nesium bromide. The pyrolysis was carried out in a large test-tube, connected with a manometer and an oil-pump. The system was evacuated to 0.5 mm. and the tube heated with an oil-bath. The pyrolysis was carried out at 220° for four hours. At the end of this period, the pressure no longer tended to rise, indicating that the evolution of gas was complete. A gray, vesicular powder remained in the tube.

In another experiment the evolution of ethylene was detected by bleeding bromine vapor into the system next to the pyrolysis tube, and condensing out the ethylene dibromide formed. After distillation, a 30% yield of ethylene dibromide was obtained, b. p. 130.5–131° at 758 mm.; density $^{25}_{4}$ 2.182.

Anal. Calcd. for $C_2H_4Br_2$: Br, 85.08. Found: Br, 85.1.

The gas evolved on hydrolysis of the pyrolysis product was found to be completely absorbed by a palladium chloride solution, indicating that it could not contain ethane or saturated hydrocarbons.

Reaction of Pyrolysis Product with Benzophenone.—The gray powder (15 g.) was suspended in an ether–benzene mixture, and benzophenone (10 g.) added. A precipitate gradually formed on the walls of the vessel. The mixture was refluxed with stirring for ten hours, and allowed to stand overnight. The mixture was hydrolyzed with ice and hydrochloric acid, and on concentration of the organic layer, benzhydrol (5 g.), m. p. 57–61.5°, was isolated. This gave on recrystallization from ligroin (b. p. 70–90°) 4.7 g., m. p. 64.5–65.5°. The substance was identified by mixed melting point with an authentic sample of benzhydrol, and by the preparation of dibenzhydryl succinate,[4] m. p. 135–137.5°. On working up the mother liquors and repeated crystallization an additional 2 g. of benzhydrol was obtained. About 1 g. of unchanged benzophenone was also obtained.

Pyrolysis of Methylmagnesium Iodide and Treatment of Product with Benzophenone.—The pyrolysis was carried out in exactly the same way as with ethylmagnesium bromide. The residual product reacted with water, a gas being evolved. The product was treated with benzophenone as above, and, after hydrolysis, 82% of the benzophenone was recovered. No benzhydrol could be isolated.

Summary

1. Ethylmagnesium bromide has been pyrolyzed at 220° *in vacuo*, ethylene being evolved.

2. The pyrolysis product reduces benzophenone to benzhydrol in a yield of 66%.

3. The pyrolysis product of methylmagnesium iodide does not reduce benzophenone.

(4) Linnemann, *Ann.*, **133**, 23 (1865).

CAMBRIDGE, MASS. RECEIVED MARCH 4, 1938

[CONTRIBUTION FROM MELLON INSTITUTE OF INDUSTRIAL RESEARCH, AND E. R. SQUIBB & SONS]

Halogeno-alkyl Glycosides. I. Monohalogeno-alkyl Derivatives

BY HAROLD W. COLES,[1] MARY L. DODDS[1] AND FRANK H. BERGEIM[2]

Halogeno-alkyl glycosides were required for another project. A search of the literature revealed that, while sugars had been condensed with numerous glycols, similar condensations had not been attempted with the halogenohydrins. Ethylene chlorohydrin had indeed served as a solvent in reactions of glucose with aldehydes.[3] Carbohydrates such as starch and cellulose have been depolymerized by treatment with chlorohydrin.[4] Reduced sugars such as mannitol and sorbitol can be condensed with chlorohydrin but the condensation does not involve carbon 1 of the sugar chain.[5]

The initial attempts to prepare the glucosides by the condensation of glucose with ethylene bromohydrin in the presence of gaseous hydrochloric acid failed to give a crystalline product. A hygroscopic sirup was obtained. Successful results were, however, obtained with the method of Fischer[6] whereby acetohalogeno sugars are condensed with glycols in the presence of silver carbonate. It was found that the halogenohydrins condensed readily at room temperature with acylhalogeno sugars in the presence of silver carbonate, provided the reactants were purified carefully. Under these conditions, the silver carbonate did not react with the halogen of the halogenohydrins.

The acylhalogeno sugars were purified by recrystallization until all free acid was removed, and they were used at once. The halogenohydrins were allowed to stand over calcium oxide until neutral to litmus, filtered, and distilled in a vacuum, the middle fraction being selected. They were likewise used immediately. It was not found necessary to reprecipitate the silver carbonate.

The preparation of tetraacetyl-β-*d*-(β-chloro-

(1) Industrial Fellows, E. R. Squibb & Sons Industrial Fellowship, Mellon Institute.

(2) Research Laboratories, E. R. Squibb & Sons, Brooklyn, N. Y.

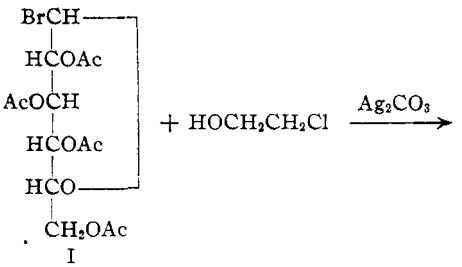
(3) Hill and Hibbert, THIS JOURNAL, **45**, 3108 (1923).

(4) Lange, U. S. Patent 1,714,565 (May 28, 1929).

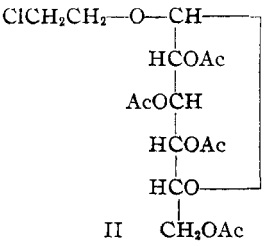
(5) Schmidt and Meyer, U. S. Patent 1,922,459 (Aug. 15, 1933).

(6) Fischer and Fischer, *Ber.*, **43**, 2521 (1910).

ethyl)-glucoside (II) from acetobromoglucose illustrates the synthesis.

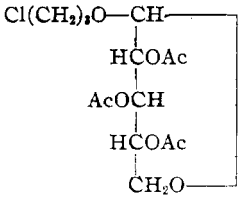


I

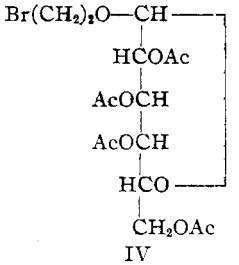


II

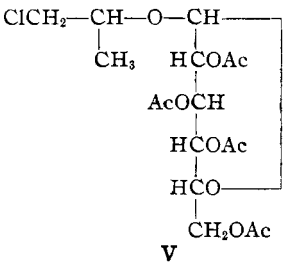
The probable structures of several other types are shown by triacetyl-β-*d*-(γ-chloropropyl)-xyloside (III), tetraacetyl-β-*d*-(β-bromoethyl)-galactoside (IV) and tetraacetyl-β-*d*-(α-methyl-β-chloroethyl)-glucoside (V)



III



IV



V

In addition, the series includes lactosides and tetrabenzoyl-halogenoalkyl-glucosides. The reaction between 1-bromo-2,3,4,6-tetramethyl-*d*-glucose[7] and the chlorohydrins seemed to go easily enough, but no crystalline products in amounts sufficient for analysis were obtained.

There were large differences in the ease with which the reaction took place with the different sugars. The best results were obtained with the glucosides, xylosides and the lactosides. There was, however, a great tendency for the lactosides to abandon the crystalline form, develop a glazed appearance and finally become resinous. Benzobromoglucose reacted with difficulty and yields were poor. Ethylene halogenohydrins and propylene chlorohydrin[8] reacted more readily than did the trimethylene chlorohydrin.

The new glycosides are listed in Table I. Several examples, illustrative of the various modifications employed, are described in full in the experimental part. The authors are grateful to Dr. Geo. D. Beal, Assistant Director of Mellon Institute, for his advice during the progress of this work.

Experimental Part

Tetraacetyl-β-*d*-(β-chloroethyl)-glucoside (II).—The proportions of the reactants used were similar to those employed by Fischer.[6] Ethylene chlorohydrin (25.2 g.) and acetobromoglucose (6 g.) were combined. The acetobromoglucose was readily soluble in the chlorohydrin. Silver carbonate (7.2 g.) was added. A lively evolution of carbon dioxide started and after one hour most of the reaction was over. The mixture was allowed to stand for several hours longer in the dark, and finally was cautiously warmed on the water-bath. The silver salts were filtered off and washed with a small amount of hot absolute alcohol. The alcohol and the excess chlorohydrin were removed by distillation in a vacuum and the flask residue dissolved in hot absolute alcohol. On standing, crystallization started and was completed by immersion of the flask in ice water. The crystals were recrystallized for analysis from hot water. The yield was 3–3.5 g. (45–50%).

The glucoside consisted of needles, melting at 114°,[9] and easily soluble in acetone, hot alcohol and hot water. They have no taste when first placed on the tongue, but gradually a bitter taste develops. The crystals gave a Beilstein test for halogen and did not reduce Benedict's solution either cold or on warming. The specific rotation in acetone was $[\alpha]^{28}D$ −21.25° (*c*, 4; *l*, 1-dm.).

Anal. Calcd. for $C_{16}H_{23}O_{10}Cl$: Cl, 8.63. Found: Cl, 8.36.[10]

Tetraacetyl-β-*d*-(γ-chloropropyl)-glucoside.—Six grams of β-acetobromoglucose was dissolved in 29.7 g. of redistilled trimethylene chlorohydrin and then 7.2 g. of silver carbonate was added. The flask was allowed to stand overnight at room temperature in complete darkness, with occasional stirring, and evolution of carbon dioxide took place freely. The reaction was completed by cautious heating on water-bath. The silver salts were removed by filtration and washed with some hot alcohol. A large amount of water was added to the alcohol filtrate which threw out a colorless, mobile sirup. The supernatant liquid was decanted and the sirup washed several times

(7) Wolfrom and Husted, THIS JOURNAL, **59**, 2559 (1937).

(8) Courtesy of the Carbide and Carbon Fellowship at Mellon Institute.

(9) All melting points are corrected for stem exposure.

(10) Analyses partly by Saul Gottlieb, Columbia University, and partly by W. W. Mills, Analytical Department, Mellon Institute.

TABLE I

MONOHALOGENO-ALKYL GLYCOSIDES

Name	Formula	Mol. wt.	M.p., °C.	Halogen, % Calcd.	Found
Glucosides					
Tetraacetyl-β-*d*-(γ-chloropropyl)	$C_{17}H_{25}O_{10}Cl$	424.657	74	8.34	8.24
Tetraacetyl-β-*d*-(β-chloroethyl)	$C_{16}H_{23}O_{10}Cl$	410.641	114	8.63	8.36
Tetrabenzoyl-β-*d*-(β-chloroethyl)	$C_{36}H_{31}O_{10}Cl$	658.705	59	5.38	5.19
Tetraacetyl-β-*d*-(β-bromoethyl)	$C_{16}H_{23}O_{10}Cl$	455.100	117.3	17.56	17.08
Tetraacetyl-β-*d*-(α-methyl-β-chloroethyl)	$C_{17}H_{25}O_{10}Cl$	424.661	113	8.34	8.07
Xylosides					
Triacetyl-β-*d*-(β-chloroethyl)[a]	$C_{13}H_{19}O_8Cl$	338.609	137	10.47	10.22
Triacetyl-β-*d*-(γ-chloropropyl)	$C_{14}H_{21}O_8Cl$	352.625	108.5–109	10.05	9.95
Lactosides					
Heptaacetyl-β-*d*-(β-chloroethyl)	$C_{28}H_{39}O_{18}Cl$	698.769	78–80	5.07	4.86
Heptaacetyl-β-*d*-(γ-chloropropyl)	$C_{29}H_{41}O_{18}Cl$	712.785	85	4.97	4.74
Heptaacetyl-β-*d*-(α-methyl-β-chloroethyl)	$C_{29}H_{41}O_{18}Cl$	712.785	95–97	4.97	5.03
Galactosides					
Tetraacetyl-β-*d*-(β-bromoethyl)	$C_{16}H_{23}O_{10}Br$	455.100	111	17.56	17.44
Tetraacetyl-β-*d*-(β-chloroethyl)	$C_{16}H_{23}O_{10}Cl$	410.641	117	8.63	8.81
Tetraacetyl-β-*d*-(γ-chloropropyl)	$C_{17}H_{25}O_{10}Cl$	424.657	78	8.34	8.60

[a] Calcd.: C, 46.07; H, 5.56. Found: C, 46.22; H, 5.78.

with water for removal of the excess chlorohydrin. The sirup, on stirring with cold distilled water, started to form long needles and crystallization was completed by immersion in ice water. For purification, the needles were dissolved in a minimum of hot absolute alcohol and chilled. They were dried in the air. The melting point was 74° (U. S. P., corr.) and the rotation was $[\alpha]^{28}D$ −12.25° (*c*, 4; *l*, 1-dm.).

Anal. Calcd. for $C_{17}H_{25}O_{10}Cl$: Cl, 8.34. Found: Cl, 8.24.

Tetraacetyl-β-*d*-(β-bromoethyl)-glucoside.—This glucoside was prepared in a manner similar to the foregoing, using ethylene bromohydrin in place of trimethylene chlorohydrin. Recrystallization of the condensate from a minimum of hot absolute alcohol gave colorless needles melting at 117.3° (U. S. P., corr.). The rotation in acetone was $[\alpha]^{28}D$ −20.5° (*c*, 4; *l*, 1-dm.).

Anal. Calcd. for $C_{16}H_{23}O_{10}Br$: Br, 17.56. Found: Br, 17.08.

Triacetyl-β-(γ-chloropropyl)-xyloside (III).—Trimethylene chlorohydrin (18 g.), acetobromoxylose (6 g.) and silver carbonate (5 g.) were allowed to react at room temperature in darkness overnight. The reaction was not as vigorous as with the ethylene chlorohydrin preparation. The silver salts were filtered off and washed with some hot absolute alcohol. A comparatively large quantity of water was added to the filtrate and the liquid chilled, whereby flaky crystals started to form. These crystals were redissolved in hot absolute alcohol, and solvent was removed by slight vacuum until crystallization started. Crystallization was completed by chilling strongly and, after separation, melted sharply at 108.5–109°.

Anal. Calcd. for $C_{14}H_{21}O_8Cl$: C, 47.60; H, 6.00. Found: C, 47.56; H, 5.94.

Summary

Alkylene halogenohydrins have been condensed with acylhalogeno sugars in the presence of silver carbonate to form a new series of halogenated alkyl glycosides.

The series of thirteen new glycosides include glucosides, xylosides, lactosides and galactosides.

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