[CONTRIBUTION FROM THE INSTITUTE OF ORGANIC CHEMISTRY OF THE UNIVERSITY OF BUDAPEST]

ADDITION OF MALEIC ANHYDRIDE TO ANETHOLE. III

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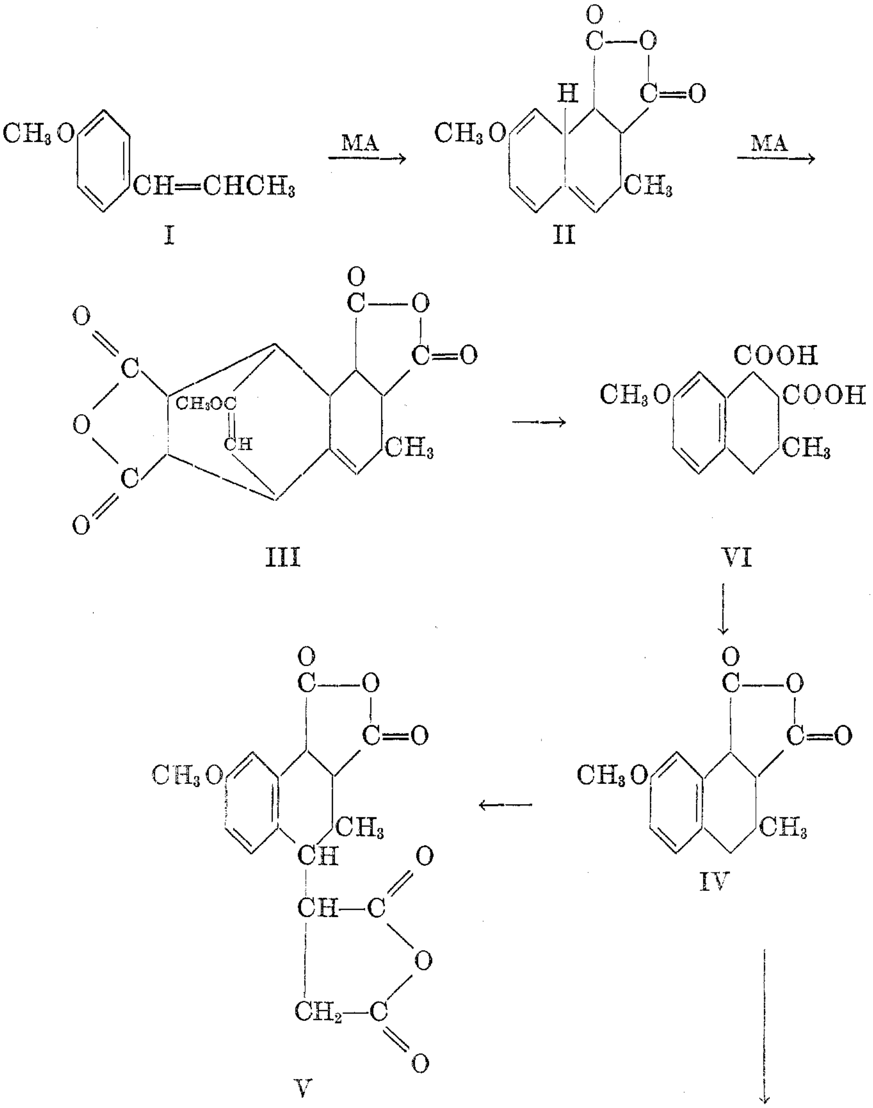
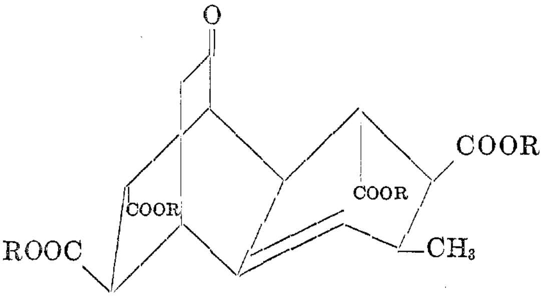
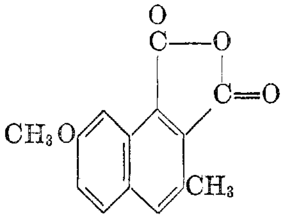
The bisadduct $C_{18}H_{16}O_7$, m.p. 242°, formed from anethole (I) and maleic anhydride (MA) has been formulated in previous papers (1) as possessing structure III and being formed by a double diene synthesis *via* the route I → II → III.





VIII
$R = CH_3$



VII

Lora Tamayo (2) expressed a different opinion. He believes that the reaction of anethole with maleic anhydride represents a diene synthesis only in its first step, the unstable intermediate II rearranging instantly to a tetralin derivative (IV)—similarly to the reaction of methyl isoeugenole and isosafrole with maleic anhydride (3)—and then reacts as IV with another mole of maleic anhydride to form, by "substitution in allyl position" (4), an endproduct of structure V.

In a previous communication (5) we have already offered evidences against the interpretation suggested by Lora Tamayo which, while being fully consistent with structure III of the bisadduct, are difficult to reconcile with structure V. We present now results of further experiments which demonstrate the inconsistency of structure V with our observations.

The interaction of the bisadduct (III) with hydriodic acid produced a mixture of reaction products, which was subsequently methylated with diazomethane and then treated with ether. An ether-insoluble crystalline product was obtained and identified with the tetramethyl keto-*trans-trans*-tetracarboxylate (VIII) in which the presence of a keto group and the *trans* position of both pairs of carboxyls has already been established (1). The ether-soluble part of the reaction products is an oil divided subsequently by fractionation *in vacuo* into (*a*) a colorless liquid, b.p. 70–80°/2 mm., not further investigated; (*b*) dimethyl fumarate; (*c*) dimethyl 3-methyl-7-methoxytetralin-*cis*-1,2-dicarboxylate (VI). The *cis* position of the carboxyls in the latter is demonstrated by its ready anhydridization in the presence of acetic anhydride at 80–90° to IV, the tetralin structure being proved by dehydrogenaton of the latter to the anhydride of 3-methyl-7-methoxynaphthalene-1,2-dicarboxylic acid (VII).

The fact that hydriodic acid produces VIII from the bisadduct finds explanation only in structure III, formula V allowing no formation of a keto group in this reaction. Also the *trans* position of the carboxyl groups would be inconsistent with formula V, such configuration being possible only if the carboxyl groups are attached to a ring. Further, the formation of fumaric acid, evidently by izomerization of primarily formed maleic acid, is difficult to reconcile with structure V, while it remains consistent with III.

Our main argument against the formation, mechanism, and structure V of the bisadduct suggested by Lora Tamayo is the behavior of IV in the presence of maleic anhydride. We have found that IV remains unchanged in the presence of maleic anhydride at 80°, the temperature at which the bisadduct is forming from anethole and maleic anhydride. Reaction between IV and maleic anhydride occurs only at 150°, this high temperature being characteristic for substitutions in the allyl position (4). The product is a compound $C_{18}H_{16}O_7$, m.p. 260°, which is isomeric with but distinctly different from, the bisadduct, m.p. 242°.

Since Lora Tamayo prepared the anethole-maleic anhydride 1:2-adduct at a temperature higher than 80°, and the resulting product had rather a low melting-point (236°), we have repeated his experiment. The product obtained proved to be identical beyond doubt with the bisadduct III, prepared by our method.

The isomeric product of m.p. 260° obtained from IV with maleic anhydride arises probably by a substitution in the allyl position, although a structure other than V may also come into consideration. Investigation of this question is under progress.

EXPERIMENTAL

The interaction of the bisadduct III with hydriodic acid. A mixture of 120 ml. of freshly distilled hydriodic acid (*sp. gr.*, 1.7) and 170 g. of acetic anhydride was refluxed for 30 minutes. After cooling to room temperature, 6.3 g. of red phosphorus and 10 g. of bisadduct III were introduced. On heating the latter rapidly dissolved. The mixture was refluxed for four hours, then, without removal of the phosphorus, evaporated at 23 mm., taken up subsequently in 30 ml. of water and evaporated again, this procedure being repeated until complete removal of all the hydriodic acid had been effected. The residue was then taken up in 100 ml. of water and filtered from phosphorus. The filtrate was evaporated, the residue being dried subsequently in a desiccator over sodium hydroxide. The amorphous product, dissolved in 40 ml. of methyl alcohol, was then esterified with an ethereal solution of diazomethane. The solution, after being treated with charcoal, was evaporated to a pale yellow oil. This was dissolved in 80 ml. of ether and allowed to stand in the ice-box for 24 hours. A crystalline product separated which, on recrystallization from methyl alcohol, yielded 0.5 g. of *tetramethyl keto-trans, trans-tetracarboxylate* (VIII), m.p. 154–155°, alone or mixed with a specimen prepared by a different method (1).

Anal. Calc'd for $C_{21}H_{26}O_9$: C, 59.7; H, 6.2.
Found: C, 59.6; H, 6.3.

The ether mother liquor of VIII was evaporated at 30 mm. and the oily residue was subjected to fractional distillation. At 70–80°/2 mm. a mobile liquid (1.5 g.) was obtained which was not further investigated. Distillation was continued at 0.07 mm. and at 240–245° a light yellow, very viscous oil distilled after the previous sublimation of a substance, which proved to be *dimethyl fumarate*, colorless prisms from acetone, m.p. 101–102°, alone or mixed with an authentic specimen.

Anal. Calc'd for $C_6H_8O_4$: C, 50.0; H, 5.6.
Found: C, 49.9; H, 5.7.

The viscous oily distillate (7.5 g.) dissolved to a great extent after two hours' refluxing with 45 ml. of 15% aqueous sodium hydroxide. The solution was treated with charcoal, filtered, and then acidified with conc'd hydrochloric acid. The solid, yielding on recrystallization from water 0.5 g. of long needles, m.p. 211°, proved to be *3-methyl-7-methoxytetralin-1,2-cis-dicarboxylic acid* (VI).

Anal. Calc'd for $C_{14}H_{16}O_5$: C, 63.6; H, 6.1; CH_3O, 11.7; CO_2H, 34.0.
Found: C, 63.4; H, 6.1; CH_3O, 11.9; CO_2H, 33.7.

Anhydride of 3-methyl-7-methoxytetralin-1,2-dicarboxylic acid. (IV). A solution of 200 mg. of VI in 2 ml. of acetic anhydride was warmed to 90° for three minutes and then evaporated *in vacuo.* The colorless, viscous oily residue was redissolved in 4 ml. of ethyl acetate, the solution being subsequently treated with charcoal and evaporated to 1 ml. This was diluted with 5 ml. of ether-petroleum ether 1:1 and concentrated to 2–3 ml., the product crystallizing on cooling, m.p. 122°.

Anal. Calc'd for $C_{14}H_{14}O_4$: C, 68.3; H, 5.7.
Found: C, 68.5; H, 5.7.

Anhydride of 3-methyl-7-methoxynaphthalene-1,2-dicarboxylic acid (VII). An intimate mixture of 27 mg. of IV and 50 mg. of 10% palladized charcoal, upon being heated in a carbon dioxide stream to 300° (metal bath), lost yellow crystals by sublimation. These were recrystallized from ethyl acetate; m.p. 214–217°, alone or mixed with a specimen prepared by another method (6).

The interaction of 3-methyl-7-methoxytetralin-1,2-dicarboxylic anhydride (IV) *with maleic anhydride.* (*a*) A mixture of 150 mg. of anhydride IV and 70 mg. of maleic anhydride was heated to 80° for three hours. The yellow-colored melt solidified on cooling. On being dissolved in 1 ml. of ethyl acetate, cooling induced crystallization. The product, filtered, and then washed with ethyl acetate, formed needles of m.p. 121°, alone or mixed with the starting material (IV).

(*b*) A mixture of 150 mg. of IV and 660 mg. of maleic anhydride was heated to 150° for four hours. The melt, crystallizing on cooling, was ground with 3 ml. of ethyl acetate in order to remove unchanged starting materials. The residue was recrystallized from the same solvent and then from acetone; m.p. 260° (decomp.), a mixture with the bisadduct III of m.p. 242° melting at 216–220°. For analysis the substance was dried at 5 mm. and 100° for two hours.

Anal. Calc'd for $C_{18}H_{16}O_7$: C, 62.8; H, 4.7.
Found: C, 62.7; H, 5.0.

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