2. Methyl *p*-toluenesulfonate has been found to be a fairly general reagent and to be particularly useful in the case of ring nitrogen compounds.

URBANA, ILLINOIS

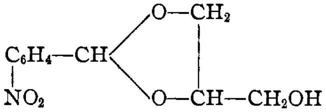
[COMMUNICATION FROM THE DEPARTMENT OF INDUSTRIAL AND CELLULOSE CHEMISTRY, McGILL UNIVERSITY]

STUDIES ON REACTIONS RELATING TO CARBOHYDRATES AND POLYSACCHARIDES. XXIV. RING MIGRATION IN THE GLYCEROL CYCLIC ACETALS. BEHAVIOR OF PARA-NITROBENZYLIDENE GLYCEROL[1]

BY HAROLD HIBBERT, MURIEL E. PLATT AND NEAL M. CARTER

RECEIVED JULY 27, 1929 PUBLISHED DECEMBER 11, 1929

The close structural relationships existing between cyclic acetals on the one hand and carbohydrates, anhydro sugars and polysaccharides on the other has been emphasized frequently in this series of communications.[2] The present investigation deals with the interconversion of the 5- and 6-membered *p*-nitrobenzylidene glycerols



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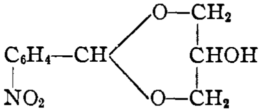

B

It has been found, in accordance with previous work carried out on the benzylidene and methylidene glycerols,[3,4] that in the presence of a trace of dry hydrochloric acid gas the six-membered derivative (B) is readily converted into an equilibrium mixture of the five- and six-membered isomers. By carrying out the reaction at 100° for one and a half hours, an equilibrium is apparently reached in which the proportion of 6:5-membered acetals is represented by 1:2.

In a second series of experiments, carried out by heating the crystalline six-membered acetal (B) with dilute hydrochloric acid ($N/10$) in a sealed tube at 100° for varying lengths of time, it was found that after about an hour an equilibrium mixture was obtained in which the six- and five-membered rings were present in the ratio of 0.37:1. In this series of experiments certain discrepancies came to light in that, for example, discordant results were obtained if the crystalline 6-membered acetal recovered

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[1] Constructed from the thesis of Muriel E. Platt as presented to the Graduate School of McGill University in June, 1929, in candidacy for the degree of Master of Science.

[2] Hibbert and co-workers, THIS JOURNAL, **45**, 734 (1923); **50**, 2235, 2242 (1928); **51**, 620 (1929).

[3] Hibbert, Whelen and Hill, *ibid.*, **50**, 2235 (1928).

[4] Hibbert and Carter, *ibid.*, **50**, 3120 (1928).

from one equilibrium experiment was used, without complete purification, for the following one. The explanation of this is probably to be found in the fact that the *p*-nitrobenzylidene glycerols exist in *cis* and *trans* forms. It was also found that while equilibrium was established after approximately a one-hour period, that this was far from being realized when the time interval fell slightly below sixty minutes. Using, however, the same pure, crystalline, *p*-nitrobenzylidene six-membered isomer (m. p. 93.5°) for each experiment, values were found as represented graphically on the accompanying curve.

The results obtained indicate the pronounced tendency of each of the two rings to pass over into an equilibrium mixture in presence of acid, and serve not only as a further illustration of "Michael's Partition Principle," but also for the necessity of avoiding acid media when conducting experiments designed to throw light on the structure of glycerol acetals, and by analogy, on carbohydrates, anhydro sugars and polysaccharides.

Experimental

Preparation of 1,3-*p*-Nitrobenzylidene Glycerol (2-*p*-Nitrophenyl-5-*m*-dioxanol).—The procedure adopted for the preparation of this compound was that developed by Hibbert and Carter.[5] A mixture of 50 g. of *p*-nitrobenzaldehyde, 33.1 g. of glycerol (3% excess over the theoretical amount) and three drops of 40% sulfuric acid as catalyst gave 29.3 g. of the 1,3-*p*-nitrobenzylidene glycerol melting at 93°; yield, 58.8%.

Interconversion of the 5- and 6-Membered Rings by the Action of Dry Hydrogen Chloride.—Two-gram samples of freshly recrystallized 1,3-*p*-nitrobenzylidene glycerol were mixed with 0.01% of their weight of dry hydrogen chloride in sealed tubes and allowed to stand for one and a half hours at 100°. The product, in each case, was then cooled to room temperature, diluted with 20 cc. of benzene and the acid neutralized with fused potassium carbonate. The solvent was removed under reduced pressure. The weight of the mixture of 1,3- and 1,2-acetals recovered was 1.2 g. The mixture was taken up in benzene and allowed to crystallize at 0° in order to isolate the 6-membered isomer. The weight of the crystalline unchanged 1,3-material was 0.4 g. The ratio of 6- to 5-membered acetal thus obtained is approximately 1:2. The low yields are presumably due to ring scission and formation of *p*-nitrobenzaldehyde and glycerol, as shown later in the experiment with $N/10$ hydrochloric acid.

Interconversion of the 5- and 6-Membered Cyclic Acetal Rings by Very Dilute Hydrochloric Acid.—Five-gram samples of 1,3-*p*-nitrobenzylidene glycerol, to which had been added 0.4 g. of $N/10$ hydrochloric acid (thus introducing the theoretical quantity of water necessary for hydrolysis of the sample) were shaken vigorously and continuously in sealed ampules at 100° for varying lengths of time. This was carried out as follows. The crystalline isomer was melted before the acid was added, the ampule sealed and then placed in the shaking apparatus. At the expiration of the given time interval, the ampule was immediately plunged into a cooling bath (−12°) to prevent further reaction. Those samples which had been heated for periods of fifteen and thirty minutes, respectively, solidified on cooling, while those heated for a longer period of time yielded a very viscous oil, thus indicating a partial conversion to the liquid isomer. The contents in each case were dissolved in 250 cc. of benzene, the trace of acid present was neutralized by shaking with 1 cc. of a dilute solution of potassium

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[5] Hibbert and Carter, This Journal, **50**, 3376 (1928).

bicarbonate, the benzene solution cooled to 10° (to prevent any change in the equilibrium) and then shaken with a cold saturated solution of sodium bisulfite to remove the *p*-nitrobenzaldehyde. The formation of an addition product indicated that some of the latter had been formed during the reaction. The free glycerol, which is insoluble in benzene, remained in the mother liquor. After drying the benzene solution over solid potassium carbonate, the solvent was removed under diminished pressure and the total amount of the 5- and 6-membered acetals determined.

The separation of the two isomers was carried out by dissolving the product in 25 cc. of warm benzene and cooling the solution for two hours at −12°. The frozen mixture was allowed to stand at room temperature for half an hour, the crystals of the 6-membered acetal filtered off at room temperature, dried and weighed. The weight of the 5-membered acetal formed was determined by difference and the ratio of 6- to 5-membered acetal calculated. The solubility of the 6-membered acetal in benzene at 22° is slight, namely, one part in one hundred and fifty.

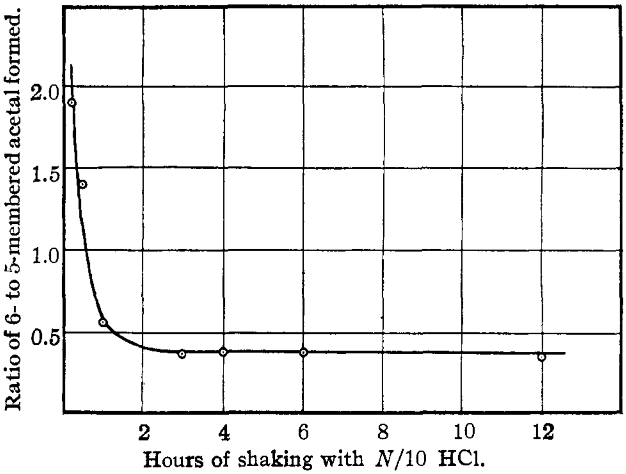

Fig. 1.

The results of the experiments are given in Table I and shown graphically on the accompanying curve (Fig. 1).

Table I

Results of Experiments

Time of heating, hrs.	0.25	0.5	1	3	4	6	12
Wt. of sample, g.	5	5	5	5	5	5	5
Comb. wt. of acetals, g.	3.4	3.1	3.6	3.3	3.35	3.6	3.1
6-Membered acetal, g.	2.25	1.8	1.3	0.9	0.9	1.0	0.8
5-Membered acetal, g.	1.15	1.3	2.3	2.4	2.45	2.6	2.3
Equil. ratio, 6:5 rings	1.9:1	1.4:1	0.56:1	0.37:1	0.38:1	0.38:1	0.35:1

Summary

1. The six-membered cyclic acetal, *p*-nitrobenzylidene glycerol, is converted, in the presence of dry hydrochloric acid gas at 100°, into an equilibrium mixture of itself with the five-membered isomer, the ratio of the former to the latter being 1:2.

2. Under similar conditions but using dilute hydrochloric acid at 100°, an equilibrium is obtained after about one hour in which the ratio of six- to five-membered acetal is 0.37:1.

3. The results indicate the ease of transformation of oxygen rings in cyclic acetals and, by analogy, point to similar conditions in the case of furanose and pyranose rings in carbohydrates, anhydro sugars and polysaccharides.

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[COMMUNICATION FROM THE DEPARTMENT OF INDUSTRIAL AND CELLULOSE CHEMISTRY, McGILL UNIVERSITY]

STUDIES OF REACTIONS RELATING TO CARBOHYDRATES AND POLYSACCHARIDES. XXV. METHYLATION PROCESSES AND TENDENCY TOWARD RING SHIFT IN GLYCEROL CYCLIC ACETALS

BY HAROLD HIBBERT, MURIEL E. PLATT[1] AND NEAL M. CARTER

RECEIVED JULY 27, 1929 PUBLISHED DECEMBER 11, 1929

In the methylation of sugars and their derivatives two methods have been employed: (1) the use of silver oxide and methyl iodide, as first originated by Purdie and developed with so much success by Irvine,[2] and (2) the use of dimethyl sulfate and sodium hydroxide, developed by Denham and Woodhouse[3] in the methylation of cellulose, and later applied by Haworth[4] in the methylation of sugars.

The silver oxide method has had a very wide application, the reaction being carried out in neutral solvents. Thus methylated aldosides, obtained by treating glucosides dissolved in methyl alcohol, with methyl iodide and dry silver oxide yielded on hydrolysis the methyl ethers of the respective aldoses.

It has been established that under these mild experimental conditions profound changes, such as racemization, the Walden Inversion or the interconversion of glucosides (α- and β-forms) do not occur. On the other hand, conclusive evidence, to some extent, is lacking as to the total absence of (a) the migration of a methyl group and (b) ring scission and ring migration.

The employment of the expensive alkyl iodides and silver oxide, as well as the necessity for finding a suitable solvent for the carbohydrate in the initial stages of the reaction, prevented a wide and general application of

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[1] Constructed from the thesis of Muriel E. Platt as presented to the Graduate School of McGill University in June, 1929, in candidacy for the degree of Master of Science.

[2] Purdie and Irvine, *J. Chem. Soc.*, **83**, 1021 (1903).

[3] Denham and Woodhouse, *ibid.*, **103**, 1735 (1913).

[4] Haworth, *ibid.*, 107, 8 (1915).