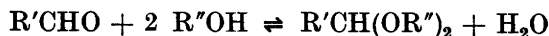


A Convenient Method for Preparing Acetals*

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The reaction between an aldehyde and an alcohol proceeds to an equilibrium:



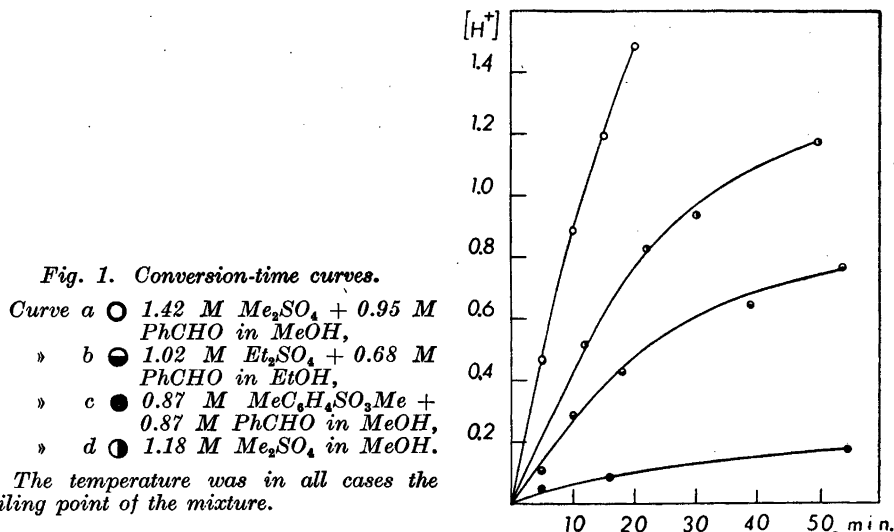
the constant of which depends on the nature of the aldehyde^{1,2}. The process is catalyzed by hydrogen ions^{3,4}, but not by hydroxyl ions, and therefore the acetalisation is of great importance in preparative chemistry as a means of protecting an aldehyde group during reactions in neutral or basic medium. For instance reduction of other groups^{5,6}, bromination and exchange of bromine against amino, cyano and hydroxyl groups² have been carried out without affecting the acetal group, which in turn is easily converted to the aldehyde group by means of aqueous acids.

Many attempts have been made to displace the equilibrium in favour of the acetal, first by using anhydrous reagents and by avoiding water in presence of acids during the isolation of the acetal. R. D. Haworth and A. Lapworth have proposed the elimination of water by distilling off the ternary azeotrope of water, alcohol and benzene⁶. L. Claisen has prepared acetals by means of orthoformic⁷ and formimino⁸ esters, B. Helferich and J. Hausen use ortho-silicic esters⁹ and W. Voss proposes the use of sulfurous esters¹⁰.

Voss also showed that these esters do not act as alkylating agents but, because of their easy hydrolyzability, eliminate water from the equilibrium. As a matter of fact they are not able to acetalise an aldehyde except in the presence of alcohol and hydrogen ions.

The method of Haworth and Lapworth is troublesome and the others require difficultly available compounds. The author, therefore, investigated the possibility of applying esters of sulfuric and *p*-toluenesulfonic acids for the removal of water. Unlike the above mentioned esters the latter when hydrolyzed form strong acids, which catalyze the acetal formation. Consequently the use of anhydrous alcohols is not necessary; on the contrary, the small water content in commercial absolute alcohols form sufficient acid to start the reaction without adding any other catalyst. It also appeared, that neutralization of the acid could be carried out without any appreciable loss by slowly adding

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the reaction mixture to a vigorously stirred mixture of sodium hydroxide and crushed ice. The yields were in the cases investigated better by this method than by the simple acetalisation with anhydrous alcohols, and of the same order of magnitude as when applying the easily hydrolysable esters mentioned above.

EXPERIMENTAL

Benzaldehyde dimethyl acetal. 10 ml benzaldehyde (0.1 mole), 80 ml methyl alcohol and 12 ml dimethyl sulfate (0.125 mole) were refluxed for half an hour and slowly added to a mixture of 150 ml 2 N sodium hydroxide and 100 g cracked ice under vigorous stirring. The acetal was extracted with ether (3 times 50 ml), dried over potassium carbonate and distilled *in vacuo*. Yield 13.4 g = 88 %.

By the same method the dimethyl acetals of butyraldehyde and anisaldehyde were prepared. Crotonaldehyde did not give any acetal.

In Table 1 the yields by different methods are compared.

Benzaldehyde diethyl acetal. Attempts to prepare this compound by the same method resulted in an impure product in about 55 % yield. The reason for the rather unsatis-

Table 1. Percentage yield of some acetals by different methods.

Method	H ⁺		Azeo- trope	HC(OEt) ₃	CH(NH)OR		Si(OR) ₄		R ₂ SO ₃	Me ₂ SO ₄	
	Me	Et	Et	Et	Me	Et	Me	Et	Me	Et	
Alkyd											
Aldehyde											
Butyr-	30 ¹¹	50 ¹¹							80 ¹⁰	72 ¹⁰	52
Croton-						0 ⁸	50 ⁹	0 ⁹			0
Benz-	37 ⁴	56 ⁶	66 ⁶	98 ⁷ , 66 ¹²		84 ⁸	70-90 ⁹		81 ¹⁰	78 ¹⁰	88
Anis-	30 ³	40 ⁶		96 ⁷ , 88 ¹³	67 ⁸	52 ⁸			84 ¹⁰		65

factory result was shown to be the very slow hydrolysis of the excess diethyl sulfate by the aqueous alkali, which caused decomposition of the acetal during the subsequent distillation.

Reaction velocity. A rough estimate of the rate of reaction between benzaldehyde and methyl alcohol in the presence of dimethyl sulfate and methyl *p*-toluenesulfonate, and of benzaldehyde and ethyl alcohol with diethyl sulfate was made by titrating samples of 1 ml at appropriate intervals with methanolic sodium methoxide. The results (Fig. 1) indicate that methyl *p*-toluenesulfonate acts too slowly and that both dimethyl and diethyl sulfate react with an adequate velocity, but as mentioned above diethyl sulfate must be abandoned. Apparently the conversion exceeds 100 %, but this is due to the reaction between alcohol and dialkyl sulfate with production of ether and sulfuric acid. This was proved in the case of dimethyl sulfate by refluxing this compound with methanol and titrating samples of 1 ml (Curve d, Fig. 1). In another run the liberated methyl ether was condensed in a dry ice-acetone bath and identified by the boiling point ($-23.6^{\circ} / 761$ mm Hg).

SUMMARY

In the acetalization of an aldehyde with methanol the yield is increased considerably by adding dimethyl sulfate.

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