CCCXXVII.—*The Structure of Normal Monosaccharides. Part VI.* 2 : 3 : 4-*Trimethyl Rhamnonolactone.*

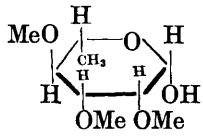
By JOHN AVERY and EDMUND LANGLEY HIRST.

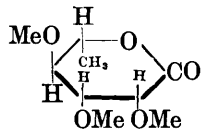
IN continuation of these studies (see Hirst and Macbeth, J., 1926, 22) 2 : 3 : 4-trimethyl rhamnose has been submitted to oxidation with bromine water and converted into crystalline l-2 : 3 : 4-*trimethyl rhamnonolactone*. The rate of hydrolysis of this lactone was studied and its velocity coefficient determined. The lactone attains equilibrium with the acid in aqueous solution after 60—80 hours, and approximately 64% of lactone is then present. The substance behaves, therefore, like other δ-lactones of the sugar series, the rate of hydrolysis being similar to that of trimethyl δ-xylonolactone and tetramethyl δ-mannonolactone.

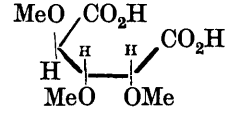
The velocity of lactonisation of 2 : 3 : 4-trimethyl rhamnonic acid was similarly studied and, for the purpose of comparison with the graphs already published for a series of twelve representative lactones (Drew, Goodyear, and Haworth, J., 1927, 1237; Haworth and Porter, J., 1928, 611), the curves may be constructed from the figures now recorded for trimethyl δ-rhamnonolactone.

The *phenylhydrazide* of l-2 : 3 : 4-*trimethyl rhamnonic acid* was obtained as a crystalline substance by the additive combination of the lactone with phenylhydrazine.

The constitution of the above lactone was controlled by oxidation to *l*-trimethoxyglutaric acid, the crystalline methylamide of which was identical with a specimen prepared by Haworth and Jones (J., 1927, 2349) from *l*-trimethyl δ-arabonolactone.


l-2 : 3 : 4-Trimethyl rhamnose.


l-2 : 3 : 4-Trimethyl δ-rhamnonolactone.


l-Trimethoxyglutaric acid.

These experimental results confirm the constitution which has been allocated to the normal methylrhamnosides during earlier studies, and it is clear that these products must be represented as pyranose forms having a six-atom ring system.

EXPERIMENTAL.

1-2 : 3 : 4-*Trimethyl Rhamnonolactone.*—Rhamnose was methylated by the methyl sulphate method, the physical and chemical properties of the trimethyl methylrhamnoside and trimethyl rhamnose obtained being identical with those of former preparations (Hirst and Macbeth, *loc. cit.*). Bromine was gradually added to a solution of trimethyl rhamnose (3·3 g.) in water (45 c.c.), maintained at 40°, until the reducing action on Fehling's solution had disappeared. After removal of the excess of bromine by aeration the solution was neutralised with silver oxide and filtered. Treatment with hydrogen sulphide, followed by filtration (charcoal), gave a clear colourless solution of trimethyl rhamnonic acid. Evaporation of the water at 40°/19 mm. gave a syrup, which was heated at 70°/0·2 mm. for 6 hours to complete the formation of lactone. The product (2·9 g.) gave on distillation (*a*) 2·6 g., b. p. 96°/0·15 mm.; (*b*) 0·3 g., b. p. 96—110°/0·11 mm. Both fractions crystallised. This *trimethyl δ-rhamnonolactone* was spread on porous earthenware and kept in a vacuum desiccator over phosphoric oxide for several days; it then had m. p. 40—41°, and $[\alpha]_D^{18°}$ — 130° (initial value) and $[\alpha]_D^{18°}$ — 78° (equilibrium value), both in water (c = 1·25). The material separated in an oily condition from solutions and could not be recrystallised (Found: C, 52·3; H, 8·0; OMe, 44·4. $C_9H_{16}O_5$ requires C, 52·9; H, 7·8; OMe, 45·6%).

The *phenylhydrazide* of *l-trimethyl rhamnonic acid* was prepared by heating together on the water-bath trimethyl rhamnonolactone (0·21 g.) and phenylhydrazine (0·11 g.), dissolved in a little dry ether, for 20 minutes. The residue, which crystallised immediately when the solvent had evaporated, was washed with cold ether and recrystallised from ether or benzene, giving long needles, m. p. 177° (Found: C, 57·9; H, 7·5; OMe, 29·8. $C_{15}H_{24}O_5N_2$ requires C, 57·7; H, 7·7; OMe, 29·8%).

Rate of Hydration of l-Trimethyl δ-Rhamnonolactone.—The velocity

of hydrolysis of the lactone in aqueous solution was determined polarimetrically, equilibrium being reached in about 140 hours and the mean value of $k_1 + k_2$ being 0·015, at 18° (time in hours, and logarithms to the base 10). The specific rotation of 2 : 3 : 4-trimethyl rhamnonic acid was obtained in the usual way : a weighed amount of the lactone was dissolved in excess of warm sodium hydroxide solution, after 20 minutes an amount of hydrochloric acid equivalent to the alkali was added to the cooled solution, and the rotation was observed immediately, $[\alpha]_D^{21°}$ + 14·5° (c = 1·140, calculated as lactone). The proportions of lactone and acid present at equilibrium were therefore 64% and 36%, respectively.

Time (hrs.).	$[\alpha]_D^{18°}$.	% Lactone.	Time (hrs.).	$[\alpha]_D^{18°}$.	% Lactone.
0	−130°	100	42	−89·5°	72
1	126	97	61	84	68
12	115	90	85	81·4	66
21	104	82	140	78·2	64
36	92	74	300	78·2	64

The velocity of lactonisation of the acid was also studied polarimetrically. Equilibrium was reached in about 50 hours at 21°. The greater velocity of reaction cannot be ascribed to the small difference of temperature between the two sets of observations and it is probably due to the catalytic action of the extraneous material present in the solution during the latter experiments.

Time (hrs.).	$[\alpha]_D^{21°}$.	% Lactone.	Time (hrs.).	$[\alpha]_D^{21°}$.	% Lactone.
0	+14·5°	0	21	−56°	46
1	+ 7·9	5	39	−73	58
2	+ 1·3	10	52	−79	63
15	−42	36	200	−79	63

Oxidation of l-*Trimethyl* δ-*Rhamnonolactone with Nitric Acid.*—A solution of crystalline trimethyl rhamnonolactone (1·25 g.) in nitric acid (12·5 c.c.; d 1·42) was heated at 70° for 15 minutes while a vigorous reaction took place. Afterwards the temperature was raised gradually to 95° and kept there for 2 hours. Oxidation had then ceased. After removal of the nitric acid by distillation under diminished pressure, with frequent additions of water, the product was dried and then esterified by boiling for 7 hours with acid methyl alcohol (50 c.c. containing 1 g. of hydrogen chloride). The resulting ester gave on distillation 0·85 g., b. p. 87°/0·11 mm., $n_D^{17·5°}$ 1·4363, $[\alpha]_D^{20°}$ + 41° in methyl alcohol (c = 1·15). These observations agree closely with those recorded for methyl arabotrimethoxyglutarate (Hirst and Smith, J., 1928, 3147), and complete proof of the identity of the ester was obtained by converting it into the corresponding crystalline amide and methylamide. A solution of the ester (0·25 g.) in cold methyl alcohol (2 c.c.) saturated with methylamine was kept for 48 hours. The methyl alcohol and the remaining

methylamine were then removed by evaporation in a vacuum desiccator and the solid residue was recrystallised from ethyl acetate–ether, giving needles, m. p. 171—173° alone or when mixed with an authentic specimen of the methylamide of *l*-arabotrimethoxyglutaric acid (Haworth and Jones, *loc. cit.*). The yield of pure product was 60% of the theoretical. The corresponding amide was prepared by treating the ester, in the usual manner, with methyl-alcoholic ammonia. The product after recrystallisation from absolute alcohol–light petroleum had $[\alpha]_D$ + 50° in water ($c = 0{\cdot}4$), m. p. 227—230° (decomp.), and comparison with an authentic specimen showed it to be the diamide of *l*-arabotrimethoxyglutaric acid (Hirst and Robertson, *loc. cit.*). Yield, 0·08 g. from 0·10 g., or 90% of the theoretical.

The authors wish to express their thanks to Professor W. N. Haworth, F.R.S., for his interest in this work.

UNIVERSITY OF BIRMINGHAM,
EDGBASTON.

[*Received, August* 31*st*, 1929.]