CVIII.—*Stereoisomeric Glucoses and the Hydrolysis of Glucosidic Acetates.*

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The Stereoisomeric α - and β -Glucoses.—In a previous communication on the correlation of the stereoisomeric α - and β -glucoses with the corresponding glucosides (Trans., 1903, 83, 1305), views were put forward

which have since been confirmed by the work of Behrend and Roth (*Annalen*, 1904, 331, 359) and quite recently by that of C. L. Jungius (*Proc. K. Akad. Wetensch. Amsterdam*, 1904, 779) on the isomeric pentacetates of glucose. There can no longer be any doubt that the supposed third (β) modification of glucose, described by Tanret, is a mixture; and that, in reality, his γ -form is the modification corresponding with the β -glucosides and therefore properly called β -glucose.

Exception has been taken by Lippmann (*Chemie der Zuckerarten*, 3rd edition, p. 1692) to the view that glucose in solution is a mixture of two stereoisomerides in equilibrium, on the ground that such a mixture, containing as it does varying amounts of α - and β -glucoses, must vary in properties according to the conditions under which the separation takes place. It is obvious that the proportion of the two forms in equilibrium in solution may be affected by factors such as changes in temperature, concentration, nature of the solvent, presence of foreign substances, &c. When separation takes place, however, the product will vary only in cases in which the conditions of deposition are sufficiently varied. In Tanret's experiments, either the entire mass of sugar in solution at the point of equilibrium was caused to separate as a whole, by precipitating with alcohol; or crystallisation was effected at a high temperature. In the latter case, the temperature selected (98°) by trial happened to be that which gave rise to an equilibrium identical with that secured prior to the precipitation by alcohol; by working under conditions different from those adopted by Tanret it is easy to obtain mixtures differing from his. Above 98° , the β -form predominates, at lower temperatures the α -modification is in excess.

Although Behrend and Roth, Jungius and Lobry de Bruyn, Lowry and we are now all in agreement as to the nature of Tanret's β -glucose and its non-existence as an entity, there is some doubt as to the nature of the product in solution. Lowry, in a recent communication (*Proc.*, 1904, 20, 108), goes so far as to suggest that together with the α - and β -forms, a saturated solution of glucose in water contains a large proportion of a third form—probably the aldehyde-hydrate. Although, in order to explain the results arrived at by Lobry de Bruyn, it is apparently necessary to admit that this form is present, yet in view of the fact that aldehydic properties are scarcely manifest, it appears highly improbable that more than relatively very small proportions can co-exist with the two γ -oxide or pentaphane forms.*

The Isomeric Glucose Pentacetates.—The opinion was expressed in a former paper (*ibid.*, p. 1310) that the conversion of α - and β -glucose pentacetates into one another did not involve the rupture

* In a former paper, having the expression "lactonartig" in mind, I somewhat incorrectly referred to glucose and the glucosides as γ -lactones.—[E. F. A.]

of the γ -oxide ring. Jungius has recently put forward most important evidence on this point, in showing that it is possible to convert one form into the other in the absence of acetic anhydride, merely by adding to the solution of the acetate in chloroform a small amount of sulphur trioxide.*

It may be pointed out that in preparing α -glucose pentacetate, somewhat prolonged boiling of the solution containing zinc chloride is necessary in order to reduce the quantity of the β -acetate to the lowest possible minimum. Prior to the appearance of Behrend and Roth's communication, one of us had attempted to prepare the α -acetate by instantaneous acetylation of α -glucose, by adding crystalline α -glucose to boiling acetic anhydride containing a catalyst,

in every case, however, the two acetates were formed.

The phenomena attending the crystallisation of the mixed acetates from a solvent such as alcohol are perhaps more easily followed when expressed graphically.

If A and B represent solutions saturated in presence of the α - and β -pentacetates and C the solution saturated in presence of both isomerides, the composition of any solution containing both compounds will be represented by a point on the accompanying diagram, unsaturated solutions being indicated by points within the figure, saturated solutions by points along the lines AC and BC , supersaturated solutions by points outside ACB . Solutions represented by points to the left of OC will deposit only the α -, whilst those to the right will deposit only β -pentacetate, on removal of the solvent. As one of these forms crystallises out, the relative proportion of the other form present will increase until finally the solution has the composition represented at C . A mixture of the α - and β -forms in the proportion in which they are in solution will then separate and continue to do so until the solution dries up: this mixture constitutes Tanret's supposed third isomeride; obviously such a mixture will be unchanged by recrystallisation from the same solvent. The crystallisation of α - and β -glucoses can be represented in the same manner.—[E. F. A.].

* It is open to question whether this is the effective agent, as chloroform is decomposed by sulphur trioxide :

(H. E. Armstrong, *Proc. Roy. Soc.*, 1870, 18, 506).

Hydrolysis of Glucosidic Acetates.

The experiments described in this section were undertaken in order to extend the data available for the consideration of the influence of configuration on properties in the case of the sugars.

The rate at which hydrolysis takes place, in the case of the pentacetates of glucose and several similar compounds in alcoholic solution, has already been studied by Kreman (*Monatsh.*, 1902, 23, 479); the curves expressing the results which he has put forward are so irregular that it is obvious that the determinations were but roughly approximate and scarcely sufficient to justify the conclusion at which he arrived that the isomeric pentacetates of glucose are hydrolysed at equal rates.

As a matter of fact, it is very difficult to obtain exact results. Hydrolysis is very easily effected and it is necessary, owing to the insolubility of the acetates in water, to dissolve them in alcohol in order to secure admixture with the alkali. In the earlier experiments, the alcoholic solution of the acetate was added to a dilute aqueous solution of alkali, the result being that sufficient heat was developed to raise the temperature of the solution considerably and as the action is half completed within a few minutes, initial errors in the adjustment of the temperature exercise a very considerable influence on the results. This difficulty has been, in part, overcome by using dilute alcohol (33 per cent.) and cooling both the alcoholic solution and the alkali before admixture below the temperature (10°) at which the interaction was allowed to proceed. Samples were withdrawn at intervals and mixed as quickly as possible with excess of cold acid.

The results obtained with the three pentacetates are recorded in the following table, x being the amount of alkali neutralised in the successive intervals of time, the values being the means of two concordant experiments; K the velocity coefficient calculated according to the equation:

$$K = \frac{1}{(a-b)t} \log \frac{(a-x)b}{(b-x)a},$$

where a is the concentration of the alkali and b that of the pentacetate. a , b , and x are conveniently expressed in terms of $N/50$ acid. Thus 10 c.c. of the alkali were equivalent to 9.5 c.c. ($=a$) of the acid solution, whilst the acid value of the pentacetate in the same volume was 6.6 ($=b$). In each experiment, 0.3 gram of pentacetate was dissolved in 50 c.c. of alcohol and 100 c.c. of water, cooled to 8° ; to this mixture, 100 c.c. of $N/25$ sodium hydroxide were added.

TABLE I.

Time in minutes.	α -Glucose pent-acetate.		β -Glucose pent-acetate.		β -Galactose pent-acetate.	
	x .	K .	x .	K .	x .	K .
2	1.0	0.00397	1.0	0.00397	1.25	0.00521
5	1.85	0.00336	1.9	0.00341	2.25	0.00444
10	2.65	0.00279	2.6	0.00271	3.075	0.00354
15	3.125	0.00242	3.15	0.00245	3.5	0.00299
20	3.425	0.00213	3.45	0.00216	3.8	0.00263
30	3.85	0.00177	3.85	0.00177	4.2	0.00217
40	4.1	0.00152	4.15	0.00156	4.5	0.00191
50	4.4	0.00142	4.4	0.00142	4.7	0.00168
65	4.675	0.00127	4.7	0.00129	4.875	0.00146
90	5.1	0.00118	5.05	0.00115	5.3	0.00137
∞	6.6	—	6.6	—	6.6	—

The accuracy attained is best gauged by inspection of the following curve in which the values of x are plotted against those of t . As the

experimental points all fall on a smooth curve, the results compare favourably with the irregular values obtained for the three compounds by Kreman.

It will be seen that the values of x and K given by the isomeric α - and β -pentacetates are identical and that β -galactose pentacetate

is hydrolysed considerably faster than the other two esters. Moreover, the value of K is not constant but decreases as change proceeds, which is an indication that the acetyl groups are not separated at the same rate.

In order to obtain further evidence as to the manner in which the acetyl groups are removed, the experiments were extended to the hydrolysis of the tetracetates of the isomeric α - and β -methylglucosides and galactosides. In this case, 0.3 gram of acetate having been dissolved in 5 c.c. of alcohol, 100 c.c. of water were added and the solution was then mixed with 100 c.c. of $N/25$ alkali. No rise in temperature was observed. The results are recorded in the following table, the values of x being derived from at least two experiments in each case. The value of K is calculated as before; $a = 8.7$, $b = 7.9$.

TABLE II.

T . Time in minutes.	x .					K .
	α -Methyl- glucoside.	α -Methyl- galactoside.	β -Methyl- glucoside.	β -Methyl- galactoside.	Mean value.	
2	2.3	2.25	2.2	2.25	2.25	0.00976
4	3.8	3.6	3.6	3.6	3.6	0.01007
6	4.6	4.5	4.4	4.55	4.5	0.01030
10	5.6	5.4	5.35	5.4	5.42	0.00996
15	6.1	5.9	5.7	6.0	6.0	0.00920
20	6.35	6.3	6.1	6.3	6.3	0.00840
30	6.6	6.65	6.5	6.65	6.6	0.00693
40	6.8	6.85	6.8	6.85	6.85	0.00638
50	6.9	6.925	6.9	6.925	6.925	0.0055
60	7.0	7.0	7.0	7.0	7.0	0.0048
∞	7.9	7.9	7.9	7.9	7.9	—

It will be seen that the four compounds are hydrolysed practically at one and the same rate, a fact of special interest when it is remembered that the acetyl groups occupy similar positions in them all. Bearing in mind the difficulty in arriving at exact results, it would seem that hydrolysis takes place at a nearly uniform rate up to the period when change is about three-fourths complete, K having a fairly constant value; that towards the close, however, change proceeds far less rapidly. It may therefore be supposed that the partially acetylated compounds are more stable than the fully acetylated—a not improbable conclusion.

Inasmuch as Kreman has shown that the behaviour of the oct-acetates of lactose and maltose is similar to that of the glucose pentacetates in that the value of K decreases with time, the behav-

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four of sucrose octacetate was of peculiar interest. The results obtained are given in the following table; the quantities used were the same as in the case of the tetracetates.

TABLE III.

<i>t</i> .	<i>x</i> .	<i>K</i> .
2 minutes	2.4	0.0106
4 "	3.8	0.0111
6 "	4.4	0.0099
10 "	5.4	0.0098
15 "	6.0	0.0093
20 "	6.2	0.0079
30 "	6.7	0.0075
40 "	7.0	0.0073
50 "	7.2	0.0072
60 "	7.3	0.0068
∞ "	7.9	—

The results appear to indicate that no distinction is to be drawn between the behaviour of the acetyl groups in the sucrose octacetate and those contained in the acetates of the glucoses from which it is derived.

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