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## Structure Reports

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# 1,3-Dibenzylimidazolidine-2-thione

Anna Mietlerek-Kropidłowska,\* Jaroslaw Chojnacki and Barbara Becker

Department of Inorganic Chemistry, Chemical Faculty, Gdansk University of Technology, 11/12 G. Narutowicza Street, 80-233 Gdańsk, Poland

Correspondence e-mail: anna.mietlerek-kropidlowaska@pg.gda.pl

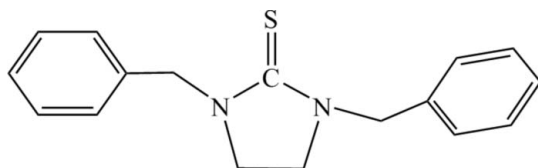
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 Key indicators: single-crystal X-ray study;  $T = 120$  K; mean  $\sigma(\text{C}-\text{C}) = 0.002$  Å;  $R$  factor = 0.037;  $wR$  factor = 0.092; data-to-parameter ratio = 16.0.

In the title compound,  $\text{C}_{17}\text{H}_{18}\text{N}_2\text{S}$ , the imidazolidine ring adopts a twisted conformation. In the crystal, molecules are linked by slipped  $\pi-\pi$  interactions between the benzene rings of neighbouring molecules [centroid-to-centroid distance = 3.903 (2) Å].

## Related literature

For background information and the synthesis of related compounds, see: Savjani & Gajjar (2011); Wazeer *et al.* (2007); Zhivotova *et al.* (2006); Jayaram *et al.* (2008). For ring-puckering parameters, see: Cremer & Pople (1975).



## Experimental

### Crystal data

 $\text{C}_{17}\text{H}_{18}\text{N}_2\text{S}$   
 $M_r = 282.39$ 

 Monoclinic,  $P2_1/c$   
 $a = 14.8492$  (8) Å

 $b = 10.2284$  (5) Å  
 $c = 10.1314$  (6) Å  
 $\beta = 107.131$  (6)°  
 $V = 1470.53$  (14) Å<sup>3</sup>  
 $Z = 4$ 

 Mo  $K\alpha$  radiation  
 $\mu = 0.21$  mm<sup>-1</sup>  
 $T = 120$  K  
 $0.45 \times 0.15 \times 0.03$  mm

### Data collection

 Oxford Xcalibur Sapphire2  
 diffractometer  
 Absorption correction: analytical  
 (*CrysAlis PRO*; Oxford  
 Diffraction, 2010)  
 $T_{\min} = 0.938$ ,  $T_{\max} = 0.993$ 

 5840 measured reflections  
 2890 independent reflections  
 2148 reflections with  $I > 2\sigma(I)$   
 $R_{\text{int}} = 0.020$ 

### Refinement

 $R[F^2 > 2\sigma(F^2)] = 0.037$   
 $wR(F^2) = 0.092$   
 $S = 0.94$   
 2890 reflections

 181 parameters  
 H-atom parameters constrained  
 $\Delta\rho_{\text{max}} = 0.32$  e Å<sup>-3</sup>  
 $\Delta\rho_{\text{min}} = -0.17$  e Å<sup>-3</sup>

Data collection: *CrysAlis PRO* (Oxford Diffraction, 2010); cell refinement: *CrysAlis PRO*; data reduction: *CrysAlis PRO*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *ORTEP-3* (Farrugia, 1997); software used to prepare material for publication: *WinGX* (Farrugia, 1999).

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Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: LX2257).

## References

- Cremer, D. & Pople, J. A. (1975). *J. Am. Chem. Soc.* **97**, 1354–1358.  
 Farrugia, L. J. (1997). *J. Appl. Cryst.* **30**, 565.  
 Farrugia, L. J. (1999). *J. Appl. Cryst.* **32**, 837–838.  
 Jayaram, P. N., Roy, G. & Mugesh, G. (2008). *J. Chem. Sci.* **120**, 143–154.  
 Oxford Diffraction (2010). *CrysAlis PRO*. Oxford Diffraction Ltd, Yarnton, Oxfordshire, England.  
 Savjani, J. K. & Gajjar, A. K. (2011). *Pak. J. Biol. Sci.* **14**, 1076–1089.  
 Sheldrick, G. M. (2008). *Acta Cryst.* **A64**, 112–122.  
 Wazeer, M. I. M., Isab, A. A. & Fettouhi, M. (2007). *Polyhedron*, **26**, 1725–1730.  
 Zhivotova, T. S., Gazaliev, A. M., Fazylov, S. D., Aitpaeva, Z. K. & Turdybekov, D. M. (2006). *Zh. Org. Khim.* **42**, 448–450.

## supporting information

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## 1,3-Dibenzylimidazolidine-2-thione

Anna Mietlerek-Kropidłowska, Jaroslaw Chojnacki and Barbara Becker

### S1. Comment

2-Imidazolidinethione derivatives exhibit applications in diverse therapeutic areas such as antimicrobial activity (Wazeer *et al.*, 2007). Moreover, 2-imidazolidinethiones are also used as a chiral auxiliary and ligands for asymmetric catalysis (Savjani & Gajjar, 2011). Herein, we report the crystal structure of the title compound.

In the title molecule (Fig. 1), the imidazolidine ring has twisted (*T*, *i.e.* half-chair) conformation. In the crystal structure (Fig. 2), molecules are connected by slipped  $\pi$ - $\pi$  interactions between the benzene rings of neighbouring molecules, with a Cg-Cg<sup>i</sup> distance of 3.903 (2) Å and an interplanar distance of 3.595 (2) Å resulting in a slippage of 1.519 Å (Cg is the centroid of the C5-C10 benzene ring).

The volume 1470.53 (14) Å<sup>3</sup> as well as the number of molecules in the elemental cell ( $Z = 4$ ) of 1,3-dibenzylimidazolidine-2-thione match the values determined for closely related 1,3-dibenzyl-1*H*-imidazole-2(3*H*)-thione (Jayaram *et al.*, 2008). These molecules differ in their 5-membered ring being either aromatic or aliphatic. Nevertheless any closer comparison of the bond lengths and angles between these two compounds is difficult due to the lack of atomic coordinates for 1,3-dibenzyl-1*H*-imidazole-2(3*H*)-thione either in the above mentioned paper or in Cambridge Structural Database. The 5-membered imidazolidine ring in the present structure adopts the conformation which is most closely described as half-chair or twisted (*T*) on C2-C3. Parameter  $Q_2$  (Cremer & Pople, 1975), which specifies the puckering amplitude and thus differentiate planar from non-planar systems, is significantly greater than zero 0.1565 (16) Å and  $\varphi_2$  parameter is 301.2 (6)° pointing to the mentioned *T* type of pucker.

### S2. Experimental

The title compound was synthesized according to the procedure reported by Zhivotova *et al.* (2006). The reaction was carried out between N,N'-dibenzylethylenediamine and carbon disulfide in the presence of KOH (molar ratio 1:1:1) in methanol. The mixture was stirred 50 min, filtered and then left for crystallization at 278 K. After a week yellowish needle-like crystals were appeared. These were filtered off and dried. The melting point was determined to be 393 K.

### S3. Refinement

All of the C-bonded hydrogen atoms were placed in the calculated positions (aromatic:  $d_{\text{CH}} = 0.95$  Å, methylene:  $d_{\text{CH}} = 0.99$  Å) and were treated as riding on their parent atoms with  $U_{\text{iso}}(\text{H}) = 1.2U_{\text{eq}}(\text{C})$ .

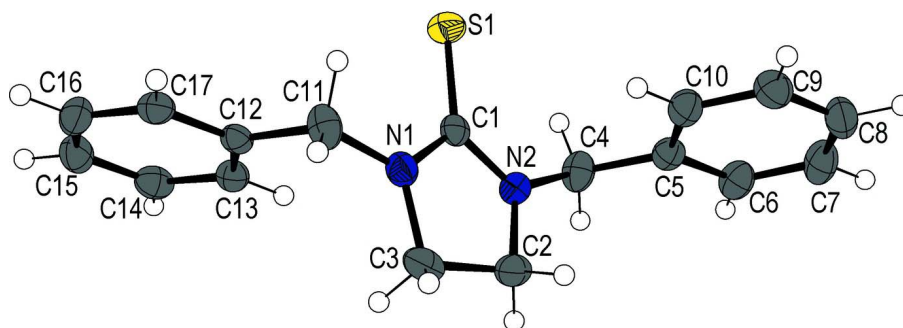


Figure 1

The molecular structure of the title compound with the atom numbering scheme. Displacement ellipsoids are drawn at the 50% probability level. H atoms are presented as small spheres of arbitrary radius.

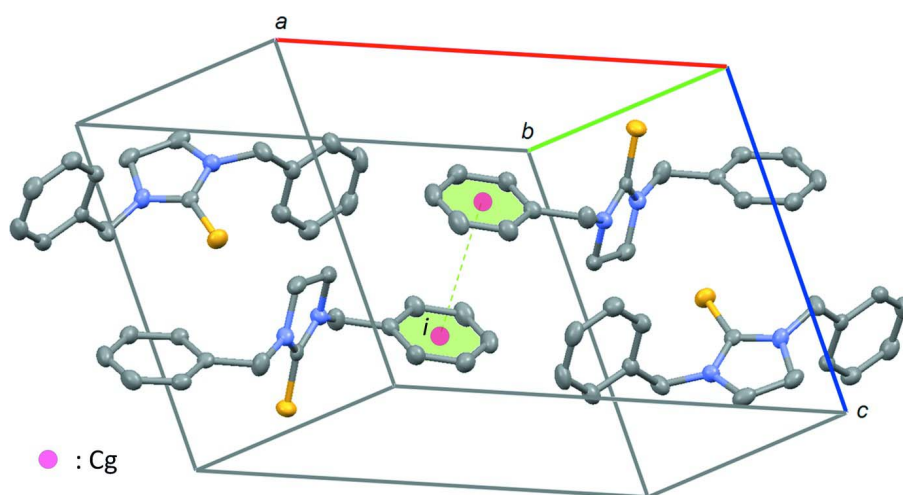


Figure 2

A view of the  $\pi$ - $\pi$  interactions (dotted lines) in the crystal structure of the title compound. H atoms non-participating in hydrogen-bonding were omitted for clarity. Cg is the centroid of the C5–C10 benzene ring. [Symmetry code: (i)  $-x + 1, -y + 1, -z + 1$ .]

### 1,3-Dibenzylimidazolidine-2-thione

#### Crystal data

$C_{17}H_{18}N_2S$

$M_r = 282.39$

Monoclinic,  $P2_1/c$

Hall symbol:  $-P 2_1/c$

$a = 14.8492(8) \text{ \AA}$

$b = 10.2284(5) \text{ \AA}$

$c = 10.1314(6) \text{ \AA}$

$\beta = 107.131(6)^\circ$

$V = 1470.53(14) \text{ \AA}^3$

$Z = 4$

$F(000) = 600$

$D_x = 1.276 \text{ Mg m}^{-3}$

Melting point: 393 K

Mo  $K\alpha$  radiation,  $\lambda = 0.71073 \text{ \AA}$

Cell parameters from 3149 reflections

$\theta = 2.9\text{--}28.3^\circ$

$\mu = 0.21 \text{ mm}^{-1}$

$T = 120 \text{ K}$

Needle, light yellow

$0.45 \times 0.15 \times 0.03 \text{ mm}$

Data collection

Oxford Xcalibur Sapphire2  
diffractometer  
Graphite monochromator  
Detector resolution: 8.1883 pixels mm<sup>-1</sup>  
 $\omega$  scans  
Absorption correction: analytical  
(*CrysAlis PRO*; Oxford Diffraction, 2010)  
 $T_{\min} = 0.938$ ,  $T_{\max} = 0.993$

5840 measured reflections  
2890 independent reflections  
2148 reflections with  $I > 2\sigma(I)$   
 $R_{\text{int}} = 0.020$   
 $\theta_{\max} = 26^\circ$ ,  $\theta_{\min} = 2.9^\circ$   
 $h = -17 \rightarrow 18$   
 $k = -11 \rightarrow 12$   
 $l = -11 \rightarrow 12$

Refinement

Refinement on  $F^2$   
Least-squares matrix: full  
 $R[F^2 > 2\sigma(F^2)] = 0.037$   
 $wR(F^2) = 0.092$   
 $S = 0.94$   
2890 reflections  
181 parameters  
0 restraints  
Primary atom site location: structure-invariant  
direct methods

Secondary atom site location: difference Fourier  
map  
Hydrogen site location: inferred from  
neighbouring sites  
H-atom parameters constrained  
 $w = 1/[\sigma^2(F_o^2) + (0.0605P)^2]$   
where  $P = (F_o^2 + 2F_c^2)/3$   
 $(\Delta/\sigma)_{\max} = 0.001$   
 $\Delta\rho_{\max} = 0.32 \text{ e } \text{\AA}^{-3}$   
 $\Delta\rho_{\min} = -0.17 \text{ e } \text{\AA}^{-3}$

Special details

**Geometry.** All s.u.'s (except the s.u. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell s.u.'s are taken into account individually in the estimation of s.u.'s in distances, angles and torsion angles; correlations between s.u.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell s.u.'s is used for estimating s.u.'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  $F^2 > 2\sigma(F^2)$  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 ( $\text{\AA}^2$ )

|     | <i>x</i>     | <i>y</i>     | <i>z</i>     | $U_{\text{iso}}^*/U_{\text{eq}}$ |
|-----|--------------|--------------|--------------|----------------------------------|
| N1  | 0.06996 (8)  | 0.45939 (12) | 0.28050 (13) | 0.0281 (3)                       |
| N2  | 0.20826 (8)  | 0.36922 (12) | 0.37091 (13) | 0.0268 (3)                       |
| S1  | 0.11232 (3)  | 0.27228 (4)  | 0.12140 (4)  | 0.03308 (14)                     |
| C1  | 0.13043 (10) | 0.36852 (14) | 0.26067 (15) | 0.0233 (3)                       |
| C2  | 0.20697 (11) | 0.47669 (16) | 0.46506 (17) | 0.0334 (4)                       |
| H2A | 0.2501       | 0.5478       | 0.4565       | 0.04*                            |
| H2B | 0.2246       | 0.4464       | 0.5621       | 0.04*                            |
| C3  | 0.10445 (11) | 0.52096 (16) | 0.41609 (17) | 0.0335 (4)                       |
| H3A | 0.0692       | 0.4899       | 0.4791       | 0.04*                            |
| H3B | 0.0997       | 0.6174       | 0.4088       | 0.04*                            |
| C4  | 0.28837 (10) | 0.28334 (16) | 0.38936 (18) | 0.0329 (4)                       |
| H4A | 0.2685       | 0.2064       | 0.3284       | 0.039*                           |
| H4B | 0.3081       | 0.2515       | 0.4859       | 0.039*                           |
| C5  | 0.37268 (10) | 0.34615 (14) | 0.35870 (16) | 0.0270 (3)                       |
| C6  | 0.46349 (11) | 0.30853 (16) | 0.43384 (18) | 0.0338 (4)                       |
| H6  | 0.4721       | 0.246        | 0.5059       | 0.041*                           |



|      |               |              |              |            |
|------|---------------|--------------|--------------|------------|
| C7   | 0.54126 (11)  | 0.36151 (16) | 0.40445 (19) | 0.0388 (4) |
| H7   | 0.6028        | 0.3343       | 0.4555       | 0.047*     |
| C8   | 0.52966 (11)  | 0.45327 (17) | 0.30165 (19) | 0.0388 (4) |
| H8   | 0.5832        | 0.49         | 0.2824       | 0.047*     |
| C9   | 0.43962 (12)  | 0.49221 (17) | 0.22599 (18) | 0.0365 (4) |
| H9   | 0.4314        | 0.5558       | 0.1551       | 0.044*     |
| C10  | 0.36144 (11)  | 0.43758 (16) | 0.25455 (16) | 0.0328 (4) |
| H10  | 0.2999        | 0.4634       | 0.202        | 0.039*     |
| C11  | -0.02190 (10) | 0.48742 (16) | 0.18592 (18) | 0.0341 (4) |
| H11A | -0.0199       | 0.4689       | 0.0909       | 0.041*     |
| H11B | -0.0345       | 0.582        | 0.1912       | 0.041*     |
| C12  | -0.10361 (10) | 0.41236 (14) | 0.21001 (15) | 0.0234 (3) |
| C13  | -0.09255 (10) | 0.31025 (14) | 0.30325 (15) | 0.0259 (3) |
| H13  | -0.0311       | 0.2852       | 0.3572       | 0.031*     |
| C14  | -0.17071 (11) | 0.24423 (15) | 0.31840 (17) | 0.0317 (4) |
| H14  | -0.1623       | 0.1741       | 0.3824       | 0.038*     |
| C15  | -0.26067 (11) | 0.27991 (17) | 0.24095 (18) | 0.0360 (4) |
| H15  | -0.3141       | 0.2351       | 0.2517       | 0.043*     |
| C17  | -0.27181 (10) | 0.38191 (17) | 0.14751 (17) | 0.0358 (4) |
| H17  | -0.3333       | 0.4069       | 0.0939       | 0.043*     |
| C18  | -0.19466 (10) | 0.44741 (15) | 0.13154 (16) | 0.0285 (4) |
| H18  | -0.2034       | 0.5169       | 0.0668       | 0.034*     |

*Atomic displacement parameters (Å<sup>2</sup>)*

|     | $U^{11}$    | $U^{22}$    | $U^{33}$    | $U^{12}$      | $U^{13}$     | $U^{23}$      |
|-----|-------------|-------------|-------------|---------------|--------------|---------------|
| N1  | 0.0252 (6)  | 0.0280 (7)  | 0.0329 (8)  | -0.0007 (5)   | 0.0113 (5)   | -0.0046 (6)   |
| N2  | 0.0244 (6)  | 0.0293 (7)  | 0.0257 (7)  | -0.0010 (5)   | 0.0059 (5)   | -0.0015 (6)   |
| S1  | 0.0371 (2)  | 0.0336 (2)  | 0.0283 (2)  | -0.00352 (17) | 0.00927 (17) | -0.00815 (18) |
| C1  | 0.0240 (7)  | 0.0229 (7)  | 0.0252 (8)  | -0.0053 (6)   | 0.0109 (6)   | 0.0004 (6)    |
| C2  | 0.0391 (9)  | 0.0360 (9)  | 0.0276 (9)  | -0.0154 (7)   | 0.0139 (7)   | -0.0060 (7)   |
| C3  | 0.0452 (10) | 0.0290 (8)  | 0.0328 (9)  | -0.0040 (7)   | 0.0214 (8)   | -0.0040 (7)   |
| C4  | 0.0266 (8)  | 0.0317 (9)  | 0.0375 (9)  | 0.0010 (7)    | 0.0050 (7)   | 0.0085 (8)    |
| C5  | 0.0265 (8)  | 0.0245 (8)  | 0.0288 (9)  | 0.0006 (6)    | 0.0064 (6)   | -0.0026 (6)   |
| C6  | 0.0293 (8)  | 0.0303 (9)  | 0.0384 (10) | 0.0034 (7)    | 0.0044 (7)   | 0.0008 (7)    |
| C7  | 0.0237 (8)  | 0.0355 (10) | 0.0542 (12) | 0.0050 (7)    | 0.0066 (7)   | -0.0051 (9)   |
| C8  | 0.0305 (9)  | 0.0398 (10) | 0.0509 (11) | -0.0061 (7)   | 0.0196 (8)   | -0.0116 (8)   |
| C9  | 0.0388 (9)  | 0.0378 (10) | 0.0348 (10) | -0.0027 (7)   | 0.0138 (7)   | 0.0011 (8)    |
| C10 | 0.0270 (8)  | 0.0373 (9)  | 0.0321 (9)  | 0.0003 (7)    | 0.0057 (7)   | 0.0012 (7)    |
| C11 | 0.0282 (8)  | 0.0341 (9)  | 0.0418 (10) | 0.0062 (7)    | 0.0133 (7)   | 0.0128 (8)    |
| C12 | 0.0254 (7)  | 0.0228 (7)  | 0.0236 (8)  | 0.0029 (6)    | 0.0095 (6)   | -0.0034 (6)   |
| C13 | 0.0267 (8)  | 0.0257 (8)  | 0.0252 (8)  | 0.0032 (6)    | 0.0076 (6)   | 0.0006 (6)    |
| C14 | 0.0406 (9)  | 0.0279 (8)  | 0.0294 (9)  | -0.0035 (7)   | 0.0145 (7)   | -0.0003 (7)   |
| C15 | 0.0310 (8)  | 0.0375 (9)  | 0.0433 (10) | -0.0097 (7)   | 0.0167 (7)   | -0.0102 (8)   |
| C17 | 0.0242 (8)  | 0.0425 (10) | 0.0371 (10) | 0.0022 (7)    | 0.0036 (7)   | -0.0073 (8)   |
| C18 | 0.0316 (8)  | 0.0291 (8)  | 0.0241 (8)  | 0.0052 (7)    | 0.0072 (6)   | -0.0008 (7)   |



## Geometric parameters (Å, °)

|            |             |               |             |
|------------|-------------|---------------|-------------|
| N1—C1      | 1.3479 (18) | C7—H7         | 0.95        |
| N1—C11     | 1.446 (2)   | C8—C9         | 1.389 (2)   |
| N1—C3      | 1.460 (2)   | C8—H8         | 0.95        |
| N2—C1      | 1.3501 (19) | C9—C10        | 1.393 (2)   |
| N2—C4      | 1.4459 (18) | C9—H9         | 0.95        |
| N2—C2      | 1.4591 (19) | C10—H10       | 0.95        |
| S1—C1      | 1.6759 (15) | C11—C12       | 1.515 (2)   |
| C2—C3      | 1.524 (2)   | C11—H11A      | 0.99        |
| C2—H2A     | 0.99        | C11—H11B      | 0.99        |
| C2—H2B     | 0.99        | C12—C13       | 1.385 (2)   |
| C3—H3A     | 0.99        | C12—C18       | 1.398 (2)   |
| C3—H3B     | 0.99        | C13—C14       | 1.390 (2)   |
| C4—C5      | 1.518 (2)   | C13—H13       | 0.95        |
| C4—H4A     | 0.99        | C14—C15       | 1.384 (2)   |
| C4—H4B     | 0.99        | C14—H14       | 0.95        |
| C5—C10     | 1.383 (2)   | C15—C17       | 1.385 (2)   |
| C5—C6      | 1.393 (2)   | C15—H15       | 0.95        |
| C6—C7      | 1.385 (2)   | C17—C18       | 1.377 (2)   |
| C6—H6      | 0.95        | C17—H17       | 0.95        |
| C7—C8      | 1.375 (3)   | C18—H18       | 0.95        |
|            |             |               |             |
| C1—N1—C11  | 125.29 (13) | C6—C7—H7      | 119.9       |
| C1—N1—C3   | 111.91 (12) | C7—C8—C9      | 119.96 (15) |
| C11—N1—C3  | 122.62 (13) | C7—C8—H8      | 120         |
| C1—N2—C4   | 125.09 (13) | C9—C8—H8      | 120         |
| C1—N2—C2   | 111.84 (12) | C8—C9—C10     | 119.72 (16) |
| C4—N2—C2   | 122.81 (12) | C8—C9—H9      | 120.1       |
| N1—C1—N2   | 108.57 (13) | C10—C9—H9     | 120.1       |
| N1—C1—S1   | 125.58 (12) | C5—C10—C9     | 120.59 (14) |
| N2—C1—S1   | 125.84 (11) | C5—C10—H10    | 119.7       |
| N2—C2—C3   | 102.42 (12) | C9—C10—H10    | 119.7       |
| N2—C2—H2A  | 111.3       | N1—C11—C12    | 115.89 (13) |
| C3—C2—H2A  | 111.3       | N1—C11—H11A   | 108.3       |
| N2—C2—H2B  | 111.3       | C12—C11—H11A  | 108.3       |
| C3—C2—H2B  | 111.3       | N1—C11—H11B   | 108.3       |
| H2A—C2—H2B | 109.2       | C12—C11—H11B  | 108.3       |
| N1—C3—C2   | 102.60 (12) | H11A—C11—H11B | 107.4       |
| N1—C3—H3A  | 111.2       | C13—C12—C18   | 118.78 (13) |
| C2—C3—H3A  | 111.2       | C13—C12—C11   | 123.52 (13) |
| N1—C3—H3B  | 111.2       | C18—C12—C11   | 117.68 (13) |
| C2—C3—H3B  | 111.2       | C12—C13—C14   | 120.44 (14) |
| H3A—C3—H3B | 109.2       | C12—C13—H13   | 119.8       |
| N2—C4—C5   | 114.39 (12) | C14—C13—H13   | 119.8       |
| N2—C4—H4A  | 108.7       | C15—C14—C13   | 120.48 (15) |
| C5—C4—H4A  | 108.7       | C15—C14—H14   | 119.8       |
| N2—C4—H4B  | 108.7       | C13—C14—H14   | 119.8       |

|              |              |                 |              |
|--------------|--------------|-----------------|--------------|
| C5—C4—H4B    | 108.7        | C14—C15—C17     | 119.14 (14)  |
| H4A—C4—H4B   | 107.6        | C14—C15—H15     | 120.4        |
| C10—C5—C6    | 118.92 (14)  | C17—C15—H15     | 120.4        |
| C10—C5—C4    | 121.38 (13)  | C18—C17—C15     | 120.70 (14)  |
| C6—C5—C4     | 119.67 (14)  | C18—C17—H17     | 119.7        |
| C7—C6—C5     | 120.57 (16)  | C15—C17—H17     | 119.7        |
| C7—C6—H6     | 119.7        | C17—C18—C12     | 120.46 (14)  |
| C5—C6—H6     | 119.7        | C17—C18—H18     | 119.8        |
| C8—C7—C6     | 120.24 (15)  | C12—C18—H18     | 119.8        |
| C8—C7—H7     | 119.9        |                 |              |
|              |              |                 |              |
| C11—N1—C1—N2 | -179.34 (13) | C5—C6—C7—C8     | 0.8 (3)      |
| C3—N1—C1—N2  | -4.12 (17)   | C6—C7—C8—C9     | -0.6 (3)     |
| C11—N1—C1—S1 | 1.4 (2)      | C7—C8—C9—C10    | -0.2 (3)     |
| C3—N1—C1—S1  | 176.58 (11)  | C6—C5—C10—C9    | -0.6 (2)     |
| C4—N2—C1—N1  | 178.56 (12)  | C4—C5—C10—C9    | -178.66 (15) |
| C2—N2—C1—N1  | -7.22 (16)   | C8—C9—C10—C5    | 0.8 (2)      |
| C4—N2—C1—S1  | -2.2 (2)     | C1—N1—C11—C12   | 91.76 (18)   |
| C2—N2—C1—S1  | 172.08 (10)  | C3—N1—C11—C12   | -82.97 (18)  |
| C1—N2—C2—C3  | 14.63 (16)   | N1—C11—C12—C13  | -8.5 (2)     |
| C4—N2—C2—C3  | -170.99 (13) | N1—C11—C12—C18  | 172.64 (13)  |
| C1—N1—C3—C2  | 12.79 (16)   | C18—C12—C13—C14 | -0.1 (2)     |
| C11—N1—C3—C2 | -171.84 (13) | C11—C12—C13—C14 | -178.92 (14) |
| N2—C2—C3—N1  | -15.51 (14)  | C12—C13—C14—C15 | -0.3 (2)     |
| C1—N2—C4—C5  | 101.77 (17)  | C13—C14—C15—C17 | 0.3 (2)      |
| C2—N2—C4—C5  | -71.85 (19)  | C14—C15—C17—C18 | -0.1 (2)     |
| N2—C4—C5—C10 | -35.3 (2)    | C15—C17—C18—C12 | -0.3 (2)     |
| N2—C4—C5—C6  | 146.64 (14)  | C13—C12—C18—C17 | 0.4 (2)      |
| C10—C5—C6—C7 | -0.2 (2)     | C11—C12—C18—C17 | 179.26 (15)  |
| C4—C5—C6—C7  | 177.88 (15)  |                 |              |

