Synthesis and Characterization of some antibacterial active transition metal complexes of 4,5-diphenyl-N-[2-(2-phenyl hydrazinyl)-phenyl]-1,2,4-triazole-3-amine

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ABSTRACT

was prepared from the reaction of ortho )-1,2,4-triazole-3-amine (L)[2-(2-phenyl hydrazinyl)phenyl][A new ligand 4,5-diphenyl-N-aminohydrazo benzene with 2-mercapto-5-phenyl-1, 3, 4-benz triazole in mole ratio (1:1). The prepared ligand characterized by Micro elemental Analysis, FT-IR, UV-Vis, and 1H,13C-NMR spectroscopy. The reaction of metal chlorides [Co(II), Ni(II), Cu(II),Hg(II) and pb(II)] with the new ligand in ethanol results the formation of deep colored metal complexes with the formula [M=[Co, Ni, Hg and Pb)] [MLCl4(H2O)], M= Cu(II) respectively. The free ligand and its metal complexes were characterized by elemental analysis (CHN), IR, UV-Vis spectra, conductivity measurements, and magnetic susceptibility and NMR (only ligand) spectral data. The physical measurements FTIR and UV-Vis spectral data showed that most of the complexes contain octahedrally coordinated central ion (II) except the square planar copper complex. The complexes showed characteristic behavior of octahedral geometry around the metal ions except Cu(II)complex showed square planer. The study biological activity of ligand (L) and its complexes showed various activity toward staphlococcus aureus and E. coli.

KEYWORDS: phenyl hydrazinyl, benzo triazole, complexes, antibacterial study.

INTRODUCTION

Triazoles are five membred heterocyclic compounds containing three nitrogen and two carbon atoms[1] The name triazoles was first given to the carbon nitrogen ring system C3N3H3 by Bladin who described its derivatives in early 1885, although the structures reported slightly incorrect. [2]. Triazole compounds are important structural fragments and serve as key synthetic intermediates in many considered industrial applications such as such as agrochemicals, optical brighteners, photostabilizers, pigments and metal chelators, corrosion pesticides [6], inhibitors [7], pesticides [8], dyes [9], polymersacid base indicator [10], detergents, and material sciences and other industrial chemicals [11]. They have been incorporated into a wide variety of therapeutically interesting drug candidates including antifungal, anti-inflammatory, diuretic, anti-HIV, CNS stimulants sedatives, hypoglycemic, antianxiety, analgesic, antimicrobial, antitubercular, antitubercular agent's and anticancer activity[ 12-17]. They are found to be effective amide surrogates in bioactive molecules because of the large dipole, H-bonding capabilities, and remarkable metabolic stabilities towards enzymatic
degradation and the pharmacological properties such as fluconazole, intraconazole, voriconazole.[18] The 1,2,4-triazole is an ubiquitous feature of many pharmaceutical and agrochemical products. The substituted 1,2,4-triazole nucleus is particularly common, and can be found in marketed drugs such as fluconazole, terconazole, and rizatRIPTANOL.[19] Urease is an enzyme that catalyzes the hydrolysis of urea to ammonia and carbamate, which is the final step of nitrogen metabolism in living organisms. [20] Carbamate rapidly and spontaneously decomposes, yielding a second molecule of ammonia. [21] These reactions may cause significant increase in pH and are responsible for negative effects of urease activity in human health and agriculture. [22]. According to above observation attempt to synthesis a new chelate ligand was done. [23] In present work, a series of new triazole compound 4,5-diphenyl-N-[2-(2-phenyl hydrazinyl)phenyl]-1,2,4-triazole-3-amine ethanol solvate with (Co(II), Ni(II), Cu(II), Hg(II) and Pb(II) ions were synthesized, structurally characterized and biological activity were investigated.

MATERIALS AND METHODS

A: Chemical:
All reagents used were annular or chemically pure grade by British Drug Houses (BDA), Merk and Fluka. Materials, ortho Amino Hydrazone Benzene(C6H5;N), 2-mercapto-5-phenyl-1,3,4-benzotriazole(C6H3(N-S)), Cobalt chloride hexahydrate (CoCl2, 6H2O), Nickel Chloride hexahydrate (NiCl2,6H2O), Copper Chloride dihydrate (CuCl2,2H2O), Mercury Chloride (HgCl2), Lead Chloride pentahydrate (PbCl2.5H2O), Ethanol 99% (CH3CH2OH), Dimethyl formamide 99.5% (DMF), Dimethyl sulfoxide 99.5% (DMSO), carbon tetrachloride 99.5% (CCl4), Chloroform 99% (CHCl3), Toluene 99% (C6H6).

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 Babel University. Melting point were determined by Gallen-Kamp apparatus. 1H, 13C- NMR spectra were recorded in DMSO using Burkert model: Ultrashield 300MHZ origin, Switzerland (Jordan) in CH3OD using TMS as an internal standard. IR spectra were recorded as KBrs discs in the rang (4000-400) cm-1 using shimadzu –FTIR. UV-visible spectra were recorded by shimadzu (UV – Vis. 160A) ultra violet spectra spectrometer at 25°C, using 1cm quartz cell and examined at the range of (200-1100)nm at 10-3 M in DMSO. Atomic absorption (A.A) technique meter were made in center of Ibn- Cina. Molar conductivity of the complexes were measured on pw 9526digital conductivity in DMSO at 10-3M. Magnetic susceptibility were determined by magnetic susceptibility balance, made, Ms-BmKI and made in Al-Nahrain University.

Preparation:
Synthesis of 4,5-diphenyl-N-[2-(2-phenyl hydrazinyl)phenyl]-1,2,4-triazole-3-amine(L): ortho amino hydrazo benzene (0.199 gm, 1.00mmol) in ethanol (5 cm3) was added to a solution of 2-mercapto-5-phenyl-1,3,4-benzotriazole (0.253 gm, 1.00 mmol) in ethanol(5 cm3). The resulting mixture was stirred at room temperature and then followed by refluxing for 5 hours. The precipitate were filtered and recrystallized from hot absolute ethanol, fine dark brown crystals were obtained m.p 98°C, yield 68%, soluble in most organic solvent as indicated in Table (1).

Synthesis of the metal complexes:
An ethanolic solution of the following metal salts was [CoCl2,6H2O (0.24 gm,1.00mmol),NiCl2,6H2O(0.24gm,1.00mmol),CuCl2,2H2O(0.10gm1.00 mmol),HgCl2 (0.27 gm 1.00 mmol) and PbCl2,5H2O (0.27 gm,1.00 mmol)] were added to a solution of the ligand (L) (0.41 gm,1.00 mmol ) in ethanol. The mixture was stirred for 1 hour. The precipitate formed was filtered, washed with distilled water and
dried under vacuum. Color, melting point, yield, metal analysis and solubility of the ligand and its metal complexes are given Table (1).

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Compound</th>
<th>no. of mole and gm</th>
<th>Mol. formula (M.W)</th>
<th>Color</th>
<th>m.pº or (dec.)</th>
<th>Yield %</th>
<th>Elemental analysis Found(calculated)</th>
<th>Solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(L) = C₈H₂₂N₆</td>
<td>1.00 0.41</td>
<td>C₂₆H₂₂N₆ (418g.mol⁻¹)</td>
<td>Dark Brown</td>
<td>96-98</td>
<td>68</td>
<td>C% 74.630 (74.64 1) H% 5.191 (5.263) N% 14.621 (14.840)</td>
<td>EtOH, C HCI, 2CH₃Cl CC H₄DMF, DMSO</td>
</tr>
<tr>
<td>2</td>
<td>[CoLCl₂H₂O]</td>
<td>1.00 0.24</td>
<td>C₂₆H₂₂N₆OCC₂O (660g.mol⁻¹)</td>
<td>Violet</td>
<td>180-182</td>
<td>69</td>
<td>C% 55.001 (55.12 3) H% 5.990 (4.240) N% 14.621 (14.840)</td>
<td>DMF, DMF</td>
</tr>
<tr>
<td>3</td>
<td>[NiLCl₂H₂O]</td>
<td>1.00 0.24</td>
<td>C₂₆H₂₂N₆OCC₂O (565g.mol⁻¹)</td>
<td>Green</td>
<td>166-168</td>
<td>88</td>
<td>C% 54.911 (55.15 2) H% 4.221 (4.242) N% 14.923 (14.840)</td>
<td>DMF, DMF</td>
</tr>
<tr>
<td>4</td>
<td>[CuLClH₂O]</td>
<td>1.00 0.24</td>
<td>C₂₆H₂₂N₆OCC₂O (565g.mol⁻¹)</td>
<td>Blue</td>
<td>202-204</td>
<td>76</td>
<td>C% 58.214 (58.31 7) H% 4.213 (4.485) N% 15.691 (15.700)</td>
<td>DMF, DMF</td>
</tr>
<tr>
<td>5</td>
<td>[HgLCl₂H₂O]</td>
<td>1.00 0.27</td>
<td>C₂₆H₂₂N₆OCC₂O (714g.mol⁻¹)</td>
<td>Dark Brown</td>
<td>210-212 (dec)</td>
<td>74</td>
<td>C% 43.563 (43.69 7) H% 3.129 (3.361) N% 11.853 (11.744)</td>
<td>DMF, DMF</td>
</tr>
<tr>
<td>6</td>
<td>[PbLCl₂H₂O]</td>
<td>1.00 0.27</td>
<td>C₂₆H₂₂N₆OCC₂O (714g.mol⁻¹)</td>
<td>Light Green</td>
<td>192-194</td>
<td>68</td>
<td>C% 43.563 (43.69 7) H% 3.129 (3.361) N% 11.853 (11.744)</td>
<td>DMF, DMF</td>
</tr>
</tbody>
</table>

Dec. = Decomposition

RESULTS AND DISCUSSION

1-H-NMR spectrum for the ligand (L):

The 1H-NMR spectrum for the new ligand (L) in DMSO-d⁶ solvent are summarized amultiplet at (&=7.02, 7.13, 7.15, 7.33, 7.49, 7.60, 7.62, and 7.79ppm.) and a multiplet signal at (&=6.44, 6.47, 6.52 and 6.75ppm.) which are due to aromatic hydrogen and carbon respectively of ligand (L) and a triplet signal at (&= 5.42, 5.59 and 5.67 ppm.) equivalent to protons assigned to (N–H) group. A signal is appeared at higher chemical shift (69.76 ppm.) for one proton could be attributed for the electron with (N=C-NH) group [8].

Fig. 1: 1H-NMR spectrum for the ligand (L)
2-\textsuperscript{13}C-NMR spectrum for the ligand (L):
\textsuperscript{13}C-NMR spectrum for the ligand shows the signals of the C\textsubscript{aromatic} carbon of the benzene ring that do not bear hydrogens were observed at (& 150.27- & 122.71ppm.) and a signals(&122.53-S115.30PPm)assigned to the carbon have one hydrogen. A signal at(& 150.59ppm)is due to(N=C)

![Image of NMR spectrum](image1)

Fig. 2: \textsuperscript{13}C-NMR spectrum for the ligand (L)

3- The infrared spectrum for the ligand (L) and complexes:
The infrared spectrum of the ligand in the Solid state does not contain the \(\nu(S-H)\) which appears in the starting material 2-mercapto-5- phenyl- 1,3,4-benzotriazole at (2600-2500)cm\(^{-1}\)region . Furthermore new bands were observed at (3181) cm\(^{-1}\)and (3065) cm\(^{-1}\)due to \(\nu(C-H)\)aromatic . Band in the (3300) cm\(^{-1}\) is due to \(\nu(N-H)\) groups[10]. Another bands at (1616)\textsuperscript{cm}\(^{-1}\) and (1024)\textsuperscript{cm}\(^{-1}\) are assigned to \(\nu(C=N)\) and \(\nu(C-N)\) respectively [11]. Infrared spectra have been used to determine whether coordination occurs through the (-NH) or only through (-NH)in ligand (L) 12.

![Image of infrared spectrum](image2)

Fig. 3: Infraed spectram for the ligand (L).

The infrared spectra of all complexes showed the multi bands in the range (3264-3210)cm\(^{-1}\)are change in shape and broad indicate \(\nu(N-H)\)group [13]. The band at (1464)\textsuperscript{cm}\(^{-1}\) is due to \(\nu(N-N)\)stretching vibration for the ligand but in the complexes were at (1456)\textsuperscript{cm}\(^{-1}\),(1474)\textsuperscript{cm}\(^{-1}\), (1473)\textsuperscript{cm}\(^{-1}\), (1475)\textsuperscript{cm}\(^{-1}\) and (1473)\textsuperscript{cm}\(^{-1}\) for the complexes Co(II), Ni(II), Cu(II),Hg(II) and pb(II) respectively[14]. Bands (M-N) in the region (510-501) cm\(^{-1}\)suggesting the coordination through nitrogen atom [15]. The bands characteristic of coordination water and (M-O) are seen in all complexes in the region (3345,815,569)cm\(^{-1}\)for Co(II), (3419,827,551)cm\(^{-1}\)for Ni (II), (3390,825,560)cm\(^{-1}\) for Cu(II),(3380,810,550) cm\(^{-1}\) for Hg (II) and (3366, 850,540) cm\(^{-1}\) for pb (II) [16].
Table 2: characteristic stretching vibration frequencies (cm\(^{-1}\)) for the ligand and its complexes

<table>
<thead>
<tr>
<th>No</th>
<th>Compound</th>
<th>(\nu(N-H)) cm(^{-1})</th>
<th>(\nu(C-H)) cm(^{-1}) Ar.</th>
<th>(\nu(C-H)) cm(^{-1}) aromatic</th>
<th>(\nu(N-N)) cm(^{-1})</th>
<th>(\nu(M-N)) cm(^{-1})</th>
<th>(\nu(M-X)) cm(^{-1})</th>
<th>(\nu(O-H)) cm(^{-1})</th>
<th>(\nu(M-O)) cm(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(LCl_2H_2O)</td>
<td>3300 (s.s)</td>
<td>3115 (s.s)</td>
<td>3065 (m.s)</td>
<td>3024 (s.s)</td>
<td>1584 (m.s)</td>
<td>1464 (s.s)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>([CoLCl_2H_2O])</td>
<td>3210 (m.br)</td>
<td>3115 (s.s)</td>
<td>3065 (m.s)</td>
<td>3024 (s.s)</td>
<td>1584 (m.s)</td>
<td>1464 (s.s)</td>
<td>419 (s.s)</td>
<td>3305 (m.s)</td>
</tr>
<tr>
<td>3</td>
<td>([NiLCl_2H_2O])</td>
<td>3210 (s.s)</td>
<td>3115 (s.s)</td>
<td>3065 (m.s)</td>
<td>3024 (s.s)</td>
<td>1584 (m.s)</td>
<td>1464 (s.s)</td>
<td>419 (s.s)</td>
<td>3305 (m.s)</td>
</tr>
<tr>
<td>4</td>
<td>([CuLCl_2H_2O])</td>
<td>3210 (s.s)</td>
<td>3115 (s.s)</td>
<td>3065 (m.s)</td>
<td>3024 (s.s)</td>
<td>1584 (m.s)</td>
<td>1464 (s.s)</td>
<td>419 (s.s)</td>
<td>3305 (m.s)</td>
</tr>
<tr>
<td>5</td>
<td>([HgLCl_2H_2O])</td>
<td>3210 (s.s)</td>
<td>3115 (s.s)</td>
<td>3065 (m.s)</td>
<td>3024 (s.s)</td>
<td>1584 (m.s)</td>
<td>1464 (s.s)</td>
<td>419 (s.s)</td>
<td>3305 (m.s)</td>
</tr>
<tr>
<td>6</td>
<td>([PbLCl_2H_2O])</td>
<td>3210 (s.s)</td>
<td>3115 (s.s)</td>
<td>3065 (m.s)</td>
<td>3024 (s.s)</td>
<td>1584 (m.s)</td>
<td>1464 (s.s)</td>
<td>419 (s.s)</td>
<td>3305 (m.s)</td>
</tr>
</tbody>
</table>

Ar=aromatic, br=broad, m=medium, s=strong, w=weak.

4- Electronic spectral, magnetic moments and conductivity measurements:

The UV-visible spectra of the ligand (L) (10\(^{-3}\)M) in dimethyl sulfoxide solution exhibited strong absorption bands at (267 nm, 3745 cm\(^{-1}\)) and (327 nm, 3058 cm\(^{-1}\)) this may attributed to the \(\pi-\pi^*\) and \(n-\pi^*\) transition respectively[16].

The UV-visible spectra for Co\(^{II}\) complex showed two bands in the region (800 nm, 12500 cm\(^{-1}\)) due to \(^{4}T_{1g} \rightarrow {^{4}T_{2g}}\) and (640nm, 15625 cm\(^{-1}\)) due to \(^{4}T_{1g} \rightarrow {^{4}A_{2g}}\).[17] The UV-visible spectrum of Ni\(^{II}\) showed one band at (850nm, 11764cm\(^{-1}\)) is due to \(^{3}A_{2g} \rightarrow {^{3}T_{1g}}\).[18] Cu\(^{II}\) complex appeared band at (468nm, 21367 cm\(^{-1}\)) is due to \(^{2}B_{1g} \rightarrow {^{2}B_{2g}}\).[19] The UV-visible spectrum for Hg(II) and Pb(II) complexes showed shifted bands compared with free ligand (L) are due to charge-transfer.[20]
Study of Ni\(^{2+}\), Cu\(^{2+}\) complexes formation in solution:

The complexes of the ligand (L) with selected ion (Ni\(^{2+}\), Cu\(^{2+}\)) were studied in solution using ethanol as solvent, in order to determine (M:L) ratio in the prepared complexes, following molar ratio method[25]. A series of solutions were prepared having a constant(C)10\(^{-3}\) M of the hydrated metal salts and the ligand (L). The (M:L) and (M:L) ratio was determined from the relationship between the absorption of the observed light and the mole ratio (M:L) found to be (1:1) for all complexes.

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

\[
K_s = \frac{1}{\alpha/(\alpha^2 C)} \quad (1)
\]

\[
\alpha = \frac{Am}{As/Am} \quad (2)
\]

\((\alpha)\) is the degree of the dissociation, (C) is the concentration of the complex (10\(^{-3}\)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 (\(\epsilon_{\text{max}}\)) (eq. 3) has been calculated using equation:

\[
A = \frac{\epsilon_{\text{max}} \cdot b \cdot c}{\alpha} \quad (3)
\]

\((A)\) is the average of three measurement of the absorption containing the same amount of metal ion and three fold excess of ligand [26], (b) is the depth of the quartz cell usually equal 1 Cm.
Table 4: As, Am, K, $\lambda_{\text{max}}$, of the Ni$^{+2}$, Cu$^{+2}$

<table>
<thead>
<tr>
<th>No.</th>
<th>Compound</th>
<th>As</th>
<th>Am</th>
<th>$\text{A}$</th>
<th>Formation Constant ($K_f$)</th>
<th>$\lambda_{\text{max}}$ (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ni- complex</td>
<td>1.99</td>
<td>2.444</td>
<td>0.185</td>
<td>$2.359\times10^4$</td>
<td>248</td>
</tr>
<tr>
<td>2</td>
<td>Cu- complex</td>
<td>1.890</td>
<td>2.302</td>
<td>0.178</td>
<td>$2.394\times10^4$</td>
<td>266</td>
</tr>
</tbody>
</table>

*Calibration Curve:*

Varied molar concentration ($10^{-5}$–$10^{-3}$ M) of mixed ethanolic of ligand and metal ions, [27] only the concentration in the region (1-3×10^{-4}M) followed Beer’s law and appeared obvious intense color. Ideal fit straight lines were observed with correlation factor $R>0.9970$ as shown in Figure 6.

*Optimum Conditions:*

To search out the interaction between the prepared ligand and metal ions under conditions for the preparation of the complexes, the spectra of combining solutions for the ligand and metal ions to attain to optimum pH and concentration, as well as maximum wave length ($\lambda_{\text{max}}$) were researched first [28] Then mole ratio metal to ligand (M:L) was defined to synthesize the complexes. Ideal concentration was studied for complex solution observed on which solution gets the maximum absorbance at constant ($\lambda_{\text{max}}$) at different pH. The trial results evidence that the absorbance of all prepared complexes are constant and maximum in a buffer solution of ammonium acetate in the pH extent (4-9). It was given that all prepared complexes had perfect pH as is shown in Figure 7.

![Fig. 6: Linear correlation between molar concentration and absorbance.](image1)

![Fig. 7: Effect of pH on absorbance ($\lambda_{\text{max}}$) for complexes.](image2)
Fig. 8: Mole ratio and Job methods for complexes solutions.

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 streptococcus aureus and gram negative bacteria like E. coli in agar diffusion method [27-28], which is used (DMSO) as a solvent. Agar diffusion method involves the exposure of the zone of inhibition toward the diffusion of microorganisms of bacterial growth around the disc was observed. Table (5).

Table 5: Antibacterial activity of the synthesized compounds

<table>
<thead>
<tr>
<th>Compound</th>
<th>Type of bacteria</th>
<th>Eschericha coli</th>
<th>Staphylococcus aureus</th>
</tr>
</thead>
<tbody>
<tr>
<td>(L) C₆H₂N₆</td>
<td></td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>[NiLCl₂H₂O]</td>
<td></td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>[CuLCl₂H₂O]</td>
<td></td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>[HgLCl₂H₂O]</td>
<td></td>
<td>+++</td>
<td>++++</td>
</tr>
</tbody>
</table>

Where : (+) =Inhibition diameter (6-8)mm.
(+++) =Inhibition diameter (8-10)mm.
(++++) =Inhibition diameter (10-20)mm.
(+++++) =Inhibition diameter (20-30)mm.
Fig. 7: (Antibacterial activity of the synthesized compounds)

**Conclusion:**
Several new coordination compounds containing triazole were synthesized in this study. The FTIR, CHN, UV and $^1$H and $^{13}$C NMR studies for the complexes showed significant evidence of complexation 1:1 when the complexes are prepared by the reflux technique. Antibacterial effects of the ligand and its metal complexes exhibited antibacterial activity against both gram positive and gram negative bacteria. These new compounds may be used as dyes for industrial processes and they may be having effectiveness against some fungi.

**REFERENCES**


23. Jawad, K., Sheneine, Yusra H. Alaraji, Chemistry of 1, 2, 4-Triazole: A Review Article, International Journal of Science and Research

24. Raafat, M.S., 2006. The chemistry of mercapto- and thione- substituted 1, 2, 4-triazoles and their utility in heterocyclic synthesis, ARKIVOC (ix) 59-112.


