Scientific paper

Microwave-Assisted Synthesis, Characterization, Crystal Structures and Antibacterial Activities of Zinc Complexes Derived from 5–Bromo-2-((cyclohexylimino)methyl)phenol

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Abstract

A dinuclear zinc complex $[Zn_2L_2]$ (**1**), and four mononuclear zinc complexes $[ZnBr_2(LH)_2]$ (**2**), $[ZnCl_2(LH)_2]$ (**3**), $[Zn(LH)_2(NCS)_2]$ (**4**) and $[ZnI(CH_3OH)L]$ (**5**), have been prepared from the Schiff base 5-bromo-2-((cyclohexylimino) methyl)phenol (HL) by microwave irradiation method. All the zinc complexes were characterized by CHN elemental analyses, infrared and electronic spectra. Structures of the complexes were further studied by single crystal X-ray determination, which reveals that all the zinc atoms in the complexes are in tetrahedral geometry. The halide and pseudohalide anions are preferred co-ligands in the preparation of such complexes with binary ligands. The biological activity of the complexes on the bacterial strains *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli* was evaluated. The complexes bearing halide and pseudohalide ligands show effective activities on the bacteria strains.

Keywords: Schiff base; zinc complex; crystal structure; antibacterial activity

1. Introduction

Microwave-assisted synthesis of various organic and coordination compounds has received much attention in recent years because it can accelerate their reactions.[1] In addition, this method has obvious advantages in providing a cheap, clean and easy handling heating way in the synthesis of various types of compounds with higher yields and less reaction time by comparing with those heating at reflux in organic solvents or solvothermal method.[2] Schiff bases can be prepared by the reaction of aldehydes and primary amines. They and their complexes have suitable biomimetic properties that can mimic the structural features of active sites, and have been widely used in various fields such as biochemical reactions and biological regulation.[3] The antimicrobial and anticancer activities of Schiff bases and their metal complexes have been widely studied.[4] When bioorganic molecules or drugs are bound to metal ions, there is drastic enhance in their biomimetic properties, therapeutic effects and pharmacological properties.[5] Zinc complexes are reported to be biological active like antimicrobial and cytotoxic.[6] In this study, the synthesis, characterization and antibacterial properties of five new zinc complexes $[Zn_2L_2]$ (**1**), $[ZnBr_2(LH)_2]$ (**2**), $[ZnCl_2(LH)_2]$ (**3**), $[Zn(LH)_2(NCS)_2]$ (**4**), and $[ZnI(CH_3OH)L]$ (**5**), derived from the Schiff base 5-bromo-2-((cyclohexylimino)methyl)phenol (HL), are presented.

2. Experimental

2. 1. Materials and Physical Methods

4-Bromosalicylaldehyde, cyclohexylamine, zinc salts and ammonium thiocyanate were obtained from TCI. The solvents were of AR grade and used as received. The microwave synthesis was carried out with a WX-4000 microwave digestion system. CHN elemental analyses were performed on a Perkin-Elmer 2400 Elemental Analyzer. Infrared spectra were recorded on a Bio-Rad FTS 135 spectrophotometer with KBr pellets. UV-Vis spectra were performed on a Lambda 35 spectrometer. X-ray single crystal structure diffraction was determined with a Bruker Smart 1000 CCD diffractometer.

2. 2. Synthesis of the Complexes

All the complexes were prepared with the same method as described. 4-Bromosalicylaldehyde (0.20 g, 1.0

mmol), cyclohexylamine (0.10 g, 1.0 mmol), methanol (30 mL) and zinc salts (1.0 mmol as follows) were placed in a Teflon-lined autoclave (30 mL). The reaction mixture was maintained at 350 K and 200 W for 10 min at the cavity of the microwave reactor. Then the reaction mixture was cooled to room temperature for about 60 min. The mixture was filtered and with the filtrate to slow evaporate in air for a week. Colorless crystals were formed and collected by filtration and washed with cold methanol.

2. 2. 1. $[Zn_2L_2]$ (1)

Zinc acetate dihydrate (0.22 g, 1.0 mmol). Yield: 0.18 g (58%). Anal. Calcd. for $C_{26}H_{30}Br_2N_2O_2Zn$ (%): C, 49.75; H, 4.82; N, 4.46. Found (%): C, 49.61; H, 4.90; N, 4.52. IR data (KBr, cm^{-1}): 1616, 1587, 1515, 1451, 1427, 1395, 1287, 1170, 1150, 1132, 1065, 927, 896, 866, 845, 800, 779, 733, 620, 603, 569, 497, 454. UV-Vis data in methanol [λ_{max} (nm), ε ($L{\cdot}mol^{-1}{\cdot}cm^{-1}$)]: 225, 19375; 245, 18720; 280, 13010; 356, 5910.

2. 2. 2. $[ZnBr_2(LH)_2]$ (2)

Zinc bromide (0.23 g, 1.0 mmol). Yield: 0.38 g (48%). Anal. Calcd. for $C_{26}H_{32}Br_4N_2O_2Zn$ (%): C, 39.55; H, 4.09; N, 3.55. Found (%): C, 39.73; H, 4.15; N, 3.47. IR data (KBr, cm^{-1}): 1618, 1589, 1518, 1452, 1433, 1413, 1313, 1222, 1178, 1130, 1065, 1019, 930, 835, 778, 749, 661, 618, 550, 454. UV-Vis data in methanol [λ_{max} (nm), ε ($L{\cdot}mol^{-1}{\cdot}cm^{-1}$)]: 227, 18230; 245, 17810; 278, 9315; 360, 5230.

2. 2. 3. $[ZnCl_2(LH)_2]$ (3)

Zinc chloride (0.14 g, 1.0 mmol). Yield: 0.32 g (45%). Anal. Calcd. for $C_{26}H_{32}Br_2Cl_2N_2O_2Zn$ (%): C, 44.57; H, 4.60; N, 4.00. Found (%): C, 44.45; H, 4.54; N, 4.07. IR data (KBr, cm^{-1}): 1618, 1589, 1520, 1450, 1427, 1405, 1314, 1218, 1165, 1130, 1063, 1015, 921, 862, 763, 676, 615, 553, 500, 463. UV-Vis data in methanol [λ_{max} (nm), ε ($L{\cdot}mol^{-1}{\cdot}cm^{-1}$)]: 226, 18325; 245, 16020; 276, 11456; 360, 6020.

2. 2. 4. $[Zn(LH)_2(NCS)_2]$ (4)

Zinc acetate dihydrate (0.22 g, 1.0 mmol) and ammonium thiocyanate (0.15 g, 2.0 mmol). Yield: 0.43 g (57%). Anal. Calcd. for $C_{28}H_{32}Br_2N_4O_2S_2Zn$ (%): C, 45.09; H, 4.32; N, 7.51. Found (%): C, 44.87; H, 4.38; N, 7.38. IR data (KBr, cm^{-1}): 3138, 2093, 1621, 1586, 1523, 1463, 1432, 1393, 1365, 1342, 1287, 1233, 1189, 1143, 1060, 1015, 973, 928, 867, 799, 738, 617, 539, 471. UV-Vis data in methanol [λ_{max} (nm), ε ($L{\cdot}mol^{-1}{\cdot}cm^{-1}$)]: 220, 16850; 262, 10900; 315, 3436; 365, 1602.

2. 2. 5. $[ZnI(CH_3OH)L]$ (5)

Zinc iodide (0.32 g, 1.0 mmol). Yield: 0.27 g (54%). Anal. Calcd. for $C_{14}H_{19}BrINO_2Zn$ (%): C, 33.26; H, 3.79; N, 2.77. Found (%): C, 33.41; H, 3.70; N, 2.65. IR data

Table 1. Crystallographic data for the zinc complexes

Complex	1	2	3	4	5
Formula	$C_{26}H_{30}Br_2N_2O_2Zn$	$C_{26}H_{32}Br_4N_2O_2Zn$	$C_{26}H_{32}Br_2Cl_2N_2O_2Zn$	$C_{28}H_{32}Br_2N_4O_2S_2Zn$	$C_{14}H_{19}BrINO_2Zn$
Formula weight	627.71	789.54	700.62	745.88	505.48
Crystal system	Monoclinic	Triclinic	Triclinic	Triclinic	Triclinic
Space group	$P2_1/c$	P-1	P-1	P-1	P-1
a (Å)	13.6013(3)	9.1058(11)	9.0954(12)	9.5033(15)	9.686(2)
b (Å)	18.5360(2)	13.4278(13)	13.1170(13)	12.1423(16)	9.887(2)
c (Å)	11.0769 (1)	13.4369(13)	13.2710(13)	14.5203(19)	10.448(2)
α (°)	90	105.602(1)	104.636(1)	84.864(2)	69.630(2)
β (°)	109.700(1)	102.410(1)	102.736(1)	72.965(2)	66.647(2)
γ (°)	90	95.859(1)	96.913(1)	72.723(2)	79.268(2)
V (Å^3)	2629.19(7)	1522.9(3)	1468.0(3)	1529.7(4)	859.8(3)
λ (Å)	0.71073	0.71073	0.71073	0.71073	0.71073
ρ_{calcd} (g cm^{-3})	1.586	1.722	1.585	1.619	1.952
Z	4	2	2	2	2
μ (mm^{-1})	3.998	6.078	3.766	3.584	5.547
θ ranges (°)	1.59–25.50	1.60–25.50	1.63–25.50	1.47–25.50	2.20–25.50
Reflections collected	59148	9152	7916	9024	4596
Independent reflections	4903	5660	5410	5665	3171
Observed reflections ($I \geq 2\sigma(I)$)	3693	2999	3608	3335	2650
Restraints	0	0	0	0	1
Parameters	298	316	316	352	184
Goodness-of-fit on F^2	1.021	0.999	1.033	0.979	1.045
Final R indices [$I \geq 2\sigma(I)$]	0.0366, 0.0775	0.0520, 0.1037	0.0399, 0.0836	0.0663, 0.1810	0.0422, 0.1128
R indices (all data)	0.0578, 0.0873	0.1176, 0.1319	0.0747, 0.0952	0.1205, 0.2381	0.0507, 0.1189

Table 2. Selected bond distances (Å) and bond angles (°) for the complexes

		1	
Zn1–O1	1.918(2)	Zn1–O2	1.921(2)
Zn1–N1	2.018(3)	Zn1–N2	1.995(3)
O1–Zn1–O2	121.39(11)	O1–Zn1–N2	112.85(11)
O2–Zn1–N2	96.46(10)	O1–Zn1–N1	95.90(10)
O2–Zn1–N1	108.78(11)	N2–Zn1–N1	123.45(11)
		2	
Zn1–O1	1.955(5)	Zn1–O2	1.956(4)
Zn1–Br3	2.3457(12)	Zn1–Br4	2.3518(11)
O1–Zn1–O2	104.3(2)	O1–Zn1–Br3	114.20(14)
O2–Zn1–Br3	103.86(13)	O1–Zn1–Br4	103.14(14)
O2–Zn1–Br4	112.81(13)	Br3–Zn1–Br4	117.99(5)
		3	
Zn1–O1	1.947(2)	Zn1–O2	1.964(2)
Zn1–Cl1	2.2168(11)	Zn1–Cl2	2.2005(12)
O1–Zn1–O2	102.87(11)	O1–Zn1–Cl2	105.24(8)
O2–Zn1–Cl2	113.03(9)	O1–Zn1–Cl1	113.18(8)
O2–Zn1–Cl1	103.02(8)	Cl2–Zn1–Cl1	118.57(5)
		4	
Zn1–O1	1.953(5)	Zn1–O2	1.933(5)
Zn1–N3	1.934(7)	Zn1–N4	1.900(7)
N4–Zn1–O2	117.4(3)	N4–Zn1–N3	119.1(3)
O2–Zn1–N3	100.8(3)	N4–Zn1–O1	99.1(3)
O2–Zn1–O1	103.3(2)	N3–Zn1–O1	116.9(3)
		5	
Zn1–O1	1.951(3)	Zn1–O2	2.039(4)
Zn1–N1	1.991(4)	Zn1–I1	2.5027(8)
O1–Zn1–N1	96.57(15)	O1–Zn1–O2	97.69(15)
N1–Zn1–O2	107.00(15)	O1–Zn1–I1	118.16(11)
N1–Zn1–I1	123.84(12)	O2–Zn1–I1	109.95(10)

(KBr, cm^{-1}): 1616, 1586, 1528, 1469, 1448, 1392, 1363, 1277, 1259, 1194, 1146, 1132, 1072, 1015, 925, 896, 855, 788, 728, 686, 617, 594, 566, 507, 451. UV-Vis data in methanol [λ_{max} (nm), ε ($L \cdot mol^{-1} \cdot cm^{-1}$)]: 223, 17220; 245, 13645; 275, 7465; 363, 4000.

2. 3. X-Ray Structure Determination

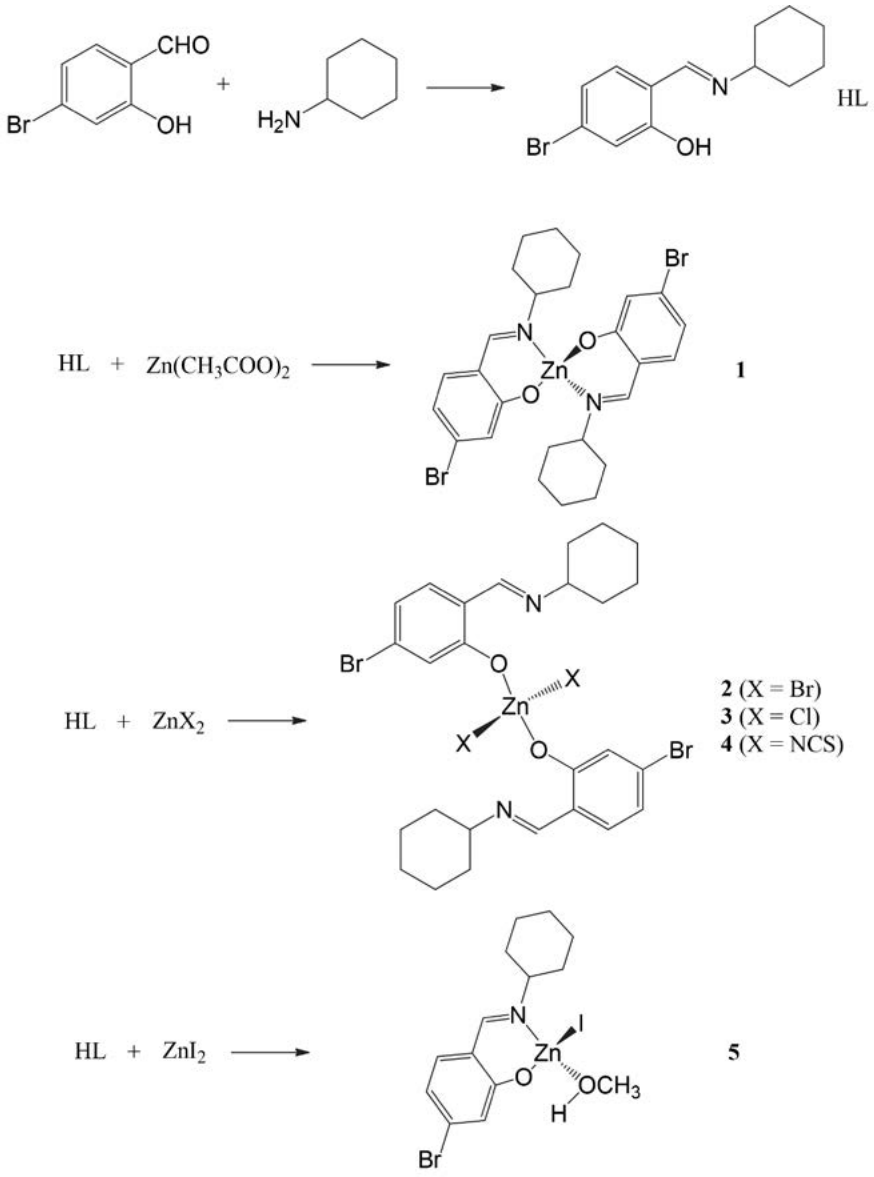
X-ray single crystal diffraction were performed on the diffractometer equipped with a graphite monochromated Mo-Kα radiation (λ = 0.71073 Å) at 298(2) K. The collected data were integrated and reduced with SAINT.[7] Structures of the five complexes were solved by direct methods and refined by full-matrix least-squares based on F^2 with SHELXL.[8] The empirical absorption correction was applied with SADABS.[9] All non-H atoms were anisotropically refined. Selected crystal data for the complexes are summarized in Table 1. Coordinate bond lengths and bond angles are provided in Table 2.

2. 4. Antibacterial Assay

The Schiff base and the five zinc complexes were assayed the *in vitro* antibacterial activities against two Gram-positive bacteria strains *Staphylococcus aureus* and *Bacillus subtilis*, and two Gram-negative bacteria strains *Escherichia coli* and *Pseudomonas aeruginosa* by agar well diffusion method with the literature method.[10] The negative control is DMSO, and the positive control is Ciprofloxacin.

2. 5. Determination of Minimum Inhibitory Concentration (MIC)

MIC values of the compounds was tested through a modified agar well diffusion method.[11] A two-fold serial dilution of each compound was prepared by first reconstituting in DMSO followed by dilution in sterile distilled water to achieve a decreasing concentration range 256 μM. Each dilution (100 μL) was introduced into wells in the agar plates seeded with 100 μL of standardized inoculums



Scheme 1. The synthetic procedure for the Schiff base and the complexes.

(10^6 cfu mL^{-1}) of the microbial strain. All test plates were incubated aerobically at 37 °C for 24 h and observed for the inhibition zones.

3. Results and Discussion

3. 1. Chemistry

Reaction of in situ formed HL with zinc acetate (for **1**), zinc bromide (for **2**), zinc chloride (for **3**), zinc acetate and ammonium thiocyanate (for **4**), and zinc iodide (for **5**), respectively, afforded the complexes (Scheme 1).

3. 2. IR and UV-Vis Spectra

In the IR spectra of the complexes, the characteristic imine stretching is observed at 1616–1621 cm^{-1} as strong signals.[12] The Schiff base ligands coordination is substantiated by the phenolic C–O stretching bands at 1165–1194 cm^{-1} in the complexes.[13] Coordination of the Schiff bases is further confirmed by the appearance of weak bands in the low wave numbers 400–600 cm^{-1}, corresponding to ν(Zn–N) and ν(Zn–O).[14] The intense absorption of the thiocyanate ligands for complex **4** appears at 2093 cm^{-1}.[15]

In the UV-Vis spectra, the bands at 220–245 nm and 262–280 nm can be attributed to π–π^* and n–π^* transitions.[16] The bands at 356–365 nm are attributed to the ligand to metal charge transfer transition (LMCT).[17]

3. 3. Structure Description of Complex 1

The molecular structure of complex **1** is shown in Fig. 1. The Zn atom is coordinated by two phenolate oxygens and two imino nitrogens from two deprotonated

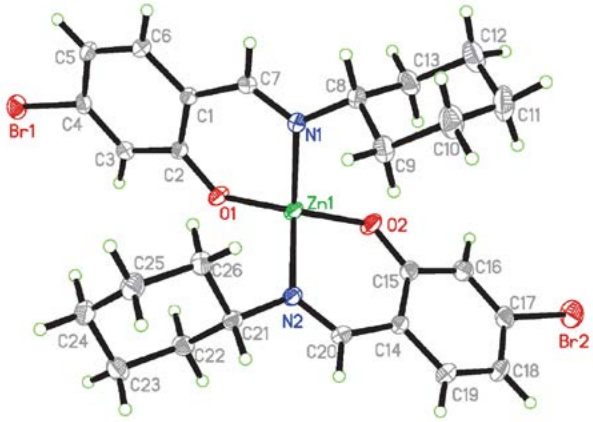


Fig. 1. Molecular structure of complex **1**. Displacement ellipsoids are drawn at the 30% probability level.

Schiff base ligands, forming tetrahedral geometry. The tetrahedral coordination is distorted from the ideal model, which can be evidenced by the bond angles, ranging from 95.90(10) to 123.45(11)°. The lengths of Zn-O bonds (1.918(2) – 1.921(2) Å) and Zn-N bonds (1.995(3) – 2.018(3) Å) are comparable to those observed in Schiff base zinc complexes with tetrahedral coordination.[18] The two six-membered chelate rings Zn1-O1-C2-C1-C7-N1 and Zn1-O2-C15-C14-C20-N2 form a dihedral angle of 80.0(3)°. The dihedral angle between the two benzene rings of the Schiff base ligands is 83.4(3)°. There are no obvious short contacts among the molecules in the crystal structure.

3. 4. Structure Description of Complexes 2, 3 and 4

The molecular structures of complexes **2**, **3** and **4** are shown in Figs. 2, 3 and 4, respectively. All the complexes are mononuclear zinc compounds. The Zn atoms in the complexes are coordinated by two phenolate oxygens from two Schiff base ligands, and two anionic ligands, *viz.* Br for **2**, Cl for **3** and NCS for **4**, forming tetrahedral geometry. The Schiff base ligand is in its zwitterionic form, with the H atom of the phenol group transferred to the N atom of the imine group, and there forms an intramolecular N-H···O hydrogen bond. The tetrahedral coordination is slightly distorted from the ideal model, which can be observed from the bond angles. The coordinate bond angles in complexes **2**, **3** and **4** are in the ranges of 103.14(14) – 117.99(5)°, 102.87(11) – 118.57(5)°, and 96.57(15) – 123.84(12)°, respectively, which are close to the value of 109°28' for a perfect tetrahedral geometry. The Zn-O, Zn-Br, Zn-Cl and Zn-N bond lengths are comparable to those observed in Schiff base zinc complexes with tetrahedral coordination.[19]

In the crystal structures of the three complexes (Figs. 5, 6, 7), the molecules are linked through hydrogen bonds (Table 3). In the packing structure of complex **2**, there is $\pi\cdots\pi$ interaction among the rings C1-C6 and C1-C6 (1 – *x*, 1 – *y*, 1 – *z*) with centroid to centroid distance of 3.904(3) Å. In the packing structure of complex **3**, there is $\pi\cdots\pi$ interaction among the rings C14-C19 and C14-C19 (1 – *x*, 1 – *y*, 1 – *z*) with centroid to centroid distance of 3.898(3) Å. In the packing structure of complex **4**, there is $\pi\cdots\pi$ interaction among the rings C1-C6 and C1-C6 (1 – *x*, 2 – *y*, – *z*) with centroid to centroid distance of 3.825(4) Å.

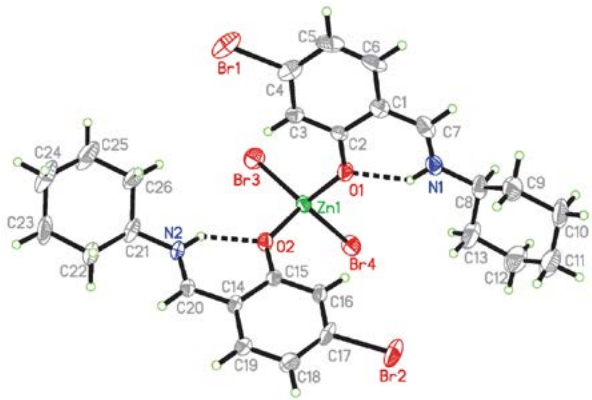


Fig. 2. Molecular structure of complex **2**. Displacement ellipsoids are drawn at the 30% probability level. Hydrogen bonds are shown as dashed lines.

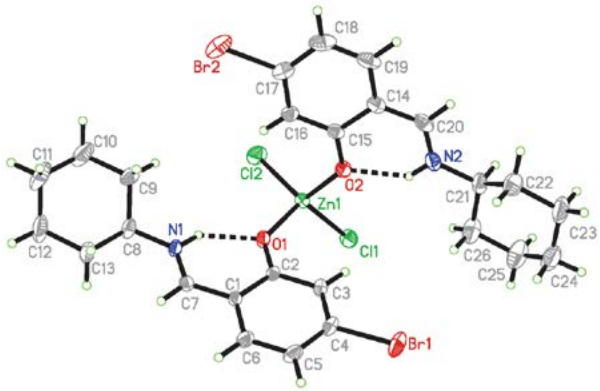


Fig. 3. Molecular structure of complex **3**. Displacement ellipsoids are drawn at the 30% probability level. Hydrogen bonds are shown as dashed lines.

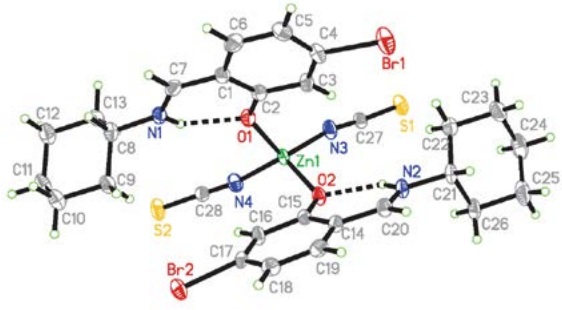


Fig. 4. Molecular structure of complex **4**. Displacement ellipsoids are drawn at the 30% probability level. Hydrogen bonds are shown as dashed lines.

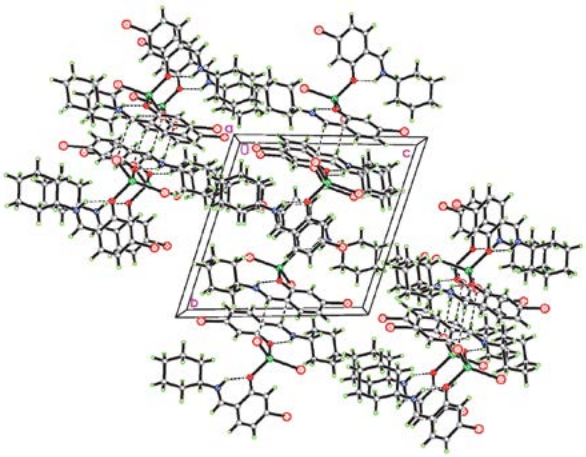


Fig. 5. Molecular packing structure of complex **2**. Hydrogen bonds are drawn as dashed lines.

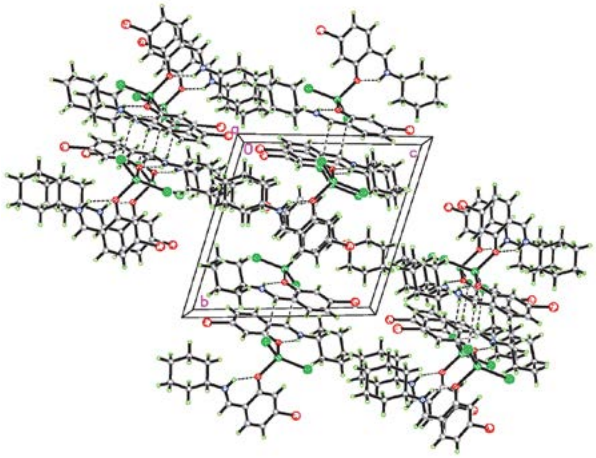


Fig. 6. Molecular packing structure of complex **3**. Hydrogen bonds are drawn as dashed lines.

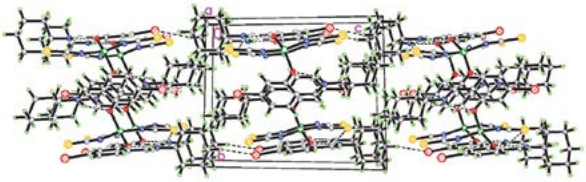


Fig. 7. Molecular packing structure of complex **4**. Hydrogen bonds are drawn as dashed lines.

3. 5. Structure Description of Complex 5

The molecular structure of the mononuclear zinc complex **5** is shown in Fig. 8. The Zn atom in the complex is coordinated by one phenolate oxygen and one imino nitrogen of a Schiff base ligand, one iodide ligand, and one methanol oxygen, forming tetrahedral geometry. The tetrahedral coordination is distorted from ideal model, which can be observed from the bond angles, ranging from 99.1(3) to 119.1(3)°. The Zn-O, Zn-N, and Zn-I bond lengths are comparable to those observed in Schiff base zinc complexes with tetrahedral coordination.[20]

As shown in Fig. 9, adjacent two molecules are linked through two O-H···O hydrogen bonds (Table 3) to form a dimer. In addition, there are $\pi\cdots\pi$ interactions among the rings C1-C6 and C1-C6 ($-x$, $1-y$, $1-z$) with centroid to centroid distance of 4.418(5) Å, and among the rings C1-C6 and C14-C19 with centroid to centroid distance of 4.893(5) Å.

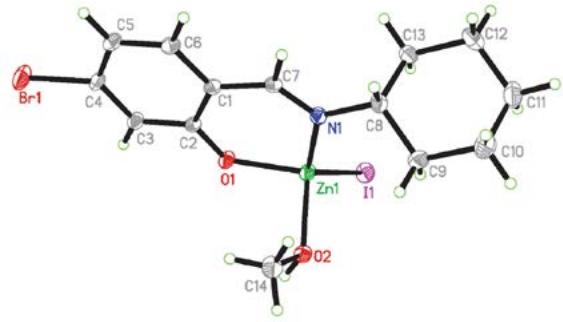


Fig. 8. Molecular structure of complex **5**. Displacement ellipsoids are drawn at the 30% probability level. Hydrogen bonds are shown as dashed lines.

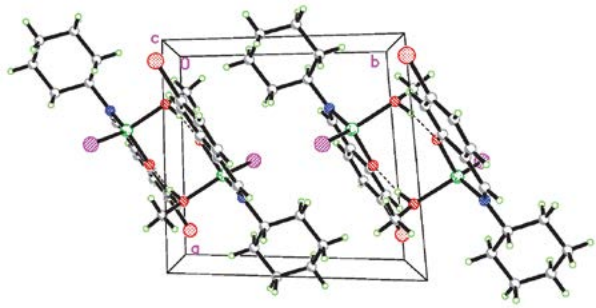


Fig. 9. Molecular packing structure of complex **5**. Hydrogen bonds are drawn as dashed lines.

Table 3. Hydrogen bond distances (Å) and bond angles (°) for the complexes

D–H···*A*	*d*(*D*–H)	*d*(H···*A*)	*d*(*D*···*A*)	Angle (*D*–H···*A*)
2				
N1–H1···O1	0.86	1.89	2.579(7)	136(5)
N2–H2···O2	0.86	1.87	2.562(6)	136(5)
3				
N1–H1···O1	0.86	1.86	2.562(3)	138(4)
N2–H2···O2	0.86	1.88	2.577(4)	136(4)
4				
O2–H2···O1^{ii}	0.85(1)	1.75(2)	2.583(4)	167(6)
5				
N1–H1···O1	0.86	1.96	2.611(8)	138(6)
N2–H2···O2	0.86	1.88	2.577(8)	136(6)

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

3. 6. Antibacterial Activities

The results of the antibacterial activities are given in Tables 4 and 5. All the complexes showed enhanced antibacterial activities as compared with the free Schiff base HL. Ciprofloxacin produced significantly sized inhibition zones against the bacteria, while DMSO produced no inhibitory effect against any of the tested organisms. HL gave inhibition zones in the range of 2.7–11.3 mm against the bacteria. The MIC results showed that complex **1** has weak activities against *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa*, and medium activity against *Bacillus subtilis*. Complexes **2**, **3** and **4** have similar activities against the bacterial strains, which are better than complex **1**. Complexes **2**, **3** and **4** have strong activities against *Bacillus subtilis*, *Escherichia coli* and *Pseudomonas aeruginosa*, and medium activity against *Staphylococcus aureus*. Complex **5** has strong activities against all the tested bacteria. The results of this study agree well with those reported previously that metal complexes have higher activities than their precursors.[21] The overtone's concept[22] and Tweedy's chelation theory[23] can explain the enhanced in antibacterial activity of the zinc complexes.

Table 4. Diameter of growth of inhibition zone (mm)

Compounds	*Staphylococcus aureus*	*Bacillus subtilis*	*Escherichia coli*	*Pseudomonas aeruginosa*
HL	5.3	11.3	6.2	2.7
1	8.5	13.8	8.7	6.3
2	9.7	16.9	14.3	13.2
3	10.2	17.3	14.6	12.9
4	9.4	15.5	13.1	10.6
5	13.4	19.7	21.2	16.8
Ciprofloxacin	25.0	21.3	25.2	23.3

Table 5. MIC values (μM)

Compounds	*Staphylococcus aureus*	*Bacillus subtilis*	*Escherichia coli*	*Pseudomonas aeruginosa*
HL	64	32	64	128
1	32	16	64	64
2	16	8	8	8
3	16	8	8	8
4	16	8	8	16
5	8	4	4	8
Ciprofloxacin	16	8	16	16

4. Conclusion

Five new zinc(II) complexes derived from 5-bromo-2-((cyclohexylimino)methyl)phenol have been synthesized with microwave assisted heating method. Structures of the complexes have been confirmed by X-ray single crystal determination. The complexes bearing halide and pesudohalide ligands have effective antibacterial activities on the bacteria strains *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli*.

Supplementary Materials

The X-ray crystallographic data in the CIF format for the structures of the complexes reported in this paper have been deposited with the Cambridge Crystallographic Data Center, and the supplementary crystallographic data can be obtained free of charge on request at www.ccdc.cam.ac.uk/conts/retrieving.html [or from The Director, Cambridge Crystallographic Data Center, CCDC, 12 Union Road, Cambridge CB2 1EZ, UK; fax: +44(0)1223-336033; email: deposit@ccdc.cam.ac.uk], quoting the CCDC numbers 2249782-2249786.

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Povzetek

Iz Schiffove baze 5-bromo-2-((cikloheksilimino)metil)fenol (HL) smo z mikrovalovnim obsevanjem pripravili dvojedrni cinkov kompleks $[Zn_2L_2]$ (**1**) in štiri dvojedrne cinkove komplekse $[ZnBr_2(LH)_2]$ (**2**), $[ZnCl_2(LH)_2]$ (**3**), $[Zn(LH)_2(NCS)_2]$ (**4**) in $[ZnI(CH_3OH)L]$ (**5**). Vse komplekse smo karakterizirali s CHN elementno analizo, infrardečo in elektronsko spektroskopijo. Strukture produktov smo določili z monokristalno rentgensko difrakcijo, ki kaže na tetraedrično geometrijo okoli cinkovih atomov v kompleksih. Halogenidni in psevdohalogenidni anioni so pogosti koligandi v pripravi tovrstnih kompleksov z binarnimi ligandi. Preučevali smo protibakterijsko aktivnost kompleksov na bakterijah *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* in *Escherichia coli*. Kompleksi s halogenidnimi in psevdohalogenidnimi ligandi kažejo dobro delovanje na omenjene bakterije.