By the oxidation of III 2-methyl-5,6-dichlorobenzoquinone-(1,4) (IV) resulted, which had been obtained by Angeletti and Oliveri[2] in another way. The reducing acetylation of IV gave the diacetate of 2,5-dioxy-3,4-dichlorotoluene (V).

### Experimental

**1-Methyl-2-hydroxy-4-chlorobenzene (I) and its Methyl Ether.**—Ullmann and Panchaud[3] described the preparation of 1-methyl-2-hydroxy-3-chlorobenzene by diazotization of the corresponding amino compound. The diazotization of 1-methyl-2-amino-4-chlorobenzene can be carried out in the same way, giving a 60% yield of distilled 1-methyl-2-hydroxy-4-chlorobenzene, b. p. 225°.[4] The chlorophenol by reaction with sodium hydroxide and dimethyl sulfate in the usual way can be transformed into the methyl ether, b. p. 206–208° (yield 80%).

**1-Methyl-2-methoxy-4-chloro-3,5-dinitrobenzene (II) (Chloro-dinitro-*o*-cresol Methyl Ether).**—Four grams of 1-methyl-2-methoxy-4-chlorobenzene is introduced dropwise into 20 ml. of cooled, fuming nitric acid followed by 10 ml. of cooled sulfuric acid. After five minutes the mixture is poured onto ice and the nitro compound is filtered by suction. By crystallization from alcohol woolly needles, m. p. 70° (60%), are obtained.

*Anal.* Calcd. for $C_8H_7O_5N_2Cl$: C, 39.3; H, 2.84; N, 11.36. Found: C, 39.4; H, 2.94; N, 11.06.

**1-Methyl-2-hydroxy-4-chloro-3,5,6-tribromobenzene.**—I was brominated in the presence of iron as catalyst as described in previous papers.[5] The crude product was purified by crystallization from glacial acetic acid as prisms, m. p. 190° (yield 65%).

*Anal.* Calcd. for $C_7H_4OClBr_3$: C, 22.13; H, 1.05; halogen, 72.59. Found: C, 22.44; H, 1.04; halogen, 72.29.

**1-Methyl-2-hydroxy-3,4,5-trichlorobenzene (III) and its Methyl Ether.**—To a cool solution of one mole of I in ten times its weight of glacial acetic acid, two moles of chlorine are added. The mixture is diluted with water and the oily precipitate collected in ether. After the evaporation of the ether the residue distils from 261–265° (765 mm.); 90% yield. Recrystallization from petrol ether gives the trichloro product (III) m. p. 74° (Zincke[1] 77°). The methylation with dimethyl sulfate and sodium hydroxide gives a 90% yield of the methyl ether, b. p. 269–271° (752 mm.). The distillate is crystallized from alcohol in thin needles, m. p. 51.5°.

*Anal.* Calcd. for $C_8H_7OCl_3$: C, 42.75; H, 3.16; Cl, 47.22. Found: C, 42.40; H, 3.02; Cl, 47.40.

**5,6-Dichloro-2-methylbenzoquinone-(1,4) (IV) and Diacetate of 2,5-Dioxy-3,4-dichlorotoluene (V).**—To a solution of 15 g. trichloro-*o*-cresol in 150 ml. glacial acetic acid and 45 ml. water 11 g. chromic anhydride is added. The mixture is stirred and slowly heated until a sample poured into water gives a pure green color. The solution is then diluted with water whereby a reddish, at first oily, substance is precipitated which later changes to a resinous cake. The mixture is kept in the refrigerator overnight and filtered by suction. By steam distillation of the crude product an orange oil is obtained which very soon solidifies and which on crystallization from alcohol gives sulfur yellow, thin, prismatic needles, m. p. 80°, undoubtedly identical with the quinone (m. p. 83°) prepared by Angeletti and Oliveri.[2]

*Anal.* Calcd. for $C_7H_4O_2Cl_2$: Cl, 37.17. Found: Cl, 36.98, 37.52.

The yield is poor because of the resinous by-products of the reaction which form the residue of the steam distillation. But the corresponding hydroquinone diacetate can be prepared in very good yield from the quinone by boiling the quinone with zinc dust, acetic anhydride and glacial acetic acid under reflux (goggles). In order to decolorize it completely, fresh zinc dust and acid mixture are added. The residual zinc dust is removed by filtration and the filtrate precipitated by adding water and stirring until the excess of acetic anhydride is decomposed. The crude product is filtered by suction, dried in vacuum and crystallized from alcohol; prisms, m. p. 118°.

*Anal.* Calcd. for $C_{11}H_{10}O_4Cl_2$: C, 47.65; H, 3.61; Cl, 25.63. Found: C, 47.69; H, 3.6; Cl, 25.55.

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[2] Angeletti and Oliveri, *Gazz. chim. ital.*, **70**, 789–795 (1940).

[3] Ullmann and Panchaud, *Ann.*, **350**, 112 (1906).

[4] All boiling points are uncorrected.

[5] M. Kohn and G. Dömötör, *Monatsh.*, **47**, 212 (1926).

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## The Rate of Esterification of Primary Alcohols by Dibasic Acid Anhydrides

BY THEODORE F. LAVINE AND CARLOTA HERKNESS

Siegel and Moran[1] recently claimed that dibasic acid anhydrides react instantaneously with primary alcohols at room temperature to form acid esters, *i. e.*

$$R'(CO)_2O + ROH \longrightarrow R'(COOR)COOH \qquad (A)$$

This conclusion could not be confirmed in this Laboratory and appears to have been the result of misinterpretation of the experimental data. The latter were obtained by titration of the reaction mixtures with alcoholic potassium hydroxide which was tacitly assumed to be a neutralization of the acid ester. The equally rapid reaction of alcoholates with anhydrides, however, was not considered, *i. e.*

$$R'(CO)_2O + OR^- \longrightarrow R'(COOR)COO^- \qquad (B)$$

although it has been utilized repeatedly for the titrimetric estimation of anhydrides[2–6] and for preparative purposes.[7,8] Since both the acid ester and the anhydride react with one equivalent of alcoholate, it is evident that this reagent can yield no information concerning the rate or extent of Reaction (A) (*i. e.*, the titration value remains constant). On the other hand, two equivalents of aqueous alkali are necessary for the neutralization of an anhydride

$$R'(CO)_2O + 2OH^- \longrightarrow R'(COO^-)_2 + H_2O \qquad (C)$$

and during the course of Reaction (A) the titer of the solution in terms of aqueous alkali will continue to decrease until a limiting value equivalent

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[1] Siegel and Moran, THIS JOURNAL, **69**, 1457 (1947).

[2] Caudri, *Rec. trav. chim.*, **48**, 778 (1929).

[3] Lavine and Toennies, *J. Biol. Chem.*, **101**, 727 (1933).

[4] Toennies and Elliot, THIS JOURNAL, **57**, 2136 (1935); **59**, 902 (1937).

[5] Bryant and Smith, *ibid.*, **58**, 2452 (1936).

[6] Kolthoff and Stenger, "Volumetric Analysis. II," Interscience Publishers, New York, N. Y., 1947, pp. 212, 228.

[7] Heitman, THIS JOURNAL, **34**, 1591 (1912).

[8] Chattaway, *J. Chem. Soc.*, **2495** (1931).

to the alcoholate titration is reached. The difference between the neutralization values by the two methods corresponds to the anhydride content.[5,6] Application of this procedure to alcoholic solutions of maleic and phthalic anhydrides yielded the results illustrated in the accompanying figure which demonstrate that alcoholysis of these anhydrides proceeds at a measurable rate. After twenty-four hours the agreement between the aqueous and alcoholate titrations was within 2%, which is evidence not only for completion of the acylation reaction but also for the absence of any appreciable hydrolysis of the acid-ester during aqueous titration.

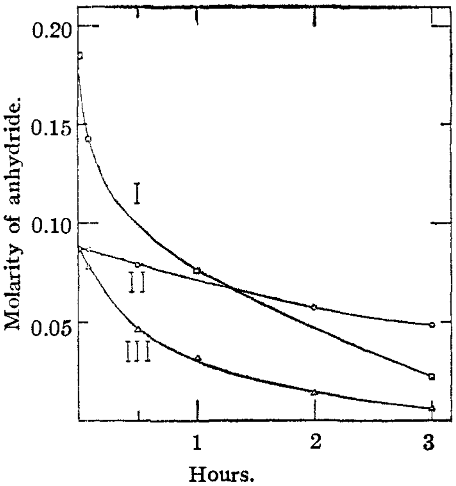

Fig. 1.—The reaction of dibasic acid anhydrides with primary alcohols at room temperature (25–27°); I, phthalic anhydride in methanol; II, maleic anhydride in ethanol; III, maleic anhydride in methanol. The solutions also contained 20% acetone by volume.

Several precautions are necessary for the quantitative application of Reaction (C) to alcohol-anhydride solutions. Because of the equilibrium between hydroxyl and alcoholate ions, either Reaction (B) or (C), or both, may ensue depending on the alcohol and its concentration. Thus, anhydrides may be titrated with aqueous alkali according to Reaction (B) if the final concentration of methanol is 70%.[2,3] Similarly, phenols and related compounds may be acylated by anhydrides in aqueous alkaline solution.[7,8] In the present instances, a 20-fold dilution with water was sufficient to eliminate the effect of alcohol on the aqueous titration. With some anhydrides (acetic and *o*-sulfobenzoic),[7] direct titration with aqueous alkali and phthaleins as indicators is not feasible because of acylation of the indicator; however, no such effect was noted with phthalic or maleic anhydrides. The possibility of hydrolysis of the ester during aqueous titration also requires consideration, although such hydrolysis is usually small under the conditions of direct titration[5] and may be evaluated when ester formation is complete.

## Experimental

Titrations were carried out with 0.1 *M* sodium methylate in methanol and 0.05 *N* aqueous sodium hydroxide, with phenolphthalein as indicator. Anhydrides at hand were used without further purification. For standardization, weighed amounts were dissolved in acetone to yield 0.25 *M* solutions and 2-ml. aliquots taken for titration with (1) sodium methylate, (2) sodium hydroxide, after dilution of the sample with 20 ml. of water, and (3) sodium hydroxide, after dilution of the sample with 20 ml. of methanol. Corrections for the inherent acidity of methanol were applied in the latter titration. The results from (1), (2) − (1) and (2) − (3), respectively, were as follows: phthalic anhydride 73.9, 73.2, 73.8%; maleic anhydride 84.6, 85.4, 84.6%.

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# The Esterification Rate of Dibasic Acid Anhydrides with Primary Alcohols at Room Temperature

BY I. G. ANDERSON AND J. KENYON

In a recent paper[1] it is stated that "mono-esterification of dibasic acid anhydrides with primary alcohols proceeds instantaneously and quantitatively at room temperature." This claim appeared to us so surprising that we felt impelled to examine it and to this end have carried out the following experiments:

(1) Absolute ethyl alcohol (2.3 g.) was added to a solution of freshly sublimed phthalic anhydride (3.7 g.) in dry acetone (25 cc.); after standing at 25° for one hour the solution was evaporated, also at 25°, to dryness. The residue (3.7 g.) consisted entirely of phthalic anhydride of unchanged melting point (128–130°).

(2) To a solution of absolute ethyl alcohol (1.0 g.) and phthalic anhydride (2.96 g.) in dry acetone (20 cc.) at 25° was added a solution of potassium hydroxide in *methyl* alcohol (202.0 cc. of 0.1 *N*) until neutrality—to phenolphthalein—was reached. The solution was then evaporated to small bulk at 25° and acidified with dilute hydrochloric acid. The precipitated oily material which separated rapidly crystallized and was removed by filtration washed with water and dried. It weighed 3.0 g. and had m. p. 80–83°.

After recrystallization from cyclohexane it had m. p. 83–84° alone and when mixed with an authentic specimen of methyl hydrogen phthalate.

It thus follows that phthalic anhydride does not undergo rapid mono-esterification with ethyl alcohol at 25° but does so with potassium methoxide. That the sodium and potassium derivatives of alcohols react readily with succinic and

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[1] Siegel and Moran, THIS JOURNAL, 69, 1457 (1947).