

A one-dimensional ladder-like coordination polymer: poly[[hexaaquabis(μ -5-nitrobenzene-1,3-dicarboxylato- $\kappa^3 O, O', O''$)(μ -oxalato- $\kappa^4 O, O': O'', O'''$)-diyttrium(III)] trihydrate]

Zhong Fu, Ying Lin, Yun-You Zhou and Hong-Tao Zhang*

College of Chemistry and Materials Science, Anhui Key Laboratory of Functional Molecular Solids, Anhui Normal University, Wuhu 241000, People's Republic of China

Correspondence e-mail: zht2006@mail.ahnu.edu.cn

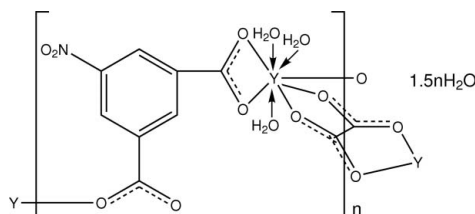
Received 14 November 2007; accepted 29 November 2007

Key indicators: single-crystal X-ray study; $T = 298$ K; mean $\sigma(\text{C}-\text{C}) = 0.008$ Å; disorder in solvent or counterion; R factor = 0.043; wR factor = 0.112; data-to-parameter ratio = 12.7.

In the crystal structure of the title one-dimensional coordination polymer, $[\text{Y}_2(\text{C}_8\text{H}_3\text{NO}_6)_2(\text{C}_2\text{O}_4)(\text{H}_2\text{O})_6] \cdot 3\text{H}_2\text{O}$, each Y^{III} ion is bridged to its neighbours by two 5-nitrobenzene-1,3-dicarboxylate (nbdc) dianions and one oxalate dianion (located on an inversion centre) to form a ladder-like polymeric structure. The two carboxylate groups of nbdc assume different modes of coordination, one is chelating whereas the other is monodentate. Three water molecules coordinate to the Y^{III} ion to complete an eight-coordinate distorted dodecahedral geometry. The ladder-like polymers are assembled together by hydrogen bonding and π - π stacking [centrio-centroid distance = 3.819 (9) Å] in the crystal structure.

Related literature

For general background, see: Biradha (2003); Braga *et al.* (2005); Burrows *et al.* (2003); Kongshaug & Fjellvag (2006); Moulton & Zaworotko (2001); Ohmori *et al.* (2004); Tang *et al.* (2006); Janiak (2003). For related structures, see: Thomas *et al.* (2002); Nordell *et al.* (2003); Janiak (2000). For related literature, see: Ren *et al.* (2006); Si *et al.* (2004).



Experimental

Crystal data

$[\text{Y}_2(\text{C}_8\text{H}_3\text{NO}_6)_2(\text{C}_2\text{O}_4)(\text{H}_2\text{O})_6] \cdot 3\text{H}_2\text{O}$
 $M_r = 846.21$
 Triclinic, $P\bar{1}$
 $a = 7.4270$ (15) Å
 $b = 9.2070$ (18) Å
 $c = 11.522$ (2) Å
 $\alpha = 74.16$ (3)°

$\beta = 71.76$ (3)°
 $\gamma = 80.01$ (2)°
 $V = 716.5$ (3) Å³
 $Z = 1$
 Mo $K\alpha$ radiation
 $\mu = 4.14$ mm⁻¹
 $T = 298$ (2) K
 $0.20 \times 0.15 \times 0.12$ mm

Data collection

Enraf-Nonius CAD-4 diffractometer
 Absorption correction: ψ scan (*XCAD4*; Harms & Wocadlo, 1995)
 $T_{\text{min}} = 0.48$, $T_{\text{max}} = 0.60$
 3018 measured reflections

2785 independent reflections
 2260 reflections with $I > 2\sigma(I)$
 $R_{\text{int}} = 0.097$
 3 standard reflections every 200 reflections
 intensity decay: 1.0%

Refinement

$R[F^2 > 2\sigma(F^2)] = 0.043$
 $wR(F^2) = 0.112$
 $S = 1.05$
 2785 reflections

220 parameters
 H-atom parameters constrained
 $\Delta\rho_{\text{max}} = 0.67$ e Å⁻³
 $\Delta\rho_{\text{min}} = -0.64$ e Å⁻³

Table 1

Selected bond lengths (Å).

O1—Y	2.414 (4)	O8—Y	2.361 (3)
O2—Y	2.424 (4)	O9—Y	2.314 (4)
O3—Y ⁱ	2.299 (3)	O10—Y	2.336 (4)
O7—Y ⁱⁱ	2.365 (3)	O11—Y	2.311 (4)

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

Table 2

Hydrogen-bond geometry (Å, °).

$D-H \cdots A$	$D-H$	$H \cdots A$	$D \cdots A$	$D-H \cdots A$
O9—H9A \cdots O2 ⁱⁱⁱ	0.85	2.14	2.735 (5)	127
O9—H9B \cdots O4 ^{iv}	0.85	2.07	2.726 (5)	134
O10—H10A \cdots O6 ⁱⁱⁱ	0.85	2.36	3.115 (7)	148
O10—H10B \cdots O12 ⁱⁱ	0.85	2.30	2.778 (6)	116
O10—H10B \cdots O12 ⁱⁱ	0.85	2.30	2.778 (6)	116
O11—H11A \cdots O4 ^v	0.85	2.09	2.694 (5)	127
O11—H11B \cdots O5 ^{vi}	0.85	2.57	2.987 (6)	111
O11—H11B \cdots O7 ^{vii}	0.85	2.23	2.784 (5)	123
O12—H12A \cdots O1	0.85	2.11	2.841 (6)	144
O12—H12B \cdots O10 ⁱ	0.85	2.21	2.953 (6)	147

Symmetry codes: (i) $x, y + 1, z$; (ii) $-x + 1, -y, -z + 1$; (iii) $-x + 1, -y, -z$; (iv) $x + 1, y - 1, z$; (v) $x, y - 1, z$; (vi) $-x, -y + 1, -z$; (vii) $x - 1, y, z$.

Data collection: *CAD-4 Software* (Enraf-Nonius, 1989); cell refinement: *CAD-4 Software*; data reduction: *XCAD4* (Harms & Wocadlo, 1995); program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *SHELXTL* (Sheldrick, 2000); software used to prepare material for publication: *SHELXTL*.

This work was funded by the Doctoral Research Launch Foundation of Anhui Normal University and the Youth Research Foundation of Anhui Normal University (grant No. 2006xqn64).

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: XU2377).

References

- Biradha, K. (2003). *CrystEngComm*, **5**, 374–384.
- Braga, D., Brammer, L. & Champness, N. R. (2005). *CrystEngComm*, **7**, 1–19.
- Burrows, A. D., Harrington, R. W., Mahon, M. F. & Teat, S. J. (2003). *Eur. J. Inorg. Chem.* pp. 766–776.
- Enraf–Nonius (1989). *CAD-4 Software*. Enraf–Nonius, Delft, The Netherlands.
- Harms, K. & Wocadlo, S. (1995). *XCAD4*. University of Marburg, Germany.
- Janiak, C. (2000). *J. Chem. Soc. Dalton Trans.* pp. 3885–3896.
- Janiak, C. (2003). *J. Chem. Soc. Dalton Trans.* pp. 2781–2804.
- Kongshaug, K. O. & Fjellvag, H. (2006). *Inorg. Chem.* **45**, 2424–2429.
- Moulton, B. & Zaworotko, M. J. (2001). *Chem. Rev.* **101**, 1629–1658.
- Nordell, K. J., Higgins, K. A. & Smith, M. D. (2003). *Acta Cryst.* **E59**, m114–m115.
- Ohmori, O., Kawano, M. & Fujita, M. (2004). *CrystEngComm*, **6**, 51–53.
- Ren, Y., Chen, S. & Gao, S. (2006). *J. Coord. Chem.* **59**, 2135–2142.
- Sheldrick, G. M. (1997). *SHELXS97* and *SHELXL97*. University of Göttingen, Germany.
- Sheldrick, G. M. (2000). *SHELXTL*. Version 6.1. Bruker AXS Inc., Madison, Wisconsin, USA.
- Si, S., Li, C., Wang, R. & Li, Y. (2004). *J. Mol. Struct.* **703**, 11–17.
- Tang, E., Dai, Y.-M., Zhang, J., Li, Z.-J., Yao, Y.-G., Zhang, J. & Huang, X.-D. (2006). *Inorg. Chem.* **45**, 6276–6281.
- Thomas, A. M., Neelakanta, G., Mahadevan, S., Nethaji, M. & Chakravarty, A. R. (2002). *Eur. J. Inorg. Chem.* pp. 2720–2726.

supplementary materials

Acta Cryst. (2008). E64, m120-m121 [doi:10.1107/S1600536807064306]

A one-dimensional ladder-like coordination polymer: poly[[hexaaquabis(μ -5-nitrobenzene-1,3-dicarboxylato- κ^3 O,O',O'')(μ -oxalato- κ^4 O,O':O'',O''')diyttrium(III)] trihydrate]

Z. Fu, Y. Lin, Y.-Y. Zhou and H.-T. Zhang

Comment

There is an intense research interest for the crystal engineering of coordination polymers owing to their intriguing molecular topologies, such as molecular grids, ladders, rings, diamondoids and honeycombs, and potential applications as functional materials (Biradha, 2003; Braga *et al.*, 2005; Janiak, 2003; Ohmori *et al.*, 2004). In order to construct the infinite structure, plentiful multidentate organic ligands are used to bridge metal ions (Moulton & Zaworotko, 2001). Among them, V-shape molecules, such as isophthalic acid and 5-amino-isophthalic acid, have received much attention because such a molecular geometry can result in unexpected structure comparing with that constructed by linear ligands (Burrows *et al.*, 2003; Tang *et al.*, 2006; Kongshaug & Fjellvag, 2006; Si *et al.*, 2004; Ren *et al.*, 2006). Herein, we present a novel ladder-like coordination polymer (I): $Y_2(C_8H_3NO_6)_2(C_2O_4)(H_2O)_6 \cdot 3(H_2O)$, in which metal ions are bridged by a V-shape ligand, 5-nitrobenzene-1,3-dicarboxylate (5-nitroisophthalate, abbreviated as 5-NIP), and oxalate ligands.

As shown in Figure 1, the Y(III) ion adopts an eight-coordinate geometry which may be described as a distorted dodecahedron (Table 1): it is bounded to three water oxygen atoms (O9, O10 and O11) and five carboxylate oxygen atoms, in which O1, O2 and O3ⁱⁱⁱ [symmetry code: (iii) $x, y - 1, z$] are from two 5-NIP ligands and O7ⁱ, O8 [symmetry code: (i) $1 - x, -y, 1 - z$] are from one oxalate ligand. The H13A/O13/H13B water molecule has a fractional site occupancy of 0.50. The ligand 5-NIP chelates the Y(III) ion *via* its O1/C1/O2 carboxylate group, while its another O3/C8/O4 carboxylate group coordinates to a symmetry related Y(III) ion in monodentate fashion *via* the atom O3. The O5/N1/O6 nitro group is almost coplanar with the phenyl ring (C2/C3/C4/C5/C6/C7). The O1/C1/O2 carboxylate group is slightly twisted from the phenyl ring with the dihedral angle of 10.26 (41)° based on the phenyl (C2/C3/C4/C5/C6/C7) and the carboxyl (O1/C1/O2) planes. The O3/C8/O4 carboxylate group is out of the phenyl plane with the dihedral angle of 44.41 (36)° based on the phenyl (C2/C3/C4/C5/C6/C7) and the carboxyl (O3/C8/O4) planes. Both two carboxylate groups of the oxalate ligand bridge two symmetry related Y(III) ions in $\eta^1:\eta^1:\mu_2$ mode. The oxalate is almost perpendicular to the phenyl plane of 5-NIP with the dihedral angle of 87.42 (26)° based on the phenyl (C2/C3/C4/C5/C6/C7) and the oxalate (O7/C9/O8/C9ⁱ/O7ⁱ/O8ⁱ) [symmetry code: (i) $1 - x, -y, 1 - z$] planes. The bond distance of two sp^2 C9—C9ⁱ [symmetry code: (i) $1 - x, -y, 1 - z$] in oxalate is elongated similar with other coordination compounds containing oxalate (Thomas *et al.*, 2002; Nordell *et al.*, 2003). Thus, the ligands 5-NIP link the neighbouring Y(III) ions in the head-to-tail mode to construct an infinite zigzag chain which runs along the *b* axis direction. Two adjacent zigzag chains are connected *via* oxalate bridging in the *c* axis direction to form a ladder-like structure with a grid of 9.207 (11)Å \times 6.138 (17)Å based on the intra-ladder intervals of Yttrium (III) ions.

(Burrows *et al.*, 2003; Tang *et al.*, 2006; Kongshaug & Fjellvag, 2006).

All ladders are assembled together through a number of hydrogen bonding (Table 2) between 5-NIP carboxyl O atoms (O1, O2 and O4), nitro O atoms (O5 and O6), oxalate O7 atom and coordination water O atoms (O9, O10 and O11) as well as lattice water molecules (O12 and O13). Among them, H10A and H11B atoms are involved in a three-centered hydrogen bond, respectively. Moreover, the center-center distance between two adjacent phenyl rings of the different ladders is

supplementary materials

3.819 (9) Å. It indicates the presence of π - π staking between two adjacent inter-ladder 5-NIP (Janiak *et al.*, 2000). Therefore all ladders are packing *via* hydrogen bonding and the π - π interactions in the crystal.

Experimental

Y₂O₃ (22.5 mg, 0.10 mmol), 5-nitro-isophthalic acid (42.2 mg, 0.20 mmol) and Na₂C₂O₄ (26.8 mg, 0.20 mmol) were dissolved in 13 ml water. The mixture was placed in a Teflon-lined stainless steel vessel (25 ml). The vessel was sealed and heated at 443 K for 1 week, then cooled to room temperature. Colorless block crystals were collected by filtration, followed by washing with water and ethanol in 45% yield (38.5 mg). The crystals became opaque when exposed for a long time in air.

Refinement

The lattice O13 water molecule was refined with a fixed site occupancy factor of 0.50. H atoms bonded to C atoms were introduced at calculated positions and refined using a riding model with C—H = 0.93 Å. All water H atoms were located in difference maps at an intermediate stage of the refinement and were then treated as riding, with O—H = 0.85 Å. $U_{\text{iso}}(\text{H}) = 1.2U_{\text{iso}}(\text{C}, \text{O})$.

Figures

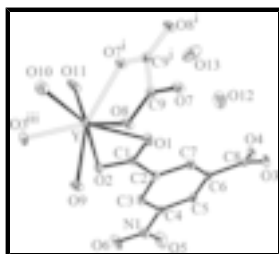


Fig. 1. The molecular structure of (I), a drawing of the asymmetric unit (solid line portion) with displacement ellipsoids at the 30% probability level, H Atoms have been omitted for clarity [symmetry code: (i) $1 - x, -y, 1 - z$; (iii) $x, y - 1, z$].

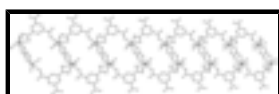


Fig. 2. Two adjacent zigzag chains connected *via* oxalate bridging to generate a ladder-like structure with a grid of 9.207 (11) Å × 6.138 (17) Å. All hydrogen atoms and the lattice water molecules have been omitted for clarity.

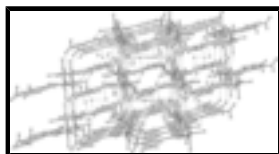


Fig. 3. A packing diagram of the title compound viewed down the *c* axis. All hydrogen atoms have been omitted for clarity.

poly[[hexaaquabis(μ -5-nitrobenzene-1,3-dicarboxylato- $\kappa^3\text{O}, \text{O}', \text{O}''$)(μ -oxalato- $\kappa^4\text{O}, \text{O}', \text{O}''', \text{O}''''$)dityttrium(III)] trihydrate]

Crystal data

[Y₂(C₈H₃NO₆)₂(C₂O₄)(H₂O)₆] \cdot 3H₂O

$M_r = 846.21$

Triclinic, *PT*

Hall symbol: -P 1

$a = 7.4270$ (15) Å

$Z = 1$

$F_{000} = 424$

$D_x = 1.961$ Mg m⁻³

Mo $K\alpha$ radiation

$\lambda = 0.71073$ Å

Cell parameters from 25 reflections

$b = 9.2070 (18) \text{ \AA}$
 $c = 11.522 (2) \text{ \AA}$
 $\alpha = 74.16 (3)^\circ$
 $\beta = 71.76 (3)^\circ$
 $\gamma = 80.01 (2)^\circ$
 $V = 716.5 (3) \text{ \AA}^3$

$\theta = 2.3\text{--}15.0^\circ$
 $\mu = 4.14 \text{ mm}^{-1}$
 $T = 298 (2) \text{ K}$
 Block, colorless
 $0.20 \times 0.15 \times 0.12 \text{ mm}$

Data collection

Enraf–Nonius CAD-4 diffractometer
 Radiation source: fine-focus sealed tube
 Monochromator: graphite
 $T = 298(2) \text{ K}$
 $\omega/2\theta$ scans
 Absorption correction: ψ scan (XCAD4; Harms & Wocadlo, 1995)
 $T_{\min} = 0.48, T_{\max} = 0.60$
 3018 measured reflections
 2785 independent reflections
 2260 reflections with $I > 2\sigma(I)$

$R_{\text{int}} = 0.097$
 $\theta_{\max} = 26.0^\circ$
 $\theta_{\min} = 1.9^\circ$
 $h = 0 \rightarrow 9$
 $k = -11 \rightarrow 11$
 $l = -13 \rightarrow 14$
 3 standard reflections every 200 reflections
 intensity decay: 1.0%

Refinement

Refinement on F^2
 Least-squares matrix: full
 $R[F^2 > 2\sigma(F^2)] = 0.043$
 $wR(F^2) = 0.112$
 $S = 1.05$
 2785 reflections
 220 parameters
 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
 $w = 1/[\sigma^2(F_o^2) + (0.0432P)^2 + 2.6078P]$
 where $P = (F_o^2 + 2F_c^2)/3$
 $(\Delta/\sigma)_{\max} < 0.001$
 $\Delta\rho_{\max} = 0.67 \text{ e \AA}^{-3}$
 $\Delta\rho_{\min} = -0.64 \text{ e \AA}^{-3}$
 Extinction correction: none

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.

supplementary materials

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (\AA^2)

	x	y	z	$U_{\text{iso}}^*/U_{\text{eq}}$	Occ. (<1)
C1	0.3395 (7)	0.2400 (6)	0.1373 (5)	0.0176 (10)	
C2	0.2913 (7)	0.3978 (6)	0.0685 (5)	0.0182 (10)	
C3	0.2644 (7)	0.4243 (6)	-0.0506 (5)	0.0200 (11)	
H3	0.2853	0.3461	-0.0909	0.024*	
C4	0.2095 (7)	0.5698 (6)	-0.1067 (5)	0.0188 (10)	
C5	0.1769 (7)	0.6925 (6)	-0.0509 (5)	0.0187 (10)	
H5	0.1321	0.7878	-0.0904	0.022*	
C6	0.2101 (7)	0.6653 (6)	0.0648 (5)	0.0181 (10)	
C7	0.2687 (7)	0.5187 (6)	0.1238 (5)	0.0201 (11)	
H7	0.2862	0.4994	0.2030	0.024*	
C8	0.1873 (7)	0.7916 (6)	0.1298 (5)	0.0187 (10)	
C9	0.6051 (7)	-0.0058 (6)	0.4632 (5)	0.0177 (10)	
N1	0.1769 (7)	0.5962 (5)	-0.2319 (4)	0.0265 (10)	
O1	0.3821 (6)	0.2183 (4)	0.2395 (3)	0.0261 (9)	
O2	0.3332 (5)	0.1288 (4)	0.0962 (3)	0.0228 (8)	
O3	0.3182 (5)	0.7902 (4)	0.1793 (3)	0.0223 (8)	
O4	0.0460 (5)	0.8849 (4)	0.1325 (4)	0.0251 (8)	
O5	0.1269 (9)	0.7245 (5)	-0.2819 (5)	0.0564 (15)	
O6	0.1979 (8)	0.4894 (5)	-0.2778 (4)	0.0461 (12)	
O7	0.7221 (5)	0.0136 (4)	0.5150 (3)	0.0214 (8)	
O8	0.6444 (5)	-0.0325 (4)	0.3571 (3)	0.0232 (8)	
O9	0.6774 (5)	-0.0796 (4)	0.1250 (3)	0.0244 (8)	
H9A	0.6641	-0.0316	0.0534	0.029*	
H9B	0.7642	-0.0428	0.1386	0.029*	
O10	0.4350 (6)	-0.3006 (4)	0.3988 (4)	0.0326 (10)	
H10A	0.5526	-0.3322	0.3807	0.039*	
H10B	0.3968	-0.3009	0.4765	0.039*	
O11	0.0652 (5)	-0.0383 (5)	0.3376 (4)	0.0318 (10)	
H11B	0.0191	0.0193	0.3884	0.038*	
H11A	0.0252	-0.0036	0.2728	0.038*	
O12	0.3768 (8)	0.3842 (5)	0.4156 (5)	0.0492 (13)	
H12B	0.3942	0.4764	0.3793	0.059*	
H12A	0.4299	0.3285	0.3639	0.059*	
O13	0.0067 (15)	0.3583 (14)	0.5020 (11)	0.068 (3)	0.50
H13A	0.0037	0.2670	0.5003	0.081*	0.50
H13B	-0.1035	0.3933	0.5392	0.081*	0.50
Y	0.39399 (7)	-0.05405 (6)	0.27921 (5)	0.01386 (15)	

Atomic displacement parameters (\AA^2)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
C1	0.018 (2)	0.018 (3)	0.017 (2)	-0.0018 (19)	-0.005 (2)	-0.004 (2)
C2	0.019 (3)	0.017 (3)	0.019 (3)	-0.002 (2)	-0.005 (2)	-0.005 (2)
C3	0.020 (3)	0.020 (3)	0.022 (3)	-0.002 (2)	-0.007 (2)	-0.008 (2)

C4	0.020 (3)	0.024 (3)	0.015 (2)	-0.004 (2)	-0.004 (2)	-0.007 (2)
C5	0.024 (3)	0.012 (2)	0.022 (3)	-0.002 (2)	-0.011 (2)	-0.002 (2)
C6	0.021 (3)	0.018 (3)	0.020 (3)	-0.004 (2)	-0.009 (2)	-0.006 (2)
C7	0.022 (3)	0.021 (3)	0.020 (3)	-0.002 (2)	-0.009 (2)	-0.005 (2)
C8	0.017 (2)	0.020 (3)	0.018 (2)	-0.004 (2)	-0.002 (2)	-0.006 (2)
C9	0.018 (3)	0.016 (3)	0.019 (3)	-0.0011 (19)	-0.006 (2)	-0.003 (2)
N1	0.034 (3)	0.027 (3)	0.021 (2)	-0.004 (2)	-0.013 (2)	-0.004 (2)
O1	0.044 (2)	0.0195 (19)	0.0213 (19)	-0.0005 (17)	-0.0204 (17)	-0.0047 (15)
O2	0.037 (2)	0.0142 (18)	0.0217 (19)	-0.0004 (15)	-0.0135 (16)	-0.0062 (15)
O3	0.0254 (19)	0.0190 (19)	0.033 (2)	0.0032 (15)	-0.0188 (17)	-0.0132 (16)
O4	0.0216 (19)	0.025 (2)	0.036 (2)	0.0056 (15)	-0.0149 (17)	-0.0160 (17)
O5	0.113 (5)	0.028 (3)	0.036 (3)	0.007 (3)	-0.046 (3)	0.000 (2)
O6	0.078 (4)	0.038 (3)	0.034 (2)	0.007 (2)	-0.029 (2)	-0.020 (2)
O7	0.0161 (17)	0.036 (2)	0.0171 (18)	-0.0056 (15)	-0.0082 (14)	-0.0089 (16)
O8	0.0213 (19)	0.037 (2)	0.0159 (18)	-0.0030 (16)	-0.0066 (15)	-0.0118 (16)
O9	0.0205 (19)	0.039 (2)	0.0171 (18)	-0.0029 (16)	-0.0058 (15)	-0.0124 (16)
O10	0.046 (3)	0.028 (2)	0.028 (2)	0.0010 (19)	-0.0182 (19)	-0.0061 (17)
O11	0.0196 (19)	0.057 (3)	0.028 (2)	0.0038 (18)	-0.0103 (16)	-0.027 (2)
O12	0.079 (4)	0.036 (3)	0.044 (3)	-0.008 (2)	-0.033 (3)	-0.008 (2)
O13	0.045 (6)	0.075 (8)	0.074 (8)	-0.031 (6)	-0.011 (6)	0.006 (6)
Y	0.0155 (2)	0.0154 (2)	0.0136 (2)	-0.00013 (16)	-0.00695 (17)	-0.00552 (17)

Geometric parameters (Å, °)

C1—O2	1.253 (6)	N1—O6	1.204 (6)
C1—O1	1.269 (6)	N1—O5	1.215 (6)
C1—C2	1.495 (7)	O1—Y	2.414 (4)
C1—Y	2.790 (5)	O2—Y	2.424 (4)
C2—C7	1.388 (7)	O3—Y ⁱⁱ	2.299 (3)
C2—C3	1.398 (7)	O7—Y ⁱ	2.365 (3)
C3—C4	1.372 (7)	O8—Y	2.361 (3)
C3—H3	0.9264	O9—Y	2.314 (4)
C4—C5	1.397 (7)	O9—H9A	0.8500
C4—N1	1.484 (7)	O9—H9B	0.8501
C5—C6	1.380 (7)	O10—Y	2.336 (4)
C5—H5	0.9288	O10—H10A	0.8500
C6—C7	1.398 (7)	O10—H10B	0.8501
C6—C8	1.507 (7)	O11—Y	2.311 (4)
C7—H7	0.9274	O11—H11B	0.8500
C8—O4	1.233 (6)	O11—H11A	0.8498
C8—O3	1.268 (6)	O12—H12B	0.8499
C9—O8	1.247 (6)	O12—H12A	0.8500
C9—O7	1.258 (6)	O13—H13A	0.8500
C9—C9 ⁱ	1.527 (9)	O13—H13B	0.8500
O2—C1—O1	119.8 (5)	H10A—O10—H10B	108.3
O2—C1—C2	120.3 (4)	Y—O11—H11B	110.1
O1—C1—C2	119.9 (4)	Y—O11—H11A	109.8
O2—C1—Y	60.2 (3)	H11B—O11—H11A	109.8

supplementary materials

O1—C1—Y	59.8 (3)	H12B—O12—H12A	109.7
C2—C1—Y	174.6 (3)	H13A—O13—H13B	109.5
C7—C2—C3	119.5 (5)	O3 ⁱⁱⁱ —Y—O11	74.28 (13)
C7—C2—C1	120.2 (4)	O3 ⁱⁱⁱ —Y—O9	78.95 (13)
C3—C2—C1	120.3 (4)	O11—Y—O9	147.86 (13)
C4—C3—C2	118.1 (5)	O3 ⁱⁱⁱ —Y—O10	74.18 (13)
C4—C3—H3	121.0	O11—Y—O10	95.62 (16)
C2—C3—H3	120.8	O9—Y—O10	93.86 (15)
C3—C4—C5	123.7 (5)	O3 ⁱⁱⁱ —Y—O8	138.88 (13)
C3—C4—N1	117.7 (4)	O11—Y—O8	139.85 (13)
C5—C4—N1	118.6 (4)	O9—Y—O8	72.16 (12)
C6—C5—C4	117.4 (5)	O10—Y—O8	79.18 (14)
C6—C5—H5	122.0	O3 ⁱⁱⁱ —Y—O7 ⁱ	133.63 (13)
C4—C5—H5	120.5	O11—Y—O7 ⁱ	71.41 (12)
C5—C6—C7	120.3 (5)	O9—Y—O7 ⁱ	140.67 (12)
C5—C6—C8	121.3 (5)	O10—Y—O7 ⁱ	79.12 (14)
C7—C6—C8	118.4 (4)	O8—Y—O7 ⁱ	68.51 (12)
C2—C7—C6	120.9 (5)	O3 ⁱⁱⁱ —Y—O1	132.35 (12)
C2—C7—H7	118.6	O11—Y—O1	90.19 (15)
C6—C7—H7	120.4	O9—Y—O1	94.96 (14)
O4—C8—O3	125.6 (5)	O10—Y—O1	153.26 (13)
O4—C8—C6	119.0 (4)	O8—Y—O1	79.61 (13)
O3—C8—C6	115.4 (4)	O7 ⁱ —Y—O1	78.08 (13)
O8—C9—O7	126.2 (4)	O3 ⁱⁱⁱ —Y—O2	79.18 (12)
O8—C9—C9 ⁱ	117.0 (5)	O11—Y—O2	80.27 (14)
O7—C9—C9 ⁱ	116.8 (5)	O9—Y—O2	77.50 (13)
O6—N1—O5	123.2 (5)	O10—Y—O2	153.13 (13)
O6—N1—C4	118.6 (5)	O8—Y—O2	120.73 (13)
O5—N1—C4	118.2 (5)	O7 ⁱ —Y—O2	123.38 (13)
C1—O1—Y	93.2 (3)	O1—Y—O2	53.60 (12)
C1—O2—Y	93.2 (3)	O3 ⁱⁱⁱ —Y—C1	105.48 (14)
C8—O3—Y ⁱⁱ	136.0 (3)	O11—Y—C1	83.57 (15)
C9—O7—Y ⁱ	118.6 (3)	O9—Y—C1	86.78 (14)
C9—O8—Y	119.0 (3)	O10—Y—C1	179.19 (14)
Y—O9—H9A	109.9	O8—Y—C1	101.50 (14)
Y—O9—H9B	109.8	O7 ⁱ —Y—C1	100.69 (14)
H9A—O9—H9B	108.4	O1—Y—C1	27.01 (13)
Y—O10—H10A	109.3	O2—Y—C1	26.64 (13)
Y—O10—H10B	109.8		
O2—C1—C2—C7	169.7 (5)	C9—O8—Y—O3 ⁱⁱⁱ	-134.9 (4)
O1—C1—C2—C7	-8.3 (7)	C9—O8—Y—O11	1.1 (5)
O2—C1—C2—C3	-8.9 (7)	C9—O8—Y—O9	177.5 (4)
O1—C1—C2—C3	173.0 (5)	C9—O8—Y—O10	-84.8 (4)
C7—C2—C3—C4	-2.3 (7)	C9—O8—Y—O7 ⁱ	-2.3 (4)

C1—C2—C3—C4	176.3 (4)	C9—O8—Y—O1	78.8 (4)
C2—C3—C4—C5	-0.8 (8)	C9—O8—Y—O2	114.6 (4)
C2—C3—C4—N1	-178.6 (4)	C9—O8—Y—C1	94.7 (4)
C3—C4—C5—C6	2.9 (8)	C1—O1—Y—O3 ⁱⁱⁱ	-6.7 (4)
N1—C4—C5—C6	-179.3 (4)	C1—O1—Y—O11	-75.3 (3)
C4—C5—C6—C7	-1.8 (7)	C1—O1—Y—O9	72.9 (3)
C4—C5—C6—C8	177.3 (4)	C1—O1—Y—O10	-178.3 (3)
C3—C2—C7—C6	3.3 (8)	C1—O1—Y—O8	143.7 (3)
C1—C2—C7—C6	-175.3 (4)	C1—O1—Y—O7 ⁱ	-146.3 (3)
C5—C6—C7—C2	-1.2 (8)	C1—O1—Y—O2	2.4 (3)
C8—C6—C7—C2	179.7 (4)	C1—O2—Y—O3 ⁱⁱⁱ	170.8 (3)
C5—C6—C8—O4	44.6 (7)	C1—O2—Y—O11	95.1 (3)
C7—C6—C8—O4	-136.2 (5)	C1—O2—Y—O9	-108.3 (3)
C5—C6—C8—O3	-136.3 (5)	C1—O2—Y—O10	178.3 (3)
C7—C6—C8—O3	42.8 (7)	C1—O2—Y—O8	-48.1 (3)
C3—C4—N1—O6	0.8 (7)	C1—O2—Y—O7 ⁱ	35.1 (3)
C5—C4—N1—O6	-177.1 (5)	C1—O2—Y—O1	-2.4 (3)
C3—C4—N1—O5	179.5 (5)	O2—C1—Y—O3 ⁱⁱⁱ	-9.4 (3)
C5—C4—N1—O5	1.5 (8)	O1—C1—Y—O3 ⁱⁱⁱ	174.9 (3)
O2—C1—O1—Y	-4.3 (5)	O2—C1—Y—O11	-81.1 (3)
C2—C1—O1—Y	173.8 (4)	O1—C1—Y—O11	103.2 (3)
O1—C1—O2—Y	4.3 (5)	O2—C1—Y—O9	68.2 (3)
C2—C1—O2—Y	-173.8 (4)	O1—C1—Y—O9	-107.5 (3)
O4—C8—O3—Y ⁱⁱ	-6.0 (8)	O2—C1—Y—O8	139.3 (3)
C6—C8—O3—Y ⁱⁱ	175.0 (3)	O1—C1—Y—O8	-36.4 (3)
O8—C9—O7—Y ⁱ	-177.9 (4)	O2—C1—Y—O7 ⁱ	-150.8 (3)
C9 ⁱ —C9—O7—Y ⁱ	2.7 (7)	O1—C1—Y—O7 ⁱ	33.5 (3)
O7—C9—O8—Y	-177.5 (4)	O2—C1—Y—O1	175.7 (5)
C9 ⁱ —C9—O8—Y	1.9 (7)	O1—C1—Y—O2	-175.7 (5)

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

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>
O9—H9A...O2 ^{iv}	0.85	2.14	2.735 (5)	127
O9—H9B...O4 ^v	0.85	2.07	2.726 (5)	134
O10—H10A...O6 ^{iv}	0.85	2.36	3.115 (7)	148
O10—H10B...O12 ⁱ	0.85	2.30	2.778 (6)	116
O10—H10B...O12 ⁱ	0.85	2.30	2.778 (6)	116
O11—H11A...O4 ⁱⁱⁱ	0.85	2.09	2.694 (5)	127
O11—H11B...O5 ^{vi}	0.85	2.57	2.987 (6)	111
O11—H11B...O7 ^{vii}	0.85	2.23	2.784 (5)	123
O12—H12A...O1	0.85	2.11	2.841 (6)	144
O12—H12B...O10 ⁱⁱ	0.85	2.21	2.953 (6)	147
C3—H3...O9 ^{iv}	0.93	2.54	3.432 (6)	161

supplementary materials

Symmetry codes: (iv) $-x+1, -y, -z$; (v) $x+1, y-1, z$; (i) $-x+1, -y, -z+1$; (iii) $x, y-1, z$; (vi) $-x, -y+1, -z$; (vii) $x-1, y, z$; (ii) $x, y+1, z$.

Fig. 1

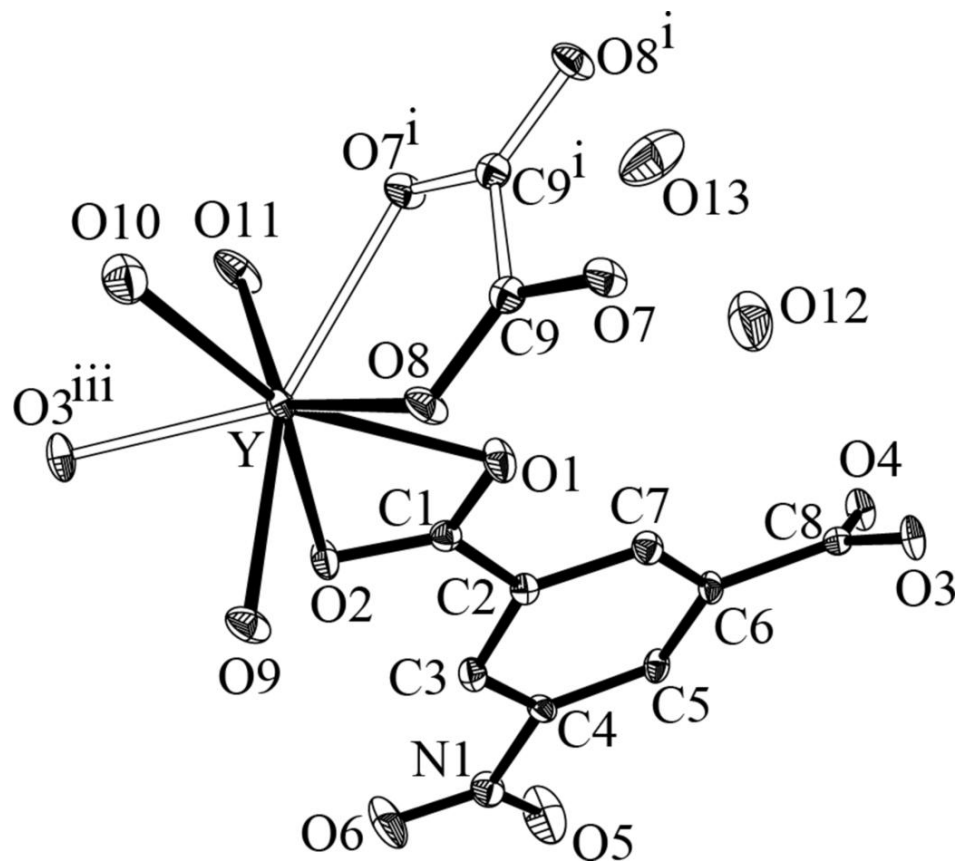


Fig. 2

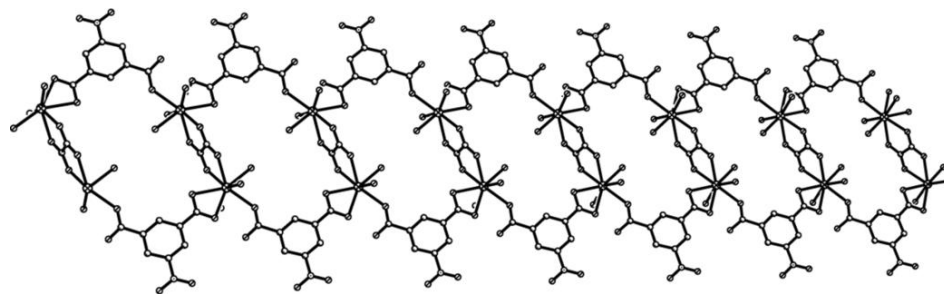


Fig. 3

