

mixed resin column. Unreacted hexonic acid was eluted from the column with 2 *N* NH₄OH and treated as before; this second treatment contributed about 20% of the final yield of sugar. The sugar mixture was dissolved in 0.2 molar Na phosphate buffer pH 7.5 (2.5% hexose w./v.) and epimerization effected by heating the solution on a steam-bath for 90 minutes. Glucose, mannose and fructose were partially separated by paper chromatography on four sheets of Whatman No. 1 filter paper (57 × 47 cm.) using phenol-water as solvent,⁶ and the sugars located by exposing the dried sheets to X-ray film. After elution from the paper the sugars were further purified by paper chromatography in butanol-acetic acid-water.⁶ The final products were shown by two-dimensional chromatography in phenol-water and butanol-ethanol-water⁶ to contain no significant quantity of radioactive contaminants.

The yields of hexoses from 2.7 millimoles of starting NaC¹⁴N were: glucose 0.496, fructose 0.055 and mannose 0.077 millimole. The total hexose obtained (0.628 millimole) was 23% of the theoretical yield.

Degradation of glucose by heterolactic fermentation⁷ after its isolation from the epimeric mixture showed that carbon atom 1 contained 100% of the total radioactivity in the molecule. Carbon atoms 2 to 6 contained no significant activity.

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Reaction of Methylal with Some Acid Anhydrides

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Claisen¹ reported that the reaction of diethylacetal with acetic anhydride gave a good yield of α -ethoxyethyl acetate. He found it necessary to conduct the reaction in a sealed tube at 150°.

Recently we have studied this reaction with methylal and acetic, propionic and *n*-butyric anhydrides and find that it proceeds smoothly in the presence of an acid catalyst to give good yields of the corresponding methoxymethyl esters. Moreover, the use of a catalyst permits the reaction to take place merely by refluxing the mixture under atmospheric pressure. The products of the reaction are the methyl and methoxymethyl esters of

TABLE I
PROPERTIES OF METHOXYMETHYL ESTERS PREPARED

	This investigation	Literature ²
Methoxymethyl acetate		
B.p., °C.	117–118	117–118
Mol. wt.	102.4	104 (calcd.)
<i>n</i> _D ²⁰	1.3917	1.3980
<i>d</i> ₄ ²⁰	1.018	0.989
<i>M</i> _R	23.21	23.97 (calcd.)
Methoxymethyl propionate		
B.p., °C.	133	133
Mol. wt.	117	118 (calcd.)
<i>n</i> _D ²⁰	0.9886	0.9872
Methoxymethyl <i>n</i> -butyrate		
B.p., °C.	152	151–152
Mol. wt.	131	132 (calcd.)
<i>d</i> ₄ ²⁰	0.9740	0.9747

(1) L. Claisen, *Ber.*, **31**, 1018 (1898).

the acid anhydride used and these can be separated readily by fractionation. The methoxymethyl esters have been prepared previously from monochloromethyl ether and the sodium salts of the corresponding acids.²

Attempts to extend the reaction to benzoic and phthalic anhydrides were not successful.

Experimental

Methoxymethyl Acetate.—The methylal used in this work was prepared from the methylal-methanol azeotrope by refluxing the latter over calcium chloride to remove most of the methanol and then distilling the product over sodium. The presence of methanol or moisture in the methylal results in decreased yield of the desired esters.

Acetic anhydride (102 g., 1 mole), methylal (76 g., 1 mole) and 1 g. of *p*-toluenesulfonic acid were refluxed gently for six hours. The mixture was then distilled through a 30-plate Oldershaw column and the cut boiling at 100–125° was collected. Redistillation gave 81 g. of a fraction boiling at 117–118° which was the desired product; *n*_D²⁰ 1.3917, *d*₄²⁰ 1.018. From the residue 14.5 g. of acetic anhydride was recovered. The yield of methoxymethyl acetate based on acetic anhydride consumed was 95%.

Methoxymethyl Propionate and *n*-Butyrate.—Methoxymethyl propionate was prepared as described above, using an equivalent amount of propionic anhydride. The cut boiling at 130–135° was washed with 10% sodium bicarbonate followed by water, dried over magnesium sulfate and fractionated. The product boiled at 133°, *d*₄²⁰ 0.9886. Thirty-one per cent. of the propionic anhydride was recovered and the yield of ester based on anhydride consumed was 94%.

Methoxymethyl *n*-butyrate was similarly prepared. The ester boiled at 155°, *d*₄²⁰ 0.9740. Of the *n*-butyric anhydride taken, 27.6% was recovered and the yield of ester on this basis was 86%.

(2) F. E. Clark, S. F. Cox and E. Mack, *THIS JOURNAL*, **39**, 712 (1917).

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The Reduction of Streptomycin with Sodium Borohydride

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The generally accepted procedure for the reduction of the aldehyde group of streptomycin involves a catalytic hydrogenation with platinum or other metals as catalyst.^{1–3} An electrochemical procedure for the reduction of streptomycin has also been reported.⁴ Chaikin and Brown⁵ demonstrated the reduction of organic aldehydes in aqueous solution with sodium borohydride. We have found sodium borohydride to be a very effective reagent with which to convert the aldehyde group of streptomycin and hydroxystreptomycin to their respective derivatives.

The completeness of the reduction of streptomycin by sodium borohydride was investigated with variations in time of reaction, temperature, pH of the solution, quantity of sodium borohydride, and purity of the streptomycin.

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(4) R. Ohdake, Y. Kojima and H. Kusakabe, *Repts. Sci. Research Inst. (Japan)*, **28**, 103 (1952).

(5) S. W. Chaikin and W. G. Brown, *THIS JOURNAL*, **71**, 122 (1949).