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3-Hydroxy-4-phenyl-2,3,4,5-tetrahydro-1*H*-1,5-benzodiazepin-2-one: *cis* isomer

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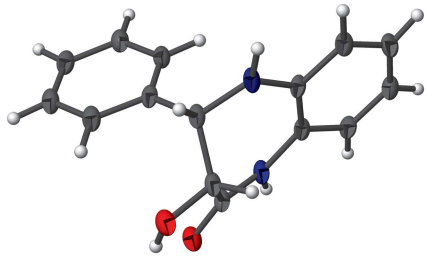
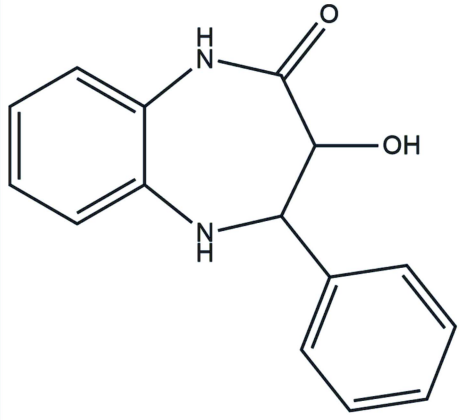
Structural data: full structural data are available from iucrdata.iucr.org

In the title compound, $C_{15}H_{14}N_2O_2$, the seven-membered benzodiazepine ring adopts a twist-boat conformation and the two aromatic rings are inclined to one another by 81.06 (15)°. In the crystal, molecules are linked by N—H···O hydrogen bonds, forming chains propagating along the [10$\bar{1}$] direction. The chains are linked by C—H···O hydrogen bonds, forming sheets parallel to the *ac* plane. Within the sheets, there are N—H···π interactions present, and C—H···π interactions link the sheets to form a three-dimensional structure.

3D view



Chemical scheme



Structure description

1,5-Benzodiazepine derivatives have been used as therapeutics for viral infections and cardiovascular disorder (Jacob *et al.*, 2011; Maleki *et al.*, 2014). They are active against potassium blockers (Claremon *et al.*, 1996) and are also employed as intermediates for the synthesis of several heterocyclic compounds (Minnih *et al.*, 2014; Ahabchane *et al.*, 1999). As part of our studies in this area, we now describe the synthesis and crystal structure of the title compound, Fig. 1.

The seven-membered ring (N1/N2/C1/C6–C9) adopts a twist-boat conformation [puckering parameters: $Q(2)$ = 0.571 (3) Å, $Q(3)$ = 0.375 (3) Å, $\varphi(2)$ = 230.7 (3)° and $\varphi(3)$ = 326.7 (5)°; total puckering amplitude Q = 0.682 (3) Å]. The dihedral angle between the aromatic rings, C1–C6 and C10–C15, is 81.06 (15)°. There is possibly an intramolecular O1—H1···O2 hydrogen bond (Table 1), but the small O—H···O angle of 122 (4)° would indicate considerable strain.

In the crystal, molecules are linked by N2—H2*A*···O1^{i} hydrogen bonds, forming chains propagating along [10$\bar{1}$]; see Table 1 and Fig. 2. The chains are linked by C8—

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

*Cg*1 and *Cg*2 are the centroids of the C1–C6 and C10–C15 rings, respectively.

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
O1—H1···O2	0.84 (4)	2.01 (4)	2.556 (3)	122 (4)
N2—H2*A*···O1^{i}	0.88 (4)	2.09 (4)	2.922 (3)	157 (3)
C8—H8···O2^{ii}	0.99 (4)	2.57 (4)	3.395 (4)	141 (3)
C12—H12···*Cg*1^{iii}	0.99 (4)	2.85 (3)	3.696 (4)	144 (3)
N1—H1*A*···*Cg*2^{ii}	0.99 (5)	2.63 (3)	3.457 (3)	149 (3)

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

H8···O2^{ii} hydrogen bonds, forming sheets parallel to the *ac* plane (Table 1 and Fig. 2). Within the sheets there are N—H···π interactions present, and C—H···π interactions link the sheets to form a three-dimensional structure (Table 1 and Fig. 3).

Synthesis and crystallization

A mixture of *o*-phenylenediamine 1 (0.03 mol) and ethyl glycidate (0.03 mol) was refluxed in 80 ml of xylene for 48 h. The resulting crude mixture was left at room temperature

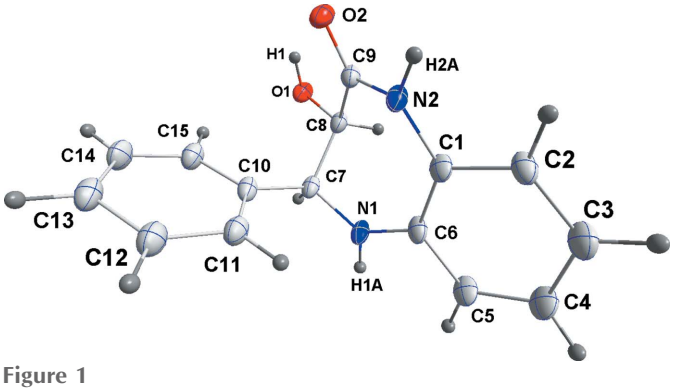


Figure 1
The molecular structure of the title compound, with the atom labelling and 50% probability ellipsoids.

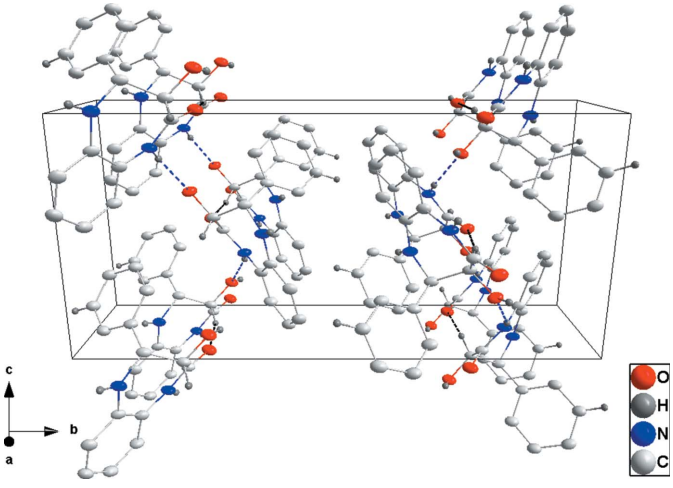


Figure 2
The crystal packing of the title compound, viewed along the *a*-axis direction. Hydrogen bonds are shown as dashed lines (see Table 1).

Table 2
Experimental details.

Crystal data	
Chemical formula	$C_{15}H_{14}N_2O_2$
M_r	254.28
Crystal system, space group	Monoclinic, $P2_1/n$
Temperature (K)	100
a, *b*, *c* (Å)	5.519 (2), 21.594 (8), 9.917 (4)
β (°)	90.405 (5)
V (Å^3)	1181.9 (7)
Z	4
Radiation type	Mo *K*α
μ (mm^{-1})	0.10
Crystal size (mm)	0.41 × 0.17 × 0.09
Data collection	
Diffractometer	Bruker SMART APEX CCD
Absorption correction	Multi-scan (*SADABS*; Bruker, 2016)
T_{min}, T_{max}	0.69, 0.99
No. of measured, independent and observed [$I > 2\sigma(I)$] reflections	10886, 2955, 2064
R_{int}	0.073
(sin $\theta/\lambda)_{max}$ (Å^{-1})	0.670
Refinement	
$R[F^2 > 2\sigma(F^2)]$, $wR(F^2)$, *S*	0.084, 0.211, 1.10
No. of reflections	2955
No. of parameters	228
H-atom treatment	All H-atom parameters refined
$\Delta\rho_{max}$, $\Delta\rho_{min}$ (e Å^{-3})	0.51, −0.37

Computer programs: *APEX3* and *SAINT* (Bruker, 2016), *SHELXT* (Sheldrick, 2015*a*), *SHELXL2014* (Sheldrick, 2015*b*), *DIAMOND* (Brandenburg & Putz, 2012) and *SHELXTL* (Sheldrick, 2008).

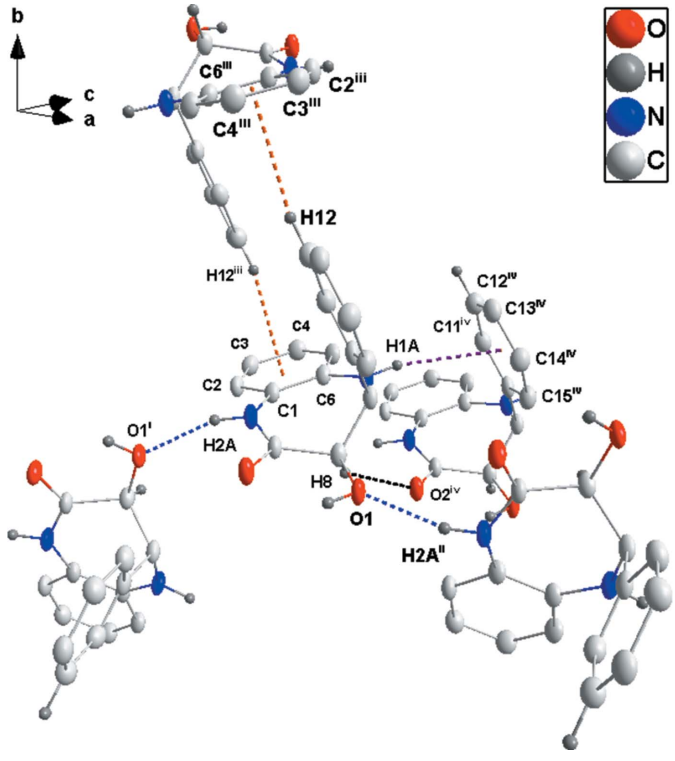


Figure 3
Details of the intermolecular N—H···O (blue dotted lines) and C—H···O (black dotted line) hydrogen bonds, as well as the N—H···π(ring) (purple dotted line) and C—H···π(ring) (orange dotted lines) interactions. [Symmetry codes: (i) $-\frac{1}{2}+x, \frac{1}{2}-y, -\frac{1}{2}+z$; (ii) $\frac{1}{2}+x, \frac{1}{2}-y, \frac{1}{2}+z$; (iii) $1-x, 1-y, 1-z$); (iv) $1+x, y, z$.]

overnight. The *trans* diastereoisomer which precipitated was filtered. The filtrate was concentrated under reduced pressure and the oil obtained was chromatographed on a silica gel column with a mixture of ether/chloroform (50/50) as eluent, and gave the *trans* and *cis* isomers, with a predominance of the *trans* isomers. The *cis* isomer was recrystallized from ethanol solution to afford the title compound as colourless crystals.

Refinement

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

Acknowledgements

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full crystallographic data

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Crystal data

$C_{15}H_{14}N_2O_2$
M_r = 254.28
Monoclinic, $P2_1/n$
a = 5.519 (2) Å
b = 21.594 (8) Å
c = 9.917 (4) Å
β = 90.405 (5)°
V = 1181.9 (7) Å^3
Z = 4
$F(000)$ = 536
D_x = 1.429 Mg m^{-3}
Mo $K\alpha$ radiation, λ = 0.71073 Å
Cell parameters from 2522 reflections
θ = 2.3–27.3°
μ = 0.10 mm^{-1}
T = 100 K
Plate, colourless
0.41 × 0.17 × 0.09 mm

Data collection

Bruker SMART APEX CCD diffractometer
Radiation source: fine-focus sealed tube
Graphite monochromator
Detector resolution: 8.3333 pixels mm^{-1}
φ and ω scans
Absorption correction: multi-scan (*SADABS*; Bruker, 2016)
T_{min} = 0.69, T_{max} = 0.99
10886 measured reflections
2955 independent reflections
2064 reflections with $I > 2\sigma(I)$
R_{int} = 0.073
θ_{max} = 28.5°, θ_{min} = 1.9°
h = −7→7
k = −28→28
l = −13→13

Refinement

Refinement on F^2
Least-squares matrix: full
$R[F^2 > 2\sigma(F^2)]$ = 0.084
$wR(F^2)$ = 0.211
S = 1.10
2955 reflections
228 parameters
0 restraints
Primary atom site location: structure-invariant direct methods
Secondary atom site location: difference Fourier map
Hydrogen site location: difference Fourier map
All H-atom parameters refined
$w = 1/[\sigma^2(F_o^2) + (0.0375P)^2 + 2.6752P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max}$ = 0.002
$\Delta\rho_{max}$ = 0.51 e Å^{-3}
$\Delta\rho_{min}$ = −0.37 e Å^{-3}

Special details

Experimental. The diffraction data were collected in three sets of 363 frames (0.5° width in ω) at φ = 0, 120 and 240°. A scan time of 40 sec/frame was used.

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.

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 $F^2 > 2\text{sigma}(F^2)$ 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}
O1	0.7374 (4)	0.22601 (11)	0.6710 (2)	0.0243 (5)
H1	0.597 (8)	0.2125 (19)	0.656 (4)	0.037 (11)*
O2	0.3865 (4)	0.24635 (11)	0.5074 (2)	0.0259 (5)
N1	1.0082 (5)	0.36774 (14)	0.5379 (3)	0.0231 (6)
H1A	1.152 (8)	0.385 (2)	0.567 (4)	0.043 (12)*
N2	0.5741 (5)	0.31730 (13)	0.3793 (3)	0.0224 (6)
H2A	0.447 (6)	0.3124 (15)	0.326 (3)	0.016 (8)*
C1	0.7618 (5)	0.35486 (15)	0.3285 (3)	0.0207 (6)
C2	0.7369 (6)	0.37111 (16)	0.1921 (3)	0.0231 (7)
H2	0.605 (7)	0.3557 (16)	0.148 (4)	0.023 (9)*
C3	0.8982 (6)	0.40866 (16)	0.1277 (3)	0.0257 (7)
H3	0.872 (7)	0.4181 (18)	0.037 (4)	0.035 (10)*
C4	1.0966 (6)	0.43153 (17)	0.1999 (3)	0.0263 (7)
H4	1.206 (7)	0.4591 (17)	0.161 (4)	0.027 (9)*
C5	1.1238 (5)	0.41670 (16)	0.3341 (3)	0.0238 (7)
H5	1.271 (7)	0.4331 (16)	0.387 (4)	0.025 (9)*
C6	0.9597 (5)	0.37839 (15)	0.4029 (3)	0.0205 (6)
C7	0.8692 (5)	0.33250 (15)	0.6340 (3)	0.0208 (7)
H7	0.985 (6)	0.3219 (15)	0.709 (3)	0.015 (8)*
C8	0.7900 (5)	0.27039 (15)	0.5704 (3)	0.0213 (7)
H8	0.923 (7)	0.2558 (16)	0.512 (4)	0.025 (9)*
C9	0.5674 (5)	0.27720 (15)	0.4819 (3)	0.0193 (6)
C10	0.6631 (5)	0.36864 (15)	0.6969 (3)	0.0209 (7)
C11	0.5912 (6)	0.42582 (16)	0.6492 (3)	0.0241 (7)
H11	0.668 (6)	0.4453 (15)	0.572 (3)	0.019 (8)*
C12	0.4053 (6)	0.45873 (17)	0.7111 (3)	0.0257 (7)
H12	0.354 (6)	0.4998 (16)	0.676 (4)	0.021 (9)*
C13	0.2881 (6)	0.43370 (17)	0.8217 (3)	0.0257 (7)
H13	0.159 (7)	0.4587 (17)	0.864 (4)	0.031 (10)*
C14	0.3598 (6)	0.37627 (17)	0.8703 (3)	0.0270 (7)
H14	0.286 (8)	0.3569 (19)	0.943 (4)	0.041 (11)*
C15	0.5472 (6)	0.34412 (17)	0.8103 (3)	0.0253 (7)
H15	0.589 (7)	0.3010 (19)	0.842 (4)	0.032 (10)*

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
O1	0.0168 (11)	0.0391 (14)	0.0168 (11)	−0.0029 (10)	−0.0052 (9)	0.0048 (9)
O2	0.0156 (10)	0.0420 (14)	0.0200 (11)	−0.0051 (9)	−0.0028 (8)	0.0034 (10)
N1	0.0114 (11)	0.0413 (17)	0.0167 (13)	−0.0052 (11)	0.0007 (9)	−0.0008 (11)
N2	0.0141 (12)	0.0399 (17)	0.0133 (12)	−0.0030 (11)	−0.0017 (9)	0.0015 (11)
C1	0.0126 (13)	0.0320 (17)	0.0176 (14)	0.0016 (12)	0.0017 (11)	−0.0017 (12)
C2	0.0187 (15)	0.0354 (18)	0.0152 (14)	0.0005 (13)	−0.0026 (11)	−0.0017 (12)
C3	0.0230 (16)	0.0355 (19)	0.0185 (16)	0.0031 (13)	0.0024 (12)	0.0001 (13)
C4	0.0196 (15)	0.0359 (19)	0.0235 (17)	−0.0016 (14)	0.0066 (12)	0.0009 (14)
C5	0.0126 (13)	0.0367 (19)	0.0221 (16)	0.0002 (12)	0.0021 (11)	−0.0022 (13)
C6	0.0133 (13)	0.0322 (17)	0.0159 (14)	0.0024 (12)	0.0022 (10)	−0.0023 (12)
C7	0.0126 (13)	0.0355 (18)	0.0143 (14)	−0.0015 (12)	−0.0006 (11)	0.0006 (12)
C8	0.0147 (14)	0.0342 (18)	0.0150 (14)	−0.0014 (12)	0.0011 (11)	0.0018 (12)
C9	0.0120 (13)	0.0321 (17)	0.0136 (14)	0.0000 (11)	−0.0010 (10)	−0.0010 (11)
C10	0.0149 (14)	0.0347 (18)	0.0130 (13)	−0.0015 (12)	−0.0014 (10)	−0.0025 (12)
C11	0.0227 (15)	0.0329 (18)	0.0169 (15)	−0.0036 (13)	0.0018 (12)	−0.0001 (13)
C12	0.0229 (16)	0.0340 (19)	0.0203 (16)	−0.0002 (13)	0.0022 (12)	−0.0002 (13)
C13	0.0176 (15)	0.039 (2)	0.0207 (16)	0.0010 (13)	0.0008 (12)	−0.0034 (14)
C14	0.0243 (16)	0.038 (2)	0.0191 (16)	0.0009 (14)	0.0032 (12)	0.0017 (14)
C15	0.0205 (15)	0.038 (2)	0.0177 (15)	0.0005 (14)	−0.0002 (12)	0.0022 (13)

Geometric parameters (Å, º)

O1—C8	1.415 (4)	C5—H5	1.03 (4)
O1—H1	0.84 (4)	C7—C10	1.517 (4)
O2—C9	1.228 (4)	C7—C8	1.544 (5)
N1—C6	1.383 (4)	C7—H7	1.00 (3)
N1—C7	1.444 (4)	C8—C9	1.512 (4)
N1—H1A	0.93 (5)	C8—H8	0.99 (4)
N2—C9	1.337 (4)	C10—C11	1.380 (5)
N2—C1	1.412 (4)	C10—C15	1.402 (4)
N2—H2A	0.88 (4)	C11—C12	1.394 (5)
C1—C2	1.403 (4)	C11—H11	0.98 (3)
C1—C6	1.409 (4)	C12—C13	1.387 (5)
C2—C3	1.366 (5)	C12—H12	0.99 (4)
C2—H2	0.91 (4)	C13—C14	1.387 (5)
C3—C4	1.394 (5)	C13—H13	0.99 (4)
C3—H3	0.94 (4)	C14—C15	1.384 (5)
C4—C5	1.376 (5)	C14—H14	0.93 (4)
C4—H4	0.93 (4)	C15—H15	1.01 (4)
C5—C6	1.407 (4)		
C8—O1—H1	108 (3)	C10—C7—H7	106.8 (19)
C6—N1—C7	128.8 (3)	C8—C7—H7	106.3 (18)
C6—N1—H1A	113 (3)	O1—C8—C9	107.8 (2)
C7—N1—H1A	118 (3)	O1—C8—C7	111.1 (2)

C9—N2—C1	131.9 (3)	C9—C8—C7	112.3 (3)
C9—N2—H2A	111 (2)	O1—C8—H8	111 (2)
C1—N2—H2A	116 (2)	C9—C8—H8	107 (2)
C2—C1—C6	119.0 (3)	C7—C8—H8	108 (2)
C2—C1—N2	114.9 (3)	O2—C9—N2	122.3 (3)
C6—C1—N2	126.1 (3)	O2—C9—C8	119.1 (3)
C3—C2—C1	122.6 (3)	N2—C9—C8	118.6 (3)
C3—C2—H2	121 (2)	C11—C10—C15	118.8 (3)
C1—C2—H2	117 (2)	C11—C10—C7	122.3 (3)
C2—C3—C4	118.8 (3)	C15—C10—C7	118.9 (3)
C2—C3—H3	119 (2)	C10—C11—C12	121.1 (3)
C4—C3—H3	122 (3)	C10—C11—H11	122 (2)
C5—C4—C3	119.6 (3)	C12—C11—H11	117 (2)
C5—C4—H4	119 (2)	C13—C12—C11	119.9 (3)
C3—C4—H4	122 (2)	C13—C12—H12	119 (2)
C4—C5—C6	122.7 (3)	C11—C12—H12	121 (2)
C4—C5—H5	120 (2)	C12—C13—C14	119.3 (3)
C6—C5—H5	118 (2)	C12—C13—H13	118 (2)
N1—C6—C5	116.5 (3)	C14—C13—H13	123 (2)
N1—C6—C1	126.3 (3)	C15—C14—C13	120.7 (3)
C5—C6—C1	117.2 (3)	C15—C14—H14	116 (3)
N1—C7—C10	113.8 (3)	C13—C14—H14	123 (3)
N1—C7—C8	109.8 (2)	C14—C15—C10	120.2 (3)
C10—C7—C8	113.8 (2)	C14—C15—H15	120 (2)
N1—C7—H7	105.7 (19)	C10—C15—H15	120 (2)

C9—N2—C1—C2	155.0 (3)	C10—C7—C8—C9	47.4 (3)
C9—N2—C1—C6	−27.6 (5)	C1—N2—C9—O2	−176.8 (3)
C6—C1—C2—C3	0.5 (5)	C1—N2—C9—C8	4.0 (5)
N2—C1—C2—C3	178.1 (3)	O1—C8—C9—O2	0.4 (4)
C1—C2—C3—C4	0.4 (5)	C7—C8—C9—O2	−122.2 (3)
C2—C3—C4—C5	−0.9 (5)	O1—C8—C9—N2	179.6 (3)
C3—C4—C5—C6	0.7 (5)	C7—C8—C9—N2	57.0 (4)
C7—N1—C6—C5	177.8 (3)	N1—C7—C10—C11	10.6 (4)
C7—N1—C6—C1	−1.9 (5)	C8—C7—C10—C11	−116.2 (3)
C4—C5—C6—N1	−179.5 (3)	N1—C7—C10—C15	−167.2 (3)
C4—C5—C6—C1	0.2 (5)	C8—C7—C10—C15	66.0 (4)
C2—C1—C6—N1	178.9 (3)	C15—C10—C11—C12	−0.6 (5)
N2—C1—C6—N1	1.6 (5)	C7—C10—C11—C12	−178.3 (3)
C2—C1—C6—C5	−0.7 (4)	C10—C11—C12—C13	−0.7 (5)
N2—C1—C6—C5	−178.1 (3)	C11—C12—C13—C14	0.7 (5)
C6—N1—C7—C10	−83.5 (4)	C12—C13—C14—C15	0.4 (5)
C6—N1—C7—C8	45.3 (4)	C13—C14—C15—C10	−1.7 (5)
N1—C7—C8—O1	157.8 (2)	C11—C10—C15—C14	1.7 (5)
C10—C7—C8—O1	−73.4 (3)	C7—C10—C15—C14	179.5 (3)
N1—C7—C8—C9	−81.4 (3)		

Hydrogen-bond geometry (Å, º)

Cg1 and Cg2 are the centroids of the C1–C6 and C10–C15 rings, respectively.

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
O1—H1···O2	0.84 (4)	2.01 (4)	2.556 (3)	122 (4)
N2—H2*A*···O1^{i}	0.88 (4)	2.09 (4)	2.922 (3)	157 (3)
C8—H8···O2^{ii}	0.99 (4)	2.57 (4)	3.395 (4)	141 (3)
C12—H12···*Cg*1^{iii}	0.99 (4)	2.85 (3)	3.696 (4)	144 (3)
N1—H1*A*···*Cg*2^{ii}	0.99 (5)	2.63 (3)	3.457 (3)	149 (3)

Symmetry codes: (i) $x-1/2, -y+1/2, z-1/2$; (ii) $x+1, y, z$; (iii) $-x+1, -y+1, -z+1$.