Synthesis, Spectroscopic and Antibacterial Activity Study of N-[2(2-phenyl hydrazinyl) phenyl]Benzothiazol-2-Amine Complexes

Shaymaa H. Naji*
Department of Chemistry, College of Education Ibn Al- Haitham, Baghdad University, Baghdad, Iraq

Abstract
The new ligand N-[2-(2-Phenyl hydrazinyl)Phenyl ]benzothiazol-2-amine (L) was prepared from the reaction of orthoaminohydrazo benzene with 2-mercaptobenzothiazole in mole ratio (1:1). It was characterized by elemental analysis (CHN), 1H, 13C-NMR, IR and UV-Vis. The complexes of the bivalent ions Co(II), Ni (II), Cu (II), Cd (II), Hg(II) and Pb(II) have been prepared and characterized. The structural feature were established by elemental analysis (CHN), IR, UV-Vis spectra, conductivity measurements, atomic absorption and magnetic susceptibility. All complexes have been showed octahedral geometry except Cu(II) complex showed square planer. Dissociation degree, stability constant and molar absorptivity (l. mol⁻¹. cm⁻¹) were calculated for all complexes. The study of biological activity for the ligand (L) and its metal complexes which was showed various activity toward staphylococcus aureus and E. Coli.

Keywords: Characterization, complexes, phenyl hydrazinyl, benzothiazole, biological study.

Introduction:
Transition metal complexes containing 3N donors are of special interest due to their applications in biomedical [1,2], biological [3,4] and asymmetrical catalysis [5,6]. Compounds with N donor atom such as 3N are considered to be good coordination ligands because they involve nitrogen atoms. The

*Email: SajadJamal82@gmail.com
importance of complexes with 3N ligands arise from use in the medical fields for therapeutic and diagnostic purposes [7,8]. One approach in the field of the design of N-N-N, ligands have to develop metal- nitrogen complexes with characteristic redox properties the intensive study of this field stems from the recognition of redox active nickel, copper, manganese and zinc- nitrogen cores along with the role of metal oxidore ductases by means of metal complexes with amine ligands [9-11]. These complexes become functional models (biomimetics) which are able to react with CO₂, CO or CH₃ moieties. As part of our continuing efforts to synthesis and characterize transition metal chelates using tridentate ligands. We describe here the synthesis and spectral investigation of new ligand N-[2-(2-phenyl hydazinyl) phenyl] benzothiazol-2-amine(L) and some of their metal complexes.

Experimental:

A: Chemicals;
All reagents were Analar or chemically pure grade by British Drug Houses (BDH), Merk and Fluka.

Materials: orthoaminohydrazobenzene (C₁₂H₁₃N₃), 2-mercapto benzothiazol (C₇H₅NS₂), Cobalt chloride hexahydrate (CoCl₂.6H₂O), Nickel chloride hexahydrate (NiCl₂.6H₂O), Copper chloride dihydrate (CuCl₂.2H₂O), Cadmium chloride dihydrate (CdCl₂.2H₂O), Mercury chloride (HgCl₂), Lead chloride pentahydrate (PbCl₂.5H₂O), Ethanol 99% (CH₃CH₂OH) Dimethylformamide 99.5% (DMF), Dimethyl sulphoxide 99.5% (DMSO), Carbon tetra chloride 99.5% (CCl₄), Chloroform 99% (CHCl₃), Toluene 99% (C₇H₈).

B: Instruments;
Elemental analysis for the new ligand (L) and complexes were determined by calibration type; Linear Regression Euro EA Elemental analysis were made in Babal University. Melting points were determined by Gallen-Kamp apparatus. ¹H, ¹³C-NMR spectra were recorded in DMSO using Burker model; Ultrashield 300 MHz origin, Switzerland (Jordan) in CH₃OD using TMS as an internal standard. IR spectra were recorded as KBr discs in the range (4000- 400) cm⁻¹ using shimadzu- FTIR. UV-visible spectra were recorded by shimadzu- UV-Vis. 160 A ultra violet spectra photometer at 25 °C, using 1 cm quartz cell and examined at the range at (200- 1100) nm at 10⁻³ M in DMSO. Atomic Absorption (A.A) technique have been measurement using shimadzu AA 680G atomic absorption spectrophotometer were made in center of Ibn- Cina. Moalr conductivity of the complexes were measured on pw 9526 digital conductivity in DMSO at 10⁻³ M. Magnetic susceptibility were recorded by magnetic susceptibility blance, model, Ms B-mk; at Al- Nahrain University.

Preparation of the Ligand (L):
Synthesis of N-[2-(2-phenyl hydrazine) phenyl] benzothiazol-2-amine(L). orthoaminohydrazobenzene (0.199gm, 1.00 mmol) in ethanol (10 cm³) was added to a solution of 2-mercaptobenzothiazole (0.167gm, 1.000 mmol) in ethanol (10 cm³). The resulting mixture was stirred at room temperature and then followed by refluxing for 6 hours. The precipitate was filtered and recrystallized from hot absolute ethanol, fine brown crystals were obtained, m.p. 72 °C, yield 70%, soluble in most organic solvents as indicated in Table-1.

Preparation of the Metal Complexes (General Procedure):
An ethanolic solution of the following metal salts [CoCl₂.6H₂O (0.24 gm. 1.00 mmol), NiCl₂.6H₂O (0.24gm. 1.00 mmol), CuCl₂.2H₂O (0.10gm. 1.00 mmol), CdCl₂.2H₂O (0.22gm. 1.00 mmol), HgCl₂ (0.27gm. 1.00 mmol) and PbCl₂.5H₂O (0.27gm 1.00 mmol)] were added to a solution of the ligand (L) (0.33 gm. 1.00 mmol) in ethanol. The mixture was stirred for 40 min. The precipitate was filtered, washed with distilled water and dried under Vacuum.
Results and Discussion:
Color, melting point, % yield, atomic absorption analysis and solubility of the ligand and its metal complexes are given in Table-1. Spectroscopic data of the metal complexes indicate that the metal ions are coordinated to the nitrogen, nitrogen and nitrogen atoms.

Table 1 - Some physical properties for the ligand (L) and its metal complexes

<table>
<thead>
<tr>
<th>NO</th>
<th>Compound</th>
<th>mool. and gm</th>
<th>Mol. Formula (M.W)</th>
<th>Color</th>
<th>m.p. oC (dec.)</th>
<th>Yield %</th>
<th>Elemental analysis Found (calculated)</th>
<th>Solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C%</td>
<td>H %</td>
</tr>
<tr>
<td>1</td>
<td>(L)C19H16N4S</td>
<td>1.00 0.33</td>
<td>C19H16N4S (332g. mol⁻¹)</td>
<td>Brown</td>
<td>70-72</td>
<td>72</td>
<td>68.65 (68.67)</td>
<td>4.79 (4.81)</td>
</tr>
<tr>
<td>2</td>
<td>[Co(L)Cl₂H₂O]</td>
<td>1.00 0.24</td>
<td>C19H18N4OSCl²Co (480g. mol⁻¹)</td>
<td>Violet</td>
<td>102-104</td>
<td>65</td>
<td>47.49 (47.50)</td>
<td>3.7 (3.75)</td>
</tr>
<tr>
<td>3</td>
<td>[NiLCl₂H₂O]</td>
<td>1.00 0.24</td>
<td>C19H18N4OSCl²Ni (479.7g. mol⁻¹)</td>
<td>Green</td>
<td>204-206</td>
<td>58</td>
<td>47.50 (47.51)</td>
<td>3.73 (3.75)</td>
</tr>
<tr>
<td>4</td>
<td>[CuLH₂O]Cl²</td>
<td>1.00 0.24</td>
<td>C19H18N4OSCuCl² (484g. mol⁻¹)</td>
<td>Blue</td>
<td>130-132</td>
<td>72</td>
<td>47.89 (47.90)</td>
<td>3.763 (3.719)</td>
</tr>
<tr>
<td>5</td>
<td>[CdLCl₂H₂O]</td>
<td>1.00 0.22</td>
<td>C19H18N4OSCl²Cd (533.4g. mol⁻¹)</td>
<td>Light yellow</td>
<td>178-180</td>
<td>76</td>
<td>36.70 (36.71)</td>
<td>2.67 (2.89)</td>
</tr>
<tr>
<td>6</td>
<td>[HgLCl₂H₂O]</td>
<td>1.00 0.27</td>
<td>C19H18N4OSCl²Hg (621.5g. mol⁻¹)</td>
<td>Dark green</td>
<td>198-200</td>
<td>76</td>
<td>36.30 (36.30)</td>
<td>2.85 (2.86)</td>
</tr>
<tr>
<td>7</td>
<td>[PbLCl₂H₂O]</td>
<td>1.00 0.27</td>
<td>C19H18N4OSCl²Pb (628g. mol⁻¹)</td>
<td>Light yellow</td>
<td>222(dec)</td>
<td>64</td>
<td>36.30 (36.30)</td>
<td>2.85 (2.86)</td>
</tr>
</tbody>
</table>

Dec.=Decomposition

1. ¹H- NMR Spectrum for the Ligand (L):
The ¹H-NMR spectrum for the new ligand (L) in DMSO-d₆, Figure (1) is showed six signals, the first three signals at (m, 8H, δ= 7.04- 7.59 ppm) and (d, t, 5H, δ= 6.45- 6.77 ppm) which are due to aromatic protons. The other signal at (s, 3H, δ= 5.44 ppm) which are due to protons of (N-H) group [12,13].

![Figure 1- The ¹H-NMR spectrum of the ligand (L)](image)

2. ¹³C-NMR spectrum for the Ligand (L):
¹³C-NMR of the free ligand shows the signals of the C_aromatic carbon of the benzene ring at (150.15, 146.23, 136.02, 129.83, 127.44 and 124.54 ppm) and signals at (122.00, 117.20, 116.72, 115.33, 113.21 and 112.87) assigned to the carbon have one hydrogen. Signal at (174.57 ppm) is due to (S–C=N) while the signal at (131.63 ppm) is due to (C–S−) [14,15].
3. The Infrared Spectrum of the Ligand (L) and Complexes:

The infrared spectrum of the ligand in the solid state does not contain the υ(S–H) which appears in the starting material 2-mercaptobenzothiazole at (2600- 2500) cm⁻¹ region. Furthermore new bands were observed at (3070) cm⁻¹ due to υ(C–H) aromatic. Band in the (3300) cm⁻¹ is due to υ(N–H) groups [16]. Another bands at (1611) cm⁻¹, (1012) cm⁻¹ and (752) cm⁻¹ are assigned to υ(C=N) and υ(C–N) + υ(C–S) respectively [17]. Infrared spectra have been used to determine whether coordination occurs through the (–NH) and (C–N) or only through (–NH) in ligand (L) [18].

The infrared spectra of all complexes showed the multi bands in the range (3281– 3210) cm⁻¹ are change in shape and broad indicate υ(N-H)group [19].The band at (1450) cm⁻¹is due to υ(N-N) streatching vibration for the ligand but in the complexes were at (1456) cm⁻¹, (1473)cm⁻¹, (1431)cm⁻¹, (1448)cm⁻¹,(1431)cm⁻¹ and ( 1447)cm⁻¹ for the complexes Co (II) , Ni (II) , Cu (II) , Cd (II) , Hg (II) and Pb (II) respectively. Bands (M–N) in the region (515– 501) cm⁻¹ suggesting the coordination through nitrogen atom [20]. The bands characteristic of coordination water and (M–O) are seen in all complexes in the region (3344,817, 569) cm⁻¹ for Co(II) , ( 3377,819,560)cm⁻¹ for Ni(II) , ( 3346,819, 563)cm⁻¹ for cu(II) , (3375,815,560)cm⁻¹ for Cd(II) , (3340, 810,569)cm⁻¹ for Hg(II)and ( 3381, 812,554)cm⁻¹for Pb(II) [21].
Table 2- Characteristic some stretching vibration frequencies (cm$^{-1}$) for the ligand and its metal complexes

<table>
<thead>
<tr>
<th>No.</th>
<th>Compound</th>
<th>$\nu$(N-H) cm$^{-1}$</th>
<th>$\nu$(C-H) cm$^{-1}$</th>
<th>$\nu$(C-N) + $\nu$(C-S) cm$^{-1}$</th>
<th>$\nu$(C=O) cm$^{-1}$</th>
<th>$\nu$(N-N) cm$^{-1}$</th>
<th>$\nu$(M-N) cm$^{-1}$</th>
<th>$\nu$(M-X) cm$^{-1}$</th>
<th>$\nu$(OH$_2$) coord. cm$^{-1}$</th>
<th>$\nu$(M-O) cm$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(L)$_2$H$_2$NS</td>
<td>3300(s.s)</td>
<td>3182(m.s)</td>
<td>3070(m.s)</td>
<td>1012(s.s)</td>
<td>752(s.s)</td>
<td>1611(s.s)</td>
<td>1600(s.s)</td>
<td>1450(s.s)</td>
<td>501(s.s)</td>
</tr>
<tr>
<td>2</td>
<td>[Co(L)$_2$Cl$_2$H$_2$O]</td>
<td>3244(m.br)</td>
<td>3113(m.s)</td>
<td>3072(m.s)</td>
<td>1011(m.br)</td>
<td>719(m.s)</td>
<td>1609(m.s)</td>
<td>1597(s.s)</td>
<td>1455(s.s)</td>
<td>424(s.s)</td>
</tr>
<tr>
<td>3</td>
<td>[Ni(L)$_2$Cl$_2$H$_2$O]</td>
<td>3248(s.s)</td>
<td>3147(m.s)</td>
<td>3060(m.s)</td>
<td>1016(c.s)</td>
<td>746(c.s)</td>
<td>1594(c.s)</td>
<td>1572(sh)</td>
<td>1473(s.s)</td>
<td>510(m.s)</td>
</tr>
<tr>
<td>4</td>
<td>[Cu(L)$_2$H$_2$O]Cl$_2$</td>
<td>3210(m.br)</td>
<td>3112(m.s)</td>
<td>3062(m.s)</td>
<td>1014(c.s)</td>
<td>746(c.s)</td>
<td>1610(s.s)</td>
<td>1600(s.s)</td>
<td>1431(s.s)</td>
<td>515(s.s)</td>
</tr>
<tr>
<td>5</td>
<td>[Cd(L)$_2$Cl$_2$H$_2$O]</td>
<td>3275(m.br)</td>
<td>3120(m.s)</td>
<td>3061(m.s)</td>
<td>1014(m.s)</td>
<td>750(c.s)</td>
<td>1610(s.s)</td>
<td>1600(m.s)</td>
<td>1448(s.s)</td>
<td>511(m.s)</td>
</tr>
<tr>
<td>6</td>
<td>[Hg(L)$_2$Cl$_2$H$_2$O]</td>
<td>3240(s.s)</td>
<td>3111(m.br)</td>
<td>3066(m.s)</td>
<td>1010(c.s)</td>
<td>754(c.s)</td>
<td>1610(s.s)</td>
<td>1599(s.s)</td>
<td>1431(s.s)</td>
<td>515(m.s)</td>
</tr>
</tbody>
</table>

$Ar = \text{aromatic}$, $asym = \text{asymmetric}$, $sym = \text{symmetric}$, $sh = \text{shoulder}$, $br=broad$, $m=\text{medium}$, $s=\text{strong}$, $w=\text{weak}$

4- The UV-Visible Spectra of the Ligand (L) and Complexes:
The UV-Visible spectra of the ligand (L) ($10^{-3}$ M) in dimethyl sulfoxide solution exhibited strong absorption bands at (227 nm, 44052 cm$^{-1}$) and (326 nm, 30674 cm$^{-1}$) this may attributed to the $\pi-\pi^*$ and $\pi-\pi^*$ transition respectively [22].

Figure 4- Infrared spectrum of the [NiLCl$_2$H$_2$O] complex

Figure 5- UV-Visible spectrum of ligand (L)
The UV-Visible spectrum for Co(II) complex showed two bands in the region (800 nm, 12500 cm\(^{-1}\)) due to \(4T_{1g} \rightarrow 4A_{2g}(F)\), and (650 nm, 15384 cm\(^{-1}\)) due to \(4T_{1g} \rightarrow 4T_{1g}(P)\) \[23\]. The U.V-Visible spectrum of Ni(II) showed two bands at (835 nm, 11976 cm\(^{-1}\)) is due to \(3A_{2g} \rightarrow 3T_{2g}\) and (611 nm, 16366 cm\(^{-1}\)) due to \(3A_{2g}(F) \rightarrow 3T_{1g}(F)\). Cu(II) complex appeared band at (465 nm, 21505 cm\(^{-1}\)) is due to \(2B_{1g} \rightarrow 2E_g\). The UV-Visible spectrum for Cd(II), Hg(II) and Pb(II) complexes showed shifted bands compared with free ligand (L) are due to charge-transfer.

![Figure 6- UV-Visible spectrum of the [CoLCl\(_2\)H\(_2\)O] complex](image)

The molar conductance were measured in DMSO solvent and concentration (10\(^{-3}\) M) at room temperature. The molar conductance values of the synthesized complexes were at the range (63.24–16.23 ohm\(^{-1}\).cm\(^2\).mol\(^{-1}\)). These results show that the complexes (Co\(^{II}\), Ni\(^{II}\), Cd\(^{II}\), Hg\(^{II}\) and Pb\(^{II}\)) are non electrolyte, while the complex of (Cu\(^{II}\)) is ionic nature in the (2:1) ratio \[24\]. The magnetic moments measurements for the solid Co\(^{II}\) complex is also indicative of three unpaired electrons per Co\(^{II}\) ion suggesting consistency with their octahedral environment. Ni\(^{II}\) complex showed the magnetic moment value of (3.05) B.M (Octahedral range) suggesting consistency with their octahedral environment. The magnetic susceptibility measurements of Cu\(^{II}\) complex is (1.91) B.M., which suggests the presence of one unpaired electron with square planer configuration \[25\]. Electronic spectral data, conductivity and magnetic moments are give in Table-3.

<table>
<thead>
<tr>
<th>NO.</th>
<th>Compound</th>
<th>(\lambda_{(nm)})</th>
<th>Wave number (cm(^{-1}))</th>
<th>Assignment Bands</th>
<th>(\varepsilon_{\text{max}}) (L.mol(^{-1}).cm(^{-1}))</th>
<th>(\Lambda) ohm(^{-1}).cm(^{-2}).mol(^{-1}) DMSO (10(^{-3}) M)</th>
<th>(\mu_{\text{eff, B.M.}})</th>
<th>Suggested structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>[L]C(_5)H(_4)N(_4)S</td>
<td>(227)</td>
<td>44052</td>
<td>(\pi \rightarrow \pi^*)</td>
<td>1010</td>
<td>511</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>[CoLCl(_2)H(_2)O]</td>
<td>(260)</td>
<td>38461</td>
<td>L. F</td>
<td>1644</td>
<td>1110</td>
<td>20.11</td>
<td>4.57</td>
</tr>
<tr>
<td>3</td>
<td>[NiLCl(_2)H(_2)O]</td>
<td>(270)</td>
<td>37037</td>
<td>L. F</td>
<td>1231</td>
<td>1102</td>
<td>16.23</td>
<td>3.05</td>
</tr>
<tr>
<td>4</td>
<td>[CuLH(_2)OCl(_2)]</td>
<td>(255)</td>
<td>39215</td>
<td>L. F</td>
<td>1320</td>
<td>546</td>
<td>63.24</td>
<td>1.91</td>
</tr>
<tr>
<td>5</td>
<td>[CdLCl(_2)H(_2)O]</td>
<td>(350)</td>
<td>30959</td>
<td>L. F</td>
<td>1221</td>
<td>901</td>
<td>17.33</td>
<td>Dia</td>
</tr>
<tr>
<td>6</td>
<td>[HgLCl(_2)H(_2)O]</td>
<td>(309)</td>
<td>32362</td>
<td>L. F</td>
<td>2460</td>
<td>1792</td>
<td>20.57</td>
<td>Dia</td>
</tr>
<tr>
<td>7</td>
<td>[PbLCl(_2)H(_2)O]</td>
<td>(338)</td>
<td>29585</td>
<td>L. F</td>
<td>983</td>
<td>156</td>
<td>18.15</td>
<td>Dia</td>
</tr>
</tbody>
</table>

**Table 3-** Electronic spectra (DMSO), conductance in DMSO and magnetic moment (B.M) for the ligand (L) and its metal complexes

**Calculation of Co(II) and Ni(II) Metal Complexes Formation in Solution:**

The complexes of the ligand (L) with selected metal ions Co(II) and Ni(II) were studied in solution using ethanol as solvent, in order to determine (M:L) ratio in the prepared complexes, following molar ratio method \[26\]. A series of solution were prepared having a concentration (C) 10\(^{-3}\) M of the
hydrated metal salts and the ligand (L). The (M:L) ratio was determined from the relationship between the absorption of the observed light and the mole ratio (M:L) which was found to be (1:1) for all complexes.

The stability constant \(K_f\) was evaluated using the following equations:

\[
K_f = \frac{1 - \alpha}{\alpha^2 c}
\]  

\(\alpha = \frac{A_m - A_s}{A_m}\)  

\((\alpha)\) is the degree of the dissociation, (C) is the concentration of the complex \((10^{-3}\,\text{M})\). (As) and (Am) are the absorbance value of the partially and fully formed complex respectively Table-4. The absorbance of the solutions were measured at \((\lambda_{\text{max}})\) of the maximum absorption. The molar absorptivity \((\varepsilon_{\text{max}})\) (eq. 3) has been calculated using equation:

\[
\text{A} = \varepsilon_{\text{max}} \times \text{b} \times \text{C}
\]

\((\text{A})\) is the average of three measurement of the absorption containing the same amount of metal ion and three fold excess of ligand [27]. \((\text{b})\) is the depth of the quartz cell usually equal 1 cm.

The free energy \((\Delta G)\) was evaluated using the following equations;

\[
\Delta G = -2.303 RT \log K_f
\]

\(R = 8.303\) and \(T = 273+25 = 298\,\text{k}\).

\[
\text{(1)} \quad K_f = 1 - \frac{\alpha}{\alpha^2 c}
\]

\[
\text{(2)} \quad \alpha = \frac{A_m - A_s}{A_m}
\]

\[
\text{(3)} \quad \text{A} = \varepsilon_{\text{max}} \times \text{b} \times \text{C}
\]

\[
\text{(4)} \quad \Delta G = -2.303 RT \log K_f
\]

**Table 4- Stability constant and \(\Delta G\) for the Co(II) and Ni(II) complexes**

<table>
<thead>
<tr>
<th>No.</th>
<th>Compound</th>
<th>As</th>
<th>Am</th>
<th>(\alpha)</th>
<th>Formation constant ((K_f))</th>
<th>(\log K_f)</th>
<th>(1/K_f)</th>
<th>(\Delta G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Co-complex</td>
<td>1.950</td>
<td>2.404</td>
<td>0.19</td>
<td>(22\times10^9)</td>
<td>4.3</td>
<td>0.23</td>
<td>-24.5</td>
</tr>
<tr>
<td>2</td>
<td>Ni-complex</td>
<td>1.755</td>
<td>2.403</td>
<td>0.27</td>
<td>(1\times10^9)</td>
<td>4</td>
<td>0.25</td>
<td>-22.7</td>
</tr>
</tbody>
</table>

\(\text{M= Co(II)},\text{Ni(II)},\text{Cd(II)},\text{Hg(II)}\) and \(\text{Pb(II)}\)  

![Figure 7- Suggested structures of the metal complexes of the ligand (L).](image)
Antibacterial Activity Study:

The antibacterial activity of the prepared ligand and its complexes were studied against selected types of microorganisms which include gram positive bacteria like *Staphylococcus aureus* and gram negative bacteria like *E. coli* in agar diffusion method [28], which is used (DMSO) as a solvent. Agar diffusion method involves the exposure of the zone of inhibition toward the diffusion of microorganisms on agar plate. The plates were incubated for (24) hrs. at (37 °C), the zone of inhibition of bacterial growth around the disc was observed Table-5.

Table 5- Effect of ligand and its complexes on gram positive and gram negative bacteria.

<table>
<thead>
<tr>
<th>No.</th>
<th>Compound</th>
<th>Staphylococcus aureus</th>
<th>E. Coli</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Diameter of inhibition zone (mm) at concentration 1mg/ml</td>
<td>Diameter of inhibition zone (mm) at concentration 5mg/ml</td>
</tr>
<tr>
<td>1</td>
<td>(L)C₈H₇N₂S</td>
<td>18.4</td>
<td>20.2</td>
</tr>
<tr>
<td>2</td>
<td>[CoLCl₂H₂O]</td>
<td>16.1</td>
<td>17.0</td>
</tr>
<tr>
<td>3</td>
<td>[NiLCl₂H₂O]</td>
<td>15.2</td>
<td>16.2</td>
</tr>
<tr>
<td>4</td>
<td>[CuL₂H₂O]Cl₂</td>
<td>16.2</td>
<td>18.6</td>
</tr>
<tr>
<td>5</td>
<td>[CdLCl₂H₂O]</td>
<td>14.4</td>
<td>15.5</td>
</tr>
<tr>
<td>6</td>
<td>[HgLCl₂H₂O]</td>
<td>13.2</td>
<td>14.2</td>
</tr>
<tr>
<td>7</td>
<td>[PbLCl₂H₂O]</td>
<td>15.0</td>
<td>16.2</td>
</tr>
</tbody>
</table>

Antibacterial effects of the ligand and its metal complexes indicated that the ligand and its metal complexes exhibited antibacterial activity against both gram positive and gram negative bacteria, Table-5.

Conclusion:

A series of complexes of Co(II), Ni(II), Cu(II), Cd(II), Hg(II) and Pb(II) with N-[2-(2-phenylhydrazinyl) phenyl] benzothiazol-2-amine (L) have been prepared and characterized. The tridentate ligand (L) (N,N,N) is binding with metal ions forming octahedral structure except with Cu(II) is forming square planer.

References:


