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ISSN: 2056-9890

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## Crystal structure of 1- $\{(Z)-[(2E)-3-(4\text{-chlorophenyl})-1\text{-phenylprop-2-en-1-ylidene]amino}\}$ -3-ethylthiourea

Ming Yueh Tan, Karen A. Crouse, Thahira Begum S. A. Ravoof and Edward R. T. Tiekink

*Acta Cryst.* (2015). E71, o1047–o1048



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# Crystal structure of 1-[(Z)-[(2E)-3-(4-chlorophenyl)-1-phenylprop-2-en-1-ylidene]amino]-3-ethylthiourea

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Received 2 December 2015; accepted 8 December 2015

Edited by W. T. A. Harrison, University of Aberdeen, Scotland

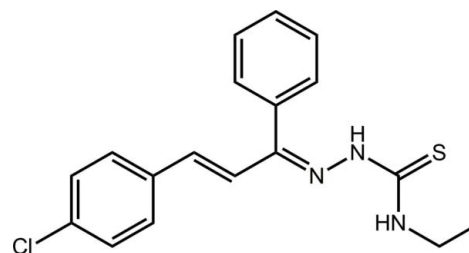
In the title thiosemicarbazone compound, C<sub>18</sub>H<sub>18</sub>ClN<sub>3</sub>S, the CN<sub>3</sub>S residue is almost planar (r.m.s. deviation = 0.0031 Å) and forms dihedral angles of 65.99 (7) and 34.60 (10)° with the phenyl and chlorobenzene rings, respectively; the dihedral angle between the aromatic rings is 85.13 (8)°. The conformation about the C=N bond is *Z*, and that about the C=C bonds is *E*. The imine N and ethyl N atoms are *syn* and are linked by an ethyl–imine N–H···N hydrogen bond. This H atom also forms an intermolecular hydrogen bond to the thione S atom, resulting in a supramolecular helical chain propagating along the *b* axis. The chains are consolidated into a three-dimensional architecture by phenyl–C–H···Cl contacts and weak  $\pi$ – $\pi$  interactions between centrosymmetrically related chlorobenzene rings [inter-centroid distance = 3.9127 (15) Å].

**Keywords:** crystal structure; hydrogen bonding; thiosemicarbazone.

**CCDC reference:** 1441045

## 1. Related literature

For background to the coordination chemistry and applications of metal thiosemicarbazones, see: Dilworth & Hueting (2012). For the structure of a closely related thiosemicarbazone compound, 1-benzothiophene-2-carbaldehyde 4-ethylthiosemicarbazone, with almost planar semicarbazone units (two molecules comprise the asymmetric unit) and *E* conformations for the C=N bonds, see: Kayed *et al.* (2009).



## 2. Experimental

### 2.1. Crystal data

C <sub>18</sub> H <sub>18</sub> ClN <sub>3</sub> S	<i>V</i> = 1778.3 (2) Å <sup>3</sup>
<i>M<sub>r</sub></i> = 343.86	<i>Z</i> = 4
Monoclinic, <i>P</i> 2 <sub>1</sub> / <i>c</i>	Mo <i>K</i> α radiation
<i>a</i> = 10.580 (1) Å	$\mu$ = 0.33 mm <sup>-1</sup>
<i>b</i> = 12.0438 (9) Å	<i>T</i> = 293 K
<i>c</i> = 13.9561 (10) Å	0.20 × 0.15 × 0.10 mm
$\beta$ = 90.196 (8)°	

### 2.2. Data collection

Agilent SuperNova Dual diffractometer with an Atlas detector	11178 measured reflections
Absorption correction: multi-scan ( <i>CrysAlis PRO</i> ; Agilent, 2013)	4078 independent reflections
<i>T</i> <sub>min</sub> = 0.800, <i>T</i> <sub>max</sub> = 1.000	1963 reflections with <i>I</i> > 2σ( <i>I</i> )
	<i>R</i> <sub>int</sub> = 0.051

### 2.3. Refinement

<i>R</i> [ <i>F</i> <sup>2</sup> > 2σ( <i>F</i> <sup>2</sup> )] = 0.038	2 restraints
<i>wR</i> ( <i>F</i> <sup>2</sup> ) = 0.120	H-atom parameters constrained
<i>S</i> = 1.00	$\Delta\rho_{\max}$ = 0.20 e Å <sup>-3</sup>
4078 reflections	$\Delta\rho_{\min}$ = -0.25 e Å <sup>-3</sup>
216 parameters	

**Table 1**

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>
N1–H1N···N3	0.88 (2)	2.25 (2)	2.629 (3)	106 (2)
N1–H1N···S1 <sup>i</sup>	0.88 (2)	2.84 (2)	3.693 (2)	165 (2)
C43–H43···Cl1 <sup>ii</sup>	0.93	2.82	3.708 (3)	160

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

Data collection: *CrysAlis PRO* (Agilent, 2013); cell refinement: *CrysAlis PRO*; data reduction: *CrysAlis PRO*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL2014* (Sheldrick, 2015); molecular graphics: *ORTEP-3 for Windows* (Farrugia, 2012) and *DIAMOND* (Brandenburg, 2006); software used to prepare material for publication: *PUBLICIF* (Westrip, 2010).

## Acknowledgements

This research was funded by Universiti Putra Malaysia (UPM) under Research University Grant Schemes (RUGS No. 9419400), the Fundamental Research Grant Scheme (FRGS No. 5524425) and the Science Fund (Science Fund No. 06–01–

04-SF810). MYT wishes to thank the UPM for the award of a Graduate Research Fellowship.

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Supporting information for this paper is available from the IUCr electronic archives (Reference: HB7555).

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## supporting information

*Acta Cryst.* (2015). E71, o1047–o1048 [doi:10.1107/S2056989015023531]

## Crystal structure of 1-*{(Z)-[(2E)-3-(4-chlorophenyl)-1-phenylprop-2-en-1-yl-idene]amino}*-3-ethylthiourea

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### S1. Refinement

### S2. Experimental

An ethanol solution (20 ml) of 4-chlorochoalcone (0.243 g, 1 mmol) was slowly added to a solution of 4-ethyl-3-thiosemicarbazide (0.119 g, 1 mmol) in absolute ethanol (20 ml), while stirring and heating for about 20 min. The yellow precipitate was filtered, washed with cold ethanol and dried *in vacuo*. Light brown prisms of the title compound were grown at room temperature from the slow evaporation of a solvent mixture of dimethylformamide and acetonitrile; *M*.pt: 154–156 °C.

### S3. Refinement

Carbon-bound H-atoms were placed in calculated positions (C—H = 0.93 to 0.97 Å) and were included in the refinement in the riding model approximation with  $U_{\text{iso}}(\text{H}) = 1.2\text{--}1.5U_{\text{eq}}(\text{C})$ . The N—H atom was refined with N—H =  $0.88 \pm 0.01$  Å, and with  $U_{\text{iso}}(\text{H}) = 1.2U_{\text{eq}}(\text{N})$ .

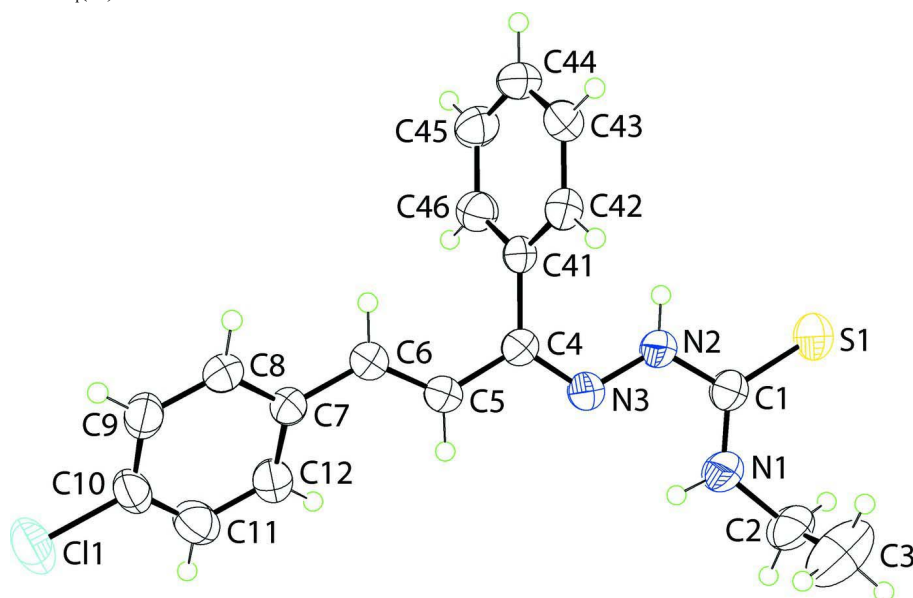
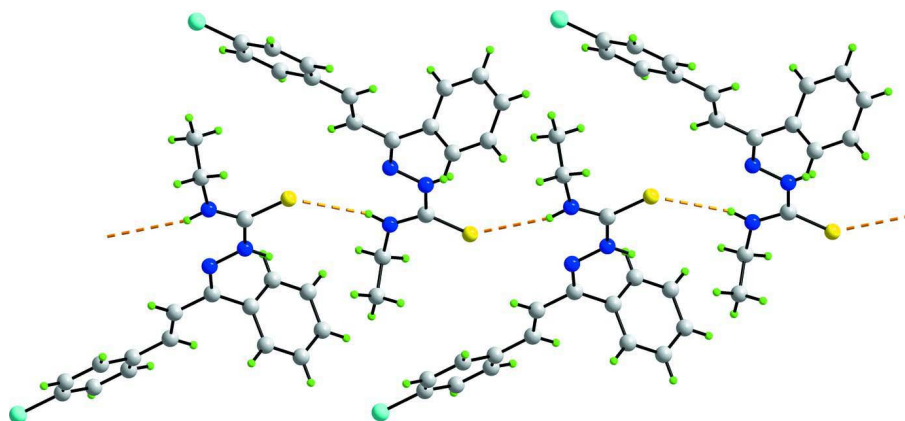


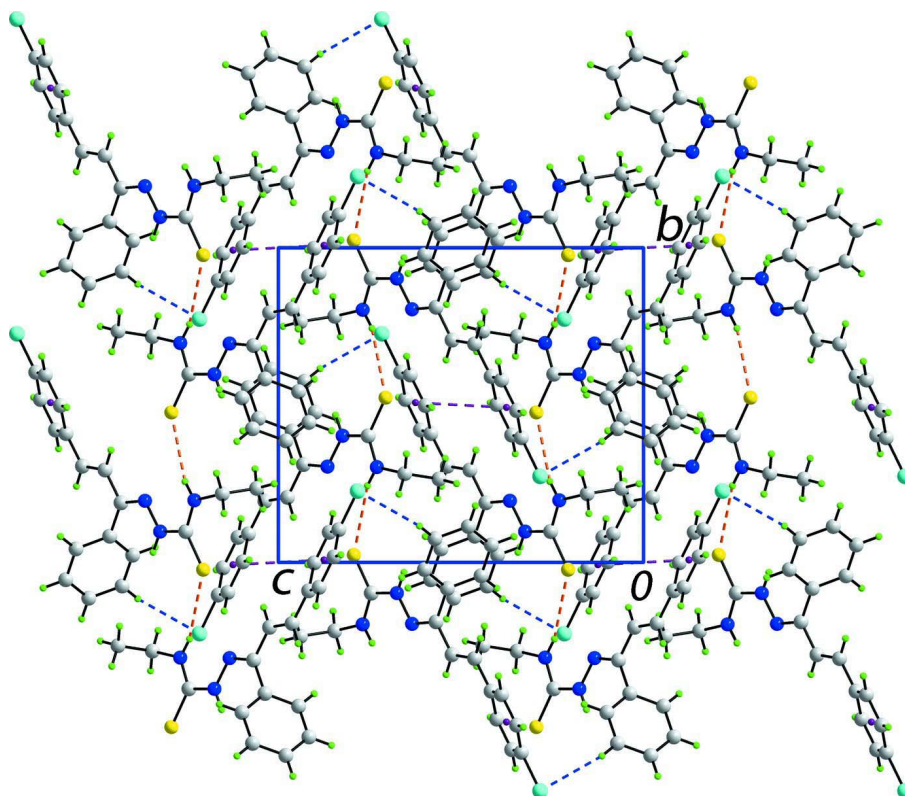
Figure 1

The molecular structure of the title compound showing displacement ellipsoids at the 50% probability level.



**Figure 2**

A view of the helical supramolecular chain along the *b* axis and sustained by N—H···S hydrogen bonds shown as orange dashed lines.



**Figure 3**

A view of the unit-cell contents in projection down the *a* axis. The N—H···S (orange), C—H···Cl (blue) and  $\pi$ — $\pi$  (purple) interactions are shown as dashed lines.

**1-[(*Z*)-[(*2E*)-3-(4-Chlorophenyl)-1-phenylprop-2-en-1-ylidene]amino]-3-ethylthiourea**

*Crystal data*

$C_{18}H_{18}ClN_3S$   
 $M_r = 343.86$

Monoclinic,  $P2_1/c$   
 $a = 10.580(1) \text{ \AA}$

$b = 12.0438$  (9) Å  
 $c = 13.9561$  (10) Å  
 $\beta = 90.196$  (8)°  
 $V = 1778.3$  (2) Å<sup>3</sup>  
 $Z = 4$   
 $F(000) = 720$   
 $D_x = 1.284$  Mg m<sup>-3</sup>

Mo  $K\alpha$  radiation,  $\lambda = 0.71073$  Å  
 Cell parameters from 2181 reflections  
 $\theta = 2.9$ – $27.5$ °  
 $\mu = 0.33$  mm<sup>-1</sup>  
 $T = 293$  K  
 Prism, light-brown  
 $0.20 \times 0.15 \times 0.10$  mm

#### Data collection

Agilent SuperNova Dual  
 diffractometer with an Atlas detector  
 Radiation source: SuperNova (Mo) X-ray  
 Source  
 Mirror monochromator  
 Detector resolution: 10.4041 pixels mm<sup>-1</sup>  
 $\omega$  scan  
 Absorption correction: multi-scan  
 (*CrysAlis PRO*; Agilent, 2013)

$T_{\min} = 0.800$ ,  $T_{\max} = 1.000$   
 11178 measured reflections  
 4078 independent reflections  
 1963 reflections with  $I > 2\sigma(I)$   
 $R_{\text{int}} = 0.051$   
 $\theta_{\max} = 27.5$ °,  $\theta_{\min} = 2.9$ °  
 $h = -13 \rightarrow 12$   
 $k = -14 \rightarrow 15$   
 $l = -18 \rightarrow 18$

#### Refinement

Refinement on  $F^2$   
 Least-squares matrix: full  
 $R[F^2 > 2\sigma(F^2)] = 0.038$   
 $wR(F^2) = 0.120$   
 $S = 1.00$   
 4078 reflections  
 216 parameters  
 2 restraints  
 Hydrogen site location: mixed

H-atom parameters constrained  
 $w = 1/[\sigma^2(F_o^2) + (0.0463P)^2]$   
 where  $P = (F_o^2 + 2F_c^2)/3$   
 $(\Delta/\sigma)_{\max} = 0.001$   
 $\Delta\rho_{\max} = 0.20$  e Å<sup>-3</sup>  
 $\Delta\rho_{\min} = -0.25$  e Å<sup>-3</sup>  
 Extinction correction: *SHELXL2014* (Sheldrick,  
 2014),  $F_c^* = kF_c[1 + 0.001x F_c^2 \lambda^3 / \sin(2\theta)]^{-1/4}$   
 Extinction coefficient: 0.0044 (7)

#### 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.

#### Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å<sup>2</sup>)

	<i>x</i>	<i>y</i>	<i>z</i>	$U_{\text{iso}}^*/U_{\text{eq}}$
S1	1.05835 (7)	-0.02341 (6)	0.20649 (5)	0.0606 (2)
Cl1	0.48690 (8)	0.72659 (6)	0.71676 (5)	0.0754 (3)
N1	1.0584 (2)	0.19712 (18)	0.23053 (16)	0.0579 (6)
H1N	1.025 (2)	0.2566 (14)	0.2562 (18)	0.070*
N2	0.9246 (2)	0.09776 (16)	0.32430 (15)	0.0543 (6)
H2N	0.900 (2)	0.0320 (11)	0.3439 (17)	0.065*
N3	0.88627 (18)	0.19560 (15)	0.36594 (14)	0.0484 (5)
C1	1.0138 (2)	0.0979 (2)	0.25424 (18)	0.0470 (6)
C2	1.1491 (2)	0.2179 (2)	0.1541 (2)	0.0636 (8)
H2A	1.2065	0.1553	0.1494	0.076*
H2B	1.1986	0.2832	0.1699	0.076*
C3	1.0860 (3)	0.2351 (4)	0.0601 (2)	0.1085 (13)
H3A	1.0393	0.1696	0.0431	0.163*

H3B	1.1485	0.2497	0.0121	0.163*
H3C	1.0292	0.2971	0.0643	0.163*
C4	0.8004 (2)	0.18918 (18)	0.43172 (16)	0.0420 (6)
C5	0.7641 (2)	0.29357 (18)	0.47552 (16)	0.0443 (6)
H5	0.8101	0.3565	0.4592	0.053*
C6	0.6697 (2)	0.30579 (18)	0.53736 (16)	0.0434 (6)
H6	0.6254	0.2419	0.5537	0.052*
C7	0.6281 (2)	0.40943 (18)	0.58244 (16)	0.0409 (6)
C8	0.5030 (2)	0.42061 (19)	0.61122 (16)	0.0463 (6)
H8	0.4477	0.3614	0.6026	0.056*
C9	0.4589 (3)	0.5176 (2)	0.65233 (16)	0.0517 (7)
H9	0.3749	0.5240	0.6708	0.062*
C10	0.5415 (3)	0.60409 (19)	0.66531 (16)	0.0504 (7)
C11	0.6661 (3)	0.5955 (2)	0.63902 (18)	0.0576 (7)
H11	0.7209	0.6548	0.6489	0.069*
C12	0.7099 (3)	0.49840 (19)	0.59786 (18)	0.0529 (7)
H12	0.7943	0.4925	0.5804	0.063*
C41	0.7411 (2)	0.08309 (17)	0.46264 (17)	0.0391 (6)
C42	0.6659 (2)	0.02282 (19)	0.39972 (17)	0.0446 (6)
H42	0.6525	0.0488	0.3377	0.054*
C43	0.6108 (2)	-0.07542 (19)	0.42866 (19)	0.0506 (7)
H43	0.5608	-0.1156	0.3860	0.061*
C44	0.6294 (2)	-0.1139 (2)	0.5200 (2)	0.0550 (7)
H44	0.5916	-0.1799	0.5394	0.066*
C45	0.7037 (2)	-0.0552 (2)	0.58311 (19)	0.0553 (7)
H45	0.7163	-0.0817	0.6450	0.066*
C46	0.7597 (2)	0.0428 (2)	0.55490 (17)	0.0491 (6)
H46	0.8101	0.0821	0.5978	0.059*

Atomic displacement parameters ( $\text{\AA}^2$ )

	$U^{11}$	$U^{22}$	$U^{33}$	$U^{12}$	$U^{13}$	$U^{23}$
S1	0.0614 (5)	0.0544 (4)	0.0661 (5)	0.0084 (3)	0.0204 (4)	-0.0080 (4)
Cl1	0.1222 (7)	0.0502 (4)	0.0539 (4)	0.0289 (4)	0.0068 (4)	-0.0074 (3)
N1	0.0567 (14)	0.0503 (14)	0.0670 (15)	-0.0007 (11)	0.0263 (12)	0.0014 (12)
N2	0.0638 (14)	0.0380 (12)	0.0614 (13)	0.0005 (10)	0.0292 (11)	-0.0016 (11)
N3	0.0531 (12)	0.0375 (11)	0.0548 (12)	0.0017 (9)	0.0176 (11)	-0.0023 (10)
C1	0.0433 (14)	0.0470 (16)	0.0506 (14)	0.0010 (11)	0.0098 (12)	-0.0017 (13)
C2	0.0500 (16)	0.0699 (18)	0.0710 (19)	-0.0065 (13)	0.0207 (15)	0.0061 (16)
C3	0.078 (2)	0.172 (4)	0.076 (2)	-0.021 (2)	0.006 (2)	0.031 (3)
C4	0.0426 (14)	0.0386 (14)	0.0450 (14)	-0.0014 (10)	0.0090 (12)	-0.0001 (12)
C5	0.0482 (15)	0.0349 (13)	0.0500 (14)	-0.0011 (10)	0.0094 (12)	-0.0001 (11)
C6	0.0465 (14)	0.0378 (14)	0.0459 (14)	-0.0015 (10)	0.0062 (12)	-0.0017 (11)
C7	0.0491 (15)	0.0368 (13)	0.0368 (13)	0.0022 (11)	0.0066 (11)	0.0014 (11)
C8	0.0537 (16)	0.0411 (14)	0.0442 (14)	0.0000 (11)	0.0115 (12)	0.0051 (12)
C9	0.0611 (17)	0.0494 (16)	0.0448 (15)	0.0155 (13)	0.0141 (13)	0.0075 (13)
C10	0.079 (2)	0.0373 (14)	0.0348 (13)	0.0122 (13)	0.0034 (13)	-0.0021 (12)
C11	0.0728 (19)	0.0446 (16)	0.0555 (16)	-0.0044 (13)	-0.0035 (15)	-0.0065 (14)

C12	0.0543 (17)	0.0489 (16)	0.0555 (16)	-0.0019 (12)	0.0096 (13)	-0.0080 (13)
C41	0.0404 (13)	0.0342 (13)	0.0427 (14)	0.0028 (10)	0.0110 (11)	-0.0028 (11)
C42	0.0470 (15)	0.0450 (14)	0.0419 (13)	0.0016 (11)	0.0075 (12)	-0.0019 (12)
C43	0.0538 (16)	0.0433 (14)	0.0547 (17)	-0.0066 (12)	0.0098 (13)	-0.0102 (13)
C44	0.0603 (17)	0.0396 (14)	0.0652 (18)	-0.0061 (12)	0.0154 (15)	0.0042 (14)
C45	0.0653 (18)	0.0503 (16)	0.0502 (15)	0.0011 (13)	0.0076 (14)	0.0104 (14)
C46	0.0532 (16)	0.0472 (15)	0.0469 (15)	-0.0046 (12)	0.0003 (12)	-0.0003 (13)

*Geometric parameters (Å, °)*

S1—C1	1.674 (2)	C7—C8	1.392 (3)
C11—C10	1.740 (2)	C7—C12	1.393 (3)
N1—C1	1.327 (3)	C8—C9	1.383 (3)
N1—C2	1.459 (3)	C8—H8	0.9300
N1—H1N	0.874 (10)	C9—C10	1.372 (4)
N2—C1	1.361 (3)	C9—H9	0.9300
N2—N3	1.376 (2)	C10—C11	1.373 (4)
N2—H2N	0.878 (10)	C11—C12	1.384 (3)
N3—C4	1.296 (2)	C11—H11	0.9300
C2—C3	1.484 (4)	C12—H12	0.9300
C2—H2A	0.9700	C41—C42	1.388 (3)
C2—H2B	0.9700	C41—C46	1.389 (3)
C3—H3A	0.9600	C42—C43	1.380 (3)
C3—H3B	0.9600	C42—H42	0.9300
C3—H3C	0.9600	C43—C44	1.370 (3)
C4—C5	1.450 (3)	C43—H43	0.9300
C4—C41	1.488 (3)	C44—C45	1.375 (4)
C5—C6	1.330 (3)	C44—H44	0.9300
C5—H5	0.9300	C45—C46	1.379 (3)
C6—C7	1.466 (3)	C45—H45	0.9300
C6—H6	0.9300	C46—H46	0.9300
C1—N1—C2	124.9 (2)	C9—C8—C7	121.6 (2)
C1—N1—H1N	119.5 (17)	C9—C8—H8	119.2
C2—N1—H1N	115.1 (17)	C7—C8—H8	119.2
C1—N2—N3	120.56 (18)	C10—C9—C8	118.7 (2)
C1—N2—H2N	115.5 (16)	C10—C9—H9	120.6
N3—N2—H2N	123.6 (16)	C8—C9—H9	120.6
C4—N3—N2	117.15 (18)	C9—C10—C11	121.3 (2)
N1—C1—N2	115.3 (2)	C9—C10—C11	119.1 (2)
N1—C1—S1	125.86 (17)	C11—C10—C11	119.6 (2)
N2—C1—S1	118.80 (17)	C10—C11—C12	119.8 (2)
N1—C2—C3	112.0 (2)	C10—C11—H11	120.1
N1—C2—H2A	109.2	C12—C11—H11	120.1
C3—C2—H2A	109.2	C11—C12—C7	120.4 (2)
N1—C2—H2B	109.2	C11—C12—H12	119.8
C3—C2—H2B	109.2	C7—C12—H12	119.8
H2A—C2—H2B	107.9	C42—C41—C46	118.9 (2)



C2—C3—H3A	109.5	C42—C41—C4	120.5 (2)
C2—C3—H3B	109.5	C46—C41—C4	120.7 (2)
H3A—C3—H3B	109.5	C43—C42—C41	120.3 (2)
C2—C3—H3C	109.5	C43—C42—H42	119.8
H3A—C3—H3C	109.5	C41—C42—H42	119.8
H3B—C3—H3C	109.5	C44—C43—C42	120.2 (2)
N3—C4—C5	115.73 (19)	C44—C43—H43	119.9
N3—C4—C41	123.63 (19)	C42—C43—H43	119.9
C5—C4—C41	120.64 (18)	C43—C44—C45	120.1 (2)
C6—C5—C4	124.7 (2)	C43—C44—H44	119.9
C6—C5—H5	117.6	C45—C44—H44	119.9
C4—C5—H5	117.6	C44—C45—C46	120.2 (2)
C5—C6—C7	126.8 (2)	C44—C45—H45	119.9
C5—C6—H6	116.6	C46—C45—H45	119.9
C7—C6—H6	116.6	C45—C46—C41	120.2 (2)
C8—C7—C12	118.1 (2)	C45—C46—H46	119.9
C8—C7—C6	119.6 (2)	C41—C46—H46	119.9
C12—C7—C6	122.3 (2)		
C1—N2—N3—C4	179.6 (2)	C9—C10—C11—C12	0.5 (4)
C2—N1—C1—N2	-176.5 (2)	C11—C10—C11—C12	-179.8 (2)
C2—N1—C1—S1	3.9 (4)	C10—C11—C12—C7	0.3 (4)
N3—N2—C1—N1	-0.2 (4)	C8—C7—C12—C11	-1.2 (4)
N3—N2—C1—S1	179.39 (19)	C6—C7—C12—C11	178.8 (2)
C1—N1—C2—C3	87.9 (4)	N3—C4—C41—C42	-65.7 (3)
N2—N3—C4—C5	178.8 (2)	C5—C4—C41—C42	114.7 (2)
N2—N3—C4—C41	-0.9 (4)	N3—C4—C41—C46	114.5 (3)
N3—C4—C5—C6	173.2 (2)	C5—C4—C41—C46	-65.2 (3)
C41—C4—C5—C6	-7.1 (4)	C46—C41—C42—C43	0.0 (3)
C4—C5—C6—C7	-179.0 (2)	C4—C41—C42—C43	-179.9 (2)
C5—C6—C7—C8	152.8 (2)	C41—C42—C43—C44	0.3 (3)
C5—C6—C7—C12	-27.2 (4)	C42—C43—C44—C45	-0.4 (4)
C12—C7—C8—C9	1.3 (3)	C43—C44—C45—C46	0.1 (4)
C6—C7—C8—C9	-178.7 (2)	C44—C45—C46—C41	0.2 (4)
C7—C8—C9—C10	-0.4 (4)	C42—C41—C46—C45	-0.2 (3)
C8—C9—C10—C11	-0.5 (4)	C4—C41—C46—C45	179.6 (2)
C8—C9—C10—C11	179.87 (18)		

Hydrogen-bond geometry ( $\text{\AA}$ ,  $^\circ$ )

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
N1—H1N $\cdots$ N3	0.88 (2)	2.25 (2)	2.629 (3)	106 (2)
N1—H1N $\cdots$ S1 <sup>i</sup>	0.88 (2)	2.84 (2)	3.693 (2)	165 (2)
C43—H43 $\cdots$ C11 <sup>ii</sup>	0.93	2.82	3.708 (3)	160

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