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Note

Crystal and molecular structure of 1,3-dihydro-4-(3,4-*O*-isopropylidene-D-*arabino*-tetritol-1-yl)-3-methyl-1-*p*-tolyl-2*H*-imidazole-2-thione

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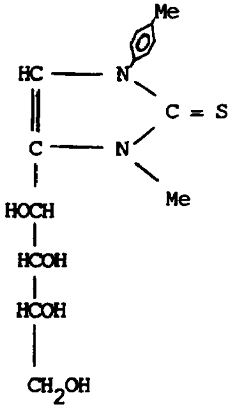
The title compound was prepared by heating **1** under reflux with 2,2-dimethoxypropane in 1,2-dimethoxyethane[1]. Neutral conditions were used in order to avoid the formation of anhydro rings[2,3]. X-Ray analysis confirmed the structure **2**, for which the bond lengths and angles are shown in Table I[‡] and a stereo view of the molecule with the atomic numbering is shown in Fig. 1.



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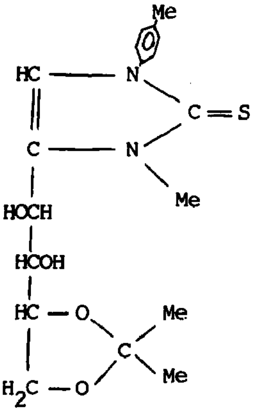

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[‡] Lists of the observed and calculated struture factors, and the anisotropic thermal parameters are deposited with, and can be obtained, from Elsevier Science Publishers B.V., BBA Data Deposition, P.O. Box 1527, Amsterdam, The Netherlands. Reference should be made to No. BBA/DD/448/*Carbohydr. Res.*, 210 (1990) 279–284.

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TABLE I

Bond lengths (Å) and angles (°) with e.s.d. values in parantheses

S–C-2	1.693(5)	C-4–C-5	1.343(7)
O-1′–C-1′	1.430(5)	C-6″–C-1″	1.374(8)
O-2′–C-2′	1.411(6)	C-6″–C-5″	1.387(9)
N-3–C-4	1.401(6)	C-1″–C-2″	1.350(9)
N-3–C-2	1.348(6)	C-3′–C-4′	1.520(9)
N-3–C-3‴	1.458(7)	O-4′–C-4′	1.413(9)
N-1–C-2	1.371(6)	O-4′–C-2$^{\mathrm{iv}}$	1.385(10)
N-1–C-5	1.396(6)	C-2″–C-3″	1.391(9)
N-1–C-1″	1.426(6)	C-3″–C-4″	1.415(10)
O-3′–C-3′	1.432(8)	C-4″–C-5″	1.341(12)
O-3′–C-2$^{\mathrm{iv}}$	1.434(8)	C-4″–C-4‴	1.531(10)
C-2′–C-1′	1.509(6)	C-2$^{\mathrm{iv}}$–C-3$^{\mathrm{iv}}$	1.471(12)
C-2′–C-3′	1.527(7)	C-2$^{\mathrm{iv}}$–C-1$^{\mathrm{iv}}$	1.530(14)
C-4–C-1′	1.509(6)		
C-2–N-3–C-3‴	122.9(4)	N-1–C-1″–C-6″	119.9(5)
C-4–N-3–C-3″	127.5(4)	C-6″–C-1″–C-2″	120.6(5)
C-4–N-3–C-2	109.6(4)	N-1–C-1″–C-2″	119.5(5)
C-5–N-1–C-1″	124.5(4)	O-3′–C-3′–C-2′	109.6(5)
C-2–N-1–C-1″	126.3(4)	C-2′–C-3′–C-4′	112.9(5)
C-2–N-1–C-5	109.1(4)	O-3′–C-3′–C-4′	102.4(5)
C-3′–O-3′–C-2$^{\mathrm{iv}}$	109.6(5)	C-4′–O-4′–C-2$^{\mathrm{iv}}$	109.1(6)
O-2′–C-2′–C-3′	107.6(4)	C-1″–C-2″–C-3″	120.5(6)
O-2′–C-2′–C-1′	112.1(4)	C-2″–C-3″–C-4″	118.6(7)
C-1′–C-2′–C-3′	111.1(4)	C-3″–C-4″–C-4‴	118.2(8)
N-3–C-4–C-5	107.3(4)	C-3″–C-4″–C-5″	119.8(6)
N-3–C-4–C-1′	123.3(4)	C-5″–C-4″–C-4‴	122.0(6)
C-1′–C-4–C-5	129.3(4)	C-6″–C-5″–C-4″	120.8(6)
C-2′–C-1′–C-4	112.3(4)	C-3′–C-4′–O-4′	103.5(6)
O-1′–C-1′–C-4	108.5(3)	O-3′–C-2$^{\mathrm{iv}}$–O-4′	106.4(6)
O-1′–C-1′–C-2′	108.0(3)	O-4′–C-2$^{\mathrm{iv}}$–C-3$^{\mathrm{iv}}$	117.7(7)
N-3–C-2–C-1	106.5(4)	O-4′–C-2$^{\mathrm{iv}}$–C-1$^{\mathrm{iv}}$	105.4(7)
S–C-2–N-1	125.8(4)	O-3′–C-2$^{\mathrm{iv}}$–C-3$^{\mathrm{iv}}$	110.6(6)
S–C-2–N-3	127.6(4)	O-3′–C-2$^{\mathrm{iv}}$–C-1$^{\mathrm{iv}}$	107.3(6)
N-1–C-5–C-4	107.4(4)	C-1$^{\mathrm{iv}}$–C-2$^{\mathrm{iv}}$–C-3$^{\mathrm{iv}}$	108.9(8)
C-1″–C-6″–C-5″	119.7(6)		

p-*Tolyl group.* — The mean value of the length of C–C bonds in the ring is 1.376(9) Å and that of C–CH_3 is 1.531(10) Å. This group is planar [maximum deviation from the least squares plane 0.009(6) Å] and the N-1 substituent is at 0.020(4) Å.

Imidazoline-2-thione group. — The S–C bond length of 1.693(5) Å is intermediate between those of a S–C single (1.81 Å) and double bond (1.56 Å). This partial double-bond character reflects the resonance of the thiourea system which is a normal feature of these compounds. The average distances N-3–C-2 and N-1–C-2 of 1.360(6) Å, N-1–C-5 and N-3–C-4 of 1.399(6) Å, and C-5–C-4 of 1.343(7) Å agree with the mean values reported for analogous compounds[4,5]. The imidazoline ring is planar [maximum deviation from the least squares plane, 0.003(5) Å].

The substituents S, C-1′, C-3‴, and C-1″ are at −0.046(1), −0.068(5), −0.036(6), and 0.061(5) Å, respectively, from the best plane. The N-3–C-3″ and N-1–C-1″ distances

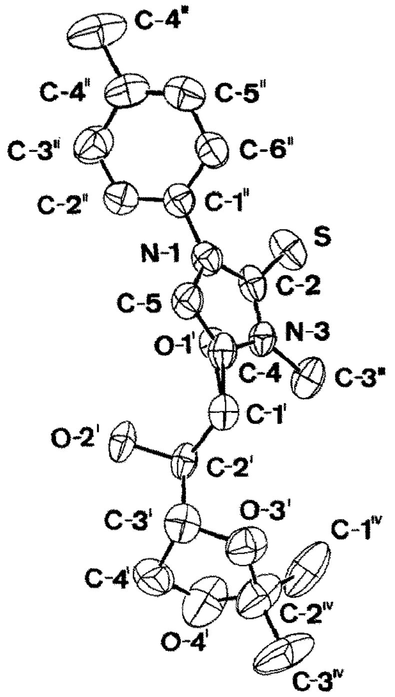

Fig. 1. A stereoscopic view of **2** showing the atomic numbering. Thermal ellipsoids enclose 50% probability.

are 1.458(7) and 1.426(7) Å, respectively. The average angles C–N–C and N–C–C are 109.4(4) and 107.4(4)°, respectively. The N–C–N angle is 106.5(4)°. The dihedral angle between the tolyl and imidazoline rings is 65.2(2)°.

Sugar chain. — The chain C-4,1′,2′,3′ is planar [maximum deviation 0.025(8) Å]. The average C–C and C–OH distances of 1.515(6) and 1.420(6) Å, respectively, and the average bond angles C–C–C and C–C–O of 111.7(4) and 109.1(3)°, respectively, are normal. Newman projections are shown in Fig. 2. According to the Klyne and Prelog rules[6], the configurations around the chiral centres C-1′,2′,3′ are *R*, *S*, and *R*, respectively, in agreement with the structure **2**.

Dioxolane ring. — The C–C distance is 1.520(9) and the mean O–C value is 1.416(9) Å. The mean C–C exocyclic distance is 1.509(11) Å. In terms of ring-puckering co-ordinates[7], the amplitude and phase magnitudes are Q 0.280(6) ψ Å and 38(1)° for the sequences C-3′, C-4′, O-4′, C-2^{iv}, and O-3′. The asymmetry parameters[8] are ΔC_s(C-4′) 0.010(3), ΔC_2(C-2^{iv}) 0.058(3), and ΔC_2(O-3′) 0.045(2), so that the conformation is an envelope with a pseudo-mirror plane through C-4′.

Crystal packing. — The crystal of **2** involves a three-dimensional network of molecules linked by hydrogen bonds. There are six hydrogen bonds:

O-2′ ··· S $(-x + 1, y + 1/2, -z + 1)$ = 3.111(3) Å, O-2′-H ··· S = 99.9(2)°;
C-3‴ ··· O-2′ $(x, -y + 1/2, z)$ = 2.907(7) Å, C-3‴-H ··· O-2′ = 155.1(4)°;
C-1′ ··· O-1′ $(x, -y + 1/2, z)$ = 2.447(6) Å, C-1′-H ··· O-1′ = 119.9(3)°;
C-1′ ··· O-3′ $(x, -y + 1/2, z)$ = 3.012(6) Å, C-1′-H ··· O-3′ = 111.7(3)°;

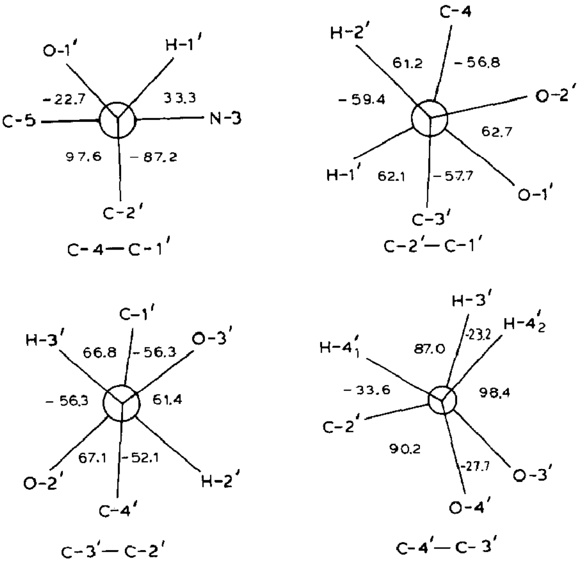

Fig. 2. Some Newman projections for **2**.

$\text{O-1}' \cdots \text{O-1}' \, (x, -y + 1/2, z) = 2.529(6)$ Å, $\text{O-1}'\text{-H} \cdots \text{O-1}' = 91.5(3)°$;
$\text{C-3}''' \cdots \text{S} \, (-x + 1, -y, -z + 1) = 3.133(6)$ Å, $\text{C-3}'''\text{-H} \cdots \text{S} = 108.4(4)°$.

The conformation of **2** in solution, deduced from the vicinal coupling constants, is similar to that deduced from the X-ray diffraction data, *i.e.*, H-1',2' are *gauche* and H-2',3' are *antiperiplanar* in solution and in the solid state. However, the torsion angles $\text{H-3}'/\text{H-4}'_1$ and $\text{H-3}'/\text{H-4}'_2$ are ~30° and 150°, respectively, in solution, and −23° and 87°, respectively, in the solid state.

EXPERIMENTAL

General methods. — The melting point was determined with an Electrothermal apparatus. The optical rotation was measured with a Perkin–Elmer 241 polarimeter. The i.r. spectrum (KBr disc) was recorded with an FT-IR Bomen MB-120 spectrophotometer. The ^{1}H- and ^{13}C-n.m.r. spectra (internal Me_4Si) were recorded with a Varian XL-200 spectrometer at 20°. Off-resonance experiments were used to assist in the assignment of signals.

*1,3-Dihydro-4-(3,4-*O*-isopropylidene-*D-arabino*-tetritol-1-yl)-3-methyl-1-*p*-tolyl-2*H*-imidazole-2-thione* (**2**). — A mixture of 1,3-dihydro-3-methyl-4-(D-*arabino*-tetritol-1-yl)-1-*p*-tolyl-2*H*-imidazole-2-thione[9] (~0.2 g, 6.16 mmol) in 1,2-dimethoxyethane–2,2-dimethoxypropane (2:1, 3 mL) was stirred and heated under reflux for 60 h, then concentrated. Column chromatography (ether–ethanol gradient) of the syrupy residue on silica gel gave **2** (107 mg, 48%), m.p. 176–177° (from ethanol), $[\alpha]_D^{23}$ +9.4° (*c* 2.2, pyridine), R_F 0.66 (40:1 ether–ethanol); ν_{max} 3358 and 3270 (OH), 3127 (HC=), 1611

(C = C heterocycle and aromatic), 1516, 1443 (C = C aromatic), 1370 (C–N, CH_3), and 842 cm^{-1} (aryl *p*-substituent). N.m.r. data (see Fig. 1 for the numbering of the atoms): ^1H (200 MHz, CD_3OD), δ 7.42–7.27 (m, 4 H, C_6H_4), 7.11 (d, 1 H, $J_{5,1'}$ 0.9 Hz, H-5), 4.85 (dd, 1 H, $J_{1',2'}$ 1.9 Hz, H-1'), 4.23 (m, 1 H, H-3'), 4.13 (dd, 1 H, $J_{4',3'}$ 6.1, $J_{4',4''}$ 8.2 Hz, H-4'), 3.97 (dd, 1 H, $J_{4'',3'}$ 5.6 Hz, H-4''), 3.70 (dd, 1 H, $J_{2',3'}$ 8.0 Hz, H-2'), 3.70 (s, 3 H, NMe), 2.39 (s, 3 H, ArMe), 1.38 and 1.34 (2 s, CMe_2); ^{13}C (50.3 MHz, $CDCl_3$), δ 161.7 (C = S), 138.2 (C-4''), 135.1 (C-1''), 130.5 (C-4), 129.4 (2 C, C-3'',5''), 125.4 (2 C, C-2'',6''), 116.7 (C-5), 109.3 ($\mathit{C}Me_2$), 74.9 (C-3'), 72.7 (C-2'), 66.6 (C-4'), 64.0 (C-1'), 32.6 (NCH_3), 26.6 and 24.9 [$C(\mathit{C}H_3)_2$], and 20.9 ($Ar\mathit{C}H_3$).

Anal. Calc. for $C_{18}H_{24}N_2O_4S$: C, 59.32; H, 6.64; N, 7.69; S, 8.80. Found: C, 59.72; H, 6.66; N, 7.29; S, 9.02.

The crystal of **2** studied was ~0.08 x 0.15 x 0.12 mm and belonged to the monoclinic system with systematic absences consistent with $P2_1$. The lattice parameters, refined using 25 reflections within the range $2 \leqslant \Theta \leqslant 14°$, were *a* 14.708(2), *b* 7.072(1), *c* 9.503(2) Å, and β 94.70(2)°. The unit cell volume *V* was 985.1 $Å^3$, and the absorption was 0.742 cm^{-1}.

An Enraf–Nonius CAD-4 diffractometer was used with monochromated Mo-K_α radiation (0.7107 Å), the $\omega/2\theta$ scan technique, and at room temperature ($0 \leqslant h < 20$, $0 \leqslant k \leqslant 9$, $-13 \leqslant l \leqslant 13$). Two standard reflections, monitored every 100 reflections, showed only statistical fluctuations. From 3076 unique reflections measured $(\sin\theta/\lambda)_{max} = 0.71\mathring{}$, 2043 were observed with $I \geqslant 2\,\sigma(I)$. $F(000) = 356$. Corrections were made for Lorentz-polarization effects, but not for extinction and absorption.

The structure was solved by direct methods using the MULTAN80 program[10]. Positional and anisotropic thermal parameters for all non-hydrogen atoms were refined by full-matrix least squares; the positions of the H atoms were calculated geometrically, except those of the hydroxyl groups which were calculated from a difference synthesis. All the H atoms were assigned the same isotropic temperature factors as the atoms to which they are bonded, and were included in the refinement with positional and thermal parameters fixed (481 parameters). Refinement was based on *F* (structure amplitudes) to minimise the function $\Sigma w(|F_o| - |F_c|)^2$ with $w = 1/\sigma^2(F_o)$.

The refinement led to a final convergence with $R = 0.069$. All parameter shifts during the final cycle of refinement were <0.12; the residual electron density in the difference map was ±0.3 e $Å^{-3}$. Atomic scattering factors were taken from the International Tables for X-Ray Crystallography[11], and all calculations were carried out with the X-Ray System[12]. The *y* co-ordinate of S was held fixed in order to define the origin.

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