

Acta Crystallographica Section E

Structure Reports

Online

ISSN 1600-5368

1-Benzoyl-3-(naphthalen-1-yl)thiourea

 Sohail Saeed,^{a*} Naghmana Rashid,^a Jerry P Jasinski^b and James A Golen^b
^aDepartment of Chemistry, Research Complex, Allama Iqbal Open University, Islamabad 44000, Pakistan, and ^bDepartment of Chemistry, Keene State College, 229 Main Street, Keene, NH 03435-2001, USA

Correspondence e-mail: sohail262001@yahoo.com

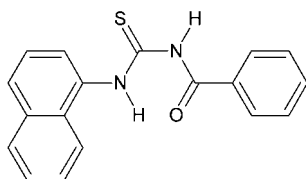
Received 25 October 2011; accepted 31 October 2011

 Key indicators: single-crystal X-ray study; $T = 173$ K; mean $\sigma(\text{C}-\text{C}) = 0.004$ Å; R factor = 0.062; wR factor = 0.135; data-to-parameter ratio = 16.9.

In the title compound, $\text{C}_{18}\text{H}_{14}\text{N}_2\text{OS}$, the dihedral angle between the mean planes of the 3-naphthyl and 1-benzoyl rings is $20.7(1)^\circ$. The crystal packing is stabilized by weak $\text{N}-\text{H}\cdots\text{S}$ interactions. Intramolecular $\text{N}-\text{H}\cdots\text{O}$ and $\text{C}-\text{H}\cdots\text{O}$ hydrogen bonding is also observed.

Related literature

For the biological activity of thiourea in medicinal chemistry, see: Saeed *et al.* (2009, 2010a,b); Maddani & Prabhu (2010). For the use of thiourea derivatives in organocatalysis, see: Jung & Kim (2008) and for their use as curing agents for epoxy resins, see: Saeed *et al.* (2011). For the use of thioureas as ligands in coordination chemistry, see: Burrows *et al.* (1999); Henderson *et al.* (2002); Schuster *et al.* (1990). For the pesticidal activity of acyl thioureas, see: Che *et al.* (1999). For standard bond lengths, see Allen *et al.* (1987).



Experimental

Crystal data

 $\text{C}_{18}\text{H}_{14}\text{N}_2\text{OS}$
 $M_r = 306.37$
 Monoclinic, $P2_1/n$
 $a = 9.7368(14)$ Å
 $b = 5.2256(10)$ Å
 $c = 28.619(4)$ Å
 $\beta = 92.126(12)^\circ$
 $V = 1455.2(4)$ Å³
 $Z = 4$
 Mo $K\alpha$ radiation
 $\mu = 0.23$ mm⁻¹
 $T = 173$ K
 $0.35 \times 0.08 \times 0.08$ mm

Data collection

 Oxford Diffraction Xcalibur Eos Gemini diffractometer
 Absorption correction: multi-scan (*CrysAlis RED*; Oxford Diffraction, 2010)
 $T_{\min} = 0.925$, $T_{\max} = 0.982$
 12731 measured reflections
 3460 independent reflections
 2206 reflections with $I > 2\sigma(I)$
 $R_{\text{int}} = 0.082$

Refinement

 $R[F^2 > 2\sigma(F^2)] = 0.062$
 $wR(F^2) = 0.135$
 $S = 1.05$
 3460 reflections
 205 parameters
 2 restraints
 H atoms treated by a mixture of independent and constrained refinement
 $\Delta\rho_{\text{max}} = 0.25$ e Å⁻³
 $\Delta\rho_{\text{min}} = -0.36$ e Å⁻³

Table 1

Hydrogen-bond geometry (Å, °).

$D-\text{H}\cdots A$	$D-\text{H}$	$\text{H}\cdots A$	$D\cdots A$	$D-\text{H}\cdots A$
$\text{N2}-\text{H2}\cdots\text{O1}$	0.86 (2)	1.85 (2)	2.600 (3)	144 (2)
$\text{N1}-\text{H1}\cdots\text{S1}^i$	0.86 (2)	2.80 (2)	3.591 (2)	153 (2)
$\text{C15}-\text{H15A}\cdots\text{O1}$	0.95	2.51	3.411 (3)	159

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

Data collection: *CrysAlis PRO* (Oxford Diffraction, 2010); cell refinement: *CrysAlis PRO*; data reduction: *CrysAlis RED* (Oxford Diffraction, 2010); program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *SHELXTL* (Sheldrick, 2008); software used to prepare material for publication: *SHELXTL*.

JPJ acknowledges the NSF-MRI program (grant No-CHE1039027) for funds to purchase the X-ray diffractometer.

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: FK2043).

References

- Allen, F. H., Kennard, O., Watson, D. G., Brammer, L., Orpen, A. G. & Taylor, R. (1987). *J. Chem. Soc. Perkin Trans. 2*, pp. S1–19.
- Burrows, A. D., Colman, M. D. & Mahon, M. F. (1999). *Polyhedron*, **18**, 2665–2671.
- Che, D.-J., Li, G., Yao, X.-L., Wu, Q.-J., Wang, W.-L. & Zhu, Y. (1999). *J. Organomet. Chem.* **584**, 190–196.
- Henderson, W., Nicholson, B. K., Dinger, M. B. & Bennett, R. L. (2002). *Inorg. Chim. Acta*, **338**, 210–218.
- Jung, S. H. & Kim, D. Y. (2008). *Tetrahedron Lett.* **49**, 5527–5530.
- Maddani, M. R. & Prabhu, K. R. (2010). *J. Org. Chem.* **75**, 2327–2332.
- Oxford Diffraction (2010). *CrysAlis PRO* and *CrysAlis RED*. Oxford Diffraction Ltd, Yarnton, England.
- Saeed, S., Rashid, N., Hussain, R. & Jones, P. G. (2011). *Eur. J. Chem.* **2**, 77–82.
- Saeed, S., Rashid, N., Hussain, R., Jones, P. G. & Bhatti, M. H. (2010b). *Cent. Eur. J. Chem.* **8**, 550–558.
- Saeed, S., Rashid, N., Jones, P. G., Ali, M. & Hussain, R. (2010a). *Eur. J. Med. Chem.* **45**, 1323–1331.
- Saeed, S., Rashid, N., Tahir, A. & Jones, P. G. (2009). *Acta Cryst.* **E65**, o1870–o1871.
- Schuster, M., Kugler, B. & Konig, K. H. (1990). *Fresenius J. Anal. Chem.* **338**, 717–720.
- Sheldrick, G. M. (2008). *Acta Cryst.* **A64**, 112–122.

supporting information

Acta Cryst. (2011). E67, o3187 [https://doi.org/10.1107/S160053681104582X]

1-Benzoyl-3-(naphthalen-1-yl)thiourea

Sohail Saeed, Naghmana Rashid, Jerry P Jasinski and James A Golen

S1. Comment

Thioureas are the subject of significant interest because of their usefulness in medicinal chemistry due to their biological activity as fungicides (Saeed *et al.*, 2010a), anticancer (Saeed *et al.*, 2010b), herbicides, rodenticides and phenoloxidase enzymatic inhibitors (Maddani & Prabhu, 2010). Recently, thiourea derivatives have found use in organocatalysis (Jung & Kim, 2008). Amino-thiourea derivatives (Saeed *et al.*, 2009) and their transition metal complexes are used as curing agents for epoxy resins (Saeed *et al.*, 2011). Thioureas have a long history as a ligand in coordination chemistry and coordinate readily to a metal *via* sulfur and oxygen (Burrows *et al.*, 1999). These hard and soft donor atoms provide a multitude of bonding possibilities (Henderson *et al.*, 2002). Hydrogen bonding behavior of some thioureas have been investigated and it is found that intramolecular hydrogen bonds between the carbonyl oxygen and a nitrogen atom is common. The complexing capacity of thiourea derivatives has been reported (Schuster *et al.*, 1990). Also, some acyl thioureas have been found to possess pesticidal activities and promote plant growth while others have been shown to have a notable positive effect on the germination of maize seeds and on the chlorophyll contents in seedling leaves (Che *et al.*, 1999). With the simultaneous presence of S, N and O electron donors, the versatility and behavior of acylthioureas as building blocks in polydentate ligands for metal ions have become a recent topic of interest. Substituted acylthiourea ligands might act as monodentate sulfur donors, bidentate oxygen and nitrogen donors. In continuation of our research program concerned with structural modification of biologically active thiourea derivatives and their transition metal complexes, we aim to incorporate the aliphatic and aromatic moieties in the substituted phenyl nucleus with thiourea functionality to obtain new functions in an attempt to improve the antimicrobial profile of these compounds. In view of the importance of thiourea derivatives, the crystal structure of the title compound, C₁₈H₁₄N₂O_S, (I), is reported.

In the title compound, (I), the dihedral angle between the mean planes of the 3-naphthyl and 1-benzoyl rings is 20.7 (1)^o (Fig. 1). Crystal packing is stabilized by weak N1—H1...S1 intermolecular interactions (Table 1, Fig. 2). N2—H2...O1 intramolecular hydrogen bonds are also observed (Table 1).

S2. Experimental

A solution of benzoyl chloride (0.01 mol) in anhydrous acetone (80 ml) and 3% tetrabutylammonium bromide (TBAB) as a phase-transfer catalyst (PTC) in anhydrous acetone was added dropwise to a suspension of dry ammonium thiocyanate (0.01 mol) in acetone (50 ml) and the reaction mixture was refluxed for 45 min. After cooling to room temperature, a solution of 1-naphthylamine (0.01 mol) in anhydrous acetone (25 ml) was added dropwise and the resulting mixture refluxed for 2.5 h. Hydrochloric acid (0.1 N, 300 ml) was added, and the solution was filtered. The solid product was washed with water and purified by re-crystallization from ethanol.

S3. Refinement

All H atoms were positioned with idealized geometry using a riding model, [$C-H = 0.95 \text{ \AA}$ and $U_{iso} = 1.2U_{eq}(C,N)$]. H(N) positions were refined freely.

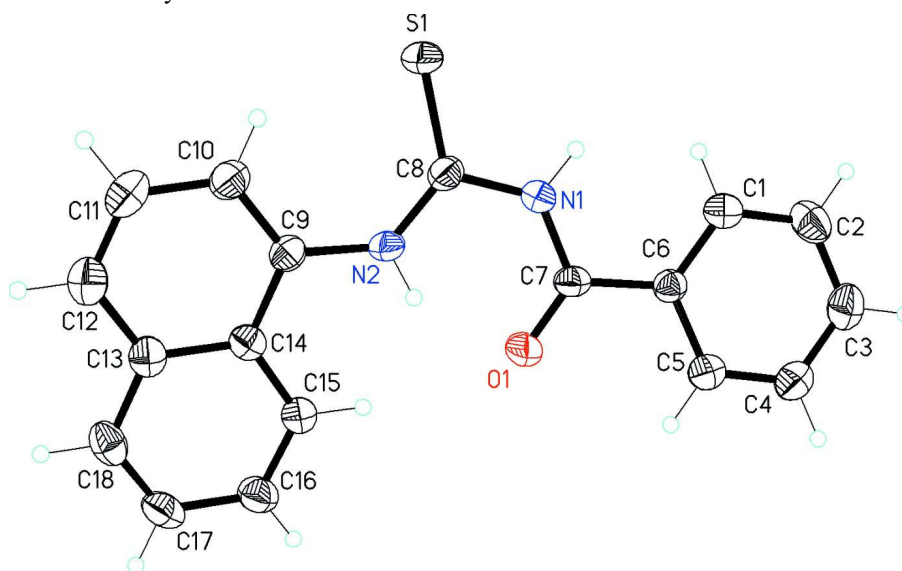


Figure 1

Molecular structure of the title compound showing the atom labeling scheme and 50% probability displacement ellipsoids.

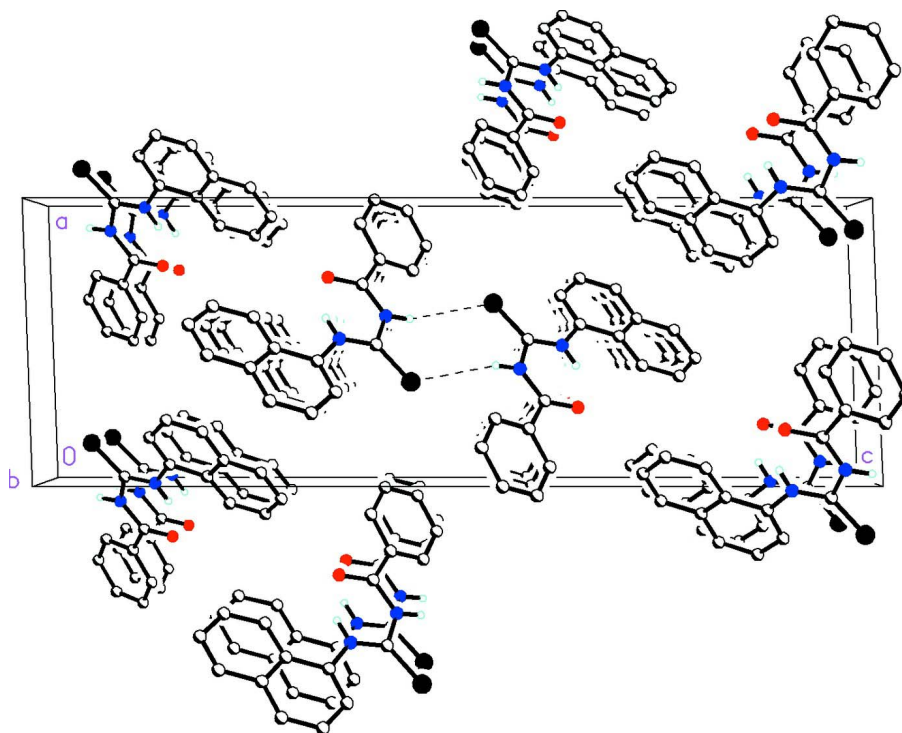


Figure 2

Packing diagram of the title compound viewed along the *b* axis. Dashed lines indicate weak N1—H1...S1 intermolecular interactions.

1-Benzoyl-3-(naphthalen-1-yl)thiourea

Crystal data

C₁₈H₁₄N₂OS $M_r = 306.37$ Monoclinic, $P2_1/n$ Hall symbol: $-P\ 2_1n$ $a = 9.7368\ (14)\ \text{\AA}$ $b = 5.2256\ (10)\ \text{\AA}$ $c = 28.619\ (4)\ \text{\AA}$ $\beta = 92.126\ (12)^\circ$ $V = 1455.2\ (4)\ \text{\AA}^3$ $Z = 4$ $F(000) = 640$ $D_x = 1.398\ \text{Mg m}^{-3}$ Mo $K\alpha$ radiation, $\lambda = 0.71073\ \text{\AA}$

Cell parameters from 1307 reflections

 $\theta = 3.5\text{--}32.3^\circ$ $\mu = 0.23\ \text{mm}^{-1}$ $T = 173\ \text{K}$

Rod, colourless

 $0.35 \times 0.08 \times 0.08\ \text{mm}$

Data collection

Oxford Diffraction Xcalibur Eos Gemini
diffractometer

Radiation source: Enhance (Mo) X-ray Source

Graphite monochromator

Detector resolution: 16.1500 pixels mm^{-1} ω scans

Absorption correction: multi-scan

(CrysAlis RED; Oxford Diffraction, 2010)

 $T_{\min} = 0.925$, $T_{\max} = 0.982$

12731 measured reflections

3460 independent reflections

2206 reflections with $I > 2\sigma(I)$ $R_{\text{int}} = 0.082$ $\theta_{\max} = 27.9^\circ$, $\theta_{\min} = 4.0^\circ$ $h = -12 \rightarrow 12$ $k = -6 \rightarrow 6$ $l = -34 \rightarrow 37$

Refinement

Refinement on F^2

Least-squares matrix: full

 $R[F^2 > 2\sigma(F^2)] = 0.062$ $wR(F^2) = 0.135$ $S = 1.05$

3460 reflections

205 parameters

2 restraints

Primary atom site location: structure-invariant
direct methodsSecondary atom site location: difference Fourier
mapHydrogen site location: inferred from
neighbouring sitesH atoms treated by a mixture of independent
and constrained refinement $w = 1/[\sigma^2(F_o^2) + (0.0427P)^2 + 0.1745P]$ where $P = (F_o^2 + 2F_c^2)/3$ $(\Delta/\sigma)_{\max} = 0.001$ $\Delta\rho_{\max} = 0.25\ \text{e \AA}^{-3}$ $\Delta\rho_{\min} = -0.36\ \text{e \AA}^{-3}$

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 (\AA^2)

	x	y	z	$U_{\text{iso}}^*/U_{\text{eq}}$
S1	0.63172 (7)	0.32704 (17)	0.54848 (3)	0.0446 (2)
O1	0.28206 (18)	0.5576 (4)	0.63936 (6)	0.0395 (5)
N1	0.4117 (2)	0.5657 (4)	0.57512 (7)	0.0300 (5)

H1	0.423 (3)	0.632 (5)	0.5480 (7)	0.036*
N2	0.4889 (2)	0.2542 (4)	0.62654 (7)	0.0280 (5)
H2	0.421 (2)	0.315 (5)	0.6413 (9)	0.034*
C1	0.2515 (3)	1.0084 (5)	0.54374 (9)	0.0313 (6)
H1A	0.3367	0.9825	0.5293	0.038*
C2	0.1632 (3)	1.1966 (5)	0.52738 (10)	0.0413 (7)
H2A	0.1872	1.2993	0.5016	0.050*
C3	0.0399 (3)	1.2359 (6)	0.54847 (11)	0.0427 (7)
H3A	-0.0216	1.3642	0.5369	0.051*
C4	0.0059 (3)	1.0899 (6)	0.58617 (10)	0.0407 (7)
H4A	-0.0784	1.1195	0.6010	0.049*
C5	0.0929 (3)	0.9015 (5)	0.60260 (10)	0.0364 (7)
H5A	0.0685	0.8010	0.6287	0.044*
C6	0.2167 (2)	0.8566 (5)	0.58122 (8)	0.0257 (5)
C7	0.3049 (2)	0.6496 (5)	0.60124 (8)	0.0272 (6)
C8	0.5082 (2)	0.3745 (5)	0.58638 (9)	0.0292 (6)
C9	0.5611 (2)	0.0543 (5)	0.64982 (9)	0.0268 (6)
C10	0.6612 (2)	-0.0889 (5)	0.62991 (9)	0.0331 (6)
H10A	0.6876	-0.0526	0.5990	0.040*
C11	0.7248 (3)	-0.2889 (6)	0.65515 (10)	0.0395 (7)
H11A	0.7964	-0.3833	0.6415	0.047*
C12	0.6859 (3)	-0.3498 (5)	0.69861 (10)	0.0379 (7)
H12A	0.7289	-0.4890	0.7147	0.046*
C13	0.5827 (2)	-0.2094 (5)	0.72029 (9)	0.0297 (6)
C14	0.5195 (2)	-0.0002 (5)	0.69628 (8)	0.0261 (5)
C15	0.4192 (2)	0.1399 (5)	0.71991 (9)	0.0306 (6)
H15A	0.3758	0.2818	0.7048	0.037*
C16	0.3832 (3)	0.0759 (5)	0.76395 (9)	0.0354 (7)
H16A	0.3159	0.1740	0.7791	0.043*
C17	0.4444 (3)	-0.1323 (5)	0.78703 (9)	0.0371 (7)
H17A	0.4181	-0.1770	0.8176	0.045*
C18	0.5413 (3)	-0.2703 (5)	0.76558 (9)	0.0339 (6)
H18A	0.5826	-0.4119	0.7815	0.041*

Atomic displacement parameters (\AA^2)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
S1	0.0376 (4)	0.0694 (6)	0.0275 (4)	0.0166 (4)	0.0126 (3)	0.0087 (4)
O1	0.0407 (11)	0.0504 (12)	0.0283 (11)	0.0153 (10)	0.0124 (8)	0.0099 (9)
N1	0.0283 (11)	0.0381 (13)	0.0239 (12)	0.0030 (10)	0.0044 (9)	0.0055 (10)
N2	0.0248 (11)	0.0373 (13)	0.0223 (11)	0.0044 (10)	0.0066 (9)	0.0002 (9)
C1	0.0320 (14)	0.0316 (15)	0.0304 (15)	-0.0021 (12)	0.0043 (11)	-0.0020 (12)
C2	0.0535 (18)	0.0349 (16)	0.0356 (16)	0.0020 (14)	0.0032 (14)	0.0069 (13)
C3	0.0403 (16)	0.0390 (17)	0.0485 (19)	0.0075 (14)	-0.0042 (14)	0.0044 (14)
C4	0.0312 (15)	0.0450 (18)	0.0460 (18)	0.0060 (14)	0.0049 (13)	0.0053 (14)
C5	0.0315 (14)	0.0396 (17)	0.0384 (16)	0.0038 (13)	0.0063 (12)	0.0069 (13)
C6	0.0249 (13)	0.0277 (14)	0.0245 (13)	-0.0005 (11)	0.0015 (10)	-0.0014 (11)
C7	0.0261 (13)	0.0317 (14)	0.0241 (13)	-0.0010 (11)	0.0055 (10)	-0.0017 (11)

C8	0.0233 (13)	0.0381 (16)	0.0260 (14)	0.0033 (12)	0.0009 (10)	-0.0009 (12)
C9	0.0237 (12)	0.0276 (14)	0.0289 (14)	-0.0001 (11)	0.0003 (10)	-0.0024 (11)
C10	0.0285 (14)	0.0390 (16)	0.0319 (15)	0.0033 (12)	0.0017 (11)	-0.0021 (12)
C11	0.0312 (15)	0.0408 (17)	0.0463 (18)	0.0070 (13)	-0.0002 (13)	-0.0087 (14)
C12	0.0376 (15)	0.0348 (16)	0.0409 (17)	0.0019 (13)	-0.0050 (13)	0.0004 (13)
C13	0.0276 (13)	0.0270 (14)	0.0340 (15)	-0.0040 (11)	-0.0040 (11)	-0.0003 (11)
C14	0.0258 (13)	0.0260 (13)	0.0263 (14)	-0.0058 (11)	-0.0010 (10)	-0.0011 (10)
C15	0.0305 (14)	0.0312 (14)	0.0301 (14)	0.0025 (12)	0.0022 (11)	0.0024 (11)
C16	0.0394 (15)	0.0372 (16)	0.0302 (15)	0.0005 (13)	0.0074 (12)	0.0024 (12)
C17	0.0410 (16)	0.0426 (17)	0.0279 (15)	-0.0078 (14)	0.0029 (12)	0.0076 (13)
C18	0.0381 (15)	0.0286 (14)	0.0342 (15)	-0.0080 (13)	-0.0083 (12)	0.0053 (12)

Geometric parameters (Å, °)

S1—C8	1.667 (2)	C6—C7	1.483 (3)
O1—C7	1.220 (3)	C9—C10	1.370 (3)
N1—C7	1.375 (3)	C9—C14	1.433 (3)
N1—C8	1.401 (3)	C10—C11	1.401 (4)
N1—H1	0.859 (16)	C10—H10A	0.9500
N2—C8	1.329 (3)	C11—C12	1.351 (4)
N2—C9	1.412 (3)	C11—H11A	0.9500
N2—H2	0.861 (16)	C12—C13	1.407 (4)
C1—C2	1.377 (4)	C12—H12A	0.9500
C1—C6	1.386 (3)	C13—C18	1.408 (4)
C1—H1A	0.9500	C13—C14	1.419 (3)
C2—C3	1.379 (4)	C14—C15	1.413 (3)
C2—H2A	0.9500	C15—C16	1.362 (3)
C3—C4	1.372 (4)	C15—H15A	0.9500
C3—H3A	0.9500	C16—C17	1.395 (4)
C4—C5	1.370 (4)	C16—H16A	0.9500
C4—H4A	0.9500	C17—C18	1.353 (4)
C5—C6	1.392 (3)	C17—H17A	0.9500
C5—H5A	0.9500	C18—H18A	0.9500
C7—N1—C8	128.1 (2)	C10—C9—N2	123.9 (2)
C7—N1—H1	119.1 (18)	C10—C9—C14	120.5 (2)
C8—N1—H1	112.8 (18)	N2—C9—C14	115.6 (2)
C8—N2—C9	132.4 (2)	C9—C10—C11	120.0 (3)
C8—N2—H2	112.6 (18)	C9—C10—H10A	120.0
C9—N2—H2	115.0 (18)	C11—C10—H10A	120.0
C2—C1—C6	120.3 (2)	C12—C11—C10	121.1 (3)
C2—C1—H1A	119.9	C12—C11—H11A	119.5
C6—C1—H1A	119.9	C10—C11—H11A	119.5
C1—C2—C3	120.1 (3)	C11—C12—C13	120.8 (3)
C1—C2—H2A	120.0	C11—C12—H12A	119.6
C3—C2—H2A	120.0	C13—C12—H12A	119.6
C4—C3—C2	120.0 (3)	C12—C13—C18	121.4 (2)
C4—C3—H3A	120.0	C12—C13—C14	119.5 (2)

C2—C3—H3A	120.0	C18—C13—C14	119.1 (2)
C5—C4—C3	120.4 (3)	C15—C14—C13	117.5 (2)
C5—C4—H4A	119.8	C15—C14—C9	124.4 (2)
C3—C4—H4A	119.8	C13—C14—C9	118.1 (2)
C4—C5—C6	120.3 (3)	C16—C15—C14	121.4 (2)
C4—C5—H5A	119.9	C16—C15—H15A	119.3
C6—C5—H5A	119.9	C14—C15—H15A	119.3
C1—C6—C5	119.0 (2)	C15—C16—C17	120.7 (3)
C1—C6—C7	124.2 (2)	C15—C16—H16A	119.7
C5—C6—C7	116.8 (2)	C17—C16—H16A	119.7
O1—C7—N1	121.8 (2)	C18—C17—C16	119.6 (3)
O1—C7—C6	120.7 (2)	C18—C17—H17A	120.2
N1—C7—C6	117.5 (2)	C16—C17—H17A	120.2
N2—C8—N1	114.9 (2)	C17—C18—C13	121.7 (3)
N2—C8—S1	128.4 (2)	C17—C18—H18A	119.2
N1—C8—S1	116.76 (19)	C13—C18—H18A	119.2
C6—C1—C2—C3	0.4 (4)	C14—C9—C10—C11	-0.6 (4)
C1—C2—C3—C4	0.9 (5)	C9—C10—C11—C12	2.2 (4)
C2—C3—C4—C5	-1.1 (5)	C10—C11—C12—C13	-1.7 (4)
C3—C4—C5—C6	0.1 (4)	C11—C12—C13—C18	-179.9 (2)
C2—C1—C6—C5	-1.5 (4)	C11—C12—C13—C14	-0.5 (4)
C2—C1—C6—C7	180.0 (2)	C12—C13—C14—C15	-178.2 (2)
C4—C5—C6—C1	1.2 (4)	C18—C13—C14—C15	1.2 (3)
C4—C5—C6—C7	179.9 (2)	C12—C13—C14—C9	2.0 (3)
C8—N1—C7—O1	-0.4 (4)	C18—C13—C14—C9	-178.6 (2)
C8—N1—C7—C6	180.0 (2)	C10—C9—C14—C15	178.8 (2)
C1—C6—C7—O1	165.4 (3)	N2—C9—C14—C15	-3.5 (4)
C5—C6—C7—O1	-13.2 (4)	C10—C9—C14—C13	-1.5 (3)
C1—C6—C7—N1	-15.0 (4)	N2—C9—C14—C13	176.2 (2)
C5—C6—C7—N1	166.4 (2)	C13—C14—C15—C16	-0.5 (4)
C9—N2—C8—N1	179.7 (2)	C9—C14—C15—C16	179.2 (2)
C9—N2—C8—S1	-0.6 (4)	C14—C15—C16—C17	-0.4 (4)
C7—N1—C8—N2	3.1 (4)	C15—C16—C17—C18	0.7 (4)
C7—N1—C8—S1	-176.7 (2)	C16—C17—C18—C13	0.0 (4)
C8—N2—C9—C10	-10.9 (4)	C12—C13—C18—C17	178.4 (3)
C8—N2—C9—C14	171.5 (3)	C14—C13—C18—C17	-0.9 (4)
N2—C9—C10—C11	-178.1 (2)		

Hydrogen-bond geometry (Å, °)

<i>D</i> —H... <i>A</i>	<i>D</i> —H	H... <i>A</i>	<i>D</i> ... <i>A</i>	<i>D</i> —H... <i>A</i>
N2—H2...O1	0.86 (2)	1.85 (2)	2.600 (3)	144 (2)
N1—H1...S1 ⁱ	0.86 (2)	2.80 (2)	3.591 (2)	153 (2)
C15—H15A...O1	0.95	2.51	3.411 (3)	159

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