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11β-Hydroxymedroxyprogesterone

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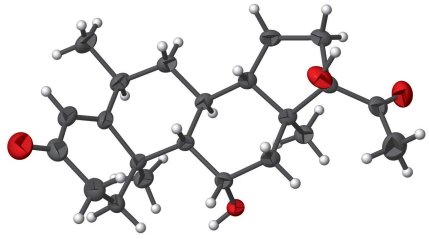
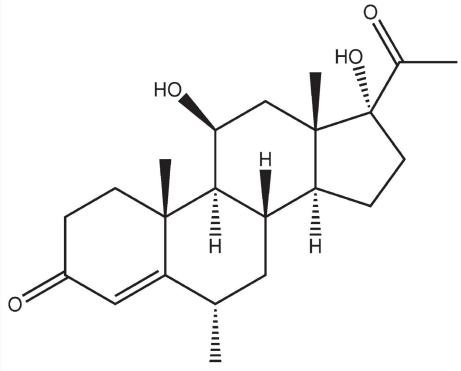
The title compound, $C_{22}H_{32}O_4$, a fungal-transformed metabolite of medroxyprogesterone, comprises one cyclohexanone ring, two cyclohexane rings and one cyclopentane ring fused together. The cyclohexanone ring has a half-chair conformation, while the cyclohexane rings possess chair conformations and the cyclopentane ring has a twisted conformation on the fused C—C bond. In the crystal, molecules are linked by strong O—H···O and also C—H···O hydrogen bonds, creating a two-dimensional network parallel to $(10\bar{1})$.

3D view



Chemical scheme



Structure description

11β-Hydroxymedroxyprogesterone, is a steroid produced by biotransformation of medroxyprogesterone (MP). Medroxyprogesterone is known as a progesterone agonist which is important as a sex hormone. The progesterone agonist activity of MP is less effective than medroxyprogesterone acetate (MPA) (Pullen *et al.*, 2006) which has been used for treatment of endometrial carcinoma (Fujiwara *et al.*, 2012). In a continuation of our work on biotransformation of steroids (Sultan *et al.*, 2014), we aimed to produce unique structurally modified derivatives of medroxyprogesterone that may be more effective than MPA. Herein we report the X-ray study of 11β-hydroxymedroxyprogesterone (Fig. 1), a biotransformation product of medroxyprogesterone.

The molecule comprises four annelated rings. Ring *A* (C1–C5/C10) is a cyclohexanone having a half-chair conformation, while rings *B* (C5–C10) and *C* (C8/C9/C11–C14) are cyclohexane rings with chair conformations. The cyclopentane ring *D* (C13–C17) adopts a twisted conformation on the fused C—C bond, C13—C14.

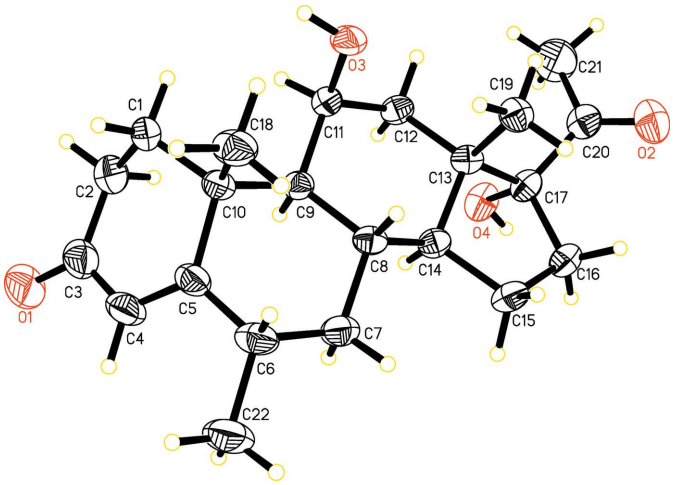


Figure 1
The molecular structure of the title compound, with displacement ellipsoids drawn at the 50% probability level.

In the crystal, the molecules are linked by strong O—H···O hydrogen bonds, O3—H3*A*···O1^{i} and O4—H4*A*···O3^{ii}, augmented by a C—H···O interaction, C18—H18*C*···O1^{i}, forming a two-dimensional network parallel to (10$\overline{1}$) (see Fig. 2 and Table 1).

Synthesis and crystallization

The title compound was obtained from the fungal transformation of medroxyprogesterone *via Trichothecium roseum* (ATCC 13411) after 8 d of fermentation. 56.6 mg of this compound was purified by recycling preparative HPLC. The compound was crystallized at room temperature from a mixture of chloroform and methanol.

Refinement

Crystal data, data collection and structure refinement details are summarized in Table 2. The absolute configuration was not determined from the X-ray data but it could be determined through the comparison of similar compounds (Ouedraogo *et al.*, 2013, Karpinska *et al.*, 2013).

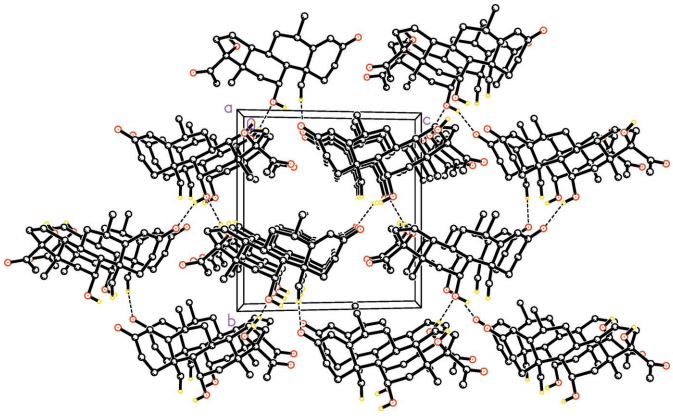


Figure 2
The crystal packing of the title compound viewed along the *a* ax1s. Dashed lines indicate hydrogen bonds.

Table 1
Hydrogen-bond geometry (Å, °).

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
O3—H3*A*···O1^{i}	0.81 (3)	2.02 (4)	2.767 (5)	153 (4)
O4—H4*A*···O3^{ii}	0.82 (5)	2.12 (5)	2.910 (5)	165 (6)
C18—H18*C*···O1^{i}	0.96	2.47	3.411 (6)	165

Symmetry codes: (i) $-x+1, y+\frac{1}{2}, -z+1$; (ii) $-x, y-\frac{1}{2}, -z$.

Table 2
Experimental details.

Crystal data	
Chemical formula	$C_{22}H_{32}O_4$
M_r	360.47
Crystal system, space group	Monoclinic, $P2_1$
Temperature (K)	302
a, *b*, *c* (Å)	6.8692 (12), 12.221 (2), 11.7933 (19)
β (°)	105.726 (5)
V (Å^3)	952.9 (3)
Z	2
Radiation type	Mo *K*α
μ (mm^{-1})	0.09
Crystal size (mm)	0.50 × 0.50 × 0.23
Data collection	
Diffractometer	Bruker APEXII CCD
Absorption correction	Multi-scan (*SADABS*; Bruker, 2009)
T_{min}, T_{max}	0.959, 0.981
No. of measured, independent and observed [$I > 2\sigma(I)$] reflections	16639, 3527, 3023
R_{int}	0.074
(sin $\theta/\lambda)_{max}$ (Å^{-1})	0.606
Refinement	
$R[F^2 > 2\sigma(F^2)]$, $wR(F^2)$, *S*	0.054, 0.122, 1.09
No. of reflections	3527
No. of parameters	248
No. of restraints	3
H-atom treatment	H atoms treated by a mixture of independent and constrained refinement
$\Delta\rho_{max}$, $\Delta\rho_{min}$ (e Å^{-3})	0.20, −0.21

Computer programs: *APEX2* and *SAINT* (Bruker, 2009), *SHELXS97* and *SHELXTL* (Sheldrick, 2008), *SHELXL2013* (Sheldrick, 2015) and *PLATON* (Spek, 2009).

Acknowledgements

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full crystallographic data

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Crystal data

$C_{22}H_{32}O_4$
M_r = 360.47
Monoclinic, $P2_1$
a = 6.8692 (12) Å
b = 12.221 (2) Å
c = 11.7933 (19) Å
β = 105.726 (5)°
V = 952.9 (3) Å^3
Z = 2
F(000) = 392
D_x = 1.256 Mg m^{-3}
Melting point = 491–493 K
Mo $K\alpha$ radiation, λ = 0.71073 Å
Cell parameters from 9916 reflections
θ = 3.1–25.5°
μ = 0.09 mm^{-1}
T = 302 K
Block, colourless
0.50 × 0.50 × 0.23 mm

Data collection

Bruker APEXII CCD diffractometer
Radiation source: fine-focus sealed tube
Detector resolution: 83.66 pixels mm^{-1}
φ and ω scans
Absorption correction: multi-scan (SADABS; Bruker, 2009)
T_{min} = 0.959, T_{max} = 0.981
16639 measured reflections
3527 independent reflections
3023 reflections with $I > 2\sigma(I)$
R_{int} = 0.074
θ_{max} = 25.5°, θ_{min} = 3.1°
h = −8→7
k = −14→14
l = −14→14

Refinement

Refinement on F^2
Least-squares matrix: full
$R[F^2 > 2\sigma(F^2)]$ = 0.054
$wR(F^2)$ = 0.122
S = 1.09
3527 reflections
248 parameters
3 restraints
Primary atom site location: structure-invariant direct methods
Secondary atom site location: difference Fourier map
Hydrogen site location: mixed
H atoms treated by a mixture of independent and constrained refinement
$w = 1/[\sigma^2(F_o^2) + (0.0268P)^2 + 0.6466P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max}$ = 0.20 e Å^{-3}
$\Delta\rho_{min}$ = −0.21 e Å^{-3}
Extinction correction: SHELXL2013 (Sheldrick, 2015), $Fc^*=kFc[1+0.001xFc^2\lambda^3/\sin(2\theta)]^{-1/4}$
Extinction coefficient: 0.023 (5)
Absolute structure: Flack (1983), **???? Friedel pairs**
Absolute structure parameter: −1.3 (6)

Special details

Geometry. All esds (except the esd in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell esds are taken into account individually in the estimation of esds in distances, angles and torsion angles; correlations between esds in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell esds is used for estimating esds involving l.s. planes.

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å²)

	x	*y*	*z*	U_{iso}*/U_{eq}
O1	0.5345 (6)	0.5911 (3)	0.6547 (3)	0.0596 (10)
O2	−0.0798 (5)	0.7685 (3)	−0.2863 (3)	0.0510 (9)
O3	0.3276 (5)	0.9316 (2)	0.1760 (3)	0.0355 (7)
O4	−0.1195 (5)	0.6185 (3)	−0.0443 (3)	0.0380 (7)
C1	0.5080 (7)	0.8207 (3)	0.4627 (3)	0.0362 (10)
H1A	0.6215	0.8519	0.5215	0.043*
H1B	0.4134	0.8794	0.4319	0.043*
C2	0.4047 (8)	0.7364 (4)	0.5217 (4)	0.0440 (11)
H2A	0.3654	0.7701	0.5866	0.053*
H2B	0.2834	0.7096	0.4655	0.053*
C3	0.5459 (8)	0.6426 (4)	0.5667 (4)	0.0442 (11)
C4	0.6824 (7)	0.6123 (4)	0.4983 (4)	0.0424 (11)
H4B	0.7656	0.5520	0.5227	0.051*
C5	0.6970 (6)	0.6660 (3)	0.4012 (4)	0.0335 (10)
C6	0.8029 (6)	0.6207 (4)	0.3160 (4)	0.0373 (10)
H6A	0.8896	0.6785	0.2987	0.045*
C7	0.6362 (6)	0.5958 (4)	0.2015 (4)	0.0365 (10)
H7A	0.7004	0.5740	0.1412	0.044*
H7B	0.5571	0.5342	0.2158	0.044*
C8	0.4922 (6)	0.6912 (3)	0.1540 (3)	0.0265 (9)
H8A	0.5650	0.7475	0.1227	0.032*
C9	0.4091 (6)	0.7421 (3)	0.2508 (3)	0.0254 (8)
H9A	0.3372	0.6822	0.2773	0.030*
C10	0.5843 (6)	0.7738 (3)	0.3623 (3)	0.0287 (9)
C11	0.2469 (6)	0.8306 (3)	0.2052 (3)	0.0273 (9)
H11A	0.1829	0.8460	0.2683	0.033*
C12	0.0800 (6)	0.7922 (3)	0.0973 (3)	0.0276 (9)
H12A	−0.0024	0.7376	0.1221	0.033*
H12B	−0.0064	0.8538	0.0653	0.033*
C13	0.1637 (5)	0.7435 (3)	0.0004 (3)	0.0232 (8)
C14	0.3119 (6)	0.6509 (3)	0.0548 (3)	0.0270 (9)
H14A	0.2367	0.6000	0.0914	0.032*
C15	0.3503 (6)	0.5910 (3)	−0.0505 (4)	0.0356 (10)
H15A	0.3845	0.5149	−0.0318	0.043*
H15B	0.4589	0.6253	−0.0757	0.043*
C16	0.1477 (6)	0.6011 (4)	−0.1461 (3)	0.0329 (9)
H16A	0.1697	0.6308	−0.2179	0.039*
H16B	0.0847	0.5298	−0.1635	0.039*
C17	0.0112 (6)	0.6779 (3)	−0.0986 (3)	0.0287 (9)

C18	0.7350 (7)	0.8583 (3)	0.3368 (4)	0.0396 (11)
H18A	0.7588	0.8424	0.2619	0.059*
H18B	0.8603	0.8543	0.3975	0.059*
H18C	0.6793	0.9305	0.3351	0.059*
C19	0.2619 (6)	0.8320 (3)	−0.0585 (4)	0.0304 (9)
H19A	0.2880	0.8027	−0.1285	0.046*
H19B	0.3868	0.8551	−0.0050	0.046*
H19C	0.1722	0.8935	−0.0789	0.046*
C20	−0.1183 (6)	0.7539 (4)	−0.1932 (4)	0.0343 (10)
C21	−0.2902 (8)	0.8123 (5)	−0.1650 (5)	0.0603 (15)
H21A	−0.2766	0.8074	−0.0819	0.090*
H21B	−0.4155	0.7793	−0.2076	0.090*
H21C	−0.2892	0.8878	−0.1872	0.090*
C22	0.9346 (9)	0.5198 (4)	0.3577 (5)	0.0591 (15)
H22A	1.0038	0.5005	0.2999	0.089*
H22B	0.8508	0.4598	0.3681	0.089*
H22C	1.0319	0.5356	0.4312	0.089*
H3A	0.382 (6)	0.960 (4)	0.239 (2)	0.037 (13)*
H4A	−0.168 (9)	0.570 (4)	−0.091 (4)	0.07 (2)*

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
O1	0.094 (3)	0.0388 (19)	0.0452 (19)	−0.0059 (19)	0.0167 (19)	0.0157 (16)
O2	0.055 (2)	0.058 (2)	0.0376 (18)	−0.0016 (17)	0.0081 (16)	0.0057 (16)
O3	0.0448 (19)	0.0208 (14)	0.0333 (16)	−0.0006 (13)	−0.0022 (14)	−0.0014 (13)
O4	0.0393 (17)	0.0384 (17)	0.0399 (16)	−0.0183 (14)	0.0167 (14)	−0.0094 (14)
C1	0.050 (3)	0.029 (2)	0.0246 (19)	0.0046 (19)	0.0016 (19)	0.0002 (17)
C2	0.057 (3)	0.043 (3)	0.033 (2)	0.004 (2)	0.013 (2)	0.004 (2)
C3	0.058 (3)	0.033 (2)	0.036 (2)	−0.007 (2)	0.005 (2)	0.0028 (19)
C4	0.052 (3)	0.026 (2)	0.042 (2)	0.004 (2)	0.000 (2)	0.006 (2)
C5	0.034 (2)	0.026 (2)	0.033 (2)	0.0022 (18)	−0.0046 (18)	0.0011 (17)
C6	0.031 (2)	0.030 (2)	0.047 (2)	0.0080 (19)	0.0045 (19)	0.002 (2)
C7	0.036 (2)	0.032 (2)	0.040 (2)	0.0093 (19)	0.0081 (19)	−0.0035 (19)
C8	0.024 (2)	0.0233 (19)	0.033 (2)	0.0021 (16)	0.0085 (17)	0.0018 (16)
C9	0.031 (2)	0.0202 (17)	0.0263 (18)	0.0003 (16)	0.0092 (16)	0.0010 (15)
C10	0.031 (2)	0.0224 (19)	0.030 (2)	0.0036 (17)	0.0037 (17)	0.0022 (16)
C11	0.030 (2)	0.026 (2)	0.0268 (19)	0.0010 (17)	0.0092 (17)	−0.0018 (16)
C12	0.023 (2)	0.028 (2)	0.033 (2)	0.0023 (16)	0.0096 (17)	−0.0026 (17)
C13	0.0174 (18)	0.0231 (18)	0.0312 (19)	−0.0022 (16)	0.0100 (16)	−0.0007 (16)
C14	0.024 (2)	0.027 (2)	0.031 (2)	0.0008 (16)	0.0102 (16)	−0.0014 (16)
C15	0.035 (2)	0.031 (2)	0.041 (2)	0.0058 (18)	0.0120 (19)	−0.0074 (18)
C16	0.036 (2)	0.031 (2)	0.033 (2)	−0.0024 (18)	0.0121 (17)	−0.0082 (18)
C17	0.025 (2)	0.031 (2)	0.031 (2)	−0.0048 (17)	0.0090 (17)	−0.0065 (17)
C18	0.038 (3)	0.027 (2)	0.048 (3)	−0.0022 (18)	0.001 (2)	0.0003 (19)
C19	0.032 (2)	0.028 (2)	0.033 (2)	−0.0034 (17)	0.0119 (18)	0.0027 (17)
C20	0.027 (2)	0.037 (2)	0.035 (2)	−0.0028 (18)	0.0005 (18)	−0.0068 (18)
C21	0.046 (3)	0.074 (4)	0.057 (3)	0.017 (3)	0.008 (3)	0.000 (3)

C22	0.053 (3)	0.047 (3)	0.065 (3)	0.025 (3)	−0.003 (3)	−0.001 (2)

Geometric parameters (Å, º)

O1—C3	1.235 (5)	C11—C12	1.537 (5)
O2—C20	1.210 (5)	C11—H11A	0.9800
O3—C11	1.433 (5)	C12—C13	1.532 (5)
O3—H3A	0.813 (14)	C12—H12A	0.9700
O4—C17	1.434 (5)	C12—H12B	0.9700
O4—H4A	0.818 (14)	C13—C19	1.537 (5)
C1—C2	1.523 (6)	C13—C14	1.540 (5)
C1—C10	1.530 (6)	C13—C17	1.562 (5)
C1—H1A	0.9700	C14—C15	1.526 (5)
C1—H1B	0.9700	C14—H14A	0.9800
C2—C3	1.502 (7)	C15—C16	1.540 (6)
C2—H2A	0.9700	C15—H15A	0.9700
C2—H2B	0.9700	C15—H15B	0.9700
C3—C4	1.441 (7)	C16—C17	1.535 (5)
C4—C5	1.346 (6)	C16—H16A	0.9700
C4—H4B	0.9300	C16—H16B	0.9700
C5—C6	1.497 (6)	C17—C20	1.537 (6)
C5—C10	1.534 (5)	C18—H18A	0.9600
C6—C22	1.530 (6)	C18—H18B	0.9600
C6—C7	1.546 (6)	C18—H18C	0.9600
C6—H6A	0.9800	C19—H19A	0.9600
C7—C8	1.533 (5)	C19—H19B	0.9600
C7—H7A	0.9700	C19—H19C	0.9600
C7—H7B	0.9700	C20—C21	1.493 (7)
C8—C14	1.536 (5)	C21—H21A	0.9600
C8—C9	1.539 (5)	C21—H21B	0.9600
C8—H8A	0.9800	C21—H21C	0.9600
C9—C11	1.542 (5)	C22—H22A	0.9600
C9—C10	1.571 (5)	C22—H22B	0.9600
C9—H9A	0.9800	C22—H22C	0.9600
C10—C18	1.548 (6)		

C11—O3—H3A	105 (3)	C11—C12—H12A	109.0
C17—O4—H4A	105 (4)	C13—C12—H12B	109.0
C2—C1—C10	113.6 (3)	C11—C12—H12B	109.0
C2—C1—H1A	108.9	H12A—C12—H12B	107.8
C10—C1—H1A	108.9	C12—C13—C19	111.3 (3)
C2—C1—H1B	108.9	C12—C13—C14	108.3 (3)
C10—C1—H1B	108.9	C19—C13—C14	112.6 (3)
H1A—C1—H1B	107.7	C12—C13—C17	116.5 (3)
C3—C2—C1	109.9 (4)	C19—C13—C17	108.1 (3)
C3—C2—H2A	109.7	C14—C13—C17	99.7 (3)
C1—C2—H2A	109.7	C15—C14—C8	119.5 (3)
C3—C2—H2B	109.7	C15—C14—C13	104.7 (3)

C1—C2—H2B	109.7	C8—C14—C13	112.8 (3)
H2A—C2—H2B	108.2	C15—C14—H14A	106.3
O1—C3—C4	122.6 (4)	C8—C14—H14A	106.3
O1—C3—C2	120.3 (5)	C13—C14—H14A	106.3
C4—C3—C2	117.0 (4)	C14—C15—C16	103.6 (3)
C5—C4—C3	124.1 (4)	C14—C15—H15A	111.0
C5—C4—H4B	118.0	C16—C15—H15A	111.0
C3—C4—H4B	118.0	C14—C15—H15B	111.0
C4—C5—C6	123.6 (4)	C16—C15—H15B	111.0
C4—C5—C10	121.7 (4)	H15A—C15—H15B	109.0
C6—C5—C10	114.4 (4)	C17—C16—C15	107.6 (3)
C5—C6—C22	115.8 (4)	C17—C16—H16A	110.2
C5—C6—C7	106.2 (3)	C15—C16—H16A	110.2
C22—C6—C7	110.8 (4)	C17—C16—H16B	110.2
C5—C6—H6A	107.9	C15—C16—H16B	110.2
C22—C6—H6A	107.9	H16A—C16—H16B	108.5
C7—C6—H6A	107.9	O4—C17—C16	111.8 (3)
C8—C7—C6	114.9 (3)	O4—C17—C20	108.7 (3)
C8—C7—H7A	108.5	C16—C17—C20	113.3 (3)
C6—C7—H7A	108.5	O4—C17—C13	107.5 (3)
C8—C7—H7B	108.5	C16—C17—C13	103.5 (3)
C6—C7—H7B	108.5	C20—C17—C13	111.8 (3)
H7A—C7—H7B	107.5	C10—C18—H18A	109.5
C7—C8—C14	110.0 (3)	C10—C18—H18B	109.5
C7—C8—C9	111.6 (3)	H18A—C18—H18B	109.5
C14—C8—C9	108.1 (3)	C10—C18—H18C	109.5
C7—C8—H8A	109.1	H18A—C18—H18C	109.5
C14—C8—H8A	109.1	H18B—C18—H18C	109.5
C9—C8—H8A	109.1	C13—C19—H19A	109.5
C8—C9—C11	113.7 (3)	C13—C19—H19B	109.5
C8—C9—C10	111.5 (3)	H19A—C19—H19B	109.5
C11—C9—C10	115.9 (3)	C13—C19—H19C	109.5
C8—C9—H9A	104.8	H19A—C19—H19C	109.5
C11—C9—H9A	104.8	H19B—C19—H19C	109.5
C10—C9—H9A	104.8	O2—C20—C21	120.8 (4)
C1—C10—C5	109.9 (3)	O2—C20—C17	121.5 (4)
C1—C10—C18	106.7 (3)	C21—C20—C17	117.7 (4)
C5—C10—C18	108.7 (3)	C20—C21—H21A	109.5
C1—C10—C9	113.3 (3)	C20—C21—H21B	109.5
C5—C10—C9	104.4 (3)	H21A—C21—H21B	109.5
C18—C10—C9	113.7 (3)	C20—C21—H21C	109.5
O3—C11—C12	108.3 (3)	H21A—C21—H21C	109.5
O3—C11—C9	113.5 (3)	H21B—C21—H21C	109.5
C12—C11—C9	112.4 (3)	C6—C22—H22A	109.5
O3—C11—H11A	107.5	C6—C22—H22B	109.5
C12—C11—H11A	107.5	H22A—C22—H22B	109.5
C9—C11—H11A	107.5	C6—C22—H22C	109.5
C13—C12—C11	112.9 (3)	H22A—C22—H22C	109.5

C13—C12—H12A	109.0	H22B—C22—H22C	109.5
C10—C1—C2—C3	56.7 (5)	C10—C9—C11—C12	−179.2 (3)
C1—C2—C3—O1	149.7 (4)	O3—C11—C12—C13	75.8 (4)
C1—C2—C3—C4	−34.3 (5)	C9—C11—C12—C13	−50.4 (4)
O1—C3—C4—C5	179.2 (5)	C11—C12—C13—C19	−69.4 (4)
C2—C3—C4—C5	3.4 (7)	C11—C12—C13—C14	54.9 (4)
C3—C4—C5—C6	−165.8 (4)	C11—C12—C13—C17	166.1 (3)
C3—C4—C5—C10	7.1 (7)	C7—C8—C14—C15	−54.7 (5)
C4—C5—C6—C22	−12.7 (6)	C9—C8—C14—C15	−176.8 (3)
C10—C5—C6—C22	173.9 (4)	C7—C8—C14—C13	−178.3 (3)
C4—C5—C6—C7	110.8 (5)	C9—C8—C14—C13	59.6 (4)
C10—C5—C6—C7	−62.6 (4)	C12—C13—C14—C15	167.6 (3)
C5—C6—C7—C8	52.0 (5)	C19—C13—C14—C15	−68.9 (4)
C22—C6—C7—C8	178.5 (4)	C17—C13—C14—C15	45.5 (4)
C6—C7—C8—C14	−169.5 (3)	C12—C13—C14—C8	−60.9 (4)
C6—C7—C8—C9	−49.6 (5)	C19—C13—C14—C8	62.6 (4)
C7—C8—C9—C11	−174.1 (3)	C17—C13—C14—C8	176.9 (3)
C14—C8—C9—C11	−53.1 (4)	C8—C14—C15—C16	−160.5 (3)
C7—C8—C9—C10	52.6 (4)	C13—C14—C15—C16	−33.1 (4)
C14—C8—C9—C10	173.7 (3)	C14—C15—C16—C17	7.1 (4)
C2—C1—C10—C5	−46.4 (5)	C15—C16—C17—O4	−94.6 (4)
C2—C1—C10—C18	−164.1 (4)	C15—C16—C17—C20	142.1 (3)
C2—C1—C10—C9	70.0 (4)	C15—C16—C17—C13	20.8 (4)
C4—C5—C10—C1	14.6 (5)	C12—C13—C17—O4	−37.5 (4)
C6—C5—C10—C1	−171.9 (4)	C19—C13—C17—O4	−163.6 (3)
C4—C5—C10—C18	131.0 (4)	C14—C13—C17—O4	78.6 (3)
C6—C5—C10—C18	−55.4 (4)	C12—C13—C17—C16	−156.0 (3)
C4—C5—C10—C9	−107.2 (4)	C19—C13—C17—C16	77.9 (4)
C6—C5—C10—C9	66.3 (4)	C14—C13—C17—C16	−39.8 (4)
C8—C9—C10—C1	−177.8 (3)	C12—C13—C17—C20	81.7 (4)
C11—C9—C10—C1	50.0 (4)	C19—C13—C17—C20	−44.4 (4)
C8—C9—C10—C5	−58.2 (4)	C14—C13—C17—C20	−162.1 (3)
C11—C9—C10—C5	169.6 (3)	O4—C17—C20—O2	−141.2 (4)
C8—C9—C10—C18	60.1 (4)	C16—C17—C20—O2	−16.2 (6)
C11—C9—C10—C18	−72.1 (4)	C13—C17—C20—O2	100.3 (4)
C8—C9—C11—O3	−73.6 (4)	O4—C17—C20—C21	40.7 (5)
C10—C9—C11—O3	57.5 (4)	C16—C17—C20—C21	165.7 (4)
C8—C9—C11—C12	49.7 (4)	C13—C17—C20—C21	−77.8 (5)

Hydrogen-bond geometry (Å, º)

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
O3—H3*A*···O1^{i}	0.81 (3)	2.02 (4)	2.767 (5)	153 (4)
O4—H4*A*···O3^{ii}	0.82 (5)	2.12 (5)	2.910 (5)	165 (6)
C12—H12*A*···O4	0.97	2.40	2.816 (5)	105
C14—H14*A*···O4	0.98	2.54	2.903 (6)	101
C16—H16*A*···O2	0.97	2.38	2.822 (6)	107

C18—H18*C*···O1^{i}	0.96	2.47	3.411 (6)	165
C19—H19*B*···O3	0.96	2.46	2.942 (6)	111

Symmetry codes: (i) −*x*+1, *y*+1/2, −*z*+1; (ii) −*x*, *y*−1/2, −*z*.