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Note

X-Ray and conformational investigations of methyl 2,6-di-*O*-acetyl-3,4-anhydro-α-DL-(6,6-$^2H_2$)talopyranoside

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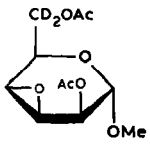
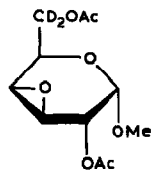
Using the X-ray method, we have established[1] that methyl 2,6-di-*O*-acetyl-3,4-anhydro-α-DL-(6,6-$^2H_2$)galactopyranoside (**2**) has a half-chair (^1H_o) conformation and confirmed the postulated[2] preference of the 5-substituent for an equatorial position. This preference, supported by the anomeric effect, is the most important factor in determining the conformation of 3,4-anhydropyranosides[2], despite the possible repulsion between the dipoles associated with the oxirane and pyranoid oxygens[3,4].



1



2

The marked preference of methyl 2,6-di-*O*-acetyl-3,4-anhydro-α-DL-(6,6-$^2H_2$)talopyranoside (**1**) for a half-chair conformation was deduced[5] on the basis of coupling constants ($J_{2e',3cis}$ 4.4, $J_{4cis,5a'}$ 1.0 Hz). However, the reason for the regioselectivity of "abnormal" oxirane ring opening in **1** and its analogues, with the preferential nucleophilic attack at C-4, was not clear[6] and a twist conformation in the transformation state has been postulated[7]. The data here discussed suggest that the polar oxygen–oxygen repulsions between vicinal pseudo-axial AcO-2 and the ring oxygen in the ground-state conformation increase the tendency of **1** to adopt the sofa conformation.

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The role of a pseudo-axial vicinal 2-substituent in determining the conformation of 3,4-anhydropyranosides is unknown, but there is probably not a marked interaction with the oxirane ring[4]. Therefore, it was of interest to study the conformation of **1** having AcO-2 pseudo-axial in order to determine the magnitude of its destabilising effect.

A parallel projection of a molecule of **1** is shown in Fig. 1. The refined positional parameters for the non-hydrogen atoms together with their B_{eq} values are given in Table I, and Tables II and III contain the bond lengths and valence angles, respectively*. Generally, the bond lengths and valence angles in **1** correspond well with those for **2** and there is a characteristic shortening of the C-3–C-4 bond. The endocyclic pyranose angles at C-3 and C-4 are close to 120°, as for olefinic atoms.

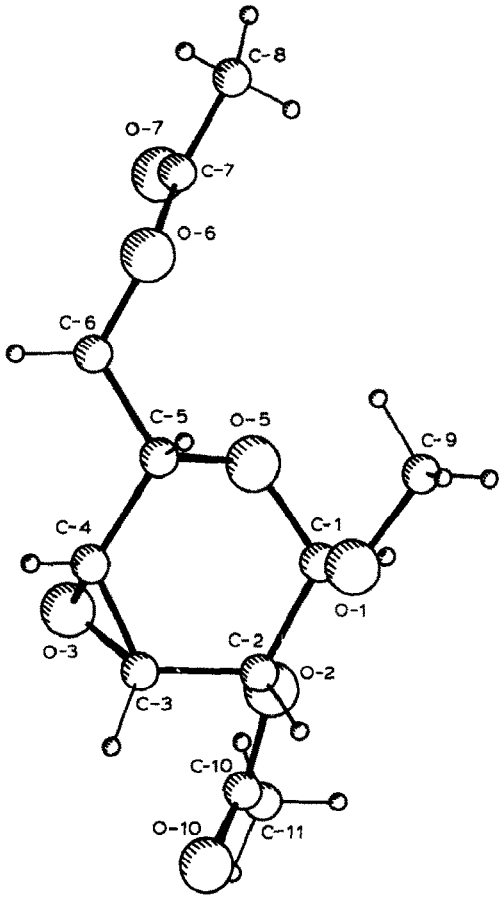

Fig. 1. A parellel projection of a molecule of **1** oriented at optimal viewing.

*Lists of structure factors and other data have been deposited with, and can be obtained from, Elsevier Science Publishers B.V., BBA Data Deposition, P.O. Box 1527, Amsterdam, The Netherlands. Reference should be made to No. BBA/DD/386/*Carbohydr. Res.*, 173 (1988) 145–149.

TABLE I

FRACTIONAL CO-ORDINATES ($\times 10^4$)[a] AND EQUIVALENT, ISOTROPIC TEMPERATURE FACTORS ($Å^2$)[b] FOR NON-HYDROGEN ATOMS OF **1**

Atom	x/a	y/b	z/c	B_{eq}
C-1	6721(2)	2625(2)	9516(2)	3.08(4)
C-2	5132(2)	3082(2)	7998(2)	2.98(4)
C-3	5403(2)	4024(2)	6907(2)	3.22(4)
C-4	7100(2)	4228(2)	7194(2)	3.46(5)
C-5	8545(2)	3516(2)	8587(2)	3.13(4)
C-6	9979(2)	3003(2)	8006(3)	4.17(5)
C-7	12414(2)	1587(2)	9737(3)	3.89(6)
C-8	13879(3)	1629(2)	11454(3)	5.38(6)
C-9	8328(2)	3380(2)	12567(2)	4.39(5)
C-10	2924(2)	1859(2)	5650(2)	3.44(5)
C-11	2357(2)	441(2)	4683(3)	4.56(5)
O-1	6977(1)	3732(1)	10955(1)	3.51(3)
O-2	4482(1)	1758(1)	6911(1)	3.31(3)
O-3	6109(1)	3806(1)	5644(1)	3.87(3)
O-5	8100(1)	2313(1)	9006(1)	3.05(3)
O-6	11472(1)	2846(1)	9597(2)	4.19(3)
O-7	12066(2)	592(2)	8583(2)	6.05(5)
O-10	2112(2)	2989(1)	5395(2)	4.61(4)

[a]In this and subsequent Tables, figures in parentheses are estimated standard deviations. [b]Calculated from anisotropic thermal parameters as $B_{eq} = 8\pi^2 \cdot D_u^{1/3}$, where D_u is the determinant of the U matrix.

TABLE II

BOND DISTANCES (Å) FOR **1**

C-1–O-1	1.396(2)	C-3–C-4	1.460(3)
O-1–C-9	1.431(2)	C-4–C-5	1.495(2)
C-1–C-2	1.516(2)	C-5–C-6	1.512(3)
C-2–O-2	1.450(2)	C-6–O-6	1.440(2)
O-2–C-10	1.343(2)	O-6–C-7	1.345(2)
C-10–O-10	1.201(2)	C-7–O-7	1.185(2)
C-10–C-11	1.481(3)	C-7–C-8	1.473(3)
C-2–C-3	1.503(3)	C-5–O-5	1.422(2)
C-3–O-3	1.438(2)	O-5–C-1	1.419(2)
O-3–C-4	1.437(2)		

An analysis of endocyclic torsion angles (Table IV) as well as asymmetry and puckering parameters for the 3,4-anhydropyranose ring in **1** suggests a hybrid $E_o + {}^1H_o$ conformation. The puckering parameters[8] were $\Phi = 310.9(2)°$ and $q_2 = 0.357(2)$ Å. The values of asymmetry parameters[9] $\Delta C_s^{O\text{-}5}$ and $\Delta C_2^{C\text{-}3\text{-}C\text{-}4}$ are both high, 12.4(2) and 14.0(2)°, respectively, thus indicating the hybrid character of the ring conformation.

The atoms C-2,3,4,5 are almost coplanar, forming a least-squares plane

TABLE III

BOND ANGLES (DEGREES) FOR **1**

O-5–C-1–C-2	112.0(2)	O-10–C-10–C-11	125.7(2)
C-1–C-2–C-3	113.4(2)	C-3–C-2–O-2	111.4(1)
C-2–C-3–C-4	119.5(1)	C-3–C-4–O-3	59.5(1)
C-3–C-4–C-5	119.6(2)	C-3–O-3–C-4	61.0(1)
C-4–C-5–O-5	112.1(1)	C-4–C-3–O-3	59.5(1)
C-5–O-5–C-1	113.8(1)	C-4–C-5–C-6	112.2(2)
O-5–C-1–O-1	112.1(1)	O-5–C-5–C-6	107.4(1)
C-1–O-1–C-9	113.0(1)	C-5–C-6–O-6	107.7(2)
C-2–C-1–O-1	106.6(1)	C-6–O-6–C-7	119.5(1)
C-1–C-2–O-2	105.1(1)	O-6–C-7–O-7	122.2(2)
C-2–O-2–C-10	116.8(1)	O-6–C-7–C-8	111.7(2)
O-2–C-10–O-10	122.0(2)	O-7–C-7–C-8	126.1(2)
O-2–C-10–C-11	112.3(2)		

TABLE IV

SOME TORSIONAL ANGLES (DEGREES) FOR **1** AND **2**

	1	**2**
C-1–C-2–C-3–C-4	9.1(2)	19.0(3)
C-2–C-3–C-4–C-5	−0.9(2)	−0.6(3)
C-3–C-4–C-5–O-5	21.9(2)	13.6(3)
C-4–C-5–O-5–C-1	−54.2(2)	−49.1(3)
C-5–O-5–C-1–C-2	64.2(2)	69.5(3)
O-5–C-1–C-2–C-3	−39.0(2)	−51.1(3)
C-2–C-1–O-1–C-9	−172.9(2)	−67.0(3)
O-5–C-1–O-1–C-9	64.1(2)	172.4(3)
O-1–C-1–C-2–O-2	−154.1(2)	−48.7(2)
O-2–C-2–C-3–O-3	−41.2(2)	−153.8(3)
C-1–C-2–C-3–O-3	77.1(2)	87.1(3)
C-1–C-2–O-2–C-10	−168.6(2)	−146.3(3)
C-2–O-2–C-10–C-11	−177.2(2)	−179.0(4)
C-4–C-5–C-6–O-6	158.6(1)	71.6(3)
O-5–C-5–C-6–O-6	−77.8(2)	−166.4(3)
C-5–C-6–O-6–C-7	125.2(2)	175.7(3)
C-6–O-6–C-7–C-8	−179.7(4)	−176.8(4)
C-6–O-6–C-7–O-7	0.5(4)	2.4(3)

characteristic for a half-chair conformation, but the addition of C-1 to this plane-defining atom-set forms a five-atom plane characteristic of a sofa conformation and supports the above hybrid assignment.

The conformation of the pyranoid ring in **1** differs from that for **2**, which was found to be almost "pure" half-chair $^1H_0$. Both O-3 and O-5 deviate from the above-mentioned least-squares planes in the same direction.

EXPERIMENTAL

A colourless crystal of **1** (0.28 × 0.18 × 0.15 mm), m.p. 55° (from ether–acetone), was subjected to X-ray diffraction measurements on a Nicolet R3m diffractometer with CuK_α radiation. The lattice parameters were obtained and refined on setting angles of 25 reflections. The intensities were collected using a $\theta/2\theta$ scan technique up to $2\theta_{max} = 110°$.

Crystal data: $C_{11}H_{14}D_2O_7$, $M_r = 260.25$, $F(000) = 276$, triclinic, space group $P\bar{1}$, $a = 8.846(3)$, $b = 9.575(2)$, $c = 8.275(6)$ Å, $\alpha = 101.43(4)$, $\beta = 114.48(4)$, $\gamma = 80.60(3)°$, $V = 622.6(5)$ Å^3, $Z = 2$, $D_x = 1.39$ Mg.m^{-3}, μ(CuK_α) = 10.1 cm^{-1}.

Of a total of 2873 collected reflections from both hemispheres, 2207 were of $I > 2\sigma(I)$. After the merging of Friedel pairs ($R_{int} = 0.037$), 1291 unique reflections were used for further calculations with Lorentz and polarisation, but no absorption, correction applied to them.

The phase problem was solved by direct methods using the MULTAN-80 program[10]. A total of 18 atoms were found in an E-map. The refinement of atomic positional and thermal parameters, initially isotropic and then anisotropic, was performed by a full-matrix, least-squares procedure, using the X-RAY-76 System, program CRYLSQ[11], with the atomic scattering factors taken from the International Tables for X-Ray Crystallography[12].

Hydrogen atoms bonded to C atoms were generated from assumed geometries, and their positions and isotropic thermal parameters were refined. The final reliability factors were $R = 0.040$, $R_w = 0.040$ (unit weights). The highest peak in the final difference map was 0.22(5) e.Å^{-3}.

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