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Note

X-Ray and conformational investigations of 7,8-dideoxy-1,2:3,4-di-*O*-isopropylidene-6-*O*-methyl-D-*glycero*-α-D-*galacto*-oct-7-ynopyranose*

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The pyranose ring of derivatives of 1,2:3,4-di-*O*-isopropylidene-α-D-galactopyranose in solution exists in the twist form regardless of the 6-substituent, and the geometry of the six-membered ring is not dependent on the polarity of the solvent or on the temperature[1]. However, X-ray investigations of some 1,2:3,4-di-*O*-isopropylidene-α-D-galactopyranose derivatives indicated that there was some conformational mobility of the pyranose ring, which can exist in twist[2], twist–boat[3,4], and twist–skew-boat[5] hybrid forms. The differences in strain energies of these forms are small (2–3 kcal.mole^{-1}).

We now report an X-ray study of 7,8-dideoxy-1,2:3,4-di-*O*-isopropylidene-6-*O*-methyl-D-*glycero*-α-D-*galacto*-oct-7-ynopyranose* (**1**).

Two symmetry-independent molecules **1A** and **1B** are shown in Fig. 1, in their natural relationship viewed at optimal orientation. The refined positional parameters for the non-hydrogen atoms of **1** together with their B_{eq} values are given in Table I[†]. The bond lengths and valence angles were close to those observed in other di-*O*-isopropylidene-α-D-galactopyranose derivatives[2–4].

The conformational analysis of **1** (Table II), consisting of calculations of ring torsion angles and of asymmetry[6] and puckering[7] parameters, demonstrated that the galactopyranose rings in **1** occur in the twist ($^{O}T_2$) conformation. There is, however, a small difference in the $^{O}T_2$ conformation of **1A** and **1B**, that in **1B** being close to

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[*] Recommended IUPAC name: 7,7,8,8-tetradehydro-7,8-dideoxy-1,2:3,4-di-*O*-isopropylidene-6-*O*-methyl-D-*glycero*-α-D-*galacto*-octopyranose.

[†] 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/384/*Carbohydr. Res.*, 173 (1988) 151–157.

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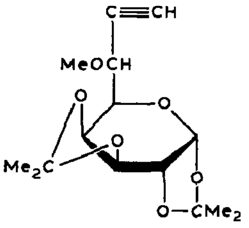

1AB

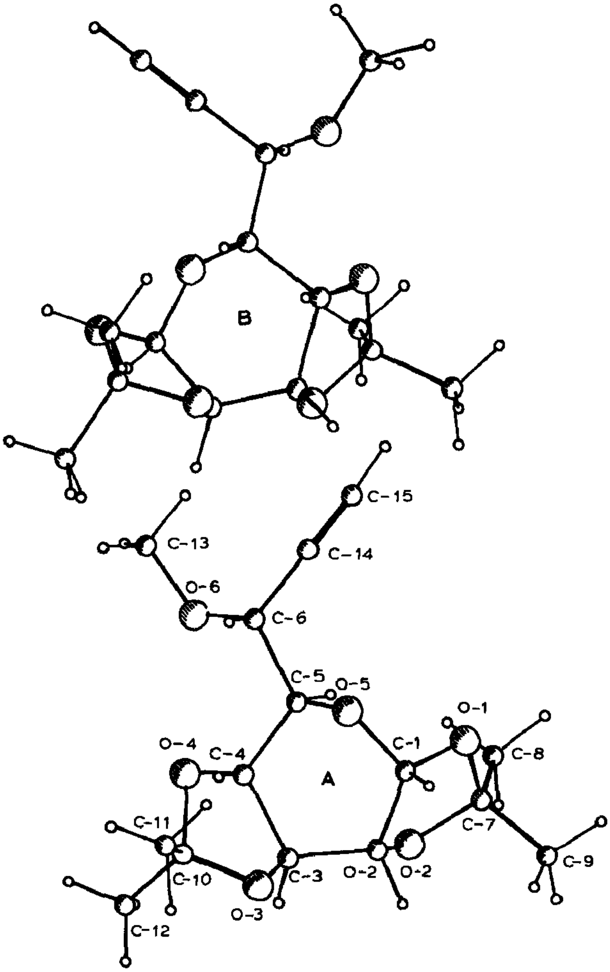

Fig. 1. Calculated projection of molecules of **1A** and **1B** with crystallographic labelling of atoms. Orientation at optimal viewing.

the ideal, whereas for that in **1A** there is some flattening as indicated by a low value (−5.8°) of the endocyclic torsion angle C-3–C-4. The twist forms of galactopyranose rings have been described[2,8].

Qualitative differences were found for the conformations of dioxolane rings

TABLE I

FRACTIONAL CO-ORDINATES ($\times 10^4$)[a] AND EQUIVALENT, ISOTROPIC TEMPERATURE FACTORS (Å^2)[b]

	1a				1b			
Atom	x/a	y/b	z/c	B_{eq}	x/a	y/b	z/c	B_{eq}
C-1	1214(5)	2672(2)	8908(6)	4.1(2)	−783(5)	86(2)	948(6)	3.8(2)
C-2	1273(5)	3143(2)	8056(6)	4.3(2)	−995(5)	497(2)	1953(6)	3.6(2)
C-3	2192(5)	3139(2)	7009(6)	3.4(2)	−2141(5)	445(2)	2670(5)	3.3(2)
C-4	2442(5)	2617(2)	6407(6)	3.6(2)	−2436(5)	−92(2)	3082(5)	3.2(2)
C-5	1799(5)	2204(2)	7081(5)	3.4(2)	−1665(5)	−474(2)	2391(5)	3.2(2)
C-6	2279(5)	1684(2)	6839(6)	4.0(2)	−2203(5)	−990(2)	2383(7)	4.2(2)
C-7	−645(6)	2927(3)	8308(9)	5.5(4)	917(5)	248(2)	2166(6)	4.1(2)
C-8	−1597(7)	2695(4)	7474(12)	8.9(4)	1653(6)	−82(3)	2994(7)	5.6(2)
C-9	−1081(8)	3294(3)	9282(11)	7.4(7)	1607(6)	678(3)	1524(7)	5.6(2)
C-10	4168(5)	3024(2)	6892(7)	4.7(2)	−4053(5)	304(2)	2153(6)	3.9(2)
C-11	5171(6)	2932(3)	7817(10)	7.6(3)	−4730(6)	191(3)	945(6)	5.0(2)
C-12	4493(7)	3317(3)	5722(8)	6.2(3)	−4769(6)	581(2)	3163(6)	4.6(2)
C-13	2917(8)	1186(3)	5092(8)	7.2(3)	−3157(10)	−1496(3)	4003(10)	9.4(4)
C-14	1483(6)	1301(2)	7349(7)	4.9(2)	−1399(6)	−1357(2)	1780(7)	5.3(2)
C-15	846(7)	999(3)	7733(9)	6.9(3)	−742(7)	−1645(3)	1346(9)	6.6(3)
O-1	7(4)	2541(1)	8901(5)	4.8(2)	405(3)	−48(1)	1136(4)	4.1(1)
O-2	171(3)	3153(2)	7437(5)	4.9(2)	−51(3)	432(1)	2847(4)	3.9(1)
O-3	3274(3)	3269(1)	7593(4)	4.2(1)	−3040(3)	580(1)	1810(4)	4.0(1)
O-4	3672(3)	2554(1)	6549(4)	4.3(4)	−3632(3)	−152(1)	2687(4)	3.7(1)
O-5	1876(3)	2268(1)	8451(3)	3.7(1)	−1500(3)	−332(1)	1094(3)	3.5(1)
O-6	2408(4)	1642(2)	5492(4)	5.2(1)	−2396(5)	−1099(2)	3722(4)	6.1(2)

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

TABLE II

CONFORMATIONS OF THE GALACTOPYRANOSE RINGS

Torsional angles (degrees)	**1a**	**1b**
O-5-C-1-C-2-C-3	−11.0(7)	−16.5(7)
C-1-C-2-C-3-C-4	33.5(7)	42.6(7)
C-2-C-3-C-4-C-5	−5.8(7)	−14.3(7)
C-3-C-4-C-5-O-5	−43.6(6)	−39.5(6)
C-4-C-5-O-5-C-1	70.8(5)	70.5(5)
C-5-O-5-C-1-C-2	−40.9(6)	−40.1(6)
Asymmetry parameters (degrees)		
ΔC_2^{2-3}	4.2(6)	1.6(6)
Puckering parameters		
Q (Å)	0.611(7)	0.649(7)
Φ (degrees)	85.8(5)	87.6(5)
Θ (degrees)	103.9(5)	98.6(5)
q_2 (Å)[a]	0.593(7)	0.641(7)
Conformation	$^{O}T_2$	$^{O}T_2$

[a] $q_2 = Q \cdot \sin \Theta$.

(Table III) in **1A** and **1B**. In **1A**, the twist conformations $^4T_3$ and $^5T_4$ are close to ideal, whereas in **1B** they are nearly ideal envelope conformations E_3 and ^5E. Of nine α-D-galactopyranose derivatives[4], in only one compound (the second of two symmetry-independent molecules[8]) did the *O*-isopropylidene rings have the same type of twist conformation; in the others, they were *E* and *T* or hybrid *E* + *T*. In **1B**, both *O*-isopropylidene rings were *E*, an arrangement not observed hitherto.

The fact that, in an asymmetric unit of the crystal cell, two independent molecules of different conformation are present ($Z = 8$) indicates that, in solution, there will be several conformations with similar stabilities.

In **1A**, the conformations of the six-membered and both five-membered rings each has an approximate two-fold axis of symmetry. Such a system of conformational forms was proved[2] to be energetically most favourable; however, there is only one reported example[8] where the all-*T* system was found crystallographically in a 1,2:3,4-di-*O*-isopropylidene-α-D-galactopyranose derivative.

EXPERIMENTAL

*7,8-Dideoxy-1,2:3,4-di-O-isopropylidene-6-O-methyl-*D-glycero-α-D-galacto-*oct-7-ynopyranose* (**1**). — A solution of 1,2:3,4-di-*O*-isopropylidene-D-*glycero*-α-D-*galacto*-oct-7-ynopyranose[9] (660 mg, 2.3 mmol) in tetrahydrofuran (5 mL) was added to a stirred suspension of sodium hydride (50% suspension in oil; 250 mg, 5

TABLE III

CONFORMATIONS OF THE *O*-ISOPROPYLIDENE RINGS[a]

1,2-O-Isopropylidene rings			*3,4-O-Isopropylidene rings*		
Torsional angles (degrees)	**1a**	**1b**	*Torsional angles (degrees)*	**1a**	**1b**
O-1–C-1–C-2–O-2	−13.2(6)	−18.3(6)	O-3–C-3–C-4–O-4	−8.8(5)	−15.3(6)
C-1–C-2–O-2–C-7	30.4(6)	31.5(7)	C-3–C-4–O-4–C-10	−13.0(6)	2.8(5)
C-2–O-2–C-7–O-1	−36.5(7)	−32.9(6)	C-4–O-4–C-10–O-3	30.4(5)	19.8(6)
O-2–C-7–O-1–C-1	27.7(7)	21.1(7)	O-4–C-10–O-3–C-3	−36.6(6)	−30.1(6)
C-7–O-1–C-1–C-2	−9.0(7)	−1.6(6)	C-10–O-3–C-3–C-4	27.7(5)	28.0(5)
Asymmetry parameters (degrees)					
ΔC_s		2.2(6)			3.5(6)
ΔC_2	3.5(6)			3.5(6)	
Puckering parameters					
q_2 (Å)[b]	0.322(7)	0.306(7)		0.318(7)	0.270(7)
Φ (degrees)	85.1(5)	73.0(5)		303.5(5)	320.3(5)
Conformation	$^{4}T_{3}$	E_3		$^{5}T_{4}$	^{5}E

[a] The indexing conforms to that for cyclopentane. [b] $q_2 = Q \cdot \sin \Theta$.

mmol) in tetrahydrofuran (5 mL). After 30 min at room temperature, methyl iodide (0.155 mL) was added and the mixture was stirred overnight at room temperature. Excess of hydride was decomposed with water (10 mL), the product was extracted with ether (3 × 30 mL), and the combined extracts were dried ($MgSO_4$) and concentrated. Column chromatography (light petroleum–ether, 4:1) of the oily residue afforded **1** (610 mg, 2.05 mmol, 89%), m.p. 109.5–110.5° (from ether–hexane, 1:3), $[\alpha]_D$ −116° (*c* 2.1, ethyl acetate). ^{1}H-N.m.r. data: *inter alia* δ 5.60 (d, 1 H, $J_{1,2}$ 4.8 Hz, H-1), 3.48 (s, 3 H, OMe), 2.38 (d, 1 H, $J_{8,6}$ 2.0 Hz, H-8), 1.57, 1.45, and 1.33 (3 s, 3 H, 3 H, 6 H, 2 CMe_2).

Anal. Calc. for $C_{15}H_{22}O_6$: C, 60.4; H, 7.4. Found: C, 60.6; H, 7.55.

X-Ray structure. — A colourless prism crystal of **1** (0.28 × 0.25 × 0.20 mm) was selected for X-ray diffraction measurements on a Siemens AED single-crystal diffractometer. Graphite-monochromated CuK_α radiation was used. Lattice parameters were refined from 25 reflections. The diffraction data were collected using a $\omega/2\theta$ scan technique up to $2\theta_{max} = 150°$. The stability of the crystal was controlled on two reflections at 50 reflection intervals at room temperature.

Crystal data for **1**: $C_{15}H_{22}O_6$, M_r = 298.33, orthorhombic, space group $P2_12_12_1$, $Z = 8$, a = 11.438(2), b = 26.848(4), c = 10.435(2) Å, V = 3204.4(9) Å^3, D_x = 1.24 Mg.m^{-3}, μ(CuK_α) = 0.76 cm^{-1}.

A total of 3462 reflections were collected, of which 1654 unique reflections were of $I > 2\sigma(I)$. The Lorentz and polarisation correction was applied to the data. No absorption correction was applied.

The structure was solved by direct methods using the SHELX-86 program[10]. A total of 42 atoms were found in an E-map. The refinement of the atomic positional and thermal parameters (initially isotropic, then anisotropic) was performed by the full-matrix, least-squares procedure (X-RAY-76 System, program CRYLSQ[11]) with the atomic scattering factors taken from International Tables for X-Ray Crystallography[12]. Hydrogen atoms bound to C atoms were generated from assumed geometries. The final reliability factors were R = 0.040 and R_W = 0.040 (unit weights). The residual electron density of the ΔF map was 0.25 e.Å^{-3}.

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