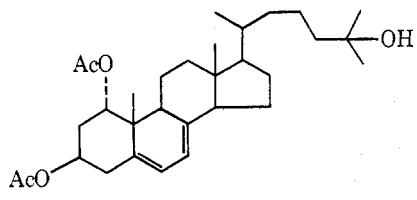
H), 1.19 (s, 6, C_{26},C_{27} H), 3.80, 3.93 (m, 2, C_4,C_5 H) 5.33, 5.21 ppm (ABq, J = 11.4 Hz, C_6,C_7 H)] which was acetylated with Ac_2O and pyridine at 80 °C to yield the triacetate **5d** (mp 89–91 °C). Bromination in $CHCl_3$ with $C_6H_5IBr_2$ gave the dibromide **2d** which was found to be identical with the product obtained from **2a.**

The C_{25}-hydroxy dibromide **2b** was treated with $(CF_3CO)_2O$ at room temperature for 4 h, and the C_{25}-trifluoroacetate, **2c,** obtained after evaporation to dryness, was dehydrobrominated by heating at 135 °C for 2 h in hexamethylphosphoramide containing 10% triethylmethylammonium dimethylphosphate[4,8] to give 20% 1α,3β-diacetoxy-25-hydroxycholesta-$\Delta^{5,7}$-diene (**6**)[5,9,10] [uv λ_{max} 262, 271, 282, and 294 nm; NMR ($CDCl_3$) δ 0.61 (s, 3, C_{18} H), 1.14 (s, 3, C_{19} H), 1.18 (s, 6, $C_{26}C_{27}$, H), 1.94, 1.97 (s, 6 OAc), 4.87 (m, 2, C_1,C_3



6

H), 5.29, 5.39 (AB q, J = 10.3 Hz, C_6,C_7 H)], accompanied by the $\Delta^{4,6}$-diene (uv λ_{max} 230, 240, 249 nm). The $\Delta^{5,7}$-diene, **6,** was transformed by irradiation, heating, and hydrolysis, as described elsewhere,[5,10] to the desired 1α,25-dihydroxyvitamin D_3 (**1b**) [uv λ 264 nm (ϵ 18 000); mass spectra M^+ at m/e 416; rapidly stimulating the formation of calcium binding protein and increasing the calcium content in the intestine of rachitic chicks].[3,5,10]

The direct introduction of OH into the side chain of a cholestane derivative at C_{25} significantly simplifies the synthesis of 1α,25-dihydroxyvitamin D_3; its photoprecursor, the $\Delta^{5,7}$-diene, can now be obtained from cholesterol by a seven-step reaction sequence.

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Supplementary Material Available. The experimental details for preparation of new compounds (3 pages). Ordering information is given on any current masthead page.

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(7) This compound was contaminated with ~10% Δ^5 isomer.
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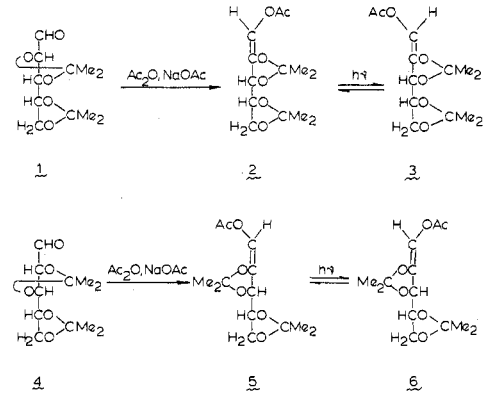
Enol Acetates of Aldehydo Sugar Derivatives. Synthesis and Crystallographic Determination of Double-Bond Geometry[1,2]

Summary: Enol acetates produced by action of acetic anhydride–sodium acetate on 2,3:4,5-di-*O*-isopropylidene-*aldehydo*-D-arabinose and -D-xylose are shown by X-ray crystallography to be the *Z* isomers, and they undergo photoisomerization to the *E* isomers.

Sir: Although aldehydo and keto derivatives of sugars are frequently used in synthesis and their derived enediols often postulated as reaction intermediates,[3] there have been few reports of stable derivatives of such enediols. Enol acetates of keto sugars have been studied in one of our laboratories,[4] and this communication reports the synthesis and characterization of enol acetates derived from some aldehydo sugar derivatives.

Heating 2,3:4,5-di-*O*-isopropylidene-*aldehydo*-D-arabinose[5] (**1**) or the D-ribose analogue in an excess of acetic anhydride containing sodium acetate for 30 min at 140 °C gave in 60% yield the *Z* isomer (**2**) of 1-*O*-acetyl-2,3:4,5-di-*O*-isopropylidene-D-*erythro*-pent-1-enitol, mp 100–100.5 °C, $[\alpha]^{23}D$ +1.85° (chloroform), whose general structure, except for the geometry about the double bond, was evident from its NMR and mass spectra. Photoisomerization of **2** in benzene–acetone with uv light gave the *E* isomer **3** as an oil, $[\alpha]^{24}D$ +122° (chloroform). Similarly, acetic anhydride–sodium acetate converted 2,3:4,5-di-*O*-isopropylidene-*aldehydo*-D-xylose[6] (**4**) into (*Z*)-1-*O*-acetyl-2,3:4,5-di-*O*-isopropylidene-D-



1 **2** **3**

4 **5** **6**

threo-pent-1-enitol (**5**), mp 61–62 °C, $[\alpha]^{22}D$ +8.4° (chloroform), which gave a first-order NMR spectrum (100 MHz) in acetone-d_6 and which could be photoisomerized to the *E* isomer (**6**), mp 68–70 °C, $[\alpha]^{24}D$ −198° (chloroform).

Assignment of double-bond geometry was achieved by crystallographic analysis of single crystals of **2** grown from ether–pentane and of **5** obtained from absolute ethanol. Intensities were collected on a Philips diffractometer with Cu Kα radiation and structures were solved by use of the Riche phase function.[7] The erythro compound (**2**, $C_{13}H_{20}O_6$) was monoclinic, space group $P2_1$, cell dimensions a = 5.435, b = 14.703, c = 9.332 Å, β = 104.15°, Z = 2, and volume 723 Å^3. The threo compound (**5**) was orthorhombic, space group $P2_12_12_1$, cell dimensions a = 5.543, b = 8.240, c = 32.336 Å, Z = 4, and volume 1477 Å^3. All hydrogen atoms were located on difference Fourier syntheses and their coordinates refined. The final R indices were 0.04 for **2** and 0.05 for **5**. Figure 1 presents a three-dimensional view of each molecule, listing bond distances, and short interatomic contacts, and Figure 2 depicts Newman projections along each carbon–carbon bond to show dihedral bond angles.

The crystallographic structures establish that the stereochemistry about the double bond is *Z* in **2** and **5**. The C-2–C-5 carbon–carbon chain of the erythro isomer (**2**) is approxi-

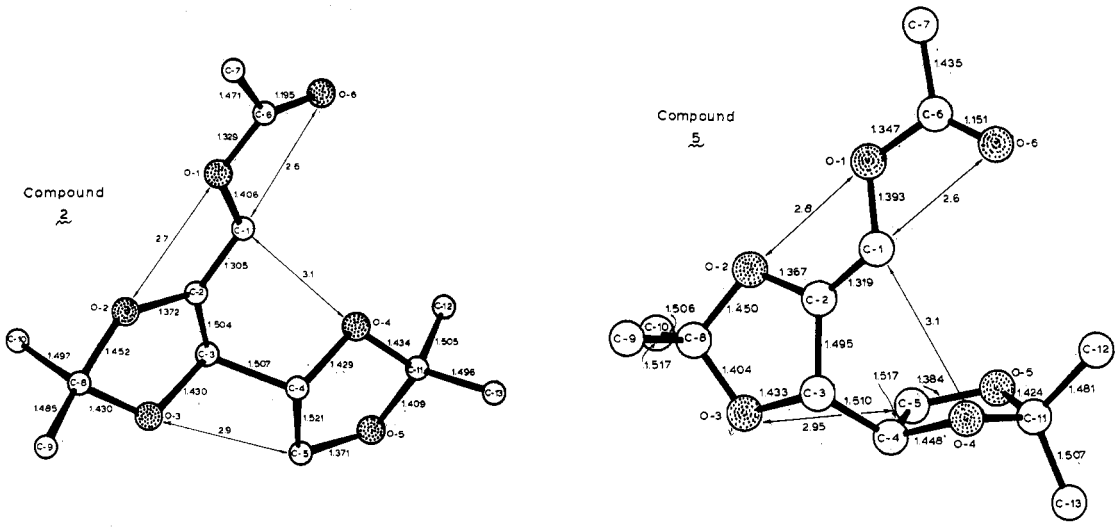


Figure 1. Crystal-structure diagrams for (*Z*)-1-*O*-acetyl-2,3:4,5-di-*O*-isopropylidene-D-*erythro*-pent-1-enitol (**2**) and its *Z* D-threo analogue (**5**), showing bond lengths and short interatomic contacts (in Å).

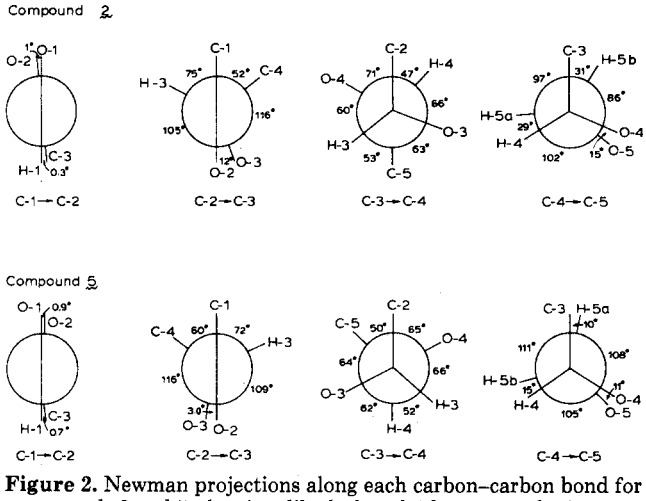


Figure 2. Newman projections along each carbon–carbon bond for compounds **2** and **5**, showing dihedral angles between substituents.

mately planar zigzag, in accord with the general conformational predictions that may be made for open-chain sugar derivatives.[8,9] In contrast, that of the threo isomer (**5**) has a sickle conformation, again as predicted by consideration of avoidance of a parallel disposition of O-2 and O-4 on the same side of the chain; the observed small (3.5 Hz) $J_{3,4}$ coupling indicates that the H-3–H-4 antiparallel rotamer is also not favored in solution. In both **2** and **5** there is an antiparallel disposition between O-3 and O-4. Envelope conformations are observed for the 4,5-dioxolane ring in **2** and the 2,3 ring in **5**, whereas the 2,3 ring in **2** and the 4,5 ring in **5** adopt twist conformations.

The observed proton–proton dihedral angles in crystalline **5** are compared in Table I with the proton–proton spin–spin couplings observed in acetone solution. It may be seen that the qualitative generalization that small couplings denote dihedral angles near 60° and large couplings indicate eclipsed or antiparallel protons is valid, but quantitative extensions to attribute precise angles from spin couplings are unjustified, as has been pointed out previously.[10] Use of the Karplus equation,[11] either with[12] or without[11] correction for electronegativity effects, to calculate predicted couplings from observed dihedral angles in the crystal, show (Table I) qualitative but not quantitative correspondence with observed couplings. Some variation between these sets of values is, of course, to be expected for compounds in solution because of absence of intermolecular packing interactions and the possibility of time averaging between conformations not differing greatly in relative free energy.

Table I. Comparison of Crystallographic Dihedral Angles and NMR Coupling Data for Compound 5

Vicinal protons	Crystallographic dihedral angle, deg	NMR proton–proton coupling constants, Hz		
		Obsvd[a]	Calcd[b]	Calcd[c]
3,4	52	3.5	2.8	4.1
4,5	137	6.4	4.9	6.4
4,5′	15	7.2	7.6	8.4

[a] At 100 MHz in acetone-d_6. [b] From the crystallographic angles by the Karplus[11] equation: $^3J_{H,H} = 4.22 - 0.5 \cos\phi + 4.50 \cos 2\phi$. [c] From the crystallographic angles by a modified[12] equation: $^3J_{H,H} = (7.8 - \cos\phi + 5.6 \cos 2\phi)(1 - 0.1X)$, where $X = \Sigma_1^4 (X_n - X_H)$ and X_n is the electronegativity of substituent n, X_H that of hydrogen.

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