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Ethyl 7-amino-1-cyclopropyl-6-fluoro-8-methoxy-4-oxo-1,4-dihydroquinoline-3-carboxylate monohydrate

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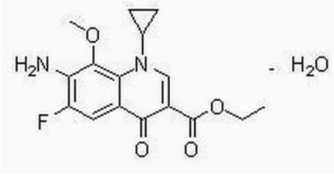
Key indicators: single-crystal X-ray study; T = 291 K; mean σ(C–C) = 0.003 Å; R factor = 0.044; wR factor = 0.126; data-to-parameter ratio = 12.8.

In the title compound, $C_{16}H_{17}FN_2O_4\cdot H_2O$, the dihedral angle between the heterocyclic ring and the benzene ring is 5.77 (9)°, that between the heterocycle and the ethoxycarbonyl plane is 15.5 (1)°, and that between the heterocyclic ring and the cyclopropane ring is 67.75 (13)°. In the crystal structure, molecules are linked into a ribbon-like structure along the c axis by N—H···O and O—H···O hydrogen bonds.

Related literature

For general background, see: Fujita & Chiba (1998).



Experimental

Crystal data

$C_{16}H_{17}FN_2O_4\cdot H_2O$
M_r = 338.33
Monoclinic, $P2_1/n$
a = 10.096 (4) Å
b = 14.699 (5) Å
c = 11.028 (6) Å
β = 94.26 (4)°
V = 1632.0 (12) Å^3
Z = 4
Mo $K\alpha$ radiation
μ = 0.11 mm^{-1}
T = 291 (2) K
0.45 × 0.42 × 0.39 mm

Data collection

Enraf–Nonius CAD-4 diffractometer
Absorption correction: none
3157 measured reflections
3009 independent reflections
1741 reflections with $I > 2\sigma(I)$
R_{int} = 0.007
3 standard reflections every 300 reflections
intensity decay: 0.8%

Refinement

$R[F^2 > 2\sigma(F^2)]$ = 0.043
$wR(F^2)$ = 0.125
S = 1.04
3009 reflections
235 parameters
H atoms treated by a mixture of independent and constrained refinement
$\Delta\rho_{max}$ = 0.20 e Å^{-3}
$\Delta\rho_{min}$ = −0.19 e Å^{-3}

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

D—H···A	D—H	H···A	D···A	D—H···A
N1—H1*N*1···O1W^{i}	0.91 (3)	2.15 (3)	2.930 (3)	143 (2)
N1—H2*N*1···O4^{ii}	0.85 (3)	2.33 (3)	3.061 (3)	144 (2)
O1*W*—H1*W*···O2^{iii}	0.84 (3)	2.13 (3)	2.916 (3)	155 (3)
O1*W*—H2*W*···O2	0.91 (3)	1.96 (3)	2.864 (3)	171 (3)

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

Data collection: *DIFRAC* (Gabe & White, 1993); cell refinement: *DIFRAC*; data reduction: *NRCVAX* (Gabe *et al.*, 1989); 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); software used to prepare material for publication: *SHELXL97*.

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: CI2556).

References

Farrugia, L. J. (1997). *J. Appl. Cryst.* **30**, 565.
Fujita, M. & Chiba, K. (1998). *Chem. Pharm. Bull.* **46**, 631–638.
Gabe, E. J., Le Page, Y., Charland, J.-P., Lee, F. L. & White, P. S. (1989). *J. Appl. Cryst.* **22**, 384–387.
Gabe, E. J. & White, P. S. (1993). *DIFRAC*. American Crystallographic Association Pittsburgh Meeting Abstract PA 104.
Sheldrick, G. M. (2008). *Acta Cryst.* A**64**, 112–122.

supporting information

Acta Cryst. (2008). E**64**, o527 [doi:10.1107/S1600536808002547]

Ethyl 7-amino-1-cyclopropyl-6-fluoro-8-methoxy-4-oxo-1,4-dihydroquinoline-3-carboxylate monohydrate

Jia Pan, Li Yang, Zhi-Hua Mao and Ling-Ling Weng

S1. Comment

Quinolone antibacterials were found several decades ago, and some excellent antibacterials have been developed and used widely now (Fujita & Chiba, 1998). An interest in search of more potent antibacterial agents led us to design and synthesis a new type of quinoline derivatives. The title compound is one of the key intermediates and we report here its crystal structure.

The pyridinone ring is planar to within ±0.057 (2) Å (Fig. 1). The dihedral angle between the pyridine and benzene rings is 5.77 (9)°, and that between the pyridine and carboxylate plane is 15.5 (1)°. In the crystal structure, the molecules are linked into a ribbon like structure along the *c* axis (Fig. 2) by N—H···O and O—H···O hydrogen bonds (Table 1).

S2. Experimental

Ethyl 7-azido-1-cyclopropyl-6-fluoro-8-methoxyl-4-oxo-1,4-dihydroquinoline-3- carboxylate (2 g, 5.8 mmol), 5% Pd/C (0.4 g) were suspended in methanol (20 ml) and the mixture was hydrogenated at 303 K for 6 h. The reaction mixture was then filtered and concentrated under vacuum. The residue obtained was purified by silica gel chromatography. Single crystals suitable for X-ray analysis were obtained by slow evaporation of a acetyl acetate-chloroform (1.2:1 *v*/*v*) solution at room temperature.

S3. Refinement

The water H atoms were located in a difference Fourier map and refined isotropically. The remaining H atoms were placed in the calculated positions [C—H = 0.93 (aromatic) and 0.96 Å (methyl)] and refined in the riding-model approximation, with U_{iso}(H) = 1.2U_{eq}(aromatic-C) and 1.5U_{eq}(methyl-C).

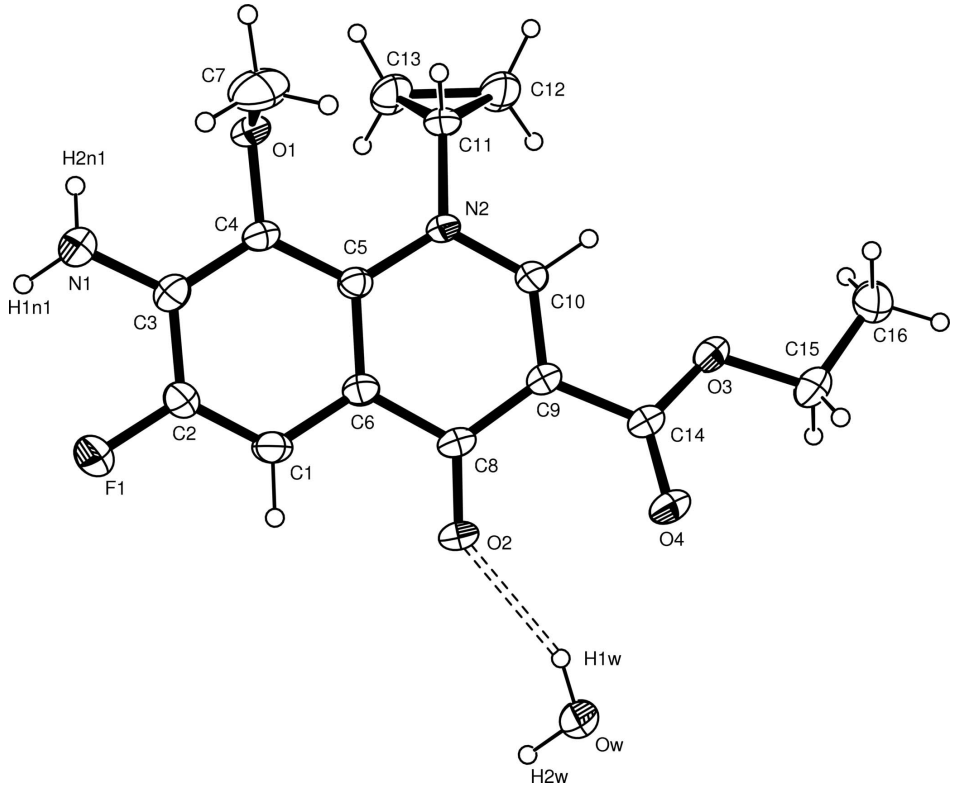


Figure 1

The molecular structure of the title compound, showing the atomic numbering scheme. Displacement ellipsoids drawn at the 30% probability level. The dashed line indicates a hydrogen bond.

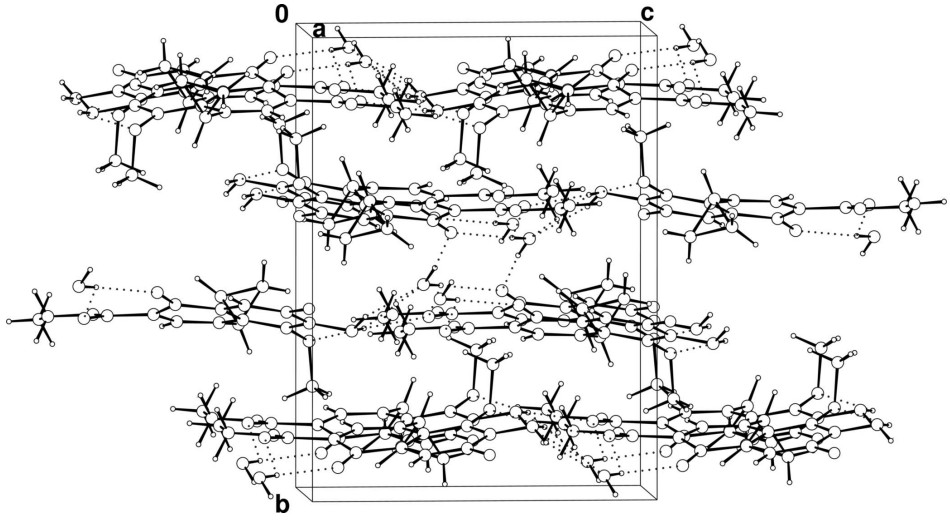


Figure 2

Crystal packing of the title compound, viwed down the *a* axis. Hydrogen bonds are shown as dashed lines.

Ethyl 7-amino-1-cyclopropyl-6-fluoro-8-methoxy-4-oxo-1,4-dihydroquinoline- 3-carboxylate monohydrate

Crystal data

$C_{16}H_{17}FN_2O_4 \cdot H_2O$
$M_r = 338.33$
Monoclinic, $P2_1/n$
Hall symbol: -P 2yn
$a = 10.096$ (4) Å
$b = 14.699$ (5) Å
$c = 11.028$ (6) Å
$\beta = 94.26$ (4)°
$V = 1632.0$ (12) Å^3
$Z = 4$
$F(000) = 712$
$D_x = 1.377$ Mg m^{-3}
Mo $K\alpha$ radiation, $\lambda = 0.71073$ Å
Cell parameters from 24 reflections
$\theta = 4.5$–$7.4°$
$\mu = 0.11$ mm^{-1}
$T = 291$ K
Block, yellow
0.45 × 0.42 × 0.39 mm

Data collection

Enraf–Nonius CAD-4 diffractometer
Radiation source: fine-focus sealed tube
Graphite monochromator
$\omega/2\theta$ scans
3157 measured reflections
3009 independent reflections
1741 reflections with $I > 2\sigma(I)$
$R_{int} = 0.007$
$\theta_{max} = 25.4°$, $\theta_{min} = 2.3°$
$h = -12 \rightarrow 12$
$k = 0 \rightarrow 17$
$l = -4 \rightarrow 13$
3 standard reflections every 300 reflections
intensity decay: 0.8%

Refinement

Refinement on F^2
Least-squares matrix: full
$R[F^2 > 2\sigma(F^2)] = 0.043$
$wR(F^2) = 0.125$
$S = 1.04$
3009 reflections
235 parameters
0 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
$w = 1/[\sigma^2(F_o^2) + (0.0627P)^2 + 0.1314P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} = 0.001$
$\Delta\rho_{max} = 0.20$ e Å^{-3}
$\Delta\rho_{min} = -0.19$ e Å^{-3}

Special details

Geometry. All e.s.d.'s (except the e.s.d. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell e.s.d.'s are taken into account individually in the estimation of e.s.d.'s in distances, angles and torsion angles; correlations between e.s.d.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell e.s.d.'s is used for estimating e.s.d.'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 (Å^2)

	x	y	z	U_{iso}*/U_{eq}
F1	0.51891 (13)	0.59935 (11)	1.01305 (12)	0.0667 (4)
O1	0.07128 (14)	0.68291 (10)	1.03507 (12)	0.0451 (4)
O2	0.33328 (14)	0.56826 (12)	0.58213 (13)	0.0519 (4)
O3	−0.04405 (16)	0.62649 (11)	0.41364 (13)	0.0552 (5)

O4	0.16963 (18)	0.62837 (18)	0.37733 (15)	0.1007 (9)
N1	0.3174 (3)	0.65375 (16)	1.14712 (18)	0.0514 (5)
H1N1	0.385 (3)	0.6210 (17)	1.184 (2)	0.068 (9)*
H2N1	0.248 (3)	0.6504 (18)	1.186 (2)	0.071 (9)*
N2	0.01966 (16)	0.64366 (12)	0.77689 (13)	0.0374 (4)
C1	0.3794 (2)	0.59542 (15)	0.83243 (19)	0.0436 (5)
H1	0.4507	0.5774	0.7894	0.052*
C2	0.3970 (2)	0.61005 (15)	0.95442 (19)	0.0433 (5)
C3	0.2938 (2)	0.63708 (14)	1.02489 (17)	0.0397 (5)
C4	0.1693 (2)	0.65127 (13)	0.96495 (17)	0.0352 (5)
C5	0.1457 (2)	0.63418 (13)	0.83915 (17)	0.0333 (5)
C6	0.2533 (2)	0.60753 (13)	0.77155 (17)	0.0358 (5)
C7	0.0710 (3)	0.78037 (18)	1.0445 (3)	0.0786 (9)
H7A	0.1564	0.8008	1.0778	0.118*
H7B	0.0041	0.7990	1.0968	0.118*
H7C	0.0523	0.8064	0.9653	0.118*
C8	0.2389 (2)	0.59719 (14)	0.63888 (17)	0.0378 (5)
C9	0.1107 (2)	0.62227 (14)	0.58234 (17)	0.0401 (5)
C10	0.0092 (2)	0.64129 (14)	0.65419 (17)	0.0397 (5)
H10	−0.0738	0.6536	0.6152	0.048*
C11	−0.1031 (2)	0.65083 (17)	0.83913 (18)	0.0449 (6)
H11	−0.1233	0.7109	0.8716	0.054*
C12	−0.2192 (2)	0.5947 (2)	0.7935 (2)	0.0723 (9)
H12A	−0.2086	0.5554	0.7242	0.087*
H12B	−0.3070	0.6208	0.7971	0.087*
C13	−0.1436 (2)	0.5712 (2)	0.9108 (2)	0.0627 (7)
H13A	−0.1857	0.5830	0.9854	0.075*
H13B	−0.0873	0.5177	0.9126	0.075*
C14	0.0853 (2)	0.62535 (17)	0.44863 (19)	0.0508 (6)
C15	−0.0802 (3)	0.6314 (2)	0.28436 (19)	0.0693 (8)
H15A	−0.0528	0.5763	0.2449	0.083*
H15B	−0.0360	0.6826	0.2493	0.083*
C16	−0.2257 (2)	0.64228 (17)	0.2653 (2)	0.0589 (7)
H16A	−0.2687	0.5904	0.2979	0.088*
H16B	−0.2506	0.6471	0.1798	0.088*
H16C	−0.2523	0.6964	0.3058	0.088*
O1W	0.5509 (2)	0.44950 (16)	0.65115 (16)	0.0715 (6)
H1W	0.606 (3)	0.446 (2)	0.598 (3)	0.091 (11)*
H2W	0.486 (3)	0.488 (2)	0.621 (3)	0.097 (11)*

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
F1	0.0396 (8)	0.1032 (12)	0.0559 (8)	0.0081 (7)	−0.0058 (6)	−0.0147 (8)
O1	0.0457 (9)	0.0567 (10)	0.0346 (7)	0.0092 (8)	0.0143 (6)	−0.0021 (7)
O2	0.0422 (9)	0.0766 (11)	0.0388 (8)	0.0138 (8)	0.0163 (7)	−0.0026 (7)
O3	0.0469 (10)	0.0891 (13)	0.0303 (8)	0.0030 (9)	0.0083 (7)	0.0013 (7)
O4	0.0523 (12)	0.215 (3)	0.0373 (10)	0.0254 (13)	0.0193 (9)	0.0150 (12)

N1	0.0482 (13)	0.0683 (15)	0.0378 (11)	0.0021 (11)	0.0036 (10)	−0.0036 (10)
N2	0.0332 (10)	0.0504 (11)	0.0298 (9)	0.0072 (8)	0.0109 (7)	0.0037 (7)
C1	0.0340 (12)	0.0527 (14)	0.0451 (13)	0.0016 (10)	0.0109 (10)	−0.0051 (10)
C2	0.0337 (12)	0.0528 (14)	0.0428 (12)	0.0019 (10)	−0.0008 (10)	−0.0034 (10)
C3	0.0449 (13)	0.0402 (12)	0.0344 (11)	−0.0043 (10)	0.0063 (9)	0.0002 (9)
C4	0.0364 (12)	0.0368 (11)	0.0340 (10)	0.0013 (9)	0.0121 (9)	0.0001 (9)
C5	0.0331 (11)	0.0336 (11)	0.0341 (10)	0.0011 (9)	0.0075 (8)	0.0031 (8)
C6	0.0337 (12)	0.0373 (12)	0.0373 (11)	−0.0026 (9)	0.0085 (9)	−0.0001 (8)
C7	0.097 (2)	0.0622 (18)	0.0805 (19)	0.0211 (17)	0.0311 (17)	−0.0148 (15)
C8	0.0384 (12)	0.0414 (12)	0.0355 (11)	−0.0007 (10)	0.0145 (9)	−0.0008 (9)
C9	0.0378 (12)	0.0518 (14)	0.0315 (11)	0.0038 (10)	0.0093 (9)	0.0018 (9)
C10	0.0350 (12)	0.0519 (14)	0.0327 (10)	0.0079 (10)	0.0069 (9)	0.0078 (9)
C11	0.0320 (12)	0.0659 (15)	0.0385 (11)	0.0082 (11)	0.0129 (9)	0.0041 (10)
C12	0.0403 (15)	0.130 (3)	0.0480 (14)	−0.0086 (15)	0.0124 (12)	0.0057 (15)
C13	0.0492 (15)	0.094 (2)	0.0469 (13)	−0.0127 (14)	0.0168 (11)	0.0119 (13)
C14	0.0444 (14)	0.0763 (17)	0.0331 (11)	0.0094 (12)	0.0123 (10)	0.0023 (11)
C15	0.0627 (18)	0.114 (2)	0.0311 (12)	0.0122 (16)	0.0048 (12)	−0.0030 (13)
C16	0.0602 (17)	0.0649 (17)	0.0508 (14)	0.0107 (13)	−0.0012 (12)	−0.0041 (12)
O1W	0.0600 (13)	0.1157 (18)	0.0396 (9)	0.0301 (12)	0.0077 (9)	−0.0035 (10)

Geometric parameters (Å, º)

F1—C2	1.356 (2)	C7—H7B	0.96
O1—C4	1.381 (2)	C7—H7C	0.96
O1—C7	1.436 (3)	C8—C9	1.442 (3)
O2—C8	1.252 (2)	C9—C10	1.371 (3)
O3—C14	1.334 (3)	C9—C14	1.479 (3)
O3—C15	1.447 (3)	C10—H10	0.93
O4—C14	1.202 (3)	C11—C13	1.486 (3)
N1—C3	1.373 (3)	C11—C12	1.490 (3)
N1—H1N1	0.91 (3)	C11—H11	0.98
N1—H2N1	0.85 (3)	C12—C13	1.492 (4)
N2—C10	1.350 (2)	C12—H12A	0.97
N2—C5	1.408 (3)	C12—H12B	0.97
N2—C11	1.465 (3)	C13—H13A	0.97
C1—C2	1.361 (3)	C13—H13B	0.97
C1—C6	1.405 (3)	C15—C16	1.477 (3)
C1—H1	0.9300	C15—H15A	0.97
C2—C3	1.403 (3)	C15—H15B	0.97
C3—C4	1.391 (3)	C16—H16A	0.96
C4—C5	1.413 (3)	C16—H16B	0.96
C5—C6	1.418 (3)	C16—H16C	0.96
C6—C8	1.467 (3)	O1W—H1W	0.84 (3)
C7—H7A	0.96	O1W—H2W	0.91 (3)
C4—O1—C7	112.45 (17)	N2—C10—C9	125.34 (19)
C14—O3—C15	117.11 (18)	N2—C10—H10	117.3
C3—N1—H1N1	114.2 (16)	C9—C10—H10	117.3

C3—N1—H2N1	113.3 (18)	N2—C11—C13	117.9 (2)
H1N1—N1—H2N1	112 (2)	N2—C11—C12	118.3 (2)
C10—N2—C5	119.16 (17)	C13—C11—C12	60.20 (17)
C10—N2—C11	117.75 (17)	N2—C11—H11	116.3
C5—N2—C11	123.00 (15)	C13—C11—H11	116.3
C2—C1—C6	119.99 (19)	C12—C11—H11	116.3
C2—C1—H1	120.0	C11—C12—C13	59.79 (16)
C6—C1—H1	120.0	C11—C12—H12A	117.8
F1—C2—C1	120.05 (19)	C13—C12—H12A	117.8
F1—C2—C3	117.01 (18)	C11—C12—H12B	117.8
C1—C2—C3	122.9 (2)	C13—C12—H12B	117.8
N1—C3—C4	121.6 (2)	H12A—C12—H12B	114.9
N1—C3—C2	120.8 (2)	C11—C13—C12	60.01 (16)
C4—C3—C2	117.47 (18)	C11—C13—H13A	117.8
O1—C4—C3	116.36 (17)	C12—C13—H13A	117.8
O1—C4—C5	122.29 (18)	C11—C13—H13B	117.8
C3—C4—C5	121.36 (18)	C12—C13—H13B	117.8
N2—C5—C4	122.81 (18)	H13A—C13—H13B	114.9
N2—C5—C6	118.12 (17)	O4—C14—O3	122.4 (2)
C4—C5—C6	119.06 (18)	O4—C14—C9	125.0 (2)
C1—C6—C5	119.07 (18)	O3—C14—C9	112.52 (18)
C1—C6—C8	118.85 (18)	O3—C15—C16	108.7 (2)
C5—C6—C8	121.99 (18)	O3—C15—H15A	109.9
O1—C7—H7A	109.5	C16—C15—H15A	109.9
O1—C7—H7B	109.5	O3—C15—H15B	109.9
H7A—C7—H7B	109.5	C16—C15—H15B	109.9
O1—C7—H7C	109.5	H15A—C15—H15B	108.3
H7A—C7—H7C	109.5	C15—C16—H16A	109.5
H7B—C7—H7C	109.5	C15—C16—H16B	109.5
O2—C8—C9	124.20 (18)	H16A—C16—H16B	109.5
O2—C8—C6	120.70 (19)	C15—C16—H16C	109.5
C9—C8—C6	115.09 (17)	H16A—C16—H16C	109.5
C10—C9—C8	119.22 (18)	H16B—C16—H16C	109.5
C10—C9—C14	119.2 (2)	H1W—O1W—H2W	107 (3)
C8—C9—C14	121.54 (18)		

Hydrogen-bond geometry (Å, º)

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
N1—H1*N*1···O1*W*^{i}	0.91 (3)	2.15 (3)	2.930 (3)	143 (2)
N1—H2*N*1···O4^{ii}	0.85 (3)	2.33 (3)	3.061 (3)	144 (2)
O1*W*—H1*W*···O2^{iii}	0.84 (3)	2.13 (3)	2.916 (3)	155 (3)
O1*W*—H2*W*···O2	0.91 (3)	1.96 (3)	2.864 (3)	171 (3)

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