

**catena-Poly[[silver(I)- $\mu$ -hexane-1,6-diamine- $\kappa^2$ N:N'] cinnamate dihydrate]**Zhong-Lu You,<sup>a,b</sup> Hai-Liang Zhu<sup>a,b\*</sup> and Wei-Sheng Liu<sup>b</sup><sup>a</sup>Department of Chemistry, Fuyang Normal College, Fuyang Anhui 236041, People's Republic of China, and <sup>b</sup>Department of Chemistry, Lanzhou University, Lanzhou 730000, People's Republic of China  
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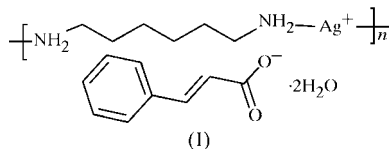
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The title compound,  $[\text{Ag}(\text{C}_6\text{H}_{16}\text{N}_2)](\text{C}_9\text{H}_7\text{O}_2) \cdot 2\text{H}_2\text{O}]_n$ , has been synthesized and characterized by elemental analysis and single-crystal X-ray diffraction. The Ag atom is coordinated in a linear configuration by two N atoms from two hexane-1,6-diamine ligands, giving a zigzag polymeric chain with an  $[-\text{Ag}-\text{N}-\text{C}-\text{C}-\text{C}-\text{C}-\text{N}-]_n$  backbone running parallel to the  $c$  axis. In the crystal packing, adjacent chains interact with the anions *via* the lattice water molecules, thus forming layers parallel to the  $bc$  plane.

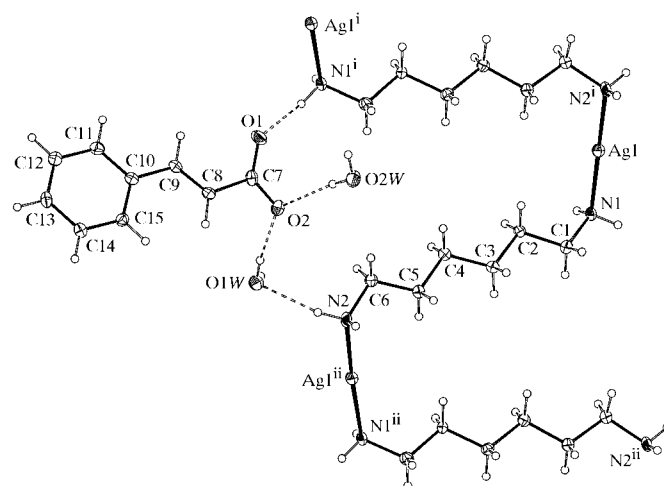
**Comment**

The structural characterization of silver(I) complexes with carboxylate anions as counter-ions or ligands has attracted much interest over the past 30 years because of the use of these compounds in a wide range of fields (Graham *et al.*, 1996; Pingrong *et al.*, 1998; Nomiya *et al.*, 2000; Kristiansson, 2001). Recently, we have reported a few dozen silver(I)-carboxylate complexes with various amines and imines, all of which have been structurally characterized (Zhu *et al.*, 1999, 2000; Zheng, Tong, Zhu & Chen, 2001; Zheng, Tong, Zhu, Fang & Chen, 2001; Usman *et al.*, 2003; Zhu, Usman *et al.*, 2003; Zhu, Zhang *et al.*, 2003; You *et al.*, 2004). As an extension of our work on the structural characterization of these silver(I) carboxylates, the title complex, (I), is reported here.

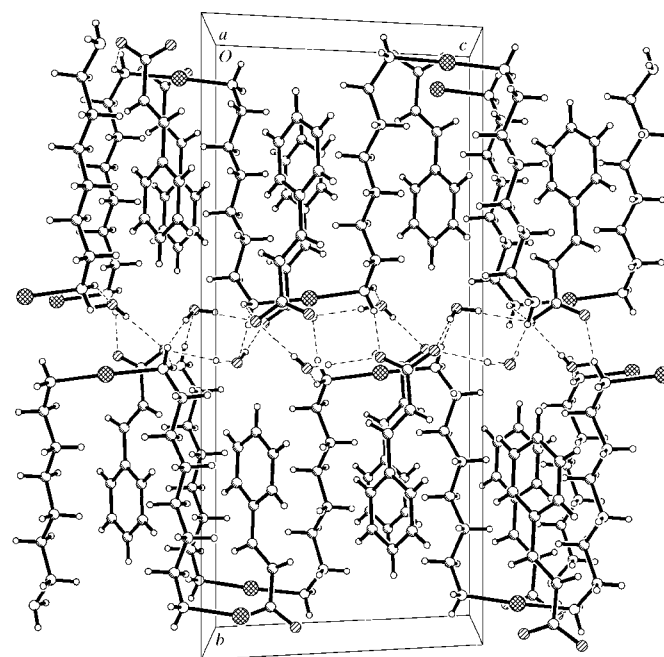


Complex (I) is a polymeric (1,6-diaminohexane)silver(I) complex. Each of the smallest repeat units in the complex contains a (1,6-diaminohexane)silver(I) cation, a cinnamate anion and two lattice water molecules, as shown in Fig. 1. In the cation, the Ag atom has a linear coordination environment and is coordinated by two N atoms from two 1,6-diaminohexane ligands. The Ag1–N1 and Ag1–N2 bond lengths

[2.133 (4) and 2.155 (4) Å, respectively] are slightly longer than the mean Ag–N bond lengths [2.126 (4) Å] reported for a similar silver complex with 1,6-diaminohexane (Zhu, Wang *et al.*, 2003). The N1–Ag1–N2 angle [174.47 (15)°], indicating a slightly distorted linear geometry for atom Ag1, is comparable to the value observed in another similar silver complex [172.37 (8)°; Zhu, Liu *et al.*, 2003]. In the anion, the

**Figure 1**

Part of the extended structure of (I), showing the atom-numbering scheme. Displacement ellipsoids are drawn at the 30% probability level. [Symmetry codes: (i)  $x - \frac{1}{2}, \frac{1}{2} - y, z - \frac{1}{2}$ ; (ii)  $\frac{1}{2} + x, \frac{1}{2} - y, \frac{1}{2} + z$ .]

**Figure 2**

The crystal packing of (I), viewed along the  $a$  axis. Ag, water O and N atoms are represented by large cross-hatched, medium hatched and medium unfilled spheres, respectively.

dihedral angle between the plane of the benzene ring and the plane of the carboxy group (O1/C7/O2) is 25.1 (4)°. The O2—C7—C8—C9 and C7—C8—C9—C10 torsion angles are −168.9 (4) and 176.8 (4)°, respectively. Atom C9 lies in the plane of the phenyl ring. The aminohexane chain is almost planar, the largest displacement from the least-squares plane being only 0.17 Å. This plane makes a dihedral angle of 4.2 (2)° with the plane of the phenyl ring.

In the crystal, the cinnamate anions are located among the chains. The Ag—N bonds link the amine molecules and the Ag atoms into a zigzag chain along the *c* axis. Adjacent chains interact with the anions *via* the lattice water molecules, thus forming layers along the *bc* direction (Fig. 2). These layers are linked together by the hydrogen bonds listed in Table 1, thus forming a three-dimensional structure.

## Experimental

All reagents and solvents were used as obtained without further purification. Silver cinnamate (1 mmol, 255 mg) and 1,6-diaminohexane (1 mmol, 116 mg) were dissolved in an ammonia solution (10 ml, 30%), and the mixture was stirred for about 20 min at room temperature. The resulting clear colorless solution was kept in air and, after slow evaporation of the solvent over a period of a week, large colorless crystals of (I) formed at the bottom of the vessel. The crystals were isolated, washed three times with water and dried in a vacuum desiccator using anhydrous CaCl<sub>2</sub> (yield 78.7%). Analysis found: C 44.19, H 6.72, N 6.82%; calculated for C<sub>15</sub>H<sub>27</sub>AgN<sub>2</sub>O<sub>4</sub>: C 44.24, H 6.68, N 6.88%.

### Crystal data

[Ag(C <sub>6</sub> H <sub>16</sub> N <sub>2</sub> )](C <sub>9</sub> H <sub>7</sub> O <sub>2</sub> )·2H <sub>2</sub> O	<i>D</i> <sub>x</sub> = 1.567 Mg m <sup>−3</sup>
<i>M</i> <sub>r</sub> = 407.26	Mo <i>K</i> α radiation
Monoclinic, <i>P</i> <sub>2</sub> <sub>1</sub> / <i>n</i>	Cell parameters from 7511 reflections
<i>a</i> = 7.272 (1) Å	<i>θ</i> = 2.8–25.5°
<i>b</i> = 23.070 (5) Å	<i>μ</i> = 1.19 mm <sup>−1</sup>
<i>c</i> = 10.753 (2) Å	<i>T</i> = 293 (2) K
<i>β</i> = 106.82 (3)°	Block, colorless
<i>V</i> = 1726.8 (5) Å <sup>3</sup>	0.45 × 0.32 × 0.19 mm
<i>Z</i> = 4	

### Data collection

Bruker SMART CCD area-detector diffractometer	3381 independent reflections
<i>φ</i> and <i>ω</i> scans	2800 reflections with <i>I</i> > 2σ( <i>I</i> )
Absorption correction: multi-scan ( <i>SADABS</i> ; Sheldrick, 1996)	<i>R</i> <sub>int</sub> = 0.035
<i>T</i> <sub>min</sub> = 0.641, <i>T</i> <sub>max</sub> = 0.798	<i>θ</i> <sub>max</sub> = 26.0°
7641 measured reflections	<i>h</i> = −6 → 8
	<i>k</i> = −28 → 26
	<i>l</i> = −13 → 13

### Refinement

Refinement on <i>F</i> <sup>2</sup>	H-atom parameters constrained
<i>R</i> [ <i>F</i> <sup>2</sup> > 2σ( <i>F</i> <sup>2</sup> )] = 0.049	<i>w</i> = 1/[σ <sup>2</sup> ( <i>F</i> <sub>o</sub> <sup>2</sup> ) + (0.0361 <i>P</i> ) <sup>2</sup> ]
<i>wR</i> ( <i>F</i> <sup>2</sup> ) = 0.097	where <i>P</i> = ( <i>F</i> <sub>o</sub> <sup>2</sup> + 2 <i>F</i> <sub>c</sub> <sup>2</sup> )/3
<i>S</i> = 1.13	(Δ/ <i>σ</i> ) <sub>max</sub> < 0.001
3381 reflections	Δ <i>ρ</i> <sub>max</sub> = 0.70 e Å <sup>−3</sup>
199 parameters	Δ <i>ρ</i> <sub>min</sub> = −0.57 e Å <sup>−3</sup>

All H atoms were placed in idealized positions and constrained to ride on their parent atoms, with N—H distances of 0.90 Å, C—H distances of 0.96 Å and O—H distances of 0.94–1.0 Å, and with *U*<sub>iso</sub>(H) values fixed at 0.08 Å<sup>2</sup>. The coordinates of the water H atoms were localized using the *HYDROGEN* program (Nardelli, 1999).

**Table 1**

Hydrogen-bonding 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>
N1—H1A...O1 <sup>i</sup>	0.90	2.03	2.901 (4)	161
N1—H1B...O2W <sup>ii</sup>	0.90	2.38	3.194 (5)	150
N2—H2B...O2 <sup>iii</sup>	0.90	2.48	3.261 (5)	144
O1W—H1WB...O2 <sup>iv</sup>	0.85	2.11	2.955 (5)	175
O2W—H2WB...O1 <sup>v</sup>	0.84	1.97	2.798 (4)	172
N2—H2A...O1W	0.90	2.11	2.977 (5)	162
O1W—H1WA...O2	0.84	2.04	2.876 (4)	172
O2W—H2WA...O2	0.86	2.24	3.091 (4)	171

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

Data collection: *SMART* (Siemens, 1996); cell refinement: *SMART*; data reduction: *SAINT* (Siemens, 1996); program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997a); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997a); molecular graphics: *SHELXTL* (Sheldrick, 1997b); software used to prepare material for publication: *SHELXTL*.

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Supplementary data for this paper are available from the IUCr electronic archives (Reference: NA1655). Services for accessing these data are described at the back of the journal.

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