aldehyde were removed by careful distillation through the column. The residue, 5 ml., was then steam distilled until 8 ml. of a two-phase distillate had been collected. The upper ethyl acetate layer was separated, the solvent evaporated and the residue taken up in 10 ml. of 95% ethanol containing 100 mg. of 2,4-dinitrophenylhydrazine and 3 drops of 12 *M* hydrochloric acid. On chilling the solution, after refluxing for five minutes, a yellow crystalline solid was obtained, m.p. 94–98°, which on eight recrystallizations from aqueous ethanol melted at 103–104.5°. A mixed melting point with heptaldehyde 2,4-dinitrophenylhydrazone of m.p. 104–105° showed no depression.

Oxidation of the Diolefin with Potassium Permanganate.—A 0.46-g. (0.00146 mole) sample of the pure diolefin dissolved in 10 ml. of acetone was treated with 2.5 g. of finely powdered potassium permanganate in small portions over a period of four hours at 0–5° in an ice-bath.[13] After adding 10 ml. of water, the manganese dioxide and excess potassium permanganate were reduced by treatment with sulfur dioxide. The colorless cloudy solution was made strongly acid by the addition of 3 ml. of 12 *M* hydrochloric acid and extracted exhaustively with diethyl ether. The combined extracts were in turn extracted with several 10–15-ml. portions of water until no further evidence of oxalic acid could be obtained as described below.

In one of the potassium permanganate oxidation experiments the ether solution obtained at this stage was extracted with 10% sodium bicarbonate. Acidification of the extract gave a pale yellow oil the volatile components of which were removed by steam distillation. The residual oil, on crystallization from ethanol, gave a 22% yield of ω-(3-methoxyphenyl)-caprylic acid, identified by analysis and mixed melting point.

The combined aqueous extracts were made basic to litmus with 6 *M* ammonium hydroxide and treated with a solution of 2 g. of calcium chloride in 5 ml. of water. The precipitate of calcium oxalate was filtered, washed with 30 ml. of hot dilute acetic acid and then with 10 ml. of water, and dried. The resulting 0.40 g. of white solid was dissolved in 200 ml. of 0.45 *M* sulfuric acid by heating on the steam-bath and rapidly titrated with a standard solution of 0.200 *M* potassium permanganate at 70°. The titer (17.08 ml.) corresponded to 0.00086 mole of oxalic acid representing a 58% yield.

In another experiment, a 20% yield of the oxalic acid present in the aqueous extracts was recovered in the form of the dihydrate.

Oxidation of the Triolefin with Potassium Permanganate.—A 0.50-g. (0.0016 mole) sample of the pure triolefin was dissolved in 20 ml. of acetone and oxidized with 3.5 g. of potassium permanganate as above except that the temperature of the reaction was maintained at 10–15°. The oxidation required 90 minutes. The calcium oxalate, 0.55 g., isolated as described above, required 31.4 ml. of 0.200 *M* potassium permanganate for titration, corresponding to 0.00157 mole of oxalic acid, or a yield of 49% based on two moles of oxalic acid per mole of triolefin.

In another experiment a 35% yield of oxalic acid dihydrate (m.p. 100–101°), identified by analysis and mixed melting point, was obtained. The aromatic fragment from the oxidation, ω-(3-methoxyphenyl)-caprylic acid was isolated in 40% yield and identified by analysis and mixed melting point.

Ultraviolet Absorption Spectra.—The ultraviolet spectra of the four components of methylcardanol were determined using a Carey recording photoelectric spectrophotometer with 0.00010 *M* solutions in 95% ethanol.

Acknowledgment.—The authors are indebted to the Irvington Varnish and Insulator Company of Irvington, New Jersey, for the supply of cardanol, and for their helpful interest in this investigation.

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[CONTRIBUTION FROM THE CHEMISTRY DEPARTMENT OF THE UNIVERSITY OF MARYLAND]

Synthesis of a Substituted Phenylnaphthalene Related to Podophyllotoxin

BY WILKINS REEVE AND HERBERT MYERS

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The synthesis of a phenylnaphthalene derivative III closely related to podophyllotoxin is described.

In attempting to synthesize one of the isomers of the podophyllotoxin–picropodophyllin series I, we have prepared a substituted 1-phenylnaphthalene (III) differing from podophyllotoxin or picropodophyllin only in that it has a naphthalene ring instead of a tetralin ring, is a methyl ester instead of a lactone, and is missing a hydroxymethyl group.

The methyl ester II was prepared by methylating the corresponding keto acid with diazomethane. The keto acid was best prepared by the oxidation of the corresponding styrene.[1] The aldehyde, 3′,4′,5′-trimethoxy-4,5-methylenedioxybenzophenone-2-carboxaldehyde, was also obtained when the reaction was carried out on a 50-g. scale.

The sodium hydride-catalyzed Stobbe condensation of II with methyl succinate gave a 16% yield of the naphthol III and a 65% yield of a crude itaconic acid mixture. When potassium *t*-butoxide was used as a catalyst, none of the naphthol was obtained. The structure assigned to III is based on analytical data, the assumption the reaction proceeds by the accepted mechanism of the Stobbe condensation[2] (which requires an intermediate lactone and thereby excludes the carbomethoxy group from the 2-position), and the fact that an alcohol solution of it couples with a cold aqueous solution of diazotized *p*-toluidine at a *p*H of 8 to give a red dye. The fact that the itaconic acid mixture is the predominant product suggests that the Stobbe reaction occurs more rapidly than the Claisen reaction. Once a salt of the itaconic acid is formed, the Claisen reaction would not be expected to occur.

Experimental

All melting points are corrected. Analyses are by Mrs. Mary Aldridge and Mr. Byron Baer of this Laboratory. Intermediates leading to the synthesis of the substituted styrene were prepared as described earlier.[3]

3′,4′,5′-Trimethoxy-4,5-methylenedioxybenzophenone-2-carboxylic Acid.—The procedure employed differs somewhat from that of Gensler and Samour[1] and is given here because the aldehyde also was obtained. Fifty grams of 2-(3′,4′,5′-trimethoxybenzoyl)-4,5-methylenedioxystyrene[1] and 42 g.

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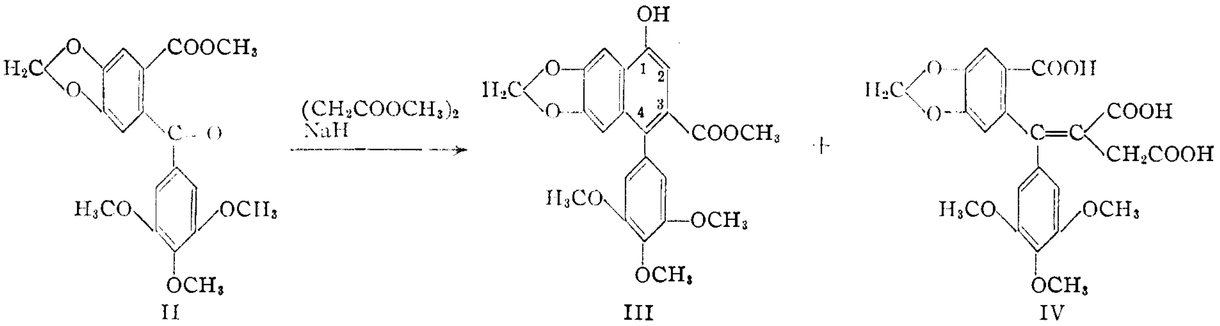
[1] W. J. Gensler and C. M. Samour, THIS JOURNAL, **73**, 5555 (1951).

[2] W. S. Johnson and G. H. Daub in "Organic Reactions," R. Adams, editor, Vol. VI, John Wiley and Sons, Inc., New York, N. Y., 1951, p. 4.

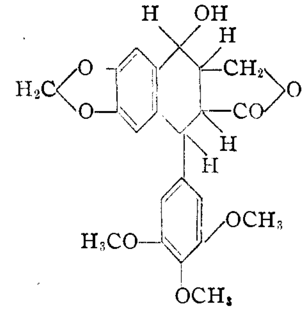
[3] W. Reeve and W. M. Eareckson, THIS JOURNAL, **72**, 5195 (1950).



II

III
(16% yield)

IV



I
Podophyllotoxin,
picropodophyllin

of solid sodium hydroxide in 1500 ml. of *t*-butyl alcohol were heated to 60° and 115 g. of potassium permanganate in 1500 ml. of warm water added as rapidly as the reaction would allow. After the addition of the permanganate, the mixture was refluxed for 20 minutes. The manganese dioxide was filtered and washed with a liter of boiling water. The filtrate was acidified with hydrochloric acid, and after standing overnight the precipitate was filtered. After air-drying, it weighed 37 g. It was triturated three times with 10% sodium bicarbonate solution, filtered and the filtrate acidified with 1:1 hydrochloric acid. There was obtained 18 g. of the desired acid, m.p. 214–216°.

The sodium bicarbonate insoluble material (18.5 g., m.p. 208–210°) was the keto aldehyde, **3′,4′,5′,-trimethoxy-4,5-methylenedioxybenzophenone-2-carboxaldehyde**. A sample for analysis was purified by dissolving in chloroform, filtering, washing the filtrate with 5% sodium bicarbonate solution, removing the chloroform by distillation, and recrystallizing from glacial acetic acid. After two recrystallizations, it melted at 222°.

Anal. Calcd. for $C_{18}H_{16}O_7$: C, 62.79; H, 4.69; $-OCH_3$, 27.04. Found: C, 62.68; H, 4.80; $-OCH_3$, 26.80.

The keto aldehyde could be oxidized to the acid using the procedure given above. A 2:1 mole ratio of potassium permanganate to aldehyde was used. From 18.5 g. of the crude aldehyde, 13.5 g. of the keto acid and 2 g. of the aldehyde were obtained.

Methyl 2-(3,4,5-Trimethoxybenzoyl)-4,5-methylenedioxybenzoate (II).—The above solid keto acid was slowly added to excess diazomethane dissolved in methylene chloride. A small amount of insoluble material was filtered off and the solvent removed by steam distillation. The residue crystallized after standing overnight. It was triturated with 100 ml. of a 5% sodium bicarbonate solution and filtered. The crude material (14.8 g., 95%, m.p. 129–130°) was recrystallized from methanol, m.p. 131–132°. Reported m.p. 127–128° and 128–129°.[4]

3-Carbomethoxy-4-(3,4,5-trimethoxyphenyl)-6,7-methylenedioxynaphthol-1 (III).—In a three-necked, 2-l. flask equipped with a sealed stirrer, condenser with calcium chloride tube and nitrogen inlet was placed 25 g. (0.067 mole) of the above keto methyl ester, 700 ml. of anhydrous toluene and 100 g. (0.67 mole) of dimethyl succinate. After sweeping the system with dry nitrogen, 35 g. (1.52 moles) of sodium hydride was added at one time and the mixture heated to reflux. One ml. of methanol was added to start the reaction. The mixture was heated at 115° for 2 hr.; after this time, no more hydrogen was evolved. The reaction mixture was chilled in an ice-bath, the excess sodium hydride decomposed by the cautious addition of water, acidified with 100 ml. of concentrated hydrochloric acid, and extracted with a total of 2 l. of ether. Most of the solid dissolved in the organic phase, the remainder being removed with the acid layer and filtered off. The ether solution was washed with water, sodium bicarbonate solution, water and then steam distilled to remove the ether and toluene. The resulting water-insoluble non-volatile material was filtered and washed with water, triturated with 400 ml. of a 10% sodium hydroxide solution and refiltered. The naphthol-1 derivative is insoluble under these conditions. The insoluble material was treated with 500 ml. of 5% hydrochloric acid, filtered and washed with water. There was obtained 5.1 g. of the desired naphthol, m.p. 195–200°. Further purification was effected by swirling the product with 100 ml. of boiling 95% ethanol and filtering while still hot. There was obtained 4 g. (16%), m.p. 201–202°. The material can be recrystallized from glacial acetic acid. The sample analyzed was recrystallized from 95% ethanol and melted at 204–205°.

Anal. Calcd. for $C_{22}H_{20}O_8$: C, 64.07; H, 4.89; $-OCH_3$, 30.10. Found: C, 64.17; H, 5.02; $-OCH_3$, 30.08.

The sodium bicarbonate solution used to wash the ether layer was acidified, and the aqueous layer decanted from the oily gum (20 g.) that precipitated. This material, which solidified on standing, presumably was a mixture of the two isomeric itaconic acids. The material could be partially purified by boiling the powdered material with benzene, in which the itaconic acids were insoluble, and by dissolving the material in an excess of ether and allowing the itaconic acids to crystallize as the ether slowly evaporated. By fractional crystallization from aqueous methanol a small sample of one of the itaconic acids was obtained, m.p. 185°. The material gave a qualitative test for the methylenedioxy group,[5] decolorized a potassium permanganate solution, and effervesced at its melting point.

Anal. Calcd. for $C_{22}H_{20}O_{11}$: C, 57.39; H, 4.38; $-OCH_3$, 20.22. Found: C, 56.76; H, 4.66; $-OCH_3$, 20.42.

The filtrate from the sodium hydroxide trituration of the crude naphthol was acidified and 11 g. of **dimethyl 1,4-cyclohexanedione-2,5-dicarboxylate** obtained which melted at 155.5–157° after two recrystallizations from aqueous ethanol. The material gave an intense violet color with ferric chloride.

Anal. Calcd. for $C_{10}H_{12}O_6$: C, 52.70; H, 5.30. Found: C, 52.78; H, 5.34.

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[4] R. D. Haworth and T. Richardson, *J. Chem. Soc.*, 348 (1936); F. Spath, F. Wessely and E. Nadler, *Ber.*, **66**, 125 (1933).

[5] J. A. Labat, *Bull. soc. chim. biol.*, **15**, 1344 (1933).