Chemistry of 2,3-Dihydroxybutyraldehyde and Related Compounds

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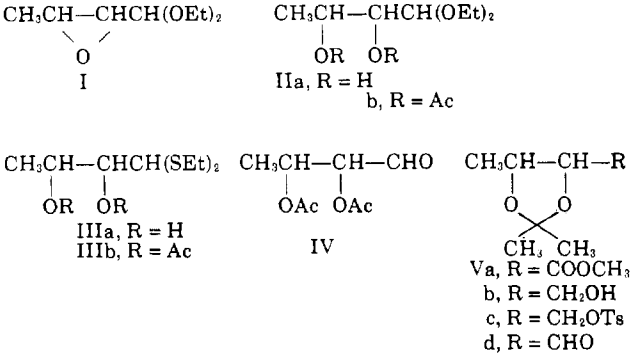
THE PREPARATION and reactions of some derivatives of 2,3-dihydroxybutyraldehyde, erythro-2,3-dihydroxybutyric acid and erythro-1,2,3-butanetriol are described. A preparation of 2,3-diacetoxybutyraldehyde (IV) (*1*) and the effort to establish the stereochemistry involved is the main subject of this paper.

The starting point for the preparation of IV was 2,3-epoxybutyraldehyde, which was prepared by the epoxidation of commercial crotonaldehyde according to the method of Payne (*2*). The mechanism proposed (*3*) would presumably give a mixture of the cis- and trans- forms of



the epoxyaldehyde. The epoxyaldehyde was converted to its acetal (I) in a 69% yield by means of triethyl orthoformate and ethanol with catalysis by ammonium sulfate. The epoxy acetal was opened to the dihydroxyacetal (IIa) in an 81% yield by the action of boiling aqueous sodium bicarbonate. Reaction of IIa with acetic anhydride–pyridine afforded the acetate derivative (IIb).

When the dihydroxyacetal (IIa) reacted with ethyl mercaptan in alcoholic hydrochloric acid, the dihydroxy mercaptal (IIIa) was obtained in a 94% yield. Acetylation of IIIa in pyridine, followed by removal of the mercaptal moiety with mercuric chloride and cadmium carbonate in aqueous acetone afforded the diacetoxyaldehyde (IV) in a 40% yield. A yellow, crystalline 2,4-dinitrophenylhydrazone derivative was obtained from IV.

The attempt to prepare the acetonide derivative (Vd) was unsuccessful. When DL-erythro-2,3-dihydroxybutyric acid (*1, 4*) was treated with an excess of acetone dimethyl ketal, the isopropylidene methyl ester (Va) was obtained in a 57% yield. The ester was reduced to the isopropylidene alcohol (Vb) with lithium aluminum hydride (69% yield), but attempts to oxidize (Vb) to the aldehyde (Vd) with chromic acid in pyridine (*5*) were unsuccessful. The alcohol was characterized as its crystalline *p*-toluenesulfonate derivative (Vc).

The stereochemistry of the diacetoxyaldehyde (IV) was investigated in the following manner. Acid hydrolysis of the erythro-isopropylidene alcohol (Vb) (prepared from the known erythro-2,3-dihydroxybutric acid) gave the previously unreported erythro-1,2,3-butanetriol, which was characterized as its tri-*p*-nitrobenzoate derivative. The diacetoxyaldehyde (IV) was reduced with lithium aluminum hydride to a 1,2,3-butanetriol. Its tri-*p*-nitrobenzoate, obtained in a 28% yield, was identical with that obtained from the 1,2,3-butanetriol derived from erythro-2,3-dihydroxybutyric acid.

Since the starting 2,3-epoxybutyraldehyde used to prepare IV was of uncertain stereochemistry, a mixture of erythro- and threo-isomers was probably obtained. The low yield (28%) of the erythro-tri-*p*-nitrobenzoate above does not alter this suspicion. It does appear that the erythro isomer of IV is the predominant one and the 2,4-dinitro-

Table I.

Compound	B.P. or M.P., ° C.	Analysis					
		Calculated			Found		
		C	H	S	C	H	S
1,1-Diethoxy-2,3-epoxybutane (I)	78.5–80.0°(20 mm. of Hg)	60.0	10.1	...	60.7	10.1	...
1,1-Diethoxy-2,3-dihydroxybutane (IIa)	94.0–95.5°(2 mm. of Hg)	53.9	10.2	...	53.8	10.5	...
1,1-Diethoxy-2,3-diacetoxybutane (IIb)	88–89°(0.5 mm. of Hg)	55.0	8.45	...	54.8	8.43	...
1,1-Diethylthio-2,3-dihydroxybutane (IIIa)	105–110°(0.3 mm. of Hg)	45.6	8.62	30.5	45.2	8.35	30.3
1,1-Diethylthio-2,3-diacetoxybutane (IIIb)	100–110°(0.2 mm. of Hg)	49.0	7.54	21.8	49.0	7.73	21.8
2,3-Diacetoxybutyraldehyde (IV)[a]	82.5–83.0°(3 mm. of Hg)	51.1	6.38	...	50.1	6.82	...
Erythro-2,2,5-trimethyl-4-carbomethoxy-1,3-dioxolane (Va)	80–82°(10 mm. of Hg)	55.2	8.10	...	55.2	8.09	...
Erythro-2.2.5-trimethyl-4-hydroxymethyl-1,3-dioxolane (Vb)	98.5–99.0°(20 mm. of Hg)	57.5	9.65	...	57.1	9.89	...
p-Toluenesulfonate of Vb (Vc)	53.5–54.0	56.0	6.71	10.7	56.0	7.00	10.4
		C	H	N	C	H	N
2,4-Dinitrophenylhydrazone of IV	129.5–130.5°	45.7	4.38	15.2	45.5	4.43	15.2
Tri-*p*-nitrobenzoate of erythro-1,2,3-butanetriol	179–180°	54.5	3.46	7.59	54.7	3.62	7.55

[a] Glattfeld and Straitiff (*1*) found b.p. 87° (4 mm. of Hg).

phenylhydrazone obtained from IV has the erythro configuration also.

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Preparation and Some Reactions of the Acetylenic Alcohols from Pinonic Acid and Homoterpenylmethyl Ketone

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Sodium and ethyl pinonate and homoterpenylmethyl ketone 6-keto-3-(1-hydroxy-1-methylethyl)-heptanoic acid γ-lactone, obtainable from the rearrangement of pinonic acid, were reacted with sodium acetylide. The expected products, 2,2-dimethyl-3-(1-hydroxy-1-methyl-2-propynyl)-cyclobutaneacetic acid, the ethyl ester of this acid and 6-hydroxy-6-methyl-3-(1-hydroxy-1-methylethyl)-7-octynoic acid γ-lactone were obtained in good yield. The alcohols were hydrated with mercuric sulfate giving the expected new ketones *cis-dl*-2,2-dimethyl-3-(1-methyl-2-oxopropyl)-cyclobutaneacetic acid and 6-hydroxy-6-methyl-3-(1-hydroxy-1-methylethyl)-7-oxo-octanoic acid γ-lactone. It was expected that a 1,4-glycol would result from reaction of two moles of pinonic acid with acetylene and a 1,6-glycol would result from oxidative coupling of the pinonic acid acetylenic alcohol. Negative results were obtained in both cases.

THE COMPOUND *cis-dl*-pinonic acid, 2,2-dimethyl-3-acetyl-cyclobutaneacetic acid, I, is easily obtainable from *dl*-α-pinene by permanganate oxidation or ozonolysis (*4*). This acid rearranges to homoterpenylmethyl ketone, 6-keto-3-(1-hydroxy-1-methylethyl)-heptanoic acid-γ-lactone, II, by action of hot aqueous mineral acids (*1, 2*). These ketones should react with acetylene in the presence of basic condensing agents like ethyl levulinate, ethyl benzoylpropionate and keto fatty acids (*5*). The purpose of the present investigation was to study the reaction of these terpenes with acetylene, and characterize and determine some of the chemical properties of the resulting acetylenic alcohols. Two new dibasic acids, 3-(2,5-dihydroxy -3- hexynylene) -2,5- bis -2,2- dimethylcyclobu-