

# Poly[di- $\mu$ -thiocyanato- $\kappa^2$ N:S; $\kappa^2$ S:N-bis[2-(1*H*-1,2,3-triazol-1-yl- $\kappa$ N<sup>3</sup>)pyrazine]cadmium(II)]

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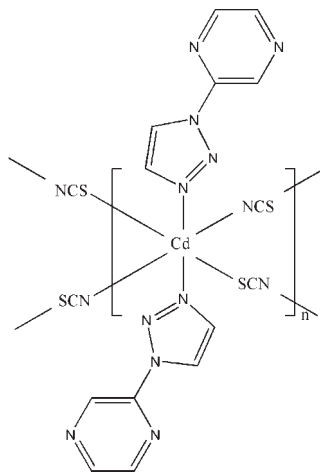
Received 14 July 2009; accepted 8 September 2009

Key indicators: single-crystal X-ray study;  $T = 298$  K; mean  $\sigma(\text{C}-\text{C}) = 0.004$  Å;  $R$  factor = 0.026;  $wR$  factor = 0.064; data-to-parameter ratio = 14.5.

In the title two-dimensional coordination polymer,  $[\text{Cd}(\text{NCS})_2(\text{C}_6\text{H}_5\text{N}_5)_2]_n$ , the  $\text{Cd}^{\text{II}}$  ion (site symmetry  $\bar{1}$ ) is coordinated by two N atoms from two 2-(1*H*-1,2,3-triazol-1-yl)pyrazine ligands and two N and two S atoms from four thiocyanate anions. The N—Cd bond lengths range from 2.323 (2) to 2.3655 (19) Å and the S—Cd bond length is 2.7117 (7) Å. The associated *cisoid* angles vary from 84.99 (7) to 95.01 (7)°, indicating that the  $\text{Cd}^{\text{II}}$  ion assumes a distorted octahedral geometry. In the complex, each thiocyanate anion functions as a bridging ligand, linking adjacent  $\text{Cd}^{\text{II}}$  ions with a separation of 6.4919 (6) Å, resulting in the formation of a two-dimensional sheet structure in the *bc* plane.

## Related literature

For a related crystal structure, see: Yang & Shi (2008). For the synthesis of  $\text{Cd}^{\text{II}}$  complexes with thiocyanate anions and pyrazine derivatives as mixed bridging ligands, see: Li *et al.* (2008); Shi *et al.* (2007).



## Experimental

### Crystal data

$[\text{Cd}(\text{NCS})_2(\text{C}_6\text{H}_5\text{N}_5)_2]$   
 $M_r = 522.86$   
Monoclinic,  $P2_1/c$   
 $a = 12.5038$  (15) Å  
 $b = 10.7240$  (13) Å  
 $c = 7.3196$  (9) Å  
 $\beta = 106.476$  (2)°

$V = 941.2$  (2) Å<sup>3</sup>  
 $Z = 2$   
Mo  $K\alpha$  radiation  
 $\mu = 1.41$  mm<sup>-1</sup>  
 $T = 298$  K  
 $0.24 \times 0.18 \times 0.16$  mm

### Data collection

Bruker SMART APEX CCD diffractometer  
Absorption correction: multi-scan (*SADABS*; Sheldrick, 1996)  
 $T_{\text{min}} = 0.728$ ,  $T_{\text{max}} = 0.806$

5139 measured reflections  
1923 independent reflections  
1735 reflections with  $I > 2\sigma(I)$   
 $R_{\text{int}} = 0.023$

### Refinement

$R[F^2 > 2\sigma(F^2)] = 0.026$   
 $wR(F^2) = 0.064$   
 $S = 1.03$   
1923 reflections

133 parameters  
H-atom parameters constrained  
 $\Delta\rho_{\text{max}} = 0.55$  e Å<sup>-3</sup>  
 $\Delta\rho_{\text{min}} = -0.34$  e Å<sup>-3</sup>

**Table 1**

Selected bond angles (°).

N6 <sup>i</sup> —Cd1—N1	84.99 (7)	N1—Cd1—S1 <sup>iii</sup>	94.56 (5)
N6 <sup>ii</sup> —Cd1—N1	95.01 (7)	N6 <sup>ii</sup> —Cd1—S1	88.93 (6)
N6 <sup>ii</sup> —Cd1—S1 <sup>iii</sup>	91.07 (6)	N1—Cd1—S1	85.44 (5)

Symmetry codes: (i)  $-x, y - \frac{1}{2}, -z + \frac{1}{2}$ ; (ii)  $x, -y + \frac{3}{2}, z - \frac{1}{2}$ ; (iii)  $-x, -y + 2, -z$ .

Data collection: *SMART* (Bruker, 1997); cell refinement: *SAINTE* (Bruker, 1997); data reduction: *SAINTE*; program(s) used to solve structure: *SHELXTL* (Sheldrick, 2008); program(s) used to refine structure: *SHELXTL*; molecular graphics: *SHELXTL*; software used to prepare material for publication: *SHELXTL*.

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: BV2122).

## References

- Bruker (1997). *SMART* and *SAINTE*. Bruker AXS Inc., Madison, Wisconsin, USA.  
Li, H., Xu, H. Y., Zhang, S. G. & Shi, J. M. (2008). *J. Coord. Chem.* **61**, 2807–2813.  
Sheldrick, G. M. (1996). *SADABS*. University of Göttingen, Germany.  
Sheldrick, G. M. (2008). *Acta Cryst.* **A64**, 112–122.  
Shi, J. M., Zhang, X., Xu, H. Y., Wu, C. J. & Liu, L. D. (2007). *J. Coord. Chem.* **60**, 647–654.  
Yang, L. Y. & Shi, J. M. (2008). *Acta Cryst.* **E64**, m1387.

## supporting information

*Acta Cryst.* (2009). E65, m1211 [doi:10.1107/S1600536809036332]

## Poly[di- $\mu$ -thiocyanato- $\kappa^2$ N:S; $\kappa^2$ S:N-bis[2-(1*H*-1,2,3-triazol-1-yl)- $\kappa$ N<sup>3</sup>]pyrazine]-cadmium(II)]

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### S1. Comment

2-(1*H*-1,2,3-triazol-1-yl)pyrazine is similar to 2-(pyrazol-1-yl)pyrazine (Yang & Shi 2008) in structure and therefore it should act as a bridging ligand. Our interest in synthesizing Cd<sup>II</sup> complexes (Shi *et al.*, 2007; Li *et al.*, 2008) with thiocyanate anions and derivatives of pyrazine as mixed bridging ligands resulted in us selecting thiocyanato and 2-(1*H*-1,2,3-triazol-1-yl)pyrazine as ligands, but only the title complex was obtained, in which 2-(1*H*-1,2,3-triazol-1-yl)pyrazine only functions as a terminal ligand. Herein we report the crystal structure of the title complex.

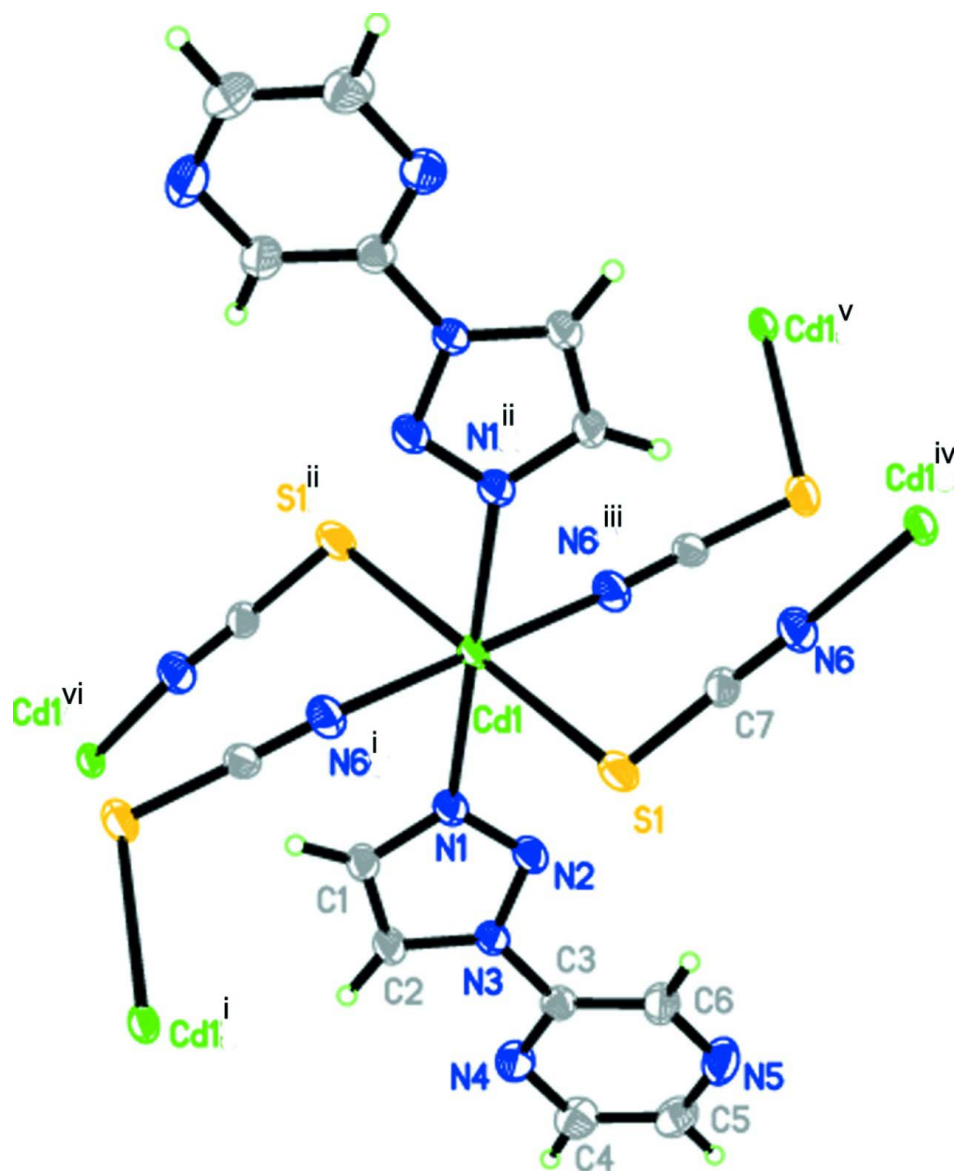
The asymmetric unit and symmetry-related fragments of (I) are shown in Fig. 1, and Fig. 1 and Table 1 reveal that Cd<sup>II</sup> atom is in a distorted octahedral CdN<sub>4</sub>S<sub>2</sub> coordination geometry. In the crystal each Cd<sup>II</sup> ion is surrounded by four other symmetry-related Cd<sup>II</sup> ions with separation with 6.4919 (6) Å and the adjacent Cd<sup>II</sup> ions were bridged by one thiocyanato anions and it forms a two-dimensional sheet on *bc* plane as shown in Fig. 2. 2-(1*H*-1,2,3-triazol-1-yl)pyrazine only acts as a monodentate ligand.

### S2. Experimental

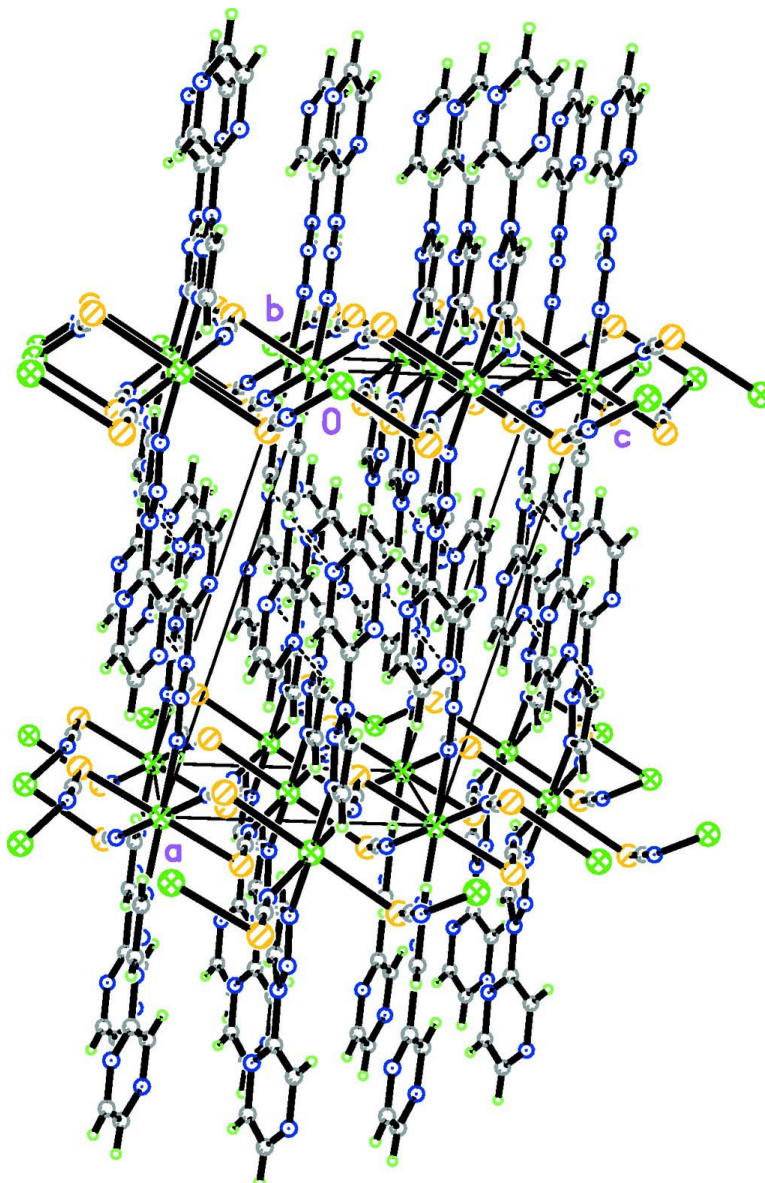
An 8 ml methanol solution of 2-(1*H*-1,2,3-triazol-1-yl)pyrazine (0.0401 g, 0.272 mmol), 5 ml water solution of Cd(ClO<sub>4</sub>)<sub>2</sub>·6H<sub>2</sub>O (0.1120 g, 0.267 mmol) and 5 ml water solution of NaSCN (0.0435 g, 0.537 mmol) were mixed together and stirred for a few minutes. The colorless single crystals were obtained after the filtrate had been allowed to stand at room temperature for ten days.

### S3. Refinement

All H atoms were placed in calculated positions and refined as riding with C—H = 0.93 Å and  $U_{\text{iso}}(\text{H}) = 1.2U_{\text{eq}}(\text{C})$ .

**Figure 1**

The coordination structure of (I) showing the atom numbering scheme with thermal ellipsoids drawn at the 30% probability level. [Symmetry codes: (i)  $-x, y - 1/2, -z + 1/2$  (ii)  $-x, -y + 2, -z$  (iii)  $x, -y + 5/2, z - 1/2$  (iv)  $-x, y + 1/2, -z - 1/2$  (v)  $-x, y - 1/2, -z - 1/2$  (vi)  $-x, y + 1/2, -z + 1/2$ ]



**Figure 2**

Unit cell and the part of the two-dimensional sheet on *bc* plane.

**Poly[di- $\mu$ -thiocyanato- $\kappa^2$ N:S; $\kappa^2$ S:N-bis[2-(1H-1,2,3-triazol-1-yl)- $\kappa$ N<sup>3</sup>]pyrazine]cadmium(II)]**

*Crystal data*

[Cd(NCS)<sub>2</sub>(C<sub>6</sub>H<sub>3</sub>N<sub>5</sub>)<sub>2</sub>]

*M<sub>r</sub>* = 522.86

Monoclinic, *P*2<sub>1</sub>/*c*

Hall symbol: -*P* 2ybc

*a* = 12.5038 (15) Å

*b* = 10.7240 (13) Å

*c* = 7.3196 (9) Å

$\beta$  = 106.476 (2)°

*V* = 941.2 (2) Å<sup>3</sup>

*Z* = 2

*F*(000) = 516

*D<sub>x</sub>* = 1.845 Mg m<sup>-3</sup>

Mo *K* $\alpha$  radiation,  $\lambda$  = 0.71073 Å

Cell parameters from 3160 reflections

$\theta$  = 2.6–28.0°

$\mu$  = 1.41 mm<sup>-1</sup>

*T* = 298 K

Block, colorless

0.24 × 0.18 × 0.16 mm

*Data collection*

Bruker SMART APEX CCD  
diffractometer  
Radiation source: fine-focus sealed tube  
Graphite monochromator  
 $\varphi$  and  $\omega$  scans  
Absorption correction: multi-scan  
(*SADABS*; Sheldrick, 1996)  
 $T_{\min} = 0.728$ ,  $T_{\max} = 0.806$

5139 measured reflections  
1923 independent reflections  
1735 reflections with  $I > 2\sigma(I)$   
 $R_{\text{int}} = 0.023$   
 $\theta_{\max} = 26.4^\circ$ ,  $\theta_{\min} = 1.7^\circ$   
 $h = -15 \rightarrow 15$   
 $k = -13 \rightarrow 12$   
 $l = -6 \rightarrow 9$

*Refinement*

Refinement on  $F^2$   
Least-squares matrix: full  
 $R[F^2 > 2\sigma(F^2)] = 0.026$   
 $wR(F^2) = 0.064$   
 $S = 1.03$   
1923 reflections  
133 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  
 $w = 1/[\sigma^2(F_o^2) + (0.0289P)^2 + 0.6077P]$   
where  $P = (F_o^2 + 2F_c^2)/3$   
 $(\Delta/\sigma)_{\max} = 0.001$   
 $\Delta\rho_{\max} = 0.55 \text{ e } \text{\AA}^{-3}$   
 $\Delta\rho_{\min} = -0.34 \text{ e } \text{\AA}^{-3}$

*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 ( $\text{\AA}^2$ )*

	<i>x</i>	<i>y</i>	<i>z</i>	$U_{\text{iso}}^*/U_{\text{eq}}$
C1	0.1593 (2)	0.7435 (2)	0.0075 (4)	0.0390 (6)
H1	0.0980	0.6904	-0.0225	0.047*
C2	0.2671 (2)	0.7082 (2)	0.0439 (4)	0.0405 (6)
H2	0.2951	0.6278	0.0441	0.049*
C3	0.44202 (19)	0.8353 (2)	0.1282 (3)	0.0348 (5)
C4	0.6101 (2)	0.7616 (3)	0.1322 (4)	0.0521 (7)
H4	0.6555	0.6987	0.1083	0.063*
C5	0.6582 (2)	0.8710 (3)	0.2116 (4)	0.0530 (7)
H5	0.7347	0.8817	0.2350	0.064*
C6	0.4896 (2)	0.9434 (3)	0.2156 (5)	0.0506 (7)
H6	0.4446	1.0041	0.2468	0.061*
C7	0.08801 (19)	1.2249 (2)	0.3671 (3)	0.0331 (5)
Cd1	0.0000	1.0000	0.0000	0.03129 (10)
N1	0.15559 (16)	0.86932 (18)	0.0222 (3)	0.0370 (5)
N2	0.25664 (17)	0.91457 (18)	0.0669 (3)	0.0393 (5)
N3	0.32500 (16)	0.81662 (17)	0.0798 (3)	0.0336 (4)

N4	0.50015 (18)	0.7423 (2)	0.0879 (4)	0.0464 (5)
N5	0.5982 (2)	0.9623 (3)	0.2560 (5)	0.0615 (7)
N6	0.07295 (19)	1.32994 (19)	0.3793 (3)	0.0452 (5)
S1	0.11190 (7)	1.07527 (6)	0.35667 (11)	0.0530 (2)

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

	$U^{11}$	$U^{22}$	$U^{33}$	$U^{12}$	$U^{13}$	$U^{23}$
C1	0.0328 (13)	0.0276 (11)	0.0548 (16)	0.0003 (9)	0.0097 (11)	-0.0064 (11)
C2	0.0363 (13)	0.0268 (11)	0.0566 (16)	0.0025 (10)	0.0104 (12)	-0.0060 (11)
C3	0.0333 (12)	0.0363 (12)	0.0350 (12)	0.0027 (10)	0.0098 (10)	-0.0011 (10)
C4	0.0379 (15)	0.0618 (18)	0.0593 (19)	0.0058 (13)	0.0181 (13)	-0.0065 (15)
C5	0.0335 (14)	0.0681 (19)	0.0564 (18)	-0.0022 (13)	0.0113 (13)	0.0008 (15)
C6	0.0370 (14)	0.0413 (15)	0.070 (2)	0.0015 (12)	0.0094 (13)	-0.0099 (14)
C7	0.0310 (12)	0.0315 (12)	0.0370 (13)	-0.0020 (9)	0.0097 (10)	-0.0056 (10)
Cd1	0.02776 (14)	0.01935 (13)	0.04655 (17)	0.00164 (8)	0.01019 (11)	0.00206 (9)
N1	0.0321 (10)	0.0283 (10)	0.0496 (13)	0.0032 (8)	0.0098 (9)	-0.0009 (9)
N2	0.0340 (11)	0.0265 (10)	0.0578 (14)	0.0039 (8)	0.0134 (10)	-0.0011 (9)
N3	0.0311 (10)	0.0274 (9)	0.0415 (11)	0.0041 (8)	0.0087 (8)	-0.0024 (8)
N4	0.0379 (12)	0.0450 (12)	0.0575 (15)	0.0042 (10)	0.0157 (10)	-0.0089 (11)
N5	0.0397 (14)	0.0541 (14)	0.085 (2)	-0.0095 (12)	0.0082 (13)	-0.0145 (15)
N6	0.0462 (13)	0.0323 (11)	0.0571 (14)	0.0036 (9)	0.0145 (11)	-0.0081 (10)
S1	0.0712 (5)	0.0266 (3)	0.0485 (4)	0.0086 (3)	-0.0037 (3)	-0.0046 (3)

*Geometric parameters (Å, °)*

C1—C2	1.352 (3)	C6—N5	1.322 (4)
C1—N1	1.355 (3)	C6—H6	0.9300
C1—H1	0.9300	C7—N6	1.150 (3)
C2—N3	1.356 (3)	C7—S1	1.638 (2)
C2—H2	0.9300	Cd1—N6 <sup>i</sup>	2.323 (2)
C3—N4	1.316 (3)	Cd1—N6 <sup>ii</sup>	2.323 (2)
C3—C6	1.375 (4)	Cd1—N1	2.3655 (19)
C3—N3	1.419 (3)	Cd1—N1 <sup>iii</sup>	2.3655 (19)
C4—N4	1.336 (4)	Cd1—S1 <sup>iii</sup>	2.7117 (7)
C4—C5	1.370 (4)	Cd1—S1	2.7117 (7)
C4—H4	0.9300	N1—N2	1.306 (3)
C5—N5	1.328 (4)	N2—N3	1.341 (3)
C5—H5	0.9300	N6—Cd1 <sup>iv</sup>	2.323 (2)
C2—C1—N1	108.6 (2)	N6 <sup>ii</sup> —Cd1—N1 <sup>iii</sup>	84.99 (7)
C2—C1—H1	125.7	N1—Cd1—N1 <sup>iii</sup>	180.0
N1—C1—H1	125.7	N6 <sup>i</sup> —Cd1—S1 <sup>iii</sup>	88.93 (6)
C1—C2—N3	104.2 (2)	N6 <sup>ii</sup> —Cd1—S1 <sup>iii</sup>	91.07 (6)
C1—C2—H2	127.9	N1—Cd1—S1 <sup>iii</sup>	94.56 (5)
N3—C2—H2	127.9	N1 <sup>iii</sup> —Cd1—S1 <sup>iii</sup>	85.44 (5)
N4—C3—C6	123.3 (2)	N6 <sup>i</sup> —Cd1—S1	91.07 (6)
N4—C3—N3	115.7 (2)	N6 <sup>ii</sup> —Cd1—S1	88.93 (6)

C6—C3—N3	121.0 (2)	N1—Cd1—S1	85.44 (5)
N4—C4—C5	122.2 (3)	N1 <sup>iii</sup> —Cd1—S1	94.56 (5)
N4—C4—H4	118.9	S1 <sup>iii</sup> —Cd1—S1	180.0
C5—C4—H4	118.9	N2—N1—C1	109.69 (19)
N5—C5—C4	121.6 (3)	N2—N1—Cd1	121.04 (14)
N5—C5—H5	119.2	C1—N1—Cd1	129.10 (16)
C4—C5—H5	119.2	N1—N2—N3	106.19 (18)
N5—C6—C3	121.0 (3)	N2—N3—C2	111.33 (19)
N5—C6—H6	119.5	N2—N3—C3	119.93 (19)
C3—C6—H6	119.5	C2—N3—C3	128.7 (2)
N6—C7—S1	178.2 (3)	C3—N4—C4	115.1 (2)
N6 <sup>i</sup> —Cd1—N6 <sup>ii</sup>	180.0	C6—N5—C5	116.6 (3)
N6 <sup>i</sup> —Cd1—N1	84.99 (7)	C7—N6—Cd1 <sup>iv</sup>	152.8 (2)
N6 <sup>ii</sup> —Cd1—N1	95.01 (7)	C7—S1—Cd1	106.59 (9)
N6 <sup>i</sup> —Cd1—N1 <sup>iii</sup>	95.01 (7)		

Symmetry codes: (i)  $-x, y-1/2, -z+1/2$ ; (ii)  $x, -y+5/2, z-1/2$ ; (iii)  $-x, -y+2, -z$ ; (iv)  $-x, y+1/2, -z+1/2$ .