The Formation of Polyhydroxy-dialdehydes. I. Xylo-trihydroxy-glutaric Dialdehyde and its Derivatives.

By Koichi IWADARE.

(Received December 27, 1940.)

Among the onoses, namely, sugars which have two carbonyl groups in separated positions, those with one aldehydic and one ketonic groups have been reported by some investigators.(1) While, very little is known about the onoses with two aldehydic groups;(2) and nothing seems to have been reported about dialdo-pentonoses, that is, trihydroxy-glutaric dialdehydes, where it should exist theoretically four such dialdehydes. So attempts were made to obtain these series of sugars, and xylo-trihydroxy-glutaric dialdehyde and *d*-lyxo-trihydroxy-glutaric dialdehyde (xylo- and lyxo-dialdo-pentonose) and their derivatives were now prepared.(3) This communication concerns with the formation of xylo-derivatives.

For this purpose, 1,2-monoacetone-*d*-glucofuranose is oxidized by lead tetracetate(4) in benzene solution. The mixture is filtered, the filtrate evaporated under diminished pressure, and 1,2-monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde is obtained by distilling the remaining sirup. It distils at 132°–136° in 0.01–0.02 mm pressure. It is a colourless hygroscopic sirup, although it can be made powdery. It is not sweet, but bitter. $[\alpha]_D^{16}=20°\pm3°$.

The phenylhydrazone of 1,2-monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde is prepared by boiling the alcoholic solution of dialdehyde with phenylhydrazine. It is recrystallized first from the mixture of benzene and petroleum ether and then from dilute alcohol. It crystallizes in colourless needles or leaflets. Melting point, 140.5°–141° (corrected). $[\alpha]_D^{10}=-41°\pm1°$ in chloroform.

The semicarbazone of 1,2-monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde is prepared by adding semicarbazide hydrochloride and potassium acetate to the aqueous solution of the acetone derivative. It crystallizes in fine colourless leaflets. The melting point is 209°–209.5° (corrected, decomposing).

Xylo-trihydroxy-glutaric dialdehyde is obtained by hydrolizing the above acetone-derivative with 1% sulphuric acid in a boiling water bath. It does not crystallize, but its *bis*-phenylhydrazone and *bis*-*p*-nitrophenylhydrazone are obtained crystalline by adding phenylhydrazine or *p*-nitrophenylhydrazine to the acidic solution of xylo-trihydroxy-glutaric dialdehyde. Melting point of *bis*-phenylhydrazone of xylo-trihydroxy-

---

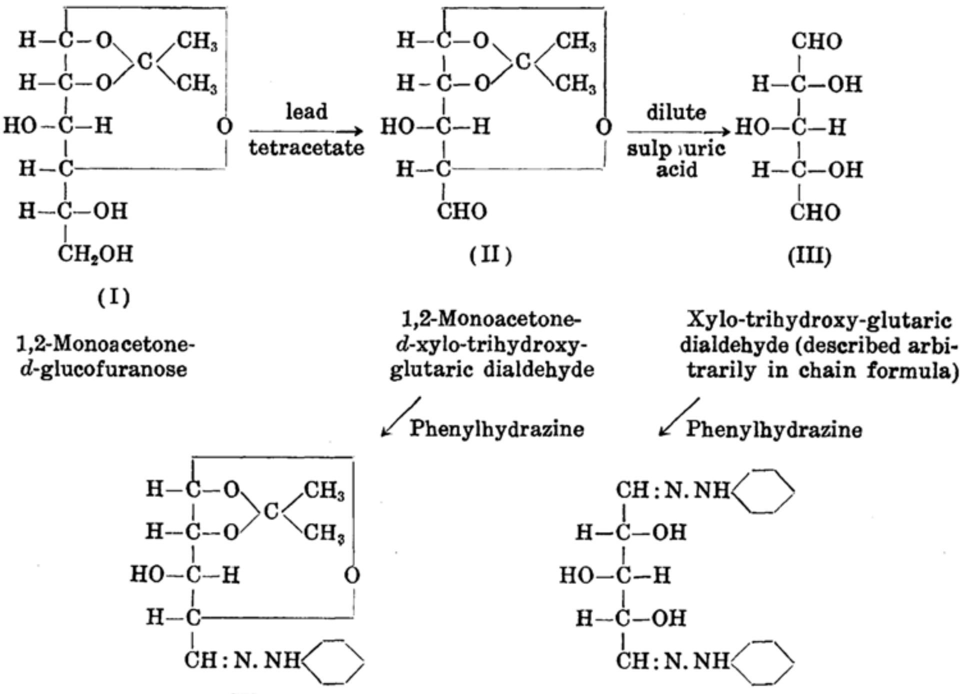
(1) For instance: B. Helferich and E. Himmen, *Ber.*, **62** (1929), 2136; B. Helferich and N. M. Bigelow, *Z. physiol. Chem.*, **200** (1931), 263.

(2) H. O. L. Fischer and H. Appel, *Helv. Chim. Acta*, **17** (1934), 1574.

(3) The author reported on these on the annual meeting of the Chemical Society of Japan in July 1940 at Sapporo.

(4) Criegee, *Ann.* **507** (1933), 159.

glutaric dialdehyde is 126.5°–127.5° (corrected), and that of its *bis-p*-nitrophenylhydrazone is 191°–192° (corrected, decomposing).



(I)
1,2-Monoacetone-*d*-glucofuranose

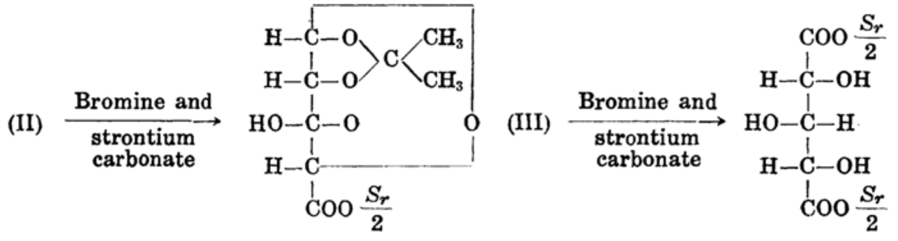
(II)
1,2-Monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde

(III)
Xylo-trihydroxy-glutaric dialdehyde (described arbitrarily in chain formula)

(IV)
1,2-Monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde monophenylhydrazone

(V)
Xylo-trihydroxy-glutaric dialdehyde *bis*-phenylhydrazone (described arbitrarily in chain formula)

By oxidizing the aldehyde groups of such dialdehyde derivatives with bromine, the corresponding carboxylic acids are obtained. Thus, strontium salt of 1,2-monoacetone-*d*-xyluronic acid is obtained by oxidizing 1,2-monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde with bromine, generated acids being neutralized by excess of strontium carbonate. And, by the same method, strontium salt of xylo-trihydroxy-glutaric acid is obtained from xylo-trihydroxy-glutaric dialdehyde.



Strontium 1,2-monoacetone-*d*-xyluronate

Strontium trihydroxy-glutarate

Experimental.

1,2-Monoacetone-d-glucofuranose. For preparing this substance, 1,2,5,6-diacetone-*d*-glucofuranose was first prepared by the slight modification of usual method.⁽⁵⁾ That is, 700 c.c. of acetone containing 40 c.c. of concentrated sulphuric acid and a few grams of acetaldehyde were mechanically shaked with 35 g. of usual *α*-*d*-glucose. The colour of the mixture soon became brownish-yellow, and the greater part of *d*-glucose disappeared after a half hour, and all but coarse grains dissolved after an hour. The mixture was neutralized by adding 150 g. of anhydrous powder of sodium carbonate, and then filtered from inorganic substances. Filtrate, coloured in light lemon-yellow, was evaporated to sirup, which was dissolved in water. The water solution was shaked three times with benzene to remove resinous material, benzene extract thus obtained washed twice with water, and combined water solution was extracted six times with each 100 c.c. of chloroform. Chloroform extract, containing diacetone-*d*-glucose, was dried with anhydrous sodium sulphate, and evaporated. About 25 g. of raw diacetone-*d*-glucose was obtained. 1,2-Monoacetone-*d*-glucofuranose was prepared by partial hydrolysis⁽⁶⁾ of diacetone derivative. Namely, 20 g. of the latter was warmed in a water bath at 50° with 400 c.c. of water containing 0.8 g. of concentrated hydrochloric acid. After two hours the mixture was neutralized with excess of silver carbonate, and filtered. The filtrate was freed from silver ions by passing sulphuretted hydrogen, filtered, and evaporated under reduced pressure. The residue was recrystallized from ethyl acetate. Melting point. 160–160.5° (corrected).

1,2-Monoacetone-d-xylo-trihydroxy-glutaric dialdehyde. Ten grams of lead tetracetate were dissolved in 200 c.c. of benzene. To this, 5 g. of monoacetone-glucose were added, and the mixture was shaked and warmed in a water bath for a few minutes. After standing for a short while, the cooled mixture was filtered and the residue was thoroughly washed with 200 c.c. of acetone. Combined filtrate and washings were evaporated under reduced pressure, the temperature of the bath not being allowed to rise above 40°. The thick sirup thus obtained was dissolved in alcohol, filtered and again evaporated in vacuo. This procedure was twice repeated. The remaining sirup was now dissolved in ether, filtered from insoluble material and the solvent was removed under diminished pressure. This sirup was distilled in high vacuum. Boiling point, 132–136° at 0.01–0.02 mm. pressure. It is a colourless, glassy and very thick sirup which can be made powdery. It is also hygroscopic. It reduces Fehling's solution very slowly at room temperature, but at once when heated. (Found: C 51.26, H 6.80. Calc. for $C_8H_{12}O_5$: C 51.06, H 6.43%). $[\alpha]_D^{16}=20°\pm3°$ in alcohol (c=0.65) thirty minutes after solution.

Monohydrazone of 1,2-monoacetone-d-xylo-trihydroxy-glutaric dialdehyde. 1,2-Monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde (0.5 g.) was dissolved in alcohol and 0.25 g. of phenylhydrazine added to it. The mixture was warmed on a water bath for about 5 minutes, and, after

---

(5) K. Freudenberg and K. Smeykal, *Ber.*, **59** (1926), 100; *Ber.*, **61** (1928), 1741.
(6) E. Fischer, *Ber.*, **28** (1895), 2496.

cooling, poured into water. The separated oil solidified on standing. It was recrystallized first from the mixture of benzene and petroleum ether, and then twice from dilute alcohol (the mixture of 2 parts of water and 1 part of alcohol). It is colourless needles or leaflets. It melts at 140.5°–141° (corrected). (Found: C 60.74, H 6.39, N 10.15. Calc. for $C_{14}H_{18}O_4N_2$: C 60.42, H 6.52, N 10.07%). $[\alpha]_D^{10} = -41° \pm 1°$ (0.2071 g. was made up to 10 c.c. by chloroform, direct reading being $-0.84°$).

Monosemicarbazone of 1,2-monoacetone-d-xylo-trihydroxy-glutaric dialdehyde. 1,2-Monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde (0.2 g.) was dissolved in 4 c.c. of water, and 0.2 g. of semicarbazide hydrochloride and 0.3 g. of potassium acetate were added to it. After standing overnight, fine colourless leaflet separated from the solution. It was filtered and washed with a small quantity of water. Melting point, 209–209.5° (corrected, decomposing). (Found: N 17.21. Calc. for $C_9H_{15}O_5N_3$: N 17.14%).

Xylo-trihydroxy-glutaric dialdehyde. 1,2-Monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde (0.5 g.) was dissolved in 30 c.c. of 0.1 N sulphuric acid and heated in a boiling water bath for an hour. The solution was neutralized with excess of barium carbonate, small quantity of active charcoal added, and the mixture was filtered. Dialdehyde was obtained as sirup by evaporating the filtrate under reduced pressure. It reduces Fehling's solution after several minutes at room temperature, but at once reduces it strongly when heated.

Bis-phenylhydrazone of xylo-trihydroxy-glutaric dialdehyde. 1,2-Monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde (0.5 g.) was hydrolized with 30 c.c. of 0.1 N sulphuric acid, and to this mixture 0.5 g. of phenylhydrazine was added. The separated mobile oil was washed with the mixture of benzene and petroleum ether, and the residual oil solidified after standing overnight. It was partly dissolved in a very small quantity of acetone, and then petroleum ether was added to this mixture. The precipitated *bis*-phenylhydrazone was recrystallized from alcohol. It melts at 126.5°–127.5° (corrected). It is colourless leaflet. (Found: C 62.05, H 6.53, N 16.86. Calc. for $C_{17}H_{20}O_3N_4$: C 62.18, H 6.17, N 17.06%).

Bis-p-nitro-phenylhydrazone of xylo-trihydroxy-glutaric dialdehyde. 1,2-Monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde (0.5 g.) was hydrolized with 30 c.c. of 0.1 N sulphuric acid, and to this mixture 0.8 g. of *p*-nitro-phenylhydrazine dissolved in dilute sulphuric acid was added. *Bis-p*-nitro-phenylhydrazone precipitated at once from the mixture. It was filtered and washed with water. And the precipitate was recrystallized from pyridine. Yellow needles. It is slightly soluble in alcohol, more in acetone. It melts at 191–192° (corrected, decomposing). (Found: N 19.82. Calc. for $C_{17}H_{18}O_7N_6$: N 20.09%).

Strontium 1,2-monoacetone-d-xyluronate. 1,2-Monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde (1 g.) was dissolved in 50 c.c. of water and 8 g. of strontium carbonate and 1.5 g. of bromine were added to it. The mixture was frequently shaked for several hours and then kept standing for two days. It was filtered from strontium carbonate, and dissolved bromine was removed by airing under reduced pressure. Then the solution was stirred on adding silver carbonate to remove bromine ions and filtered. Sulphuretted hydrogen was passed in the filtrate to eliminate silver ion and the mixture was again filtered. When the filtrate was evaporated under reduced pressure to a small volume, a considerable quantity of white precipitate appeared. Then the concentration was stopped, and alcohol was added to it. The mixture was filtered after standing for a short while. Strontium 1,2-monoacetone-*d*-xyluronate thus obtained is white crystalline powder and is slightly soluble in water. (Found: C 38.41, H 4.63, Sr 17.99. Calc. for $C_{16}H_{22}O_{12}Sr$: C 38.91, H 4.46, Sr 17.75%).

Strontium xylo-trihydroxy-glutarate. 1,2-Monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde (0.5 g.) was hydrolized with 30 c.c. of 0.1 N sulphuric acid and to this mixture 5 g. of strontium carbonate and 1.6 g. of bromine were added. After standing overnight it was filtered and the filtrate was treated just like above mentioned method for strontium 1,2-monoacetone-*d*-xyluronate. Strontium xylo-trihydroxy-glutarate is slightly soluble in water. (Found: Sr 33.46. Calc. for $C_5H_6O_7Sr$: Sr 32.98%).

Summary.

By the oxidation of 1,2-monoacetone-*d*-glucofuranose with lead tetraacetate, 1,2-monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde was obtained, which distils at 132–136° at 0.01–0.02 mm. pressure, and has specific rotatory power, $[\alpha]_D^{16}$, of 20°±3° in alcohol. Its monophenylhydrazone melts at 140.5–141° and has specific rotatory power, $[\alpha]_D^{10}$, of −41°±1° in chloroform, and its monosemicarbazone melts at 209.5°. 1,2-Monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde was hydrolized to xylo-trihydroxy-glutaric dialdehyde and *bis*-phenylhydrazone and *bis*-*p*-nitrophenyl-hydrazone of the latter were obtained. Melting points of them are 126.5–127.5° and 191–192° respectively. 1,2-Monoacetone-*d*-xylo-trihydroxy-glutaric dialdehyde and xylo-trihydroxy-glutaric dialdehyde were oxidized by bromine in presence of strontium carbonate, and strontium 1,2-monoacetone-*d*-xyluronate and strontium xylo-trihydroxy-glutarate were obtained respectively.

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

Chemical Institute, Faculty of Science,
Imperial University of Tokyo.