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Note

An n.m.r. study of 1,2,3-tri-*O*-acetyl-β-L-rhamnopyranose and 1,2,4-tri-*O*-acetyl-α-L-rhamnopyranose, and the X-ray structure of the former

ELIZABETH LEE, NOEL GAVIN, PATRICK MCARDLE, AND DESMOND CUNNINGHAM
Chemistry Department, University College, Galway (Ireland)

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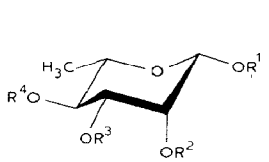
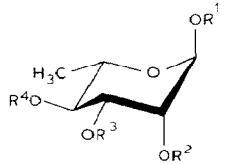
Reaction of L-rhamnose with 5 mol of acetic anhydride in the presence of sodium acetate at room temperature gave a mixture of products from which the crystalline title 1,2,3-β (**1**, 8.5%) and 1,2,4-α-triacetate (**2**, 1.8%) were isolated after column chromatography, together with a mixture (38%) of **1** and **2** in which **1** preponderated. A ~1.4:1 α,β-mixture (11.5%) of L-rhamnopyranose tetra-acetate was also obtained, and could be anomerised to give the syrupy α-anomer[1].



1 $R^1 = R^2 = R^3 = Ac, R^4 = H$



2 $R^1 = R^2 = R^4 = Ac, R^3 = H$

The structure of **1** was assigned on the basis of the ^{1}H-n.m.r. data: the signals for H-1 (δ 5.84, d, $J_{1,2}$ ~1 Hz), H-2 (δ 5.46, dd, $J_{2,3}$ 3.3 Hz), and H-3 (δ 4.92, dd, $J_{3,4}$ 9.3, $J_{3,2}$ 3.3 Hz) indicated the location of the acetyl groups and the β configuration. Likewise, for **2**, the low-field signals were associated with H-1 (δ 6.03, $J_{1,2}$ 1.7 Hz), H-2 (δ 5.09, dd, $J_{2,3}$ 3.7 Hz), and H-4 (δ 4.91, t, $J_{3,4} = J_{4,5} = 9.9$ Hz), consistent with the 1,2,4-α-triacetate structure.

The ^{13}C-n.m.r. data for **1** and **2** are given in Table I, together with the values reported[2] for the 1,2-di- (**3**), 2,4-di- (**4**), and 1,2,3,4-tetra-acetate (**5**) of α-L-rhamnopyranose, and the 1,2-di- (**6**), 2,3-di- (**7**), and 1,2,3,4-tetra-acetate (**8**) of β-L-rhamnopyranose. Selective ^{1}H-spin-decoupling experiments allowed complete assignment of the resonances in the spectrum of **2**. Since the H-4,5 resonances of **1** could not be separated, the ^{13}C signals at 70.3 and 73.3 p.p.m. could not be assigned unambiguously. However, by comparison with related compounds, the peak at lower field was assigned to C-5.

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TABLE I

^{13}CHEMICAL SHIFT DATA[a] FOR L-RHAMNOPYRANOSE ACETATES

Compound	*Configuration*	*Location of acetyl groups*	*C-1*	*C-2*	*C-3*	*C-4*	*C-5*	*C-6*	*CH_3CO*	*CH_3CO*
2	α	1,2,4	90.4	71.3	68.2	73.9	68.3	17.4	168.5–171.4	20.9–21.0
3	α	1,2	91.4	71.4	70.2	72.9	70.6	17.6	—	—
4	α	2,4	92.0	73.5	68.2	75.0	66.2	17.5	—	—
5	α	1,2,3,4	91.2	69.1	71.9	70.7	71.0	17.5	—	—
1	β	1,2,3	90.4	68.8	73.4	70.3	73.3	17.5	168.6–170.8	20.8–20.9
6	β	1,2	91.6	71.3	72.1	73.5	72.7	17.6	—	—
7	β	2,3	92.6	70.5	71.2	74.1	72.6	17.7	—	—
8	β	1,2,3,4	90.6	68.8	70.9	70.6	71.5	17.5	—	—

[a]P.p.m. downfield from the signal for Me_4Si.

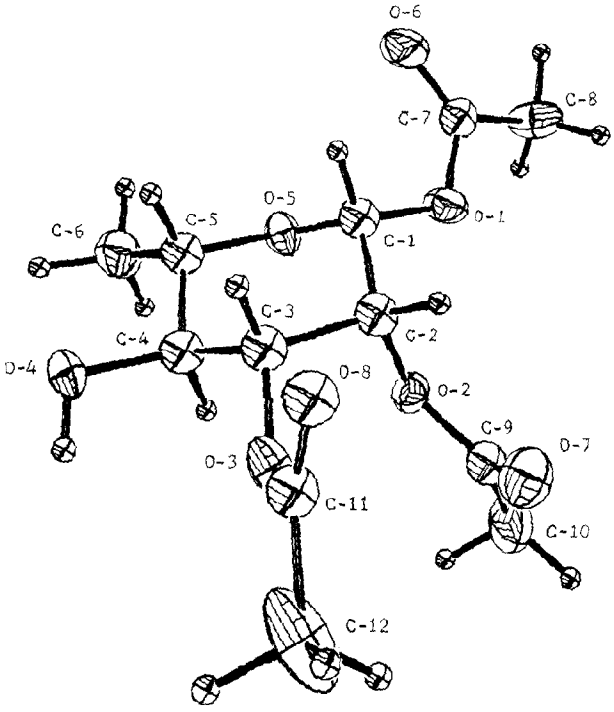

Fig. 1. ORTEP[9] drawing of 1,2,3-tri-*O*-acetyl-β-L-rhamnopyranose (**1**), and the numbering scheme.

Comparison of the ^{13}C-n.m.r. data for the 1,2,4-α-triacetate **2** and the 1,2-α-diacetate **3** showed that acetylation caused a negative (upfield) shift of 2.0–2.3 p.p.m. in the resonances for the β-carbon atoms (*i.e.*, for C-3 and C-5, in **2**) and a downfield shift in the resonance for the α-carbon (1.00 p.p.m. for C-4 in **2**), as expected. A similar trend was observed on acetylation of **2** to give **5** (β-carbons: 2.2–3.2 p.p.m. for C-2 and C-4; α-carbon: 3.7 p.p.m. for C-3). The acetylation of HO-1 in the 2,4-α-diacetate **4** caused upfield shifts of 1.6 p.p.m. in the signal for the α-carbon (C-1) and 2.2 p.p.m. for the β-carbon (C-2), and had a significant effect (downfield shift of 2.1 p.p.m.) upon the chemical shift of C-5, as expected[2].

Acetylation of HO-4 in **1** to give **8** caused an upfield shift of 1.8–2.5 p.p.m. in the resonances of the β-carbons (C-5 and C-3) and a small downfield shift (0.3 p.p.m.) in the resonance for the α-carbon (C-4). Acetylation of HO-1 in the 2,3-β-diacetate **7** caused upfield shifts of 2.2 and 1.7 p.p.m. in the signals for the α- (C-1) and β- (C-2) carbons, and a small downfield shift (0.7 p.p.m.) for the C-5 signal, as expected.

1,2,3-Tri-*O*-acetyl-β-L-rhamnopyranose (**1**) was subjected to X-ray crystallography. A perspective view of the molecule, showing the numbering, is given in

TABLE II

CRYSTAL DATA FOR **1** COLLECTED IN THE RANGE 0–18 *h*, 0–7 *k*, 0–8 *l*

Mol. wt.	290
Formula	$C_{12}H_{18}O_8$
Crystal size	0.20 × 0.15 × 0.17 mm
Space group	*P*2,2,2.
a (Å)	18.520(6)
b (Å)	8.646(4)
c (Å)	9.359(5)
U (Å^3)	1498.6
μ (cm^{-1})	0.70
*F*000	616.0
Z	4
Radiation Mo-K_α	
Graphite monochromator	λ 0.7093 Å
Diffractometer	Enraf–Nonius CAD4F
Orienting reflections,	
Range	25, $13 < \theta < 20°$
Temperature (°)	22
Scan method	ω–2θ
Data collection range	$2 < 2\theta < 48°$
Total $I > 3\sigma I$	550
No. of parameters fitted	144
R^a	4.99%
$R_w{}^b$	5.90
Largest shift/e.s.d., final cycle	<0.001
Largest positive peak (e/Å^3)	0.08
Largest negative peak (e/Å^3	−0.08

$^aR = [\Sigma|F_o - F_c|]/\Sigma|F_o|$. $^bR = \{[\Sigma w(|F_o - F_c|)^2]/\Sigma w(|F_o|)^2]\}^{1/2}$; $w = 1/[(\sigma F_o)^2 - 0.0044*F_o^2]$.

Fig. 1. The C–C bond lengths in the sugar ring have a mean value of 1.51 Å, in agreement with values observed for other carbohydrates, and there is a $^1C_4$ conformation with C-2, C-3, C-5, and O-5 coplanar (within 0.03 Å; C-1 and C-4, respectively, lie 0.66 Å above and below this plane).

EXPERIMENTAL

Acetylation of L-*rhamnose.* — A mixture of L-rhamnose (5 g, 30.6 mmol), anhydrous sodium acetate (1.5 g), and acetic anhydride (14 mL, 148 mmol) was stirred for 42 h at room temperature, then filtered, and the insoluble material (sodium acetate and unreacted sugar) was washed with benzene. The combined filtrate and washings were co-concentrated with water–methanol (1:1) to remove traces of acetic acid. T.l.c. (benzene–methanol, 10:1) of the resulting syrup (6.8 g) showed two major components [tetra- (R_F ~0.9) and tri-acetate (R_F ~0.6)], and a third product (presumably diacetate) with R_F ~0.2.

The syrupy mixture was eluted from a column (33 × 3 cm) of silica gel (50–100 mesh) with benzene, and fractions (100 mL) were collected and concentrated.

Fractions 1–8 gave syrupy tetra-*O*-acetyl-α,β-L-rhamnopyranose (**3**, 1.6 g), $[\alpha]_D$ −34° (*c* 1.1, chloroform). N.m.r. data ($CDCl_3$): δ 6.01 (d, $J_{1,2}$ 1.2 Hz, H-1α), 5.84 (d, $J_{1,2}$ ~1 Hz, H-1β); αβ-ratio ~1.4:1. Anomerisation[3] of **3** with acetic acid–acetic anhydride and sulphuric acid gave syrupy tetra-*O*-acetyl-α-L-rhamnopyranose, $[\alpha]_D$ −50° (*c* 1.2, chloroform); lit.[1] $[\alpha]_D$ −61.7° (chloroform). N.m.r. data ($CDCl_3$): δ 6.04 (d, 1 H, $J_{1,2}$ 1.2 Hz, H-1), 5.60–5.10 (m, 3 H, H-2,3,4), 2.32–1.96 (12 H, 4 AcO), 1.24 (d, 3 H, $J_{5,6}$ 6 Hz, Me-5).

Fractions 9–16 contained tetra- and tri-acetate.

Fractions 17–28 contained triacetate **1** contaminated with triacetate **2**. Fractional crystallisation from di-isopropyl ether gave 1,2,3-tri-*O*-acetyl-β-L-rhamnopyranose (**1**) as needles, m.p. 164–167°, [α] +34° (*c* 0.9, chloroform), and 1,2,4-tri-*O*-acetyl-α-L-rhamnopyranose (**2**; 160 mg, 1.8%) as fine needles, m.p. 145–149°, $[\alpha]_D$ −41° (*c* 1.1, chloroform). Fractions 29–51 and fractions 52–93, eluted with ether–benzene (5.95), also contained **1** (total yield, 730 mg, 8.3%).

^{1}H-N.m.r. data for **1** ($CDCl_3$): δ 5.84 (d, 1 H, $J_{1,2}$ 1.1 Hz, H-1), 5.46 (dd, 1 H, H-2), 4.92 (dd, 1 H, $J_{3,2}$ 3.3, $J_{3,4}$ 9.3 Hz, H-3), 2.71 (d, 1 H, $J_{HO,4}$ 5 Hz, HO-4), 2.18–2.07 (3 s, 9 H, 3 Ac), 1.41 (d, 3 H, $J_{5,6}$ 5.7 Hz, Me-5), and 3.77–3.57 (m, H-4,5).

Anal. Calc. for $C_{12}H_{18}O_8$: C, 49.66; H, 6.21. Found: C, 49.09; H, 6.24.

^{1}H-N.m.r. data for **2** ($CDCl_3$): δ 6.03 (d, 1 H, $J_{1,2}$ 1.7 Hz, H-1), 5.09 (dd, 1 H, $J_{2,3}$ 3.7 Hz, H-2), 4.91 (t, 1 H, $J_{3,4} = J_{4,5}$ = 9.9 Hz, H-4), 4.05 (m, 1 H, H-3), 3.87 (m, 1 H, H-5), 2.81 (d, 1 H, HO-3), 2.18–2.14 (3 s, 9 H, 3 Ac), and 1.21 (d, 3 H, $J_{5,6}$ 6.3 Hz, Me-5).

Anal. Found: C, 50.02; H, 6.21.

Fractions 94–129, eluted with ether–benzene (1:9), and fractions 130–139, eluted with ether–benzene (15:85), gave a syrupy mixture (3.30 g, 38.2%) of **1** contaminated with **2**.

Fractions 130–139, eluted with ether–benzene (15:85), gave a syrup (390 mg) which contained triacetate and, presumably, diacetate.

N.m.r. spectra were recorded with a JEOL GX-270 spectrometer for solutions in $CDCl_3$ (internal Me_4Si). The ^{13}C-n.m.r. data are given in Table I.

*X-Ray crystallography**. — The crystallographic data are given in Table II. The structure was solved by a direct method, SHELX-86[4], and refined by full-matrix least squares using SHELX-76[5]. Data were corrected for Lorentz and polarisation effects but not for absorption. Hydrogen atoms were included in the calculated positions with fixed thermal parameters. The eight oxygen atoms and C-6,8,10,12 were refined anistropically. The thermal parameters were terms U_{ij} of

$$\exp.\ [-2\Pi^2(U_{11}h^2a^{*2} + U_{22}k^2b^{*2} + U_{33}l^2c^{*2} + 2U_{12}hka^*b^* + 2U_{13}hla^*c^* + 2U_{23}klb^*c^*)].$$

The atomic scattering factors for non-hydrogen and hydrogen atoms and the

*Lists of atomic co-ordinates, bond lengths and angles, and anisotropic and isotropic thermal parameters have been deposited with, and may 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/425/*Carbohydr. Res.*, 197 (1990) 270–275.

anomalous dispersion correction factors for non-hydrogen atoms were taken from the literature[6–8]. All calculations were performed on a VAX 8700 computer. The ORTEP program was used to obtain the drawings[9].

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