IUCrData

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rac-1-(2-{[(Benzyloxy)carbonyl]amino}cyclohexyl)-pyrrolidin-1-ium chloride

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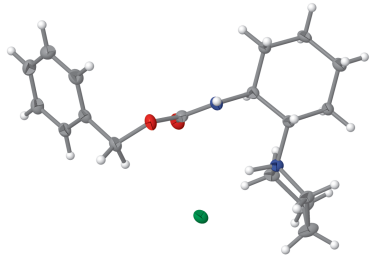
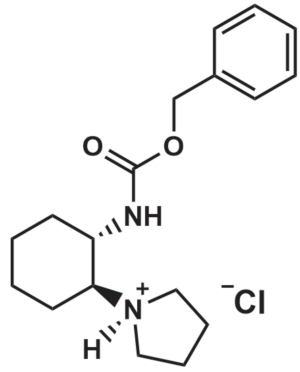
Structural data: full structural data are available from iucrdata.iucr.org

The crystal structure of $C_{19}H_{26}N_2O_2^+\cdot Cl^-$, an intermediate in the synthesis of the selective κ-opioid receptor agonist U50,488, is reported. The compound crystallizes as a centrosymmetric structure with both (*S*,*S*)- and (*R*,*R*)-enantiomers in the unit cell. In the crystal, the chloride ion facilitates the formation of enantiomeric pairs through N—H···Cl hydrogen bonds involving both pyrrolidine and the carbamate nitrogen atoms.

3D view



Chemical scheme



Structure description

The title compound, $C_{19}H_{26}N_2O_2^+\cdot Cl^-$ (Fig. 1), was synthesized as an intermediate in the preparation of U50,488, a selective κ-opioid receptor agonist (Chesis & Welch, 1990; Kato *et al.*, 2025). In the arbitrarily chosen asymmetric molecule, atoms C1 and C6 have S configuration but crystal symmetry generates a racemic mixture and the unit cell contains. two molecules of each enantiomer [(*S*,*S*) and (*R*,*R*)]. Fig. 1 illustrates the (*S*,*S*)-enantiomer. The cyclohexane ring adopts a chair conformation, with the two substituents in a *trans* configuration. As a result of the significantly reduced basicity of the carbamate-protected nitrogen atom (benzyloxycarbonyl: Cbz), protonation occurs exclusively at the pyrrolidine nitrogen atom. The N2—C6 bond length is 1.512 (3) Å, whereas the distance between the Cbz-bonded nitrogen atom and the cyclohexane carbon atom, N1—C1, is slightly shorter at 1.456 (3) Å. The N1—C7 (carbamate carbonyl) bond is notably shorter at 1.339 (3) Å, reflecting its partial double-bond character. The chloride ion (Cl1) participates in hydrogen bonding with the N2—H2 and $N1^i$—$H1^i$ groups [symmetry code (i): $1-x, -y, 1-z$; Table 1], which facilitates the formation of enantiomeric pairs. No other significant short-range interactions are observed. The crystal packing is illustrated in Fig. 2.

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

D—H···A	D—H	H···A	D···A	D—H···A
N2—H2···Cl1	1.00	2.20	3.086 (2)	147
N1—H1···Cl1^{i}	0.88	2.40	3.256 (2)	164

Symmetry code: (i) $-x+1, -y, -z+1$.

Synthesis and crystallization

The title compound was synthesized according to a reported method (Chesis & Welch, 1990). Single crystals suitable for X-ray analysis were obtained by dissolving the compound in a minimum amount of methanol at 298 K followed by slow evaporation.

Refinement

Crystal data, data collection and structure refinement details are summarized in Table 2.

Funding information

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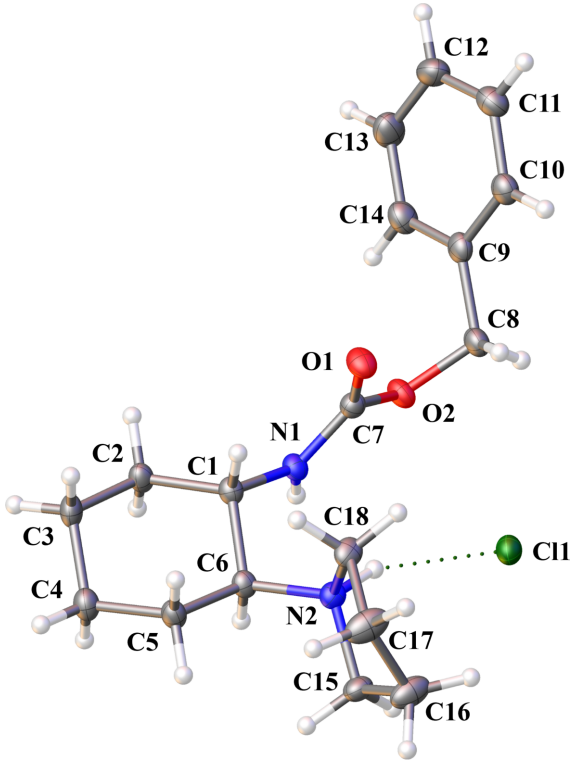

Figure 1
The molecular structure of title compound with displacement ellipsoids drawn at the 50% probability level. The N2—H2···Cl1 hydrogen bond is shown as a dashed line.

Table 2
Experimental details.

Crystal data	
Chemical formula	$C_{18}H_{27}N_2O_2^+\cdot Cl^-$
M_r	338.86
Crystal system, space group	Monoclinic, $P2_1/c$
Temperature (K)	100
a, b, c (Å)	8.8647 (2), 9.7156 (2), 20.2752 (4)
β (°)	94.339 (2)
V (Å^3)	1741.21 (6)
Z	4
Radiation type	Cu $K\alpha$
μ (mm^{-1})	2.03
Crystal size (mm)	0.36 × 0.18 × 0.12
Data collection	
Diffractometer	XtaLAB Synergy, Single source at home/near, HyPix3000
Absorption correction	Multi-scan (*CrysAlis PRO*; Rigaku OD, 2025)
T_{min}, T_{max}	0.381, 1.000
No. of measured, independent and observed [$I > 2\sigma(I)$] reflections	14901, 3180, 2676
R_{int}	0.164
(sin $\theta/\lambda)_{max}$ (Å^{-1})	0.603
Refinement	
$R[F^2 > 2\sigma(F^2)]$, $wR(F^2)$, S	0.064, 0.178, 1.01
No. of reflections	3180
No. of parameters	208
H-atom treatment	H-atom parameters constrained
$\Delta\rho_{max}$, $\Delta\rho_{min}$ (e Å^{-3})	0.65, −0.41

Computer programs: *CrysAlis PRO* (Rigaku OD, 2025), *SHELXT* (Sheldrick, 2015*a*), *SHELXL2019/3* (Sheldrick, 2015*b*) and *OLEX2* (Dolomanov *et al.*, 2009).

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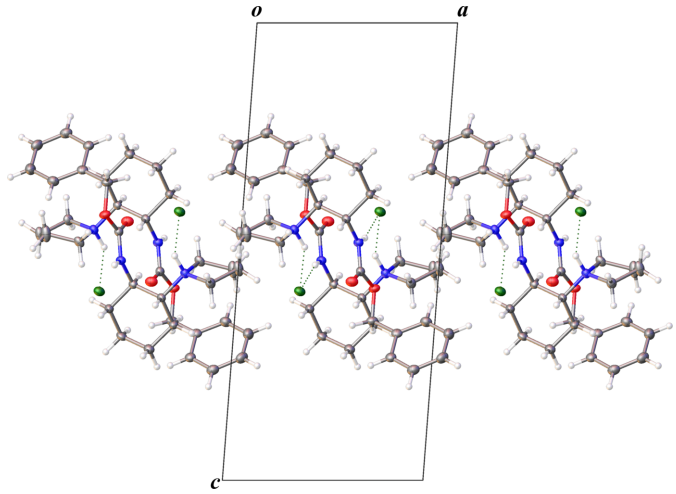

Figure 2
Partial packing diagram viewed along the *b*-axis direction.

full crystallographic data

IUCrData (2026). **11**, x260664 [https://doi.org/10.1107/S2414314626006644]

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Crystal data

$C_{18}H_{27}N_2O_2^+ \cdot Cl^-$
M_r = 338.86
Monoclinic, $P2_1/c$
a = 8.8647 (2) Å
b = 9.7156 (2) Å
c = 20.2752 (4) Å
β = 94.339 (2)°
V = 1741.21 (6) Å^3
Z = 4
$F(000)$ = 728
D_x = 1.293 Mg m^{-3}
Cu $K\alpha$ radiation, λ = 1.54184 Å
Cell parameters from 8831 reflections
θ = 4.4–68.1°
μ = 2.03 mm^{-1}
T = 100 K
Block, clear colourless
0.36 × 0.18 × 0.12 mm

Data collection

XtaLAB Synergy, Single source at home/near, HyPix3000 diffractometer
Radiation source: micro-focus sealed X-ray tube, PhotonJet-i
Multi-layer mirror optics monochromator
Detector resolution: 10.0000 pixels mm^{-1}
ω scans
Absorption correction: multi-scan (CrysAlisPro; Rigaku OD, 2025)
T_{min} = 0.381, T_{max} = 1.000
14901 measured reflections
3180 independent reflections
2676 reflections with $I > 2\sigma(I)$
R_{int} = 0.164
θ_{max} = 68.5°, θ_{min} = 4.4°
h = −10→8
k = −11→11
l = −24→24

Refinement

Refinement on F^2
Least-squares matrix: full
$R[F^2 > 2\sigma(F^2)]$ = 0.064
$wR(F^2)$ = 0.178
S = 1.01
3180 reflections
208 parameters
0 restraints
Hydrogen site location: inferred from neighbouring sites
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.122P)^2]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max}$ = 0.001
$\Delta\rho_{max}$ = 0.65 e Å^{-3}
$\Delta\rho_{min}$ = −0.40 e Å^{-3}

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}
Cl1	0.31462 (6)	0.06975 (6)	0.58705 (2)	0.0226 (2)
O2	0.68572 (18)	0.16204 (17)	0.58084 (7)	0.0215 (4)
O1	0.57094 (19)	0.37007 (17)	0.56586 (7)	0.0245 (4)
N1	0.5890 (2)	0.2179 (2)	0.48064 (8)	0.0181 (4)
H1	0.618740	0.134590	0.470518	0.022*
N2	0.2644 (2)	0.21635 (19)	0.45218 (9)	0.0182 (4)
H2	0.322548	0.170743	0.490319	0.022*
C1	0.5188 (2)	0.3044 (2)	0.42834 (10)	0.0179 (5)
H1A	0.492998	0.395406	0.447612	0.021*
C7	0.6101 (2)	0.2600 (2)	0.54351 (10)	0.0183 (5)
C6	0.3730 (2)	0.2361 (2)	0.39897 (10)	0.0179 (5)
H6	0.400210	0.142869	0.382696	0.021*
C2	0.6294 (2)	0.3276 (3)	0.37494 (10)	0.0214 (5)
H2A	0.717101	0.381232	0.393971	0.026*
H2B	0.667271	0.237397	0.360558	0.026*
C10	0.7936 (3)	0.3590 (2)	0.73147 (11)	0.0238 (5)
H10	0.697356	0.362906	0.749084	0.029*
C5	0.3017 (2)	0.3171 (3)	0.33981 (10)	0.0211 (5)
H5A	0.272816	0.410166	0.354293	0.025*
H5B	0.209221	0.269600	0.321311	0.025*
C8	0.6864 (3)	0.1819 (3)	0.65116 (10)	0.0229 (5)
H8A	0.693608	0.091032	0.673296	0.027*
H8B	0.589551	0.224578	0.661408	0.027*
C9	0.8150 (3)	0.2712 (2)	0.67860 (11)	0.0221 (5)
C4	0.4151 (3)	0.3290 (3)	0.28676 (11)	0.0242 (5)
H4A	0.442449	0.236041	0.271673	0.029*
H4B	0.368708	0.380359	0.248206	0.029*
C3	0.5565 (3)	0.4038 (3)	0.31501 (11)	0.0235 (5)
H3A	0.529334	0.498243	0.328111	0.028*
H3B	0.629696	0.410856	0.280652	0.028*
C18	0.1956 (3)	0.3474 (2)	0.47908 (11)	0.0219 (5)
H18A	0.216769	0.353724	0.527632	0.026*
H18B	0.236822	0.430222	0.458357	0.026*
C11	0.9107 (3)	0.4408 (3)	0.75879 (12)	0.0276 (6)
H11	0.895194	0.499022	0.795300	0.033*
C15	0.1335 (2)	0.1212 (3)	0.43074 (11)	0.0223 (5)
H15A	0.114951	0.120563	0.381971	0.027*
H15B	0.154834	0.025961	0.446143	0.027*
C14	0.9565 (3)	0.2657 (3)	0.65384 (11)	0.0278 (6)
H14	0.973179	0.204827	0.618453	0.033*
C13	1.0742 (3)	0.3482 (3)	0.68013 (12)	0.0342 (6)
H13	1.170438	0.344158	0.662529	0.041*
C12	1.0507 (3)	0.4367 (3)	0.73232 (13)	0.0310 (6)
H12	1.130400	0.494489	0.749859	0.037*
C16	−0.0008 (3)	0.1796 (3)	0.46268 (15)	0.0321 (6)

H16A	−0.003924	0.146304	0.508713	0.038*
H16B	−0.096824	0.154879	0.437297	0.038*
C17	0.0269 (3)	0.3338 (3)	0.46088 (16)	0.0361 (7)
H17A	−0.000492	0.371580	0.416221	0.043*
H17B	−0.032244	0.382295	0.493291	0.043*

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
Cl1	0.0271 (4)	0.0218 (4)	0.0193 (3)	−0.0014 (2)	0.0049 (2)	0.00011 (19)
O2	0.0269 (9)	0.0217 (9)	0.0154 (7)	0.0035 (6)	−0.0020 (6)	0.0003 (6)
O1	0.0335 (9)	0.0187 (9)	0.0212 (7)	0.0033 (7)	0.0021 (7)	−0.0023 (6)
N1	0.0209 (9)	0.0176 (10)	0.0159 (8)	0.0025 (7)	0.0021 (7)	−0.0010 (7)
N2	0.0182 (9)	0.0171 (10)	0.0196 (9)	0.0015 (7)	0.0038 (7)	−0.0011 (7)
C1	0.0179 (11)	0.0192 (12)	0.0166 (9)	0.0028 (9)	0.0023 (8)	0.0012 (8)
C7	0.0172 (11)	0.0189 (12)	0.0190 (10)	−0.0008 (9)	0.0021 (8)	0.0005 (9)
C6	0.0167 (11)	0.0206 (12)	0.0166 (10)	0.0024 (9)	0.0027 (8)	0.0002 (8)
C2	0.0178 (11)	0.0295 (13)	0.0172 (10)	−0.0003 (9)	0.0026 (8)	0.0016 (9)
C10	0.0253 (11)	0.0265 (14)	0.0192 (10)	0.0020 (10)	0.0002 (9)	0.0031 (9)
C5	0.0187 (11)	0.0279 (13)	0.0167 (10)	0.0000 (9)	0.0010 (8)	0.0022 (9)
C8	0.0282 (12)	0.0245 (13)	0.0156 (10)	−0.0009 (10)	0.0003 (9)	0.0014 (9)
C9	0.0266 (12)	0.0219 (12)	0.0177 (10)	0.0010 (10)	0.0010 (9)	0.0052 (9)
C4	0.0250 (12)	0.0285 (14)	0.0194 (10)	0.0016 (10)	0.0043 (9)	0.0029 (9)
C3	0.0250 (12)	0.0286 (13)	0.0177 (10)	0.0003 (10)	0.0070 (9)	0.0043 (10)
C18	0.0243 (12)	0.0182 (13)	0.0245 (10)	0.0013 (9)	0.0091 (9)	−0.0039 (9)
C11	0.0329 (13)	0.0271 (14)	0.0223 (11)	0.0015 (10)	−0.0018 (10)	−0.0022 (9)
C15	0.0215 (11)	0.0198 (12)	0.0260 (11)	−0.0053 (9)	0.0035 (9)	−0.0026 (9)
C14	0.0301 (13)	0.0323 (14)	0.0214 (10)	0.0013 (11)	0.0040 (9)	−0.0021 (10)
C13	0.0247 (13)	0.0499 (18)	0.0283 (12)	−0.0042 (12)	0.0034 (10)	0.0025 (11)
C12	0.0302 (14)	0.0345 (16)	0.0273 (12)	−0.0087 (11)	−0.0046 (11)	0.0007 (10)
C16	0.0226 (13)	0.0252 (14)	0.0498 (16)	−0.0026 (10)	0.0113 (11)	−0.0074 (11)
C17	0.0224 (13)	0.0257 (14)	0.0610 (18)	0.0014 (10)	0.0092 (12)	−0.0067 (12)

Geometric parameters (Å, º)

O2—C7	1.361 (3)	C8—C9	1.505 (3)
O2—C8	1.438 (2)	C9—C14	1.387 (3)
O1—C7	1.222 (3)	C4—H4A	0.9900
N1—H1	0.8800	C4—H4B	0.9900
N1—C1	1.456 (3)	C4—C3	1.522 (3)
N1—C7	1.339 (3)	C3—H3A	0.9900
N2—H2	1.0000	C3—H3B	0.9900
N2—C6	1.512 (3)	C18—H18A	0.9900
N2—C18	1.530 (3)	C18—H18B	0.9900
N2—C15	1.521 (3)	C18—C17	1.519 (4)
C1—H1A	1.0000	C11—H11	0.9500
C1—C6	1.532 (3)	C11—C12	1.389 (4)
C1—C2	1.531 (3)	C15—H15A	0.9900

C6—H6	1.0000	C15—H15B	0.9900
C6—C5	1.531 (3)	C15—C16	1.509 (3)
C2—H2A	0.9900	C14—H14	0.9500
C2—H2B	0.9900	C14—C13	1.389 (4)
C2—C3	1.524 (3)	C13—H13	0.9500
C10—H10	0.9500	C13—C12	1.392 (4)
C10—C9	1.394 (3)	C12—H12	0.9500
C10—C11	1.389 (4)	C16—H16A	0.9900
C5—H5A	0.9900	C16—H16B	0.9900
C5—H5B	0.9900	C16—C17	1.520 (4)
C5—C4	1.531 (3)	C17—H17A	0.9900
C8—H8A	0.9900	C17—H17B	0.9900
C8—H8B	0.9900		

C7—O2—C8	115.01 (17)	C5—C4—H4A	109.7
C1—N1—H1	118.7	C5—C4—H4B	109.7
C7—N1—H1	118.7	H4A—C4—H4B	108.2
C7—N1—C1	122.57 (19)	C3—C4—C5	109.70 (18)
C6—N2—H2	106.8	C3—C4—H4A	109.7
C6—N2—C18	116.17 (17)	C3—C4—H4B	109.7
C6—N2—C15	112.74 (16)	C2—C3—H3A	109.5
C18—N2—H2	106.8	C2—C3—H3B	109.5
C15—N2—H2	106.8	C4—C3—C2	110.82 (19)
C15—N2—C18	106.98 (16)	C4—C3—H3A	109.5
N1—C1—H1A	108.9	C4—C3—H3B	109.5
N1—C1—C6	109.55 (18)	H3A—C3—H3B	108.1
N1—C1—C2	109.78 (17)	N2—C18—H18A	110.8
C6—C1—H1A	108.9	N2—C18—H18B	110.8
C2—C1—H1A	108.9	H18A—C18—H18B	108.9
C2—C1—C6	110.80 (17)	C17—C18—N2	104.63 (18)
O1—C7—O2	123.21 (19)	C17—C18—H18A	110.8
O1—C7—N1	126.7 (2)	C17—C18—H18B	110.8
N1—C7—O2	110.08 (18)	C10—C11—H11	120.3
N2—C6—C1	109.97 (16)	C10—C11—C12	119.5 (2)
N2—C6—H6	107.6	C12—C11—H11	120.3
N2—C6—C5	112.16 (17)	N2—C15—H15A	110.8
C1—C6—H6	107.6	N2—C15—H15B	110.8
C5—C6—C1	111.58 (18)	H15A—C15—H15B	108.8
C5—C6—H6	107.6	C16—C15—N2	104.98 (18)
C1—C2—H2A	109.1	C16—C15—H15A	110.8
C1—C2—H2B	109.1	C16—C15—H15B	110.8
H2A—C2—H2B	107.9	C9—C14—H14	119.6
C3—C2—C1	112.29 (18)	C9—C14—C13	120.8 (2)
C3—C2—H2A	109.1	C13—C14—H14	119.6
C3—C2—H2B	109.1	C14—C13—H13	120.1
C9—C10—H10	119.5	C14—C13—C12	119.8 (2)
C11—C10—H10	119.5	C12—C13—H13	120.1
C11—C10—C9	121.0 (2)	C11—C12—C13	120.0 (2)

C6—C5—H5A	109.7	C11—C12—H12	120.0
C6—C5—H5B	109.7	C13—C12—H12	120.0
C6—C5—C4	109.61 (18)	C15—C16—H16A	111.1
H5A—C5—H5B	108.2	C15—C16—H16B	111.1
C4—C5—H5A	109.7	C15—C16—C17	103.08 (19)
C4—C5—H5B	109.7	H16A—C16—H16B	109.1
O2—C8—H8A	109.0	C17—C16—H16A	111.1
O2—C8—H8B	109.0	C17—C16—H16B	111.1
O2—C8—C9	112.97 (18)	C18—C17—C16	103.8 (2)
H8A—C8—H8B	107.8	C18—C17—H17A	111.0
C9—C8—H8A	109.0	C18—C17—H17B	111.0
C9—C8—H8B	109.0	C16—C17—H17A	111.0
C10—C9—C8	119.6 (2)	C16—C17—H17B	111.0
C14—C9—C10	118.8 (2)	H17A—C17—H17B	109.0
C14—C9—C8	121.6 (2)		

O2—C8—C9—C10	145.6 (2)	C2—C1—C6—C5	−53.9 (2)
O2—C8—C9—C14	−36.2 (3)	C10—C9—C14—C13	−1.4 (4)
N1—C1—C6—N2	59.7 (2)	C10—C11—C12—C13	−1.9 (4)
N1—C1—C6—C5	−175.20 (16)	C5—C4—C3—C2	58.8 (3)
N1—C1—C2—C3	173.48 (19)	C8—O2—C7—O1	13.8 (3)
N2—C6—C5—C4	−177.93 (19)	C8—O2—C7—N1	−167.13 (18)
N2—C18—C17—C16	31.3 (3)	C8—C9—C14—C13	−179.5 (2)
N2—C15—C16—C17	34.8 (3)	C9—C10—C11—C12	1.1 (4)
C1—N1—C7—O2	−176.42 (17)	C9—C14—C13—C12	0.5 (4)
C1—N1—C7—O1	2.6 (3)	C18—N2—C6—C1	69.0 (2)
C1—C6—C5—C4	58.2 (2)	C18—N2—C6—C5	−55.8 (2)
C1—C2—C3—C4	−55.3 (3)	C18—N2—C15—C16	−15.5 (2)
C7—O2—C8—C9	−87.6 (2)	C11—C10—C9—C8	178.7 (2)
C7—N1—C1—C6	−118.2 (2)	C11—C10—C9—C14	0.6 (3)
C7—N1—C1—C2	119.9 (2)	C15—N2—C6—C1	−167.05 (18)
C6—N2—C18—C17	117.1 (2)	C15—N2—C6—C5	68.2 (2)
C6—N2—C15—C16	−144.4 (2)	C15—N2—C18—C17	−9.8 (2)
C6—C1—C2—C3	52.3 (3)	C15—C16—C17—C18	−41.2 (3)
C6—C5—C4—C3	−60.1 (3)	C14—C13—C12—C11	1.2 (4)
C2—C1—C6—N2	−179.06 (18)		

Hydrogen-bond geometry (Å, º)

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
N2—H2···Cl1	1.00	2.20	3.086 (2)	147
N1—H1···Cl1^{i}	0.88	2.40	3.256 (2)	164

Symmetry code: (i) −*x*+1, −*y*, −*z*+1.