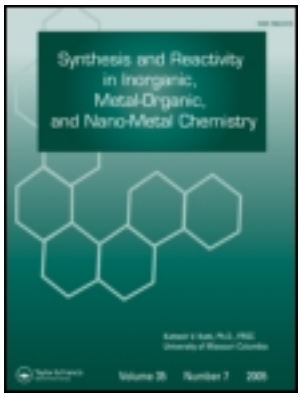

Synthesis and Reactivity in Inorganic, Metal-Organic, and Nano-Metal Chemistry

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Synthesis, Crystal Structure, and Cytotoxic Property of bis(5-Chloro-2-nitrobenzoato)bis(2-piperidin-1-ylethylamine)disilver(I)

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Synthesis, Crystal Structure, and Cytotoxic Property of bis(5-Chloro-2-nitrobenzoato)bis(2-piperidin-1-ylethylamine)disilver(I)

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5-Chloro-2-nitrobenzoic acid reacts with silver oxide and 2-piperidin-1-ylethylamine to give a centrosymmetric dinuclear silver(I) complex, $[Ag_2(C_7H_3ClNO_4)(C_7H_{16}N_2)_2]$. The complex was characterized by elemental analysis and X-ray diffraction. The two Ag atoms are bridged by two 2-piperidin-1-ylethylamine ligands, generating a 10-membered chelate ring. The distance between the two Ag atoms is 2.948(2) Å. Each Ag atom in the complex is three-coordinated by one primary amine and one ternary amine N atoms from two symmetry-related 2-piperidin-1-ylethylamine ligands, and by one carboxylate O atom of a 5-chloro-2-nitrobenzoate ligand, forming a distorted Y-shaped coordination. In the crystal structure, the molecules are linked through intermolecular N–H···O hydrogen bonds, forming chains running along the *a*-axis. The complex shows effective cytotoxic property to both carcinoma and normal cells.

Keywords crystal structure, cytotoxic property, hydrogen bonding, silver complex, synthesis

INTRODUCTION

Silver(I) complexes with carboxylate anions as counterions or ligands are a group of metal compounds that have received much attention for their wide usage in many fields.[1–3] Studying the variety of products in the self-assembly processes between labile metal ions and multidentate ligands is an interesting topic in supramolecular chemistry. The balance between the formation of different structures is often subtle. Factors that affect the coordination topology include not only the highly influential factors of metal and ligand coordination preferences but also anion-based influences. The latter factor is particularly interesting in silver(I) complexes.[4–6] Owing to the versatile coordination geometry of silver, coordination numbers from two to six are possible,[4–9] and because of the relatively weak nature of many Ag–ligand interactions, including some anion–Ag interactions, such complexes are particularly susceptible to the influence of weaker supramolecular forces. Thus, it is not possible to precisely predict what structure will be formed for the silver(I) complex, and more work needs to be done to understand better the influence effects of such complexes, which has becoming an interesting topic in supramolecular chemistry. Recently, we have reported a few silver(I) complexes.[10,11] As a further study of the silver complexes, here the synthesis, crystal structure, and cytotoxic property of a new silver(I) complex with the formula $[Ag_2(C_7H_3ClNO_4)(C_7H_{16}N_2)_2]$ is reported.

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EXPERIMENTAL

Materials and Measurements

All chemicals and reagents were commercially available and used without further purification. C, H, and N elemental analyses were performed on a Perkin-Elmer 240C elemental analyzer (USA). The X-ray diffraction was carried out on a Bruker SMART 1000 CCD area diffractometer (Germany) at 298(2) K.

Synthesis of the Complex

Ag_2O (0.1 mmol, 23.2 mg) and 5-chloro-2-nitrobenzoic acid (0.2 mmol, 40.3 mg) were dissolved in an ammonia solution (10 mL, 30%), and the mixture was stirred for 30 min at room temperature under dark. The methanolic solution of 2-piperidin-1-ylethylamine (0.2 mmol, 25.6 mg) was added to the previous mixture with stirring. The final mixture was further stirred for 30 min at room temperature under dark. The resulting clear colorless solution was kept in dark for several days, yielding colorless block-shaped single crystals suitable for X-ray diffraction. Yield: 63%. Anal. Calcd. for $C_{28}H_{38}Ag_2Cl_2N_6O_8$: C, 38.5; H, 4.4; N, 9.6. Found (%): C, 38.4; H, 4.5; N, 9.7.

X-Ray Crystallography

A suitable single crystal of the complex was mounted on the top of a glass fiber. Graphite-monochromatized Mo-Kα radiation ($\lambda = 0.71073$ Å) and the ω scan technique were used

TABLE 1
Crystallographic data for the complex

Formula	$C_{28}H_{38}Ag_2Cl_2N_6O_8$
FW	873.3
Crystal shape/color	Block/colorless
Crystal size /mm	0.27 × 0.23 × 0.23
Crystal system	Monoclinic
Space group	$P2_1/c$
a /Å	7.589(2)
b /Å	10.003(2)
c /Å	22.284(3)
β /°	94.300(3)
V /Å^3	1686.9(5)
Z	2
λ (Mo$K\alpha$) /Å	0.71073
T /K	298(2)
μ /mm^{-1} (Mo-$K\alpha$)	1.375
T_{min}	0.7078
T_{max}	0.7427
No. of measured reflections	7350
No. of unique reflections and R_{int}	2743 and 0.0470
No. of observed reflections	2544
data/restraints/parameters	2743/0/208
F(000)	880
Goodness-of-fit on F^2	1.161
R_1, wR_2 [$I \geq 2\sigma(I)$]	0.0925, 0.2104
R_1, wR_2 (all data)	0.0982, 0.2137

to collect the diffraction data. Absorption correction was applied using SADABS.[12] The crystal structure was solved with direct method and refined with a full-matrix least-squares technique using SHELXTL package.[13] Anisotropic thermal parameters were applied to all non-hydrogen atoms. Hydrogen atoms were generated geometrically. The crystallographic data and the details of the data collection and refinement for the complex are listed in Table 1. Selected bond lengths and angles are given in Table 2. Hydrogen bonding information is given in Table 3.

TABLE 2
Selected bond lengths (Å) and angles (°) for the complex

Bond lengths			
Ag1–N1A	2.207(10)	Ag1–O3	2.293(8)
Ag1–N2	2.372(10)		
Bond angles			
N1–Ag1–O3A	133.4(4)	N1–Ag1–N2A	122.7(4)
O3–Ag1–N2	100.8(3)		

Symmetry code for A: 2 – x, 1 – y, 2 – z.

TABLE 3
Hydrogen-bonding geometry (Å, °)

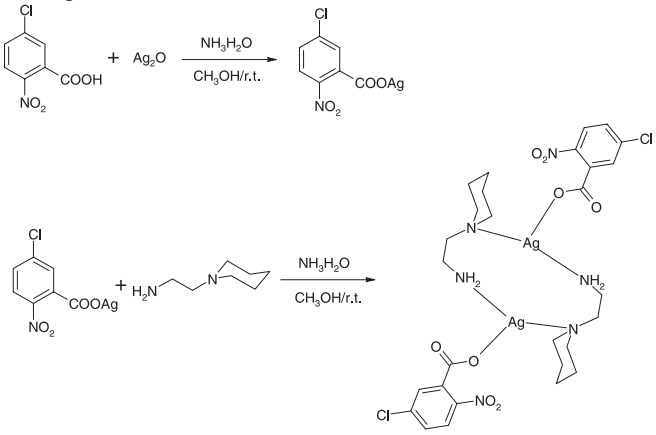
D–H···A	D–H	H···A	D···A	D–H···A
N1–H1B···O3	0.90	2.15	3.00(2)	158
N1–H1A···O4^{i}	0.90	2.09	2.93(2)	156

Symmetry code for i: 1 + x, y, z.

RESULTS AND DISCUSSION

Synthesis

The synthetic procedure of the complex is described as following:



Structure Description of the Complex

The molecular structure of the complex is shown in Figure 1. The complex is a centrosymmetric dinuclear silver(I) compound, with the inversion center located at the midpoint of the two Ag atoms. The two Ag atoms are bridged by two 2-piperidin-1-ylethylamine ligands, generating a 10-membered chelate ring. The Ag···Ag distance in the molecule of the complex is 2.948(2) Å. Each Ag atom is three-coordinated by one primary amine and one ternary amine N atoms from two symmetry-related 2-piperidin-1-ylethylamine ligands, and by one carboxylate O atom of a 5-chloro-2-nitrobenzoate ligand, forming a distorted Y-shaped coordination. The Ag–N and Ag–O bond lengths in the present complex are comparable with the values observed in other silver(I) complexes.[10,11,14,15] The distortion of the coordination can be observed from the bond angles related to the Ag atom, ranging from 100.8(3) to 133.4(4)°. The Ag atom deviates from the least-squares plane defined by the three donor atoms by 0.227(3) Å. The piperidine rings of the 2-piperidin-1-ylethylamine ligands are in perfect chair conformation. The C1-C6 benzene ring forms dihedral angles of 84.6(5)° and 4.7(5)°, respectively, with the planes defined by the O1-N3-O2 nitro and O3-C7-O4 carboxy groups. The formation of the intramolecular N1–H1B···O3 hydrogen bond and the intermolecular N1–H1A···O4^{i} (symmetry code for i: 1 + x, y, z)

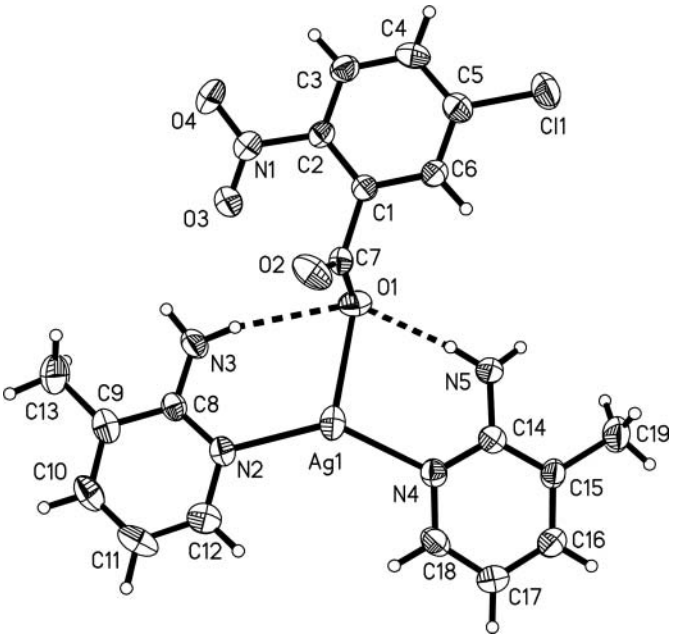


FIG. 1. The structure of the complex with 30% probability level. Intramolecular N–H···O hydrogen bonds are shown as dashed lines.

hydrogen bond may severely influence the conformation of the complex.

In the crystal structure of the complex, molecules are linked through intermolecular N–H···O hydrogen bonds, forming chains running along the *a*-axis, as shown in Figure 2.

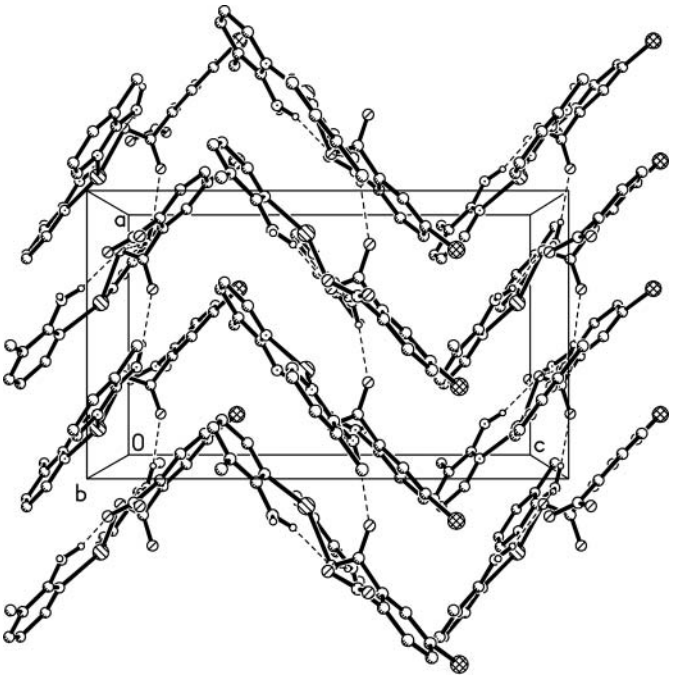


FIG. 2. Molecular packing of the complex, viewed along the *b*-axis. Intermolecular N–H···O hydrogen bonds are shown as dashed lines.

TABLE 4
Cytotoxic results of the complex (IC_{50}, μM)

Hela	HepG2	BGC	95-D	CNE	L-02	NIH 3T3
17.5	9.3	15.0	28.5	6.3	35.3	56.2

Cytotoxic Tests

Five human solid carcinoma cell lines, *Hela* (cervix adenocarcinoma), *HepG2* (hepatocellular carcinoma), *BGC* (gastric carcinoma), *95-D* (lung carcinoma), and *CNE* (rhinocarcinoma), and two normal cell lines, *NIH 3T3* (mouse normal fibroblast) and *L-02* (human normal liver cell), were obtained from Hubei Cancer Hospital. These cells were subcultured in media RMPI 1640 (GIBCO-BRL product) with 10% fetal bovine serum (Hyclone product), at 37°C with 5% cells mL^{-1} and were planted in a 96-well tissue culture plate, and then were exposed to the test compounds with concentrations ranging from 2.5 to 100 μg mL^{-1} for 48 h. The cells were pigmented by MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide], and the O. D. values were measured by ELX800 (universal microplate reader, BIO-TEK Instruments, Inc., Beijing, China) under 490 nm wavelength. Each test was performed in triplicate. The IC_{50} values are listed in Table 4. It can be seen that the complex shows effective cytotoxic property to both carcinoma and normal cells, which is accord with those reported by Zhu et al.[16] Yet, it is difficult to conclude the structure–activity relationship, since there is a significant difference among the structures. Further work should be carried out to prepare analogous silver(I) complexes through appropriate chemical modification for higher activity and selectivity, as well as to explore the structure–activity relationship.

SUPPLEMENTARY MATERIALS

Crystallographic data for the complex has been deposited with the Cambridge Crystallographic Data Centre (CCDC 862028).

REFERENCES

1. Fang, X.-Q.; Deng, Z.-P.; Huo, L.-H.; Wan, W.; Zhu, Z.-B.; Zhao, H.; Gao, S. New family of silver(I) complexes based on hydroxyl and carboxyl groups decorated arenesulfonic acid: syntheses, structures, and luminescent properties. *Inorg. Chem.* **2011**, *50*, 12562–12574.
2. Yilmaz, F.; Yilmaz, V.T.; Soyer, E.; Buyukgungor, O. Syntheses, crystal structures, spectroscopic, fluorescence and thermal properties of silver(I) 5,5-diethylbarbiturato complexes with some aminopyridines. *Inorg. Chim. Acta*, **2010**, *363*, 3165–3171.
3. Melaiye, A.; Simons, R.S.; Milsted, A.; Pingitore, F.; Wesdemiotis, C.; Tessier, C.A.; Youngs, W.J. Formation of water-soluble pincer silver(I)-carbene complexes: a novel antimicrobial agent. *J. Med. Chem.* **2004**, *47*, 973–977.
4. Custer, P.D.; Carrison, J.C.; Tessier, C.A.; Young, W.J. Anion directed synthesis of paddlane and trisilver tweezer complexes based upon silver coordination chemistry. *J. Am. Chem. Soc.* **2005**, *127*, 5738–5739.

5. Lee, S.Y.; Lee, S.S. Anion-directed supramolecular silver(I) complexes of an O_2S_2-macrocycle: cyclic oligomer and 2-D coordination polymers. *CrystEngComm* **2010**, *12*, 3471–3475.
6. Dobrzanska, L. Anion directed supramolecular architectures of silver(I) complexes with 1,3-bis(imidazol-1-ylmethyl)-2,4,6-trimethylbenzene and a reversible, solvent-induced structural change during a single-crystal-to-single-crystal transformation. *CrystEngComm* **2011**, *13*, 2303–2309.
7. Caballero, A.B.; Maclaren, J.K.; Rodriguez-Dieguez, A.; Vidal, I.; Dobado, J.A.; Salas, J.M.; Janiak, C. Dinuclear silver(I) complexes for the design of metal-ligand networks based on triazolopyrimidines. *Dalton Trans.* **2011**, *40*, 11845–11855.
8. Yuan, Y.-M.; Li, W.-H. Synthesis and crystal structure of a tetranuclear silver(I) complex with pyridine-2,4-dicarboxylate and 2-amino-6-methylpyridine. *Synth. React. Inorg. Met.-Org. Nano-Met. Chem.* **2010**, *40*, 490–494.
9. Li, Q.-J.; Li, W.-H. Synthesis and crystal structure of a polymeric silver(I) complex with 4-chlorobenzoate and *N*-propylethane-1,2-diamine. *Synth. React. Inorg. Met.-Org. Nano-Met. Chem.* **2011**, *41*, 694–697.
10. Wang, N.; Li, B. Synthesis, crystal structure and cytotoxic property of bis(4-chlorobenzoato)biss[1-(2-aminoethyl)piperidine]disilver(I). *J. Chem. Crystallogr.* **2011**, *41*, 219–222.
11. Wang, N.; Shi, Q. Synthesis, crystal structure, and cytotoxic property of (5-chloro-2-nitrobenzoato)bis(3-methyl-2-pyridylamine)silver(I). *Synth. React. Inorg. Met.-Org. Nano-Met. Chem.* **2011**, *41*, 727–730.
12. Sheldrick, G.M. *SADABS Program for Empirical Absorption Correction of Area Detector*; University of Göttingen, Göttingen, Germany, **1996**.
13. Sheldrick, G.M. *SHELXTL, Version 6.10, Software Reference Manual*; Bruker Instrumentation, Madison, WI, **2000**.
14. Bowmaker, G.A.; Effendy, Lim, K.C.; Skelton, B.W.; Sukarianingsih, D.; White, A.H. Syntheses, structures and vibrational spectroscopy of some 1:2 and 1:3 adducts of silver(I) oxyanion salts with pyridine and piperidine bases containing non-coordinating 2(,6)-substituents. *Inorg. Chim. Acta* **2005**, *358*, 4342–4370.
15. Liu, X.-Y.; Zhu, H.-L.; Fun, H.-K. Synthesis and characterization of Ag(I) salts with pyridine derivatives, *Synth. React. Inorg. Met.-Org. Nano-Met. Chem.* **2005**, *35*, 149–154.
16. Zhu, H.-L.; Zhang, X.-M.; Liu, X.-Y.; Wang, X.-J.; Liu, G.-F.; Usman, A.; Fun, H.-K. Clear Ag–Ag bonds in three silver(I) carboxylate complexes with high cytotoxicity properties. *Inorg. Chem. Commun.* **2003**, *6*, 1113–1116.