinone, the condensation product of anisole and quinone.

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[CONTRIBUTION FROM THE KEDZIE CHEMICAL LABORATORY, MICHIGAN STATE COLLEGE]

ACTION OF AROMATIC ALCOHOLS ON AROMATIC COMPOUNDS IN THE PRESENCE OF ALUMINUM CHLORIDE. VII. CONDENSATION OF BENZYL ALCOHOL WITH PARA-CRESOL

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Para-cresol and benzyl alcohol in the molecular ratio of 2 to 1 dissolved in petroleum ether and treated with 0.5 mole of aluminum chloride gave a condensation product which upon fractional distillation yielded 35% of crude mono and 36% of crude dibenzylated *p*-cresol. When the reactants were used in the ratio of 3 to 1, with the same amount of aluminum chloride, the yields were 53 and 30%, respectively. Crystallization of the monobenzylated *p*-cresol from petroleum ether in the cold gave transparent needles melting at 35–36°. The dibenzylated *p*-cresol did not crystallize.

These compounds were found to agree in properties with those prepared by Claisen¹ by the action of benzyl chloride on the sodium salt of *p*-cresol in toluene, except that he did not obtain the monobenzyl derivative in crystal form.

The 2-benzyl-4-methylphenol was easily soluble in dilute potassium hydroxide and when treated with the calculated amount of benzoyl chloride gave the ester. As was anticipated, the 2,6-dibenzyl-4-methylphenol was not soluble, even in strong potassium hydroxide, but formed a solid. This, however, treated with benzoyl chloride reacted to produce the ester.

Bromination of 2-benzyl-4-methylphenol in chloroform gave 2-benzyl-4-methyl-6-bromophenol. This configuration was proved by preparing the same compound by benzylating 4-methyl-6-bromophenol by the Claisen reaction. In addition a small amount of 4-methyl-6-bromophenyl benzyl ether was obtained.

The monobenzylated *p*-cresol was further characterized by preparing benzene sulfonic and toluene sulfonic esters by the pyridine method.

Experimental

Benzyl Alcohol and *p*-Cresol with Aluminum Chloride.—A mixture of 108 g. of *p*-cresol, 54 g. of benzyl alcohol and 75 g. of petroleum ether (40–60°) was placed in a tall cylinder and stirred mechanically while adding 33 g. of anhydrous aluminum chloride in small portions over a period of one hour. The temperature was kept below 30°.

¹ Claisen, *Ann.*, **442**, 210 (1925).