The Formation of Polyhydroxy-dialdehydes. III. *l*-Lyxo-trihydroxy-glutaric Dialdehyde and its Derivatives.

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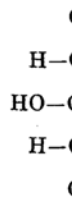
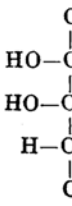
Theoretically there should exist four dialdo-pentonoses, that is, trihydroxy-glutaric dialdehydes, and, among them, xylo- and *d*-lyxo-trihydroxy-glutaric dialdehydes (I and II) were reported in the first and second papers. This communication is concerned with the formation of *l*-lyxo-derivatives (or *l*-arabo-derivatives) (III).



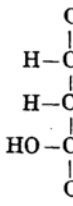
Xylo-trihydroxy-glutaric dialdehyde*

(I)



d-Lyxo-trihydroxy-glutaric dialdehyde*

(II)



l-Lyxo-trihydroxy-glutaric dialdehyde*

(III)

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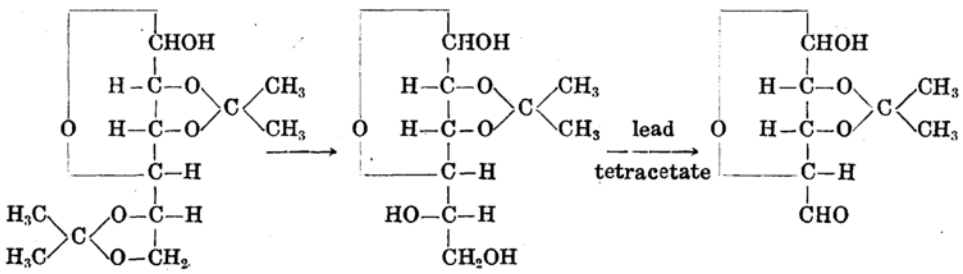
(1) K. Iwadare, I, this Bulletin, **16**(1941), 40; II, *ibid.*, **16**(1941), 144.

* These formulas are described arbitrarily in chain.

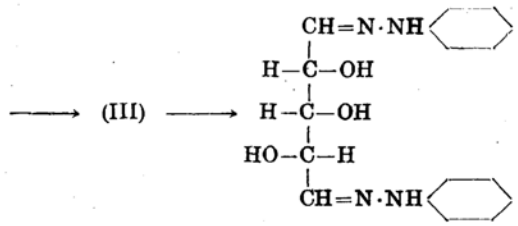
For obtaining *d*-lyxo-trihydroxy-glutaric dialdehyde, 2,3-monoacetone-*d*-mannofuranose was used as the starting substance, therefore it is plain that *l*-lyxo-trihydroxy-glutaric dialdehyde would be obtained from 2,3-monoacetone-*l*-mannofuranose. *l*-Mannose is obtained by cyanhydrin synthesis from *l*-arabinose[2], and shaken mechanically with acetone which contains a small quantity of concentrated sulphuric acid. 2,3,5,6-Di-acetone-*l*-mannofuranose thus obtained crystallizes into colourless needles, m.p. 122°–122.5°, and has specific rotatory power, $[\alpha]_D$, of –27° in acetone. It is dissolved in biphthalate buffer solution (*p*H 4.4), and the solution is distilled by heating in an oil-bath at 140–150° for 1.5 hours, the necessary quantity of water being added during the distillation to keep the volume of the solution constant. Then the buffer solution containing diacetone-*l*-mannose and monoacetone-*l*-mannose which is obtained by partial hydrolysis of diacetone-derivative is neutralized (phenolphthalein) and evaporated to small volume under the diminished pressure, and extracted with ether for 72 hours. The ether extract is evaporated to thick sirup and thoroughly washed with boiling petroleum benzine to remove diacetone-mannose. The remaining sirup of 2,3-monoacetone-*l*-mannofuranose is dissolved in benzene and oxidized with lead tetracetate. The reaction mixture is filtered, the filtrate evaporated under the diminished pressure, and the remaining sirup is hydrolyzed by warming with dilute sulphuric acid. On adding phenylhydrazine to the solution, *bis*-phenylhydrazone of *l*-lyxo-trihydroxy-glutaric dialdehyde precipitates immediately. It is recrystallized from acetone on adding petroleum ether and then from alcohol. It crystallizes into colourless needles, m.p. 165–165.5° (corrected, decomposing). $[\alpha]_D$=+73° in pyridine. *l*-Lyxo-trihydroxy-glutaric dialdehyde is obtained as sirup by decomposing the above-mentioned *bis*-phenylhydrazone with benzaldehyde. The specific rotation of this dialdehyde is calculated by directly measuring the rotation of its aqueous solution, which is obtained by decomposing the known quantity of its *bis*-phenylhydrazone, on the assumption that the conversion is quantitative. Thus, the specific rotatory power of *l*-lyxo-trihydroxy-glutaric dialdehyde, $[\alpha]_D^{10}$, is found to be –17°. *Bis*-*p*-nitro-phenylhydrazone of *l*-lyxo-trihydroxy-glutaric dialdehyde is obtained by adding the acidic aqueous solution of *p*-nitro-phenylhydrazine to the aqueous solution of the dialdehyde. Orange leaflets, m.p. 203.5–204° (decomposing).



2,3,5,6-Diacetone-*l*-mannofuranose (IV)

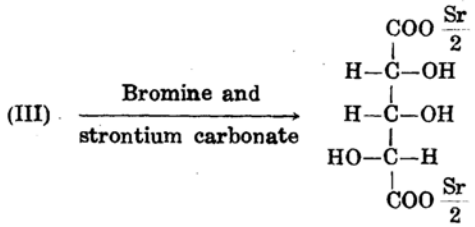
2,3-Monoacetone-*l*-mannofuranose (V)

(2) E. Fischer, *Ber.*, **23**(1890), 370; **24**(1891), 2683.



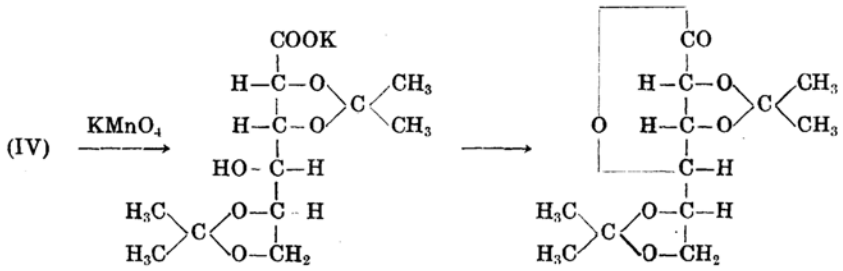
Bis-phenylhydrazone of *l*-lyxo-trihydroxy-glutaric dialdehyde*

By oxidizing the aldehyde groups of *l*-lyxo-trihydroxy-glutaric dialdehyde with bromine in the presence of strontium carbonate, strontium *l*-lyxo-trihydroxy glutarate is obtained.



Strontium *l*-lyxo-trihydroxy glutarate

By the way, diacetone-*l*-mannose is oxidized with potassium permanganate in alkaline solution, and potassium salt of diacetone-*l*-mannonic acid is obtained. This salt is converted into diacetone-*l*-mannonolactone, m.p. 124–124.5°, which agrees with that of *d*-isomer[3].



Potassium diacetone-*l*-mannonate

Diacetone-*l*-mannonolactone

Experimental. *2,3,5,6-Diacetone*-l-*mannofuranose.* Thirty grams of *l*-mannose, prepared from *l*-arabinose by cyanhydrin synthesis, were mechanically shaken for 6 hours with 1,200 c.c. of acetone containing 27 cc of concentrated sulphuric acid. The solution was neutralized with excess of anhydrous sodium carbonate and filtered. The filtrate, now coloured in light lemon-yellow, was concentrated to dryness under the

(3) Ohle and Berend, *Ber.*, **58**(1925), 2591.

diminished pressure. The crystalline residue was recrystallized from benzine. Yield, 28 g. It was recrystallized from ether by adding petroleum ether. Colourless needles, m.p. 122–122.5°. $[\alpha]_D=-27°$ in acetone (c=1.84). (Found: C, 55.49; H, 7.67. Calculated for $C_{12}H_{20}O_6$: C, 55.37; H, 7.73%).

*Monoacetone-*l*-mannofuranose.* Diacetone-*l*-mannose (5 g) was dissolved in 125 cc of biphthalate buffer solution of *p*H 4.4, and the mixture was distilled by heating in an oil-bath at 140–150° for 1.5 hours, the necessary quantity of water being added from time to time to maintain the initial volume. Then the solution was cooled, neutralized to phenolphthalein, evaporated to about 15 cc under the reduced pressure, and extracted continuously with ether for 72 hours. The ether extract was concentrated to sirup. In order to remove diacetone-derivative from the sirup, 30 cc of petroleum benzine (70–90°) was added to it, and the mixture was heated on a boiling water-bath, and stirred mechanically for 30 minutes. Benzine extract was removed by decantation, and the remaining sirup was again extracted with benzine just like as above. This procedure was repeated ten times and monoacetone-*l*-mannofuranose remained as sirup.

Bis-*phenylhydrazone of* l-*lyxo-trihydroxy-glutaric dialdehyde.* Benzene (30 cc) was added to monoacetone-*l*-mannose (1.4 g), the mixture was warmed at 60° and lead tetracetate (3 g) was added to it. After warmed 5 minutes, it was cooled, filtered and washed with acetone. The combined filtrate and washings were evaporated in vacuum to sirup. The remaining sirup was dissolved in 50 cc of N/20-sulphuric acid, and warmed on a water-bath for half an hour. It was evaporated in vacuum to remove the isolated acetone, filtered if necessary, and phenylhydrazine (2 g) was added to it. A considerable quantity of precipitate soon appeared from the mixture. It was filtered, dried, and dissolved in acetone. Acetone solution was filtered, if necessary, and *bis*-phenylhydrazone was precipitated by adding petroleum ether. It was recrystallized from alcohol into fine colourless needles, m.p., 165–165.5° (corrected, decomposing). $[\alpha]_D=+73°$ in pyridine (c=0.47). (Found: C, 62.41; H, 6.27; N 17.41. Calculated for $C_{17}H_{20}O_3N_4$: C, 62.18; H, 6.14; N, 17.06%).

l-*Lyxo-trihydroxy-glutaric dialdehyde.* The equilibrium rotatory power of *l*-lyxo-trihydroxy-glutaric dialdehyde was calculated from the rotatory power of its aqueous solution obtained by decomposition of the known quantity of its *bis*-phenylhydrazone. That is, 0.412 g of *bis*-phenylhydrazone was suspended in 6 cc of water and decomposed by benzaldehyde as mentioned above. The aqueous solution was made up to 10 cc by adding water and its rotatory power was measured with 1 dm tube. $\alpha_D=-0.32°$. As 0.186 g of free dialdehyde should be obtained from 0.412 g of its *bis*-phenylhydrazone, the specific rotatory power, $[\alpha]_D$, of *l*-lyxo-trihydroxy-glutaric dialdehyde is −17°.

Bis-p-*nitro-phenylhydrazone of* l-*lyxo-trihydroxy-glutaric dialdehyde.* Obtained just as d-isomer described in the previous paper[1], m.p., 203.5–204° (decomposing). (Found: N, 20.41. Calculated for $C_{17}H_{18}O_7N_6$: N, 20.09%).

Strontium l-*lyxo-trihydroxy-glutarate.* Obtained just as *d*-isomer described in the previous paper[1]. (Found: Sr, 33.34. Calculated for $C_6H_6O_7Sr$: Sr, 32.98%).

Potassium salt of diacetone-l-*mannonic acid.* Diacetone-*l*-mannose (1.5 g) was dissolved in 150 cc of water, and 0.33 g of potassium hydroxide and 0.65 g of potassium permanganate were added. After being kept on standing overnight, the mixture was filtered, the filtrate was neutralized with carbon dioxide, and evaporated under the reduced pressure. The residue was washed with ether and then extracted with cold alcohol. The alcohol extract was evaporated to small volume and ether was added to it. Fine needles appeared gradually. Yield, 1.25 g. They were recrystallized from acetone by adding benzene. $[\alpha]_D^{10}=+32.2°$ in water (c=1.34). (Found: K, 12.02. Calculated for $C_{12}H_{19}O_7K.H_2O$: K, 11.76%).

Diacetone-l-*mannonolactone.* Potassium salt of diacetone-*l*-mannonic acid (0.65 g) was dissolved in 2.2 cc of N-sulphuric acid, and the solution was at once extracted with ether. The ether extract was washed with water, dried wih anhydrous sodium sulphate, and evaporated in vacuum. The residue was crystallized from petroleum benzine into colourless needles. M.p., 124–124.5°. (Found: C, 55.68; H, 6.81. Calculated for $C_{12}H_{18}O_6$: C, 55.80; H, 7.02%).

Summary.

Following compounds were obtained in crystals: 2,3,5,6-Diacetone-*l*-mannofuranose, m.p., 122–122.5° and $[\alpha]_D=-27°$ (in acetone). *Bis*-phenylhydrazone of *l*-lyxo-trihydroxy-glutaric dialdehyde, m.p., 165–165.5° and $[\alpha]_D=+73°$ (in pyridine). *Bis*-*p*-nitro-phenyl-hydrazone of *l*-lyxo-trihydroxy-glutaric dialdehyde, m.p., 203.5–204°. Potassium diacetone-*l*-mannonate, $[\alpha]_D^{10}=+32.2°$ (in water). And diacetone-*l*-mannonolactone, m.p. 124–124.5°.

In conclusion the author wishes to express his hearty thanks to Prof. B. Kubota for his kind advice for this experiment.

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