Crystal structure of methyl 4-(4-hydroxyphenyl)-6-methyl-2-oxo-1,2,3,4-tetrahydropyrimidine-5-carboxylate monohydrate

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The title hydrate, $C_{13}H_{14}N_2O_4 \cdot H_2O$, crystallizes with two formula units in the asymmetric unit ($Z' = 2$). The dihedral angles between the planes of the tetrahydropyrimidine ring and the 4-hydroxyphenyl ring and ester group are 86.78 (4) and 6.81 (6)°, respectively, for one molecule and 89.35 (4) and 3.02 (4)° for the other. In the crystal, the organic molecules form a dimer, linked by a pair of N—H···O hydrogen bonds. The hydroxy groups of the organic molecules donate O—H···O hydrogen bonds to water molecules. Further, the hydroxy group accepts N—H···O hydrogen bonds from amides whereas the water molecules donate O—H···O hydrogen bonds to the both the amide and ester carbonyl groups. Other weak interactions, including C—H···O, C—H···π and π–π, further consolidate the packing, generating a three-dimensional network.

1. Chemical context

Dihydropyrimidine (DHPM) derivatives are used in the treatment of disease as antiviral, antitumor, antibacterial and antimalarial agents, as first reported by the Italian chemist Pietro Biginelli in 1893 [Kappe (2000), Nayak et al. (2010) and references therein]. We have been working on the synthesis of various DHPM derivatives for better biological activities (Narayanaswamy et al., 2013; Nayak et al., 2011) and a wide range of applications (Nayak et al., 2009, 2010). Here, we report the synthesis and single-crystal structure of the title compound, (I).
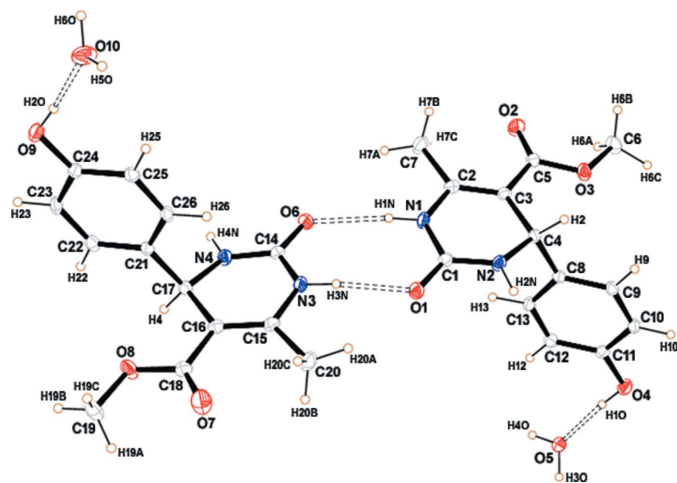
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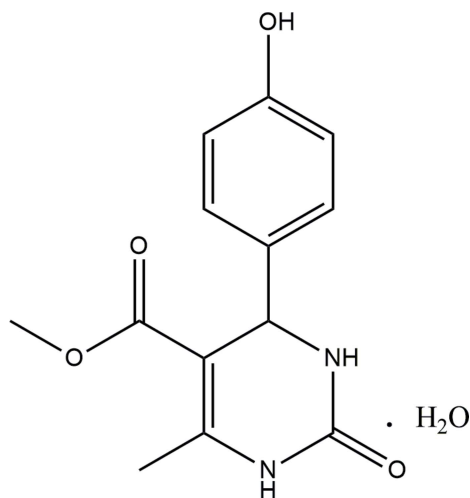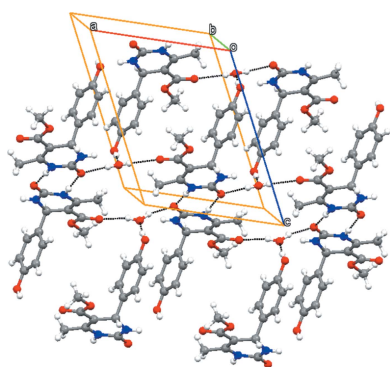
Figure 1
The asymmetric unit of the title compound with 50% probability ellipsoids. The double-dashed lines indicate hydrogen bonds.

2. Structural commentary

Compound (I) crystallizes as a monohydrate with two formula units in the asymmetric unit ($Z' = 2$), which may be supported by the formation of hydrogen bonds between the hydroxy-phenyl group and the water molecule and dimer formation through N—H···O hydrogen bonds (Fig. 1). The dihedral angles between the planes of the six-membered tetrahydro-pyrimidine ring with its 4-hydroxyphenyl and ester substituents are 86.78 (4) and 6.81 (6)°, respectively, for the N1-
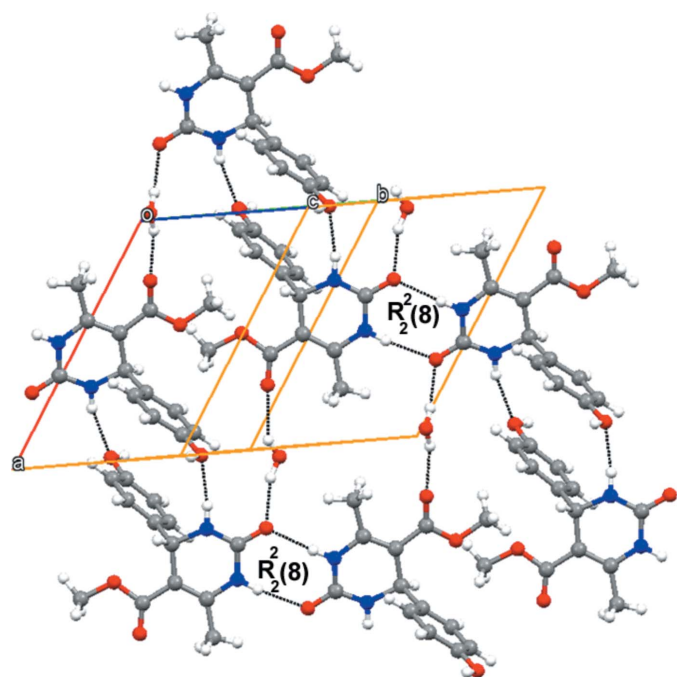
Table 1
Hydrogen-bond geometry (Å, °).

$Cg1$ and $Cg2$ are the centroids of the C8–C13 and C21–C26 rings, respectively.

D—H···A	D—H	H···A	D···A	D—H···A
N1—H1N···O6	0.878 (19)	2.10 (2)	2.9762 (16)	173.1 (17)
N3—H3N···O1	0.88 (2)	1.98 (2)	2.8626 (16)	174 (2)
N2—H2N···O9^i	0.89 (2)	2.02 (2)	2.8971 (19)	170.0 (18)
N4—H4N···O4^{ii}	0.87 (2)	2.13 (2)	2.9738 (19)	163.4 (18)
O4—H1O···O5	0.87 (2)	1.78 (2)	2.6473 (16)	175 (2)
O9—H2O···O10	0.90 (2)	1.73 (2)	2.6189 (17)	174.7 (19)
O5—H4O···O2^{iii}	0.84 (2)	2.15 (2)	2.8549 (19)	141 (2)
O5—H3O···O1^{iv}	0.91 (3)	1.91 (3)	2.786 (2)	162 (2)
C20—H20C···O5^{iv}	1.00 (2)	2.56 (2)	3.332 (2)	133.7 (17)
C26—H26···O3^v	0.971 (17)	2.571 (18)	3.4607 (18)	152.4 (14)
C6—H6B···$Cg2^{vi}$	0.989 (19)	2.70 (2)	3.392 (2)	127.1 (16)
C19—H19C···$Cg1^{vii}$	0.98 (2)	2.84 (2)	3.395 (2)	116.5 (16)

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

containing molecule and 89.35 (4)° and 3.02 (4)°, respectively, for the other.

3. Supramolecular features

In the crystal of (I), the DHPM molecules form dimers through N—H···O hydrogen bonds with an $R_2^2(8)$ graph-set motif (Fig. 2). The hydroxy groups of the dihydropyrimidine molecules donate O—H···O hydrogen bonds to water molecules, which may explain the preference for the monohydrated crystalline form. Further, the hydroxy group accepts N—H···O hydrogen bonds from amide groups whereas the water molecule donates O—H···O hydrogen bonds to the both the amide and ester carbonyl groups (Table 1). The key

Figure 2
Crystal structure of title compound showing the dimers formed by N—H···O hydrogen bonds as well as the links to the water molecules, which donate O—H···O hydrogen bonds to the ester groups.
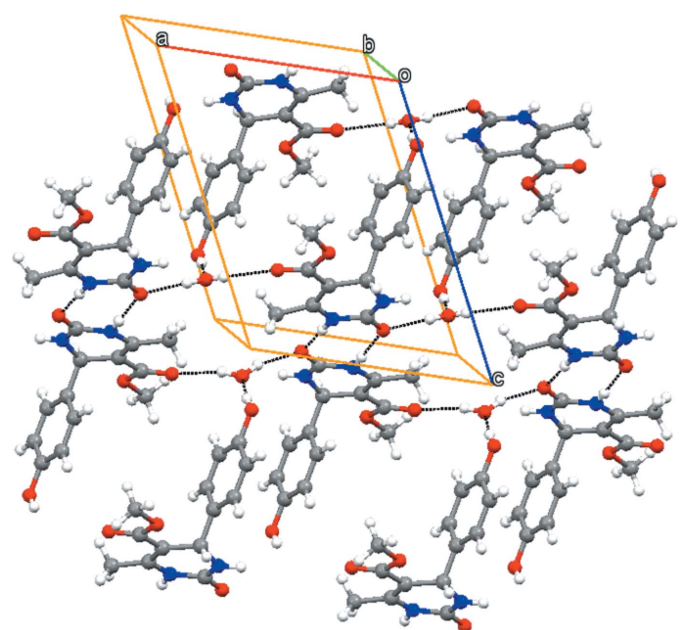

Figure 3
Three-dimensional crystal structure of the title compound showing the role of the water molecules in the hydrogen-bonding network.

Table 2
Experimental details.

Crystal data	
Chemical formula	$C_{13}H_{14}N_2O_4 \cdot H_2O$
M_r	280.28
Crystal system, space group	Triclinic, $P\overline{1}$
Temperature (K)	150
a, b, c (Å)	10.7527 (6), 11.6731 (6), 12.4456 (7)
α, β, γ (°)	98.236 (2), 112.374 (1), 108.944 (2)
V (Å^3)	1301.16 (13)
Z	4
Radiation type	Mo $K\alpha$
μ (mm^{-1})	0.11
Crystal size (mm)	$0.23 \times 0.20 \times 0.15$
Data collection	
Diffractometer	Bruker Kappa APEXII DUO
Absorption correction	Multi-scan (*SADABS*; Bruker, 2008)
T_{min}, T_{max}	0.926, 0.934
No. of measured, independent and observed [$I > 2\sigma(I)$] reflections	21716, 5116, 4387
R_{int}	0.044
$(\sin \theta/\lambda)_{max}$ (Å^{-1})	0.617
Refinement	
$R[F^2 > 2\sigma(F^2)]$, $wR(F^2)$, S	0.038, 0.099, 1.04
No. of reflections	5116
No. of parameters	489
H-atom treatment	All H-atom parameters refined
$\Delta\rho_{max}, \Delta\rho_{min}$ (e Å^{-3})	0.23, −0.28

Computer programs: *APEX2* and *SAINT* (Bruker, 2008), *SHELXS97* (Sheldrick, 2008), *SHELXL2014/7* (Sheldrick, 2015), *Mercury* (Farrugia, 2012) and *ORTEP-3 for Windows* (Macrae *et al*, 2008).

role of the water molecule in the hydrogen-bonding network is shown in Fig. 3.

Weak interactions including C—H···O, C—H···π and π···π [$Cg1\cdots Cg2(2 - x, 1 - y, 1 - z) = 3.652$ (1) Å; $Cg1$ and $Cg2$ are the centroids of the C8–C13 and C21–C26 rings, respectively] help to consolidate the packing and a three-dimensional network arises.

4. Database survey

A search of the Cambridge structural Database (CSD) (*Conquest* Version 1.17; Groom *et al.*, 2016) for methyl 4-(4-hydroxyphenyl)-6-methyl 2-oxo-1,2,3,4-tetrahydropyrimidine-5-carboxylate gave no hits; however, the crystal structures of sixteen hydroxyphenyl-substituted DHPM derivatives were found. These structures include four 2-hydroxyphenyl-substituted DHPM molecules, one 3-hydroxy-substituted and eleven 4-hydroxyphenyl-substituted DHPM molecules. It is interesting to note that five of the 4-hydroxyphenyl-substituted DHPM molecules prefer to crystallize in a hydrated form (ZOHFIN: Vishnevskii *et al.* 2014; VOJDOO: Das *et al.*, 2008; VOJDOO01: Nayak *et al.*, 2009; POWXIJ: Thenmozhi *et al.*, 2009; XISMES: Liu *et al.*, 2008). However, of these only ethyl 4-(4-hydroxyphenyl)-6-methyl-2-oxo-1,2,3,4-tetrahydropyrimidine-5 carboxylate (VOJDOO: Das *et al.*, 2008) crystallizes with a higher formula unit ($Z' > 1$), *i.e.* its structure has three formula units in the asymmetric unit ($Z' = 3$) in the monohydrated form. Hence, the title compound is the second

member of this family of monohydrates to crystallize with higher formula units in the asymmetric unit ($Z' = 2$). The CSD analysis clearly suggests that 4-hydroxy-substituted DHPM molecule are prone to crystallize in their hydrated form compared to 3-hydroxy or 2-hydroxy-substituted DHPM molecules; this may be due to the observed O—H···O hydrogen bonding with water molecule acceptors with the hydroxyl group in the preferred *para* position.

5. Synthesis and crystallization

The title compound was obtained by the reaction of three components, *viz.* methyl acetoacetate, 4-hydroxy-benzaldehyde and urea in ethanol solution according to a reported procedure (Tumtin *et al.*, 2010). The reaction progress was monitored by thin layer chromatography and after the completion of the reaction, the solvent was removed and the solid obtained was recrystallized from ethanol to obtain the pure product. Colorless single crystals suitable for X-ray diffraction analysis were obtained by slow evaporation of a solution in ethanol (yield 75%, m.p. 412.3 K). FT–IR ν_{max} cm^{-1}: 3379 (O—H), 3248 (N—H), 2963 (sp^2 C—H), 2845 (sp^3 C—H), 1763 (C=O ester), 1682 (C=O amide), 1594 (C=C alkene), 1514 (C=C aromatic) and 1260 (C—O, ester).

6. Refinement

Crystal data, data collection and structure refinement details are summarized in Table 2. All hydrogen atoms were located in difference Fourier maps and freely refined.

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supporting information

Crystal structure of methyl 4-(4-hydroxyphenyl)-6-methyl-2-oxo-1,2,3,4-tetra-hydropyrimidine-5-carboxylate monohydrate

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Computing details

Data collection: *APEX2* (Bruker, 2008); cell refinement: *SAINT* (Bruker, 2008); data reduction: *SAINT* (Bruker, 2008); program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL2014/7* (Sheldrick, 2015); molecular graphics: *ORTEP-3 for Windows* (Farrugia, 2012) and *Mercury* (Macrae *et al.* (2008); software used to prepare material for publication: *SHELXL2014/7* (Sheldrick, 2015).

Methyl 4-(4-hydroxyphenyl)-6-methyl-2-oxo-1,2,3,4-tetrahydropyrimidine-5-carboxylate monohydrate

Crystal data

$C_{13}H_{14}N_2O_4 \cdot H_2O$	$Z = 4$
$M_r = 280.28$	$F(000) = 592$
Triclinic, $P\bar{1}$	$D_x = 1.431$ Mg m^{-3}
$a = 10.7527$ (6) Å	Mo $K\alpha$ radiation, $\lambda = 0.71073$ Å
$b = 11.6731$ (6) Å	Cell parameters from 740 reflections
$c = 12.4456$ (7) Å	$\theta = 2.2–30.1°$
$\alpha = 98.236$ (2)°	$\mu = 0.11$ mm^{-1}
$\beta = 112.374$ (1)°	$T = 150$ K
$\gamma = 108.944$ (2)°	Plate, colorless
$V = 1301.16$ (13) Å^3	$0.23 \times 0.20 \times 0.15$ mm

Data collection

Bruker Kappa APEXII DUO diffractometer	21716 measured reflections
Radiation source: fine-focus sealed tube	5116 independent reflections
Graphite monochromator	4387 reflections with $I > 2\sigma(I)$
ω scans	$R_{int} = 0.044$
Absorption correction: multi-scan (SADABS; Bruker, 2008)	$\theta_{max} = 26.0°$, $\theta_{min} = 2.3°$
	$h = -13 \rightarrow 13$
	$k = -14 \rightarrow 14$
$T_{min} = 0.926$, $T_{max} = 0.934$	$l = -15 \rightarrow 15$

Refinement

Refinement on F^2	0 restraints
Least-squares matrix: full	Primary atom site location: structure-invariant direct methods
$R[F^2 > 2\sigma(F^2)] = 0.038$	
$wR(F^2) = 0.099$	Secondary atom site location: difference Fourier map
$S = 1.04$	
5116 reflections	Hydrogen site location: difference Fourier map
489 parameters	All H-atom parameters refined

$w = 1/[\sigma^2(F_o^2) + (0.046P)^2 + 0.5474P]$
    where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} = 0.001$

$\Delta\rho_{max} = 0.23$ e Å^{-3}
$\Delta\rho_{min} = -0.28$ 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 (Å^2)

	x	*y*	*z*	U_{iso}*/U_{eq}
C1	0.39164 (15)	0.54081 (12)	0.87596 (12)	0.0139 (3)
C2	0.60979 (15)	0.53784 (13)	0.86203 (12)	0.0148 (3)
C3	0.53110 (14)	0.42096 (12)	0.77764 (12)	0.0136 (3)
C4	0.36594 (14)	0.34937 (12)	0.73347 (12)	0.0133 (3)
C5	0.60417 (15)	0.35855 (12)	0.72784 (13)	0.0153 (3)
C6	0.56565 (17)	0.17576 (14)	0.58648 (15)	0.0209 (3)
C7	0.77354 (16)	0.61333 (15)	0.91932 (15)	0.0213 (3)
C8	0.26914 (14)	0.32159 (12)	0.59847 (12)	0.0135 (3)
C9	0.16677 (15)	0.19821 (12)	0.52680 (13)	0.0147 (3)
C10	0.07261 (15)	0.17160 (12)	0.40490 (13)	0.0153 (3)
C11	0.07936 (15)	0.26965 (13)	0.35266 (12)	0.0142 (3)
C12	0.18128 (15)	0.39416 (13)	0.42297 (13)	0.0155 (3)
C13	0.27411 (15)	0.41876 (13)	0.54497 (13)	0.0155 (3)
C14	0.62129 (15)	0.92206 (13)	1.09772 (12)	0.0144 (3)
C15	0.40117 (15)	0.90446 (13)	1.12011 (12)	0.0149 (3)
C16	0.46382 (15)	1.02900 (13)	1.18448 (12)	0.0149 (3)
C17	0.62246 (15)	1.11457 (12)	1.21918 (12)	0.0142 (3)
C18	0.37813 (15)	1.08432 (13)	1.22405 (13)	0.0179 (3)
C19	0.37283 (19)	1.26713 (15)	1.32473 (17)	0.0253 (3)
C20	0.24606 (16)	0.81093 (14)	1.07923 (14)	0.0209 (3)
C21	0.72322 (14)	1.15937 (12)	1.35558 (12)	0.0134 (3)
C22	0.81179 (15)	1.28805 (12)	1.41893 (13)	0.0154 (3)
C23	0.90581 (15)	1.32811 (12)	1.54268 (13)	0.0160 (3)
C24	0.91207 (14)	1.23915 (13)	1.60557 (12)	0.0146 (3)
C25	0.82479 (15)	1.10980 (13)	1.54369 (13)	0.0146 (3)
C26	0.73188 (14)	1.07151 (12)	1.41985 (13)	0.0140 (3)
N1	0.53814 (13)	0.59703 (11)	0.90574 (11)	0.0163 (3)
N2	0.31652 (13)	0.42046 (11)	0.80401 (11)	0.0153 (3)
N3	0.48323 (13)	0.85228 (11)	1.08401 (11)	0.0162 (3)
N4	0.68018 (13)	1.04716 (11)	1.15386 (11)	0.0154 (3)
O1	0.33372 (11)	0.59969 (9)	0.91804 (9)	0.0185 (2)
O2	0.73271 (11)	0.40171 (9)	0.74845 (10)	0.0225 (2)
O3	0.50735 (11)	0.24088 (9)	0.64955 (9)	0.0191 (2)
O4	−0.01614 (11)	0.23932 (9)	0.23188 (9)	0.0178 (2)
O5	−0.03765 (13)	0.44197 (10)	0.16905 (11)	0.0253 (3)
O6	0.68445 (10)	0.86842 (9)	1.05711 (9)	0.0181 (2)

O7	0.25613 (12)	1.02650 (11)	1.21377 (13)	0.0372 (3)
O8	0.45133 (11)	1.21067 (9)	1.27839 (10)	0.0215 (2)
O9	1.00441 (11)	1.28271 (9)	1.72845 (9)	0.0182 (2)
O10	1.02933 (13)	1.10134 (11)	1.82525 (11)	0.0279 (3)
H2	0.3460 (16)	0.2653 (14)	0.7513 (13)	0.012 (4)*
H4	0.6248 (16)	1.1903 (14)	1.1908 (14)	0.013 (4)*
H6C	0.801 (2)	0.695 (2)	0.9685 (19)	0.042 (6)*
H6A	0.6325 (19)	0.1504 (15)	0.6451 (15)	0.020 (4)*
H6B	0.618 (2)	0.2300 (17)	0.5497 (17)	0.032 (5)*
H7A	0.473 (2)	0.1020 (18)	0.5170 (18)	0.037 (5)*
H7B	0.810 (2)	0.6203 (19)	0.8581 (19)	0.043 (6)*
H7C	0.823 (2)	0.572 (2)	0.971 (2)	0.050 (6)*
H9	0.1627 (17)	0.1297 (15)	0.5647 (14)	0.014 (4)*
H10	0.0015 (18)	0.0858 (15)	0.3535 (15)	0.017 (4)*
H12	0.1873 (18)	0.4638 (16)	0.3874 (15)	0.023 (4)*
H13	0.3430 (18)	0.5067 (16)	0.5956 (15)	0.022 (4)*
H19A	0.272 (2)	1.2425 (19)	1.2587 (19)	0.041 (5)*
H19B	0.430 (2)	1.355 (2)	1.354 (2)	0.050 (6)*
H19C	0.369 (2)	1.2410 (18)	1.3956 (18)	0.035 (5)*
H20A	0.224 (2)	0.8036 (18)	1.1506 (19)	0.040 (5)*
H20B	0.176 (2)	0.8369 (18)	1.0264 (18)	0.035 (5)*
H20C	0.232 (2)	0.725 (2)	1.0365 (19)	0.043 (6)*
H22	0.8056 (18)	1.3477 (16)	1.3726 (15)	0.022 (4)*
H23	0.9677 (18)	1.4181 (16)	1.5872 (15)	0.019 (4)*
H25	0.8305 (18)	1.0473 (15)	1.5905 (15)	0.020 (4)*
H26	0.6728 (17)	0.9814 (15)	1.3765 (14)	0.014 (4)*
H1N	0.587 (2)	0.6755 (18)	0.9547 (16)	0.025 (4)*
H3N	0.442 (2)	0.7732 (19)	1.0363 (18)	0.034 (5)*
H2N	0.220 (2)	0.3872 (16)	0.7813 (16)	0.024 (4)*
H4N	0.769 (2)	1.0913 (17)	1.1660 (16)	0.025 (5)*
H1O	−0.017 (2)	0.308 (2)	0.2135 (19)	0.045 (6)*
H2O	1.007 (2)	1.218 (2)	1.759 (2)	0.047 (6)*
H3O	−0.126 (3)	0.447 (2)	0.147 (2)	0.049 (6)*
H4O	0.033 (2)	0.513 (2)	0.1929 (19)	0.040 (6)*
H5O	0.954 (3)	1.045 (2)	1.824 (2)	0.050 (6)*
H6O	1.115 (3)	1.097 (2)	1.870 (2)	0.048 (6)*

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
C1	0.0135 (7)	0.0148 (6)	0.0126 (6)	0.0056 (5)	0.0053 (5)	0.0037 (5)
C2	0.0130 (7)	0.0171 (7)	0.0149 (7)	0.0068 (5)	0.0060 (5)	0.0064 (5)
C3	0.0112 (6)	0.0138 (6)	0.0153 (7)	0.0050 (5)	0.0053 (5)	0.0056 (5)
C4	0.0118 (6)	0.0104 (6)	0.0175 (7)	0.0041 (5)	0.0075 (5)	0.0021 (5)
C5	0.0140 (7)	0.0136 (6)	0.0176 (7)	0.0055 (5)	0.0065 (6)	0.0058 (5)
C6	0.0216 (8)	0.0187 (7)	0.0271 (8)	0.0102 (6)	0.0155 (7)	0.0031 (6)
C7	0.0136 (7)	0.0198 (7)	0.0219 (8)	0.0025 (6)	0.0057 (6)	−0.0002 (6)
C8	0.0104 (6)	0.0133 (6)	0.0171 (7)	0.0055 (5)	0.0071 (5)	0.0021 (5)

C9	0.0139 (7)	0.0123 (6)	0.0196 (7)	0.0061 (5)	0.0091 (6)	0.0039 (5)
C10	0.0120 (7)	0.0112 (6)	0.0192 (7)	0.0035 (5)	0.0067 (6)	−0.0008 (5)
C11	0.0111 (6)	0.0171 (7)	0.0147 (7)	0.0067 (5)	0.0066 (5)	0.0019 (5)
C12	0.0140 (7)	0.0137 (6)	0.0190 (7)	0.0056 (5)	0.0079 (6)	0.0051 (5)
C13	0.0112 (6)	0.0111 (6)	0.0201 (7)	0.0026 (5)	0.0061 (6)	0.0010 (5)
C14	0.0125 (6)	0.0160 (6)	0.0116 (6)	0.0059 (5)	0.0026 (5)	0.0034 (5)
C15	0.0121 (7)	0.0191 (7)	0.0117 (6)	0.0066 (5)	0.0038 (5)	0.0041 (5)
C16	0.0119 (7)	0.0173 (7)	0.0157 (7)	0.0063 (5)	0.0060 (5)	0.0052 (5)
C17	0.0137 (7)	0.0128 (6)	0.0169 (7)	0.0061 (5)	0.0074 (6)	0.0038 (5)
C18	0.0142 (7)	0.0180 (7)	0.0205 (7)	0.0067 (6)	0.0072 (6)	0.0050 (6)
C19	0.0263 (9)	0.0200 (8)	0.0398 (10)	0.0132 (7)	0.0224 (8)	0.0086 (7)
C20	0.0140 (7)	0.0191 (7)	0.0216 (8)	0.0023 (6)	0.0065 (6)	−0.0007 (6)
C21	0.0100 (6)	0.0131 (6)	0.0173 (7)	0.0048 (5)	0.0074 (5)	0.0015 (5)
C22	0.0150 (7)	0.0126 (6)	0.0207 (7)	0.0057 (5)	0.0104 (6)	0.0041 (5)
C23	0.0134 (7)	0.0098 (6)	0.0214 (7)	0.0021 (5)	0.0089 (6)	−0.0012 (5)
C24	0.0101 (6)	0.0163 (6)	0.0153 (7)	0.0050 (5)	0.0062 (5)	−0.0008 (5)
C25	0.0120 (6)	0.0142 (6)	0.0187 (7)	0.0058 (5)	0.0079 (6)	0.0041 (5)
C26	0.0110 (6)	0.0095 (6)	0.0190 (7)	0.0028 (5)	0.0068 (5)	0.0008 (5)
N1	0.0130 (6)	0.0115 (6)	0.0173 (6)	0.0017 (5)	0.0051 (5)	−0.0016 (5)
N2	0.0101 (6)	0.0147 (6)	0.0172 (6)	0.0030 (5)	0.0060 (5)	0.0001 (5)
N3	0.0128 (6)	0.0126 (6)	0.0178 (6)	0.0032 (5)	0.0053 (5)	−0.0005 (5)
N4	0.0119 (6)	0.0142 (6)	0.0175 (6)	0.0034 (5)	0.0071 (5)	0.0013 (5)
O1	0.0154 (5)	0.0168 (5)	0.0201 (5)	0.0061 (4)	0.0074 (4)	−0.0002 (4)
O2	0.0129 (5)	0.0211 (5)	0.0301 (6)	0.0053 (4)	0.0101 (4)	0.0021 (4)
O3	0.0158 (5)	0.0139 (5)	0.0264 (6)	0.0052 (4)	0.0114 (4)	0.0000 (4)
O4	0.0158 (5)	0.0165 (5)	0.0148 (5)	0.0042 (4)	0.0039 (4)	0.0023 (4)
O5	0.0141 (6)	0.0149 (5)	0.0356 (6)	0.0039 (5)	0.0036 (5)	0.0026 (5)
O6	0.0150 (5)	0.0169 (5)	0.0202 (5)	0.0072 (4)	0.0073 (4)	0.0008 (4)
O7	0.0200 (6)	0.0253 (6)	0.0613 (9)	0.0033 (5)	0.0247 (6)	−0.0035 (6)
O8	0.0200 (5)	0.0154 (5)	0.0342 (6)	0.0086 (4)	0.0173 (5)	0.0051 (4)
O9	0.0152 (5)	0.0160 (5)	0.0152 (5)	0.0027 (4)	0.0041 (4)	−0.0005 (4)
O10	0.0135 (6)	0.0255 (6)	0.0367 (7)	0.0048 (5)	0.0054 (5)	0.0119 (5)

Geometric parameters (Å, º)

C1—O1	1.2481 (17)	C15—C20	1.4984 (19)
C1—N2	1.3342 (17)	C16—C18	1.4659 (19)
C1—N1	1.3653 (18)	C16—C17	1.5177 (19)
C2—C3	1.3579 (19)	C17—N4	1.4776 (17)
C2—N1	1.3872 (18)	C17—C21	1.5188 (19)
C2—C7	1.4973 (19)	C17—H4	0.994 (15)
C3—C5	1.4647 (19)	C18—O7	1.2105 (18)
C3—C4	1.5218 (18)	C18—O8	1.3444 (17)
C4—N2	1.4745 (17)	C19—O8	1.4499 (17)
C4—C8	1.5182 (19)	C19—H19A	0.99 (2)
C4—H2	1.009 (15)	C19—H19B	0.94 (2)
C5—O2	1.2127 (17)	C19—H19C	0.98 (2)
C5—O3	1.3548 (17)	C20—H20A	1.01 (2)

C6—O3	1.4491 (17)	C20—H20B	0.96 (2)
C6—H6A	0.968 (17)	C20—H20C	1.00 (2)
C6—H6B	0.989 (19)	C21—C26	1.3931 (19)
C6—H7A	1.03 (2)	C21—C22	1.3946 (19)
C7—H6C	0.95 (2)	C22—C23	1.384 (2)
C7—H7B	0.98 (2)	C22—H22	0.968 (17)
C7—H7C	0.96 (2)	C23—C24	1.391 (2)
C8—C9	1.3917 (19)	C23—H23	0.975 (17)
C8—C13	1.3918 (19)	C24—O9	1.3699 (17)
C9—C10	1.384 (2)	C24—C25	1.3965 (19)
C9—H9	0.982 (16)	C25—C26	1.383 (2)
C10—C11	1.3904 (19)	C25—H25	0.999 (17)
C10—H10	0.972 (16)	C26—H26	0.971 (16)
C11—O4	1.3696 (16)	N1—H1N	0.878 (19)
C11—C12	1.3966 (19)	N2—H2N	0.890 (19)
C12—C13	1.385 (2)	N3—H3N	0.88 (2)
C12—H12	0.976 (17)	N4—H4N	0.867 (19)
C13—H13	0.983 (17)	O4—H1O	0.86 (2)
C14—O6	1.2472 (17)	O5—H3O	0.91 (2)
C14—N4	1.3386 (18)	O5—H4O	0.83 (2)
C14—N3	1.3706 (18)	O9—H2O	0.90 (2)
C15—C16	1.3523 (19)	O10—H5O	0.86 (3)
C15—N3	1.3869 (18)	O10—H6O	0.90 (2)
O1—C1—N2	122.43 (12)	N4—C17—C16	109.46 (11)
O1—C1—N1	120.57 (12)	N4—C17—C21	109.83 (11)
N2—C1—N1	116.97 (12)	C16—C17—C21	113.17 (11)
C3—C2—N1	119.80 (12)	N4—C17—H4	106.2 (9)
C3—C2—C7	126.65 (13)	C16—C17—H4	109.2 (9)
N1—C2—C7	113.53 (12)	C21—C17—H4	108.7 (9)
C2—C3—C5	120.57 (12)	O7—C18—O8	121.30 (13)
C2—C3—C4	121.63 (12)	O7—C18—C16	126.02 (13)
C5—C3—C4	117.78 (11)	O8—C18—C16	112.66 (12)
N2—C4—C8	108.71 (10)	O8—C19—H19A	109.5 (12)
N2—C4—C3	109.65 (11)	O8—C19—H19B	106.2 (14)
C8—C4—C3	115.47 (11)	H19A—C19—H19B	112.9 (18)
N2—C4—H2	105.7 (9)	O8—C19—H19C	110.4 (11)
C8—C4—H2	107.5 (9)	H19A—C19—H19C	111.3 (16)
C3—C4—H2	109.4 (9)	H19B—C19—H19C	106.4 (17)
O2—C5—O3	121.53 (13)	C15—C20—H20A	111.6 (12)
O2—C5—C3	127.41 (13)	C15—C20—H20B	111.1 (12)
O3—C5—C3	111.05 (11)	H20A—C20—H20B	106.6 (16)
O3—C6—H6A	107.7 (10)	C15—C20—H20C	109.4 (12)
O3—C6—H6B	112.2 (11)	H20A—C20—H20C	107.8 (16)
H6A—C6—H6B	110.0 (14)	H20B—C20—H20C	110.3 (16)
O3—C6—H7A	103.6 (11)	C26—C21—C22	118.39 (13)
H6A—C6—H7A	115.1 (14)	C26—C21—C17	120.28 (12)
H6B—C6—H7A	108.1 (15)	C22—C21—C17	121.31 (12)

C2—C7—H6C	110.7 (12)	C23—C22—C21	121.08 (13)
C2—C7—H7B	112.1 (12)	C23—C22—H22	121.6 (10)
H6C—C7—H7B	109.6 (17)	C21—C22—H22	117.3 (10)
C2—C7—H7C	109.8 (13)	C22—C23—C24	119.74 (12)
H6C—C7—H7C	107.8 (18)	C22—C23—H23	121.3 (9)
H7B—C7—H7C	106.7 (17)	C24—C23—H23	119.0 (10)
C9—C8—C13	118.41 (13)	O9—C24—C23	118.02 (12)
C9—C8—C4	120.22 (12)	O9—C24—C25	121.92 (12)
C13—C8—C4	121.27 (12)	C23—C24—C25	120.06 (13)
C10—C9—C8	121.23 (13)	C26—C25—C24	119.37 (12)
C10—C9—H9	120.3 (9)	C26—C25—H25	121.7 (10)
C8—C9—H9	118.5 (9)	C24—C25—H25	118.9 (10)
C9—C10—C11	119.66 (12)	C25—C26—C21	121.36 (12)
C9—C10—H10	122.1 (9)	C25—C26—H26	119.4 (9)
C11—C10—H10	118.2 (9)	C21—C26—H26	119.3 (9)
O4—C11—C10	117.81 (12)	C1—N1—C2	123.79 (12)
O4—C11—C12	122.17 (12)	C1—N1—H1N	115.9 (12)
C10—C11—C12	120.02 (13)	C2—N1—H1N	120.3 (12)
C13—C12—C11	119.37 (13)	C1—N2—C4	126.69 (12)
C13—C12—H12	119.8 (10)	C1—N2—H2N	115.7 (11)
C11—C12—H12	120.8 (10)	C4—N2—H2N	115.6 (11)
C12—C13—C8	121.30 (12)	C14—N3—C15	123.93 (12)
C12—C13—H13	119.6 (10)	C14—N3—H3N	114.0 (13)
C8—C13—H13	119.1 (10)	C15—N3—H3N	120.9 (13)
O6—C14—N4	123.48 (13)	C14—N4—C17	126.51 (12)
O6—C14—N3	119.81 (12)	C14—N4—H4N	117.2 (12)
N4—C14—N3	116.70 (12)	C17—N4—H4N	115.1 (12)
C16—C15—N3	119.54 (12)	C5—O3—C6	115.32 (11)
C16—C15—C20	127.09 (13)	C11—O4—H1O	109.9 (14)
N3—C15—C20	113.36 (12)	H3O—O5—H4O	112.6 (19)
C15—C16—C18	119.77 (12)	C18—O8—C19	113.98 (11)
C15—C16—C17	122.02 (12)	C24—O9—H2O	111.0 (15)
C18—C16—C17	118.21 (12)	H5O—O10—H6O	113 (2)
N1—C2—C3—C5	178.24 (12)	C15—C16—C18—O8	−175.05 (12)
C7—C2—C3—C5	−3.6 (2)	C17—C16—C18—O8	5.71 (18)
N1—C2—C3—C4	−2.98 (19)	N4—C17—C21—C26	−68.68 (15)
C7—C2—C3—C4	175.15 (13)	C16—C17—C21—C26	53.97 (16)
C2—C3—C4—N2	−5.41 (17)	N4—C17—C21—C22	109.60 (14)
C5—C3—C4—N2	173.40 (11)	C16—C17—C21—C22	−127.75 (13)
C2—C3—C4—C8	117.77 (14)	C26—C21—C22—C23	−0.2 (2)
C5—C3—C4—C8	−63.42 (15)	C17—C21—C22—C23	−178.55 (12)
C2—C3—C5—O2	−3.9 (2)	C21—C22—C23—C24	−0.3 (2)
C4—C3—C5—O2	177.25 (13)	C22—C23—C24—O9	−178.78 (12)
C2—C3—C5—O3	177.24 (12)	C22—C23—C24—C25	0.6 (2)
C4—C3—C5—O3	−1.58 (17)	O9—C24—C25—C26	179.01 (12)
N2—C4—C8—C9	−108.73 (13)	C23—C24—C25—C26	−0.4 (2)
C3—C4—C8—C9	127.59 (13)	C24—C25—C26—C21	−0.2 (2)

N2—C4—C8—C13	67.52 (16)	C22—C21—C26—C25	0.5 (2)
C3—C4—C8—C13	−56.15 (17)	C17—C21—C26—C25	178.83 (12)
C13—C8—C9—C10	0.6 (2)	O1—C1—N1—C2	−179.62 (12)
C4—C8—C9—C10	176.94 (12)	N2—C1—N1—C2	2.45 (19)
C8—C9—C10—C11	−0.3 (2)	C3—C2—N1—C1	5.2 (2)
C9—C10—C11—O4	−179.75 (12)	C7—C2—N1—C1	−173.19 (13)
C9—C10—C11—C12	0.3 (2)	O1—C1—N2—C4	169.09 (12)
O4—C11—C12—C13	179.50 (12)	N1—C1—N2—C4	−13.0 (2)
C10—C11—C12—C13	−0.6 (2)	C8—C4—N2—C1	−113.04 (14)
C11—C12—C13—C8	0.8 (2)	C3—C4—N2—C1	14.04 (18)
C9—C8—C13—C12	−0.8 (2)	O6—C14—N3—C15	−176.36 (12)
C4—C8—C13—C12	−177.17 (12)	N4—C14—N3—C15	2.68 (19)
N3—C15—C16—C18	−179.33 (12)	C16—C15—N3—C14	−7.4 (2)
C20—C15—C16—C18	1.5 (2)	C20—C15—N3—C14	171.83 (12)
N3—C15—C16—C17	−0.1 (2)	O6—C14—N4—C17	−170.82 (12)
C20—C15—C16—C17	−179.25 (13)	N3—C14—N4—C17	10.18 (19)
C15—C16—C17—N4	10.20 (18)	C16—C17—N4—C14	−15.85 (18)
C18—C16—C17—N4	−170.57 (11)	C21—C17—N4—C14	108.97 (14)
C15—C16—C17—C21	−112.65 (14)	O2—C5—O3—C6	−4.45 (19)
C18—C16—C17—C21	66.57 (15)	C3—C5—O3—C6	174.46 (11)
C15—C16—C18—O7	6.7 (2)	O7—C18—O8—C19	1.7 (2)
C17—C16—C18—O7	−172.58 (15)	C16—C18—O8—C19	−176.70 (12)

Hydrogen-bond geometry (Å, º)

Cg1 and Cg2 are the centroids of the C8–C13 and C21–C26 rings, respectively.

D—H···A	D—H	H···A	D···A	D—H···A
N1—H1N···O6	0.878 (19)	2.10 (2)	2.9762 (16)	173.1 (17)
N3—H3N···O1	0.88 (2)	1.98 (2)	2.8626 (16)	174 (2)
N2—H2N···O9i	0.89 (2)	2.02 (2)	2.8971 (19)	170.0 (18)
N4—H4N···O4ii	0.87 (2)	2.13 (2)	2.9738 (19)	163.4 (18)
O4—H1O···O5	0.87 (2)	1.78 (2)	2.6473 (16)	175 (2)
O9—H2O···O10	0.90 (2)	1.73 (2)	2.6189 (17)	174.7 (19)
O5—H4O···O2iii	0.84 (2)	2.15 (2)	2.8549 (19)	141 (2)
O5—H3O···O1iv	0.91 (3)	1.91 (3)	2.786 (2)	162 (2)
C20—H20C···O5iv	1.00 (2)	2.56 (2)	3.332 (2)	133.7 (17)
C26—H26···O3v	0.971 (17)	2.571 (18)	3.4607 (18)	152.4 (14)
C6—H6B···Cg2vi	0.989 (19)	2.70 (2)	3.392 (2)	127.1 (16)
C19—H19C···Cg1vii	0.98 (2)	2.84 (2)	3.395 (2)	116.5 (16)

Symmetry codes: (i) x−1, y−1, z−1; (ii) x+1, y+1, z+1; (iii) −x+1, −y+1, −z+1; (iv) −x, −y+1, −z+1; (v) −x+1, −y+1, −z+2; (vi) x, y, z−1; (vii) x, y+1, z+1.