Synthesis, Characterization and Investigation of Antimicrobial Activity of New Schiff Base, 2-(((2-((4-hydroxybenzylidene) amino)ethyl)imino)methyl) phenol and Its Cu(II) and Ni(II) Complexes

Abstract

New complexes of Cu (II) and Ni (II) with the Schiff Base, 2-(((2-((4-hydroxybenzylidene) amino)ethyl)imino)methyl) phenol have been prepared and characterized by analytical and physico-chemical techniques, such as magnetic susceptibility, conductivity measurements, electronic and IR spectral studies. The infrared spectral studies revealed the tetra-dentate nature of the Schiff base in the complexes. A square- planar geometry is suggested for all the obtained complexes. The prepared complexes were evaluated for their antimicrobial activity showing moderate outcome.

Keywords: Schiff base ligands, Transition Metals, Salicylaldehyde, Antibacterial activity.

1 Introduction

Schiff base named after Hugo Schiff (1864) are the compounds containing azomethine group (-HC=N-) formed by the condensation reaction of any primary amine with aldehyde or ketone[1]. During Schiff base formation the active carbonyl group (-C=O) is replaced by an imine or azomethine group. Schiff base constitutes a very important group of N, O donor chelating ligands[2]. Schiff bases and its complexes are used as pigments and dyes, catalysts, intermediate in organic synthesis, and as a polymer stabilizer[3]. Schiff bases are versatile -C=N (imine) containing compounds possessing broad spectrum of biological activity and incorporation of metals in the form of

complexes showed some degree of antibacterial, antifungal, antitumor, anticancer and anti-inflammatory activity [4-8].

Metal complexes involving derivatives of salicylaldehyde and aromatic or aliphatic amines are of massive significance because of their potential use as catalyst for some catalytic reactions[9-13] and biological activities[14-15] etc. Salophen ligand offers a tetradentate chelating system to form stable metal complexes and thus they have very strong π to π* intermolecular interactions. Transition metal complexes derived from salophen-type ligands have widespread applications such as homogeneous and heterogeneous catalysts in various organic transformation reactions.

Metal complexes of Mn(II), Fe(II), Co(II) and Cd(II) ions with Schiff base ligand 4-{(pyridin-2-ylimino)methyl}phenol derived from 2-amino pyridine with 4-hydroxybenzaldehyde have recently been reported by M.S. Hossoin et al[16]. The observed values confirmed that all the synthesized complexes have octahedral geometry. The Schiff base and its metal complexes have been found to have moderate to strong antibacterial activity.

Two new symmetrical Schiff bases have been prepared by the condensation of ethylenediamine and two benzaldehyde derivatives, namely 2-hydroxybenzaldehyde and 2,4-dimethoxybenzaldehyde and Schiff base ligands and their Iron complexes were characterized by electronic absorption spectra, 1H NMR and IR spectroscopies[17].

To the best of our knowledge, Cu(II) and Ni(II) metals complexes of unsymmetric Schiff base derived from 4-Hydroxy benzaldehyde and salicylaldehyde with ethan-1,2-diamine have not been reported yet.Keeping these facts in view the significance of metal in biology, we here in report the synthesis and characterization of a new Schiff base ligand derived from Salicylaldehyde, ethane-1,2-diamine and 4-Hydroxybenzaldehyde in the ratio (1:1:1).

2 Experimental

2.1 Chemicals and Reagents

2-hydroxy benzaldehyde (99.99%), Parahydroxy benzaldehyde, Ethane-1,2-diamine (99.99%),$CaCO_3$(99.99%) and Ethanol, DMSO were used as solvent. All

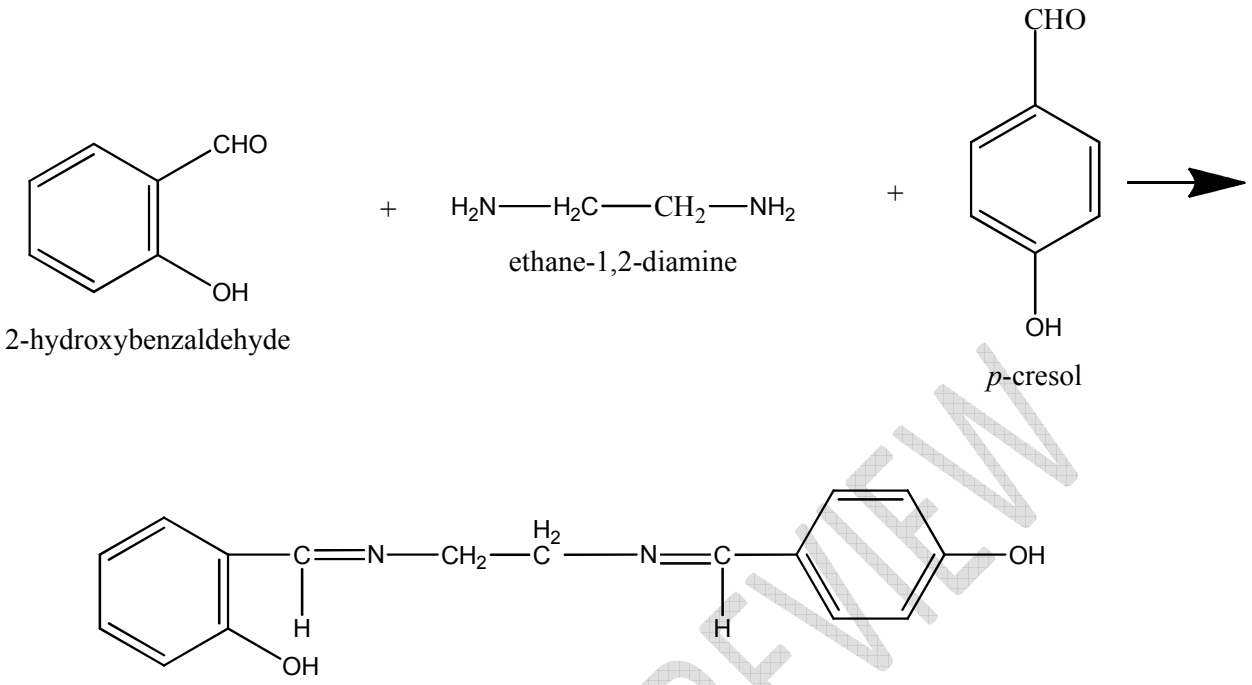
Chemicals with high purity used in this work were purchased from Merck and Loba chemicals.

2.2 Materials

All metal(II) salts were used as nitrate. The solvents were purified by distillation procedure. The melting point or the decomposition temperature of all the prepared ligand and metal complexes were observed in an electro thermal melting point apparatus. Infrared spectra were recorded on a FTIR-8400, SHIMADZU, Japan using a KBr disc, in Central Science Lab of Rajshahi University. The thermogravimetric analysis (TGA) was performed on Perkin Elmer Simultaneous Thermal Analyzer, STA-8000. UV-Vis spectra were recorded in DMSO .The The Gouy Method were used to measure the magnetic moment of the solid complexes. The electrical conductance measurements were made at room temperature in freshly prepared aqueous solution in DMSO .The purity of the ligand and metal complexes were tested by Thin Layer Chromatography (TLC).

2.3 Preparation of Schiff base 2-(((2-((4-hydroxybenzylidene) amino) ethyl)imino) methyl)phenol

Schiff base ligands were prepared according to the known method from the condensation of the respective diamine with the corresponding aldehydes in a molar ratio of 1:1:1, respectively ,using ethanol as a solvent. To a stirring solution of ethane-1,2-diamine (0.7mL, 10.00 mmol) dissolved in about 10.00 mL ethanol, a solution of salicylaldehyde (1.06 mL, 10.00 mmol) and 4-Hydroxybenzaldehyde in 10.00 mL of ethanol was added drop wise through two different neck of a three neck R.B flask. This has resulted an lemon color solution, which was refluxed and stirred for 5 hours. The reaction mixture was cooled and kept for evaporation at room temperature leading to isolation of solid lemon product. The precipitate were filtered off, washed several times with Cyclohexane and finally dried in a desicator over $CaCl_2$[18-19]. The Schiff bases were obtained in good yields. The product(Ligand L_3) was found to be soluble in EtOH, MeOH, DCM, DMF and DMSO.



2-(((2-((4-hydroxybenzylidene)amino)ethyl)imino)methyl)phenol

Scheme 1: Synthesis of Schiff base ligand (L_3) Schiff base 2-(((2-((4-hydroxybenzylidene) amino) ethyl)imino) methyl)phenol.

2.4 General Procedure for Synthesis of Complexes

The Schiff base ligand (0.134g,0.5mmol) was dissolved in 15.00 mL hot ethanol. The hot ethanolic solution of the ligand was slowly added to a hot 1:1 (metal: ligand) aqueous ethanolic solution of the metal salts. The resulting solution was refluxed for 6 h. The solution was reduced to one third by evaporating the solvent. The solution was cooled .The (Cu^{2+}- parrot green, Ni^{2+}-brown) colored precipitate was separated by filtration. The solid was washed several times with ethanol. The complex was soluble in DCM, DMF and DMSO.

General formula of metal complexes: $M(L_3)$ [Where M = Metal ion]

2.3 Antibacterial studies

Any chemical or biological agent that either destroys or inhibits the growth of microorganisms is called antimicrobial agent. The synthesized Schiff base ligand and the metal complexes were screened for their antibacterial activity against pathogenic bacterial strains, Gram negative(*Escherichia coli) and* Gram-positive (*Staphylococcus aureus*), The disc diffusion method[20-21] was adopted for the determination of antibacterial activity. The observed data of antimicrobial activity of all the compounds and the standard drug are given in (**Table 4**).

3 Results and discussion

All of the synthesized ligand and metal complexes were air and moisture stable .The complexes are intensely colored, amorphous solids, which decomposes above 230°C . Molar conductance values of the compounds in DMSO showed low values indicating them to be non-electrolyte[22]. The analytical and physical data (color, melting point, molar conductivity and magnetic moment) of ligand and the complexes with Cu(II), Ni(II) metal ions are listed in (**Table 1**). For the Cu(II) complexes the magnetic moments were 1.85 B.M indicating paramagnetic nature. This value corresponds to a square planar geometry[23-24]. For the Ni(II) complex the value for the magnetic moments is 0.25 B.M indicates the diamagnetic complex of Ni(II) with square planar geometry[25].

Table 1. Analytical and Physical Properties of L_3 and its Complexes

Symbol of compounds	Molecular formula of compounds	Melting point/ºC	Color	Solubility DMSO and DMF	Molar Conductance $Ohm^{-1}cm^2mol^{-1}$	μ eff in B.M
L_3	$[C_{16}H_{16}O_2N_2]$	170	Lemon	(+)Ve	8	-
Cu-L_3	$[C_{16}H_{14}N_2O_2Cu]$	230	Parrot Green	(+)Ve	10	1.85
Ni-L_3	$[C_{16}H_{14}N_2O_2Ni]$	270	Brown	(+)Ve	12	Dia

3.1 Infrared spectra

IR spectra of the Schiff base showed a strong bands at 1632cm^{-1} assigned [20, 26] to the azomethine, ν(-HC=N) linkage. It was assumed that amino and aldehyde moieties of the starting reagents were absent and had been converted into the azomethine moiety (Scheme 1). In comparison of the spectra of Schiff base and its metal complexes (**Table 2**) suggested that Schiff base coordinated to metal ions using three donors indicated that the ligand acted as a bidentate ligand. The band appearing at 1631 cm^{-1} and 1603 cm^{-1} due to azomethine (-CH=N) of Schiff base metal complexes was shifted to lower frequency represented [27] .Two weak low frequency new absorption bands at 763 cm^{-1} and 467 cm^{-1} that assigned the ν(M-O) and ν(M-N) frequency of Cu(II) complexes. Another two frequency were observed at 764cm^{-1} and 467cm^{-1} assigning the ν(M-O) and ν(M-N) vibration of Ni(II) complex [20-21, 28].

Table 2. Characteristic IR absorption peaks in cm^{-1} units

Symbol of compounds	Compounds	ν(OH)	ν(C=N)	ν(M-O)	ν(M-N)
L_3	$[C_{16}H_{16}O_2N_2]$	3435	1632	-	-
Cu-L_3	$[C_{16}H_{14}N_2O_2Cu]$	3436	1631	763	467
Ni-L_3	$[C_{16}H_{14}N_2O_2Zn]$	3435	1623	758	468

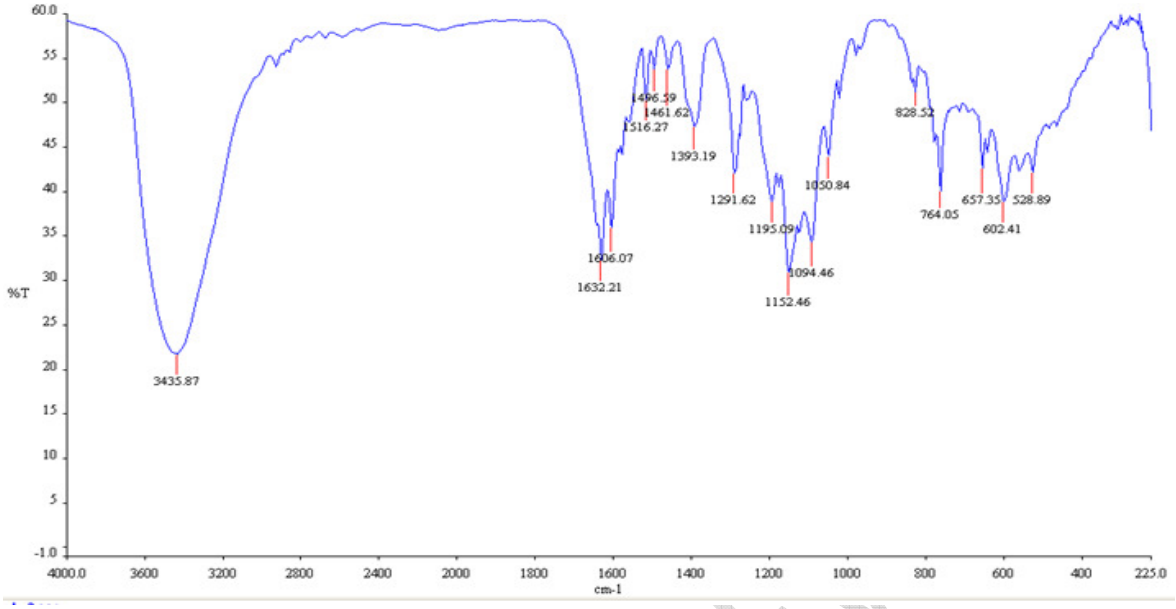


Figure 1: IR Spectrum of L_3

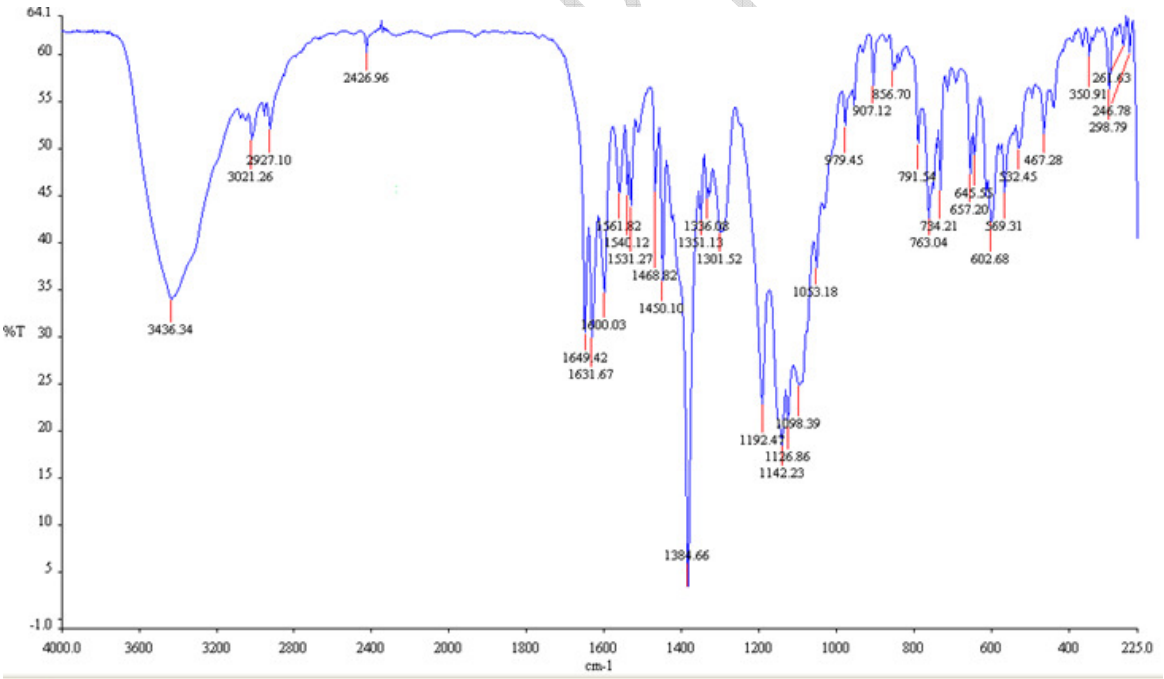


Figure 2: IR Spectrum of L_3-Cu

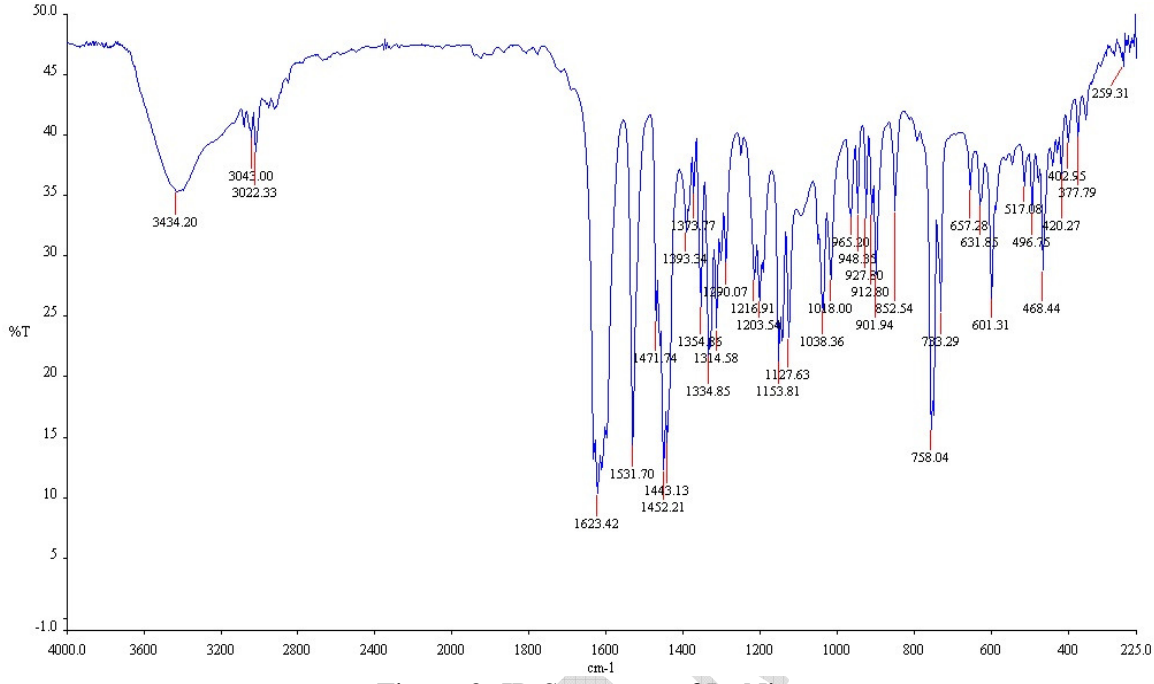


Figure 3: IR Spectrum of L_3-Ni

3.2 Electronic spectra

The UV-Visible spectral data have been presented in the **Fig. 4** and all observations are recorded in (**Table 3**). The electronic spectra of free ligand showed two absorption bands at 278 nm and 340 nm, which may be assigned as π-π*and n-π* transition[29]. The electronic spectra of Cu(II) complex showed absorption bands at 272 nm and 370 nm which may be assigned π-π*and n-π*which may be assigned to charge transfer transition.The electronic spectra of the Ni(II) complex showed two bands observed at 275 nm and 375 nm which may be assigned to charge transfer transition. Both metal complexes may be supported square planar geometry [30].The electronic spectra were recorded in DMSO.

Table 3. UV- Visible Spectrum of Ligand L_2 and its Complexes

Symbol of compounds	Molecular formula of compounds	Wavelength in nm	Assignment
L_3	$[C_{16}H_{16}O_2N_2]$	262 311	π-π* n-π*
Cu-L_3	$[C_{16}H_{14}N_2O_2Cu]$	268 365	π-π* C.T transition
Ni-L_3	$[C_{16}H_{14}N_2O_2Ni]$	262 340	π-π* C.T transition

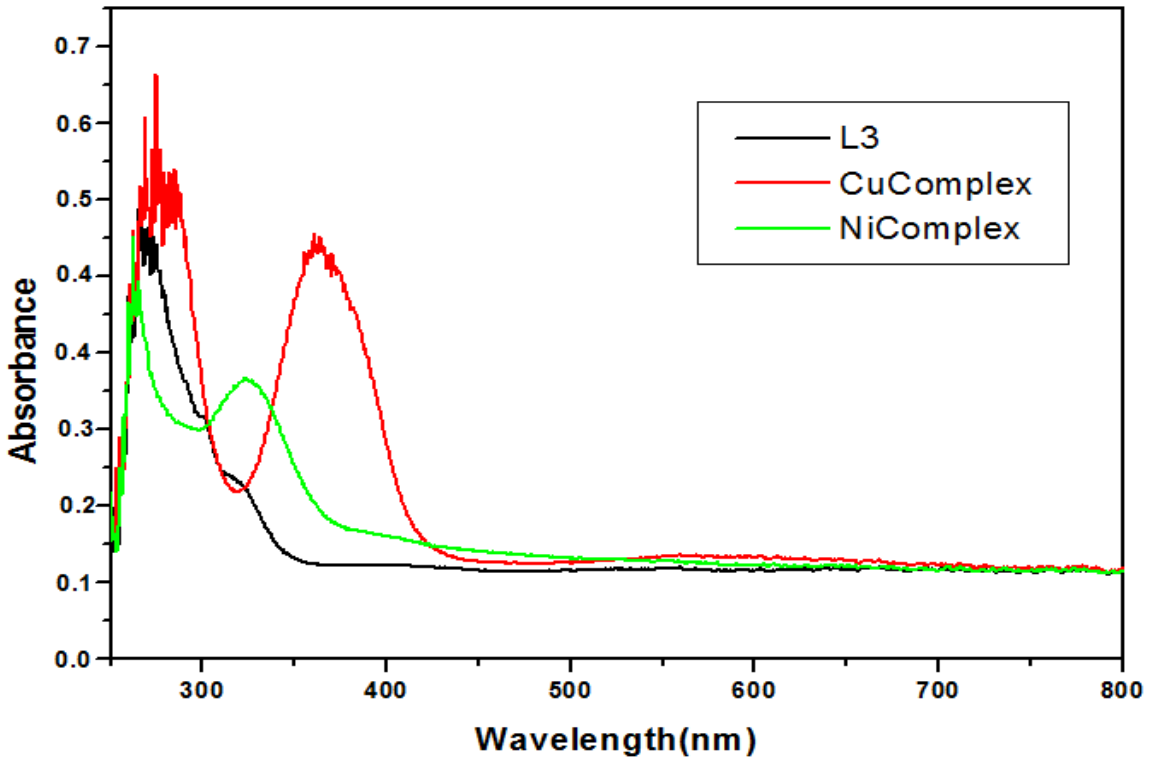


Figure 4 : UV- Visible spectra of the L_3 and its complexes

On the basis of the above physical and chemical characterization, the probable structure of the complex is given below:

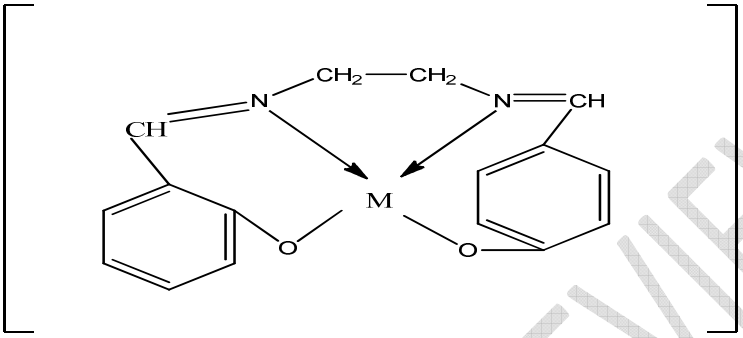


Figure 5: Proposed structure of metal complex[Where M=Cu(II) and Ni(II)]

3.3 Antibacterial result

The free Schiff base ligand and their metal complexes were screened for their antibacterial activity against the strains the *Escherichia coli, Staphylococcus aureus*. The compounds were tested at a concentration of 60 μg in DMSO solution using the paper disc diffusion method[31-32]. The susceptibility zones were measured in diameter (mm) and the result are listed in (**Table 4**). It can be seen from this table, standard Kanamycin showed good activity against two mentioned bacteria when compared with all our synthesized compounds. The susceptibility zones were the clear zones around the discs killing the bacteria. The Schiff base and metal complexes individually exhibited varying degrees of inhibitory effects on the growth of tested bacterial species. The metal complexes showed more antibacterial activity than Schiff base ligand. Such increased activity of the metal chelates can be explained on the basis of Overtone's concept and Tweedy's chelation theory [33]. Activity against two pathogenic bacteria in this studyfollows the following trend: Kanamycin-30 > Cu-L3> Ni-L3 > L3

Table 4. Inhibition zone in mm of tested compound against two bacteria

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Compounds	*Escherichia coli* (Gram negative)	*Staphylococcus aureus* (Gram positive)
Kanamycin(30µg */disc*)	30	35
L_3	8	9
Cu-L_3	16	13
Ni-L_3	10	12

4 Conclusions

In this paper, we have explored the synthesis and coordination chemistry of Cu(II) and Ni(II) complexes with new Schiff base ligand derived from the condensation reaction of Salicylaldehyde and 4-hydroxybenzaldehyde with ethane-1,2-diamine. The physicochemical analysis indicated the formation of four coordinated metal complexes. IR spectral analysis indicated that N and O atoms are coordinated to central metal atom. Magnetic moment, UV-Visible confirmed the proposed square planar structure of metal complexes. Yield of the complexes were in the range 67%-72%. Biological activity revealed that the Cu complex showed strong antibacterial activities compared to the ligand and Ni complex.

5 References

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