A Novel Schiff base ligands of isoxazole and their Co(II), Ni(II), Cu(II) and Zn(II) complexes: synthesis, spectroscopic characterization, studies on thermal behavior and biological activity.

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Abstract:

Schiff bases are excellent ligands which are synthesized from the condensation of primary amine with carbonyl group. The Co(II), Ni(II), Cu(II) and Zn(II) metal complexes have been synthesized with isoxazole Schiff bases. A tetra dentate Schiff ligand [4-[(5-methylisoxazol-3-yl)Sulfonyl Benzylidene]amine [MSBPMA] (L₁) has been synthesized via the reaction of sulphanomatoxazole with stoichiometric amount of pyrrole 2-carbaldehyde in ethanol solution. Ligand \( \text{N} \{\text{E} \} \text{-1H-Imidazol-3-yl} \text{-N} \{\text{Imino metylidine} \text{-3-Hydroxy-3-Isoxazol}\} \) [NIINIHI (L₂) was prepared by reaction of histamine with 3-hydroxy 5-carbaldehyde Isoxazole in absolute methanol and ligand \( \text{N} \{\text{E} \} \text{-3-Hydroxy-3-Isoxazol} \text{-4H Chromine} \text{-Imino methyl Isoxazole} \text{-NHIIMC} \) (L₃) on the other hand, was obtained through a reaction between muscinol and Chromine 3-Carbaldehyde in hot ethanolic solution. The ligands and their metal complexes were well characterized by the elemental analysis, FT IR, \(^1\)H-NMR, UV-Visible spectra, Mass spectral data and molar conductance. Thermal behaviors of all compounds were investigated from room temperature to 800°C with heating rate of 10°C /minute, and also biological studies, the results exhibited suitable antibacterial (Pseudomonas and Bacillus) and antifungal (Angier and R.solani) properties for ligands and metal complexes. The study has shown that the complexation of ligands to metal ion center to enhancement of antibacterial /anti fungal activity.

Key words: Schiff bases, metal chelate, histamine, muscinol, antimicrobial activity.

1. Introduction

Schiff bases also known as azomethine compounds are the product of a condensation reaction of an aldehyde and amine. Schiff bases are as important chelating ligand can be and liked to metal ions via azomethine nitrogen atom and other probable coordination groups and consequently they are able to stabilized the metal ions in various oxidation states in the various heterocyclic Schiff base having O, N and S donor atoms have been reported by several scientist [1]. The isoxazole Schiff base complex have been investigated extensively for last several decades leading to new synthesis and the wide application of such as in pharmaceutical as well as agrochemical industry, nitrogen-containing heterocyclic building blocks are of great importance to both medical and organic chemists recently, Schiff base and especially some of their coordination compounds have attracted considerable attention because of their usage in catalysis reaction such as mediated oxygenation of olefin[2], reduction of aromatic compounds [3], water photolysis [4] and etc. Tetra dentate 3-amino 5-methyl Isoxazole schiff bases with a N₂; O₂ donor atom set are known to coordinate with metal ions, and this has attracted many researchers [5]. In the present investigation we report here synthesis spectroscopic characterization studies on thermal behavior and biological activity of MSBPMA (L₁), NINIHI (L₂) and NHIIMC (L₃) ligands and their metals complexes.

2. Experimental

2.1 material and spectral measurement

All chemicals and solvent used were of analytical grade. Elemental analysis was carried out on Elementar Vario ELII. Conductance measurement of 0.001M solution of the complexes in DMSO was carried out on an equiptronic models no Eq.660A. IR spectrum was recorded on FTIR Spectrophotometer in the range of 400-4000cm\(^{-1}\). Purity of the synthesis compounds was checked by Thin-layer chromatography (TLC) glass plates are coated with silica gel 60F were used. Whereas the mass spectrum of these ligands were obtained using a VG-707E mass spectrometer the elections impact excitation was 70eV. The weight loss and thermal behavior of the sample are investigated by thermo gravimetric analysis (TGA) and differential scanning calorimetric (DSC) performed on a TA
instrument Q600SDT. Sample, heated at a rate of 10°C/min from room temp 800°C.

2.2.1. Preparation of the ligand (L₁) [MSBPMA]

The ligand of MSBPMA [4-{[5-methylisoxazol-3-yl] Sulfonyl Benzyl dine}-N-[ (E)-1-(2-Pyrrrol)methylidine)amine has been synthesized by refluxing the reaction mixture of ethanol solution (30 ml) of sulphametoxazole (0.01 mol) with ethanol solution (30 ml) of pyrrole 2-carbaldehyde (0.01 mol) for about 2-3 hours at 60-70°C the resulting solution was concentrated up to 10 ml on a water bath the mixture was allowed to stand overnight. After that the colored solid product was dried under reduced pressure over anhydrous CaCl₂. That purity of synthesized compound was monitored by TLC using silica gel-G.

2.2.2. Preparation of the liganda (L₂) [NINHI].

The ligand of NINHI[N-[(E)-1H-Imidazol-3-yl]-N-{[Imino methylidine]-3-Hydroxy-3-Isoxazol)] has been synthesized by refluxing the reaction mixture of 3-hydroxy 5-carbaldehyde isoxazole (0.1 mol) in 20 ml methanol and adds to the histamine (0.1 mol) dissolved in 20 ml methanol than the reaction was refluxed for 4 hrs at 50-60°C. After complete refluxation of Schiff base was separated out on removal of the solvent at room temperature. A light yellowish crystalline solid obtained and then dried over anhydrous CaCl₂ in vacuum.

2.2.3. Preparation of the ligands (L₃) [NHIIMC].

The ligand NHIIMC [N-{[3-hydroxy-3-Isoxazol] Imino} methyl 4-oxo-4H Chromine] was prepared by modification of the reported method [6,7]. A solution of 0.1 mol muscinol (dissolved in 20 ml ethanol) was slowly added to a solution of 0.1 mole of Chromine 2-carbaldehyde (4-oxo-4H Chromine 3-carbaldehyde) (in 20 ml ethanol). After stirring the reaction mixture for 30 min, then the mixture of the above solution was refluxed for about 4-5 hrs at 60-70°C. The resulting solution was concentrated up to 10 ml on water bath. The mixture was allowed to stand overnight after that the solid product was filtrated and the recrystallized with ethanol. The purity of synthesis ligand was checked by TLC using gel-G.

The above synthesized ligands were characterized by using UV-Visible, IR, ¹³H-NMR and Mass spectrum.

2.3. General procedure for preparation of the metal complexes.

Co(II), Ni(II), Cu(II) and Zn(II) complexes were prepared by the addition 5 mol of Co(CH₃COO)₂.4H₂O, Ni(CH₃COO)₂.4H₂O, Cu(C₂H₃COO)₂.4H₂O, and Zn(CH₃COO)₂.2H₂O of water, into a solution of 10 mol of the ligand(1:2 molar ratio) the color of the complexes changes in a solution few minutes. The mixture was then refluxed for 2-3 hrs. At 50-60°C the precipitated solid were filtrated from the reaction mixture. The solid were washed with methanol and them with dry ethyl ether, following by drying at 60°C over night.

2.4. 1. Antimicrobial activity:

The ligands and corresponding complexes were evaluated for their antibacterial activity against bacillus and pseudomonas, and antifungal activity against Angier and R. solani by the agar-well diffusion method [8]. These studied bacteria and fungi were incubated into nutrient both for 24 hrs and Malt-Extracted both for 48 hrs respectively.

In this method, nutrient agar for bacteria and Malt-Extracted agar sterilized in a flask and cooled to 50°C was distributed [50 ml] to sterilized Petri dishes (10 cm in diameter) after injecting 0.1 ml cultures of bacteria or fungus, prepared at mentioned above and allowed to solidify the diluted plate method was used to enumerate microorganisms (10⁵ cell mL⁻¹) for 24 hrs. By using a sterilized proper tube (3 mm dia) wells were drug in the culture plates. Ligands or metal complexes dissolved in DMSO were added (100 m mol) to the wells. The Petri dishes were left at 4°C for 2 hrs and then the plates were incubated at 30°C for bacteria 18-24 hrs and 72 hrs for fungi. At the end of the period inhibition zones formed on the medium evaluated as millimeters (mm) dia. The control sample were DMS only.

2.4.2. Determination of minimal inhibitory concentration (MIC)

Nutrient and Malt-Extract are employed as basal medium for the growth of bacteria and fungi respectively. The culture medium (20 ml) was
poured into Petri dishes (9mm) and maintained at 45°C until the sample was incorporated into the agar. The sample was added as 1ml using an automatic micropipette while constantly stirring to assure a uniform distribution. Each sample was tested and 200 micro mol mL-1 in DMSO. The different bacterial strain was layered to place 30 ml over the surface of the solidification culture medium containing a sample. After the bacteria were absorbed into the agar, the plates were incubated at 30°C for 24-48 hrs. Bacterial growth was monitored visually and the MIC was determined.

3. Results and discussion

The elemental analysis of ligands and metal complexes some physical properties are summarized in Table-1.

The analytical data of the complexes corresponding well with general formula [M (II)(L)2].2H2O, the molar conductance value of all metal complexes were found to be low in 10^-3 M DMSO solution, indicating all complexes are electrolyte.

![Chemical Structures](Fig-1, Fig-2, Fig-3, Fig-4, Fig-5)

(Where M= Co (II), Ni (II), Cu (II) and Zn (II) )

(Where M= Co (II), Ni (II), Cu (II) and Zn (II) )
Table-1. Analytical data and some physical properties

| Compounds | Colours | yield | C% Calc(Found) | H% Calc(Found) | N% Calc(Found) | M% Calc(Found) | Melting point | MolarConO
<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C_{10}O_{2}N_{3}H_{13} (L_{3})</td>
<td>Light Yellow</td>
<td>82%</td>
<td>65.08 (65.04)</td>
<td>4.40 (4.37)</td>
<td>14.23 (14.21)</td>
<td>_</td>
<td>186-188°C</td>
<td>_</td>
</tr>
<tr>
<td>Co(II)(L_{2})·2H_{2}O</td>
<td>Green</td>
<td>84%</td>
<td>56.63 (56.45)</td>
<td>4.42 (4.35)</td>
<td>12.38 (12.31)</td>
<td>7.66 (7.45)</td>
<td>210-212°C</td>
<td>8.21</td>
</tr>
<tr>
<td>Ni(II)(L_{2})·2H_{2}O</td>
<td>Yellow Green</td>
<td>79%</td>
<td>56.60 (56.43)</td>
<td>4.37 (4.22)</td>
<td>12.32 (12.15)</td>
<td>7.69 (7.52)</td>
<td>2240-243°C</td>
<td>6.56</td>
</tr>
<tr>
<td>Cu(II)(L_{2})·2H_{2}O</td>
<td>Blue</td>
<td>87%</td>
<td>56.54 (56.42)</td>
<td>4.39 (4.21)</td>
<td>12.30 (12.23)</td>
<td>7.71 (7.56)</td>
<td>254-256°C</td>
<td>8.65</td>
</tr>
<tr>
<td>Zn(II)(L_{2})·2H_{2}O</td>
<td>Yellow</td>
<td>80%</td>
<td>56.49 (56.42)</td>
<td>4.38 (4.21)</td>
<td>12.37 (12.23)</td>
<td>7.65 (7.42)</td>
<td>198-200°C</td>
<td>7.02</td>
</tr>
<tr>
<td>C_{10}O_{2}N_{3}H_{10} (L_{2})</td>
<td>Light yellow</td>
<td>81%</td>
<td>60.67 (60.45)</td>
<td>5.61 (5.45)</td>
<td>31.46 (31.23)</td>
<td>_</td>
<td>105-107°C</td>
<td>_</td>
</tr>
<tr>
<td>Co(II)(L_{2})·2H_{2}O</td>
<td>Dark Green</td>
<td>87%</td>
<td>48.64 (48.43)</td>
<td>5.40 (5.34)</td>
<td>25.22 (25.14)</td>
<td>11.71 (11.23)</td>
<td>142-144°C</td>
<td>8.65</td>
</tr>
<tr>
<td>Ni(II)(L_{2})·2H_{2}O</td>
<td>Green</td>
<td>89%</td>
<td>48.60 (48.45)</td>
<td>5.37 (5.34)</td>
<td>25.26 (25.22)</td>
<td>11.73 (11.65)</td>
<td>161-165°C</td>
<td>6.89</td>
</tr>
<tr>
<td>Cu(II)(L_{2})·2H_{2}O</td>
<td>Blue</td>
<td>92%</td>
<td>48.61 (48.56)</td>
<td>5.39 (5.22)</td>
<td>25.24 (25.13)</td>
<td>11.75 (11.56)</td>
<td>173-175°C</td>
<td>8.45</td>
</tr>
<tr>
<td>Zn(II)(L_{2})·2H_{2}O</td>
<td>Light yellow</td>
<td>82%</td>
<td>48.63 (48.34)</td>
<td>5.35 (5.23)</td>
<td>25.21 (25.12)</td>
<td>11.77 (11.65)</td>
<td>126-128°C</td>
<td>6.23</td>
</tr>
<tr>
<td>C_{10}O_{2}N_{3}H_{10} (L_{3})</td>
<td>Yellow green</td>
<td>83%</td>
<td>62.22 (62.12)</td>
<td>3.70 (3.34)</td>
<td>10.37 (10.22)</td>
<td>_</td>
<td>205-209°C</td>
<td>_</td>
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<tr>
<td>Co(II)(L_{3})·2H_{2}O</td>
<td>Green</td>
<td>85%</td>
<td>53.50 (53.34)</td>
<td>3.82 (3.65)</td>
<td>8.91 (8.87)</td>
<td>8.28 (8.12)</td>
<td>256-258°C</td>
<td>7.46</td>
</tr>
<tr>
<td>Ni(II)(L_{3})·2H_{2}O</td>
<td>Light Green</td>
<td>89%</td>
<td>53.47 (53.34)</td>
<td>3.84 (3.65)</td>
<td>8.94 (8.65)</td>
<td>8.29 (8.21)</td>
<td>267-269°C</td>
<td>6.21</td>
</tr>
<tr>
<td>Cu(II)(L_{3})·2H_{2}O</td>
<td>Blue</td>
<td>92%</td>
<td>53.45 (53.21)</td>
<td>3.87 (3.67)</td>
<td>8.93 (8.54)</td>
<td>8.28 (8.23)</td>
<td>279-284°C</td>
<td>7.89</td>
</tr>
<tr>
<td>Zn(II)(L_{3})·2H_{2}O</td>
<td>Light Yellow</td>
<td>84%</td>
<td>53.43 (53.34)</td>
<td>3.86 (3.76)</td>
<td>8.90 (8.86)</td>
<td>8.24 (8.23)</td>
<td>231-233°C</td>
<td>6.66</td>
</tr>
</tbody>
</table>

3.1. Thermal analysis:

The heating rates were suitably controlled at 10°C min⁻¹ under nitrogen atmosphere, and the weight loss was measured from the ambient temperature up to 800°C. The TGA curves of all metal complexes show that the initial mass loss occurring with 100-300°C range is interpreted as loss of mass and hydrated water molecules during the chelate drying process and the second weight loss at around more than 300°C range is due to loss of coordinated water molecules. Temperature was a horizontal and the find product of decomposition at this temperature region corresponds to metal oxide. Presence of water molecule is further confirmed by the endothermic bands observed is the respective
DTA curve in the temperature region where the TGA curves loss in weight. In addition to the endothermic bands, the bands appeared at higher temperature; represent phase transition, oxidation and more decomposition of the compound.

3.2.1. $^1$H- NMR and Mass spectrum of Ligand (L$_1$) [MSBPMA].

The $^1$H-NMR spectra of the ligand (L$_1$) recorded in CDCl$_3$ showed the following signals. (C-CH$_3$) three protons at 3.2δ (S,3H) and (N-H) proton on pyrrole ring at 9.02 δ (S,1H), and the imino proton (N=C-H) appeared at 8.72 δ (S,1H). The Mass spectra of the ligand show molecular ion peaks which are good agreement with the expected value. The Mass spectra of the ligand (L$_1$), give a peak at 298 m/z which was also supported by the Nitrogen rule since the compound possesses three Nitrogen atoms.

3.2.2. $^1$H-NMR and Mass spectrum of Ligand (L$_2$) [NINIIIHI].

In $^1$H-NMR (CDCl$_3$) the imino proton appeared at 8.52 δ on the pyrrole ring at 9.07 δ (S,1H), (N-H) proton and hydroxyl group on isoxazole ring at 4.56δ (S,1H), (-OH). The Mass spectra of the ligand showed a molecular ion peak at 182 m/z, which was also supported by the Nitrogen rule since the compound possesses four Nitrogen atoms.

3.2.3. $^1$H-NMR and Mass spectrum of Ligand (L$_3$) [NHIIMIC].

The $^1$H-NMR spectra of the Schiff base ligand is recorded in DMSO-d$_6$. The 1H-NMR spectra of Schiff base ligand (L$_3$) at peaks 7.42δ and 4.35δ are singlet. Those peaks are assignable for the proton of azomethine group and hydroxyl group on isoxazole ring respectively. The Mass spectra of the ligand showed molecular ion peak which is good agreement with the expected value. The Mass spectra of ligand (L$_3$) give a peak at 271 m/z, which is assigned for (L+H) peak.

3.3. IR Spectra of metal complexes:

3.3.1. M (II) (MSBPMA)$_2$2H$_2$O, IR spectra

The IR spectrum of M (II) (MSBPMA)$_2$2H$_2$O as summarized in Table-2 shows the following features. A strong band appeared at 1612cm$^{-1}$ in (L$_1$), this band can be assigned to ν(C=N) stretching vibration[9]. In these complexes the vibration band ν (C=N) is shifted by 10-20cm$^{-1}$ to higher or lower wave numbers. These indicated the possibility of coordination of the amino nitrogen to metal ion. The ring skeletal vibrations ν (C=O) were consistent in all complexes, the bands ν(S=O) stretching, at 1521-1528cm$^{-1}$ and another band also ν(C-H) stretching at range 3006-3014cm$^{-1}$ unaffected by complexation. Which indicative of involvement of the pyrrole ring in the complexation also a band at 3215cm$^{-1}$ attributed to ν(N-H) stretching in the ligand (L$_1$) disappeared in its metal complexes [10]. In the low frequency region the bands observed in the complexes in the region 557-562cm$^{-1}$ was attributed to ν (M-N). All the data suggested that the metal was bonded to the pyrrole ring Nitrogen and the imino Nitrogen [11].

3.3.2. M(II) (NINIIIHI)$_2$2H$_2$O, IR spectra

The IR spectrum of L$_2$[NINIIIHI] as summarized in the Table-2 shows the following features. The ligand showed strong band 1616 cm$^{-1}$ due to ν (C=N) which is assignable to the Schiff base which appeared in the synthesized ligand. This band gets shifted by 10-20 cm$^{-1}$ to lower or higher wave numbers in complexation. These indicating the co-ordination through azomethine nitrogen to metal ion. The band ν(C=H) is unaffected by complexation. Which indicated of involvement of the isoxazole ring ν (C-O-N) band vibration frequently 1220 cm$^{-1}$ is shifted by 10-20 cm$^{-1}$ to higher or lower wave numbers. These indicated the possibility of coordinating the isoxazole Oxygen to metal ion. The low frequency region, the bands are observed in the complexes in the region 460-476cm$^{-1}$ was attributed to ν (M-O) and in the region 559-564cm$^{-1}$ was attributed to ν (M-N). All the IR data suggested that the metal ion was bonded to the ligand L$_2$ (NINIIIHI) through the isoxazole ring Oxygen and the imino Nitrogen[12].

3.3.3. M(II) (NHIIMIC)$_2$2H$_2$O, IR spectra

The IR spectrum of the ligand NHIIMIC metal complexes Showed ( Fig-6 ) the band observed of 1600cm$^{-1}$ region in the ligand is assigned to the azomethine group ν (C = N ) was Shift to this band in metal complexes towards higher or lower frequencies region. There indicated the possibility of coordination of the imino nitrogen to metal ion. the ring skeletal vibrations ν (C-O-C ) and free ν ( OH ) bands are not unaffected by
complexation. In the low frequency region the bands are observed in the complexes in the region 559-567 cm\(^{-1}\) attributed to \(\nu (M-N)\) and the region 467-475 cm\(^{-1}\) was attributed to \(\nu (M-O)\). All the IR data suggested that the metal is bonded to the Schiff base through Oxygen and imino Nitrogen.

All the Co(II), Ni(II), Cu(II) and Zn (II) complexes showed a broad difference band at 3440-3480 cm\(^{-1}\) and another band at 770-796 cm\(^{-1}\) at lower frequency region indicating the presence of water molecules in the co-ordination sphere. This fact is also supported by the results of elemental analysis [13].

**Table-2: IR Absorption frequencies of ligands and metal complexes.**

<table>
<thead>
<tr>
<th>compounds</th>
<th>(\nu (C=N))</th>
<th>(\nu (C=\equiv N))</th>
<th>(\nu (N-H))</th>
<th>(\nu (M-O))</th>
<th>(\nu (M-N))</th>
<th>(\nu (C=\equiv C))</th>
<th>(\nu (S=O))</th>
<th>Water coordinated</th>
</tr>
</thead>
<tbody>
<tr>
<td>[MSBPMA ] (L(_1))</td>
<td>1612</td>
<td>3010</td>
<td>3215</td>
<td>–</td>
<td>1522</td>
<td>1140</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Co (II)(L(_1))(_2)_2H(_2)O</td>
<td>1621</td>
<td>3003</td>
<td>–</td>
<td>562</td>
<td>1527</td>
<td>1142</td>
<td>792</td>
<td></td>
</tr>
<tr>
<td>Ni (II)(L(_1))(_2)_2H(_2)O</td>
<td>1625</td>
<td>3012</td>
<td>–</td>
<td>557</td>
<td>1529</td>
<td>1145</td>
<td>781</td>
<td></td>
</tr>
<tr>
<td>Cu (II)(L(_1))(_2)_2H(_2)O</td>
<td>1630</td>
<td>3006</td>
<td>–</td>
<td>560</td>
<td>1521</td>
<td>1140</td>
<td>786</td>
<td></td>
</tr>
<tr>
<td>Zn (II)(L(_1))(_2)_2H(_2)O</td>
<td>1605</td>
<td>3014</td>
<td>–</td>
<td>561</td>
<td>1528</td>
<td>1141</td>
<td>789</td>
<td></td>
</tr>
<tr>
<td>[ NINIHI ] (L(_2))</td>
<td>1616</td>
<td>3024</td>
<td>3217</td>
<td>–</td>
<td>559</td>
<td>–</td>
<td>–</td>
<td>780</td>
</tr>
<tr>
<td>Co (II)(L(_2))(_2)_2H(_2)O</td>
<td>1624</td>
<td>3021</td>
<td>3222</td>
<td>466</td>
<td>1521</td>
<td>1142</td>
<td>787</td>
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</tr>
<tr>
<td>Ni (II)(L(_2))(_2)_2H(_2)O</td>
<td>1624</td>
<td>3016</td>
<td>3219</td>
<td>472</td>
<td>564</td>
<td>–</td>
<td>–</td>
<td>782</td>
</tr>
<tr>
<td>Cu (II)(L(_2))(_2)_2H(_2)O</td>
<td>1632</td>
<td>3017</td>
<td>3226</td>
<td>474</td>
<td>562</td>
<td>–</td>
<td>–</td>
<td>779</td>
</tr>
<tr>
<td>Zn (II)(L(_2))(_2)_2H(_2)O</td>
<td>1610</td>
<td>3010</td>
<td>3220</td>
<td>476</td>
<td>560</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>[ NHIIMC ] (L(_3))</td>
<td>1600</td>
<td>2982</td>
<td>–</td>
<td>–</td>
<td>1523</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Co (II)(L(_3))(_2)_2H(_2)O</td>
<td>1612</td>
<td>2992</td>
<td>–</td>
<td>471</td>
<td>567</td>
<td>1521</td>
<td>–</td>
<td>794</td>
</tr>
<tr>
<td>Ni (II)(L(_3))(_2)_2H(_2)O</td>
<td>1621</td>
<td>2999</td>
<td>–</td>
<td>475</td>
<td>561</td>
<td>1538</td>
<td>–</td>
<td>789</td>
</tr>
<tr>
<td>Cu (II)(L(_3))(_2)_2H(_2)O</td>
<td>1625</td>
<td>3012</td>
<td>–</td>
<td>467</td>
<td>565</td>
<td>1522</td>
<td>–</td>
<td>782</td>
</tr>
<tr>
<td>Zn (II)(L(_3))(_2)_2H(_2)O</td>
<td>1592</td>
<td>3014</td>
<td>–</td>
<td>473</td>
<td>559</td>
<td>1529</td>
<td>–</td>
<td>786</td>
</tr>
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</table>
3.4. Electronic Spectral data of metal complexes:-

The electronic spectra of metal complexes were recorded in DMSO in the range 4,000 cm^{-1}- 40,000 cm^{-1}. The electronic spectra of Co(II) complexes showed bands around 9,951-13,564 cm^{-1}; 17,641-20,412 cm^{-1} and 25,524-29,861 cm^{-1} assigned to the electronic transition 4T_{1g} (F) → 2T_{2g} (F), 4T_{1g} → 4T_{2g} (F) and 4T_{1g} → 4T_{2g} (p) respectively. These transitions are in fair agreement with the predicted values of octahedral geometry[14]. The electronic spectra of Ni(II) complexes showed three bands around 9,867-13,242 cm^{-1}, 15,421-18,600 cm^{-1} and 25,641-28,074 cm^{-1} assigned to the electronic transition 3A_{2g}(F) → 3T_{2g} (F), 3A_{2g} → 3T_{1g} (F) and 3A_{2g}(F) → 3T_{1g} (F) respectively these transitions of those complexes are suggesting octahedral geometry[15]. The spectra of Cu(II) complexes showed two bands are in the visible region 12,561-14,249 cm{-1} and 18,963-22,469 cm^{-1} are assigned to 2B_{1g} → 2A_{1g} and 2B_{1g} → 2E_{1g} transitions respectively those electronic bands are suggesting square planar geometry of the Cu(II) complexes[16]. The present Zn (II) complexes show no d-d bands as expects for a d^{10} system. Those Zn (II) complexes have been found to the diamagnetic in nature.

On the basis of the physical and spectra data of the complexes discussed above, one can assume that the metal ions are bonded to the Schiff base via the Oxygen and Nitrogen as illustrated in Fig.4-6

3.5. Antimicrobial activity:

The new ligands and metal complexes were evacuated. For antibacterial activity against pseudomonas, Bacillus and in antifungal activity against A.niger and R.solani by using agar-well diffusion. The complexes are activity than the ligands. The copper complexes are much more activity than other metal complexes showed in microbial activity against all microorganism and most complexes have antifungal effect except Zn (II) metal complexes. The Cu (II) complexes are showed the best activity against A.niger and R.Solani.

All complexes show antibacterial activities against pseudomonas and Bacillus inhibition zone results were dependants on the type of ligands and the position of chelton with metal ion[17]. Antimicrobial activities are also reported as minimum inhibitory concentration (MIC) values, defined as the lowest concentration of an antimicrobial that visibly inhibits growth of the bacteria after over night incubation. Minimum inhibitory concentration (MIC) of 50.00 μ mol mL^{-1} where observed in all microorganism tested. The variation in the effective in different complexes against different organism depend either on different in the permeability of the cell of the microbes [18].

4. Conclusion

The result of this investigation supports the suggested structure of the metal complexes. Octahedral and square planar geometry were suggested for all complexes, the Schiff base ligands were found to be biologically active and their metal complexes display enhanced antimicrobial activity against one or more strains, chelating tends to the ligands act as more powerful and potent bactericidal agent.

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