LXXXVIII.—*Derivatives of Lyxofuranose.*

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SINCE the normal variety of trimethyl lyxose obtained by methylating α-methyl-lyxoside can be transformed successively into a δ-lactone and *d*-trimethoxyglutaric acid (J., 1928, 3147), normal

derivatives of lyxose must belong to the pyranose type of sugar compounds. This conclusion is, however, in direct conflict with the opinions of Phelps and Hudson (*J. Amer. Chem. Soc.*, 1926, **48**, 503; 1928, **50**, 2049), who uphold the view that α-methyl-lyxoside is furanose in type. The arguments used by these authors are based entirely on optical relationships, and reasons have already been given (*loc. cit.*) for doubting their applicability in the present instance. The question has now been put to a further experimental test by the preparation of derivatives of lyxose which indubitably have the furanose structure. These new substances show no relationship to α-methyl-lyxoside but are, on the other hand, typical γ-sugar derivatives. Lyxose therefore falls completely into line with all the other aldoses and ketoses which have been examined, in giving a series of "normal" derivatives which are pyranose in type and a series of more labile γ-derivatives which have the furanose structure.

The study of methyl-lyxofuranoside is of particular interest in view of the important claims made by Irvine and Burt (J., 1924, **125**, 1343) concerning the instability of the closely related γ-methyl-mannoside. The latter substance is said to change spontaneously into the pyranose form and to yield by structural transformation a considerable proportion of the methylated pyranose variety on treatment with methyl sulphate and alkali. On this account we have examined the behaviour of methyl-lyxofuranoside with particular care. No such anomalous properties have been observed. The substance remains unchanged on being kept for prolonged periods, and methylation, either by methyl sulphate or by silver oxide and methyl iodide, proceeds without structural transformation. In view of these observations it seemed unreasonable to suppose that the configurationally related mannose derivative should differ so fundamentally, and experiments were instituted with "γ"-methylmannoside in order to decide this point. As a result we are convinced that Irvine and Burt's conclusions are erroneous, and that in fact neither methyl-lyxofuranoside nor methylmannofuranoside suffers ring displacement during methylation. The experimental evidence, in the case of the mannose derivative, is furnished in the preceding paper (Haworth, Hirst, and Webb).

The starting point of the present investigation was methyl-lyxofuranoside (II), which was prepared by the action of cold methyl-alcoholic hydrogen chloride on lyxose (I). The reaction was accompanied by a comparatively rapid rise in specific rotation, followed by a slow fall to a constant equilibrium value. A similar but more rapid series of changes was observed in hot solutions. When the reaction was stopped at the point of maximum rotation,

the product consisted mainly of methyl-lyxofuranoside, but at equilibrium the solution contained mainly normal α-methyl-lyxoside.

It is well known that similar reactions occur with other reducing sugars and that in certain cases, notably with galactose and arabinose, a rich proportion of the methyl-furanoside is present at equilibrium. Furthermore, the direct methylation of galactose by methyl sulphate and alkali gives a mixture of furanose and pyranose forms and it would be no matter for surprise should conditions be found under which the methylation of glucose by methyl sulphate would yield derivatives of glucofuranose (Whitnah, *J. Amer. Chem. Soc.*, 1929, **51**, 3490). This author apparently believes that structural determinations made by the methylation method may be rendered invalid by the tendency of the free sugars to yield derivatives of both the furanose and the pyranose type. It is therefore necessary to point out that the structures assigned to the methylglucosides and their derivatives do not depend on results obtained by methylating the free sugars, and that in consequence the observations of Whitnah can have no bearing on the different opinions held respectively by Hudson and by Haworth and the present authors concerning the structure of the methylglucosides.

Owing to the excessive solubility of lyxose and its derivatives, pure methyl-lyxofuranoside could not be obtained and the substance was examined in the form of a syrup, which contained both the α- and the β-form of methyl-lyxofuranoside (75%), together with free lyxose (15%) and methyl-lyxopyranoside (10%). Details of the method of analysis are given in the experimental section. Methyl-lyxofuranoside showed no tendency to change spontaneously into the pyranose form. It was very sensitive to dilute acids, hydrolysis being complete in less than 20 minutes with *N*/15-hydrochloric acid at 95°.

Treatment of the above mixture containing 75% of methyl-lyxofuranoside with methyl sulphate and alkali under conditions which ensured the destruction of free lyxose gave an excellent yield of the fully methylated derivative. This was a liquid which contained *trimethyl methyl-lyxofuranoside* (90%) (III) and trimethyl methyl-lyxopyranoside (10%). A mixture of similar composition was obtained by methylation with silver oxide and methyl iodide. It is obvious from these figures that no transformation of furanose derivative into pyranose took place during methylation. Trimethyl methyl-lyxofuranoside was very readily hydrolysed by dilute acids and by taking advantage of this property it was possible to obtain *trimethyl lyxofuranose* (IV) almost entirely free from the corresponding pyranose form. This was accomplished by hydrolysing the mixture of normal and γ-trimethyl methyl-lyxosides with *N*/15-

hydrochloric acid at 95°; the trimethyl methyl-lyxopyranoside then remained unaltered and was removed subsequently by fractional distillation. Trimethyl lyxofuranose was isolated as an uncrystallisable liquid with strong reducing properties, which condensed rapidly in the cold with methyl-alcoholic hydrogen chloride. When heated, trimethyl lyxofuranose underwent autocondensation, two molecules uniting with elimination of one molecule of water to give a crystalline non-reducing substance $C_{16}H_{30}O_9$, which was shown to be the *hexamethyl* derivative (V) of a non-reducing dipentose containing two lyxofuranose residues. The high value of the specific rotation, $[\alpha]_D^{20°}$ + 114° in water, would appear to show that both glucosidic groups are α- in configuration. No such autocondensation was observed with trimethyl lyxopyranose (Hirst and Smith, *loc. cit.*) and it is evident that the increased reactivity in the present case is to be ascribed to the presence of the furanose ring structure.

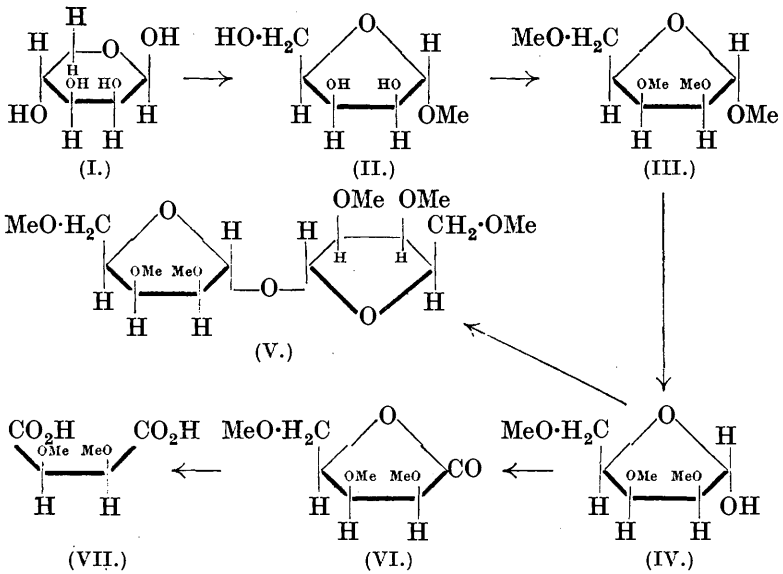
Tetramethyl mannofuranose may be expected to give in a similar way the octamethyl derivative of a disaccharide, and it is possible that this condensation may have been effected by Irvine and Burt (*loc. cit.*, p. 1348). Unfortunately, the evidence provided by these authors is insufficient to show whether the compound formed is similar in type to that described above, and the situation is further complicated by the fact that the product is referred to as tetramethyl dimannose. Even if this name is a misprint for octamethyl dimannose, there still remains the difficulty that the analytical composition of Irvine and Burt's substance corresponded to the formula $C_{16}H_{26}O_9$, which they ascribe to tetramethyl dimannose ($C_{16}H_{30}O_{11}$), but which in fact is the formula neither of that substance nor of octamethyl dimannose ($C_{20}H_{38}O_{11}$).

The structure of methyl-lyxofuranoside and its methylated derivatives was established by the preparation of crystalline trimethyl γ-lyxonolactone, obtained by the action of bromine water on trimethyl lyxofuranose. The phenylhydrazide prepared from this lactone was identical with the phenylhydrazide obtained from the trimethyl γ-lyxonolactone which had been prepared previously by epimerising trimethyl γ-xylonolactone (Haworth and Long, J., 1929, 345). Since the structure of the latter substance as a γ-lactone has been established (Haworth and Porter, J., 1928, 611), it follows that "γ"-methyl-lyxoside and its derivatives must belong to the furanose class.

The conversion of trimethyl γ-lyxonolactone into the acid proceeded so slowly in aqueous solution that after 1000 hours equilibrium was far from being attained. The conversion of acid into lactone was equally slow, and in consequence only an approximate

value can be given for the proportion of lactone present at equilibrium. This appeared to be about 55%. There is a marked resemblance in these respects between trimethyl γ-lyxonolactone and the stereochemically related tetramethyl γ-mannonolactone (Drew, Goodyear, and Haworth, J., 1927, 1237).

Confirmatory evidence concerning the structure of the trimethyl γ-lyxonolactone was obtained by methylating crystalline γ-lyxonolactone, which had been prepared by oxidising lyxose with bromine water. A comparison of the corresponding phenylhydrazides served to prove the identity of the trimethyl γ-lyxonolactone thus obtained with the material derived from methyl-lyxofuranoside. It will be seen by reference to the experimental section that the methylation of γ-lyxonolactone by silver oxide and methyl iodide is complicated by the tendency of the lactone ring to open in the presence of the water eliminated during the methylation process. From the silver lyxonate then formed, methylated derivatives of methyl lyxonate are obtained.



Still further evidence of the presence of a furanose ring structure in trimethyl methyl-lyxofuranoside was provided by oxidising the substance with nitric acid under conditions which give a quantitative yield of trimethoxyglutaric acid from trimethyl-lyxopyranose. In the present instance the product was mainly *i*-dimethoxysuccinic acid (VII), no trace of which is obtained under these conditions from trimethyl-lyxopyranose. The behaviour during the oxidation,

and the yield of *i*-dimethoxysuccinic acid, which was identified in the form of its crystalline methyl ester, conform exactly with observations recorded during similar oxidation experiments with other methylated furanose derivatives.

When the mixture containing methyl-lyxofuranoside (75%), methyl-lyxopyranoside (10%), and lyxose (15%) was methylated with silver oxide and methyl iodide the main product was, as indicated above, trimethyl methyl-lyxoside, but the process was accompanied by complex oxidative changes which were probably due to the action of silver oxide on the free lyxose present. In addition to trimethyl methyl-lyxoside there was obtained a small amount (4%) of a crystalline substance which analysis showed to be a *methyl* ester of formula $C_4H_5O_2(OMe)_2 \cdot CO_2Me$. The possibility that the molecular weight corresponds to some multiple of the simple formula $C_8H_{14}O_6$ has not been definitely excluded, but the low b. p. of the substance renders such a contingency very improbable. Further experiments are in progress by which it is hoped to determine the structure of this oxidation product.

EXPERIMENTAL.

Methyl-lyxofuranoside.—Polarimetric observations on a solution of lyxose in 1% methyl-alcoholic hydrogen chloride at 20° showed that the specific rotation increased gradually to a maximum value $[\alpha]_D^{20°} + 72°$ (10 hours) and thereafter decreased to a constant value $[\alpha]_D^{20°} + 42°$ (100 hours). Similar changes took place with more rapidity in hot solutions, and the final product was mainly α-methyl-lyxoside. Accordingly, lyxose (10 g.) was dissolved in cold 1% methyl-alcoholic hydrogen chloride (300 c.c.) and kept at 20° until the maximum value $[\alpha]_D^{20°} + 73°$ was attained (10 hours). The acid was then neutralised with silver carbonate, and the methyl alcohol removed at 30° under diminished pressure in the presence of a little silver carbonate. The syrup which remained was extracted three times with ethyl acetate at 20° and the extracts were evaporated to dryness at 30°/15 mm. A stiff syrup remained (10 g.) which was perfectly stable when kept in a dry atmosphere free from acid fumes. It contained methyl-lyxofuranoside, methyl-lyxopyranoside and free lyxose. $[\alpha]_D^{20°} + 62°$ in water ($c = 1{\cdot}07$).

On treatment with *N*/15-hydrochloric acid at 95° rapid hydrolysis of the methyl-lyxofuranoside took place: $[\alpha]_D^{20°} + 62°$ (initial); $-4°$ (10 mins.); $-6°$ (20 mins., constant value). The rate of hydrolysis is much more rapid than that of α-methyl-lyxoside under similar conditions (Phelps and Hudson, *loc. cit.*). The concentration of hydrochloric acid was then increased to *N*/2 and the heating continued. Hydrolysis of the pyranoside was complete in

50 minutes, the final rotation value being $[\alpha]_D^{20°}$ — 13° (calc. as free lyxose), which is very close to the recognised equilibrium value for lyxose.

The amount of free lyxose (15%) was estimated by the Willstätter–Schudel method (*Ber.*, 1918, **51**, 780; Goebel, *J. Biol. Chem.*, 1927, **72**, 801). Control estimations in which pure lyxose was used gave quantitative results. From the above figures, $[\alpha]_D$ + 40° being taken as the probable rotation value for the mixture of α- and β-methyl-lyxopyranosides, it was calculated that the reaction product consisted of free lyxose (15%), methyl-lyxopyranoside (10%), and methyl lyxofuranoside (75%) (Found: OMe, 16·8. Calc. for the above mixture, 15·9%).

Methylation of Methyl-lyxofuranoside by Methyl Sulphate.—The mixture described in the previous section was dissolved in acetone (6 g. in 15 c.c.) and treated in the usual manner with methyl sulphate (40 c.c.) and 30% aqueous sodium hydroxide (70 c.c.). The temperature ranged from 55—70° and excess of alkali was added at the beginning of the reaction to destroy the free lyxose. Methylation of the product (5·2 g.) was completed by the use of Purdie's reagents, and the resultant non-reducing syrup (5·2 g., $n_D^{17°}$ 1·4477) was distilled, giving a colourless hygroscopic liquid (4·8 g.), b. p. about 90°/0·06 mm., $n_D^{17°}$ 1·4457, $[\alpha]_D^{22°}$ + 52° in water (c = 0·6), $[\alpha]_D^{22°}$ + 41° in methyl alcohol (c = 1·3), $[\alpha]_D^{22°}$ + 52°, equilibrium value after heating with 1% methyl-alcoholic hydrogen chloride. In N/15-aqueous hydrochloric acid at 95° hydrolysis of the trimethyl methylfuranosidic portion of the distillate occurred rapidly: $[\alpha]_D^{20°}$ + 52° (initial value); + 48° (10 mins.); + 37° (30 mins.); + 34° (50 mins., constant value). After a further 50 minutes' heating with boiling N/2-hydrochloric acid the constant value $[\alpha]_D^{20°}$ + 31° (calculated as trimethyl methyl-lyxoside) was attained, the presence of a small amount of trimethyl methyl-lyxopyranoside being thus indicated. Since trimethyl lyxopyranose has $[\alpha]_D^{20°}$ — 22° (equilibrium value in water) and trimethyl lyxofuranose has $[\alpha]_D^{20°}$ + 39° (equilibrium value in water; see below), it follows that the quantities of *trimethyl methyl-lyxofuranoside* and trimethyl methyl-lyxopyranoside in the distillate were about 90% and 10% respectively (Found: C, 52·1; H, 8·6; OMe, 58·5. $C_9H_{18}O_5$ requires C, 52·4; H, 8·7; OMe, 60·2%).

Trimethyl Lyxofuranose.—The mixture (4 g.) of trimethyl methyl-lyxofuranoside and trimethyl methyl-lyxopyranoside was heated at 100° with N/15-hydrochloric acid (100 c.c.) until the rotation was $[\alpha]_D^{20°}$ + 32° (1 hour). Under these conditions hydrolysis of the pyranose form would be inappreciable. The solution was neutralised with silver carbonate, filtered, and evaporated under

diminished pressure to a mobile syrup, which was dissolved in ether. After removal of the ether the product was distilled, giving two fractions : (a) a mixture of trimethyl lyxofuranose and unhydrolysed trimethyl methyl-lyxopyranoside (0·83 g.), b. p. about 95°/0·04 mm., $n_D^{16°}$ 1·4531; (b) *trimethyl lyxofuranose* (2·3 g.), b. p. about 95°/0·04 mm., $n_D^{16°}$ 1·4580, $[\alpha]_D^{20°}$ + 39° in water (c = 1·05). This rotation is in good agreement with that obtained for trimethyl lyxofuranose by hydrolysis of a crystalline condensation compound (see below). Furthermore, only trimethyl γ-lyxonolactone was obtained by oxidation of the trimethyl lyxofuranose, which must therefore be free from contamination by its pyranose isomeride (Found : C, 49·8; H, 8·4; OMe, 48·1. $C_8H_{16}O_5$ requires C, 50·0; H, 8·3; OMe, 48·4%).

Trimethyl lyxofuranose condensed rapidly with methyl alcohol containing 1% of hydrogen chloride at 20° : $[\alpha]_D^{20°}$ + 15° (4 mins. after dissolution); + 13° (7 mins.); + 13° (10 mins.); + 14° (18 mins.); + 21° (30 mins.); + 36° (60 mins.); + 42° (90 mins.); + 45° (120 mins.); + 55° (300 mins.); + 60° (final equilibrium value). Under similar conditions the condensation of trimethyl lyxopyranose with methyl alcohol was very slow : $[\alpha]_D^{20°}$ — 9° (initial value); — 12° (150 mins.); — 18° (3000 mins.). The equilibrium value for the pyranose form is $[\alpha]_D^{20°}$ + 21° (Hirst and Smith, *loc. cit.*). In both cases the β-isomeride of the methyl-lyxoside is formed more rapidly than the α-variety.

Fraction (a) was hydrolysed by boiling for 30 minutes with 2*N*-hydrochloric acid. The distilled product (yield, 70%) was a colourless liquid, b. p. 95—100°/0·03 mm., $n_D^{15°}$ 1·4605, $[\alpha]_D^{21°}$ + 16° in water (c = 0·7) (Found : OMe, 46·5. Calc., 48·4%). These figures show that the distillate was trimethyl lyxose containing about 60% of the furanose form ($[\alpha]_D$ + 39°) and 40% of the pyranose form ($[\alpha]_D$ — 22°). This is equivalent to the presence of 11% of the pyranose form in the trimethyl methyl-lyxoside, in good agreement with the value 10% previously obtained.

Condensation of Trimethyl Lyxofuranose to give a Hexamethyl Dipentose.—When trimethyl lyxofuranose was distilled slowly, only a portion of it could be recovered unchanged. The remainder was a colourless liquid, b. p. about 160°/0·05 mm., which solidified on cooling. After being drained on porous earthenware and recrystallised from light petroleum (b. p. 40—60°), it gave bunches of needles, m. p. 77°, which had no action on boiling Fehling's solution but reduced it strongly after hydrolysis with 3% hydrochloric acid. During the hydrolysis the specific rotation, $[\alpha]_D^{20°}$ + 114° (initial value), decreased in 15 minutes to a constant value + 43° ($[\alpha]_D^{20°}$ + 41°, calculated as trimethyl lyxose). The physical and chemical

properties of the new substance indicated that it was the *hexamethyl* derivative of a non-reducing dipentose formed by the autocondensation of two molecules of trimethyl lyxofuranose and this view was confirmed by analysis (Found: C, 52·3; H, 8·0; OMe, 49·3. $C_{16}H_{30}O_9$ requires C, 52·4; H, 8·2; OMe, 50·8%).

Trimethyl γ-Lyxonolactone.—A solution of trimethyl lyxofuranose (1·6 g.) in water (20 c.c.) was treated with bromine (2 c.c.), and kept for 4 days at 35—40°: the reducing properties had then disappeared. The bromine was removed by aeration, an excess of silver oxide was added, and the filtered solution was titrated exactly with hydrochloric acid to liberate the trimethyl lyxonic acid from its silver salt. On evaporation under diminished pressure, followed by heating at 100°/10 mm. to complete the lactonisation, a syrup was obtained which was freed from some inorganic material by solution in ether. On removal of the solvent crystalline trimethyl lyxonolactone was obtained (1·4 g.) which on distillation gave a solid crystalline mass (1·3 g.), b. p. 170°/12 mm., m. p. 37—40°, $n_D^{18°}$ 1·4569, $[\alpha]_D^{20°}$ + 82·5° in water (initial value, decreasing with extreme slowness). Recrystallisation from ether–light petroleum (b. p. 40—60°) gave needles 4—5 cm. long, m. p. 44°, $[\alpha]_D^{20°}$ + 82·5° in water (c = 0·5) (Found: C, 50·5; H, 7·0; OMe, 49·3. Calc. for $C_8H_{14}O_5$: C, 50·5; H, 7·4; OMe, 49·0%).

If the trimethyl lyxofuranose had been contaminated with trimethyl lyxopyranose, the specific rotation of the freshly distilled lactone before recrystallisation would have been less than $[\alpha]_D^{20°}$ + 82°, owing to the presence of some trimethyl δ-lyxonolactone ($[\alpha]_D^{20°}$ + 35·5°). The above observations therefore provide additional evidence of the homogeneity of the trimethyl lyxofuranose.

When an ethereal solution of the lactone was heated with the calculated quantity of phenylhydrazine, the corresponding phenylhydrazide was formed. This was washed with ether and on recrystallisation from benzene gave needles, m. p. 140° alone or in admixture with the phenylhydrazide of the acid obtained by the epimerisation of trimethyl xylonolactone (Haworth and Long, *loc. cit.*) (Found: C, 56·2; H, 7·3; N, 9·6; OMe, 31·5. Calc. for $C_{14}H_{22}O_5N_2$: C, 56·4; H, 7·4; N, 9·4; OMe, 31·2%).

Hydrolysis of Trimethyl γ-Lyxonolactone.—The hydrolysis of the crystalline lactone in aqueous solution was studied polarimetrically. Mutarotation was extremely slow and the behaviour throughout was that of a γ-lactone. The rotation of the free acid was determined in the usual manner by forming the sodium salt, adding the equivalent amount of hydrochloric acid, and determining the rotation immediately. $[\alpha]^{20°}$ − 21° in water (c = 0·5, calculated as lactone).

Conversion of lactone into acid.

Time (hours).	$[\alpha]_D^{20°}$.	% of lactone present.	Time (hours).	$[\alpha]_D^{20°}$.	% of lactone present.
0	+82·5°	100	474	65·0°	83·0
24	80	97·6	551	63·9	82·0
73	77·7	95·3	644	62·3	80·4
145	75·1	92·8	883	57·0	75·3
378	67·1	85·1	1000	56·5	74·8

The conversion of the acid into lactone in aqueous solution proceeded so slowly that equilibrium had not been attained at the end of 500 hours. A direct determination of the proportion of acid and lactone present at equilibrium was therefore impracticable, but an approximate value (55% of lactone) was deduced by extrapolation.

Conversion of acid into lactone.

Time (hours).	$[\alpha]_D^{20°}$.	% of lactone present.	Time (hours).	$[\alpha]_D^{20°}$.	% of lactone present.
0	−20·8°	0	75	+ 6·4°	26
24	−16·0	4·6	140	14·4	34
50	− 4·4	16	500	25·6	45

Methylation of γ-Lyxonolactone.—Lyxonolactone was prepared from lyxose by heating the sugar with bromine water at 30° for several days. Hydrobromic acid was removed by means of silver oxide and the resulting solution of silver lyxonate was then treated with the exact quantity of hydrochloric acid required to precipitate the silver. Evaporation of the water in a vacuum left a syrup which soon crystallised and pure lyxonolactone, m. p. 109°, was obtained after one recrystallisation from ethyl acetate.

This lactone (2 g.) was methylated in the usual way with Purdie's reagents. Six consecutive treatments were carried out, the addition of methyl alcohol being necessary in the first three in order to effect solution. Fractional distillation of the final product showed that a complex mixture of substances had been formed. The following fractions were taken: (a) 0·14 g., bath temp. 107°/0·04 mm., $n_D^{14°}$ 1·4350; (b) 0·9 g., bath temp. 115°/0·08 mm., $n_D^{13°}$ 1·4372; (c) 0·27 g., bath temp. 125°/0·03 mm., $n_D^{12°}$ 1·4381; (d) 0·72 g., bath temp. 140—150°/0·03 mm., $n_D^{11°}$ 1·4484. The fractions (a), (b) and (c) were esteric in nature and contained substances which were more highly methylated than trimethyl-lyxonolactone, possibly methyl tetramethyl-lyxonate, $C_{10}H_{20}O_6$, and methyl trimethyl-lyxonate, $C_9H_{18}O_6$ [Found for (b): C, 49·5; H, 8·3; OMe, 64·5. $C_{10}H_{20}O_6$ requires C, 50·8; H, 8·5; OMe, 65·6%. $C_9H_{18}O_6$ requires C, 48·7; H, 8·1; OMe, 55·8%].

Fraction (d) was mainly trimethyl lyxonolactone (Found: C, 50·4; H, 8·3; OMe, 53·0%). It was not sufficiently pure to crystal-

lise, but the presence of trimethyl γ-lyxonolactone was proved by preparing from it the corresponding phenylhydrazide, which was formed in good yield when an ethereal solution of the liquid was heated on the water-bath with phenylhydrazine. One recrystallisation from benzene sufficed to give the pure phenylhydrazide, m. p. 140° (alone or when mixed with the phenylhydrazide of the acid obtained from trimethyl lyxofuranose).

Oxidation of Trimethyl Methyl-lyxofuranoside with Nitric Acid.—Trimethyl methyl-lyxofuranoside (2 g.) was heated for 8 hours at 90° with nitric acid (*d* 1·42; 20 c.c.). Evolution of nitrous fumes had then almost ceased. The remaining nitric acid was removed by distillation under diminished pressure at 50°, with frequent addition of water. The stiff syrup obtained was boiled for 6 hours with 2% methyl-alcoholic hydrogen chloride. After neutralisation of the acid by silver carbonate the methyl alcohol was removed by distillation under diminished pressure and the product was distilled, giving a colourless liquid (0·9 g.), b. p. 135—140°/12 mm. No methyl oxalate could be detected and there was no still residue. The distillate, after nucleation with a crystal of methyl *i*-dimethoxysuccinate, began to crystallise. After being kept for several weeks, the solid was drained on porous tile and recrystallised from ether–light petroleum, giving flat plates (0·4 g.), m. p. 68° alone or when mixed with an authentic specimen prepared from *i*-tartaric acid.

Methylation of Methyl-lyxofuranoside by Purdie's Reagents.—The crude methyl-lyxofuranoside described above (10 g.) was methylated six times with silver oxide and methyl iodide. The product was distilled, giving 7·9 g., b. p. 70—74°/0·08 mm., and 3·5 g., b. p. 75—90°/0·08 mm. A small quantity (4%) of a crystalline oxidation product (A) separated from both fractions. This was removed by draining on porous tile, after which the liquid was recovered by extraction with chloroform and redistilled; b. p. 75°/0·1 mm., $n_D^{17°}$ 1·4431, $[\alpha]_D^{20°}$ + 41° in water (c = 3·6), $[\alpha]_D^{20°}$ + 53° in 1% methyl-alcoholic hydrogen chloride (equilibrium value after being heated at 100° for 6 hours). The distillate was mainly trimethyl methyl-lyxofuranoside, but contained also the corresponding pyranoside (15—20%) and probably also a little of the above-mentioned crystalline product (Found: OMe, 56·8%). Hydrolysis with dilute hydrochloric acid gave the corresponding mixture of trimethyl lyxofuranose and trimethyl lyxopyranose. This had b. p. 95°/0·04 mm., $n_D^{11°}$ 1·4598, $[\alpha]_D^{20°}$ + 27° in water (c = 3·3) (Found: OMe, 47·5%). Oxidation with bromine water gave the mixed γ- and δ-lactones as a liquid, b. p. 108°/0·1 mm., $n_D^{20°}$ 1·4553, $[\alpha]_D^{20°}$ + 76° in water (initial value); + 65° (23 hours); + 63° (41 hours); + 58° (90 hours); + 50° (200 hours); + 45° (300 hours); + 41° (900 hours).

The comparatively rapid fall in rotation during the first 50 hours, followed by the slow change which still persisted after 1000 hours, is characteristic of a mixture of a γ- and a δ-lactone. Since the trimethyl γ- and δ-lyxonolactones have respectively $[\alpha]_D^{20°} + 82{\cdot}5°$ and $[\alpha]_D^{20°} + 36°$, the proportion of δ-lactone was about 15%. After some time the trimethyl γ-lyxonolactone crystallised; m. p. 44°. Preparation of the phenylhydrazide from the liquid which drained away from the crystalline γ-lactone gave mainly the phenylhydrazide obtainable from trimethyl δ-lyxonolactone.

The crystalline oxidation product (A) was easily soluble in the usual organic solvents, soluble with difficulty in water, and was recrystallised from light petroleum, giving long colourless needles, m. p. 127—128°, $[\alpha]_D^{20°} + 175°$ in water ($c = 0{\cdot}53$). The substance was neutral to litmus and had no action on boiling Fehling's solution. The presence of an ester group was proved by titration with hot alkali, and after alkaline hydrolysis the high specific rotation was retained. When the *ester* was heated for 2 hours at 80° with 3% hydrochloric acid, the rotation decreased to 0°; the resulting solution, after exact neutralisation with sodium hydroxide, did not reduce boiling Fehling's solution but quickly decolorised neutral permanganate [Found: C, 46·5; H, 6·8; OMe, 45·1; CO_2Me, 28·0. $C_4H_5O_2(OMe)_2{\cdot}CO_2Me$ requires C, 46·6; H, 6·8; OMe, 45·1; CO_2Me, 28·6%].

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