

# catena-Poly[[diaqua(4,4'-trimethylenedipyridine- $\kappa$ N)cobalt(II)]- $\mu$ -terephthalato- $\kappa^2$ O<sup>1</sup>:O<sup>4</sup>]

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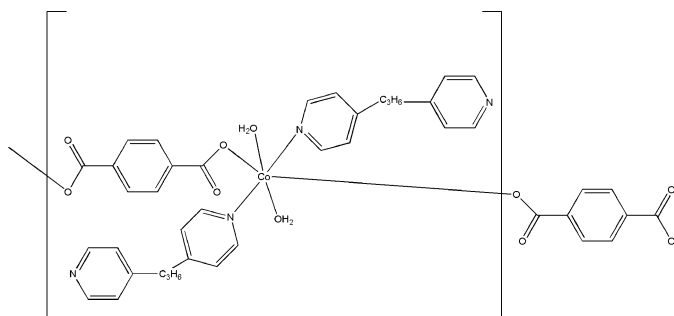
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Key indicators: single-crystal X-ray study;  $T = 293$  K; mean  $\sigma(\text{C}-\text{C}) = 0.007$  Å;  $R$  factor = 0.070;  $wR$  factor = 0.179; data-to-parameter ratio = 13.2.

The title compound,  $[\text{Co}(\text{C}_8\text{H}_4\text{O}_4)(\text{C}_{13}\text{H}_{14}\text{N}_2)_2(\text{H}_2\text{O})_2]_n$ , was obtained by the reaction of  $\text{CoCl}_2$ , 4,4'-trimethylenedipyridine and terephthalic acid in a 1:1:1 ratio. The octahedrally coordinated cobalt ions are bridged by 4,4'-trimethylenedipyridine ligands, generating a chain. These chains are further linked by  $\text{O}-\text{H}\cdots\text{O}$  and  $\text{O}-\text{H}\cdots\text{N}$  hydrogen bonds, giving a three-dimensional network.

## Related literature

For a related structure, see Manna *et al.* (2005).



## Experimental

### Crystal data

$[\text{Co}(\text{C}_8\text{H}_4\text{O}_4)(\text{C}_{13}\text{H}_{14}\text{N}_2)_2(\text{H}_2\text{O})_2]$   
 $M_r = 655.60$   
 Monoclinic,  $P2_1/c$   
 $a = 11.232$  (2) Å  
 $b = 9.3784$  (19) Å  
 $c = 15.182$  (3) Å  
 $\beta = 96.19$  (3)°  
 $V = 1589.9$  (5) Å<sup>3</sup>  
 $Z = 2$   
 Mo  $K\alpha$  radiation  
 $\mu = 0.59$  mm<sup>-1</sup>  
 $T = 293$  (2) K  
 $0.20 \times 0.14 \times 0.08$  mm

### Data collection

Bruker SMART 1K CCD area-detector diffractometer  
 Absorption correction: multi-scan (*SADABS*; Sheldrick, 2004)  
 $T_{\min} = 0.891$ ,  $T_{\max} = 0.954$   
 8438 measured reflections  
 2726 independent reflections  
 2167 reflections with  $I > 2\sigma(I)$   
 $R_{\text{int}} = 0.068$

### Refinement

$R[F^2 > 2\sigma(F^2)] = 0.070$   
 $wR(F^2) = 0.179$   
 $S = 1.13$   
 2726 reflections  
 207 parameters  
 H-atom parameters constrained  
 $\Delta\rho_{\text{max}} = 1.05$  e Å<sup>-3</sup>  
 $\Delta\rho_{\text{min}} = -0.62$  e Å<sup>-3</sup>

**Table 1**

Hydrogen-bond geometry (Å, °).

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
$\text{O3}-\text{H3A}\cdots\text{N2}^i$	0.93	1.90	2.820 (5)	171
$\text{O3}-\text{H3B}\cdots\text{O2}^{ii}$	1.03	1.71	2.704 (4)	161

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

Data collection: *SMART* (Bruker, 2001); cell refinement: *SAINT* (Bruker, 2001); data reduction: *SAINT*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *SHELXTL* (Sheldrick, 2008); software used to prepare material for publication: *SHELXTL* and local programs.

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: BT2833).

## References

- Bruker (2001). *SMART* and *SAINT*. Bruker AXS Inc., Madison, Wisconsin, USA.  
 Manna, S. C., Konar, S., Zangrando, E., Okamoto, K., Ribas, J. & Chaudhuri, N. R. (2005). *Eur. J. Inorg. Chem.* pp. 4646–4654.  
 Sheldrick, G. M. (2004). *SADABS*. University of Göttingen, Germany.  
 Sheldrick, G. M. (2008). *Acta Cryst.* **A64**, 112–122.

**supplementary materials**

*Acta Cryst.* (2009). E65, m135 [ doi:10.1107/S1600536808043584 ]

***catena*-Poly[[diaqua(4,4'-trimethylenedipyridine- $\kappa$ N)cobalt(II)]- $\mu$ -terephthalato- $\kappa^2$ O<sup>1</sup>:O<sup>4</sup>]**

**X.-L. Qi**

**Comment**

Co is six-coordinated by two terephthalate O atoms, two N atoms of 4,4'-trimethylenedipyridines and two water molecules in a distorted octahedral fashion. The Co—O and Co—N bond lengths are in the normal range. The 4,4'-trimethylenedipyridine and terephthalate ligands adopt bidentate coordinated modes. As shown in Fig. 2, a chain structure is formed. These chains are further linked by O—H $\cdots$ O and O—H $\cdots$ N hydrogen bonds to generate a three-dimensional network.

**Experimental**

CoCl<sub>2</sub>(1.0 mmol), terephthalic acid (1 mmol), and 4,4'-trimethylenedipyridine (1 mmol) were dissolved in water (10 ml). The solution was heated in a 25 ml Teflon lined reaction vessel at 433 K for *ca* 3 days and then cooled to room temperature. Purple crystals were obtained in a yield of 65%.

**Refinement**

All non-water H atoms were positioned geometrically and refined by using a riding model with C—H = 0.93–0.96 Å and with  $U_{\text{iso}}(\text{H}) = 1.2$  times  $U_{\text{eq}}(\text{C})$ , the water H atoms are firstly found, then refined freely.

**Figures**

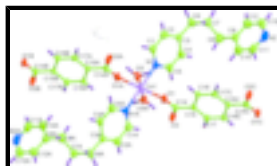


Fig. 1. An *ORTEP* view of the Co centre and its surrounding ligands with 50% displacement ellipsoids for non-H atoms. Symmetry code: (A)  $-x,-y,-z$

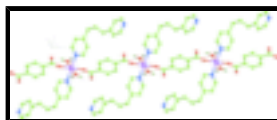


Fig. 2. Partial packing diagram of the title compound.

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*Crystal data*

[Co(C<sub>8</sub>H<sub>4</sub>O<sub>4</sub>)(C<sub>13</sub>H<sub>14</sub>N<sub>2</sub>)<sub>2</sub>(H<sub>2</sub>O)<sub>2</sub>]

$M_r = 655.60$

Monoclinic,  $P2_1/c$

$a = 11.232$  (2) Å

$F_{000} = 686$

$D_x = 1.369$  Mg m<sup>-3</sup>

Mo  $K\alpha$  radiation

$\lambda = 0.71073$  Å

Cell parameters from 3657 reflections

## supplementary materials

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$b = 9.3784 (19) \text{ \AA}$   
 $c = 15.182 (3) \text{ \AA}$   
 $\beta = 96.19 (3)^\circ$   
 $V = 1589.9 (5) \text{ \AA}^3$   
 $Z = 2$

$\theta = 1.4\text{--}27.9^\circ$   
 $\mu = 0.59 \text{ mm}^{-1}$   
 $T = 293 (2) \text{ K}$   
Block, purple  
 $0.20 \times 0.14 \times 0.08 \text{ mm}$

### Data collection

Bruker SMART 1K CCD area-detector diffractometer  
Radiation source: sealed tube  
Monochromator: graphite  
Detector resolution:  $8.192 \text{ pixels mm}^{-1}$   
 $T = 293(2) \text{ K}$   
Thin-slice  $\omega$  scans  
Absorption correction: Multi-scan (SADABS; Sheldrick, 2004)  
 $T_{\min} = 0.891, T_{\max} = 0.954$   
8438 measured reflections

2726 independent reflections  
2167 reflections with  $I > 2\sigma(I)$   
 $R_{\text{int}} = 0.068$   
 $\theta_{\text{max}} = 25.0^\circ$   
 $\theta_{\text{min}} = 1.8^\circ$   
 $h = -11 \rightarrow 13$   
 $k = -8 \rightarrow 11$   
 $l = -17 \rightarrow 18$

### Refinement

Refinement on  $F^2$   
Least-squares matrix: full  
 $R[F^2 > 2\sigma(F^2)] = 0.070$   
 $wR(F^2) = 0.179$   
 $S = 1.13$   
2726 reflections  
207 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  
 $w = 1/[\sigma^2(F_o^2) + (0.0794P)^2 + 1.059P]$   
where  $P = (F_o^2 + 2F_c^2)/3$   
 $(\Delta/\sigma)_{\text{max}} < 0.001$   
 $\Delta\rho_{\text{max}} = 1.05 \text{ e \AA}^{-3}$   
 $\Delta\rho_{\text{min}} = -0.62 \text{ e \AA}^{-3}$   
Extinction correction: none

### Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters ( $\text{\AA}^2$ )

	<i>x</i>	<i>y</i>	<i>z</i>	$U_{\text{iso}}^*/U_{\text{eq}}$
Co1	0.0000	0.0000	0.0000	0.0323 (3)
O1	0.1776 (3)	-0.0428 (3)	-0.0026 (2)	0.0398 (8)
O2	0.2160 (3)	-0.0377 (4)	-0.1445 (2)	0.0560 (10)
O3	0.0130 (3)	-0.0481 (3)	0.1394 (2)	0.0409 (8)
N1	0.0522 (3)	0.2209 (4)	0.0279 (2)	0.0369 (9)
N2	0.7841 (4)	0.5278 (5)	0.2442 (3)	0.0562 (12)
C1	0.0265 (4)	0.2912 (5)	0.1005 (3)	0.0451 (11)
H1	-0.0263	0.2493	0.1359	0.054*
C2	0.0747 (4)	0.4234 (5)	0.1253 (3)	0.0479 (12)
H2	0.0544	0.4674	0.1765	0.057*

C3	0.1530 (4)	0.4901 (5)	0.0739 (3)	0.0378 (10)
C4	0.1764 (4)	0.4190 (5)	-0.0026 (3)	0.0443 (11)
H4	0.2263	0.4604	-0.0405	0.053*
C5	0.1259 (4)	0.2869 (5)	-0.0226 (3)	0.0449 (12)
H5	0.1441	0.2415	-0.0739	0.054*
C6	0.2111 (4)	0.6317 (5)	0.1003 (4)	0.0541 (14)
H6A	0.1600	0.6837	0.1367	0.065*
H6B	0.2183	0.6877	0.0474	0.065*
C7	0.3359 (4)	0.6137 (5)	0.1519 (4)	0.0544 (14)
H7A	0.3618	0.7056	0.1764	0.065*
H7B	0.3290	0.5496	0.2013	0.065*
C8	0.4310 (5)	0.5574 (6)	0.0989 (4)	0.0612 (15)
H8A	0.4361	0.6191	0.0482	0.073*
H8B	0.4073	0.4634	0.0767	0.073*
C9	0.5539 (4)	0.5470 (5)	0.1508 (3)	0.0436 (11)
C10	0.6121 (4)	0.4186 (5)	0.1644 (4)	0.0516 (13)
H10	0.5755	0.3347	0.1429	0.062*
H3B	-0.0679	-0.0089	0.1545	0.09 (2)*
H3A	0.0837	-0.0307	0.1753	0.10 (2)*
C11	0.7261 (4)	0.4149 (6)	0.2103 (4)	0.0553 (14)
H11	0.7639	0.3268	0.2176	0.066*
C12	0.6140 (5)	0.6664 (6)	0.1852 (4)	0.0579 (14)
H12	0.5787	0.7559	0.1780	0.070*
C13	0.7273 (5)	0.6521 (6)	0.2307 (4)	0.0602 (15)
H13	0.7660	0.7341	0.2531	0.072*
C14	0.2472 (4)	-0.0357 (4)	-0.0632 (3)	0.0364 (10)
C15	0.3786 (3)	-0.0193 (4)	-0.0300 (3)	0.0314 (9)
C16	0.4142 (4)	0.0107 (4)	0.0580 (3)	0.0365 (10)
H16	0.3566	0.0188	0.0974	0.044*
C17	0.4659 (4)	-0.0292 (4)	-0.0888 (3)	0.0366 (10)
H17	0.4436	-0.0482	-0.1484	0.044*

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

	$U^{11}$	$U^{22}$	$U^{33}$	$U^{12}$	$U^{13}$	$U^{23}$
Co1	0.0153 (5)	0.0487 (5)	0.0327 (5)	-0.0044 (3)	0.0010 (3)	0.0013 (3)
O1	0.0221 (16)	0.0495 (18)	0.048 (2)	-0.0006 (12)	0.0036 (14)	0.0055 (13)
O2	0.0219 (18)	0.099 (3)	0.046 (2)	-0.0012 (16)	0.0005 (15)	-0.0105 (18)
O3	0.0268 (17)	0.0538 (19)	0.041 (2)	-0.0043 (13)	-0.0021 (14)	0.0020 (14)
N1	0.028 (2)	0.041 (2)	0.042 (2)	-0.0028 (15)	0.0054 (16)	-0.0006 (16)
N2	0.033 (2)	0.089 (4)	0.046 (3)	0.002 (2)	-0.0009 (19)	0.011 (2)
C1	0.035 (3)	0.054 (3)	0.047 (3)	-0.003 (2)	0.009 (2)	-0.001 (2)
C2	0.041 (3)	0.058 (3)	0.044 (3)	0.004 (2)	0.000 (2)	-0.009 (2)
C3	0.024 (2)	0.043 (2)	0.044 (3)	0.0035 (18)	-0.0083 (18)	-0.001 (2)
C4	0.036 (3)	0.048 (3)	0.049 (3)	-0.011 (2)	0.003 (2)	0.003 (2)
C5	0.038 (3)	0.049 (3)	0.049 (3)	-0.009 (2)	0.008 (2)	0.000 (2)
C6	0.034 (3)	0.048 (3)	0.077 (4)	0.000 (2)	-0.009 (2)	-0.011 (2)
C7	0.037 (3)	0.056 (3)	0.068 (4)	0.001 (2)	-0.006 (2)	-0.019 (3)

## supplementary materials

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C8	0.039 (3)	0.078 (4)	0.062 (4)	0.001 (3)	-0.012 (3)	-0.014 (3)
C9	0.032 (3)	0.053 (3)	0.045 (3)	0.003 (2)	-0.002 (2)	-0.002 (2)
C10	0.044 (3)	0.049 (3)	0.062 (4)	-0.006 (2)	0.006 (2)	0.007 (2)
C11	0.041 (3)	0.064 (4)	0.062 (4)	0.012 (3)	0.009 (3)	0.022 (3)
C12	0.046 (3)	0.054 (3)	0.071 (4)	0.004 (2)	-0.009 (3)	-0.005 (3)
C13	0.045 (3)	0.069 (4)	0.064 (4)	-0.016 (3)	-0.008 (3)	-0.006 (3)
C14	0.020 (2)	0.043 (3)	0.046 (3)	-0.0023 (17)	0.0015 (19)	0.0016 (19)
C15	0.018 (2)	0.037 (2)	0.039 (3)	0.0000 (16)	0.0010 (17)	-0.0018 (17)
C16	0.018 (2)	0.054 (3)	0.039 (3)	-0.0029 (18)	0.0095 (18)	-0.0022 (19)
C17	0.023 (2)	0.046 (3)	0.040 (3)	-0.0013 (17)	0.0032 (18)	-0.0042 (18)

### *Geometric parameters (Å, °)*

Co1—O1 <sup>i</sup>	2.039 (3)	C6—H6A	0.9700
Co1—O1	2.039 (3)	C6—H6B	0.9700
Co1—O3 <sup>i</sup>	2.154 (3)	C7—C8	1.500 (7)
Co1—O3	2.154 (3)	C7—H7A	0.9700
Co1—N1 <sup>i</sup>	2.183 (3)	C7—H7B	0.9700
Co1—N1	2.183 (3)	C8—C9	1.517 (7)
O1—C14	1.271 (5)	C8—H8A	0.9700
O2—C14	1.247 (6)	C8—H8B	0.9700
O3—H3B	1.0283	C9—C10	1.375 (7)
O3—H3A	0.9271	C9—C12	1.381 (7)
N1—C5	1.339 (5)	C10—C11	1.390 (7)
N1—C1	1.342 (6)	C10—H10	0.9300
N2—C11	1.318 (7)	C11—H11	0.9300
N2—C13	1.334 (7)	C12—C13	1.388 (7)
C1—C2	1.389 (7)	C12—H12	0.9300
C1—H1	0.9300	C13—H13	0.9300
C2—C3	1.386 (7)	C14—C15	1.515 (6)
C2—H2	0.9300	C15—C16	1.381 (6)
C3—C4	1.388 (6)	C15—C17	1.398 (6)
C3—C6	1.515 (6)	C16—C17 <sup>ii</sup>	1.389 (6)
C4—C5	1.383 (6)	C16—H16	0.9300
C4—H4	0.9300	C17—C16 <sup>ii</sup>	1.389 (6)
C5—H5	0.9300	C17—H17	0.9300
C6—C7	1.540 (7)		
O1 <sup>i</sup> —Co1—O1	180.00 (16)	C7—C6—H6B	109.1
O1 <sup>i</sup> —Co1—O3 <sup>i</sup>	90.88 (12)	H6A—C6—H6B	107.9
O1—Co1—O3 <sup>i</sup>	89.12 (12)	C8—C7—C6	115.3 (5)
O1 <sup>i</sup> —Co1—O3	89.12 (12)	C8—C7—H7A	108.5
O1—Co1—O3	90.88 (12)	C6—C7—H7A	108.5
O3 <sup>i</sup> —Co1—O3	180.00 (16)	C8—C7—H7B	108.5
O1 <sup>i</sup> —Co1—N1 <sup>i</sup>	86.99 (12)	C6—C7—H7B	108.5
O1—Co1—N1 <sup>i</sup>	93.01 (12)	H7A—C7—H7B	107.5
O3 <sup>i</sup> —Co1—N1 <sup>i</sup>	91.14 (12)	C7—C8—C9	113.9 (4)

O3—Co1—N1 <sup>i</sup>	88.86 (12)	C7—C8—H8A	108.8
O1 <sup>i</sup> —Co1—N1	93.01 (12)	C9—C8—H8A	108.8
O1—Co1—N1	86.99 (12)	C7—C8—H8B	108.8
O3 <sup>i</sup> —Co1—N1	88.86 (12)	C9—C8—H8B	108.8
O3—Co1—N1	91.14 (12)	H8A—C8—H8B	107.7
N1 <sup>i</sup> —Co1—N1	180.0 (2)	C10—C9—C12	116.7 (5)
C14—O1—Co1	133.1 (3)	C10—C9—C8	121.7 (4)
Co1—O3—H3B	100.2	C12—C9—C8	121.6 (4)
Co1—O3—H3A	120.2	C9—C10—C11	119.6 (5)
H3B—O3—H3A	121.8	C9—C10—H10	120.2
C5—N1—C1	116.4 (4)	C11—C10—H10	120.2
C5—N1—Co1	119.8 (3)	N2—C11—C10	124.4 (5)
C1—N1—Co1	123.3 (3)	N2—C11—H11	117.8
C11—N2—C13	115.7 (4)	C10—C11—H11	117.8
N1—C1—C2	123.3 (4)	C9—C12—C13	119.6 (5)
N1—C1—H1	118.4	C9—C12—H12	120.2
C2—C1—H1	118.4	C13—C12—H12	120.2
C3—C2—C1	120.2 (4)	N2—C13—C12	124.0 (5)
C3—C2—H2	119.9	N2—C13—H13	118.0
C1—C2—H2	119.9	C12—C13—H13	118.0
C2—C3—C4	116.3 (4)	O2—C14—O1	125.9 (4)
C2—C3—C6	121.9 (4)	O2—C14—C15	119.4 (4)
C4—C3—C6	121.8 (4)	O1—C14—C15	114.7 (4)
C5—C4—C3	120.2 (4)	C16—C15—C17	118.8 (4)
C5—C4—H4	119.9	C16—C15—C14	120.8 (4)
C3—C4—H4	119.9	C17—C15—C14	120.4 (4)
N1—C5—C4	123.5 (4)	C15—C16—C17 <sup>ii</sup>	121.3 (4)
N1—C5—H5	118.2	C15—C16—H16	119.3
C4—C5—H5	118.2	C17 <sup>ii</sup> —C16—H16	119.3
C3—C6—C7	112.4 (4)	C16 <sup>ii</sup> —C17—C15	119.9 (4)
C3—C6—H6A	109.1	C16 <sup>ii</sup> —C17—H17	120.1
C7—C6—H6A	109.1	C15—C17—H17	120.1
C3—C6—H6B	109.1		
O1 <sup>i</sup> —Co1—O1—C14	-175 (95)	C2—C3—C6—C7	94.5 (5)
O3 <sup>i</sup> —Co1—O1—C14	2.6 (4)	C4—C3—C6—C7	-84.7 (6)
O3—Co1—O1—C14	-177.4 (4)	C3—C6—C7—C8	68.8 (6)
N1 <sup>i</sup> —Co1—O1—C14	93.7 (4)	C6—C7—C8—C9	177.5 (4)
N1—Co1—O1—C14	-86.3 (4)	C7—C8—C9—C10	118.4 (5)
O1 <sup>i</sup> —Co1—N1—C5	-130.3 (3)	C7—C8—C9—C12	-62.9 (7)
O1—Co1—N1—C5	49.7 (3)	C12—C9—C10—C11	-0.5 (7)
O3 <sup>i</sup> —Co1—N1—C5	-39.5 (3)	C8—C9—C10—C11	178.3 (5)
O3—Co1—N1—C5	140.5 (3)	C13—N2—C11—C10	-1.2 (8)
N1 <sup>i</sup> —Co1—N1—C5	82 (48)	C9—C10—C11—N2	1.1 (8)
O1 <sup>i</sup> —Co1—N1—C1	58.2 (4)	C10—C9—C12—C13	0.0 (8)
O1—Co1—N1—C1	-121.8 (4)	C8—C9—C12—C13	-178.7 (5)

## supplementary materials

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O3 <sup>i</sup> —Co1—N1—C1	149.1 (4)	C11—N2—C13—C12	0.7 (8)
O3—Co1—N1—C1	-30.9 (4)	C9—C12—C13—N2	-0.2 (9)
N1 <sup>i</sup> —Co1—N1—C1	-90 (48)	Co1—O1—C14—O2	-21.8 (7)
C5—N1—C1—C2	-1.9 (7)	Co1—O1—C14—C15	156.4 (3)
Co1—N1—C1—C2	169.9 (3)	O2—C14—C15—C16	167.4 (4)
N1—C1—C2—C3	0.5 (7)	O1—C14—C15—C16	-10.9 (6)
C1—C2—C3—C4	1.5 (7)	O2—C14—C15—C17	-10.2 (6)
C1—C2—C3—C6	-177.7 (4)	O1—C14—C15—C17	171.5 (4)
C2—C3—C4—C5	-2.1 (7)	C17—C15—C16—C17 <sup>ii</sup>	-0.8 (7)
C6—C3—C4—C5	177.1 (4)	C14—C15—C16—C17 <sup>ii</sup>	-178.5 (4)
C1—N1—C5—C4	1.2 (7)	C16—C15—C17—C16 <sup>ii</sup>	0.8 (7)
Co1—N1—C5—C4	-170.8 (4)	C14—C15—C17—C16 <sup>ii</sup>	178.5 (4)
C3—C4—C5—N1	0.8 (7)		

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

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

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
O3—H3A $\cdots$ N2 <sup>iii</sup>	0.93	1.90	2.820 (5)	171
O3—H3B $\cdots$ O2 <sup>i</sup>	1.03	1.71	2.704 (4)	161

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



Fig. 1

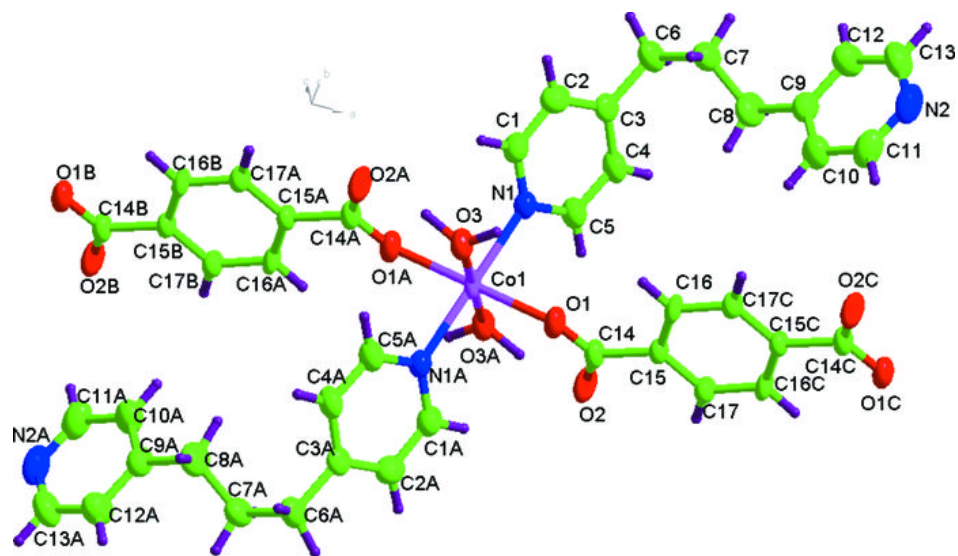


Fig. 2

