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(1*S*,2*R*,3*R*,8*R*,10*S*)-3-Chloro-2,8-dihydroxy-3,7-dimethyl-11-methylidene-13-oxabicyclo[8.3.0]tridec-6-en-12-one

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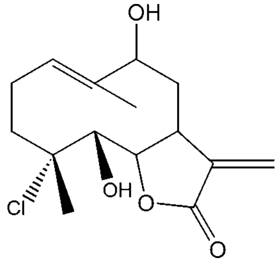
Key indicators: single-crystal X-ray study; T = 180 K; mean σ(C–C) = 0.002 Å; R factor = 0.027; wR factor = 0.070; data-to-parameter ratio = 16.5.

The title compound, $C_{15}H_{21}ClO_4$, was synthesized from 9α-hydroxyparthenolide (9α-hydroxy-4,8-dimethyl-12-methylen-3,14-dioxatricyclo[9.3.0.0^{2,4}]tetradec-7-en-13-one), which was isolated from the chloroform extract of the aerial parts of *Anvillea radiata*. The molecule is built up from fused five- and ten-membered rings. The five-membered lactone ring has an envelope conformation with the flap atom, C(H)-C-C(H), displaced by 0.2325 (15) Å from the mean plane through the remaining four atoms, whereas the ten-membered ring displays an approximate chair–chair conformation. The dihedral angle between the two rings is 66.4 (2)°. In the crystal, molecules are linked into chains propagating along the *a* axis by O—H⋯O hydrogen bonds.

Related literature

For the isolation and biological activity of 9α-hydroxyparthenolide, see: El Hassany *et al.* (2004). For the reactivity of this sesquiterpene, see: Castaneda-Acosta *et al.* (1993); Neukirch *et al.* (2003); Hwang *et al.* (2006); Neelakantan *et al.* (2009). For conformational analysis, see: Cremer & Pople (1975)



Experimental

Crystal data

$C_{15}H_{21}ClO_4$	V = 1502.90 (6) Å^3
M_r = 300.77	Z = 4
Orthorhombic, $P2_12_12_1$	Mo $K\alpha$ radiation
a = 8.0224 (2) Å	μ = 0.26 mm^{-1}
b = 12.1532 (2) Å	T = 180 K
c = 15.4147 (4) Å	0.35 × 0.27 × 0.17 mm

Data collection

Agilent Xcalibur Eos Gemini ultra diffractometer	8982 measured reflections
Absorption correction: multi-scan (*CrysAlis PRO*; Agilent, 2010)	3053 independent reflections
T_{min} = 0.889, T_{max} = 1.000	2944 reflections with $I > 2\sigma(I)$
	R_{int} = 0.019

Refinement

$R[F^2 > 2\sigma(F^2)]$ = 0.027	$\Delta\rho_{max}$ = 0.21 e Å^{-3}
$wR(F^2)$ = 0.070	$\Delta\rho_{min}$ = −0.21 e Å^{-3}
S = 1.04	Absolute structure: Flack (1983), 614 Friedel pairs
3053 reflections	Flack parameter: −0.06 (5)
185 parameters	
H-atom parameters constrained	

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

D—H⋯A	D—H	H⋯A	D⋯A	D—H⋯A
O3—H3⋯O4^{i}	0.82	1.96	2.763 (1)	167
O4—H4⋯O3^{ii}	0.82	2.17	2.980 (1)	171

Symmetry codes: (i) $x-\frac{1}{2}, -y+\frac{3}{2}, -z+1$; (ii) $x+1, y, z$.

Data collection: *CrysAlis PRO* (Agilent, 2010); cell refinement: *CrysAlis PRO*; data reduction: *CrysAlis PRO*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *ORTEP-3 for Windows* (Farrugia, 1997) and *PLATON* (Spek, 2009); software used to prepare material for publication: *WinGX* (Farrugia, 1999).

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Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: IM2319).

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Acta Cryst. (2011). E**67**, o2826–o2827 Moumou *et al.* • $C_{15}H_{21}ClO_4$ **o2827**

supporting information

Acta Cryst. (2011). E**67**, o2826–o2827   [doi:10.1107/S1600536811039717]

(1*S*,2*R*,3*R*,8*R*,10*S*)-3-Chloro-2,8-dihydroxy-3,7-dimethyl-11-methylidene-13-oxabicyclo[8.3.0]tridec-6-en-12-one

Mohamed Moumou, Ahmed Benharref, Jean-Claude Daran, Ahmed Elhakmaoui, Mohamed Akssira and Moha Berraho

S1. Comment

Our work lies within the framework of the evaluation of medicinal plants and in particular, *Anvillea radiata*. The main constituent of the chloroform extract of the aerial parts of *Anvillea radiata* is 9α-hydroxyparthenolide (El Hassany *et al.*, 2004). The reactivity of this sesquiterpene lactone and its derivatives has been the subject of several studies (Castaneda-Acosta *et al.*, 1993; Neukirch *et al.*, 2003; Hwang *et al.*, 2006; Neelakantan *et al.*, 2009), in order to prepare products with a high added value that can be used in the pharmacological industry. In the same context, we have treated 9α-hydroxyparthenolide with 5% of titanium tetrachloride ($TiCl_4$)and obtained (1*S*, 2*R*, 3*R*, 8*R*, 10*S*)-3-chloro-2,8- dihydroxy-3,7-dimethyl-11-methylene-13-oxabicyclo[8.3.0]tridec-6-en-12-one with a yield of 52%. The structure of this new product was determined by its single-crystal X-ray structure. The molecule contains two fused rings which exhibit different conformations. The molecular structure of the title compound, Fig.1, shows the lactone ring to adopt an envelope conformation, as indicated by Cremer & Pople (1975) puckering parameters QT = 0.147 (2) Å and $\varphi 2$ = 58.1 (5)°. The ten-membered ring displays an approximate chair-chair conformation.In the crystal structure, molecules are linked into chains (Fig. 2) running along the *a* axis by intermolecular O—H···O hydrogen bonds (Table 1). Owing to the presence of Cl atom, the absolute configuration could be fully confirmed, by refining the Flack parameter (Flack, 1983) as C1(*S*), C2(*R*), C3(*R*), C8(*R*)and C10(*S*).

S2. Experimental

To a solution of 9α-hydroxyparthenolide (500 mg, 1.89 mmol) in 20 ml dichloromethane are added in small portions and carefully a catalytic amount (5%) of titanium tetrachloride ($TiCl_4$). The reaction mixture was kept at room temperature and stirred for 3 h. Afterwards it was hydrolysed with 20 ml of water and extracted three times with dichloromethane (20 mL). The organic phases are combined, dried over anhydrous Na_2SO_4 and then evaporated under reduced pressure. The resulting residue is purified by chromatography on silica gel with hexane /ethyl acetate (30/70) as eluent. This allowed us to isolate in pure 291 mg (0,98 mmol, 52%) of (1*S*, 2*R*, 3*R*, 8*R*, 10*S*)-3-chloro-2,8-dihydroxy-3,7-dimethyl-11-methylene-13-oxabicyclo[8.3.0]tridec-6-en-12-one. The title compound was recrystallized from ethyl acetate to produce crystals suitable for X-ray diffraction.

S3. Refinement

All H atoms were fixed geometrically and treated as riding with C—H = 0.96 Å (methyl), 0.97 Å (methylene), 0.98 Å (methine) and O–H = 0.82 Å with $U_{iso}(H) = 1.2U_{eq}$(methylene, methine) or $U_{iso}(H) = 1.5U_{eq}$ (methyl, OH).

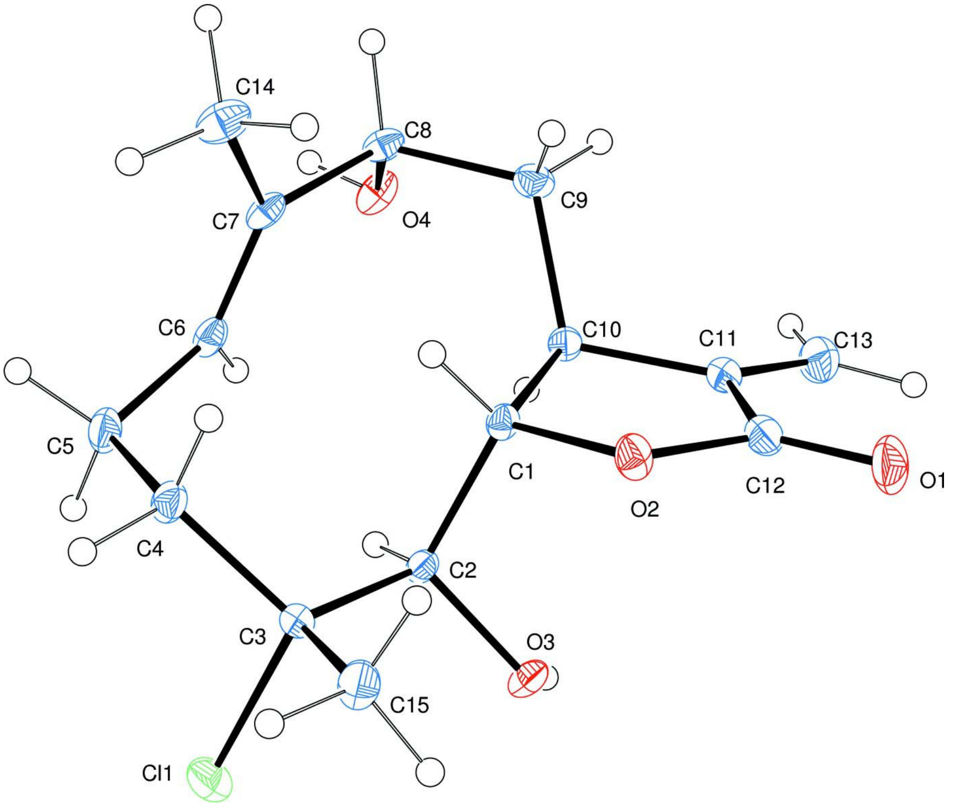

Figure 1

Molecular structure of the title compound with the atom-labelling scheme. Displacement ellipsoids are drawn at the 30% probability level. H atoms are represented as small spheres of arbitrary radii.

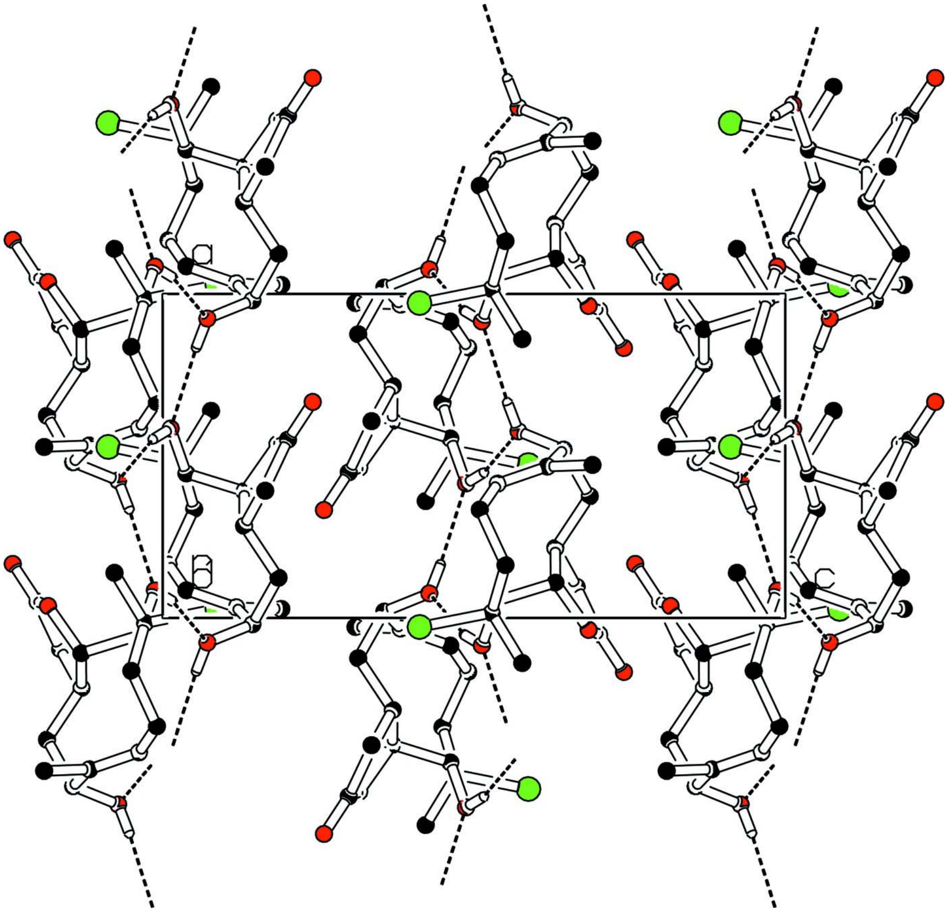

Figure 2

Packing view showing the C–H···O hydrogen bonds as dashed lines. H atoms not involved in hydrogen bonding have been omitted for clarity.

(1*S*,2*R*,3*R*,8*R*,10*S*)-3-Chloro-2,8- dihydroxy-3,7-dimethyl-11-methylidene-13-oxabicyclo[8.3.0]tridec-6-en-12-one

Crystal data

$C_{15}H_{21}ClO_4$	$F(000) = 640$
$M_r = 300.77$	$D_x = 1.329$ Mg m^{-3}
Orthorhombic, $P2_12_12_1$	Mo $K\alpha$ radiation, $\lambda = 0.71073$ Å
Hall symbol: P 2ac 2ab	Cell parameters from 8982 reflections
$a = 8.0224$ (2) Å	$\theta = 3.6$–$26.4°$
$b = 12.1532$ (2) Å	$\mu = 0.26$ mm^{-1}
$c = 15.4147$ (4) Å	$T = 180$ K
$V = 1502.90$ (6) Å^3	Prism, colourless
$Z = 4$	0.35 × 0.27 × 0.17 mm

Data collection

Agilent Xcalibur Eos Gemini ultra diffractometer	Detector resolution: 16.1978 pixels mm^{-1}
Radiation source: Enhance (Mo) X-ray Source	ω scans
Graphite monochromator	Absorption correction: multi-scan (*CrysAlis PRO*; Agilent, 2010)

$T_{\min} = 0.889$, $T_{\max} = 1.000$	$\theta_{\max} = 26.4°$, $\theta_{\min} = 3.6°$
8982 measured reflections	$h = -10 \rightarrow 9$
3053 independent reflections	$k = -15 \rightarrow 15$
2944 reflections with $I > 2\sigma(I)$	$l = -18 \rightarrow 19$
$R_{\text{int}} = 0.019$	

Refinement

Refinement on F^2	Hydrogen site location: inferred from neighbouring sites
Least-squares matrix: full	H-atom parameters constrained
$R[F^2 > 2\sigma(F^2)] = 0.027$	$w = 1/[\sigma^2(F_o^2) + (0.0362P)^2 + 0.3492P]$ where $P = (F_o^2 + 2F_c^2)/3$
$wR(F^2) = 0.070$	$(\Delta/\sigma)_{\max} = 0.001$
$S = 1.04$	$\Delta\rho_{\max} = 0.21$ e Å^{-3}
3053 reflections	$\Delta\rho_{\min} = -0.21$ e Å^{-3}
185 parameters	Absolute structure: Flack (1983), 614 Friedel pairs
0 restraints	Absolute structure parameter: −0.06 (5)
Primary atom site location: structure-invariant direct methods	
Secondary atom site location: difference Fourier map	

Special details

Experimental. Empirical absorption correction using spherical harmonics, implemented in SCALE3 ABSPACK scaling algorithm. CrysAlisPro (Agilent, 2010)

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

Refinement. Refinement of F^2 against ALL reflections. The weighted R-factor wR and goodness of fit S are based on F^2, conventional R-factors R are based on F, with F set to zero for negative F^2. The threshold expression of $F^2 > \sigma(F^2)$ is used only for calculating R-factors(gt) *etc*. and is not relevant to the choice of reflections for refinement. R-factors based on F^2 are statistically about twice as large as those based on F, and R- factors based on ALL data will be even larger.

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

	x	y	z	U_{iso}*/U_{eq}
Cl	0.47204 (6)	0.42068 (3)	0.58743 (3)	0.03475 (11)
C1	0.60869 (16)	0.59828 (11)	0.36912 (9)	0.0169 (3)
H1	0.6725	0.5379	0.3432	0.020*
C2	0.55399 (17)	0.56590 (10)	0.46192 (9)	0.0169 (3)
H2	0.6465	0.5833	0.5011	0.020*
C3	0.51598 (18)	0.44248 (11)	0.47165 (9)	0.0193 (3)
C4	0.66321 (18)	0.36766 (11)	0.44947 (11)	0.0226 (3)
H4A	0.6774	0.3691	0.3870	0.027*
H4B	0.6322	0.2931	0.4651	0.027*
C5	0.83398 (18)	0.39143 (12)	0.49062 (11)	0.0271 (3)
H5A	0.8208	0.3935	0.5532	0.033*
H5B	0.9085	0.3310	0.4770	0.033*
C6	0.91472 (16)	0.49718 (12)	0.46184 (10)	0.0211 (3)
H6	0.9289	0.5519	0.5034	0.025*
C7	0.96724 (17)	0.51863 (11)	0.38212 (10)	0.0201 (3)
C8	1.01946 (18)	0.63373 (12)	0.35599 (10)	0.0213 (3)
H8	1.1106	0.6281	0.3139	0.026*

C9	0.87577 (18)	0.69698 (12)	0.31401 (10)	0.0231 (3)
H9A	0.8484	0.6619	0.2593	0.028*
H9B	0.9135	0.7711	0.3012	0.028*
C10	0.71583 (16)	0.70436 (11)	0.36933 (10)	0.0181 (3)
H10	0.7458	0.7230	0.4292	0.022*
C11	0.59596 (18)	0.78895 (13)	0.33507 (10)	0.0228 (3)
C12	0.44945 (19)	0.73049 (13)	0.29884 (11)	0.0264 (3)
C13	0.6075 (2)	0.89766 (13)	0.33538 (12)	0.0329 (4)
H13A	0.5217	0.9401	0.3123	0.039*
H13B	0.7013	0.9316	0.3587	0.039*
C14	0.9722 (2)	0.43627 (13)	0.30957 (11)	0.0296 (3)
H14A	0.9579	0.3636	0.3327	0.044*
H14B	1.0777	0.4409	0.2804	0.044*
H14C	0.8842	0.4517	0.2692	0.044*
C15	0.36070 (18)	0.40750 (12)	0.42250 (11)	0.0267 (3)
H15A	0.3759	0.4215	0.3617	0.040*
H15B	0.2666	0.4485	0.4433	0.040*
H15C	0.3415	0.3304	0.4314	0.040*
O1	0.33335 (15)	0.76689 (11)	0.25906 (9)	0.0408 (3)
O2	0.46321 (13)	0.62157 (8)	0.31574 (7)	0.0235 (2)
O3	0.41528 (12)	0.63183 (8)	0.48730 (7)	0.0219 (2)
H3	0.4483	0.6844	0.5159	0.033*
O4	1.07598 (12)	0.69787 (8)	0.42835 (8)	0.0261 (2)
H4	1.1646	0.6730	0.4461	0.039*

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
Cl	0.0427 (2)	0.03388 (19)	0.0276 (2)	0.00420 (18)	0.00966 (18)	0.00940 (16)
C1	0.0124 (6)	0.0175 (6)	0.0206 (7)	0.0001 (5)	−0.0032 (5)	0.0002 (5)
C2	0.0130 (6)	0.0169 (6)	0.0208 (7)	0.0019 (5)	0.0001 (5)	−0.0004 (5)
C3	0.0188 (7)	0.0195 (6)	0.0195 (7)	0.0008 (5)	0.0027 (6)	0.0042 (5)
C4	0.0204 (7)	0.0152 (6)	0.0322 (8)	0.0012 (5)	0.0019 (6)	0.0009 (6)
C5	0.0201 (7)	0.0237 (8)	0.0374 (9)	0.0051 (6)	−0.0026 (7)	0.0084 (6)
C6	0.0134 (6)	0.0208 (6)	0.0290 (8)	0.0032 (5)	−0.0038 (6)	−0.0013 (6)
C7	0.0109 (6)	0.0205 (6)	0.0289 (8)	0.0014 (5)	−0.0007 (6)	−0.0065 (6)
C8	0.0150 (7)	0.0231 (7)	0.0257 (7)	−0.0018 (5)	0.0029 (6)	−0.0057 (6)
C9	0.0200 (7)	0.0253 (7)	0.0240 (8)	−0.0045 (6)	0.0034 (6)	0.0022 (6)
C10	0.0155 (6)	0.0179 (6)	0.0208 (7)	−0.0011 (5)	−0.0002 (6)	0.0018 (6)
C11	0.0201 (7)	0.0255 (7)	0.0228 (8)	0.0007 (6)	0.0026 (6)	0.0061 (6)
C12	0.0217 (7)	0.0308 (8)	0.0267 (8)	−0.0005 (6)	0.0007 (7)	0.0100 (6)
C13	0.0331 (9)	0.0247 (8)	0.0408 (10)	0.0031 (7)	0.0023 (8)	0.0073 (7)
C14	0.0240 (8)	0.0288 (8)	0.0361 (9)	−0.0018 (6)	0.0042 (7)	−0.0135 (7)
C15	0.0191 (7)	0.0201 (7)	0.0410 (9)	−0.0039 (6)	−0.0041 (7)	0.0039 (7)
O1	0.0255 (6)	0.0461 (7)	0.0507 (8)	0.0016 (5)	−0.0121 (6)	0.0243 (6)
O2	0.0193 (5)	0.0256 (5)	0.0255 (5)	−0.0039 (4)	−0.0078 (5)	0.0052 (4)
O3	0.0156 (5)	0.0193 (5)	0.0308 (6)	0.0022 (4)	0.0021 (4)	−0.0050 (4)
O4	0.0169 (5)	0.0233 (5)	0.0380 (7)	0.0005 (4)	−0.0052 (4)	−0.0100 (5)

Geometric parameters (Å, º)

Cl—C3	1.8384 (15)	C8—C9	1.529 (2)
C1—O2	1.4557 (16)	C8—H8	0.9800
C1—C2	1.5471 (19)	C9—C10	1.5433 (19)
C1—C10	1.5495 (18)	C9—H9A	0.9700
C1—H1	0.9800	C9—H9B	0.9700
C2—O3	1.4260 (16)	C10—C11	1.504 (2)
C2—C3	1.5380 (18)	C10—H10	0.9800
C2—H2	0.9800	C11—C13	1.324 (2)
C3—C15	1.519 (2)	C11—C12	1.483 (2)
C3—C4	1.5292 (19)	C12—O1	1.1997 (19)
C4—C5	1.537 (2)	C12—O2	1.3536 (18)
C4—H4A	0.9700	C13—H13A	0.9300
C4—H4B	0.9700	C13—H13B	0.9300
C5—C6	1.506 (2)	C14—H14A	0.9600
C5—H5A	0.9700	C14—H14B	0.9600
C5—H5B	0.9700	C14—H14C	0.9600
C6—C7	1.325 (2)	C15—H15A	0.9600
C6—H6	0.9300	C15—H15B	0.9600
C7—C14	1.5014 (19)	C15—H15C	0.9600
C7—C8	1.5148 (19)	O3—H3	0.8200
C8—O4	1.4343 (17)	O4—H4	0.8200

O2—C1—C2	110.16 (11)	O4—C8—H8	108.5
O2—C1—C10	106.51 (10)	C7—C8—H8	108.5
C2—C1—C10	111.53 (11)	C9—C8—H8	108.5
O2—C1—H1	109.5	C8—C9—C10	114.96 (12)
C2—C1—H1	109.5	C8—C9—H9A	108.5
C10—C1—H1	109.5	C10—C9—H9A	108.5
O3—C2—C3	111.50 (11)	C8—C9—H9B	108.5
O3—C2—C1	109.40 (11)	C10—C9—H9B	108.5
C3—C2—C1	113.23 (11)	H9A—C9—H9B	107.5
O3—C2—H2	107.5	C11—C10—C9	112.17 (12)
C3—C2—H2	107.5	C11—C10—C1	102.32 (11)
C1—C2—H2	107.5	C9—C10—C1	114.31 (12)
C15—C3—C4	110.83 (12)	C11—C10—H10	109.3
C15—C3—C2	112.77 (11)	C9—C10—H10	109.3
C4—C3—C2	113.89 (11)	C1—C10—H10	109.3
C15—C3—Cl	106.66 (10)	C13—C11—C12	122.32 (15)
C4—C3—Cl	106.23 (10)	C13—C11—C10	129.51 (15)
C2—C3—Cl	105.86 (9)	C12—C11—C10	108.16 (13)
C3—C4—C5	118.97 (12)	O1—C12—O2	121.48 (15)
C3—C4—H4A	107.6	O1—C12—C11	129.15 (15)
C5—C4—H4A	107.6	O2—C12—C11	109.36 (13)
C3—C4—H4B	107.6	C11—C13—H13A	120.0
C5—C4—H4B	107.6	C11—C13—H13B	120.0
H4A—C4—H4B	107.0	H13A—C13—H13B	120.0

C6—C5—C4	114.97 (12)	C7—C14—H14A	109.5
C6—C5—H5A	108.5	C7—C14—H14B	109.5
C4—C5—H5A	108.5	H14A—C14—H14B	109.5
C6—C5—H5B	108.5	C7—C14—H14C	109.5
C4—C5—H5B	108.5	H14A—C14—H14C	109.5
H5A—C5—H5B	107.5	H14B—C14—H14C	109.5
C7—C6—C5	125.30 (14)	C3—C15—H15A	109.5
C7—C6—H6	117.3	C3—C15—H15B	109.5
C5—C6—H6	117.3	H15A—C15—H15B	109.5
C6—C7—C14	124.62 (13)	C3—C15—H15C	109.5
C6—C7—C8	121.08 (13)	H15A—C15—H15C	109.5
C14—C7—C8	114.22 (12)	H15B—C15—H15C	109.5
O4—C8—C7	112.49 (12)	C12—O2—C1	111.36 (11)
O4—C8—C9	107.12 (11)	C2—O3—H3	109.5
C7—C8—C9	111.61 (12)	C8—O4—H4	109.5

Hydrogen-bond geometry (Å, º)

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
O3—H3···O4^{i}	0.82	1.96	2.763 (1)	167
O4—H4···O3^{ii}	0.82	2.17	2.980 (1)	171

Symmetry codes: (i) *x*−1/2, −*y*+3/2, −*z*+1; (ii) *x*+1, *y*, *z*.