

# Poly[[aqua( $\mu_2$ -oxalato)( $\mu_2$ -2-oxido-pyridinium-3-carboxylato)-dysprosium(III)] monohydrate]

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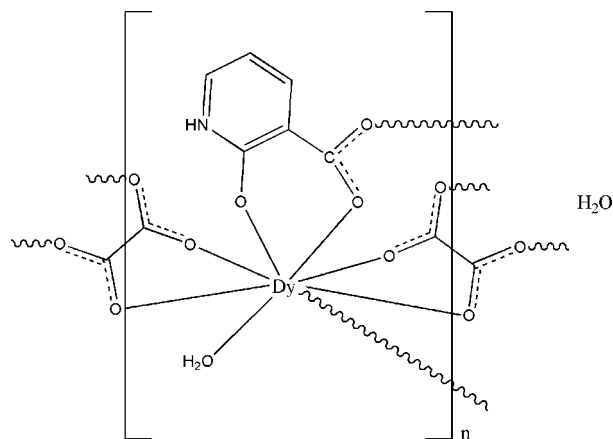
Received 20 December 2008; accepted 7 January 2009

Key indicators: single-crystal X-ray study;  $T = 296$  K; mean  $\sigma(\text{C}-\text{C}) = 0.011$  Å;  $R$  factor = 0.030;  $wR$  factor = 0.077; data-to-parameter ratio = 11.6.

In the title complex,  $\{[\text{Dy}(\text{C}_6\text{H}_4\text{NO}_3)(\text{C}_2\text{O}_4)(\text{H}_2\text{O})]\cdot\text{H}_2\text{O}\}_n$ , the  $\text{Dy}^{\text{III}}$  ion is coordinated by seven O atoms from two 2-oxidopyridinium-3-carboxylate ligands, two oxalate ligands and one water molecule, displaying a distorted bicapped trigonal-prismatic geometry. The carboxylate groups of the 2-oxidopyridinium-3-carboxylate and oxalate ligands link dysprosium metal centres, forming layers parallel to (100). These layers are further connected by intermolecular O—H...O hydrogen-bonding interactions involving the coordinated water molecules, forming a three-dimensional supra-molecular network. The uncoordinated water molecule is involved in N—H...O and O—H...O hydrogen-bonding interactions within the layer.

## Related literature

For background to the molecular self-assembly of supra-molecular architectures, see: Moulton & Zaworotko (2001); Zeng *et al.* (2007).



## Experimental

### Crystal data

$[\text{Dy}(\text{C}_6\text{H}_4\text{NO}_3)(\text{C}_2\text{O}_4)(\text{H}_2\text{O})]\cdot\text{H}_2\text{O}$	$\gamma = 80.305$ (2)°
$M_r = 424.65$	$V = 563.4$ (2) Å <sup>3</sup>
Triclinic, $P\bar{1}$	$Z = 2$
$a = 6.5359$ (15) Å	Mo $K\alpha$ radiation
$b = 9.561$ (2) Å	$\mu = 6.68$ mm <sup>-1</sup>
$c = 9.734$ (2) Å	$T = 296$ (2) K
$\alpha = 71.906$ (2)°	$0.17 \times 0.16 \times 0.14$ mm
$\beta = 78.800$ (3)°	

### Data collection

Bruker APEXII area-detector diffractometer	2926 measured reflections
Absorption correction: multi-scan (APEX2; Bruker, 2004)	2003 independent reflections
$T_{\text{min}} = 0.397$ , $T_{\text{max}} = 0.455$	1888 reflections with $I > 2\sigma(I)$
(expected range = 0.342–0.393)	$R_{\text{int}} = 0.021$

### Refinement

$R[F^2 > 2\sigma(F^2)] = 0.030$	172 parameters
$wR(F^2) = 0.077$	H-atom parameters constrained
$S = 1.09$	$\Delta\rho_{\text{max}} = 2.29$ e Å <sup>-3</sup>
2003 reflections	$\Delta\rho_{\text{min}} = -1.55$ e Å <sup>-3</sup>

**Table 1**

Hydrogen-bond geometry (Å, °).

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
$\text{N1}-\text{H1}\cdots\text{O2W}$	0.86	1.99	2.785 (9)	154
$\text{O1W}-\text{H1W}\cdots\text{O2}^i$	0.85	1.94	2.732 (7)	155
$\text{O1W}-\text{H2W}\cdots\text{O4}^{ii}$	0.85	2.07	2.751 (7)	137
$\text{O2W}-\text{H4W}\cdots\text{O1}^{iii}$	0.85	2.26	3.080 (8)	163
$\text{O2W}-\text{H4W}\cdots\text{O6}^{iii}$	0.85	2.36	2.878 (8)	120

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

Data collection: APEX2 (Bruker, 2004); cell refinement: SAINT (Bruker, 2004); data reduction: SAINT; program(s) used to solve structure: SHELXS97 (Sheldrick, 2008); program(s) used to refine structure: SHELXL97 (Sheldrick, 2008); molecular graphics: ORTEPIII (Burnett & Johnson, 1996) and PLATON (Spek, 2003); software used to prepare material for publication: SHELXL97.

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Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: DN2421).

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## References

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**supplementary materials**

*Acta Cryst.* (2009). E65, m177-m178 [ doi:10.1107/S1600536809000580 ]

## Poly[[aqua( $\mu_2$ -oxalato)( $\mu_2$ -2-oxidopyridinium-3-carboxylato)dysprosium(III)] monohydrate]

C.-D. Huang, J.-X. Huang, Y.-Y. Wu, Y.-Y. Lian and R.-H. Zeng

### Comment

Molecular self-assembly of supramolecular architectures has received much attention during recent decades (Zeng *et al.*, 2007; Moulton & Zaworotko, 2001). The structures and properties of such systems depend on the coordination and geometric preferences of both the central metal ions and the bridging building blocks, as well as the influence of weaker non-covalent interactions, such as hydrogen bonds and  $\pi$ - $\pi$  stacking interactions. Recently, we obtained the title coordination polymer, which was synthesized under hydrothermal conditions.

In the structure of the title compound, each Dy<sup>III</sup> centre is in a bicapped trigonal prismatic geometry, defined by seven oxygen atoms from two 2-oxidopyridinium-3-carboxylate ligands, one oxalate ligand, and one water molecule Fig. 1. The Dy<sup>III</sup> ions are linked by 2-oxidopyridinium-3-carboxylate ligands and oxalate ligands to form a layer in the *bc* plane, and the adjacent Dy $\cdots$ Dy separations are 5.858 (4), 6.186 (5) and 6.239 Å, respectively. The layers are further connected by intermolecular O—H $\cdots$ O hydrogen bonding interactions involving the coordinated water molecules to form a three-dimensional supramolecular network (Table 1, Fig. 2). Within each layer, free water molecules further link the complexes through N-H $\cdots$ O and O-H $\cdots$ O bonding interactions (Table 1).

### Experimental

A mixture of Dy<sub>2</sub>O<sub>3</sub> (0.375 g; 1 mmol), 2-oxynicotinic acid (0.127 g; 1 mmol), oxalic acid (0.09 g; 1 mmol), water (10 ml) in the presence of HNO<sub>3</sub> (0.024 g; 0.385 mmol) was stirred vigorously for 20 min and then sealed in a Teflon-lined stainless-steel autoclave (20 ml, capacity). The autoclave was heated and maintained at 446 K for 2 days, and then cooled to room temperature at 5 K h<sup>-1</sup> and obtained the colorless block crystals.

### Refinement

Water H atoms were tentatively located in difference Fourier maps and were refined with distance restraints of O—H = 0.85 Å and H $\cdots$ H = 1.39 Å, and with  $U_{\text{iso}}(\text{H}) = 1.5 U_{\text{eq}}(\text{O})$ , and then were treated as riding mode. H atoms attached to C and N atoms were placed at calculated positions and were treated as riding on their parent atoms with C—H = 0.93 Å, and N—H = 0.86 Å with  $U_{\text{iso}}(\text{H}) = 1.2 U_{\text{eq}}(\text{C,N})$ .

## Figures

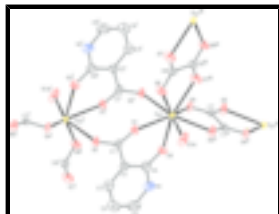


Fig. 1. The molecular structure showing the atomic-numbering scheme. Displacement ellipsoids drawn at the 30% probability level. Symmetry codes: (i)  $1 - x, 1 - y, 2 - z$ ; (ii)  $1 - x, 2 - y, 1 - z$ ; (iii)  $1 - x, 2 - y, 2 - z$ .

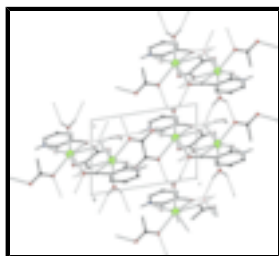


Fig. 2. A view of the three-dimensional supramolecular network. Hydrogen bonds are shown as dashed lines.

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### Crystal data

$[\text{Dy}(\text{C}_6\text{H}_4\text{NO}_3)(\text{C}_2\text{O}_4)(\text{H}_2\text{O})] \cdot \text{H}_2\text{O}$

$M_r = 424.65$

Triclinic,  $P\bar{1}$

Hall symbol:  $-P\ 1$

$a = 6.5359(15)\ \text{\AA}$

$b = 9.561(2)\ \text{\AA}$

$c = 9.734(2)\ \text{\AA}$

$\alpha = 71.906(2)^\circ$

$\beta = 78.800(3)^\circ$

$\gamma = 80.305(2)^\circ$

$V = 563.4(2)\ \text{\AA}^3$

$Z = 2$

$F_{000} = 402$

$D_x = 2.503\ \text{Mg m}^{-3}$

Mo  $K\alpha$  radiation

$\lambda = 0.71073\ \text{\AA}$

Cell parameters from 6377 reflections

$\theta = 1.7\text{--}28.0^\circ$

$\mu = 6.68\ \text{mm}^{-1}$

$T = 296(2)\ \text{K}$

Block, colourless

$0.17 \times 0.16 \times 0.14\ \text{mm}$

### Data collection

Bruker APEXII area-detector diffractometer

Radiation source: fine-focus sealed tube

Monochromator: graphite

$T = 296(2)\ \text{K}$

$\varphi$  and  $\omega$  scans

Absorption correction: multi-scan (APEX2; Bruker, 2004)

$T_{\min} = 0.397, T_{\max} = 0.455$

2926 measured reflections

2003 independent reflections

1888 reflections with  $I > 2\sigma(I)$

$R_{\text{int}} = 0.021$

$\theta_{\text{max}} = 25.2^\circ$

$\theta_{\text{min}} = 2.2^\circ$

$h = -7 \rightarrow 7$

$k = -11 \rightarrow 9$

$l = -11 \rightarrow 7$

Refinement

Refinement on $F^2$	Secondary atom site location: difference Fourier map
Least-squares matrix: full	Hydrogen site location: inferred from neighbouring sites
$R[F^2 > 2\sigma(F^2)] = 0.030$	H-atom parameters constrained
$wR(F^2) = 0.077$	$w = 1/[\sigma^2(F_o^2) + (0.0379P)^2 + 2.6561P]$
$S = 1.09$	where $P = (F_o^2 + 2F_c^2)/3$
2003 reflections	$(\Delta/\sigma)_{\max} = 0.001$
172 parameters	$\Delta\rho_{\max} = 2.29 \text{ e } \text{\AA}^{-3}$
Primary atom site location: structure-invariant direct methods	$\Delta\rho_{\min} = -1.55 \text{ e } \text{\AA}^{-3}$
	Extinction correction: none

Special details

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

	$x$	$y$	$z$	$U_{\text{iso}}^*/U_{\text{eq}}$
Dy1	0.59123 (5)	0.79001 (3)	0.80042 (3)	0.01511 (12)
O4	0.3353 (7)	0.8866 (5)	0.6354 (5)	0.0200 (10)
O1	0.7142 (8)	0.5573 (5)	0.9516 (5)	0.0228 (10)
O7	0.5714 (9)	0.9762 (6)	1.1684 (5)	0.0332 (13)
C6	0.7318 (12)	0.4932 (8)	0.6786 (8)	0.0255 (15)
O3	0.6553 (9)	0.6282 (5)	0.6621 (5)	0.0276 (11)
C8	0.5595 (11)	0.9416 (7)	1.0579 (7)	0.0205 (14)
O6	0.6333 (8)	0.8228 (5)	1.0278 (5)	0.0278 (11)
C7	0.3857 (10)	0.9806 (7)	0.5168 (7)	0.0162 (13)
O5	0.2701 (8)	1.0470 (5)	0.4234 (5)	0.0243 (11)
C1	0.7310 (10)	0.4252 (8)	0.9513 (7)	0.0204 (14)
N1	0.7737 (11)	0.4446 (7)	0.5575 (7)	0.0350 (15)
H1	0.7413	0.5052	0.4768	0.042*
C2	0.7787 (11)	0.3863 (7)	0.8109 (7)	0.0222 (14)
C3	0.8671 (14)	0.2456 (9)	0.8087 (9)	0.0353 (18)
H3	0.8970	0.1760	0.8954	0.042*
C5	0.8633 (15)	0.3065 (10)	0.5567 (10)	0.044 (2)
H5	0.8909	0.2816	0.4693	0.053*

## supplementary materials

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C4	0.9127 (16)	0.2052 (10)	0.6788 (10)	0.051 (3)
H4	0.9756	0.1107	0.6775	0.061*
O2	0.7138 (8)	0.3183 (5)	1.0690 (5)	0.0232 (10)
O1W	0.9535 (9)	0.7979 (7)	0.7825 (6)	0.0398 (14)
H1W	1.0327	0.7410	0.8417	0.060*
H2W	1.0234	0.8615	0.7177	0.060*
O2W	0.7275 (12)	0.5642 (8)	0.2640 (7)	0.0591 (19)
H3W	0.6854	0.6442	0.2877	0.089*
H4W	0.7313	0.5812	0.1725	0.089*

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

	$U^{11}$	$U^{22}$	$U^{33}$	$U^{12}$	$U^{13}$	$U^{23}$
Dy1	0.01446 (19)	0.01602 (18)	0.01286 (17)	-0.00079 (12)	-0.00214 (11)	-0.00175 (12)
O4	0.018 (3)	0.023 (2)	0.015 (2)	-0.007 (2)	-0.0030 (18)	0.0031 (18)
O1	0.029 (3)	0.020 (2)	0.017 (2)	-0.001 (2)	-0.0044 (19)	-0.0022 (19)
O7	0.046 (4)	0.029 (3)	0.027 (3)	0.009 (2)	-0.018 (2)	-0.011 (2)
C6	0.027 (4)	0.026 (4)	0.024 (4)	-0.006 (3)	0.000 (3)	-0.009 (3)
O3	0.038 (3)	0.025 (3)	0.019 (2)	0.003 (2)	-0.007 (2)	-0.008 (2)
C8	0.018 (4)	0.019 (3)	0.022 (3)	0.000 (3)	-0.002 (3)	-0.004 (3)
O6	0.035 (3)	0.023 (3)	0.026 (3)	0.008 (2)	-0.013 (2)	-0.009 (2)
C7	0.012 (4)	0.016 (3)	0.018 (3)	0.002 (3)	0.000 (2)	-0.004 (3)
O5	0.019 (3)	0.027 (3)	0.021 (2)	-0.006 (2)	-0.0065 (19)	0.005 (2)
C1	0.008 (3)	0.027 (4)	0.022 (3)	-0.006 (3)	-0.001 (2)	0.000 (3)
N1	0.041 (4)	0.037 (4)	0.028 (3)	-0.004 (3)	0.001 (3)	-0.015 (3)
C2	0.016 (4)	0.022 (3)	0.027 (4)	-0.003 (3)	0.001 (3)	-0.007 (3)
C3	0.036 (5)	0.029 (4)	0.038 (4)	-0.006 (4)	0.003 (4)	-0.009 (3)
C5	0.048 (6)	0.049 (5)	0.041 (5)	-0.006 (4)	0.006 (4)	-0.029 (4)
C4	0.063 (7)	0.034 (5)	0.053 (6)	-0.001 (5)	0.009 (5)	-0.021 (4)
O2	0.019 (3)	0.021 (2)	0.022 (2)	-0.001 (2)	-0.0043 (19)	0.0049 (19)
O1W	0.022 (3)	0.054 (4)	0.029 (3)	-0.010 (3)	-0.009 (2)	0.015 (3)
O2W	0.067 (5)	0.070 (5)	0.039 (4)	-0.019 (4)	-0.015 (3)	-0.004 (3)

### Geometric parameters ( $\text{\AA}$ , $^\circ$ )

Dy1—O3	2.289 (5)	C7—O5	1.244 (8)
Dy1—O1W	2.352 (5)	C7—C7 <sup>ii</sup>	1.549 (12)
Dy1—O2 <sup>i</sup>	2.357 (5)	C1—O2	1.277 (8)
Dy1—O1	2.364 (4)	C1—C2	1.488 (9)
Dy1—O5 <sup>ii</sup>	2.366 (4)	N1—C5	1.353 (11)
Dy1—O7 <sup>iii</sup>	2.391 (5)	N1—H1	0.8600
Dy1—O6	2.402 (5)	C2—C3	1.377 (11)
Dy1—O4	2.415 (4)	C3—C4	1.398 (12)
O4—C7	1.247 (8)	C3—H3	0.9300
O1—C1	1.250 (8)	C5—C4	1.336 (13)
O7—C8	1.239 (8)	C5—H5	0.9300
C6—O3	1.275 (9)	C4—H4	0.9300
C6—N1	1.361 (9)	O1W—H1W	0.8500

C6—C2	1.424 (10)	O1W—H2W	0.8490
C8—O6	1.255 (8)	O2W—H3W	0.8534
C8—C8 <sup>iii</sup>	1.547 (13)	O2W—H4W	0.8503
O3—Dy1—O1W	90.9 (2)	N1—C6—C2	115.8 (7)
O3—Dy1—O2 <sup>i</sup>	90.55 (18)	C6—O3—Dy1	136.4 (4)
O1W—Dy1—O2 <sup>i</sup>	148.35 (17)	O7—C8—O6	127.9 (6)
O3—Dy1—O1	73.20 (16)	O7—C8—C8 <sup>iii</sup>	116.5 (7)
O1W—Dy1—O1	75.35 (18)	O6—C8—C8 <sup>iii</sup>	115.6 (7)
O2 <sup>i</sup> —Dy1—O1	74.84 (16)	C8—O6—Dy1	120.2 (4)
O3—Dy1—O5 <sup>ii</sup>	81.96 (17)	O5—C7—O4	126.4 (6)
O1W—Dy1—O5 <sup>ii</sup>	67.74 (17)	O5—C7—C7 <sup>ii</sup>	116.8 (7)
O2 <sup>i</sup> —Dy1—O5 <sup>ii</sup>	143.60 (16)	O4—C7—C7 <sup>ii</sup>	116.8 (7)
O1—Dy1—O5 <sup>ii</sup>	134.77 (17)	C7—O5—Dy1 <sup>ii</sup>	120.1 (4)
O3—Dy1—O7 <sup>iii</sup>	148.30 (17)	O1—C1—O2	122.5 (6)
O1W—Dy1—O7 <sup>iii</sup>	105.1 (2)	O1—C1—C2	120.4 (6)
O2 <sup>i</sup> —Dy1—O7 <sup>iii</sup>	89.70 (19)	O2—C1—C2	117.1 (6)
O1—Dy1—O7 <sup>iii</sup>	136.90 (16)	C5—N1—C6	123.9 (7)
O5 <sup>ii</sup> —Dy1—O7 <sup>iii</sup>	79.21 (18)	C5—N1—H1	118.0
O3—Dy1—O6	144.68 (17)	C6—N1—H1	118.0
O1W—Dy1—O6	75.02 (19)	C3—C2—C6	119.6 (7)
O2 <sup>i</sup> —Dy1—O6	85.84 (17)	C3—C2—C1	119.9 (7)
O1—Dy1—O6	71.95 (16)	C6—C2—C1	120.5 (6)
O5 <sup>ii</sup> —Dy1—O6	119.90 (17)	C2—C3—C4	121.4 (8)
O7 <sup>iii</sup> —Dy1—O6	66.91 (16)	C2—C3—H3	119.3
O3—Dy1—O4	77.17 (17)	C4—C3—H3	119.3
O1W—Dy1—O4	135.23 (16)	C4—C5—N1	121.4 (8)
O2 <sup>i</sup> —Dy1—O4	75.68 (15)	C4—C5—H5	119.3
O1—Dy1—O4	137.50 (15)	N1—C5—H5	119.3
O5 <sup>ii</sup> —Dy1—O4	67.92 (15)	C5—C4—C3	117.9 (8)
O7 <sup>iii</sup> —Dy1—O4	72.20 (16)	C5—C4—H4	121.0
O6—Dy1—O4	134.95 (16)	C3—C4—H4	121.0
C7—O4—Dy1	118.2 (4)	C1—O2—Dy1 <sup>i</sup>	128.1 (4)
C1—O1—Dy1	136.4 (4)	Dy1—O1W—H1W	125.7
C8—O7—Dy1 <sup>iii</sup>	120.8 (4)	Dy1—O1W—H2W	124.6
O3—C6—N1	117.2 (6)	H1W—O1W—H2W	109.7
O3—C6—C2	127.0 (6)	H3W—O2W—H4W	109.6

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

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

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
N1—H1 $\cdots$ O2W	0.86	1.99	2.785 (9)	154
O1W—H1W $\cdots$ O2 <sup>iv</sup>	0.85	1.94	2.732 (7)	155
O1W—H2W $\cdots$ O4 <sup>v</sup>	0.85	2.07	2.751 (7)	137

## supplementary materials

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O2W—H4W...O1 <sup>vi</sup>	0.85	2.26	3.080 (8)	163
O2W—H4W...O6 <sup>vi</sup>	0.85	2.36	2.878 (8)	120

Symmetry codes: (iv)  $-x+2, -y+1, -z+2$ ; (v)  $x+1, y, z$ ; (vi)  $x, y, z-1$ .

Fig. 1

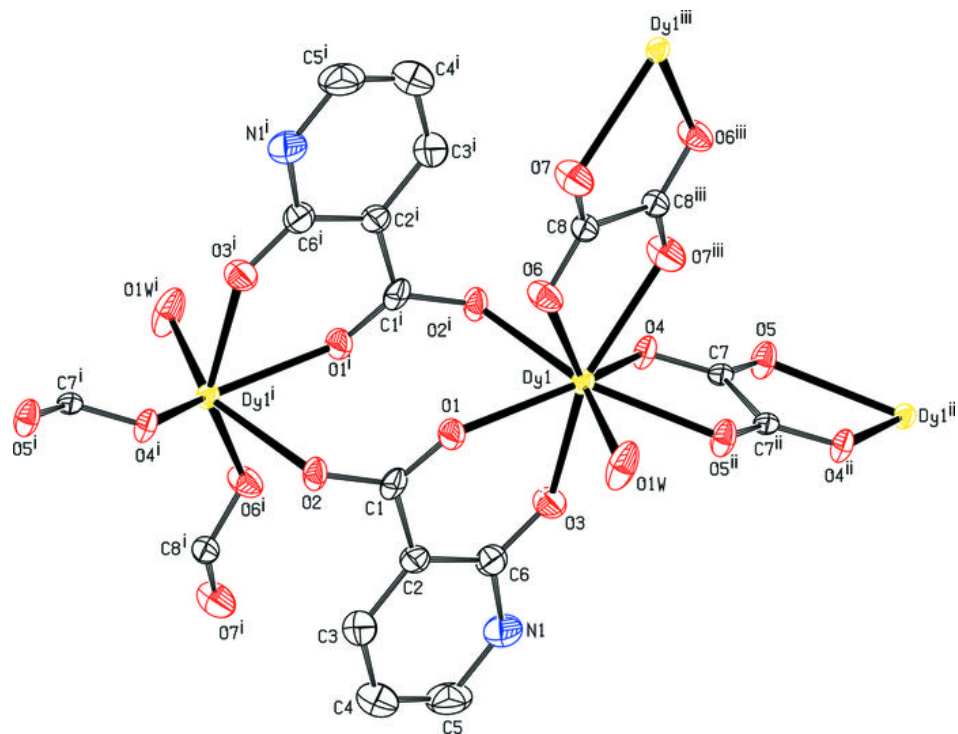


Fig. 2

