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Structure of (±)-*exo*-4′-Hydroxy-*exo*-6′-hydroxymethyl-*endo*-3′-thymin-1-yl-2′,7′-dioxabicyclo[3.2.0]heptane

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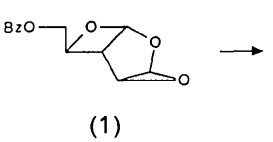
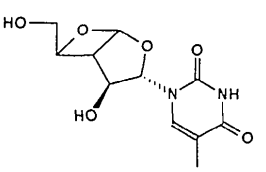
Abstract. 1-(*exo*-4-Hydroxy-*exo*-6-hydroxymethyl-2,7-dioxabicyclo[3.2.0]hept-*endo*-3-yl)-5-methyl-2,4-(1*H*,3*H*)-pyrimidinedione, $C_{11}H_{14}N_2O_6$, $M_r = 270.24$, triclinic, $P\bar{1}$, $a = 10.0636$ (17), $b = 10.4054$ (20), $c = 11.9671$ (15) Å, $\alpha = 96.552$ (15), $\beta = 108.031$ (11), $\gamma = 90.498$ (14)°, $V = 1182.5$ (3) Å^3, $Z = 4$, $D_x = 1.518$ g cm^{-3}, λ(Cu $K\alpha$) = 1.54056 Å, $\mu = 10.2$ cm^{-1}, $F(000) = 568$, $T = 295$ K, $R = 0.076$, $wR = 0.067$ for 1974 reflections with $I_{net} > 2.5\sigma(I_{net})$. The structure determination confirmed unambiguously the NMR analyses of the title compound, clearly showing the nitrogenous base *trans* to the adjacent hydroxyl group. The title compound is a potentially useful precursor for the preparation of unconventional nucleosides and may possess biological activity.

Experimental. The title compound (2) was prepared according to the method described by Hambalek & Just (1992). Its recrystallization from acetone/hexane



(1)



(2)

gave bone-white crystals, m.p. 467–469 K, one of which (0.10 × 0.20 × 0.25 mm) was used for data collection at 295 K using the $\theta/2\theta$ scan mode. Cell parameters from 21 reflections in the 2θ range 15–25°. Data were collected on a Rigaku AFC-6*S* diffractometer with graphite-monochromated Cu $K\alpha$ radiation. Three standards measured every 100 reflections were used for scaling and had an overall drop in intensity of 0.2%. No correction was made for absorption. Averaging of 414 symmetry-equivalent reflections gave a merging R value of 1.2%. Parameters related to crystal data and intensity collection are given in Table 1. The structure was solved by direct methods using *SHELXS*86 (Sheldrick, 1985) and refined using *NRCVAX* system programs (Gabe, Le Page, Charland, Lee & White, 1989). The two crystallographically independent molecules in the asymmetric unit showed only slight differences in bond lengths and angles, therefore, only one molecule is shown in Fig. 1. H atoms were included in calculated positions and were not refined. Final atomic parameters are listed in Table 2.† All non-H atoms were refined anisotropically. Scattering factors from *International Tables for X-ray Crystallography* (1974, Vol. IV).

Table 1. *Data collection and crystal parameters*

Scan width (°)	1.5 + 0.3tanθ
Scan rate (° min^{-1})	4
2θ range (°)	5–110
h, k, l ranges	−10 to 10, 0 to 11, −12 to 12
No. of reflections measured	3182
No. of unique reflections	2975
No. of reflections with $I_{net} > 2.5\sigma(I_{net})$	1975
No. of parameters	344
Secondary-extinction coefficient*	0.116 (15)
For significant reflections	$R = 0.076$, $wR = 0.067$
For all reflections	$R = 0.133$, $wR = 0.069$
Goodness-of-fit	2.86
Weighting scheme	$w = 1/\sigma^2(F_o) + 0.00003(F_o)^2$
Max. shift/e.s.d. in last cycle	0.003
Difference Fourier peaks (e Å^{-3})	0.38, −0.58

* Secondary-extinction coefficient as in Larson (1970). The refined parameter is the average mosaic block size in μm.

An *ORTEP*II plot (Johnson, 1976) of (2) is shown in Fig. 1. Bond lengths and angles, except those involving H atoms, are given in Table 3. A stereoplot showing packing of the unit cell has been deposited as supplementary material. The structure consists of a puckered 2,7-dioxabicyclo[3.2.0]heptane moiety with the nitrogenous base *cis* to the oxetane ring and *trans* to the adjacent hydroxyl function. Intermolecular hydrogen bonds are inferred to exist between O(2)—O(6″*A*) at x, y, z [2.719 (6) Å], O(4)—O(4′*A*) at $x+1$, y, z [2.674 (7) Å], N(3)—O(2*A*) at $x+1$, y, z [2.860 (6) Å] and O(6*A*″)—N(3*A*) at $x+1$, y, z [2.803 (7) Å].

† Lists of structure factors, calculated H-atom parameters, anisotropic thermal parameters and torsion angles, and a stereo-view of the packing within the unit cell have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 71146 (21 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England. [CIF reference: CD1029]

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Table 2. *Atomic parameters and B_{eq} values* (Å^2) *with e.s.d.'s in parentheses*

B_{eq} is the mean of the principal values for the anisotropic mean displacement tensor, B, transformed to orthogonal axes.

	x	y	z	B_{eq}
O(2)	0.3001 (5)	0.8959 (4)	0.7869 (4)	3.57 (25)
O(4)	0.6722 (5)	1.1336 (5)	0.7676 (4)	4.2 (3)
O(2′)	0.2568 (5)	1.1486 (4)	1.0574 (4)	3.04 (23)
O(4′)	0.0174 (5)	0.9668 (5)	0.8875 (4)	4.0 (3)
O(7′)	0.2142 (5)	1.3517 (4)	0.9828 (4)	3.9 (3)
O(6″)	−0.0600 (6)	1.4529 (5)	0.8803 (5)	6.2 (4)
N(1)	0.3632 (5)	1.0866 (5)	0.9082 (4)	2.5 (3)
N(3)	0.4852 (6)	1.0177 (5)	0.7791 (5)	2.9 (3)
C(2)	0.3767 (7)	0.9933 (6)	0.8210 (6)	2.9 (3)
C(4)	0.5808 (7)	1.1213 (6)	0.8147 (6)	3.0 (4)
C(5)	0.5670 (7)	1.2116 (6)	0.9131 (6)	3.1 (3)
C(5Me)	0.6747 (8)	1.3191 (7)	0.9669 (7)	4.1 (4)
C(6)	0.4586 (7)	1.1901 (6)	0.9530 (5)	2.7 (3)
C(3′)	0.2489 (7)	1.0576 (6)	0.9582 (6)	2.9 (3)
C(4′)	0.1033 (7)	1.0671 (6)	0.8703 (6)	3.0 (4)
C(5′)	0.0571 (7)	1.1999 (6)	0.9029 (6)	2.9 (4)
C(1′)	0.1602 (7)	1.2466 (6)	1.0252 (6)	3.2 (4)
C(6′)	0.1201 (8)	1.3138 (7)	0.8622 (6)	3.8 (4)
C(6″)	0.0300 (9)	1.4215 (8)	0.8143 (7)	5.6 (5)
O(2*A*)	−0.5013 (5)	0.8566 (4)	0.5730 (4)	3.44 (24)
O(4*A*)	−0.7070 (5)	0.4812 (5)	0.3563 (5)	6.0 (3)
O(2*A*′)	−0.2181 (5)	0.8636 (4)	0.3960 (4)	3.05 (23)
O(4*A*′)	−0.1710 (5)	1.0117 (5)	0.6483 (5)	6.1 (3)
O(7*A*′)	−0.0749 (5)	0.6833 (4)	0.4416 (4)	2.94 (22)
O(6*A*″)	0.2077 (4)	0.7239 (4)	0.5873 (4)	3.38 (24)
N(1*A*)	−0.3974 (5)	0.7538 (5)	0.4451 (4)	2.26 (25)
N(3*A*)	−0.6018 (5)	0.6683 (5)	0.4621 (5)	3.1 (3)
C(2*A*)	−0.5006 (7)	0.7652 (6)	0.4987 (6)	2.7 (4)
C(4*A*)	−0.6094 (7)	0.5604 (7)	0.3808 (6)	3.4 (4)
C(5*A*)	−0.4975 (7)	0.5544 (6)	0.3290 (6)	2.9 (3)
C(5Me*A*)	−0.4965 (8)	0.4419 (7)	0.2388 (6)	4.4 (4)
C(6*A*)	−0.3996 (7)	0.6487 (6)	0.3625 (5)	2.8 (3)
C(3*A*′)	−0.2976 (7)	0.8692 (6)	0.4757 (6)	2.6 (3)
C(4*A*′)	−0.1924 (7)	0.8785 (6)	0.6011 (6)	3.0 (4)
C(5*A*′)	−0.0561 (7)	0.8323 (6)	0.5837 (5)	2.7 (3)
C(1*A*′)	−0.0821 (7)	0.8216 (6)	0.4509 (6)	2.6 (3)
C(6*A*′)	−0.0349 (7)	0.6866 (6)	0.5699 (6)	2.9 (4)
C(6*A*″)	0.1118 (7)	0.6482 (6)	0.6212 (6)	3.0 (4)

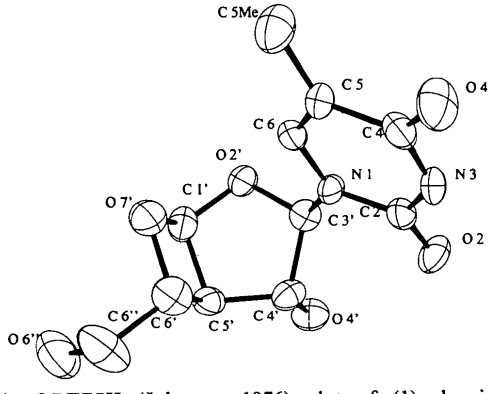

Fig. 1. *ORTEP*II (Johnson, 1976) plot of (1) showing the numbering scheme. Ellipsoids are drawn at 50% probability. H atoms have been omitted for clarity.

Related literature. The reaction of the racemic epoxide (1) with persilylated pyrimidine bases, catalyzed by zinc chloride, gave after suitable deprotection, novel types of nucleoside analogues (2) with a well-defined stereochemistry (Hambalek & Just, 1992). The title compound is a potentially useful precursor for the preparation of unconventional nucleosides and may possess biological activity. The methodology used in the preparation of (2) could be useful in the synthesis of many other unusual carbohydrates.

Table 3. *Bond distances* (Å) *and angles* (°) *with e.s.d.'s in parentheses*

O(2)—C(2)	1.219 (8)	O(2*A*)—C(2*A*)	1.228 (7)
O(4)—C(4)	1.231 (8)	O(4*A*)—C(4*A*)	1.217 (8)
O(2′)—C(3′)	1.412 (8)	O(2*A*′)—C(3*A*′)	1.419 (7)
O(2′)—C(1′)	1.418 (8)	O(2*A*′)—C(1*A*′)	1.419 (8)
O(4′)—C(4′)	1.422 (8)	O(4*A*′)—C(4*A*′)	1.424 (8)
O(7′)—C(1′)	1.427 (8)	O(7*A*′)—C(1*A*′)	1.435 (7)
O(7′)—C(6′)	1.466 (9)	O(7*A*′)—C(6*A*′)	1.458 (8)
O(6″)—C(6″)	1.392 (10)	O(6*A*″)—C(6*A*″)	1.420 (8)
N(1)—C(2)	1.381 (8)	N(1*A*)—C(2*A*)	1.379 (8)
N(1)—C(6)	1.379 (8)	N(1*A*)—C(6*A*)	1.383 (8)
N(1)—C(3′)	1.495 (8)	N(1*A*)—C(3*A*′)	1.495 (8)
N(3)—C(2)	1.368 (9)	N(3*A*)—C(2*A*)	1.360 (8)
N(3)—C(4)	1.376 (8)	N(3*A*)—C(4*A*)	1.384 (8)
C(4)—C(5)	1.463 (9)	C(4*A*)—C(5*A*)	1.442 (10)
C(5)—C(5Me)	1.491 (10)	C(5*A*)—C(5Me*A*)	1.501 (9)
C(5)—C(6)	1.346 (10)	C(5*A*)—C(6*A*)	1.321 (10)
C(3′)—C(4′)	1.528 (10)	C(3*A*′)—C(4*A*′)	1.538 (9)
C(4′)—C(5′)	1.510 (9)	C(4*A*′)—C(5*A*′)	1.524 (9)
C(5′)—C(1′)	1.531 (9)	C(5*A*′)—C(1*A*′)	1.519 (9)
C(5′)—C(6′)	1.534 (10)	C(5*A*′)—C(6*A*′)	1.530 (9)
C(6′)—C(6″)	1.500 (11)	C(6*A*′)—C(6*A*″)	1.490 (10)

C(3′)—O(2′)—C(1′)	110.8 (5)	C(3*A*′)—O(2*A*′)—C(1*A*′)	110.2 (5)
C(1′)—O(7′)—C(6′)	91.3 (5)	C(1*A*′)—O(7*A*′)—C(6*A*′)	91.2 (4)
C(2)—N(1)—C(6)	121.4 (5)	C(2*A*)—N(1*A*)—C(6*A*)	120.6 (5)
C(2)—N(1)—C(3′)	114.7 (5)	C(2*A*)—N(1*A*)—C(3*A*′)	113.8 (5)
C(6)—N(1)—C(3′)	123.5 (5)	C(6*A*)—N(1*A*)—C(3*A*′)	125.4 (5)
C(2)—N(3)—C(4)	127.8 (5)	C(2*A*)—N(3*A*)—C(4*A*)	127.3 (5)
O(2)—C(2)—N(1)	122.4 (6)	O(2*A*)—C(2*A*)—N(1*A*)	122.3 (6)
O(2)—C(2)—N(3)	123.2 (6)	O(2*A*)—C(2*A*)—N(3*A*)	122.8 (6)
N(1)—C(2)—N(3)	114.5 (6)	N(1*A*)—C(2*A*)—N(3*A*)	114.9 (5)
O(4)—C(4)—N(3)	121.4 (6)	O(4*A*)—C(4*A*)—N(3*A*)	120.0 (6)
O(4)—C(4)—C(5)	123.5 (6)	O(4*A*)—C(4*A*)—C(5*A*)	125.2 (6)
N(3)—C(4)—C(5)	115.0 (6)	N(3*A*)—C(4*A*)—C(5*A*)	114.7 (6)
C(4)—C(5)—C(5Me)	119.2 (6)	C(4*A*)—C(5*A*)—C(5Me*A*)	119.1 (6)
C(4)—C(5)—C(6)	117.5 (6)	C(4*A*)—C(5*A*)—C(6*A*)	118.6 (6)
C(5Me)—C(5)—C(6)	123.2 (6)	C(5Me*A*)—C(5*A*)—C(6*A*)	122.3 (6)
N(1)—C(6)—C(5)	123.6 (6)	N(1*A*)—C(6*A*)—C(5*A*)	123.8 (6)
O(2′)—C(3′)—N(1)	110.1 (5)	O(2*A*′)—C(3*A*′)—N(1*A*)	109.7 (5)
O(2′)—C(3′)—C(4′)	106.0 (5)	O(2*A*′)—C(3*A*′)—C(4*A*′)	106.7 (5)
N(1)—C(3′)—C(4′)	112.6 (5)	N(1*A*)—C(3*A*′)—C(4*A*′)	113.6 (5)
O(4′)—C(4′)—C(3′)	106.5 (5)	O(4*A*′)—C(4*A*′)—C(3*A*′)	107.8 (5)
O(4′)—C(4′)—C(5′)	112.1 (5)	O(4*A*′)—C(4*A*′)—C(5*A*′)	107.9 (5)
C(3′)—C(4′)—C(5′)	105.4 (5)	C(3*A*′)—C(4*A*′)—C(5*A*′)	105.2 (5)
C(4′)—C(5′)—C(1′)	104.6 (5)	C(4*A*′)—C(5*A*′)—C(1*A*′)	104.8 (5)
C(4′)—C(5′)—C(6′)	116.4 (6)	C(4*A*′)—C(5*A*′)—C(6*A*′)	118.6 (5)
C(1′)—C(5′)—C(6′)	85.0 (5)	C(1*A*′)—C(5*A*′)—C(6*A*′)	85.4 (5)
O(2′)—C(1′)—O(7′)	113.5 (5)	O(2*A*′)—C(1*A*′)—O(7*A*′)	113.4 (5)
O(2′)—C(1′)—C(5′)	107.9 (5)	O(2*A*′)—C(1*A*′)—C(5*A*′)	108.9 (5)
O(7′)—C(1′)—C(5′)	92.7 (5)	O(7*A*′)—C(1*A*′)—C(5*A*′)	92.1 (5)
O(7′)—C(6′)—C(5′)	91.0 (5)	O(7*A*′)—C(6*A*′)—C(5*A*′)	90.8 (5)
O(7′)—C(6′)—C(6″)	112.3 (6)	O(7*A*′)—C(6*A*′)—C(6*A*″)	112.0 (5)
C(5′)—C(6′)—C(6″)	120.0 (6)	C(5*A*′)—C(6*A*′)—C(6*A*″)	115.2 (5)
O(6″)—C(6″)—C(6′)	110.4 (6)	O(6*A*″)—C(6*A*″)—C(6*A*′)	111.7 (5)

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