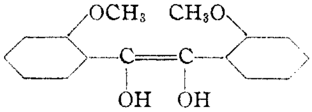
[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF HOWARD UNIVERSITY, WASHINGTON, D. C.]

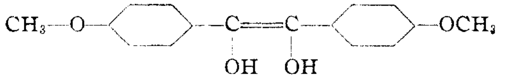
The Effect of Methoxyl toward Stabilizing Ene-diols

BY R. P. BARNES AND WENDELL M. LUCAS[1]

In keeping with a mechanism recently presented in connection with the effect of the *p*-methoxyl group on the rearrangement of anisbenzoin into benzanisoin,[2] the authors set out to investigate the stability of 2,2′-dimethoxydiphenylacetyleneglycol (I) and 4,4′-dimethoxydiphenylacetyleneglycol (II).

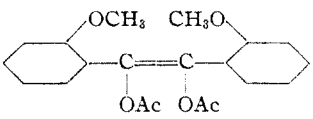


I

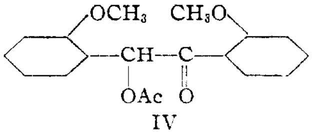


II

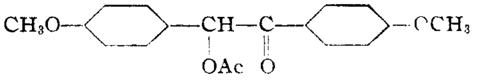
The 2,2′- and 4,4′-dimethoxybenzoins were prepared and acetylated.[3] In cases previously reported,[2,3,4] this method of acetylation has served admirably to convert α-hydroxy ketones into diacetates of ene-diols. In the case of these two substituted benzoins the presence of the methoxyl groups similarly placed in the aromatic nuclei seems to stabilize the benzoins by repressing enolization, with the result that no diacetate is obtained in either case. The monoacetates (IV and V) are obtained in excellent yield in both cases. Further acetylation of the monoacetate (IV) yields a small amount of the diacetate (III); under similar treatment, the monoacetate (V) does not yield any of the diacetate (VIII). Thus the methoxyl effect is real. The strong electron release tendency of one methoxyl group is offset by the same tendency of the similarly placed methoxyl group from the opposite direction. The para substituents are more powerful than the ortho



III



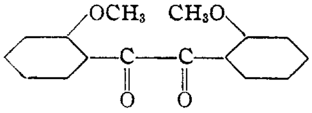
IV



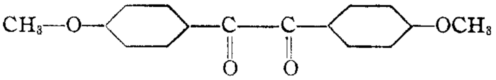
V

The original conception of the effect of similarly placed methoxyl groups was that it would serve to stabilize the ene-diols—or at least prevent ketonization.

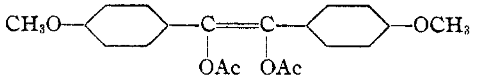
Not being able to obtain the ene-diol diacetates by direct acetylation, we prepared the 2,2′- and 4,4′-dimethoxybenzils, (VI) and (VII), and reduced them catalytically in the presence of acetic anhydride, according to the method of Thompson,[5] producing the diacetates (III) and (VIII), respectively. These diacetates cannot be hydrolyzed to the monoacetates in acetic acid solution in the presence of potassium acetate.[3] Hydrolysis of the diacetates (III) and (VIII) by means of sulfuric acid resulted in the 2,2′-dimethoxybenzoin (IX) and the 4,4′-dimethoxybenzil (VII), respectively.



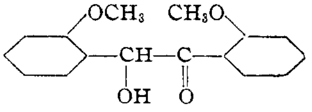
VI



VII



VIII



IX

Thus the 2,2′-dimethoxydiphenylacetylene glycol (I) shows a tendency toward ketonization, whereas the 4,4′-dimethoxydiphenylacetyleneglycol (II) is autoxidized. These results indicate conclusively that methoxyl groups in the para positions have a greater stabilizing effect on both the

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[1] In partial fulfillment of the requirements for the Master's degree.

[2] R. P. Barnes and V. J. Tulane, THIS JOURNAL, **63**, 867 (1941).

[3] R. P. Barnes and V. J. Tulane, *ibid.*, **62**, 894 (1940).

[4] Dauben, Evans and Meltzer, *ibid.*, **63**, 1883 (1941).

[5] R. B. Thompson, *ibid.*, **61**, 1281 (1939).

benzoin and the ene-diol, which is the intermediate in the hydrolysis of the diacetate, than do methoxyl groups in the ortho positions.

Experimental

2,2'-Dimethoxylbenzoin Monoacetate (IV).—To a solution of 17 g. of 2,2'-dimethoxybenzoin in 90 cc. of acetic anhydride was added 8.5 g. of freshly fused potassium acetate, and the mixture refluxed on the steam-bath for thirty minutes. After cooling thoroughly, the solution was poured into 500 cc. of cold water and stirred vigorously to decompose the excess acetic anhydride. A yellow oil separated and solidified. It was filtered, washed thoroughly with water and dried. The crude yield was 21 g. This solid was crystallized from ether and melted at 102°.

Anal. Calcd. for $C_{18}H_{18}O_5$: OCH_3, 19.73. Found: OCH_3, 19.66.

4,4'-Dimethoxybenzoin Monoacetate (V).—This monoacetate was prepared from 17 g. of the 4,4'-dimethoxybenzoin under the same conditions as above. The crude yield was 20 g. Recrystallized from ether, it melted at 93.5°.

Anal. Calcd. for $C_{18}H_{18}O_5$: OCH_3, 19.73. Found: OCH_3, 19.76.

Acetylation of the Monoacetates (IV) and (V).—A solution of 5 g. of the 2,2'-dimethoxybenzoin monoacetate in 30 cc. of acetic anhydride was refluxed gently for three and one-half hours with 10 g. of freshly fused potassium acetate. The reaction mixture darkened after one and one-half hours. It was thoroughly chilled and poured with rapid stirring into 500 cc. of cold water. A brown oil separated, which, after several washings with cold water, solidified. The solid was crystallized from 40 cc. of dilute alcohol (3:2), yielding 4 g. of a light brown crystalline solid which melted from 99–101°. This solid was warmed for a few minutes with 75 cc. of ether. A small portion of the solid was insoluble in ether. The ether-soluble portion gave the pure unchanged monoacetate, melting and mix-melting at 102°. Three and one-half grams of unchanged monoacetate was recovered. The ether-insoluble fraction (0.8 g.) was recrystallized from the least amount of alcohol in which it is extremely soluble. The practically colorless crystals melted at 149°.

Anal. Calcd. for $C_{20}H_{20}O_6$: OCH_3, 17.41. Found: OCH_3, 17.34.

A 5-g. sample of the 4,4'-dimethoxybenzoin monoacetate was treated similarly. There resulted 3.5 g. of an oil from which 2.5 g. of the starting material was recovered.

Reduction of 2,2'-Dimethoxybenzil.—To a solution of 5 g. of the benzil in 75 cc. of acetic anhydride was added 1 g. of freshly fused zinc chloride and 0.08 g. of Adams catalyst. The solution was treated for seven and one-half hours in the Burgess–Parr hydrogenation apparatus. At the end of this treatment the product was poured into a liter of ice and water. A solid separated. It was filtered, washed with water, and crystallized from an alcohol-acetone solution. The yield was 2.5 g., melting at 150°, giving no depression in melting point with the 149°-melting substance obtained by way of acetylation of the 2,2'-dimethoxybenzoin monoacetate.

Reduction of 4,4'-Dimethoxybenzil.—A solution of 5 g. of the benzil with 1 g. of freshly fused zinc chloride in 150 cc. of acetic anhydride to which was added 0.1 g. of Adams catalyst, was subjected to hydrogenation for a period of twelve hours. The product was worked up as above. The colorless solid obtained was crystallized from methanol, yielding 3.5 g. of material melting from 118–123°. After repeated recrystallizations, the substance melted from 121–124°.

Anal. Calcd. for $C_{20}H_{20}O_6$: OCH_3, 17.41. Found: OCH_3, 17.49.

A small amount (0.1 g.) of colorless material insoluble in methanol was recrystallized from acetone and melted at 215°. This material failed to give a test for acetic acid.

Treatment of the Diacetates with Acetic Acid and Potassium Acetate.—Both diacetates were subjected to the following treatment: Four-tenths of a gram of the diacetate was dissolved in 10 cc. of acetic acid with 0.7 g. of potassium acetate and refluxed for seven hours. In each case the diacetate was recovered.

Hydrolysis of 2,2'-Dimethoxydiphenylacetyleneglycol Diacetate.—A solution of 0.85 g. of the diacetate in 20 cc. of cold concentrated sulfuric acid is green. This solution was put in an atmosphere of nitrogen and allowed to stand overnight. The green solution was poured onto finely cracked ice. A colorless solid separated. It was filtered, washed and dried and crystallized from alcohol. It melted and mix-melted with the original material at 150°. To a suspension of 0.7 g. of the diacetate in 10 cc. of alcohol was added 30 cc. of 20% sulfuric acid. The mixture was refluxed for one hour. The solid dissolved in about fifteen minutes. The solution was chilled, and a colorless crystalline solid separated. This solid melted from 94–97°. It mix-melted with the monoacetate from 80–85°; it gave no depression when mix-melted with the 2,2'-dimethoxybenzoin.

Hydrolysis of 4,4'-Dimethoxydiphenylacetyleneglycol Diacetate.—One gram of the diacetate was dissolved in 30 cc. of cold concentrated sulfuric acid. The green solution was allowed to stand at room temperature for thirty minutes, and was then poured onto finely cracked ice. A cream colored solid separated. It was filtered, washed and dried, and recrystallized from alcohol. It melted at 133°. The mix-melt with anisil was unchanged.

Summary

1. 2,2'- and 4,4'-dimethoxybenzoins can be effectively acetylated to the corresponding monoacetates, but not to the corresponding acetyleneglycol diacetates.

2. 2,2'- and 4,4'-dimethoxydiphenylacetyleneglycol diacetates can be obtained by catalytic hydrogenation in acetic anhydride solution.

3. The diacetates are not hydrolyzable to the monoacetates in acetic acid solution.

4. When completely hydrolyzed, the intermediate 2,2'-dimethoxydiphenylacetyleneglycol ketonizes to the benzoin, while the intermediate 4,4'-dimethoxydiphenylacetyleneglycol, being more resistant toward ketonization, is autoxidized to the corresponding benzil.

WASHINGTON, D. C.
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