methyl tin. Small quantities of methane and unsaturated hydrocarbons are also formed.

PROVIDENCE, RHODE ISLAND

[CONTRIBUTION FROM THE UNITED COLLEGE OF ST. SALVATOR AND ST. LEONARD, UNIVERSITY OF ST. ANDREWS]

THE COUPLING OF GLUCOSE AND GAMMA-FRUCTOSE. CONVERSION OF SUCROSE INTO ISO-SUCROSE

BY JAMES COLQUHOUN IRVINE AND JOHN WALTER HYDE OLDHAM

RECEIVED JULY 19, 1929 PUBLISHED DECEMBER 11, 1929

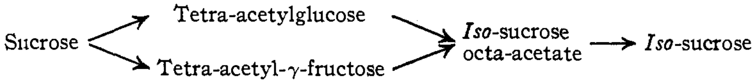
From the theoretical standpoint the primary condition necessary for the synthesis of sucrose is to have in hand an equimolecular mixture of tetra-acetylglucose and tetra-acetyl-γ-fructose which can be subjected to the action of a dehydrating agent. In a previous paper[1] we have described the results obtained when the required γ-form of tetra-acetylfructose was prepared both from fructose and from inulin but when the compound was condensed with tetra-acetylglucose the only crystalline product isolated by us was not the octa-acetate of sucrose but the corresponding derivative of a new disaccharide which we termed "*iso*-sucrose." This failure to synthesize sucrose octa-acetate cannot be attributed to faulty manipulation in the sense that traces of acids had decomposed any sucrose derivatives which had been formed. Nor can it be ascribed to the use of a fructose acetate containing an oxygen ring in a different position from that present in the fructose component of sucrose. In our former work we established, and have since confirmed, the fact that *iso*-sucrose is much more readily hydrolyzed by acids than sucrose itself, and the ready isolation of the *less stable* disaccharide is a guarantee that the more stable isomeride had not been decomposed. Lest it be maintained that the tetra-acetylfructose used by us was not the same γ-form as is present in sucrose, we have now varied the procedure so as to ensure that this objection cannot apply.

When sucrose octa-acetate is acted on by acetyl bromide dissolved in glacial acetic acid, the disaccharide is ruptured into its components and the product consists of an equimolecular mixture of tetra-acetylglucose and tetra-acetyl-γ-fructose. It might reasonably have been expected that such a mixture would represent the ideal starting material for the synthesis of sucrose, but all attempts to re-condense the constituents by the action of phosphoric anhydride have again resulted in the formation of crystalline *iso*-sucrose octa-acetate. As before, the reaction yielded syrupy acetates of disaccharides other than *iso*-sucrose and, on occasions, *iso*-trehalose octa-acetate was isolated, but despite numerous variations in procedure no evidence has been obtained of the formation of sucrose

---

[1] Irvine, Oldham and Skinner, THIS JOURNAL, **51**, 1279 (1929).

octa-acetate in this reaction. The series of changes may be summarized in the following scheme



The above scheme has been supplemented by using tetra-acetyl-γ-fructose derived from an entirely different source.

It will be recalled[2] that a tri-acetylanhydrofructose may be obtained from inulin tri-acetate and we find that this compound when treated with acetyl chloride and dry hydrogen chloride is converted smoothly into tetra-acetyl-γ-fructose showing the correct constants. The condensation of this tetra-acetyl-γ-fructose with tetra-acetylglucose by the agency of phosphoric anhydride once more gave *iso*-sucrose octa-acetate melting at 130–131°. Incidentally, this result shows that, in all probability, tri-acetylanhydrofructose contains one oxygen ring in the γ-position, and in this respect resembles the remainder of the inulin molecule.

Experimental

Action of Acetyl Bromide on Sucrose Octa-acetate.—The correct conditions for carrying out this reaction were established only after a large number of trial experiments had been made in which the concentration of the reagent and the time of the reaction were varied over wide limits. Owing to the destructive action of hydrogen bromide on fructose derivatives it is advisable to arrest the change when not more than one-half of the sucrose octa-acetate has been hydrolyzed.

A 5% solution of sucrose octa-acetate in glacial acetic acid containing 15% of acetyl bromide was maintained at the temperature of the room; the optical rotation increased steadily in the dextro-sense and at the end of approximately fifty hours the reaction was arrested by cooling in ice, diluting largely with acetic acid and thereafter adding powdered ice with active stirring. When all of the acetyl bromide was decomposed a solution of sodium acetate was added in slight excess of that required to neutralize the hydrogen bromide and the mixture was then warmed at 60° for forty-five minutes. Blank experiments showed that this treatment converts acetobromoglucose quantitatively into tetra-acetylglucose.

The cold solution was then extracted six times with chloroform, the material extracted being isolated, dissolved in benzene and the benzene solution thereafter extracted with water. The aqueous extract contained the desired mixture of glucose and fructose tetra-acetates. while unaltered sucrose octa-acetate remained in the benzene.

TABLE I

DATA SHOWING THE RELATIVE YIELDS UNDER DIFFERENT CONDITIONS

Concentration of sucrose octa-acetate, 5%; of acetyl bromide, 15%

No.	Acetate g.	Duration of expt., hours	Final $[\alpha]_D$	Total prod., g.	Extracted by C_6H_6, g.	Extracted by Water, g.
I	50	67	+123.8°	43.9	16.9	23.9
II	50	43	+104.2°	48.5	27.5	19.2

The procedure of Experiment II was adopted as the most satisfactory practical method.

---

[2] Irvine and Stevenson, THIS JOURNAL, **51**, 2197 (1929).

Examination of the Mixed Acetates of Glucose and Fructose.—On extracting the aqueous solution with chloroform and subsequent removal of this solvent, the mixed acetates remained as a colorless, viscous sirup. The acetyl content was 48.6%; calcd., 49.3%; in chloroform solution $[\alpha]_D = +58.0°$ for $c = 3.068$. From these results it is possible to calculate the relative proportions of tetracetyl-γ-fructose and tetra-acetylglucose in the mixture. The activity of tetracetyl-γ-fructose in chloroform shows slight variation but the average value for $[\alpha]_D$ is +34.5°. Applying this figure the above mixture should contain

Tetra-acetyl-γ-fructose	49.2%
Tetra-acetylglucose	50.8%

This composition was confirmed. A weighed quantity of the mixture (about 0.5 g.) was dissolved in water containing a little acetone and, after cooling in ice, a slight excess of 2 *N* sodium hydroxide was added. Twenty minutes later sufficient acid was added to make the solution approximately *N*/10 and the rotation was determined. Under the conditions specified the solution, which contained glucose and fructose, gave $[\alpha]_D = -17.7°$. Control experiments established that under the same conditions tetra-acetyl-γ-fructose gives the end-point $[\alpha]_D = -89.4°$, while that for tetra-acetylglucose is $[\alpha]_D$ +50.3°. It follows that the mixture of acetates under examination contained 48.5% of tetra-acetyl-γ-fructose as against 49.2% determined by the direct method.

Condensation of the Hexose Acetates.—This was carried out by the action of phosphoric anhydride as previously described.[1] The total product of the condensation showed the usual reducing action on Fehling's solution and from the mixture *iso*-sucrose octa-acetate (m. p. 129–131° $[\alpha]_D$ in chloroform +19.3°) was the only crystalline compound obtained. The identity of this product with the *iso*-sucrose octa-acetate previously described by us was confirmed.

Conversion of Triacetylanhydrofructose into Tetra-acetyl-γ-fructose.—Seven and four-tenths grams of crystalline triacetylanhydrofructose was dissolved in 74 cc. of acetyl chloride saturated with dry hydrogen chloride. The solution was preserved at the temperature of the room for six weeks, the rotation being determined at intervals until the darkening of the liquid interfered with accurate reading. The initial value, $[\alpha]_D$ +4.3°, increased to the approximate maximum of +55.2°, at which stage the acetyl chloride was removed in a vacuum. On taking up the product in glacial acetic acid, powdered ice was added and thereafter water, the system being kept homogeneous if necessary by the addition of more acetic acid. After extensive dilution with water the liquid was extracted six times with chloroform and, on removal of the solvent and thorough drying of the residue at 100° in a vacuum, the product was taken up in benzene. When the benzene solution was extracted with water, unchanged tri-acetylanhydrofructose (weight = 1.8 g.) remained behind and 4.09 g. of tetra-acetyl-γ-fructose passed into the solution, from which it was isolated in the usual way. Found: CH_3CO, 50.0%; n_D 1.4652; $[\alpha]_D$ in benzene +38.1° for $c = 4.9\%$; after alkaline hydrolysis in the cold, $[\alpha]_D$ calculated on the weight of hexose formed was −89.0°. The corresponding values for tetra-acetyl-γ-fructose prepared by other methods are: CH_3CO, 50.8% (calcd., 49.4%), n_D 1.4645; $[\alpha]_D$ in benzene +38.7° for $c = 5.4\%$; specific rotation on cold alkaline hydrolysis −89.4°. No description of the condensation of this specimen of tetra-acetyl-γ-fructose with tetra-acetylglucose is necessary as the procedure and results were the same as in former experiments.

Summary

1. Sucrose octa-acetate has been converted into an equimolecular mixture of tetra-acetylglucose and tetra-acetyl-γ-fructose.

2. This mixture when subjected to the condensing action of phosphoric anhydride has not yielded sucrose octa-acetate, the only crystalline product obtained being the octa-acetate of *iso*-sucrose.
3. Tri-acetylanhydrofructose has been converted into tetra-acetyl-γ-fructose, thereby proving that one oxygen ring in the former is in the same position which it occupies in the remainder of the inulin molecule.
4. Tetra-acetyl-γ-fructose obtained as described in 3 above has been condensed with tetra-acetylglucose. In this case also, *iso*-sucrose octa-acetate was the only crystalline derivative isolated.
5. In none of the condensations now described has any evidence been forthcoming that sucrose derivatives are formed.

ST. ANDREWS, SCOTLAND

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF DUKE UNIVERSITY]

PREPARATION OF AMINO-ACETAL

BY JOHANNES S. BUCK AND SAMUEL N. WRENN

RECEIVED JULY 19, 1929 PUBLISHED DECEMBER 11, 1929

Amino-acetal, $NH_2CH_2CH(OC_2H_5)_2$, on account of its reactivity and versatility, is a synthetic reagent of considerable importance. A search of the literature revealed only three reasonably promising methods, the reduction of nitro-acetal[1] by sodium and alcohol, the reduction of glycine ester by sodium amalgam to amino-acetaldehyde and the conversion of this into amino-acetal,[2] and the action of ammonia on the halogen acetals, which has been investigated by several different workers.[3]

No record was found of attempts to prepare amino-acetal in quantity. For this purpose the action of ammonia on the halogen substituted acetals was investigated. The authors have made use of a steel autoclave of 1100-cc. capacity, fitted with a special ammonia gage and having a working pressure of 1000 pounds. Provision was made for connecting the apparatus to an ammonia tank. With this apparatus a number of runs were made, using chloro-, bromo- and iodo-acetal, and varying the amount of ammonia, the time of heating and the temperature. Chloro- and bromo-acetal proved to be unsatisfactory on account of the low yield and the amount of tarry matter produced; iodo-acetal gave good results.

Experimental

Iodo-acetal was prepared by iodinating acetal in the presence of iodic acid, substantially as described by Hesse[4] and employed by Losanitsch.[5]

---

[1] Losanitsch, *Ber.*, **42**, 4044 (1909).

[2] Fischer, *ibid.*, **41**, 1019 (1908); Neuberg, *ibid.*, **41**, 956 (1908).

[3] Natterer, *Monatsh*, **5**, 507 (1884); Wohl, *Ber.*, **21**, 616 (1888); **39**, 1951 (1906); Wolff, *ibid.*, **21**, 1481 (1888); Marckwald, *ibid.*, **25**, 2354 (1892); Hartung and Adkins, THIS JOURNAL, **49**, 2517 (1927).

[4] Hesse, *Ber.*, **30**, 1442 (1897).

[5] Losanitsch, *ibid.*, **42**, 4044 (1909).