In vitro antimicrobial screening of metal complexes of Schiff base derived from streptomycin and amoxicillin: Synthesis, characterization and molecular modeling

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Abstract: A series of three new metal (II) complexes of Schiff base were synthesized from the novel ligand derived from Streptomycin and Amoxicillin in stoichiometric ratio. They were characterized by elemental analysis and spectral techniques like IR, ^{1}H NMR, electronic spectrum and mass spectrum. IR spectral data suggested that the tetradentate ligand has coordination to metal ions through azomethine nitrogen, glycosidic oxygen and two amine nitrogens. Electronic spectral measurement indicated square planar geometry of Ni and Zn-complexes and tetrahedral geometry of Cu-complex with diamagnetic behavior. Molar conductivity measurements revealed non-electrolyte nature of the complexes where metal ions have coordination through doubly negative charged anions of the Schiff base. The thermal behavior (TGA/DTA) of the complexes was studied and kinetic parameters were determined by Coats-Redfern method. XRPD technique revealed monoclinic crystal systems for Ni- and Zn-complexes and hexagonal crystal system for Cu-complex. The possible geometries of the metal complexes with their bond length were optimized by MM2 calculations using CsChem3D Ultra-11 program package software. Antibacterial sensitivity of the ligand and its metal complexes were assayed *in vitro* against four bacterial pathogens viz. *E. coli, B. subtilis, S. aureus* and *K. pneumonia* by Kirby Bauer paper disc diffusion method and showed moderate to better potency.

Keywords: Antibiotics, Aminoglycoside, Streptomycin, Schiff Base, β-Lactam

1. Introduction

The unbelievable adaptability and flexible metabolic power developed by disease causing pathogens are the major problems for the increased antibacterial resistance that requires myopic thinking in the scientific world and in the pharmaceutical industry. In the long journey of antibiotics, dating back from the discovery of naturally procured penicillin to the semi synthetic drugs [1], there is still a challenging and evolutionary demand in the field of medical science for the better search of efficacious therapeutic drugs. Mono therapy and multidrug therapy being unsuccessful [2], extensive research investigations have to be forecasted for the redesign of previous drugs, hoping desirous and improved activities against diseases. The drugs in conjugation with metal ions, after the discovery of cisplatin [3] has knocked coordination chemistry to be a subject of great interest and has now become a multidisciplinary area having a wide range of applications based on structural variety. Schiff bases are versatile pharmacophore [4] that cave in metal ions within it due to presence of various donor atoms and are considered to have medicinal and pharmaceutical importance with broad spectrum of biological significances like anti-tubercular [5], anticancer [6], antimicrobial, analgesic [7] and anti-inflammatory [8] actions. In search of new and potentially active Schiff base, we have selected two antibiotics viz. streptomycin and amoxicillin as a better starting compound and augmentation of antibacterial activity was reported by insertion of metal ions into synthesized Schiff base. Streptomycin (Str) is a bacteriocidal aminoglycosidic antibiotic with three components: streptidine, streptose, and N-methyl-L-glucosamine [9]. It was a first antibiotic actively used in the treatment of tuberculosis and also bears potential actions against non-tuberculosis infections caused by various bacterial pathogens [10]. Its antibacterial function is related

to interference with normal protein synthesis. However, ototoxicity was the severe limitations of its use in clinical practice that causes permanent sensorineural hearing loss in human [11, 12]. Amoxicillin (Amx) is a semi synthetic bacteriolytic β-lactam antibiotic drug of class penicillin comparable to ampicillin in antibacterial spectrum and particularly used in the treatment of respiratory tract infections [13]. The bio-functional activity of amoxicillin is related to lactam ring that inhibits bacterial growth by proteolysis mechanism. In order to address their therapeutic failures and serious limitations, their modular design in derived form has spurred the growth of interest and been considered as a topic of research. In the present investigation, synthesis and characterization of novel Schiff base ligand (StrAmx) by using streptomycin and amoxicillin, and its transition metal complexes with different bio-metal ions due to their chelating behavior, have been reported. In vitro antibacterial evaluation of the novel ligand and its metal complexes was carried against *E. coli, B. Subtilis, S. aureus* and *Klebsiela pneumoniea* by measuring diameter of zone of inhibition in mm to know the potentiality of such compounds.
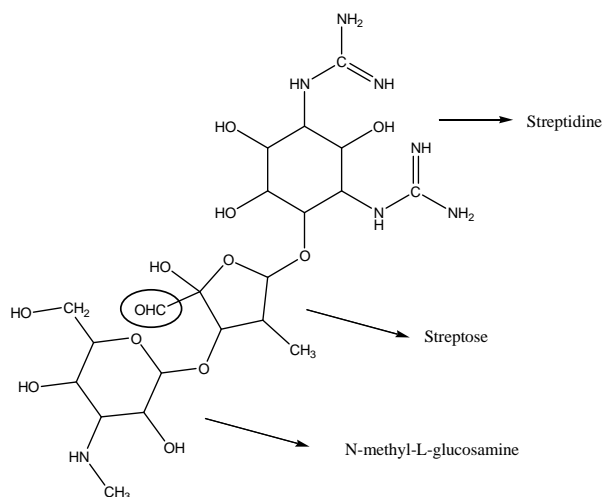

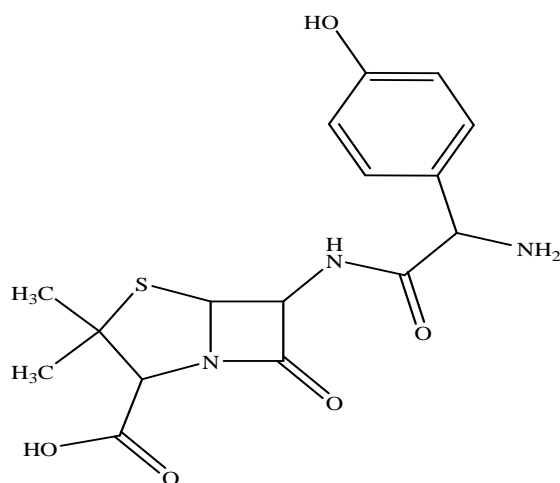*Figure 1. Structure of Streptomycin.*

Figure 2. Structure of Amoxicillin.

2. Experimental

2.1. Materials

All the chemicals used were of analytical grade and were procured from local dealers of BDH, Merk & Sigma Aldrich co. Chloride salts of Nickel, Copper and Zinc viz. $NiCl_2.6H_2O$, $CuCl_2.2H_2O$ and $ZnCl_2$ were used as supplied for the synthesis of metal complexes of novel ligand. Distilled methanol mixed with double distilled water had been used as solvent for the synthesis.

2.2. Instruments

The elemental analysis (C, H and N) of the complexes were profound by using Elementar vario EL III (Germany) model. Characteristic shifts in IR band positions had been analyzed by intimate observations of infrared spectra of ligand and metal complexes that were run as KBr discs in the range 4000-400 cm^{-1} on a *Shimadzu* Infrared Spectrophotometer. ^{1}HNMR spectra were recorded in DMSO-d6 solvent on a Bruker advanced 400MHz instrument. Mass spectra were carried out TOF-MS on water KC-455 model in DMSO. The XRD powder pattern was recorded on a vertical type Philips 1130/00 x-ray diffractometer, operated at 40kV and 50 Ma generators using the monochromitised CuKα line at wavelength 1.54056 Å as the radiation sources. Crystallographic data were analyzed by CRYSFIRE and CHECKCELL software programme. The molecular structures of the complexes were optimized by CsChem 3D Utra-11 programme.

2.3. Synthesis and Characterization of Novel Schiff Base Ligand

To the warm and homogenously stirred solution of alkaline (pH 8) Streptomycin sulphate (4 mmol, 2.718 gm) dissolved in 30 ml aqueous methanol (1:1), was added a well stirred and hot solution of Amoxicillin trihydrate (4 mmol, 1.678 gm) dissolved in 30 ml (1:1) aqueous methanol. The pH of the solution was adjusted by adding NaOH solution. The mixture was stirred under heat on magnetic stirrer and was refluxed for 15 hrs at 35^{0}C. The light orange colored solid was obtained by reducing its volume by placing over the hot plate. It was further recrystallized and dried under vacuum over anhydrous $CaCl_2$.

Light Orange solid. Mol. wt. 928.96. Yield: (85%, 3.158 gm), Anal. Cal. for $C_{37}H_{56}N_{10}O_{16}S$: C, 47.839; H, 6.08; N, 15.08; O, 27.56; S, 3.45. Found: C, 47.78; H, 6.12; N, 15.13; O, 27.60; S, 3.40%. FTIR (KBr, cm^{-1}); 1686.49 (s, νC=N, azomethine); 1774.96 (s, νC=O, carboxylic); 1588.99 (s, νC=O, lactam); 1144.48, 1120.44 (m, νC-O-C, glycosidic); 3462.11 (s,br, νO-H,); 1020.96 (C-O-C, cyclic ether); 1735.65, 1718.19 (νC=N, non azomethine); 3178.66 (s,br, νN-H str.); 3041.00 (νC-H, aromatic); 2970.10, 2928.09 (νC-H, methyl). ^{1}H NMR (in DMSO-d$_6$ solvent, δ, ppm): 1.83-2.1 (alc. -OH, 7H); 7.45 (imine H, 1H); 7.59 (N-H amide, 1H); 1.98-2.15 (N-H amine); 1.2-2.5 (CH$_3$,

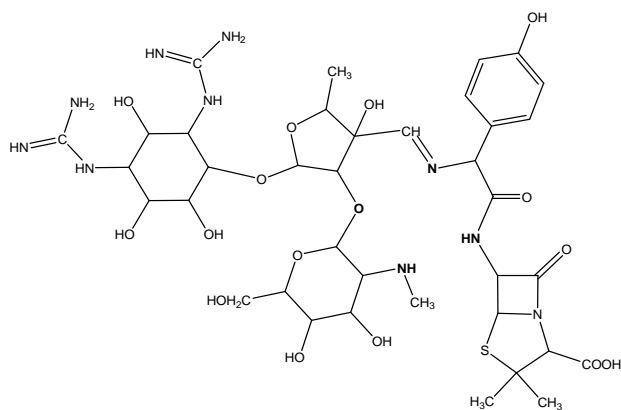12H); 6.5-6.91 (Ar-H, 4H); 10.89 (COOH); 3.0-5.46 (cyclic CH, 16H); 5.4 (Ph-OH, 1H); TOFMS: m/z = 928

Figure 3. *Proposed Structure of novel Schiff base ligand.*

2.4. Synthesis and Characterization of Metal Complexes

To the hot and magnetically stirred 50 ml (1:1) aqueous methanolic solution of novel Schiff base ligand (0.4 mmol,), was added 5 ml methanolic solution of metal chloride salts. The mixture was then stirred and refluxed alternately at 45^0C for another 15 hrs. On cooling, the precipitates of metal complexes of different colour were obtained, filtered and washed with methanol and dried over anhydrous $CaCl_2$.

2.4.1. Ni-Complex

Yellow solid, M. Pt. 350^0C, Mol. wt. 985.65. Yield: (78%, 3.07 gm), Anal. Cal. for $C_{37}H_{54}N_{10}NiO_{16}S$: C, 47.087; H, 5.52; N, 14.21; O, 25.97; S, 3.25; Ni, 5.95. Found: C, 47.14; H, 5.54; N, 14.18; O, 26.01; S, 3.21; Ni, 5.91%. FTIR (KBr, cm^{-1}); 1630.65 (s, vC=N, azomethine); 1136.11 (m, vC-O-C, glycosidic); 3462.11 (s,br, vO-H,); 1020.96 (C-O-C, cyclic ether); 3175.80 (s,br, vN-H str.); 503.12 (w, vNi-N); 435.14 (w, vNi-O). ^{1}H NMR (in DMSO-d_6 solvent, δ, ppm): 8.34 (imine H); 1.83-2.1 (alc. -OH, 7H); 1.2-2.5 (CH$_3$, 12H); 6.5-6.91 (Ar-H, 4H); 10.89 (COOH); 3.0-5.46 (cyclic CH, 16H); 5.4 (Ph-OH, 1H); TOFMS: m/z = 984.

2.4.2. Cu-Complex

Gray solid, M. Pt. 320^0C, Mol. wt. 990.49. Yield: (80%, 3.16 gm), Anal. Cal. for $C_{37}H_{54}CuN_{10}O_{16}S$: C, 44.867; H, 5.50; N, 14.14; O, 25.84; S, 3.24; Cu, 6.42. Found: C, 44.81; H, 5.53; N, 14.18; O, 25.78; S, 3.18, Cu, 6.38%. FTIR (KBr, cm^{-1}); 1628.44 (s, vC=N, azomethine); 1130.06 (m, vC-O-C, glycosidic); 3462.11 (s,br, vO-H,); 1020.96 (C-O-C, cyclic ether); 3172.75 (s,br, vN-H str.); 495.00 (vCu-N); 428.58 (vCu-O). ^{1}H NMR (in DMSO-d_6 solvent, δ, ppm): 8.15 (imine H); 1.83-2.1 (alc. -OH, 7H); 1.2-2.5 (CH$_3$, 12H); 6.5-6.91 (Ar-H, 4H); 10.89 (COOH); 3.0-5.46 (cyclic CH, 16H); 5.4 (Ph-OH, 1H); TOFMS: m/z = 989.

2.4.3. Zn-Complex

Crimson solid, M. Pt. 305^0C, Mol. wt. 992.34. Yield: (75%, 2.97 gm), Anal. Cal. for $C_{37}H_{54}N_{10}O_{16}SZn$: C, 44.783; H, 5.48; N, 14.11; O, 25.80; S, 3.23; Zn, 6.59. Found: C, 44.75; H, 5.51; N, 14.08; O, 25.78; S, 3.19, Zn, 6.61%. FTIR (KBr, cm^{-1}); 1622.61 (s, vC=N, azomethine); 1135.65 (m, vC-O-C, glycosidic); 3462.11 (s,br, vO-H,); 1020.96 (C-O-C, cyclic ether); 3176.30 (s,br, vN-H str.); 480.75 (vZn-N); 432.00 (vZn-O). ^{1}H NMR (in DMSO-d_6 solvent, δ, ppm): 7.89 (imine H); 1.83-2.1 (alc. -OH, 7H); 1.2-2.5 (CH$_3$, 12H); 6.5-6.91 (Ar-H, 4H); 10.89 (COOH); 3.0-5.46 (cyclic CH, 16H); 5.4 (Ph-OH, 1H); TOFMS: m/z = 990.

2.5. Antibacterial Study

In vitro antibacterial assay of novel ligand conjugated with different metals was studied by Kirby Bauer paper disc diffusion method [14, 15], using Mueller-Hinton's agar nutrient media and maintaining pH at 7.4 for better bacterial growth. Fresh cultures of standard bacteria viz. *E. coli, B. subtilis, S. aureus* and *Klebsiella pneumoniea* were collected from microbiology lab. of KIST medical college, Kathmandu, Nepal and well isolated colonies of the selected bacterial pathogens were cultured in tryptic soy broth. The inoculums was spread over nutrient agar media, prepared as usual in Petri plates using stick swab and the well sterilized Paper discs of 6 mm diameter (Whatman no. 1) impregnated with test compounds at the concentration of 0.001 g/ml in DMSO were placed on the previously seeded bacterial culture. Amoxicillin 10 microgram disc of 6 mm size (HIMEDIA co.) was used as standard (+ve control). DMSO, which exhibited no antimicrobial activity against the test bacterial pathogens, was used as negative control. Afterwards, the Petri plates were incubated at 37^0C and the diameter of zone of inhibition around each disc was measured after overnight of incubation.

3. Results and Discussion

3.1. Infrared Spectral Analysis

The IR spectral comparision of the novel ligand and its metal complexes had been used to ascertain the binding mode of the metal ions at donor sites of the ligand. Shift in the positions of strong intensity band at 1686.49 cm^{-1} characteristic for azomethine C=N stretch in Schiff base ligand to lower wave numbers 1630.65, 1628.44 and 1622.61 cm^{-1} for Ni, Cu and Zn complexes respectively supported the coordination of the azomethine nitrogen to the metal centers. This fact was further substantiated by the appearance of a new band around 500 cm^{-1} assignable for v_{M-N} vibration. The negative band shift from 3178.66 cm^{-1} assignable for N-H stretch in ligand was in good agreement for the coordination of metal ions with deprotonated nitrogen of amine group. Glycosidic C-O-C asymmetric and symmetric stretch at 1144.48 and 1120.44 cm^{-1} in ligand have also changed to lower wave number, indicating metal-oxygen binding mode. Additional information regarding the coordination of metal ions with oxygen was appearance of medium intensity band in the region of 440 - 430 cm^{-1} assignable to v_{M-O} stretching vibration. A strong

sharp band observed at 1588.99 cm^{-1} assignable for v(C=O) lactam was restored in the metal complexes.
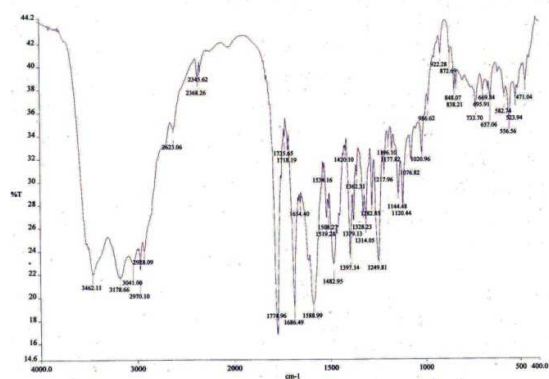

Figure 4. IR spectra of novel ligand.

3.2. ^{1}H NMR Spectral Analysis

^{1}H NMR spectral comparison of novel Schiff base ligand and its metal complexes was made to confirm the binding nature of ligand with metal ions viz. Ni(II) , Cu(II) and Zn(II) . The integral intensities of each signal in the ^{1}H NMR spectra of ligand and metal ion complexes were found to agree with the number of different types of protons present. The formation of Schiff base was confirmed by extinction of aldehyde proton at 7.52 ppm and the appearance of imine proton signal at 7.45 ppm with reference to DMSO-d$_6$ in ^{1}H NMR spectra. The coordination of imino group to the metal ions was confirmed by the change of chemical shift of the imine proton from 7.14 to 8.434 ppm on complexation with considered metal ions.
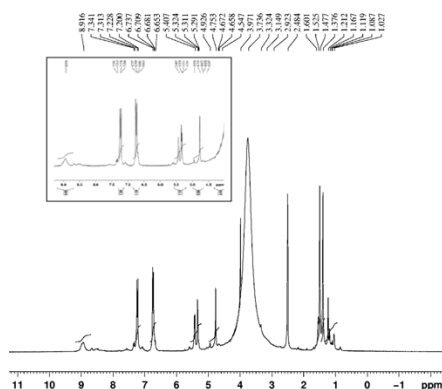

Figure 5. ^{1}H NMR spectra of ligand.

3.3. Electronic Spectra

The room temperature magnetic susceptibility data of the Ni-complex revealed that, the complex is essentially diamagnetic and of low spin with ^{1}A$_{1g}$ →^{1}A$_{2g}$→^{1}E$_g$ transitions respectively. The complex is therefore, said to have square planar geometry. It was diamagnetic and there was no band seen below 1000 nm. The observed $\mu_{eff.}$ 1.81 BM of the Cu-complex was very close to the spin only

value of an unpaired electron (1.73 BM) which indicated that the orbital contribution is almost quenched by the crystal field. Electronic spectra of the complex showed only three bands in the region 540-450 nm due to transition ^{2}B$_{1g}$→A$_{1g}$→^{1}E$_g$ and charge transfer respectively which corresponds to tetrahedral geometry. The Zn complex was diamagnetic and had a square planar structure as confirmed by its electronic transition spectra.

3.4. Molar Conductivity

The molar conductivity (Λ_M) data (1.5-5.8 Ω^{-1} mol^{-1} cm^{-1}) were measured at 25^{0}C using 10^{-3} M solutions of the complexes in CHCl$_3$ solvent. These values revealed that all the complexes are non-electrolyte due to the absence of any counter ion in the complexes. The molar conductance values of these complexes indicated that the novel Schiff base ligand was coordinated to the Ni(II), Cu(II) and Zn(II) ions as a doubly negative charged anions. Therefore it seems that the two amino (-NH) have been deprotonated and bonded to the metal ions as nitrogen anions.

3.5. X-Ray Powder Diffraction Study

Single crystal growth of the complexes had been failed, so X-ray powder diffraction technique was carried to get useful crystal data to deduce accurate cell parameters, crystal system and the cell volume. Powder diffraction patterns of ligand and metal complexes were recorded and crystallographic data are listed in the table. The diffraction pattern reveals the crystalline nature of the complex and the data confirmed the monoclinic crystal system for Ni and Zn complexes. Similarly hexagonal crystal system had been achieved for Cu complex.

Table 1. Crystal Lattice Parameters of ligand and Metal Complexes.

Compounds	Ligand	Ni-Complex	Cu-Complex	Zn-Complex
Formula	C$_{37}$H$_{56}$N$_{10}$O$_{16}$S	C$_{37}$H$_{54}$N$_{10}$NiO$_{16}$S	C$_{37}$H$_{54}$CuN$_{10}$O$_{16}$S	C$_{37}$H$_{54}$N$_{10}$O$_{16}$SZn
FW	928.96	985.65	990.49	992.34.
Temp (K)	293	293	293	293
Wavelength	1.54056	1.54056	1.54056	1.54056
Crystal System	Tetragonal	Monoclinic	Hexagonal	Monoclinic
Space group	P/mmm	P2/m	P6/ mmm	P121/m1
Unit cell dimension				
a(Å)	12.717	1.8527	24.7801	13.211
b(Å)	12.717	11.4297	11.771	8.5631
c(Å)	16.652	8.7017	9.2018	9.2018
α^o	90.00	90.00	90.00	90.00
β^o	90.00	97.198	90.00	91.226
γ^o	90.00	90.00	90.00	90.00
Volume (A^3)	2693.37	1465.683	2678.61	1085.76
θ range (0)	21.696-75.106	13.811-61.987	10-65	12-67
Limiting indices	0 ≤ h ≤ 4 0 ≤ k ≤6 0 ≤1 ≤3	-6 ≤ h ≤ 4 0 ≤ k ≤ 7 0 ≤1 ≤ 4	-10 ≤ h ≤ 6 0 ≤ k ≤ 1 0 ≤1 ≤ 5	-1 ≤ h ≤ 3 -4 ≤ k ≤ 5 0 ≤1 ≤ 7
Particle size(nm)	11.922	80.82	55.99	10.92
Intensity (%)	7.2–100	5.9–100	4.5-100	3.4-100
R indices	0.0000156	0.0000615	0.0000754	0.0000362
Density	1.07405	1.7437	1.034	1.151
Z	2	2	1	1

3.6. Thermal Decomposition Kinetics

The thermodynamic and kinetic parameters for the non-isothermal decomposition of the complexes such as order of reaction (n), enthalpy change (ΔH*), activation energy (E*), entropy change (ΔS*) and Gibb's free energy change (ΔG*) were evaluated by thermo gravimetric (DT) and differential thermo gravimetric (DTA) analysis. Thermo gravimetric analysis data for the metal complexes revealed that nearly 15% of the total mass of the Ni and Cu-complexes reduced between 75^0C and 240^0C, followed by considerable decomposition up to 600^0C that corresponds to the decomposition of the ligand leaving metal oxide, NiO and CuO respectively as residue. Zn-complex decomposed nearly 9% of the total mass up to the temperature 160^0C followed by considerable decomposition of its ligand up to 550^0C, leaving ZnO as residue. These decomposition patterns were in good agreement with suggested formulae of the complexes. By the analysis of the non-isothermal TG, using the integral method of Coats-Redfern relation [16, 17, 18], kinetic parameters of decomposition were calculated.

$$\ln\left[-\frac{\ln(1-\alpha)}{T^2}\right] = \ln\left[\frac{AR}{\varphi E^*}\right] - \frac{E^*}{RT}$$

Where α is the mass loss up to the temperature T, R is the gas constant, E* is the activation energy in J mole^{-1} and φ is the linear heating rate. A straight line plot of left hand side of the equation against 1/T gave a slop from which E* was

calculated while its intercept value corresponds to frequency factor (A). The entropy of activation ΔS* in J K^{-1} mol^{-1}, enthalpy change (ΔH*) and Gibb's free energy change (ΔG*) [19] were calculated by using the equations:

$$\Delta S^* = R \ln\left[\frac{Ah}{k_B T}\right]$$

$$\Delta H^* = E^* - RT$$

$$\Delta G^* = \Delta H^* - T\Delta S^*$$

Where, k_B is the Boltzmann constant, h the plank's constant and T is the DTG peak temperature.

The Coats-Redfern linearization plots, confirmed the first order kinetics for the decomposition process. The calculated values of thermodynamic activation parameters for the decomposition steps of the metal complexes are reported in Table 4. According to the kinetic data obtained from the TG curves, the activation energy relates the thermal stability of the metal complexes. Among metal complexes, activation energy increases as complex 2 < complex 3 < complex 1. Same trends happen with thermal stability of metal complexes. Negative entropy values of all the complexes indicated that the complexes were formed spontaneously. It also indicated a more ordered activated state that may be possible through the chemisorptions of oxygen and other decomposition products. These negative entropy values of activation are compensated by the values of the enthalpies of activation, leading to almost the same values for the free energy of activation.

Table 2. *Thermodynamic activation parameters of the metal complexes.*

Complex	Order/n	Steps	E*/ Jmol^{-1}	A/sec^{-1}	ΔS*/ J K^{-1}mol^{-1}	ΔH*/ J mol^{-1}	ΔG*/ kJ mol^{-1}	k×10^2 s^{-1}	Thermal effect
$C_{37}H_{54}N_{10}NiO_{16}S$	1	I	48.05	0.235×10^5	-91.49	120.65	93.33	1.17	Endo.
		II	114	0.428 ×10^5	-363.33	75.89	25.43	1.41	Exo.
$C_{37}H_{54}CuN_{10}O_{16}S$	1	I	16.58	2.38 ×10^5	-305.74	114.75	121.81	4.62	Exo.
		II	23.35	1.365 × 10^5	-114.81	235.53	926.98	1.13	Exo.
$C_{37}H_{54}N_{10}O_{16}SZn$	1	I	31.42	1.25 ×10^5	-67.345	125.41	37.22	1.98	Exo.
		II	32.21	3.21 ×10^4	-94.96	140.35	48.34	2.21	Endo.

3.7. Antibacterial Activity

In vitro antibacterial screening of the ligand and the metal complexes was assayed against various bacterial strains and the potentiality of the complexes was evaluated by measuring the diameter of zone of inhibition in mm. The prescription of the antimicrobial results showed graphically, revealed that both free ligand and its metal complexes exhibited moderate to better antibacterial activity. Such increased activity of metal complexes may be considered due to chelation of metal ions with Schiff base with enhanced lipophilicity due to delocalization of pi-electrons over the whole chelate ring. This increased lipophilicity enhances the penetration of complexes into the lipid membranes and blocks the metal binding sites in enzymes of microorganisms [20, 21]. These complexes also disturb the respiration process of the cell and thus block the synthesis of proteins, which restricts further growth of the organism. The data revealed that the activity of the ligand

enhanced on complexation comparable to the standard used. Overall comparison of observed data gave information that metal complexes are more active than free ligand against all bacteria.
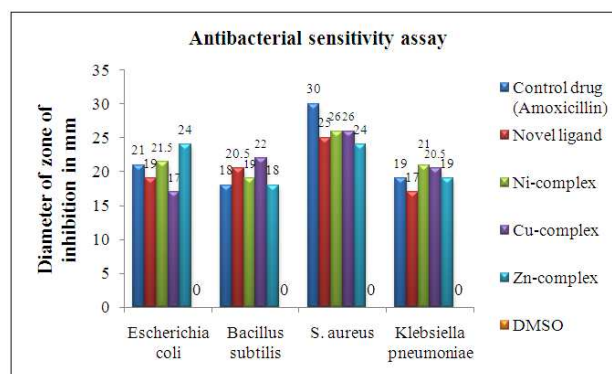

Figure 6. *Comparative antibacterial potency of synthesized compounds with standard drug.*

Concentration of sample = 0.001 g/ ml of DMSO
Concentration of control drug = 10μg / disc.
(0) = No sensitivity
Zone of inhibition (mm): 20 or >20 sensitive

4. Molecular Modeling Study

3D molecular modeling of the proposed structure of the metal complexes was studied by CsChem 3D Ultra program package and revealed tetrahedral geometry for Cu-complex and square planar geometry for Ni and Zn-

complexes [22]. The correct stereochemistry was assured through, manipulation and modification of the molecular coordinates to obtain reasonable and low energy molecular geometries. Energy minimization was repeated several times to find the minimum [23]. The change in bond length values of metal-nitrogen and metal-oxygen in the complexes compared with ligand further suggest their coordination. The details of the bond lengths and bond angles as per 3D structure of the metal complexes optimized by MM2 calculations are given in the table.
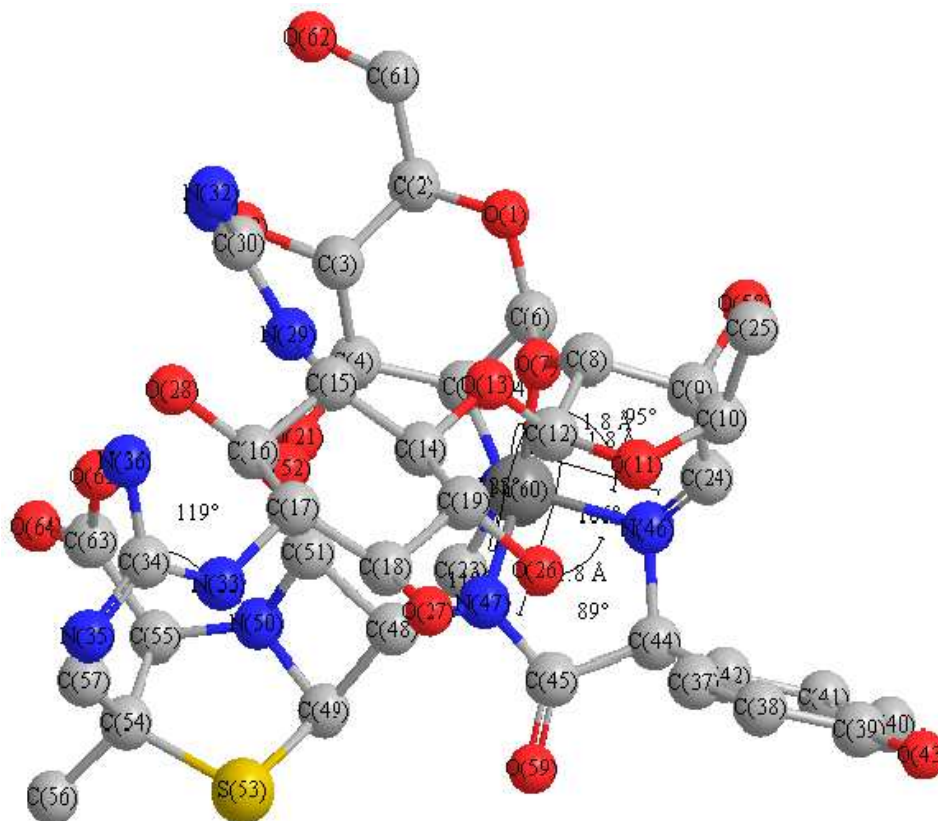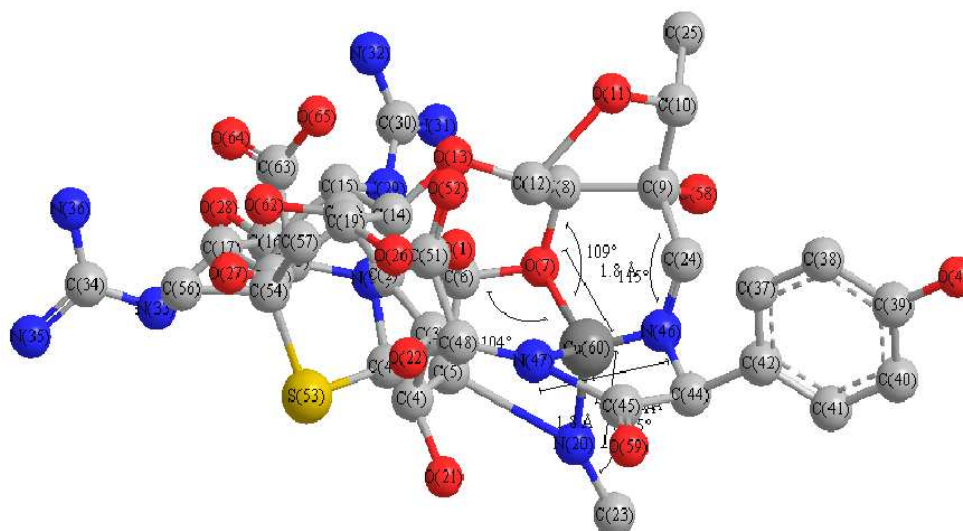

Figure 7. *Optimized Structure of Nickel complex.*
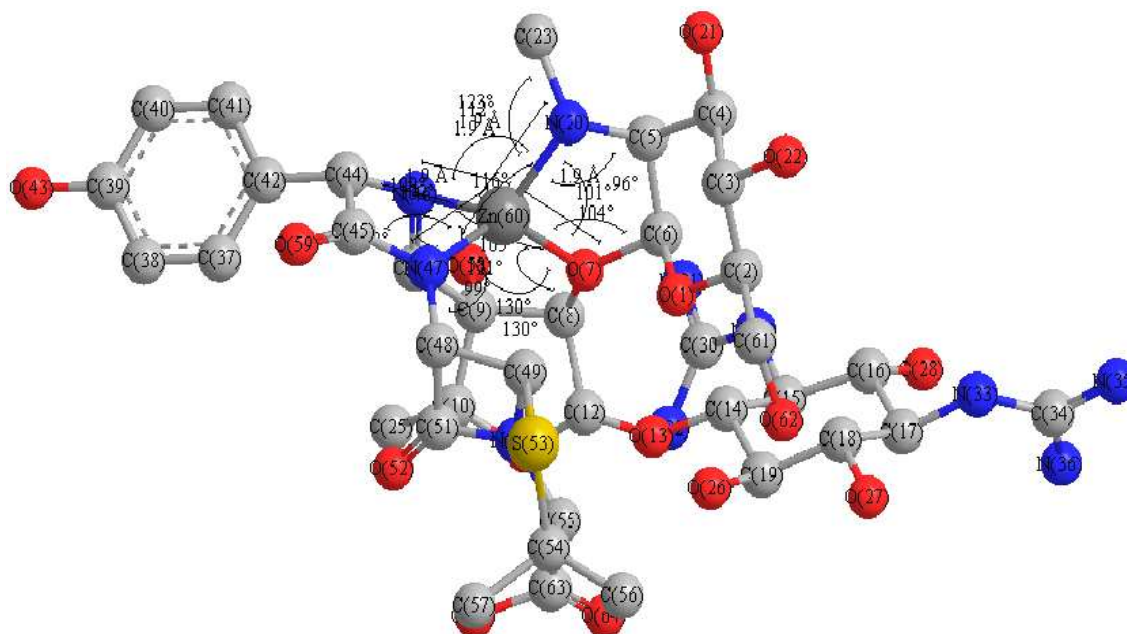

Figure 8. *Optimized Structure of Copper complex.*

Figure 9. *Optimized Structure of Zinc complex.*

Table 3. *Bond length and bond angle results of metal complexes.*

Nickel Complex		Copper Complex		Zinc Complex	
Bond lengths		Bond lengths		Bond lengths	
N(46)-Ni(60)	1.8302	N(46)-Cu(60)	1.3030	N(46)-Zn(60)	1.9352
O(7)-Ni(60)	1.8039	Cu(60)-N(47)	1.8460	O(7)-Zn(60)	1.9275
N(47)-Ni(60)	1.8166	Cu(60)-N(20)	1.8460	N(47)-Zn(60)	1.9293
Bond angles		O(7)-Cu(60)	1.8100	N(20)-Zn(60)	1.9300
N(47)-Ni(60)-N(46)	88.9349	Bond angles		Bond angles	
N(47)-Ni(60)-N(20)	119.1831	Cu(60)-O(7)-C(8)	109.5000	Zn(60)-N(47)-C(48)	129.7704
N(47)-Ni(60)-O(7)	123.3601	Cu(60)-O(7)-C(6)	104.0000	Zn(60)-N(47)-C(45)	108.5763
N(46)-Ni(60)-N(20)	106.4453	N(46)-C(24)-C(9)	115.1000	Zn(60)-N(46)-C(24)	99.1209
N(46)-Ni(60)-O(7)	94.7126	Cu(60)-N(20)-C(23)	145.4178	Zn(60)-N(46)-C(44)	101.5375
N(20)-Ni(60)-O(7)	113.6983	Cu(60)-N(20)-C(5)	69.1644	Zn(60)-N(20)-C(23)	111.9931
				Zn(60)-N(20)-C(5)	104.0956

5. Conclusion

We have successfully synthesized metal Ni(II), Cu(II) & Zn(II)-complexes of novel Schiff base ligand derived from Streptomycin and Amoxicillin. Spectral, thermal and other analytical data revealed the real correlation with the proposed and suggested structure. Molar conductivity measurement recommended non electrolytic nature of the complexes. Further, molecular modeling and electronic spectral data measurement strongly recommend tetrahedral geometry of Cu-complex and square planar geometry for Ni and Zn-complexes. Negative entropy values obtained by thermal decomposition calculations, using Coats-Redfern equation indicated the spontaneous formation of metal complexes. The two antibiotics in conjugation with metals lead to better antibiotic activities. The antibacterial screening of the synthesized ligand and its metal complexes against various pathogenic bacteria suggested improved antibacterial activities. Comparable antibacterial sensitivity test of the ligand and metal complexes showed that they bear strong activity against S. aureus.

Acknowledgements

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