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# Crystal structure of a 2:1 piroxicam–gentisic acid co-crystal featuring neutral and zwitterionic piroxicam molecules

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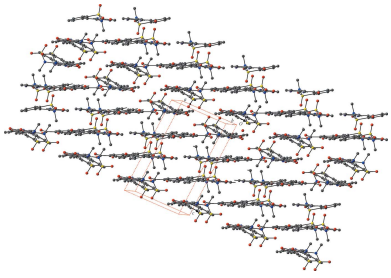
A new 2:1 co-crystal of piroxicam and gentisic acid [systematic name: 4-hydroxy-1,1-dioxo-*N*-(pyridin-2-yl)-2*H*-1λ$^6$,2-benzothiazine-3-carboxamide–2-(4-oxido-1,1-dioxo-2*H*-1λ$^6$,2-benzothiazine-3-amido)pyridin-1-ium–2,5-dihydroxybenzoic acid, $2C_{15}H_{13}N_3O_4S\cdot C_7H_6O_4$] has been synthesized using a microfluidic platform and initially identified using Raman spectroscopy. In the co-crystal, one piroxicam molecule is in its neutral form and an intramolecular O—H···O hydrogen bond is observed. The other piroxicam molecule is zwitterionic (proton transfer from the OH group to the pyridine N atom) and two intramolecular N—H···O hydrogen bonds occur. The gentisic acid molecule shows whole-molecule disorder over two sets of sites in a 0.809 (2):0.191 (2) ratio. In the crystal, extensive hydrogen bonding between the components forms layers propagating in the *ab* plane.

## 1. Chemical context

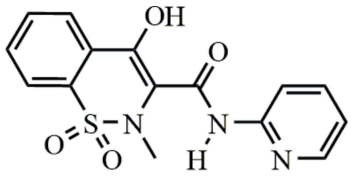
Piroxicam is a non-steroidal anti-inflammatory drug classified as a BCS Class II drug due to its low aqueous solubility (Amidon *et al.*, 1995; Thayer, 2010). Co-crystallization of an active pharmaceutical ingredient (API) and an FDA-approved counter-ion is a common technique employed to increase the solubility of the API (Trask *et al.*, 2005). In this work, we explored the co-crystallization of piroxicam and gentisic acid. In a previous study, piroxicam was co-crystallized with 23 carboxylic acids yielding 50 co-crystals. From this work, three co-crystals of piroxicam and gentisic acid were identified with Raman spectroscopy, but no crystal structures were reported (Childs & Hardcastle, 2007). In our prior work, we reported the crystal structure of two co-crystals of piroxicam and gentisic acid, one was a 1:1 co-crystal and the second was a solvated co-crystal that incorporated acetone into the crystal in a 1:1:1 molar ratio (Horstman *et al.*, 2015). In this work we describe the crystal structure of a 2:1 piroxicam:gentisic acid co-crystal.

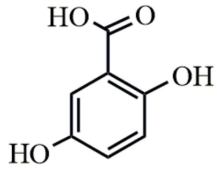


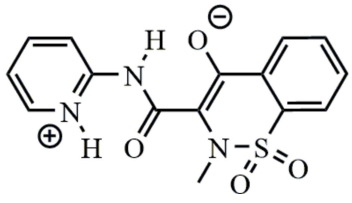
## 2. Structural commentary

The asymmetric unit of this co-crystal consists of two piroxicam molecules and one gentisic acid molecule, with all atoms residing on general positions (Fig. 1). One of the piroxicam molecules is neutral and the other is a zwitterion: the two molecules exhibit two different conformations in the crystal structure. In the neutral S2-containing molecule, intramolecular hydrogen bonding exists between the hydroxyl

proton H8 [H···$A$ = 1.79 (3) Å] and the amide oxygen atom O7. In the S2 molecule, free rotation about the C—C bond (C1 and C10) allows a second zwitterionic conformation in which intramolecular hydrogen bonds exist between the amine proton H2 and the enolate oxygen atom O4 [H···$A$ = 1.85 (2) Å] and the pyridinium proton H3 and the amide oxygen atom O3 [H···$A$ = 2.19 (2) Å]. Further details of the hydrogen bonding are provided in Table 1.







The gentisic acid molecule shows whole molecule disorder over two orientations rotated by approximately 180° in the plane of the aromatic ring with site occupancies of 0.809 (2):0.191 (2). The major orientation participates in intramolecular hydrogen bonding between the O11 hydroxide substituent of the benzene ring and the O9 oxygen atom of the carboxylic acid [H···$A$ = 1.89 (3) Å]. The major orientation also participates in intermolecular hydrogen bonding. The minor orientation of the gentisic acid molecule also displays intramolecular hydrogen bonding between the O11$B$ hydroxide substituent and the O9$B$ oxygen atom of the carboxylic acid (H···$A$ = 1.89 Å) but does not participate in intermolecular hydrogen bonding.

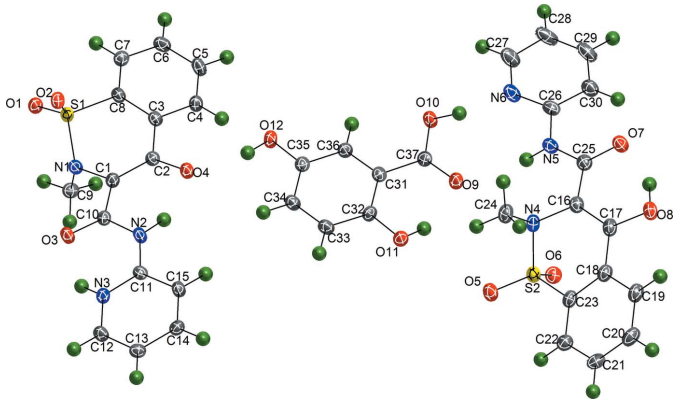


**Figure 1**
The molecular structure of the title co-crystal, showing 35% probability ellipsoids for non-H atoms and spheres of arbitrary size for H atoms. Only the major component of the disordered gentisic acid is shown.

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

| $D$—H···$A$ | $D$—H | H···$A$ | $D$···$A$ | $D$—H···$A$ |
|---|---|---|---|---|
| N2—H2···O4 | 0.88 (2) | 1.85 (2) | 2.6169 (18) | 145.2 (19) |
| N3—H3···O3 | 0.78 (2) | 1.99 (2) | 2.6027 (19) | 135 (2) |
| N3—H3···O3$^{i}$ | 0.78 (2) | 2.19 (2) | 2.8034 (19) | 136 (2) |
| O8—H8···O7 | 0.88 (3) | 1.79 (3) | 2.5722 (19) | 148 (2) |
| N5—H5···O9 | 0.84 (2) | 2.25 (2) | 3.074 (2) | 167 (2) |
| O10—H10···N6 | 0.91 (3) | 1.74 (3) | 2.637 (3) | 167 (3) |
| O11—H11···O9 | 0.81 (3) | 1.89 (3) | 2.614 (2) | 148 (3) |
| O12—H12···O4$^{ii}$ | 0.81 (3) | 1.94 (3) | 2.738 (3) | 164 (4) |
| O10$B$—H10$B$···O4$^{ii}$ | 0.84 | 1.67 | 2.508 (12) | 172 |
| O11$B$—H11$B$···O2$^{i}$ | 0.84 | 2.57 | 3.061 (6) | 118 |
| O11$B$—H11$B$···O9$B$ | 0.84 | 1.89 | 2.614 (9) | 143 |
| O12$B$—H12$B$···N6 | 0.84 | 2.10 | 2.856 (12) | 149 |

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

## 3. Supramolecular features

In the crystal, hydrogen bonds (Table 1) between the piroxicam and gentisic acid molecules form hexameric units that propagate along the $a$-axis direction (Fig. 2). These units pack into layers in the $ab$ plane; the layers stack along the $c$-axis direction, Fig. 3.

The repeating motif of the hexameric unit is formed by one gentisic acid molecule hydrogen bonded to two piroxicam molecules, one of each conformation (*i.e.* neutral and zwitterion). The non-zwitterionic form of piroxicam accepts hydrogen bonds from the gentisic acid *via* O—H···N bonds between the carboxylic acid and the pyridine ring of piroxicam [H···$A$ = 1.74 (3) Å] as well as N—H···O bonds between the carbonyl oxygen atom of gentisic acid and the amine nitrogen atom of piroxicam [H···$A$ = 2.25 (2) Å]. The zwitterionic form of piroxicam accepts hydrogen bonds from the gentisic acid *via* O—H···O bonds between the 5-hydroxy substituent of gentisic acid and the enolate oxygen atom of piroxicam [H···$A$ = 1.94 (3) Å]. The repeat units are linked together by N—H···O bonds between the pyridinium nitrogen atoms and

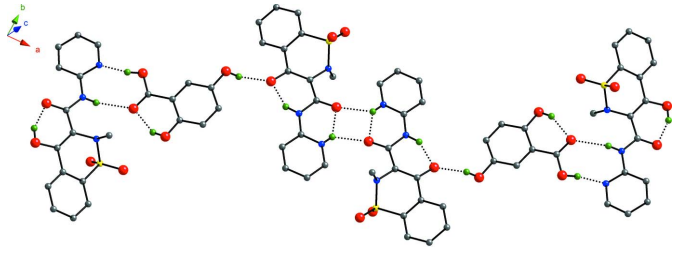


**Figure 2**
Ball-and-stick model highlighting the hydrogen-bonding network in the title co-crystal. Only the major component of the disordered gentisic acid is shown. Color key: C gray, N blue, H green, O red, and S yellow. H atoms not involved in hydrogen bonding have been omitted for clarity.

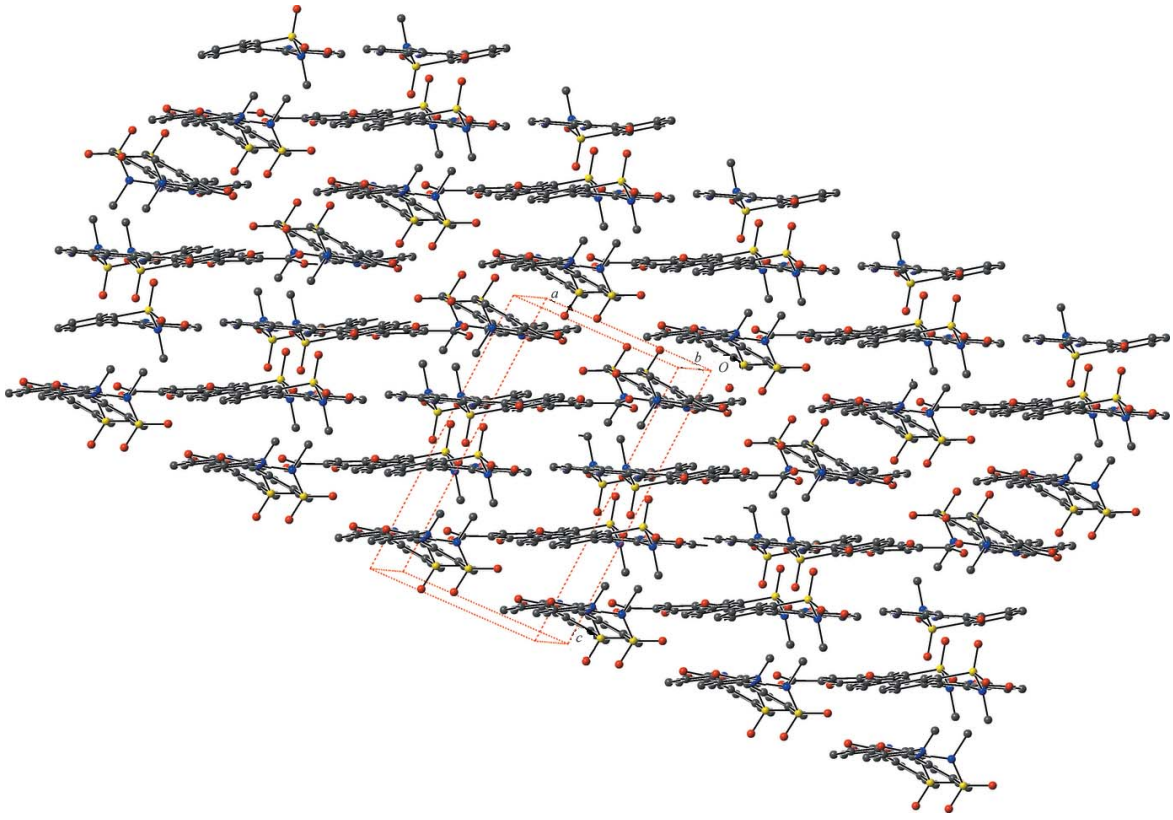



**Figure 3**
Ball-and-stick packing diagram of the co-crystal, as viewed approximately down the *b* axis, highlighting the layers formed by the packing of the hexameric units. Color key: C gray, N blue, O red, and S yellow. H atoms have been omitted for clarity.

the amide oxygen atoms of the zwitterionic form of piroxicam [H···*A* = 2.19 (2) Å].

## 4. Synthesis and crystallization

Piroxicam (>=98.0%) and gentisic acid (>=98.0%) were used as purchased from Sigma–Aldrich (St. Louis, MO, USA). Acetonitrile (>=99.9%) was used as purchased from Fisher Scientific (Fair Lawn, NJ, USA). A 1:2 molar ratio of piroxicam:gentisic acid was dissolved in acetonitrile. The concentration of piroxicam in acetonitrile was near saturation (∼0.034 *M*). The resulting solution was introduced into a microfluidic platform. The microfluidic platform was a 6 × 6 array of single microwells (∼100 nl) (Horstman *et al.*, 2015). After being filled, the microfluidic platform was placed inside a petri dish and then the petri dish was sealed with parafilm to slow the rate of solvent evaporation. The crystallization solution evaporated over the course of one day, after which crystals were observed *via* optical microscopy. Specifics of the microfluidic platform fabrication and operation have been previously reported (Horstman *et al.*, 2015). Once crystals were observed, Raman spectroscopy was used to distinguish between crystals. Within one microfluidic chip, three different co-crystals of piroxicam and gentisic acid were observed, two of which had been previously reported (Horstman *et al.*, 2015) and one new solid form, reported here. Once the new co-crystals had been identified, we removed the crystals from the microfluidic platform.

## 5. Refinement

Crystal data, data collection and structure refinement details are summarized in Table 2. The gentisic acid molecule shows whole molecule disorder over two sets of sites: the like C—O and C—C distances were restrained to be similar (s.u. 0.01 Å). Similar displacement amplitudes (s.u. 0.01) were imposed on disordered sites overlapping by less than the sum of van der Waals radii.

All O—H and N—H hydrogen atoms were located in the difference map except for those on the minor-disordered component of the gentisic acid. The H atoms located in the difference map were allowed to refine the O—H/N—H bond distances. These H atoms refined to good hydrogen-bonding positions (Hamilton & Ibers, 1968). The hydroxyl H atoms on the minor-disordered component of gentisic acid were optimized by rotation about *R*—O bonds with idealized O—H and *R*—H distances. These H atoms are also in good hydrogen-bonding locations. Methyl H-atom positions, *R*—$CH_3$, were optimized by rotation about *R*—C bonds with idealized C—H, *R*···H and H···H distances. The remaining H atoms were included as riding idealized contributors. Methyl, hydroxyl and amine H atom $U_{iso}$ values were assigned as $1.5U_{eq}$ of the

**Table 2**
Experimental details.

| | |
|---|---|
| Crystal data | |
| Chemical formula | $2C_{15}H_{13}N_3O_4S{\cdot}C_7H_6O_4$ |
| $M_r$ | 816.80 |
| Crystal system, space group | Triclinic, $P\overline{1}$ |
| Temperature (K) | 105 |
| $a, b, c$ (Å) | 8.8764 (3), 13.4060 (5), 15.2678 (6) |
| $\alpha, \beta, \gamma$ (°) | 80.4660 (15), 85.4332 (15), 78.4602 (15) |
| $V$ (Å$^3$) | 1753.48 (11) |
| $Z$ | 2 |
| Radiation type | Cu $K\alpha$ |
| $\mu$ (mm$^{-1}$) | 2.05 |
| Crystal size (mm) | 0.15 × 0.15 × 0.03 |
| | |
| Data collection | |
| Diffractometer | Bruker D8 Venture/Photon 100 |
| Absorption correction | Integration (*SADABS*; Bruker, 2014) |
| $T_{min}$, $T_{max}$ | 0.867, 0.965 |
| No. of measured, independent and observed [$I > 2\sigma(I)$] reflections | 49307, 6416, 5801 |
| $R_{int}$ | 0.037 |
| (sin $\theta/\lambda)_{max}$ (Å$^{-1}$) | 0.602 |
| | |
| Refinement | |
| $R[F^2 > 2\sigma(F^2)]$, $wR(F^2)$, $S$ | 0.033, 0.086, 1.11 |
| No. of reflections | 6416 |
| No. of parameters | 637 |
| No. of restraints | 374 |
| H-atom treatment | H atoms treated by a mixture of independent and constrained refinement |
| $\Delta\rho_{max}$, $\Delta\rho_{min}$ (e Å$^{-3}$) | 0.24, −0.40 |

Computer programs: *APEX2*, *SAINT*, *XPREP*, and *XCIF* (Bruker, 2014), *SHELXS2014-4* and *SHELXTL* (Sheldrick, 2008), *SHELXL2014-6* (Sheldrick, 2015) and *CrystalMaker* (CrystalMaker, 1994).

carrier atom; remaining H-atom $U_{iso}$ were assigned as 1.2 × carrier $U_{eq}$.

The $(\overline{1}\,\overline{1}2)$ reflection was omitted from the final refinement because it was partially obscured by the shadow of the beamstop in some orientations.

## Acknowledgements

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# supporting information

*Acta Cryst.* (2016). E**72**, 1714-1717 [https://doi.org/10.1107/S2056989016017321]

## Crystal structure of a 2:1 piroxicam–gentisic acid co-crystal featuring neutral and zwitterionic piroxicam molecules

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### Computing details

Data collection: *APEX2* (Bruker, 2014); cell refinement: *SAINT* (Bruker, 2014); data reduction: *SAINT* (Bruker, 2014) and *XPREP* (Bruker, 2014); program(s) used to solve structure: *SHELXS2014-4* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL2014-6* (Sheldrick, 2015); molecular graphics: *SHELXTL* (Sheldrick, 2008), *CrystalMaker* (*CrystalMaker*, 1994); software used to prepare material for publication: *XCIF* (Bruker, 2014).

**4-Hydroxy-1,1-dioxo-*N*-(pyridin-2-yl)-2*H*-1$\lambda^6$,2-benzothiazine-3-carboxamide–2-(4-oxido-1,1-dioxo-2*H*-1$\lambda^6$,2-benzothiazine-3-amido)pyridin-1-ium–2,5-dihydroxybenzoic acid**

*Crystal data*

$2C_{15}H_{13}N_3O_4S\cdot C_7H_6O_4$
$M_r$ = 816.80
Triclinic, $P\overline{1}$
$a$ = 8.8764 (3) Å
$b$ = 13.4060 (5) Å
$c$ = 15.2678 (6) Å
$\alpha$ = 80.4660 (15)°
$\beta$ = 85.4332 (15)°
$\gamma$ = 78.4602 (15)°
$V$ = 1753.48 (11) Å$^3$
$Z$ = 2
$F(000)$ = 848
$D_x$ = 1.547 Mg m$^{-3}$
Cu $K\alpha$ radiation, $\lambda$ = 1.54178 Å
Cell parameters from 9375 reflections
$\theta$ = 2.9–68.1°
$\mu$ = 2.05 mm$^{-1}$
$T$ = 105 K
Plate, colourless
0.15 × 0.15 × 0.03 mm

*Data collection*

Bruker D8 Venture/Photon 100 diffractometer
Radiation source: microfocus sealed tube
Multilayer mirrors monochromator
profile data from $\varphi$ and $\omega$ scans
Absorption correction: integration (SADABS; Bruker, 2014)
$T_{min}$ = 0.867, $T_{max}$ = 0.965
49307 measured reflections
6416 independent reflections
5801 reflections with $I > 2\sigma(I)$
$R_{int}$ = 0.037
$\theta_{max}$ = 68.3°, $\theta_{min}$ = 2.9°
$h$ = −10→10
$k$ = −16→15
$l$ = −18→18

*Refinement*

Refinement on $F^2$
Least-squares matrix: full
$R[F^2 > 2\sigma(F^2)]$ = 0.033
$wR(F^2)$ = 0.086
$S$ = 1.11
6416 reflections
637 parameters
374 restraints
Hydrogen site location: mixed
H atoms treated by a mixture of independent and constrained refinement

$w = 1/[\sigma^2(F_o^2) + (0.0348P)^2 + 1.2991P]$
where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} = 0.001$

$\Delta\rho_{max} = 0.24$ e Å$^{-3}$
$\Delta\rho_{min} = -0.40$ e Å$^{-3}$

*Special details*

**Experimental**. One distinct cell was identified using APEX2 (Bruker, 2014). Thirty frame series were integrated and filtered for statistical outliers using SAINT (Bruker, 2013) then corrected for absorption by integration using SAINT/SADABS v2014/2 (Bruker, 2014) to sort, merge, and scale the combined data. No decay correction was applied.

**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**. Structure was phased by direct methods (Sheldrick, 2014). Systematic conditions suggested the ambiguous space group. The space group choice was confirmed by successful convergence of the full-matrix least-squares refinement on $F^2$. The final map had no significant features. A final analysis of variance between observed and calculated structure factors showed little dependence on amplitude and resolution.

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

| | *x* | *y* | *z* | $U_{iso}$*/$U_{eq}$ | Occ. (<1) |
|---|---|---|---|---|---|
| S1 | 0.90408 (4) | 0.14390 (3) | 0.54955 (3) | 0.01390 (10) | |
| O1 | 0.82965 (14) | 0.05638 (9) | 0.56665 (8) | 0.0187 (3) | |
| O2 | 0.94543 (13) | 0.18072 (9) | 0.45902 (8) | 0.0171 (3) | |
| O3 | 0.63926 (13) | 0.43288 (9) | 0.53570 (8) | 0.0190 (3) | |
| O4 | 1.07869 (13) | 0.38775 (9) | 0.63196 (8) | 0.0179 (3) | |
| N1 | 0.79315 (16) | 0.23889 (11) | 0.59094 (9) | 0.0146 (3) | |
| N2 | 0.82451 (16) | 0.51014 (11) | 0.57712 (10) | 0.0153 (3) | |
| H2 | 0.918 (3) | 0.4941 (16) | 0.5974 (14) | 0.023* | |
| N3 | 0.60509 (16) | 0.63109 (12) | 0.53091 (10) | 0.0154 (3) | |
| H3 | 0.571 (3) | 0.5850 (18) | 0.5199 (14) | 0.023* | |
| C1 | 0.86562 (19) | 0.32602 (13) | 0.59352 (11) | 0.0146 (3) | |
| C2 | 1.01351 (19) | 0.31258 (13) | 0.62393 (11) | 0.0146 (3) | |
| C3 | 1.10283 (19) | 0.20511 (13) | 0.64669 (11) | 0.0145 (3) | |
| C4 | 1.22916 (19) | 0.18627 (14) | 0.70002 (11) | 0.0170 (4) | |
| H4A | 1.2584 | 0.2418 | 0.7215 | 0.020* | |
| C5 | 1.3123 (2) | 0.08704 (14) | 0.72188 (12) | 0.0208 (4) | |
| H5A | 1.3976 | 0.0754 | 0.7586 | 0.025* | |
| C6 | 1.2726 (2) | 0.00480 (14) | 0.69087 (12) | 0.0214 (4) | |
| H6A | 1.3307 | −0.0627 | 0.7062 | 0.026* | |
| C7 | 1.1480 (2) | 0.02107 (14) | 0.63738 (12) | 0.0186 (4) | |
| H7A | 1.1199 | −0.0349 | 0.6158 | 0.022* | |
| C8 | 1.06514 (19) | 0.12048 (13) | 0.61587 (11) | 0.0148 (3) | |
| C9 | 0.6952 (2) | 0.21086 (14) | 0.67045 (12) | 0.0203 (4) | |
| H9A | 0.6442 | 0.1555 | 0.6607 | 0.030* | |
| H9B | 0.6174 | 0.2711 | 0.6812 | 0.030* | |
| H9C | 0.7591 | 0.1874 | 0.7221 | 0.030* | |
| C10 | 0.76774 (19) | 0.42370 (13) | 0.56612 (11) | 0.0143 (3) | |
| C11 | 0.74705 (19) | 0.60956 (13) | 0.56233 (11) | 0.0138 (3) | |
| C12 | 0.5198 (2) | 0.72695 (13) | 0.51690 (11) | 0.0176 (4) | |

| | | | | | |
|---|---|---|---|---|---|
| H12A | 0.4189 | 0.7375 | 0.4961 | 0.021* | |
| C13 | 0.5776 (2) | 0.80883 (13) | 0.53244 (11) | 0.0179 (4) | |
| H13A | 0.5187 | 0.8768 | 0.5222 | 0.022* | |
| C14 | 0.7258 (2) | 0.79029 (13) | 0.56383 (11) | 0.0165 (3) | |
| H14A | 0.7689 | 0.8464 | 0.5744 | 0.020* | |
| C15 | 0.81005 (19) | 0.69159 (13) | 0.57964 (11) | 0.0159 (3) | |
| H15A | 0.9100 | 0.6793 | 0.6021 | 0.019* | |
| S2 | 0.69631 (5) | 0.91958 (3) | 0.90830 (3) | 0.01758 (11) | |
| O5 | 0.55243 (14) | 0.92712 (10) | 0.86939 (9) | 0.0249 (3) | |
| O6 | 0.71653 (14) | 0.87123 (10) | 0.99842 (8) | 0.0221 (3) | |
| O7 | 1.23078 (14) | 0.76608 (10) | 0.90420 (8) | 0.0239 (3) | |
| O8 | 1.15980 (15) | 0.96135 (11) | 0.90637 (8) | 0.0224 (3) | |
| H8 | 1.218 (3) | 0.900 (2) | 0.9064 (15) | 0.034* | |
| N4 | 0.83342 (17) | 0.85905 (11) | 0.84673 (9) | 0.0177 (3) | |
| N5 | 1.04254 (18) | 0.67834 (12) | 0.88379 (10) | 0.0197 (3) | |
| H5 | 0.950 (3) | 0.6828 (18) | 0.8715 (15) | 0.030* | |
| N6 | 1.06042 (17) | 0.50686 (12) | 0.87478 (11) | 0.0243 (4) | |
| C16 | 0.9849 (2) | 0.86239 (14) | 0.87249 (11) | 0.0179 (4) | |
| C17 | 1.0193 (2) | 0.95255 (14) | 0.88695 (11) | 0.0190 (4) | |
| C18 | 0.9022 (2) | 1.04731 (14) | 0.88701 (11) | 0.0186 (4) | |
| C19 | 0.9434 (2) | 1.14325 (15) | 0.88329 (12) | 0.0223 (4) | |
| H19A | 1.0489 | 1.1488 | 0.8781 | 0.027* | |
| C20 | 0.8303 (2) | 1.23013 (15) | 0.88712 (13) | 0.0251 (4) | |
| H20A | 0.8590 | 1.2953 | 0.8839 | 0.030* | |
| C21 | 0.6755 (2) | 1.22358 (15) | 0.89559 (12) | 0.0236 (4) | |
| H21A | 0.5993 | 1.2840 | 0.8983 | 0.028* | |
| C22 | 0.6316 (2) | 1.12915 (14) | 0.90012 (12) | 0.0205 (4) | |
| H22A | 0.5259 | 1.1241 | 0.9059 | 0.025* | |
| C23 | 0.7451 (2) | 1.04244 (14) | 0.89609 (11) | 0.0177 (4) | |
| C24 | 0.8156 (2) | 0.88255 (15) | 0.74935 (12) | 0.0234 (4) | |
| H24A | 0.7116 | 0.8770 | 0.7362 | 0.035* | |
| H24B | 0.8914 | 0.8335 | 0.7198 | 0.035* | |
| H24C | 0.8322 | 0.9527 | 0.7276 | 0.035* | |
| C25 | 1.0965 (2) | 0.76629 (14) | 0.88733 (11) | 0.0195 (4) | |
| C26 | 1.1243 (2) | 0.57710 (14) | 0.90290 (12) | 0.0190 (4) | |
| C27 | 1.1306 (2) | 0.40771 (16) | 0.89178 (16) | 0.0338 (5) | |
| H27A | 1.0865 | 0.3576 | 0.8708 | 0.041* | |
| C28 | 1.2628 (2) | 0.37473 (16) | 0.93788 (16) | 0.0339 (5) | |
| H28A | 1.3088 | 0.3038 | 0.9490 | 0.041* | |
| C29 | 1.3263 (2) | 0.44807 (16) | 0.96739 (14) | 0.0304 (5) | |
| H29A | 1.4172 | 0.4278 | 0.9999 | 0.036* | |
| C30 | 1.2588 (2) | 0.55046 (16) | 0.94990 (13) | 0.0254 (4) | |
| H30A | 1.3025 | 0.6017 | 0.9693 | 0.031* | |
| O9 | 0.72760 (18) | 0.66660 (12) | 0.81992 (11) | 0.0214 (4) | 0.809 (2) |
| O10 | 0.8016 (3) | 0.5013 (2) | 0.8038 (3) | 0.0235 (7) | 0.809 (2) |
| H10 | 0.888 (4) | 0.514 (2) | 0.8249 (19) | 0.035* | 0.809 (2) |
| O11 | 0.47005 (19) | 0.77049 (14) | 0.75304 (11) | 0.0209 (4) | 0.809 (2) |
| H11 | 0.546 (4) | 0.758 (2) | 0.782 (2) | 0.031* | 0.809 (2) |

| | | | | | |
|---|---|---|---|---|---|
| O12 | 0.3599 (3) | 0.3988 (2) | 0.6873 (2) | 0.0234 (6) | 0.809 (2) |
| H12 | 0.272 (4) | 0.407 (3) | 0.672 (2) | 0.035* | 0.809 (2) |
| C31 | 0.5536 (2) | 0.58575 (16) | 0.75879 (14) | 0.0152 (5) | 0.809 (2) |
| C32 | 0.4463 (3) | 0.67789 (19) | 0.73843 (19) | 0.0152 (6) | 0.809 (2) |
| C33 | 0.3109 (3) | 0.67561 (19) | 0.69899 (15) | 0.0185 (5) | 0.809 (2) |
| H33A | 0.2387 | 0.7377 | 0.6840 | 0.022* | 0.809 (2) |
| C34 | 0.2805 (3) | 0.5836 (2) | 0.68143 (17) | 0.0186 (5) | 0.809 (2) |
| H34A | 0.1877 | 0.5830 | 0.6546 | 0.022* | 0.809 (2) |
| C35 | 0.3854 (3) | 0.49164 (17) | 0.70295 (14) | 0.0172 (5) | 0.809 (2) |
| C36 | 0.5210 (5) | 0.4934 (2) | 0.7409 (4) | 0.0163 (7) | 0.809 (2) |
| H36A | 0.5931 | 0.4310 | 0.7551 | 0.020* | 0.809 (2) |
| C37 | 0.6998 (3) | 0.5882 (2) | 0.79668 (14) | 0.0167 (5) | 0.809 (2) |
| O9B | 0.1664 (7) | 0.5901 (5) | 0.6578 (4) | 0.0206 (16) | 0.191 (2) |
| O10B | 0.3138 (14) | 0.4318 (6) | 0.6853 (10) | 0.021 (2) | 0.191 (2) |
| H10B | 0.2402 | 0.4157 | 0.6631 | 0.032* | 0.191 (2) |
| O11B | 0.2617 (7) | 0.7479 (5) | 0.6992 (4) | 0.0197 (15) | 0.191 (2) |
| H11B | 0.2006 | 0.7193 | 0.6775 | 0.030* | 0.191 (2) |
| O12B | 0.7796 (13) | 0.4710 (8) | 0.8181 (12) | 0.023 (3) | 0.191 (2) |
| H12B | 0.8381 | 0.5004 | 0.8411 | 0.035* | 0.191 (2) |
| C31B | 0.4054 (8) | 0.5709 (5) | 0.7243 (5) | 0.0140 (14) | 0.191 (2) |
| C32B | 0.3839 (10) | 0.6760 (6) | 0.7300 (8) | 0.011 (2) | 0.191 (2) |
| C33B | 0.4961 (9) | 0.7113 (8) | 0.7689 (7) | 0.0185 (18) | 0.191 (2) |
| H33B | 0.4817 | 0.7822 | 0.7743 | 0.022* | 0.191 (2) |
| C34B | 0.6284 (10) | 0.6449 (6) | 0.7999 (6) | 0.0200 (17) | 0.191 (2) |
| H34B | 0.7037 | 0.6701 | 0.8263 | 0.024* | 0.191 (2) |
| C35B | 0.6496 (9) | 0.5409 (6) | 0.7919 (6) | 0.0181 (17) | 0.191 (2) |
| C36B | 0.5395 (19) | 0.5046 (9) | 0.7541 (17) | 0.016 (3) | 0.191 (2) |
| H36B | 0.5550 | 0.4338 | 0.7484 | 0.019* | 0.191 (2) |
| C37B | 0.2857 (10) | 0.5323 (6) | 0.6866 (7) | 0.017 (2) | 0.191 (2) |

*Atomic displacement parameters (Å²)*

| | $U^{11}$ | $U^{22}$ | $U^{33}$ | $U^{12}$ | $U^{13}$ | $U^{23}$ |
|---|---|---|---|---|---|---|
| S1 | 0.01315 (19) | 0.0118 (2) | 0.0172 (2) | −0.00249 (15) | −0.00408 (15) | −0.00194 (15) |
| O1 | 0.0190 (6) | 0.0134 (6) | 0.0248 (6) | −0.0051 (5) | −0.0039 (5) | −0.0020 (5) |
| O2 | 0.0183 (6) | 0.0175 (6) | 0.0166 (6) | −0.0050 (5) | −0.0041 (5) | −0.0019 (5) |
| O3 | 0.0139 (6) | 0.0157 (6) | 0.0277 (7) | −0.0021 (5) | −0.0080 (5) | −0.0021 (5) |
| O4 | 0.0145 (6) | 0.0142 (6) | 0.0259 (6) | −0.0031 (5) | −0.0062 (5) | −0.0029 (5) |
| N1 | 0.0128 (7) | 0.0118 (7) | 0.0193 (7) | −0.0025 (5) | −0.0020 (6) | −0.0015 (6) |
| N2 | 0.0112 (7) | 0.0134 (7) | 0.0212 (7) | −0.0022 (6) | −0.0049 (6) | −0.0010 (6) |
| N3 | 0.0146 (7) | 0.0135 (7) | 0.0193 (7) | −0.0040 (6) | −0.0042 (6) | −0.0025 (6) |
| C1 | 0.0148 (8) | 0.0126 (8) | 0.0170 (8) | −0.0037 (7) | −0.0024 (6) | −0.0020 (6) |
| C2 | 0.0155 (8) | 0.0143 (9) | 0.0136 (8) | −0.0025 (7) | −0.0016 (6) | −0.0015 (6) |
| C3 | 0.0130 (8) | 0.0151 (9) | 0.0147 (8) | −0.0021 (7) | −0.0016 (6) | −0.0007 (6) |
| C4 | 0.0160 (8) | 0.0166 (9) | 0.0191 (9) | −0.0042 (7) | −0.0039 (7) | −0.0019 (7) |
| C5 | 0.0167 (9) | 0.0211 (10) | 0.0231 (9) | −0.0019 (7) | −0.0081 (7) | 0.0022 (7) |
| C6 | 0.0183 (9) | 0.0156 (9) | 0.0275 (10) | 0.0019 (7) | −0.0046 (7) | 0.0003 (7) |
| C7 | 0.0202 (9) | 0.0153 (9) | 0.0202 (9) | −0.0028 (7) | −0.0028 (7) | −0.0024 (7) |

| | | | | | | |
|---|---|---|---|---|---|---|
| C8 | 0.0124 (8) | 0.0167 (9) | 0.0148 (8) | −0.0019 (7) | −0.0022 (6) | −0.0014 (7) |
| C9 | 0.0193 (9) | 0.0186 (9) | 0.0228 (9) | −0.0055 (7) | 0.0025 (7) | −0.0023 (7) |
| C10 | 0.0148 (8) | 0.0141 (9) | 0.0147 (8) | −0.0038 (7) | −0.0013 (6) | −0.0024 (6) |
| C11 | 0.0129 (8) | 0.0150 (8) | 0.0128 (8) | −0.0021 (6) | −0.0002 (6) | −0.0008 (6) |
| C12 | 0.0155 (8) | 0.0162 (9) | 0.0197 (9) | −0.0007 (7) | −0.0047 (7) | −0.0002 (7) |
| C13 | 0.0181 (9) | 0.0138 (9) | 0.0205 (9) | 0.0003 (7) | −0.0018 (7) | −0.0024 (7) |
| C14 | 0.0183 (8) | 0.0158 (9) | 0.0162 (8) | −0.0050 (7) | 0.0007 (7) | −0.0038 (7) |
| C15 | 0.0126 (8) | 0.0185 (9) | 0.0175 (8) | −0.0041 (7) | −0.0022 (6) | −0.0031 (7) |
| S2 | 0.0170 (2) | 0.0154 (2) | 0.0212 (2) | −0.00564 (16) | −0.00270 (16) | −0.00123 (16) |
| O5 | 0.0197 (7) | 0.0201 (7) | 0.0361 (8) | −0.0052 (5) | −0.0079 (6) | −0.0028 (6) |
| O6 | 0.0242 (7) | 0.0200 (7) | 0.0218 (7) | −0.0076 (5) | 0.0007 (5) | 0.0004 (5) |
| O7 | 0.0175 (6) | 0.0289 (7) | 0.0258 (7) | −0.0037 (5) | −0.0018 (5) | −0.0063 (6) |
| O8 | 0.0186 (6) | 0.0261 (7) | 0.0245 (7) | −0.0079 (5) | −0.0030 (5) | −0.0043 (6) |
| N4 | 0.0197 (8) | 0.0170 (8) | 0.0179 (7) | −0.0054 (6) | −0.0051 (6) | −0.0023 (6) |
| N5 | 0.0157 (7) | 0.0179 (8) | 0.0245 (8) | −0.0002 (6) | −0.0042 (6) | −0.0022 (6) |
| N6 | 0.0168 (8) | 0.0185 (8) | 0.0365 (9) | −0.0050 (6) | −0.0032 (7) | 0.0021 (7) |
| C16 | 0.0182 (9) | 0.0206 (9) | 0.0157 (8) | −0.0052 (7) | −0.0021 (7) | −0.0027 (7) |
| C17 | 0.0196 (9) | 0.0249 (10) | 0.0139 (8) | −0.0088 (7) | −0.0003 (7) | −0.0019 (7) |
| C18 | 0.0228 (9) | 0.0205 (9) | 0.0140 (8) | −0.0073 (7) | −0.0004 (7) | −0.0031 (7) |
| C19 | 0.0256 (10) | 0.0252 (10) | 0.0192 (9) | −0.0121 (8) | 0.0015 (7) | −0.0049 (7) |
| C20 | 0.0345 (11) | 0.0198 (10) | 0.0243 (10) | −0.0126 (8) | 0.0030 (8) | −0.0058 (8) |
| C21 | 0.0297 (10) | 0.0196 (10) | 0.0218 (9) | −0.0046 (8) | 0.0026 (8) | −0.0056 (7) |
| C22 | 0.0225 (9) | 0.0206 (10) | 0.0188 (9) | −0.0055 (7) | 0.0019 (7) | −0.0034 (7) |
| C23 | 0.0228 (9) | 0.0179 (9) | 0.0139 (8) | −0.0076 (7) | −0.0015 (7) | −0.0015 (7) |
| C24 | 0.0281 (10) | 0.0251 (10) | 0.0183 (9) | −0.0062 (8) | −0.0067 (7) | −0.0031 (7) |
| C25 | 0.0195 (9) | 0.0253 (10) | 0.0137 (8) | −0.0043 (7) | 0.0004 (7) | −0.0034 (7) |
| C26 | 0.0154 (8) | 0.0204 (9) | 0.0190 (9) | −0.0015 (7) | 0.0015 (7) | −0.0001 (7) |
| C27 | 0.0214 (10) | 0.0198 (10) | 0.0591 (14) | −0.0076 (8) | −0.0027 (9) | 0.0023 (9) |
| C28 | 0.0195 (10) | 0.0210 (11) | 0.0543 (14) | −0.0003 (8) | 0.0019 (9) | 0.0087 (9) |
| C29 | 0.0178 (9) | 0.0333 (12) | 0.0338 (11) | 0.0011 (8) | −0.0035 (8) | 0.0069 (9) |
| C30 | 0.0217 (9) | 0.0272 (11) | 0.0255 (10) | −0.0006 (8) | −0.0045 (8) | −0.0020 (8) |
| O9 | 0.0207 (9) | 0.0158 (8) | 0.0298 (9) | −0.0042 (6) | −0.0090 (7) | −0.0047 (6) |
| O10 | 0.0165 (11) | 0.0150 (14) | 0.0404 (16) | −0.0010 (10) | −0.0108 (10) | −0.0061 (12) |
| O11 | 0.0210 (9) | 0.0140 (9) | 0.0291 (9) | −0.0034 (7) | −0.0057 (7) | −0.0047 (7) |
| O12 | 0.0183 (14) | 0.0172 (14) | 0.0385 (11) | −0.0057 (10) | −0.0092 (11) | −0.0085 (12) |
| C31 | 0.0151 (10) | 0.0154 (11) | 0.0150 (10) | −0.0035 (8) | −0.0011 (8) | −0.0010 (8) |
| C32 | 0.0178 (14) | 0.0120 (11) | 0.0167 (12) | −0.0052 (11) | −0.0006 (12) | −0.0022 (9) |
| C33 | 0.0155 (12) | 0.0170 (13) | 0.0212 (12) | 0.0009 (10) | −0.0034 (9) | −0.0014 (9) |
| C34 | 0.0144 (12) | 0.0208 (14) | 0.0200 (11) | −0.0009 (11) | −0.0030 (9) | −0.0035 (12) |
| C35 | 0.0168 (11) | 0.0168 (11) | 0.0188 (10) | −0.0049 (9) | 0.0001 (8) | −0.0034 (9) |
| C36 | 0.0169 (14) | 0.0128 (13) | 0.019 (2) | −0.0031 (10) | −0.0016 (10) | −0.0014 (10) |
| C37 | 0.0178 (12) | 0.0158 (13) | 0.0164 (11) | −0.0036 (11) | −0.0018 (9) | −0.0013 (9) |
| O9B | 0.017 (3) | 0.017 (3) | 0.029 (4) | −0.004 (3) | −0.012 (3) | −0.002 (3) |
| O10B | 0.021 (6) | 0.013 (5) | 0.031 (4) | −0.006 (4) | −0.006 (4) | −0.005 (4) |
| O11B | 0.012 (3) | 0.017 (4) | 0.030 (4) | 0.001 (3) | −0.015 (3) | −0.002 (3) |
| O12B | 0.018 (5) | 0.015 (6) | 0.039 (6) | −0.004 (4) | −0.014 (4) | −0.002 (5) |
| C31B | 0.014 (3) | 0.013 (3) | 0.015 (3) | −0.001 (2) | −0.002 (2) | −0.005 (2) |
| C32B | 0.011 (4) | 0.008 (3) | 0.016 (3) | −0.003 (3) | −0.006 (4) | −0.004 (3) |

| | | | | | | |
|---|---|---|---|---|---|---|
| C33B | 0.019 (4) | 0.013 (4) | 0.024 (4) | −0.006 (4) | 0.002 (3) | −0.003 (4) |
| C34B | 0.017 (4) | 0.017 (4) | 0.024 (3) | −0.003 (3) | 0.000 (3) | −0.003 (3) |
| C35B | 0.013 (3) | 0.021 (4) | 0.021 (3) | −0.004 (3) | −0.006 (3) | 0.000 (3) |
| C36B | 0.012 (4) | 0.018 (4) | 0.017 (4) | 0.000 (4) | −0.003 (3) | −0.001 (4) |
| C37B | 0.019 (4) | 0.014 (4) | 0.018 (4) | 0.002 (4) | 0.001 (3) | −0.005 (4) |

*Geometric parameters (Å, º)*

| | | | |
|---|---|---|---|
| S1—O2 | 1.4333 (12) | C18—C19 | 1.397 (3) |
| S1—O1 | 1.4361 (12) | C18—C23 | 1.404 (3) |
| S1—N1 | 1.6299 (14) | C19—C20 | 1.383 (3) |
| S1—C8 | 1.7646 (17) | C19—H19A | 0.9500 |
| O3—C10 | 1.241 (2) | C20—C21 | 1.389 (3) |
| O4—C2 | 1.285 (2) | C20—H20A | 0.9500 |
| N1—C1 | 1.449 (2) | C21—C22 | 1.387 (3) |
| N1—C9 | 1.477 (2) | C21—H21A | 0.9500 |
| N2—C11 | 1.363 (2) | C22—C23 | 1.384 (3) |
| N2—C10 | 1.392 (2) | C22—H22A | 0.9500 |
| N2—H2 | 0.88 (2) | C24—H24A | 0.9800 |
| N3—C11 | 1.344 (2) | C24—H24B | 0.9800 |
| N3—C12 | 1.348 (2) | C24—H24C | 0.9800 |
| N3—H3 | 0.78 (2) | C26—C30 | 1.396 (3) |
| C1—C2 | 1.395 (2) | C27—C28 | 1.374 (3) |
| C1—C10 | 1.437 (2) | C27—H27A | 0.9500 |
| C2—C3 | 1.499 (2) | C28—C29 | 1.377 (3) |
| C3—C4 | 1.396 (2) | C28—H28A | 0.9500 |
| C3—C8 | 1.405 (2) | C29—C30 | 1.375 (3) |
| C4—C5 | 1.388 (2) | C29—H29A | 0.9500 |
| C4—H4A | 0.9500 | C30—H30A | 0.9500 |
| C5—C6 | 1.385 (3) | O9—C37 | 1.238 (3) |
| C5—H5A | 0.9500 | O10—C37 | 1.318 (4) |
| C6—C7 | 1.388 (3) | O10—H10 | 0.91 (3) |
| C6—H6A | 0.9500 | O11—C32 | 1.356 (3) |
| C7—C8 | 1.388 (2) | O11—H11 | 0.81 (3) |
| C7—H7A | 0.9500 | O12—C35 | 1.370 (4) |
| C9—H9A | 0.9800 | O12—H12 | 0.81 (3) |
| C9—H9B | 0.9800 | C31—C36 | 1.400 (4) |
| C9—H9C | 0.9800 | C31—C32 | 1.407 (3) |
| C11—C15 | 1.399 (2) | C31—C37 | 1.471 (3) |
| C12—C13 | 1.362 (3) | C32—C33 | 1.395 (4) |
| C12—H12A | 0.9500 | C33—C34 | 1.386 (4) |
| C13—C14 | 1.397 (2) | C33—H33A | 0.9500 |
| C13—H13A | 0.9500 | C34—C35 | 1.396 (3) |
| C14—C15 | 1.377 (2) | C34—H34A | 0.9500 |
| C14—H14A | 0.9500 | C35—C36 | 1.383 (5) |
| C15—H15A | 0.9500 | C36—H36A | 0.9500 |
| S2—O6 | 1.4293 (13) | O9B—C37B | 1.245 (8) |
| S2—O5 | 1.4295 (13) | O10B—C37B | 1.323 (9) |

| | | | |
|---|---|---|---|
| S2—N4 | 1.6428 (15) | O10B—H10B | 0.8400 |
| S2—C23 | 1.7624 (18) | O11B—C32B | 1.356 (8) |
| O7—C25 | 1.238 (2) | O11B—H11B | 0.8400 |
| O8—C17 | 1.337 (2) | O12B—C35B | 1.373 (9) |
| O8—H8 | 0.88 (3) | O12B—H12B | 0.8400 |
| N4—C16 | 1.441 (2) | C31B—C36B | 1.394 (9) |
| N4—C24 | 1.482 (2) | C31B—C32B | 1.400 (8) |
| N5—C25 | 1.369 (2) | C31B—C37B | 1.464 (8) |
| N5—C26 | 1.401 (2) | C32B—C33B | 1.394 (9) |
| N5—H5 | 0.84 (2) | C33B—C34B | 1.388 (9) |
| N6—C26 | 1.334 (2) | C33B—H33B | 0.9500 |
| N6—C27 | 1.343 (3) | C34B—C35B | 1.393 (8) |
| C16—C17 | 1.360 (3) | C34B—H34B | 0.9500 |
| C16—C25 | 1.457 (3) | C35B—C36B | 1.378 (10) |
| C17—C18 | 1.471 (3) | C36B—H36B | 0.9500 |
| | | | |
| O2—S1—O1 | 117.92 (7) | C20—C19—H19A | 120.1 |
| O2—S1—N1 | 108.03 (7) | C18—C19—H19A | 120.1 |
| O1—S1—N1 | 108.36 (7) | C19—C20—C21 | 121.01 (18) |
| O2—S1—C8 | 110.48 (7) | C19—C20—H20A | 119.5 |
| O1—S1—C8 | 109.35 (8) | C21—C20—H20A | 119.5 |
| N1—S1—C8 | 101.39 (8) | C22—C21—C20 | 120.24 (18) |
| C1—N1—C9 | 115.16 (13) | C22—C21—H21A | 119.9 |
| C1—N1—S1 | 114.32 (11) | C20—C21—H21A | 119.9 |
| C9—N1—S1 | 116.52 (11) | C23—C22—C21 | 118.57 (17) |
| C11—N2—C10 | 125.83 (15) | C23—C22—H22A | 120.7 |
| C11—N2—H2 | 121.7 (14) | C21—C22—H22A | 120.7 |
| C10—N2—H2 | 112.4 (14) | C22—C23—C18 | 122.17 (17) |
| C11—N3—C12 | 123.43 (16) | C22—C23—S2 | 120.38 (14) |
| C11—N3—H3 | 117.4 (16) | C18—C23—S2 | 117.37 (14) |
| C12—N3—H3 | 119.1 (16) | N4—C24—H24A | 109.5 |
| C2—C1—C10 | 125.28 (15) | N4—C24—H24B | 109.5 |
| C2—C1—N1 | 121.38 (15) | H24A—C24—H24B | 109.5 |
| C10—C1—N1 | 113.28 (14) | N4—C24—H24C | 109.5 |
| O4—C2—C1 | 123.40 (15) | H24A—C24—H24C | 109.5 |
| O4—C2—C3 | 118.03 (14) | H24B—C24—H24C | 109.5 |
| C1—C2—C3 | 118.55 (15) | O7—C25—N5 | 123.18 (17) |
| C4—C3—C8 | 117.53 (15) | O7—C25—C16 | 120.74 (17) |
| C4—C3—C2 | 120.01 (15) | N5—C25—C16 | 116.05 (16) |
| C8—C3—C2 | 122.46 (15) | N6—C26—C30 | 122.23 (17) |
| C5—C4—C3 | 120.54 (16) | N6—C26—N5 | 114.40 (16) |
| C5—C4—H4A | 119.7 | C30—C26—N5 | 123.35 (17) |
| C3—C4—H4A | 119.7 | N6—C27—C28 | 123.5 (2) |
| C6—C5—C4 | 120.85 (16) | N6—C27—H27A | 118.2 |
| C6—C5—H5A | 119.6 | C28—C27—H27A | 118.2 |
| C4—C5—H5A | 119.6 | C27—C28—C29 | 117.72 (19) |
| C5—C6—C7 | 120.00 (16) | C27—C28—H28A | 121.1 |
| C5—C6—H6A | 120.0 | C29—C28—H28A | 121.1 |

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| C7—C6—H6A | 120.0 | C30—C29—C28 | 120.25 (19) |
| C8—C7—C6 | 118.87 (16) | C30—C29—H29A | 119.9 |
| C8—C7—H7A | 120.6 | C28—C29—H29A | 119.9 |
| C6—C7—H7A | 120.6 | C29—C30—C26 | 118.22 (19) |
| C7—C8—C3 | 122.22 (15) | C29—C30—H30A | 120.9 |
| C7—C8—S1 | 120.18 (13) | C26—C30—H30A | 120.9 |
| C3—C8—S1 | 117.59 (13) | C37—O10—H10 | 107.2 (19) |
| N1—C9—H9A | 109.5 | C32—O11—H11 | 106 (2) |
| N1—C9—H9B | 109.5 | C35—O12—H12 | 108 (3) |
| H9A—C9—H9B | 109.5 | C36—C31—C32 | 119.5 (2) |
| N1—C9—H9C | 109.5 | C36—C31—C37 | 120.9 (2) |
| H9A—C9—H9C | 109.5 | C32—C31—C37 | 119.6 (2) |
| H9B—C9—H9C | 109.5 | O11—C32—C33 | 117.8 (2) |
| O3—C10—N2 | 120.69 (15) | O11—C32—C31 | 123.0 (2) |
| O3—C10—C1 | 123.59 (15) | C33—C32—C31 | 119.2 (2) |
| N2—C10—C1 | 115.71 (14) | C34—C33—C32 | 120.6 (2) |
| N3—C11—N2 | 119.99 (15) | C34—C33—H33A | 119.7 |
| N3—C11—C15 | 117.96 (15) | C32—C33—H33A | 119.7 |
| N2—C11—C15 | 122.04 (15) | C33—C34—C35 | 120.4 (2) |
| N3—C12—C13 | 120.29 (16) | C33—C34—H34A | 119.8 |
| N3—C12—H12A | 119.9 | C35—C34—H34A | 119.8 |
| C13—C12—H12A | 119.9 | O12—C35—C36 | 118.2 (2) |
| C12—C13—C14 | 118.25 (16) | O12—C35—C34 | 122.4 (2) |
| C12—C13—H13A | 120.9 | C36—C35—C34 | 119.4 (2) |
| C14—C13—H13A | 120.9 | C35—C36—C31 | 120.9 (2) |
| C15—C14—C13 | 120.70 (16) | C35—C36—H36A | 119.6 |
| C15—C14—H14A | 119.7 | C31—C36—H36A | 119.6 |
| C13—C14—H14A | 119.7 | O9—C37—O10 | 121.5 (2) |
| C14—C15—C11 | 119.34 (15) | O9—C37—C31 | 122.7 (2) |
| C14—C15—H15A | 120.3 | O10—C37—C31 | 115.8 (2) |
| C11—C15—H15A | 120.3 | C37B—O10B—H10B | 109.5 |
| O6—S2—O5 | 119.45 (8) | C32B—O11B—H11B | 109.5 |
| O6—S2—N4 | 107.35 (8) | C35B—O12B—H12B | 109.5 |
| O5—S2—N4 | 108.47 (8) | C36B—C31B—C32B | 120.0 (7) |
| O6—S2—C23 | 108.59 (8) | C36B—C31B—C37B | 120.9 (7) |
| O5—S2—C23 | 109.83 (8) | C32B—C31B—C37B | 119.1 (6) |
| N4—S2—C23 | 101.66 (8) | O11B—C32B—C33B | 116.5 (7) |
| C17—O8—H8 | 106.5 (16) | O11B—C32B—C31B | 124.8 (7) |
| C16—N4—C24 | 113.57 (14) | C33B—C32B—C31B | 118.6 (7) |
| C16—N4—S2 | 112.35 (11) | C34B—C33B—C32B | 121.3 (8) |
| C24—N4—S2 | 116.08 (12) | C34B—C33B—H33B | 119.4 |
| C25—N5—C26 | 126.35 (16) | C32B—C33B—H33B | 119.4 |
| C25—N5—H5 | 119.4 (16) | C33B—C34B—C35B | 119.4 (8) |
| C26—N5—H5 | 114.2 (16) | C33B—C34B—H34B | 120.3 |
| C26—N6—C27 | 118.03 (17) | C35B—C34B—H34B | 120.3 |
| C17—C16—N4 | 120.42 (16) | O12B—C35B—C36B | 117.0 (9) |
| C17—C16—C25 | 121.07 (16) | O12B—C35B—C34B | 122.9 (9) |
| N4—C16—C25 | 118.42 (15) | C36B—C35B—C34B | 120.1 (7) |

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| O8—C17—C16 | 123.01 (17) | C35B—C36B—C31B | 120.6 (9) |
| O8—C17—C18 | 114.49 (16) | C35B—C36B—H36B | 119.7 |
| C16—C17—C18 | 122.43 (16) | C31B—C36B—H36B | 119.7 |
| C19—C18—C23 | 118.14 (17) | O9B—C37B—O10B | 122.6 (8) |
| C19—C18—C17 | 121.45 (16) | O9B—C37B—C31B | 122.2 (7) |
| C23—C18—C17 | 120.31 (16) | O10B—C37B—C31B | 115.2 (8) |
| C20—C19—C18 | 119.86 (18) | | |

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| O2—S1—N1—C1 | −62.23 (13) | C16—C17—C18—C23 | 17.4 (3) |
| O1—S1—N1—C1 | 168.95 (11) | C23—C18—C19—C20 | −1.0 (3) |
| C8—S1—N1—C1 | 53.93 (13) | C17—C18—C19—C20 | −177.36 (16) |
| O2—S1—N1—C9 | 159.44 (12) | C18—C19—C20—C21 | 0.7 (3) |
| O1—S1—N1—C9 | 30.63 (14) | C19—C20—C21—C22 | −0.2 (3) |
| C8—S1—N1—C9 | −84.39 (13) | C20—C21—C22—C23 | 0.1 (3) |
| C9—N1—C1—C2 | 93.30 (19) | C21—C22—C23—C18 | −0.4 (3) |
| S1—N1—C1—C2 | −45.60 (19) | C21—C22—C23—S2 | 176.15 (13) |
| C9—N1—C1—C10 | −84.02 (18) | C19—C18—C23—C22 | 0.9 (3) |
| S1—N1—C1—C10 | 137.08 (13) | C17—C18—C23—C22 | 177.31 (16) |
| C10—C1—C2—O4 | 1.0 (3) | C19—C18—C23—S2 | −175.77 (13) |
| N1—C1—C2—O4 | −176.02 (15) | C17—C18—C23—S2 | 0.6 (2) |
| C10—C1—C2—C3 | −177.70 (15) | O6—S2—C23—C22 | −97.44 (15) |
| N1—C1—C2—C3 | 5.3 (2) | O5—S2—C23—C22 | 34.84 (17) |
| O4—C2—C3—C4 | 19.5 (2) | N4—S2—C23—C22 | 149.56 (14) |
| C1—C2—C3—C4 | −161.71 (16) | O6—S2—C23—C18 | 79.31 (15) |
| O4—C2—C3—C8 | −160.13 (15) | O5—S2—C23—C18 | −148.41 (13) |
| C1—C2—C3—C8 | 18.6 (2) | N4—S2—C23—C18 | −33.69 (15) |
| C8—C3—C4—C5 | −0.6 (2) | C26—N5—C25—O7 | 3.8 (3) |
| C2—C3—C4—C5 | 179.71 (16) | C26—N5—C25—C16 | −174.46 (16) |
| C3—C4—C5—C6 | 0.4 (3) | C17—C16—C25—O7 | −7.8 (3) |
| C4—C5—C6—C7 | −0.1 (3) | N4—C16—C25—O7 | 175.54 (15) |
| C5—C6—C7—C8 | 0.0 (3) | C17—C16—C25—N5 | 170.47 (16) |
| C6—C7—C8—C3 | −0.2 (3) | N4—C16—C25—N5 | −6.2 (2) |
| C6—C7—C8—S1 | −178.95 (14) | C27—N6—C26—C30 | −0.9 (3) |
| C4—C3—C8—C7 | 0.5 (2) | C27—N6—C26—N5 | −178.99 (17) |
| C2—C3—C8—C7 | −179.81 (15) | C25—N5—C26—N6 | −164.95 (16) |
| C4—C3—C8—S1 | 179.26 (13) | C25—N5—C26—C30 | 17.0 (3) |
| C2—C3—C8—S1 | −1.1 (2) | C26—N6—C27—C28 | 1.2 (3) |
| O2—S1—C8—C7 | −99.16 (15) | N6—C27—C28—C29 | −0.5 (3) |
| O1—S1—C8—C7 | 32.21 (16) | C27—C28—C29—C30 | −0.6 (3) |
| N1—S1—C8—C7 | 146.49 (14) | C28—C29—C30—C26 | 0.8 (3) |
| O2—S1—C8—C3 | 82.06 (14) | N6—C26—C30—C29 | −0.1 (3) |
| O1—S1—C8—C3 | −146.57 (13) | N5—C26—C30—C29 | 177.80 (17) |
| N1—S1—C8—C3 | −32.29 (15) | C36—C31—C32—O11 | −179.4 (3) |
| C11—N2—C10—O3 | 4.3 (3) | C37—C31—C32—O11 | −0.8 (4) |
| C11—N2—C10—C1 | −174.59 (15) | C36—C31—C32—C33 | −1.4 (4) |
| C2—C1—C10—O3 | 176.72 (16) | C37—C31—C32—C33 | 177.3 (2) |
| N1—C1—C10—O3 | −6.1 (2) | O11—C32—C33—C34 | 179.3 (2) |
| C2—C1—C10—N2 | −4.4 (2) | C31—C32—C33—C34 | 1.2 (4) |

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| N1—C1—C10—N2 | 172.79 (14) | C32—C33—C34—C35 | −0.1 (4) |
| C12—N3—C11—N2 | 178.15 (16) | C33—C34—C35—O12 | 179.6 (3) |
| C12—N3—C11—C15 | −1.3 (2) | C33—C34—C35—C36 | −0.8 (4) |
| C10—N2—C11—N3 | −2.9 (3) | O12—C35—C36—C31 | −179.8 (4) |
| C10—N2—C11—C15 | 176.52 (15) | C34—C35—C36—C31 | 0.6 (6) |
| C11—N3—C12—C13 | 1.7 (3) | C32—C31—C36—C35 | 0.5 (6) |
| N3—C12—C13—C14 | −0.6 (3) | C37—C31—C36—C35 | −178.1 (3) |
| C12—C13—C14—C15 | −0.8 (3) | C36—C31—C37—O9 | −174.1 (3) |
| C13—C14—C15—C11 | 1.2 (3) | C32—C31—C37—O9 | 7.3 (3) |
| N3—C11—C15—C14 | −0.2 (2) | C36—C31—C37—O10 | 6.5 (4) |
| N2—C11—C15—C14 | −179.62 (15) | C32—C31—C37—O10 | −172.1 (3) |
| O6—S2—N4—C16 | −59.05 (13) | C36B—C31B—C32B—O11B | 176.7 (16) |
| O5—S2—N4—C16 | 170.60 (12) | C37B—C31B—C32B—O11B | −3.3 (16) |
| C23—S2—N4—C16 | 54.87 (13) | C36B—C31B—C32B—C33B | −2 (2) |
| O6—S2—N4—C24 | 167.90 (12) | C37B—C31B—C32B—C33B | 177.7 (10) |
| O5—S2—N4—C24 | 37.55 (15) | O11B—C32B—C33B—C34B | −177.8 (9) |
| C23—S2—N4—C24 | −78.18 (14) | C31B—C32B—C33B—C34B | 1.3 (17) |
| C24—N4—C16—C17 | 87.5 (2) | C32B—C33B—C34B—C35B | 0.1 (16) |
| S2—N4—C16—C17 | −46.7 (2) | C33B—C34B—C35B—O12B | 177.7 (12) |
| C24—N4—C16—C25 | −95.81 (18) | C33B—C34B—C35B—C36B | 0 (2) |
| S2—N4—C16—C25 | 129.92 (14) | O12B—C35B—C36B—C31B | −178.8 (17) |
| N4—C16—C17—O8 | −176.38 (15) | C34B—C35B—C36B—C31B | −1 (3) |
| C25—C16—C17—O8 | 7.1 (3) | C32B—C31B—C36B—C35B | 2 (3) |
| N4—C16—C17—C18 | 6.9 (3) | C37B—C31B—C36B—C35B | −178.1 (16) |
| C25—C16—C17—C18 | −169.68 (16) | C36B—C31B—C37B—O9B | −178.4 (16) |
| O8—C17—C18—C19 | 16.6 (2) | C32B—C31B—C37B—O9B | 1.5 (15) |
| C16—C17—C18—C19 | −166.38 (17) | C36B—C31B—C37B—O10B | 1 (2) |
| O8—C17—C18—C23 | −159.65 (16) | C32B—C31B—C37B—O10B | −178.7 (11) |

*Hydrogen-bond geometry (Å, º)*

| *D*—H···*A* | *D*—H | H···*A* | *D*···*A* | *D*—H···*A* |
|---|---|---|---|---|
| N2—H2···O4 | 0.88 (2) | 1.85 (2) | 2.6169 (18) | 145.2 (19) |
| N3—H3···O3 | 0.78 (2) | 1.99 (2) | 2.6027 (19) | 135 (2) |
| N3—H3···O3$^{i}$ | 0.78 (2) | 2.19 (2) | 2.8034 (19) | 136 (2) |
| O8—H8···O7 | 0.88 (3) | 1.79 (3) | 2.5722 (19) | 148 (2) |
| N5—H5···O9 | 0.84 (2) | 2.25 (2) | 3.074 (2) | 167 (2) |
| O10—H10···N6 | 0.91 (3) | 1.74 (3) | 2.637 (3) | 167 (3) |
| O11—H11···O9 | 0.81 (3) | 1.89 (3) | 2.614 (2) | 148 (3) |
| O12—H12···O4$^{ii}$ | 0.81 (3) | 1.94 (3) | 2.738 (3) | 164 (4) |
| O10*B*—H10*B*···O4$^{ii}$ | 0.84 | 1.67 | 2.508 (12) | 172 |
| O11*B*—H11*B*···O2$^{i}$ | 0.84 | 2.57 | 3.061 (6) | 118 |
| O11*B*—H11*B*···O9*B* | 0.84 | 1.89 | 2.614 (9) | 143 |
| O12*B*—H12*B*···N6 | 0.84 | 2.10 | 2.856 (12) | 149 |

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