

due to reduction of the toluene produced to methylcyclohexane. In such cases the reduction was continued well beyond the calculated end-point. No reductive fission of a benzylalkylamine has been observed, although, in one case where such an amine was known to be present, the corresponding hexahydrobenzylalkylamine was formed.

The authors are indebted to Mr. W. S. Ide for

the microanalyses recorded. Melting points are corrected.

Summary

By reductive debenzoylation of benzyldialkylamines, dialkylamines may be obtained readily in a state of purity.

TUCKAHOE, NEW YORK

RECEIVED APRIL 22, 1941

[CONTRIBUTION FROM THE CHEMISTRY LABORATORY OF NORTHWESTERN UNIVERSITY]

Condensation of Methoxyacetaldehyde to 2,4-Dimethylaldotetrose: Methoxyacetaldehyde and Ethoxyacetaldehyde

BY CHARLES D. HURD AND JOHN LEO ABERNETHY

In 1938 Drake¹ and collaborators published directions for the synthesis of methoxyacetaldehyde and ethoxyacetaldehyde by dehydrogenation of the corresponding alcohols over a hot copper catalyst. Yields were 8–10%, based on the starting materials. In catalytic efficiency, copper chromite was stated to be less effective than copper. In independent work performed prior to the appearance of this article, we obtained about 5% conversion of β -methoxyethyl alcohol over copper chromite at 360° to methoxyacetaldehyde and had abandoned it in favor of a method wherein the alcohol was oxidized in the wet way. Based on the starting materials, the yields by this process were 17% for methoxyacetaldehyde and 10% for ethoxyacetaldehyde. This method, therefore, gives actual yields as good as or better than those obtained by dehydrogenation, it uses equipment which is considerably simpler, and it does not involve the preparation of the catalyst.

Dichromic oxidizing mixture was used, the essential feature of the process being the rapid removal of the aldehyde from the reaction mixture once it was formed. This was done by an adaptation of the method² used for the oxidation of propyl alcohol to propionaldehyde; but the method was less satisfactory with methoxyacetaldehyde than with propionaldehyde because the greater volatility of the latter makes it easier to remove it promptly from the solution. Propionaldehyde boils at 48° whereas methoxyacetaldehyde¹ boils at 90–92° (azeotrope with 12.8% water, b. p. 83–86°, or 88.8°). The somewhat higher boiling

point of ethoxyacetaldehyde¹ (b. p. 105–106°; azeotrope with 21.8% water, b. p. 90–91°) makes for greater difficulty of prompt removal of it from water, thereby explaining the somewhat smaller yield.

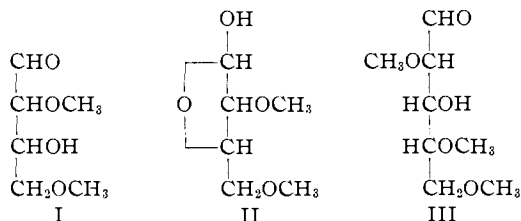
A study of the molecular weight of these alkoxyaldehydes was undertaken in view of the anomalous results reported in the article by Drake and collaborators. Their observed value (99.5) for ethoxyacetaldehyde is reasonably near theory (88), but the value given (117) for methoxyacetaldehyde obviously is much too high (theory, 74). It was found in the present study that the values for the molecular weights of these compounds increase with time, suggesting the onset of a polymerization process. The rate of this process fell off after the first few hours. Black taped vessels were ineffective in preventing this polymerization. The effect of hydroquinone was negligible also. Polymerization also occurred in a tinned container which contained hydroquinone, but at a little slower rate.

Condensation to 2,4-Dimethylaldotetrose.—The original purpose of this investigation was to study the condensation of methoxyacetaldehyde to see if it would give rise to a methylated tetrose. This condensation occurred fairly readily in the presence of solutions of either potassium carbonate or potassium cyanide, somewhat better yields being obtained with the carbonate.

It seemed reasonable to infer that the 2,4-dimethylaldotetrose formed would possess open chain structure I rather than cyclic structure II. If so, this opens a new route to methylated derivatives of aldehyde forms of sugars.

(1) Drake, Duvall, Jacobs, Thompson and Sonnichsen, *THIS JOURNAL*, **60**, 73 (1938).

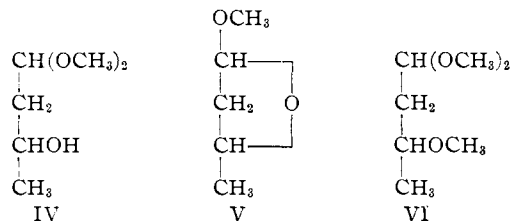
(2) Hurd and Meinert, "Organic Syntheses," Vol. XII, John Wiley and Sons, New York, N. Y., 1932, p. 64.



A β -hydroxy aldehyde of this type is 2,4,5-trimethyl-D-arabinose (III), prepared by degradation of 3,5,6-trimethyl-D-gluconamide³ with sodium hypochlorite. Haworth and co-workers pointed out that III behaved as an aldehyde sugar in spite of its available hydroxy group.

Aldol is another such β -hydroxy aldehyde. Its infrared spectrum⁴ supports the open chain structure rather than the cyclic.

To obtain confirmatory evidence on this point, aldol was converted to its acetal and then subjected to complete methylation. If aldol has the open chain structure, $\text{CH}_3\text{CHOHCH}_2\text{CHO}$, the acetal would be methyl β -hydroxybutyral (IV), whereas if it has the cyclic structure the acetal would be methyl β -butyraldoside (V).



Compound V would be incapable of further methylation whereas IV would be expected to yield methyl β -methoxybutyral (VI). This methylation to VI did occur so it may be concluded that aldol possesses an open chain configuration. By analogy, it seems reasonable to believe that the 2,4-dimethylaldotetrose prepared from methoxyacetaldehyde possesses formula I.

Experimental Part

Oxidation of β -Methoxyethyl Alcohol.—A 2-liter, 3-necked flask was fitted with a dropping funnel, a glass tube for admitting carbon dioxide, and a reflux bulb condenser set at an angle of 45°. Water at 75–80° was circulated through the condenser. Another condenser, directed downward, was attached to the top of the first condenser. It was water-cooled.

In the flask was placed 125 cc. (1.60 moles) of β -methoxyethyl alcohol and it was heated to boiling. Carbon dioxide was bubbled through the liquid fast enough to stir it efficiently but not fast enough to carry the alcohol vapors

through the condenser. Then, during thirty minutes, a mixture of 165 g. (0.56 mole) of potassium dichromate, 120 cc. of concd. sulfuric acid, and 1000 cc. of water was added through the dropping funnel. Vigorous boiling was maintained continuously and for fifteen minutes after all the oxidizing agent had been added.

The 100 cc. of distillate was fractionated in an atmosphere of carbon dioxide with these results (°C., cc.): 50–86, 3; 86–92, 20; 92–100, 5; 100, 56; 100–125, 11; residue, 5. The 86–92° fraction (20 cc., 22 g.) was the azeotrope of methoxyacetaldehyde and water. It represented a yield of 16.7%, since the azeotrope contains¹ 12.8% water. This fraction gave a purple fuchsin test and yielded a 2,4-dinitrophenylhydrazone, m. p. 123–125°.

Only 11.5 g. was obtained in the 88–92° fraction when the solvent was changed to acetic acid. A hot solution of 85 g. (0.85 mole) of chromium trioxide in 800 cc. of glacial acetic acid was added dropwise during thirty minutes into 125 cc. of boiling β -methoxyethyl alcohol. Otherwise, identical conditions were maintained. Some esterification to methoxyethyl acetate occurred concurrently.

Oxidation of β -Ethoxyethyl Alcohol.—The directions were the same as for the lower homolog. From 130 cc. (1.34 moles) was obtained 13–15 g. of the azeotrope of ethoxyacetaldehyde and water in duplicate runs. This represents a 10% yield. The 2,4-dinitrophenylhydrazone, prepared from it, melted correctly at 116–117°.

Molecular Weight Determinations

Azeotropes of water and methoxyacetaldehyde and of water and ethoxyacetaldehyde were collected in a carbon dioxide atmosphere. These were dried over anhydrous magnesium sulfate and fractionated through a Vigreux column. Dry carbon dioxide was maintained as an atmosphere. Methoxyacetaldehyde was collected at 89–91° and ethoxyacetaldehyde at 100–102°. Molecular weights were determined cryoscopically in thiophene-free benzene. Results are summarized in Table I. The molecular weights were determined after specific time intervals under varying conditions represented by these symbols: L, light present (*i. e.*, aldehyde was left in a glass tube). B, blackened glass tube used to hold the aldehyde (black tape was used). H, hydroquinone was added in 1% amounts; T, a tin container was used rather than glass.

TABLE I

Time interval, hours	MOLECULAR WEIGHTS OF ALKOXYACETALDEHYDES					
	1	2	3	4	8	36
	Methoxyacetaldehyde, mol. wt.					
L	78.1	98.9	...	115.8	...	119.5
B	79.2	..	...	112.1	...	...
B, H	78.7	..	...	...	116.4	...
T, H	79.1	..	...	...	111.3	...
	Ethoxyacetaldehyde, mol. wt.					
L	91.1	..	102.6	...	122.0	...
B	90.3	..	...	...	119.3	...
B, H	90.7	..	...	...	118.9	...
T, H	90.5	..	...	...	113.9	...

2,4-Dimethylaldotetrose.—To 25 cc. of aqueous methoxyacetaldehyde, b. p. 75–97°, prepared by oxidation of

(3) Haworth, Peat and Whetstone, *J. Chem. Soc.*, 1975 (1938).

(4) Backes, *Compt. rend.*, **207**, 74 (1938).

120 g. of β -methoxyethyl alcohol, was added with stirring 10 g. of potassium carbonate at 0°. The solution was stirred four hours at 5–10°, then was left in an ice box for two days. The solution turned a golden yellow and the aldol was salted out in the cold with potassium carbonate. The resultant oily liquid was extracted with six 25-cc. portions of ether, then dried over anhydrous sodium sulfate, the solvent removed, and the remaining liquid (8 cc.) fractionated under 5 mm. pressure in a carbon dioxide atmosphere. About 4 cc. came over at 20–77°. This portion absorbed bromine from a solution of bromine in carbon tetrachloride. Approximately 2.5 cc. distilled at 77–80°. This was the 2,4-dimethylaldotetrose. There was some tarry residue (1 cc.) in the flask after the distillation.

By the use of a 2.5% solution of potassium cyanide, instead of potassium carbonate, 2 cc. of the 2,4-dimethylaldotetrose was obtained.

When carbon tetrachloride was used as the solvent for extraction, only 1.5 cc. of the dimethyltetrose resulted in the case where potassium carbonate was used as the condensing agent and only 1 cc. where potassium cyanide was used as the condensing agent.

A deep red coloration was given with fuchsin aldehyde reagent with one drop of the substance and a silver mirror was obtained with ammoniacal silver nitrate solution.

Anal. Calcd. for $C_6H_{12}O_4$: C, 48.6; H, 8.2. Found: C, 48.5, 48.6; H, 8.5, 8.3.

Methyl β -Methoxybutyral.—Fifteen cc. of methyl β -hydroxybutyral, b. p. 82–88° (13 mm.), was prepared from aldol, methanol, and hydrogen chloride by Helferich's method.⁵ Methylation of this substance with methyl sulfate and alkali gave rise to polymerization products only, but the methylation procedure developed by Pacsu and Trister⁶ led to satisfactory results.

Fifteen grams of the acetal was dissolved in 150 cc. of dry ether in a flask fitted with a calcium chloride drying tube. To this solution was added 1.5 g. of clean sodium wire and then the mixture was shaken gently for six hours. After this time it was allowed to stand at room temperature overnight. Then the solution was decanted rapidly into a distilling flask containing 20 cc. of methyl iodide. Precipitation of sodium iodide began immediately and the resulting

cloudy solution was evaporated under reduced pressure to a paste. A 30-cc. portion of methyl iodide was added to the paste and the cloudy solution was carefully stoppered to keep it dry. It was then vigorously stirred for five hours and left at room temperature for sixteen hours. To the resulting mixture was added 50 cc. of dry ether and 1 g. of activated carbon. The sodium iodide and carbon were filtered off and washed with two 50-cc. portions of dry ether. The combined filtrate and washings were evaporated under reduced pressure to a yellow oil. The oil was clarified twice in petroleum ether solution with activated carbon. On evaporation under reduced pressure the clear filtrate gave about 10 cc. of a yellow oil. On distillation at 17 mm., 2.5 cc. of substance was collected below 76°, 6.0 cc. between 76–102°, and 1.0 cc. above 102°. The 76–102° fraction was refractionated to obtain 3.5 g. of methyl β -methoxybutyral at 90–96° (17 mm.).

Anal. Calcd. for $C_7H_{16}O_3$: C, 56.7; H, 10.9. Found: C, 56.4, 56.5; H, 11.3, 11.3.

Summary

Directions are given for the preparation of methoxyacetaldehyde and ethoxyacetaldehyde by oxidation of β -methoxy- and β -ethoxyethyl alcohols, respectively, with chromic acid. The molecular weights of these alkoxyacetaldehydes increase with time, the rate of this polymerization process falling off after the first few hours.

Methoxyacetaldehyde underwent condensation to 2,4-dimethylaldotetrose in the presence of either potassium carbonate or potassium cyanide solutions. Reasons are given which support the open chain structure for this dimethylaldotetrose, rather than the 4-membered heterocyclic hemiacetal structure.

The open chain character of aldol, another β -hydroxy aldehyde, was demonstrated by methylation. Methyl β -methoxybutyral was synthesized.

EVANSTON, ILLINOIS

RECEIVED MAY 15, 1941

(5) Helferich, *Ber.*, **52**, 1800 (1919).

(6) Pacsu and Trister, *This Journal*, **61**, 2442 (1939).