

(μ -5-Carboxy-1*H*-imidazole-4-carboxylato- $\kappa^4 N^1, O^5: N^3, O^4$)bis[amminesilver(I)]

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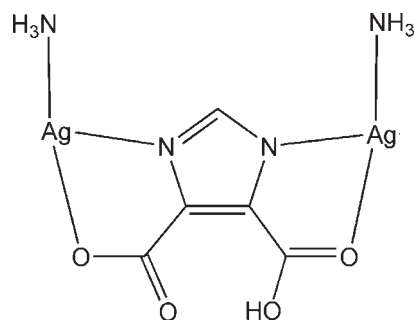
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Key indicators: single-crystal X-ray study; $T = 190$ K; mean $\sigma(C-C) = 0.004$ Å; R factor = 0.018; wR factor = 0.044; data-to-parameter ratio = 11.4.

In the title compound, $[Ag_2(C_5H_2N_2O_4)(NH_3)_2]$, each of the two Ag^I atoms is coordinated by two N atoms from an ammonia molecule and a 5-carboxy-1*H*-imidazole-4-carboxylate ligand in an almost linear geometry, and by one carboxylate O atom with a weak interaction. The Ag atoms are assembled into a linear tetramer through $Ag \cdots Ag$ interactions. Each Ag tetramer is linked by four 5-carboxy-1*H*-imidazole-4-carboxylate ligands, forming a puckered chain. The complex involves a strong intramolecular $O-H \cdots O$ hydrogen bond.

Related literature

For general background to coordination polymers, see: Ferey (2008); Ma *et al.* (2009); Moulton & Zaworotko (2001); Tranchemontagne *et al.* (2009). For related structures with the 4,5-imidazoledicarboxylic acid ligand, see: Caudle *et al.* (1997); Fang & Zhang (2006); Han *et al.* (2005); Zhong *et al.* (2006).

**Experimental***Crystal data*

$[Ag_2(C_5H_2N_2O_4)(NH_3)_2]$
 $M_r = 403.89$
 Monoclinic, $C2/c$
 $a = 18.3800$ (12) Å
 $b = 8.3243$ (5) Å

$c = 13.6696$ (8) Å
 $\beta = 113.160$ (1)°
 $V = 1922.9$ (2) Å³
 $Z = 8$
 Mo $K\alpha$ radiation

$\mu = 4.07$ mm⁻¹
 $T = 190$ K

0.35 × 0.25 × 0.10 mm

Data collection

Bruker SMART APEX CCD diffractometer
 Absorption correction: multi-scan (SADABS; Bruker, 2001)
 $T_{min} = 0.330$, $T_{max} = 0.686$

5211 measured reflections
 1911 independent reflections
 1721 reflections with $I > 2\sigma(I)$
 $R_{int} = 0.019$

Refinement

$R[F^2 > 2\sigma(F^2)] = 0.018$
 $wR(F^2) = 0.044$
 $S = 1.05$
 1911 reflections
 168 parameters

H atoms treated by a mixture of independent and constrained refinement
 $\Delta\rho_{max} = 0.45$ e Å⁻³
 $\Delta\rho_{min} = -0.50$ e Å⁻³

Table 1

Selected bond lengths (Å).

Ag1—N1	2.134 (2)	Ag2—N3	2.133 (3)
Ag1—N4	2.123 (3)	Ag2—O1	2.607 (2)
Ag1—O4	2.628 (2)	Ag1 \cdots Ag1 ⁱ	2.9916 (5)
Ag2—N2	2.132 (2)	Ag1 \cdots Ag2 ⁱⁱ	3.0021 (4)

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

Hydrogen-bond geometry (Å, °).

$D-H \cdots A$	$D-H$	$H \cdots A$	$D \cdots A$	$D-H \cdots A$
O2—H2 \cdots O3	1.19 (8)	1.26 (8)	2.448 (3)	172 (6)

Data collection: SMART (Bruker, 2007); cell refinement: SAINT (Bruker, 2007); data reduction: SAINT; program(s) used to solve structure: SHELXS97 (Sheldrick, 2008); program(s) used to refine structure: SHELXL97 (Sheldrick, 2008); molecular graphics: DIAMOND (Brandenburg, 1999); software used to prepare material for publication: SHELXTL (Sheldrick, 2008).

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Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: HY2243).

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supplementary materials

Acta Cryst. (2009). E65, m1523 [doi:10.1107/S1600536809045747]

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Comment

Coordination polymers are rapidly increasing because of their intriguing structures and wide potential applications as functional materials (Ferey, 2008; Ma *et al.*, 2009; Moulton & Zaworotko, 2001; Tranchemontagne *et al.*, 2009). Complexes with 4,5-imidazoledicarboxylic acid ligand have been recently reported (Caudle *et al.*, 1997; Fang & Zhang, 2006; Zhong *et al.*, 2006). The title compound is a new Ag^I complex built with 4,5-imidazoledicarboxylic acid ligand.

The asymmetric unit consists of two crystallographically independent Ag^I atoms, one partly deprotonated 4,5-imidazoledicarboxylate ligand and two ammonia molecules (Fig. 1). Each Ag^I atom is bonded to an ammonia molecule and one N atom and one O atom from the 4,5-imidazoledicarboxylate ligand in a chelating coordination mode. The Ag—N distances range from 2.123 (3) to 2.134 (2) Å (Table 1), and the N—Ag—N bond angles range from 173.75 (11) to 177.4 (11)°. It is worth to note that the bond distances of Ag—O [2.628 (2) and 2.607 (2) Å] are much longer than that observed in the reported silver carboxylate complexes (Han *et al.*, 2005), indicating weak interaction between the Ag^I atom and the carboxylate O atom. Ag1 and Ag2 are assembled into an Ag^I2···Ag^I1···Ag^I1···Ag^I2 linear tetramer through the Ag···Ag interactions (Fig. 2) [Ag1···Ag1ⁱ = 2.9916 (5) and Ag1···Ag2ⁱⁱ = 3.0021 (4) Å; symmetry codes: (i) -x, y, 1/2 - z; (ii) x, 2 - y, -1/2 + z]. Moreover, there exists a strong hydrogen bond (O2—H2···O3) in the complex molecule (Table 2).

Experimental

A solution of 4,5-imidazoledicarboxylic acid (6.5 mg, 0.05 mmol) in 2 ml water containing triethylamine (14 μ l, 1 mmol) was directly mixed with a solution of AgNO₃ in 2 ml of 25% aqueous ammonia. The resulting yellow solution was allowed to slowly crystallize at room temperature in dark. After one week, brown single crystals were collected by filtration, washed with small amounts of water and dried in air.

Refinement

H atoms were located in a difference Fourier map and refined isotropically.

Figures

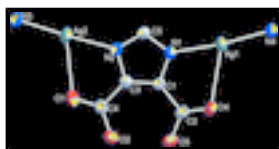


Fig. 1. The molecular structure of the title compound. Displacement ellipsoids are drawn at the 50% probability level.

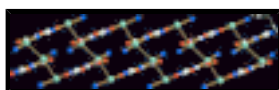


Fig. 2. The one-dimensional puckered chain assembled by Ag tetramers and 4,5-imidazoledicarboxylate ligands. Dashed lines denote Ag···Ag interactions.

supplementary materials

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Crystal data

[Ag ₂ (C ₅ H ₂ N ₂ O ₄)(NH ₃) ₂]	$F_{000} = 1536$
$M_r = 403.89$	$D_x = 2.790 \text{ Mg m}^{-3}$
Monoclinic, $C2/c$	Mo $K\alpha$ radiation, $\lambda = 0.71073 \text{ \AA}$
Hall symbol: $-C\ 2yc$	Cell parameters from 1780 reflections
$a = 18.3800 (12) \text{ \AA}$	$\theta = 2.4\text{--}26.1^\circ$
$b = 8.3243 (5) \text{ \AA}$	$\mu = 4.07 \text{ mm}^{-1}$
$c = 13.6696 (8) \text{ \AA}$	$T = 190 \text{ K}$
$\beta = 113.160 (1)^\circ$	Block, brown
$V = 1922.9 (2) \text{ \AA}^3$	$0.35 \times 0.25 \times 0.10 \text{ mm}$
$Z = 8$	

Data collection

Bruker SMART APEX CCD diffractometer	1911 independent reflections
Radiation source: fine-focus sealed tube	1721 reflections with $I > 2\sigma(I)$
Monochromator: graphite	$R_{\text{int}} = 0.019$
$T = 190 \text{ K}$	$\theta_{\text{max}} = 26.1^\circ$
φ and ω scans	$\theta_{\text{min}} = 2.4^\circ$
Absorption correction: multi-scan (SADABS; Bruker, 2001)	$h = -22 \rightarrow 18$
$T_{\text{min}} = 0.330$, $T_{\text{max}} = 0.686$	$k = -10 \rightarrow 9$
5211 measured reflections	$l = -16 \rightarrow 16$

Refinement

Refinement on F^2	Secondary atom site location: difference Fourier map
Least-squares matrix: full	Hydrogen site location: inferred from neighbouring sites
$R[F^2 > 2\sigma(F^2)] = 0.018$	H atoms treated by a mixture of independent and constrained refinement
$wR(F^2) = 0.044$	$w = 1/[\sigma^2(F_o^2) + (0.02P)^2 + 2.4121P]$
$S = 1.05$	where $P = (F_o^2 + 2F_c^2)/3$
1911 reflections	$(\Delta/\sigma)_{\text{max}} = 0.001$
168 parameters	$\Delta\rho_{\text{max}} = 0.45 \text{ e \AA}^{-3}$
Primary atom site location: structure-invariant direct methods	$\Delta\rho_{\text{min}} = -0.50 \text{ e \AA}^{-3}$
	Extinction correction: none

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

x	y	z	$U_{\text{iso}}^*/U_{\text{eq}}$
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Ag2	0.206133 (14)	0.79951 (3)	0.660249 (17)	0.03620 (8)
O1	0.17397 (15)	0.5366 (3)	0.54751 (18)	0.0476 (6)
N2	0.15598 (14)	0.8616 (3)	0.49573 (18)	0.0306 (5)
Ag1	0.060181 (14)	1.13414 (3)	0.201582 (18)	0.03346 (8)
C1	0.11079 (17)	0.8155 (3)	0.3218 (2)	0.0269 (6)
C2	0.08372 (18)	0.7496 (4)	0.2126 (2)	0.0322 (7)
C3	0.13893 (16)	0.7428 (4)	0.4199 (2)	0.0275 (6)
C4	0.15067 (17)	0.5712 (4)	0.4527 (2)	0.0323 (7)
C5	0.13741 (19)	0.9977 (4)	0.4412 (2)	0.0332 (7)
N1	0.11022 (14)	0.9785 (3)	0.33560 (18)	0.0302 (5)
N3	0.25466 (19)	0.7478 (4)	0.8265 (2)	0.0366 (6)
N4	0.0094 (2)	1.3080 (4)	0.0800 (2)	0.0368 (6)
O2	0.13419 (14)	0.4656 (3)	0.37827 (19)	0.0436 (6)
O3	0.08142 (16)	0.5948 (3)	0.20328 (18)	0.0480 (6)
O4	0.06587 (15)	0.8395 (3)	0.13591 (16)	0.0441 (6)
H1	0.1399 (19)	1.094 (4)	0.467 (3)	0.040 (9)*
H2	0.112 (4)	0.523 (9)	0.291 (6)	0.17 (3)*
H3	0.275 (2)	0.836 (5)	0.869 (3)	0.062 (12)*
H4	0.300 (2)	0.686 (5)	0.843 (3)	0.058 (12)*
H5	0.218 (2)	0.696 (4)	0.844 (3)	0.042 (10)*
H6	0.041 (2)	1.385 (5)	0.078 (3)	0.060 (13)*
H7	-0.034 (3)	1.348 (5)	0.083 (3)	0.060 (13)*
H8	-0.004 (3)	1.271 (6)	0.024 (4)	0.073 (16)*

Atomic displacement parameters (\AA^2)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
Ag2	0.03743 (15)	0.04560 (16)	0.02245 (12)	0.00084 (10)	0.00842 (10)	0.00281 (10)
O1	0.0657 (16)	0.0373 (12)	0.0384 (13)	0.0061 (11)	0.0189 (12)	0.0123 (10)
N2	0.0315 (13)	0.0331 (13)	0.0236 (12)	0.0025 (10)	0.0072 (11)	-0.0013 (10)
Ag1	0.03572 (14)	0.03391 (14)	0.02914 (13)	0.00315 (10)	0.01104 (10)	0.00742 (9)
C1	0.0292 (15)	0.0262 (14)	0.0257 (14)	-0.0018 (11)	0.0112 (12)	-0.0028 (11)
C2	0.0312 (16)	0.0350 (16)	0.0281 (15)	-0.0025 (13)	0.0091 (13)	-0.0058 (13)
C3	0.0238 (14)	0.0324 (15)	0.0271 (14)	0.0005 (11)	0.0110 (12)	0.0006 (12)
C4	0.0318 (16)	0.0319 (16)	0.0357 (16)	0.0040 (12)	0.0159 (13)	0.0032 (13)
C5	0.0407 (18)	0.0283 (16)	0.0256 (14)	0.0030 (13)	0.0076 (13)	-0.0036 (12)
N1	0.0348 (14)	0.0288 (12)	0.0236 (11)	0.0020 (10)	0.0078 (11)	0.0023 (10)
N3	0.0409 (17)	0.0394 (16)	0.0255 (13)	-0.0030 (13)	0.0087 (13)	-0.0003 (12)
N4	0.0449 (18)	0.0308 (15)	0.0293 (15)	0.0008 (13)	0.0089 (14)	0.0015 (12)
O2	0.0585 (15)	0.0284 (11)	0.0447 (13)	0.0004 (10)	0.0212 (12)	-0.0026 (10)
O3	0.0710 (17)	0.0340 (12)	0.0370 (12)	-0.0047 (12)	0.0189 (12)	-0.0112 (10)
O4	0.0606 (15)	0.0428 (13)	0.0230 (11)	0.0044 (11)	0.0100 (11)	-0.0014 (10)

Geometric parameters (\AA , $^\circ$)

Ag1—N1	2.134 (2)	C2—O4	1.223 (4)
Ag1—N4	2.123 (3)	C2—O3	1.294 (4)
Ag1—O4	2.628 (2)	C3—C4	1.487 (4)
Ag2—N2	2.132 (2)	C4—O2	1.287 (4)

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Ag2—N3	2.133 (3)	C5—N1	1.338 (4)
Ag2—O1	2.607 (2)	C5—H1	0.87 (4)
Ag1—Ag1 ⁱ	2.9916 (5)	N3—H3	0.92 (4)
Ag1—Ag2 ⁱⁱ	3.0021 (4)	N3—H4	0.93 (4)
O1—C4	1.228 (4)	N3—H5	0.90 (4)
N2—C5	1.325 (4)	N4—H6	0.87 (4)
N2—C3	1.377 (4)	N4—H7	0.87 (4)
C1—N1	1.371 (4)	N4—H8	0.77 (5)
C1—C3	1.373 (4)	O2—H2	1.19 (8)
C1—C2	1.481 (4)	O3—H2	1.26 (8)
N2—Ag2—N3	177.40 (11)	C1—C3—C4	132.2 (3)
N2—Ag2—O1	71.12 (8)	N2—C3—C4	120.0 (2)
N3—Ag2—O1	111.27 (10)	O1—C4—O2	123.4 (3)
N2—Ag2—Ag1 ⁱⁱⁱ	96.10 (7)	O1—C4—C3	119.5 (3)
N3—Ag2—Ag1 ⁱⁱⁱ	82.35 (9)	O2—C4—C3	117.1 (3)
O1—Ag2—Ag1 ⁱⁱⁱ	104.71 (6)	N2—C5—N1	114.1 (3)
C4—O1—Ag2	109.3 (2)	N2—C5—H1	127 (2)
C5—N2—C3	105.0 (2)	N1—C5—H1	119 (2)
C5—N2—Ag2	135.2 (2)	C5—N1—C1	104.3 (2)
C3—N2—Ag2	119.74 (19)	C5—N1—Ag1	134.8 (2)
N4—Ag1—N1	173.75 (11)	C1—N1—Ag1	120.49 (18)
N4—Ag1—O4	115.67 (10)	Ag2—N3—H3	114 (3)
N1—Ag1—O4	70.43 (8)	Ag2—N3—H4	109 (2)
N4—Ag1—Ag1 ⁱ	99.91 (10)	H3—N3—H4	101 (3)
N1—Ag1—Ag1 ⁱ	76.36 (7)	Ag2—N3—H5	109 (2)
O4—Ag1—Ag1 ⁱ	106.67 (5)	H3—N3—H5	112 (3)
N4—Ag1—Ag2 ⁱⁱ	82.99 (10)	H4—N3—H5	111 (3)
N1—Ag1—Ag2 ⁱⁱ	99.09 (7)	Ag1—N4—H6	115 (3)
O4—Ag1—Ag2 ⁱⁱ	87.07 (6)	Ag1—N4—H7	111 (3)
Ag1 ⁱ —Ag1—Ag2 ⁱⁱ	162.610 (12)	H6—N4—H7	111 (4)
N1—C1—C3	108.8 (2)	Ag1—N4—H8	112 (4)
N1—C1—C2	119.1 (2)	H6—N4—H8	103 (4)
C3—C1—C2	132.0 (3)	H7—N4—H8	104 (4)
O4—C2—O3	122.5 (3)	C4—O2—H2	113 (3)
O4—C2—C1	120.6 (3)	C2—O3—H2	113 (3)
O3—C2—C1	116.9 (3)	C2—O4—Ag1	108.15 (19)
C1—C3—N2	107.8 (2)		

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

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

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
O2—H2 \cdots O3	1.19 (8)	1.26 (8)	2.448 (3)	172 (6)

Fig. 1

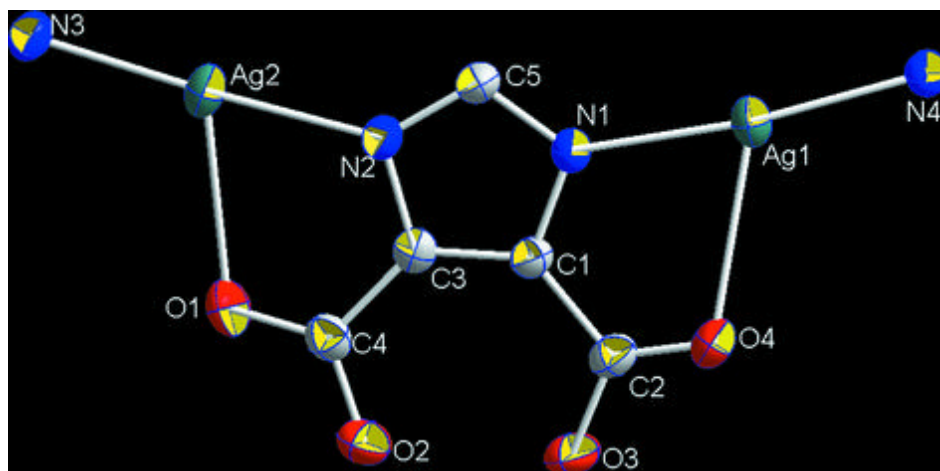


Fig. 2

