Anal., Calcd. for $C_{21}H_{28}O_3 \cdot H_2O$: C, 72.80; H, 8.73. Found: C, 72.77, 72.63; H, 8.69, 8.61.

Attempted Acetonide Formation with Estriol-3-methyl Ether.—Estriol-3-methyl ether (350 mg., m.p. 157–158°) was covered with 35 cc. of anhydrous acetone and treated with 5 cc. of 8% hydrogen chloride in absolute acetone as usual. After thirty minutes swirling, 50 cc. of aqueous potassium carbonate (≈ 1.5 g. of potassium carbonate) was added in one portion, mixed at once, and placed at 5°. After a day at 5°, the precipitated white plates were filtered, washed well with water (0.5% pyridine), and then dried in the oven. The recovery of estriol-3-methyl ether melting at 158–159.5° was 334 mg.

3(β),16(α),17(α)-Trihydroxyandrostane (XXVI).—Adams catalyst (0.10 g.) was suspended in 10 cc. of acetic acid and reduced with hydrogen; then 155 mg. of pure 3(β),16(α),17(α)-triacetoxy-Δ^5-androstene (VII) in 25 cc. of absolute ethanol was added. Hydrogenation was carried out for thirty minutes at atmospheric pressure, the catalyst removed by filtration, and the solution of hydrogenated steroid evaporated *in vacuo*. Saponification of the crystalline residue was accomplished by refluxing for one hour in a solution of 20 cc. of 2 *N* sodium hydroxide and 60 cc. of ethanol. The neutral residue was recrystallized consecutively from aqueous ethanol, aqueous methanol, absolute acetone, aqueous methanol, absolute acetone, and from aqueous ethanol to give 64 mg. of triol melting at 251–253° (XXVI).

Anal. Calcd. for $C_{19}H_{32}O_3$: C, 73.98; H, 10.46. Found: C, 73.97, 73.87; H, 10.49, 10.41; $[\alpha]^{26}D + 18°$ (c = 0.53 in 95% ethanol)[26].

Acknowledgment.—The authors wish to thank Dr. Frank Stodola for his aid in determining the identity of his and their samples of androstanetriol triacetate. They wish also to extend their appreciation to Dr. Hans Hirschmann for his sample of androstenediol diacetate and for determining the optical rotation of their androstane-3(β),16(α),17(α)-triol. To the United States Standard Products Company, who gave generous financial support to this project, the authors are greatly indebted. Micro-analyses were performed by Dr. E. W. D. Huffman, Denver.

Summary

The 16,17-ketols resulting from the zinc–acetic acid reduction of 16-oximino-17-ketosteroids and 16,17-diketosteroids have been found to be 16-keto-17(α)-hydroxysteroids.

The steric structures of steroidal 16,17-glycols have been determined.

(26) This optical rotation was determined by Dr. Hans Hirschmann.

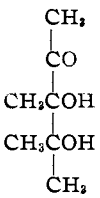
DALLAS, TEXAS RECEIVED JUNE 30, 1948

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF NORTHWESTERN UNIVERSITY]

2,3-Dimethyl-4-pentyne-2,3-diol as a Source of C-Methyl Sugars

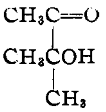
BY CHARLES D. HURD AND JAMES MOFFAT

At the outset of this work it was planned to synthesize a monosaccharide whose alcohol groups were tertiary. 3,4-Dimethyl-3,4-dihydroxy-2-pentanone (I) was selected. Such a structure obviously may be regarded as 1,2,3,3-C-tetramethylglycerose. These steps were visualized in the synthesis: acetone to dimethylethynylcarbinol to 3-methyl-3-hydroxy-2-butanone (II) following known procedures, then to 2,3-dimethyl-4-pentyne-2,3-diol (III) by condensation with acetylene, and finally to I by hydration of III.



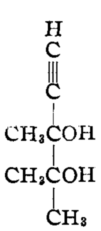
$$\begin{array}{c} CH_3 \\ | \\ CO \\ | \\ CH_3COH \\ | \\ CH_3COH \\ | \\ CH_3 \end{array}$$

I



$$\begin{array}{c} CH_3C{=}O \\ | \\ CH_3COH \\ | \\ CH_3 \end{array}$$

II



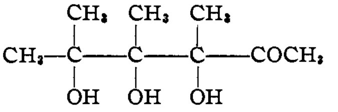
$$\begin{array}{c} H \\ C \\ ||| \\ C \\ | \\ CH_3COH \\ | \\ CH_3COH \\ | \\ CH_3 \end{array}$$

III

Steps through the synthesis of III were completed when the work was interrupted by war. Shortly thereafter, Favorskii and Onishchenko[1] announced their synthesis of both I and III, preparing III by pyrolysis of 2,3,6,7-tetramethyl-4-octyne-2,3,6,7-tetraol (IV), $CH_3(CMeOH)_2$-$C{\equiv}C(CMeOH)_2CH_3$. IV was prepared by gradual addition of II into a mixture of potassium hydroxide and dry ether previously saturated with acetylene. They produced I by hydrating the triple bond of III with mercuric sulfate and dilute sulfuric acid.

We prepared III in about 90% yields directly from II by use of sodium acetylide with liquid ammonia as solvent. The acetic ester of III was prepared readily with ketene as the acetylating agent, whereas it could not be prepared with acetic anhydride and pyridine.

The present synthesis seems general. In other words, just as I is obtainable from II, a similar sequence of steps from I should give rise to a C-pentamethyltetrose:



$$\begin{array}{ccccccc} & CH_3 & & CH_3 & & CH_3 & \\ & | & & | & & | & \\ CH_3- & C & - & C & - & C & -COCH_3 \\ & | & & | & & | & \\ & OH & & OH & & OH & \end{array}$$

Experimental

Dimethylethynylcarbinol and 3-methyl-3-hydroxy-2-butanone (II) were made in accordance with previously established directions.[2] 2,3-Dimethyl-4-pentyne-2,3-diol (III) was synthesized from the latter as follows.

To 300 ml. of dry liquid ammonia at −78° in a protected 3-necked flask was added 10.3 g. of sodium. Dry

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(1) A. E. Favorskii and A. S. Onishchenko, *J. Gen. Chem.* (*U. S. S. R.*), **11**, 1111 (1941); *C. A.*, **37**, 3735 (1943).

(2) Hurd and McPhee, THIS JOURNAL, **69**, 239 (1947); **71**, 398 (1949).

acetylene gas was passed into the solution until the blue color of the solution was discharged, after which 21.3 g. of 3-methyl-3-hydroxy-2-butanone was added dropwise with stirring. After a reaction period of four hours, the processing steps included distilling off the ammonia, dissolving the residue in water, extracting the solution with ether, drying over potassium carbonate and distilling. The yield of product collected at 75–77° (6 mm.) was 22.9–24.3 g. (86–91%); n^{25}_D 1.4600; d^{25}_4 1.001.

Anal. Calcd. for $C_7H_{12}O_2$: C, 65.59; H, 9.43. Found: C, 65.42; H, 9.11.

Diacetate.—A solution was prepared containing 5.5 g. of III, 20–25 g. of benzene, and two drops of sulfuric acid previously dissolved in ether. Ketene was passed into this solution for an hour at room temperature then for thirty minutes at 70–75°. Acidic impurities were removed by rinsing with sodium bicarbonate solution and with water. Then, after drying, the solvent was removed. Most of the product distilled at 120° (15 mm.); yield, 4.2 g. The thick, colorless distillate set to a crystalline mass within a few minutes; m. p. 54–56°. The crystals were very soluble in most organic solvents, including ligroin. The product is very volatile in steam.

Crystallization from solvents was not an easy matter. A 9:1 water–alcohol mixture maintained below 45° (to avoid liquefying the crystals) was the best solvent found. Purification is more readily achieved by sublimation. With conditions chosen at 130° and 40 mm. pure crystals were obtained melting at 55.0–55.5° (uncor.).

Anal. Calcd. for $C_{11}H_{16}O_4$: C, 62.25; H, 7.60. Found: C, 62.62; H, 7.60.

Acknowledgments.—This investigation was supported by a grant during 1942 from the Graduate School of Northwestern University. Micro combustion analyses were performed by Dr. T. S. Ma. Assistance in the purification of the diacetate was given by Dr. Arthur Berger.

Summary

3,4-Dimethyl-4-pentyne-2,3-diol and its diacetate are described. Attention is called to the fact that the hydration product of the former, namely, 3,4-dimethyl-3,4-dihydroxy-2-pentanone may be regarded as a monosaccharide composed of tertiary alcohol groups.

EVANSTON, ILLINOIS RECEIVED AUGUST 23, 1948

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY AND CHEMICAL ENGINEERING OF THE UNIVERSITY OF WASHINGTON]

Studies of Hemiacetal Formation in Alcohol–Aldehyde Systems. I. Cryoscopic Studies

BY F. E. MCKENNA,[1] H. V. TARTAR AND E. C. LINGAFELTER

The existence of an equimolar addition compound between an alcohol and an aldehyde was probably first mentioned by Jacobson.[1a] He considered the structure to be $CH_3CHOHOC_2H_5$ and called it an aldehyde alcoholate. Perkin[2] noted an initial decrease followed by a rapid increase in temperature when an aldehyde is mixed with an alcohol or water; this change was ascribed to a depolymerization of the alcohol or water followed by compound formation. The term hemiacetal came to be used for this type of supposed addition compound because of the purported relationship to the well-known acetal molecule.

Several more recent workers have investigated binary mixtures of aldehydes and alcohols for evidence on the existence of the hemiacetal. Wolf and Merkel[3] have confirmed Perkin's finding on the temperature changes when aldehydes and alcohols are mixed together. Curves representing density or index of refraction as a function of the composition presented by Adkins and Broderick[4] showed maxima at 50 mole per cent. Herold and Wolf[5] using absorption spectra measurements found maximum absorption with equimolar proportions, the band due to the carbonyl group being replaced by one characteristic of the ether-like linkage ascribed to the hemiacetal. They observed a time lag for this change of absorption which was attributed to the gradual establishment of a hemiacetal–alcohol–aldehyde equilibrium.

De Leeuw[6] determined the freezing point curve for the system acetaldehyde–ethanol. He found two maxima with aldehyde to alcohol ratios of 1:1 and 1:2. He also postulated that the latter compound in the presence of a dehydrating agent or of a catalyst could lose water to form the acetal.

Schimmel and Company[7] reported that mixtures of aliphatic alcohols and aldehydes (*n*-heptyl to *n*-undecyl) gave crystalline compounds of constant composition, 1:1. They were unable to prepare any derivatives of these substances because the reagents caused dissociation to aldehyde and alcohol.

The present results reported herein are from a cryoscopic investigation of the systems: *n*-heptanol–*n*-heptaldehyde, and methanol–propionaldehyde. Previously Schimmel and Company[7] had reported a melting point of 2° for the product obtained from an equimolar mixture of *n*-heptanol and *n*-heptaldehyde. The system methanol–propionaldehyde affords compounds with the smallest alkyl groups adapted to convenient investigation.

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[1] Present address: Air Reduction Sales Co., Research Laboratories, Murray Hill, New Jersey.

[1a] Jacobson, *Ber.*, **4**, 215 (1871).

[2] Perkin, *J. Chem. Soc.*, **45**, 477 (1881); **51**, 826 (1887).

[3] Wolf and Merkel, *Z. physik. Chem.*, **187**, 61 (1940).

[4] Adkins and Broderick, THIS JOURNAL, **50**, 499 (1928).

[5] Herold and Wolf, *Z. physik. Chem.*, **2B**, 39 (1928); **12B**, 194 (1931); **16B**, 213 (1932); **18B**, 265 (1932); *Z. Elektrochem.*, **38**, 633 (1932); **39**, 566 (1933).

[6] De Leeuw, *Z. physik. Chem.*, **77**, 284 (1911).

[7] Schimmel and Co., *Ann. Reports*, p. 71 (1933).