TABLE I

PHYSICAL PROPERTIES OF R—C≡C—R′

Nature of R	Nature of R′	B. p., °C.	Mm.	d^{20}_4	$n^{20}D$	MR Calcd.	MR Found
CH_2=CH—	C_2H_5—	83	747	0.748	1.4523	27.44	28.84
C_4H_9—	CH_3—	110–111	747	.748	1.4230	32.53	32.72
C_4H_9—	C_2H_5—	129–130	747	.748	1.4261	37.15	37.62
C_5H_{11}—	C_2H_5—	153–155	745	.765	1.4299	41.77	41.80
C_6H_{13}—	CH_3—	155–156	747	.769	1.4331	41.77	41.85

acetylene diluted with its own volume of dry ether was added dropwise with constant stirring by means of a mercury-sealed motor-driven stirrer. The mixture was allowed to stand overnight and then refluxed with stirring for two and one-half hours. To this preparation was added slowly 170 g. (1.1 moles) of ethyl sulfate diluted with ether. The mixture was again refluxed with stirring for twelve hours. At the end of that time, some of the ether and ethyl bromide formed was removed by distillation through an efficient fractionating column. When the reaction mixture had become quite pasty it was treated with cold dilute hydrochloric acid sufficient to dissolve all solid. The organic layer was removed, washed with distilled water and then with 250 ml. of 20% sodium hydroxide and dried over calcium chloride to which a few pellets of potassium hydroxide had been added. Fractionation gave 38.4 g. (70% yield) of octine-3, b. p., 130–131 at 745 mm.

The product was frequently contaminated with sulfur dioxide which was easily removed, however, by washing with dilute alkali followed by drying and redistillation.

In the preparation of ethylvinylacetylene, the vinylacetylene was passed as a gas into the ethylmagnesium bromide contained in a three-necked flask fitted with a liquid ammonia condenser.[8] The vinylacetylene magnesium bromide was treated with ethyl sulfate and the product purified as described above.

Summary

A number of dialkylacetylenes have been prepared by alkylation of acetylenic Grignard reagents with alkyl sulfates.

(8) Vaughn and Pozzi, *J. Chem. Ed.*, **8**, 2433 (1931).

NOTRE DAME, IND. RECEIVED MARCH 16, 1936

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE OHIO STATE UNIVERSITY]

The Mechanism of Carbohydrate Oxidation. XIX. The Preparation of Disaccharide Antipodes

BY LEONARD C. KREIDER AND WM. LLOYD EVANS

Beginning with the classical work of Emil Fischer on the configuration of the sugars, chemists have been deeply interested in the synthesis of the optical antipodes of the carbohydrates, compounds in which the characteristic physical constants of each member of the pair are exactly like those of the other member, save only the constants relating to optical properties, in which case the numerical values are identical, but carry the opposite sign. Among the carbohydrates many examples of optical antipodes have been prepared in the monosaccharide series and in the simple glycosides of the monosaccharides. Optical antipodes among the disaccharides are theoretically possible, but a search of the literature failed to disclose any known examples. It occurred to the authors that if a molecule of the optically inactive keto-triose, dihydroxyacetone, could be joined in true biosidic linkage with a molecule of the *d*-form of an optically active monose a true optically active disaccharide would result. Then if dihydroxyacetone could be joined in the same manner to the *l*-form of the same optically active monose, a second optically active disaccharide would be formed which should be *the exact optical antipode of the first.*

Four recent events made the preparation of such disaccharide pairs possible: (1) the preparation of dihydroxyacetone mono-acetate;[1] (2) an improved method for the preparation of *d*-arabinose;[2] (3) an improved method for the preparation of *l*-xylose[3] which resulted from research on vitamin C and (4) evidence that dihydroxyacetone can be incorporated readily as a constituent of a disaccharide.[4]

The experimental part that follows describes

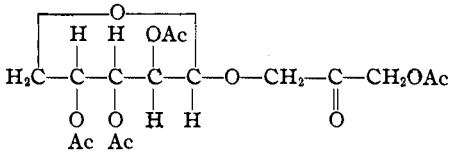
(1) H. O. L. Fischer, E. Baer and L. Feldmann, *Ber.*, **63**, 1732 (1930).

(2) R. C. Hockett and C. S. Hudson, THIS JOURNAL, **56**, 1632 (1934).

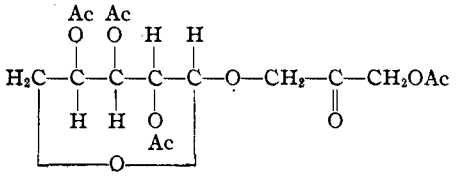
(3) L. Vargha, *Ber.*, **68**, 18 (1935); H. Appel, *J. Chem. Soc.*, 425 (1935).

(4) L. C. Kreider and W. L. Evans, THIS JOURNAL, **57**, 229 (1935).

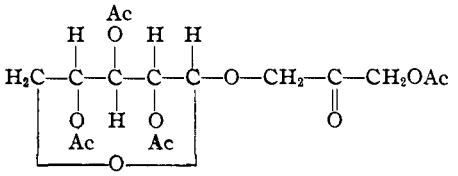
the preparation of two pairs of disaccharide acetates that are optical antipodes



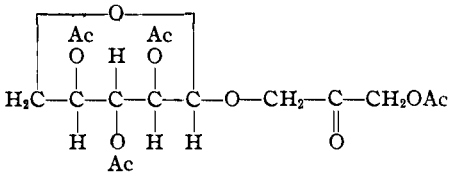
β-*d*-Arabinosidodihydroxyacetone tetraacetate



β-*l*-Arabinosidodihydroxyacetone tetraacetate



β-*d*-Xylosidodihydroxyacetone tetraacetate



β-*l*-Xylosidodihydroxyacetone tetraacetate

A disaccharide racemate, β-*d*,β-*l*-arabinosidodihydroxyacetone tetraacetate, is also described.

Experimental Part

Preparation of Starting Materials.—Dihydroxyacetone monoacetate was prepared according to the directions of Fischer, Baer and Feldmann.[1] The acetobromopentoses used were prepared, with a few minor modifications, directly from their respective pentoses according to the method of Levene and Raymond,[5] final recrystallization being made from anhydrous, alcohol-free ether. The Drierite[6] (soluble anhydrite) used as the internal reaction desiccant, was finely powdered and known to be of full dehydrating power. The benzene for the reaction medium was thiophene free and dried over Drierite. The silver carbonate was prepared in subdued light by slowly adding a solution of 7.5 g. sodium carbonate in 100 cc. of water (0.4 mole) to a solution of 30.0 g. silver nitrate in 400 cc. of water (1.0 mole) with constant stirring. The light yellow precipitate was filtered by suction, washed well with water, then with absolute alcohol and finally with ether and dried in a vacuum oven at 40° for a day.

All the following compounds here reported were obtained in crystalline condition and were recrystallized to constant melting point and rotation.

(5) P. A. Levene and A. L. Raymond, *J. Biol. Chem.*, **90**, 247 (1931).

(6) W. A. Hammond and J. R. Withrow, *Ind. Eng. Chem.*, **25**, 653, 1112 (1933).

β-*d*-Arabinosidodihydroxyacetone Tetraacetate.—The preparation of this compound was conducted in a three-necked round-bottomed flask of suitable size which carried in the middle neck a high-speed motor stirrer of efficient design running under mercury seal. One side-neck carried a drying tube charged with granular Drierite and the other a solid stopper. The stirring was then started and the following materials added: 10.9 g. (2.0 mole) of dihydroxyacetone monoacetate, 90 cc. (25 mole) of benzene, 11.4 g. (1.0 mole) of silver carbonate and 23 g. (4 mole) of finely powdered Drierite. The above mixture was vigorously stirred for twenty minutes to ensure the reactants being absolutely anhydrous. At this point 14.0 g. (1.0 mole) of acetobromo-*d*-arabinose was added in ten equal portions at about ten-minute intervals, vigorous stirring being continued throughout this time and for at least three hours after the last addition of acetobromo-*d*-arabinose.

At this point the stirring was stopped and the solid materials removed from the benzene solution by suction filtration. The residue was washed twice with small amounts of benzene, the washings being added to the filtrate. The combined benzene solutions were then placed in a separatory funnel and washed four times with about equal volumes of water to remove the excess dihydroxyacetone monoacetate. The resulting benzene solution was dried over calcium chloride and then evaporated under vacuum to a thick, light-yellow sirup, the bath temperature being kept below 45°.

The sirup was then dissolved in a small quantity of warm ether. Crystallization usually took place before the solution was completed. If it did not crystallize then it always did on cooling and gentle rubbing with a glass rod. The yield was 5.2 g. or 32% of the theoretical, based on the acetobromo-*d*-arabinose used. For purification, the crude crystals were dissolved in chloroform, warmed and treated with Norite, filtered and then very carefully evaporated to a moderately thick sirup. This was warmed to 40° and then ten times its volume of warm ether added and mixed to homogeneous solution. Crystallization took place on cooling slowly, yielding large, well-defined, thick crystal plates; m. p. 102° (corr.); $[\alpha]^{21}D$ +9.04° (*c*, 3.5; $CHCl_3$).

Anal. Calcd. for $C_8H_{10}O_7(COCH_3)_4$: acetyl, 10.26 cc. of 0.1 *N* NaOH per 100 mg. Found: acetyl, 10.18 cc.

β-*l*-Arabinosidodihydroxyacetone Tetraacetate.—This compound was prepared exactly in the same manner as β-*d*-arabinosidodihydroxyacetone tetraacetate except that acetobromo-*l*-arabinose was substituted for the acetobromo-*d*-arabinose. The average yield was about 33–35% as in the case of the *d*-compound. Slow crystallization again gave beautiful crystals in the form of thick plates; m. p. 102° (corr.) $[\alpha]^{21}D$ −9.07° (*c*, 3.3; $CHCl_3$).

Anal. Calcd. for $C_8H_{10}O_7(COCH_3)_4$: acetyl, 10.26 cc. of 0.1 *N* NaOH per 100 mg. Found: acetyl, 10.28 cc.

β-*d*-*l*-Arabinosidodihydroxyacetone Tetraacetate.—Equal portions (1.0 g.) of purified β-*d*-arabinosidodihydroxyacetone tetraacetate and β-*l*-arabinosidodihydroxyacetone tetraacetate were dissolved in the least possible volume of warm ether and allowed to crystallize as the solution slowly cooled and evaporated spontaneously. A single large, well-formed crystal was chosen and washed with ether. This was dried and the rotation taken in a 2-

dm. micro polarimeter tube. The rotation observed was $[\alpha]^{22}D \pm 0.0°$ (c, 2.7; $CHCl_3$). The melting point of similar well-defined crystal which was powdered was found to be 116° (corr.). The melting point of each of the pure constituents taken separately is 102° (corr.) and a mixed melting point of approximately equal portions of each constituent was 87–89° (corr.). These facts would seem to indicate that a true racemate was formed.

β-d-Xylosidodihydroxyacetone Tetraacetate.—This compound was prepared in the same manner as β-d-arabinosidodihydroxyacetone tetraacetate (except acetobromo-d-xylose was substituted for acetobromo-d-arabinose) through the point where the benzene solution had been evaporated to a thick sirup. Here the sirup was taken up in ether, the resulting solution being allowed to stand at room temperature for a week, open to the air through a protecting calcium chloride tube. The ether that evaporated was replaced daily to prevent the solution from becoming so viscous as to retard the formation of crystals. Crystals started to grow usually within a day (even without seeding) and at the end of a week nearly all the product that would crystallize had separated. The crystals were filtered and washed with ether. The mother liquors were then treated as above and ordinarily a small additional amount of quite pure product was obtained after another two weeks' standing. The total yield averaged about 33–35%. The purification of the crude material was exactly like that of β-d-arabinosidodihydroxyacetone tetraacetate. These crystals were deposited in long, fine needles; m. p. 117° (corr.) $[\alpha]^{22}D$ −60.3° (c, 3.2; $CHCl_3$).

Anal. Calcd. for $C_8H_{10}O_7(COCH_3)_4$: acetyl, 10.26 cc. of 0.1 *N* NaOH per 100 mg. Found: acetyl, 10.19 cc.

Acetobromo-l-xylose.—This was prepared essentially according to the method of Levene and Raymond[5] directly from l-xylose. The yield was 28% based on the l-xylose used, the low yield probably being due in part to the small quantity of material at our disposal. The crude material was recrystallized twice from warm absolute ether, yielding "rock candy"-like crystals; m. p. 102° (corr.) $[\alpha]^{23}D$ −211.6° (c, 3.5; $CHCl_3$). The values of acetobromo-d-xylose as given in the literature[7] are presented here for comparison: m. p. 102° $[\alpha]^{20}D$ +212.2°.

Anal. Calcd. for $C_{11}H_{15}O_7Br$: Br, 55.39. Found: Br, 55.73.

β-l-Xylosidodihydroxyacetone Tetraacetate.—This compound was prepared and purified in exactly the same manner as β-d-xylosidodihydroxyacetone tetraacetate, except that acetobromo-l-xylose was substituted for acetobromo-d-xylose. The yield was only 20%, which was probably due largely to the small amounts of material with which we were forced to work in its preparation; m. p. 117° (corr.) $[\alpha]^{23}D$ +60.2° (c, 1.74; $CHCl_3$). It crystallized in needle-like clusters.

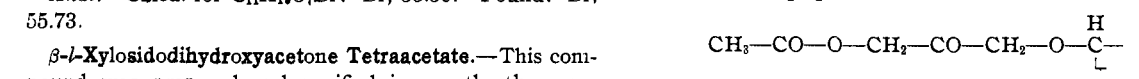
Anal. Calcd. for $C_8H_{10}O_7(COCH_3)_4$: acetyl, 10.26 cc. of 0.1 *N* NaOH per 100 mg. Found: acetyl, 10.27 cc

No attempt was made to prepare d,l-xylosidodihydroxyacetone tetraacetate because of the small amount of the l-variety at our disposal.

(7) J. K. Dale, THIS JOURNAL, **37**, 2745 (1915).

Discussion

In making the above new compounds the α and β designations were assigned, with such exceptions as noted below, on the basis Hudson suggested:[8] "The names should be so selected that for all sugars which are genetically related to d-glucose the subtraction of the rotation of the β form from that of the α form gives a positive difference and for all sugars which are genetically related to l-glucose an equal negative difference." Isbell[9] in a preliminary note arising from work he has in progress on the reaction rate of oxidation in ring sugars, has recently restated this rule in a more fundamental manner by pointing out that the words "which are genetically related to d-glucose" should be replaced by the words *which have the oxygen ring lying to the right*, and that the words "which are genetically related to l-glucose" should have substituted for them in the same way the words *which have the oxygen ring lying to the left*. When the configuration of the sugar does not determine the position of the ring, as in the case in xylose and arabinose, he has this to say: "The reaction rates" (of oxidation) "for the pentoses, sugars in which the position of the rings are not known from the configurations, show that normal α-d-xylose, β-d-lyxose, β-d-ribose and l-arabinose (+191°) are genetically related to the d-hexoses, and their oxygen rings lie to the right." As the "difference" mentioned in the quotation from Hudson is 2*A* in the sense in which he uses these terms, it follows that the assignment of the α and the β names must be so made that the value of *A* must always be positive for sugars in which the oxygen ring is to the right and always be negative for sugars in which the oxygen ring is to the left. In this paper *A* is taken to mean the group



and *B* the remainder of the molecule. The values of *B*, used in calculating the values of *A* given below, were in all cases equal to one-half the algebraic sum of the molecular rotations of the α and the β forms of the fully acetylated parent sugars.

β-d-glucosidodihydroxyacetone pentaacetate
A = +32,200 (oxygen ring right)

β-d-arabinosidodihydroxyacetone tetraacetate
A = −33,600 (oxygen ring left)

β-l-arabinosidodihydroxyacetone tetraacetate
A = +33,600 (oxygen ring right)

(8) C. S. Hudson, *ibid.*, **31**, 66 (1909).
(9) H. S. Isbell, *J. Chem. Ed.*, **12**, 96 (1935).

β-*d*-xylosidodihydroxyacetone tetraacetate
$A = +33{,}700$ (oxygen ring right)
β-*l*-xylosidodihydroxyacetone tetraacetate
$A = -33{,}700$ (oxygen ring left)

(The value of A for β-*d*-glucosidodihydroxyacetone pentaacetate may be derived from its rotation of $[\alpha]^{18}D$ $-25.2°$ reported by Kreider and Evans.[4])

The above numerical values of A agree among themselves very closely when it is remembered that the Van't Hoff rule of optical superposition on which these calculations are based is known to be only approximate in its quantitative predictions. These values tend to substantiate the structure ascribed to the new compounds reported in the experimental part of this paper.

Acknowledgment.—The authors wish to express their thanks to Dr. Ralph T. Major, of Merck and Company, for his kind gift of the *l*-xylose used in carrying out a portion of the work described in this paper.

Summary

1. The preparation of the following new compounds in crystalline condition has been accomplished: β-*d*-arabinosidodihydroxyacetone tetraacetate, β-*l*-arabinosidodihydroxyacetone tetraacetate, β-*d*-xylosidodihydroxyacetone tetraacetate, β-*l*-xylosidodihydroxyacetone tetraacetate, and β-acetobromo-*l*-xylose.

2. The first disaccharide to contain a pentose and a triose as its constituent parts has been prepared.

3. The first examples of pairs of disaccharide derivatives that are exact optical antipodes have been synthesized in β-*d*- and β-*l*-arabinosidodihydroxyacetone tetraacetate and in β-*d*- and β-*l*-xylosidodihydroxyacetone tetraacetate.

4. The first disaccharide racemate has been demonstrated in the case of β-*dl*-arabinosidodihydroxyacetone tetraacetate.

COLUMBUS, OHIO RECEIVED MARCH 18, 1936

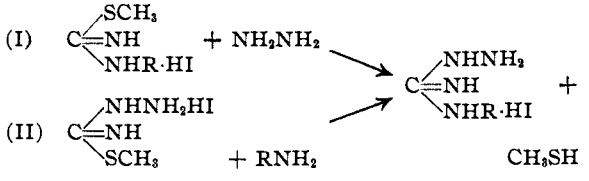
[CONTRIBUTION NO. 29 FROM THE DEPARTMENT OF CHEMISTRY OF THE POLYTECHNIC INSTITUTE OF BROOKLYN]

Reduction of Nitroguanidine. V. The Synthesis of (a) α-Methyl-, (b) α-Ethyl-, (c) α-*n*-Butyl-γ-aminoguanidine[1]

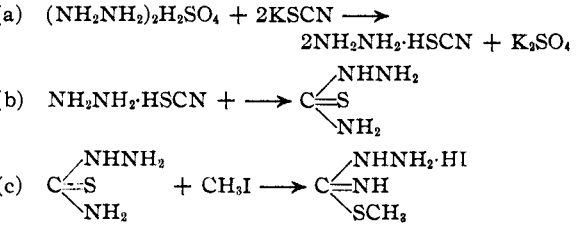
BY G. W. KIRSTEN AND G. B. L. SMITH

Introduction

In this study of the reduction of nitroguanidine, α-alkyl-γ-aminoguanidines are of interest as the final reduction products of α-alkyl-γ-nitroguanidines. The two general schemes of synthesis used were as follows: (I) S-methyl-N-alkyl isothioureas were allowed to react with hydrazine hydrate; (II) S-methyl-N-aminoisothiourea was treated with primary alkylamines. These reactions can be formulated as



The S-methyl-N-aminoisothiourea was prepared through the following series of reactions



α-Methyl-γ-aminoguanidinium iodide was made by both methods, while method (I) alone was used in case of the two other preparations. The synthesis of α-phenyl-γ-aminoguanidine was unsuccessful.

Experimental

α-Methyl-γ-aminoguanidinium Iodide.—S-N-Dimethylisothiourea iodide[2] (58 g.) was dissolved in 100 ml. of water and 13 g. of hydrazine hydrate in a total volume of 50 ml. (aqueous solution) was added.[3] After the evolution of methyl mercaptan had ceased the solution was concentrated to crystallization and the solid product was dissolved in 100 ml. of hot ethanol and cooled. One hundred

(1) This paper was abstracted from part of the thesis submitted by Mr. Kirsten to the faculty of the Polytechnic Institute of Brooklyn in partial fulfilment of the requirements for the degree of Master of Science in Chemistry in June, 1935. On the basis of this thesis Mr. Kirsten was awarded a "certificate of commendation of research" by the Society of the Sigma Xi in 1935.

(2) (a) Delepines, *Compt. rend.*, **144**, 1126 (1907); (b) Andreasch, *Monatsh.*, **2**, 277 (1881). (c) Schenck, *Z. physiol. Chem.*, **77**, 328 (1912).

(3) Smith and Anzelmi, THIS JOURNAL, **57**, 2730 (1935).