Iraqi Journal for Applied Science (IJAS)
Vol. 1, No. 3, December, 2024, pp. 1-10
ISSN: 3006-5828, DOI:10.69923/er966f98

Synthesis, characterization and biological activity of a new Schiff base oxime-imine ligand and its Zn (II) and Ni (II) complexes

Mahmood Rafid Mahmood[1] **, Abdul Salam Abdul Kareem Abdul Rahman** [2]

[1]Department of Chemistry, College of Education for Pure Sciences,
University of Diyala, Diyala, Iraq
[2]Department of Chemistry, College of Education for Pure Sciences,
University of Diyala, Diyala, Iraq

Article Information

Article history:

Received: 30, 04, 2024
Revised: 25, 08, 2024
Accepted: 05, 10, 2024
Published: 30,12, 2024

Keywords:
Schiff base
Oxime
Biological activity

Abstract

In this study, a new ligand derived from Schiff base oxime-imine, namely (3Z)-3-((2-aminophenyl) imino) butan-2-one oxime (L) was prepared by the reaction of o-phenylenediamine with diacetyl monooxime at refluxing methanol. The structure of the ligand was confirmed by elemental analysis, and spectroscopic instruments (IR, UV-Vis, ^{1}H, ^{13}CNMR and Maas spectrometry). Complexes of Zn (II) and Ni (II) metal ions with the specified ligand have been synthesized by reacting their chloride salts with the ligand in refluxing methanol, using a 1:1 mole ratio of (ligand: metal). Elemental analysis, spectroscopic techniques, magnetic moments and molar conductivity measurements confirmed the structure of the prepared complexes. The geometry of complexes was tetrahedral and square planar, for Zn (II) and Ni (II) respectively.

Corresponding Author:

Mahmood Rafid Mahmood
Department of Chemistry, College of Education for Pure Sciences,
University of Diyala
Baqubah City, Diyala Governorate, Iraq
Email: mahmoodrafid3@gmail.com

1. INTRODUCTION

Schiff base compounds contain an azomethine group (-HC=N-) and were first reported by Hugo Schiff in 1864. These compounds are also known as anils, imines, or azomethines. Typically, they are formed by the condensation of a ketone or an aldehyde with a primary amine[1]. Schiff bases are among the most widely used organic compounds. its play a vital role in coordination chemistry, due to their ability to react with a range of metal ions forming stable complexes which have applications in different fields[2]. Schiff base-oxime ligands and Their complexes which contain imine and oxime groups play a very important role in medicine as chelating therapeutics, as pharmaceutical drugs, as inhibitors of specified enzymes and used in the biosynthesis of some nitrogen oxide compounds [3, 4]. Di oximes are amphoteric ligands because of slightly basic nitrogen atoms and moderately acidic hydroxyl groups forming different structural geometries with most transition metal ions[5, 6]. In addition, oxime metal ion complexes have an excellent ability to make good coordination sites[7, 8]. Vic-Dioxime complexes are used as model compounds for examining the structure of some biological compounds such as B_{12} and coenzyme B_{12}, which have important uses in biological mechanisms [9]. Moreover, they are important in medical, industrial and analytical applications, these compounds exhibit various noteworthy attributes, such as high thermal stability, flame retardancy, and degradability. As a result, they have been widely employed in catalyst development, gas separation, and drug release industries[9, 10].

Although a large number of oximes and their transition metal ion complexes have been studied, there have been little amine-imine-oxime complexes reported [11]. Several examples of nickel Schiff base complexes have been reported, highlighting their significant functions, including their important role as catalysts in olefin epoxidation and oxidation reactions[12].

Some oxime Schiff bases and their metal complexes exhibit antibiotic, antiviral, and antitumor activities. It has been suggested that the azomethine linkage is responsible for the biological activities of Schiff bases, which include antitumor, antibacterial, antifungal, and herbicidal effects[13]. Oxime ligands can form stable biological and toxicological metal complexes with a wide range of metals. There is a growing interest in the synthesis and characterization of biologically active transition metal complexes, both within our group and in the broader research community[14].

2. METHOD

All reagents and solvents used in preparation were of reagent quality. Diacetylmonooxime, o-phenlene diamine, as well as $ZnCl_2$, $NiCl_2.6H_2O$, and CCl_4, were utilized as received without additional purification. Elemental analyses (C.H.N) were conducted using the Eager 300 for EA112. Infrared spectra were acquired using a SHIMADZU 8400S Spectrophotometer with KBr and CsI pellets. Proton and carbon-13 nuclear magnetic resonance (NMR) spectra were recorded using a Bruker 400 MHz instrument.
UV-Vis spectra were obtained using a spectrophotometer with a quartz cell of 1.0 cm path length. Magnetic susceptibilities for complexes were measured at room temperature using Sherwood Scientific equipment. Molar conductivity data for complexes were determined utilizing an A Starter 3000A apparatus.

Synthesis of (3Z)-3-((2-aminophenyl) imino) butan-2-one oxime (L). (1.05g, 8.9 mmole) of o-phenlene diamine were dissolved in 10 mL of methanol with continuous stirring. A solution of (1g, 8.9 mmole) of diacetylmonoxime was added dropwise to the solution in a round bottom flask. The mixture was refluxed for 3 hours. Then the mixture had a clear crystalline brown, which later transformed into a crystalline brown precipitate. The precipitate was filtered off, washed with 5ml of methanol, then with 3ml of cold ethanol and dried. Color: crystalline brown (Yield 0.5g, 29%), (m.p; 180-182 °C).

Synthesis of complexes

Synthesis of [LZnCl]Cl (C_1). (0.2g, 1 mmole) of (L) were dissolved in 10 ml of methanol, followed by the dissolution of (0.13g 1 mmole) of Zinc Chloride in 5 ml of methanol. The first mixture was then added to the second one under continuous stirring.
The resulting mixture was heated to (82 °C) and refluxed for 3hr. Subsequently, the mixture was filtered, washed with a few drops of methanol, and the residue was collected and dried. The weight of the residue was determined to be (0.09g). Color: Reddish brown; (Yield 0.18g, 56%), (m.p; 112-118 °C).

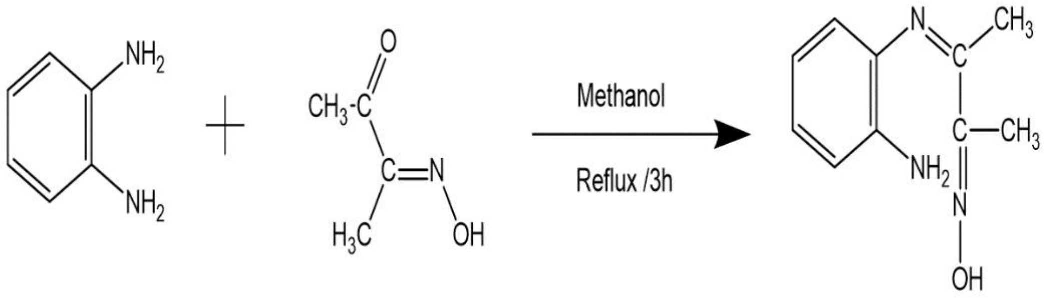
Synthesis of $LNiCl_2$. (C_2). The compound (C_2) was prepared by the same procedure as compound (**C_1**) The substance (0.24g, 1 mmole) ($NiCl_2.6H_2O$) was used instead of, (0.13g,1mmole) $ZnCl_2$.
Color: Red; (Yield 0.2g, 71%), (m.p; 313-316 °C).

Study of the biological activity. The synthesized compounds were subjected to biological activity testing against two bacterial species, namely *E. coli and S. aureus*, utilizing the diffusion method[15]. To evaluate their biological activities, three distinct concentrations of these compounds were prepared. The starting concentration was established at 100 µg/mL, and a secondary concentration was attained by dissolving a portion of the compounds in DMSO to reach 50 µg/mL. Furthermore, a third concentration of 25 µg/mL was incorporated into the testing procedure.

Preparation of Mueller Hinton Agar. For preparing this medium, 38 grams were dissolved in 1 liter of distilled water, then sterilized using an autoclave at 121°C and 15 psi for 15 minutes. Once cooled, the medium was transferred into sterile dishes and refrigerated until needed. Using a micropipette, 100 µl of the substance was added to each well separately. Sterile distilled water was used as the representation for positive and negative controls. Subsequently, the dishes were incubated at 37°C for 24 hours[15, 16].

3. RESULTS AND DISCUSSION

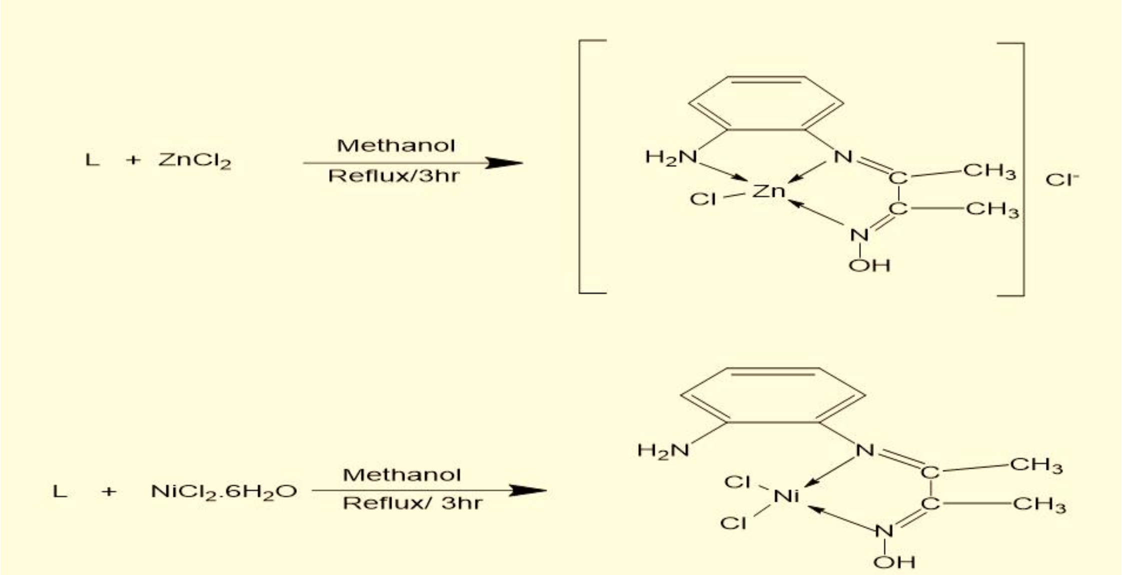
A New oxime-Imene ligand was Synthesis from the reaction of (o-phenlene diamine) according to the following procedure shown in Scheme 1. The structure of the synthesized ligand is validated through elemental analyses, showing good agreement with the calculated values (refer to Table 1), as depicted in Scheme 2.



Scheme 1. Synthesis route of the ligand

Table 1. Elemental analysis data and physical properties for ligand and its complexes

No	Molecular Formula	M.wt g/mol	Yield%	Colour	m.p°C
L	C10H13N3O	191.23	29%	crystalline brown	180-182
C1	C10H13Cl2ZnN3O	326.48	56%	Reddish brown	112-118
C2	C10H13Cl2NiN3O	319.6	71%	Red	313-316



Scheme 2. Preparation route of the Complexes

3.1. Synthesis and characterization for L and its complexes

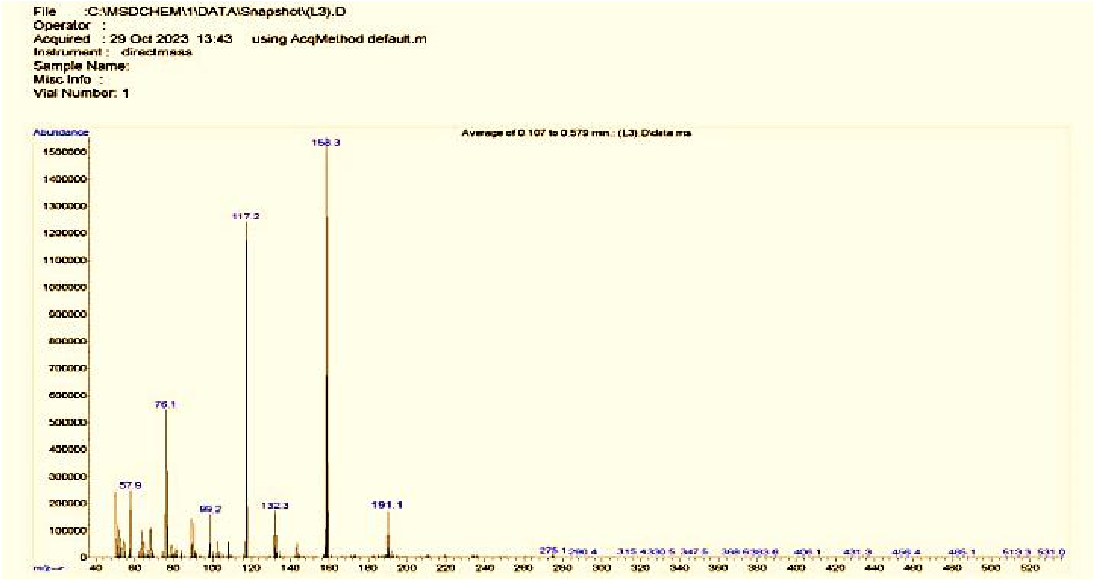
All complexes were synthesized using identical procedures. Microanalysis of the elements and metal analysis closely matched the calculated values, as shown in Table 1. Structural characterization of the complexes was achieved through spectroscopic analyses, magnetic moment measurements, and molar conductivity.

3.1.1. EI mass spectrum for ligand

EI mass spectrum of the ligand showed a parent ion peak at m/z = 191.23 corresponds to (M^+) confirming the molecular weight of the ligand, Figure (1).

3.1.2. IR spectra for the ligand L and its complexes

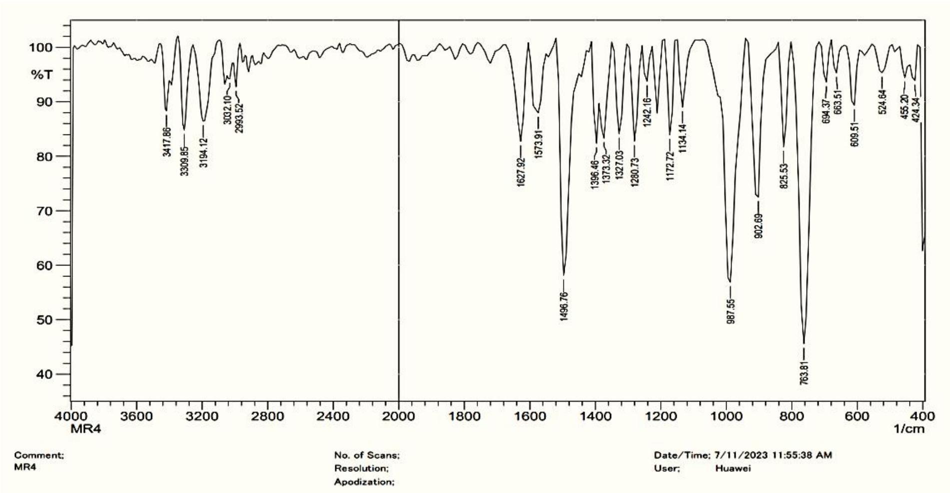
The infrared spectrum of ligand L displayed distinctive peaks. The peak at 3309 is belong to symmetric and asymmetric (N-H) stretching frequencies. The medium peak at 3417 cm^{-1} is assigned to ν(O-H) stretching frequency of the oxime group.The Peaks at 1627 and 1496 cm^{-1} are due to ν(C=N) stretching frequency of azomethine imine and oxime respectively. However, these peaks are shifted to lower frequencies in complexes and showed at the (1573-1404) cm^{-1} range. This is attributed to the participation of the nitrogen atoms of the imine and oxime group in complexation with metal ions. The peak of the ligand at 1134 cm^{-1} is belong to ν(N-O) stretching frequency.



File :C:\MSDCHEM\1\DATA\Snapshot\(L3).D
Operator :
Acquired : 29 Oct 2023 13:43 using AcqMethod default.m
Instrument : directmass
Sample Name:
Misc Info :
Vial Number: 1

Figure 1. EI mass spectrum for the Ligand

Moreover, this peak shifted to higher and lower frequencies in complexes and appeared at the (1141-1103) cm^{-1} elucidate a complexation with the ligand through the nitrogen atom of the oxime group. In addition. all the spectra of the complexes appeared further peaks at lower frequencies showed at (470-424) cm^{-1} and (223-262) cm^{-1} range belong to ν(M-N) and ν(M-Cl) stretching frequencies respectively [17, 18]. These peaks are absent in the ligand spectra see Table (2) and Figures (2,3,4).

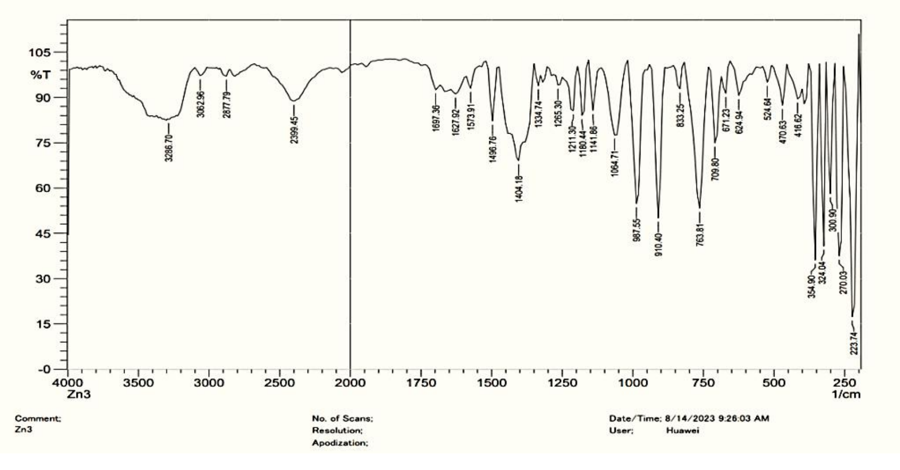


Comment:
MR4

No. of Scans:
Resolution:
Apodization:

Date/Time: 7/11/2023 11:55:38 AM
User: Huawei

Figure 2. The infrared spectrum of the Ligand



Comment:
Zn3

No. of Scans:
Resolution:
Apodization:

Date/Time: 8/14/2023 9:26:03 AM
User: Huawei

Figure 3. The infrared spectrum of [LZnCl]Cl complex

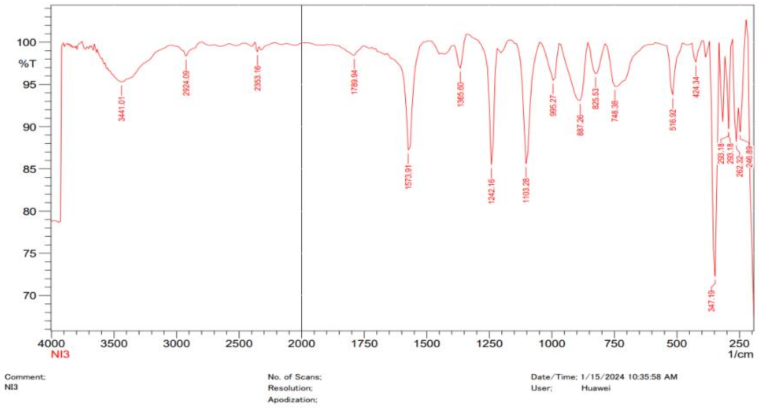


Figure 4. The infrared spectrum of $LNiCl_2$ complex

Table 2. Infrared spectra for ligand and its complexes

No	V(N-H) Assm. Ssm.	V(O-H) Oxime H_2O	V(C-H) Arom. Aliph.	V(C=N) Imine	V(C=N) Oxime	v(N-O)	V(C-H) o.o.p Arom.	V(M-N)	v(M-Cl)
L	3309m	3417w	3032w 2993w	1627s	1496m	1134m	987m	-----	-----
[LZnCl] Cl	3286w	-----	3062w 2877w	1496m	1404m	1141m	763w	470w	223m
$LNiCl_2$	3170w	3441w	3010w 2924w	1573w	1365w	1103m	995w	424w	262w

3.1.3. U.V-Vis Spectra of ligand and its complexes

U.V - Vis. The spectra of the ligand, Figure (5), appeared an intense peak at (258 nm) (38760 cm^{-1}) (E_{Max}=1839 $molar^{-1} . cm^{-1}$) and (316 nm) (31646 cm^{-1}) indicated ligand field (π→π*), (n → π*).

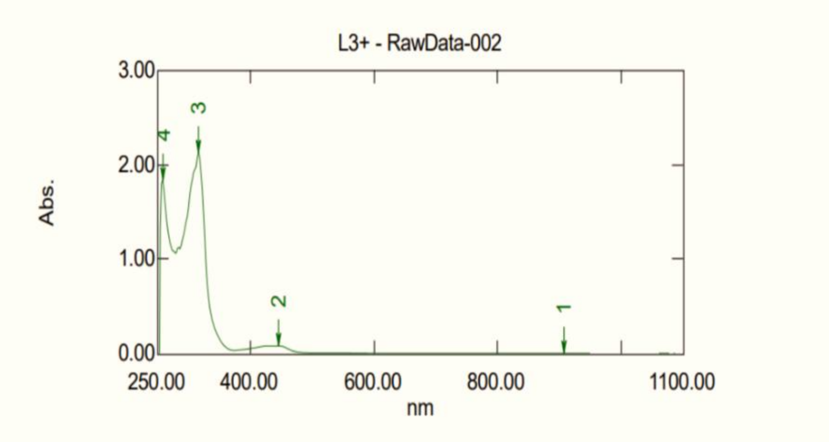


Figure 5. UV-VIS spectrum for the ligand

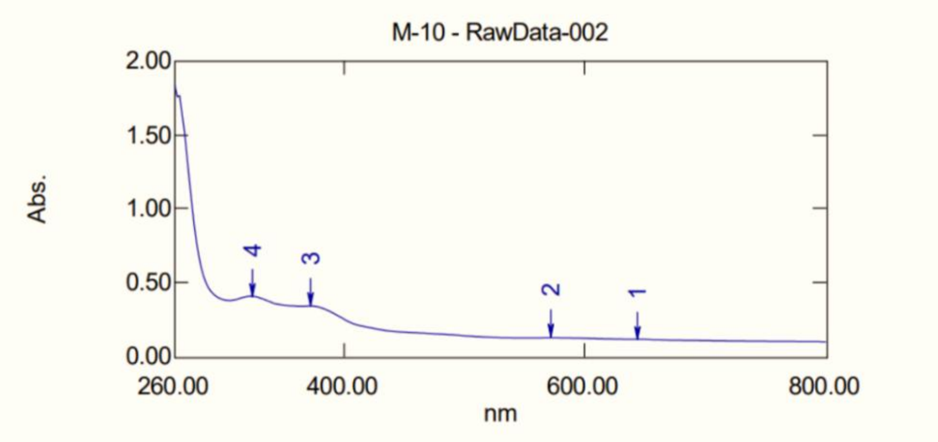


Figure 6. UV-VIS spectrum for $LNiCl_2$ complex

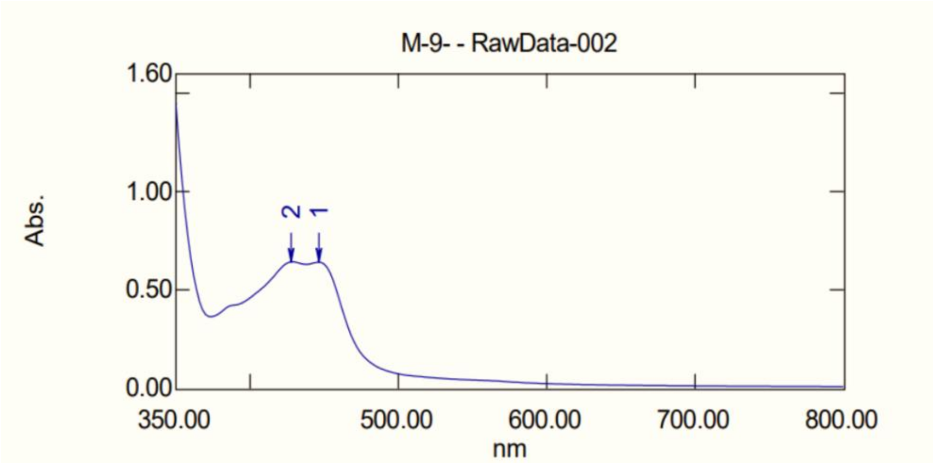


Figure 7. UV-VIS spectrum for [LZnCl]Cl complex

3.1.4. Molar conductivity

Zn (II) complex exhibited molar conductance within the (136) S·cm²·mole⁻¹, suggesting ionic behavior with a 1:1 ratio. Conversely, the Ni (II) complex displayed characteristics of a non-electrolyte [21], Table 4**.**

Table 4. The molar conductance of the complexes

COMP.	COMPLEX	Molar conductivity (S.cm^2.mole^{-1}^)
C_1	[LZn Cl]Cl	136
C_2	$LNiCl_2$	0

3.1.5. Magnetic Moments

The effective magnetic moment values for the $LNiCl_2$ complex (0.7), indicating an square planar and tetrahedral geometry around Ni(II) and Zn(II) metal ion.[19, 22]. Table (5).

Table 5. Magnetic Moment (μ_{eff} =B.M) of L complexes at 298K and suggested stereochemical structures.

Compound	μ_{eff}. B.M	Proposed Geometry
[LZnCl] Cl	diamagnetic	tetrahedral
$LNiCl_2$	0.7	Square planar

3.1.6. ^{1}HNMR spectrum for L ligand and [LZnCl] Cl complex

The spectra of the ligand in DMSO-d^6 solvent is presented in Figure (8) appeared a signal at (11.41 ppm,1H, singlet) belong to (O-H) of the oxime group. though, this signal vanished when D_2O was introduced into the solution. The aromatic protons gave a signal at (7.96-7.7 ppm,4H, multiplet). It's noteworthy, that the singlet peak at (6.55 ppm,2H, singlet) equivalent to proton is due to NH_2. However, this signal disappeared after the addition of D_2O to the solution [23].

The signals for CH_3 protons adjacent to (–C=N–OH) showed a signal at (2.66 ppm,3H, singlet), While the chemical shift for the CH_3 adjacent to C_9 emerged at (1.92 ppm,3H, singlet)[24]. furthermore, the spectra for the LZnCl] Cl complex appeared a signal as foreseeable chemical shift (11.40 ppm,1H, singlet). The signal of aromatic protons appeared at chemical shift (7.95-7.70 ppm,2H, doublet). The signal of NH_2 was shifted to a higher field and showed at (5.87 ppm,2H, singlet) attributed to complex formation. The CH_3 signal adjacent to (–C=NOH) showed at a chemical shift (2.66 ppm,3H, singlet)[25]. However, this signal was shifted to a higher field upon complexation. The signal of CH_3 adjacent to (-C=N-) appeared at (1.92 ppm,3H,singlet)[26]. All data are listed in Table (6).

Table 6. ^{1}HNMR data for the ligand and LZnCl] Cl complex

Funct. Group	δ(ppm) (Ligand)	δ(ppm) (C_1)
–C=N–OH	11.41 (s, 1H)	11.40 (s, 1H)
C–H (aromatic)	(7.7-7.96) (m, 4H)	(7.70-7.95) (m, 4H)
CH3–C=N–OH	2.66 (s, 3H)	2.67 (s, 3H)
CH3–C=N–	1.92 (s, 3H)	1.93 (s, 3H)
NH2	6.55 (s, 2H)	5.87 (s, 2H)

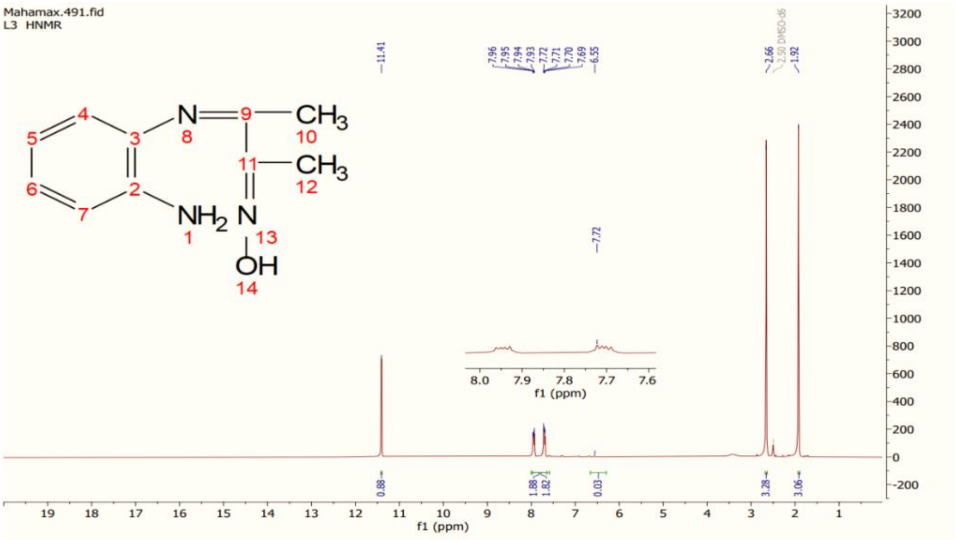


Figure 8. ^{1}HNMR spectrum of the ligand

3.1.6. ^{13}CNMR spectrum for ligand and [LZnCl] Cl complex

The spectra of the ligand, Figure (9) in DMSO-D^6 appeared a signal at 153.49 ppm belong to (-C=NOH). The signal at 152.53 ppm is due to (-C=N-). The signals at 127.51-139.90 ppm range attributed to (C_2,C_3,C_4,C_5,C_6,C_7 (aromatic). The signal of (CH_3-C=N-) showed at 22.26 ppm. In addition, the signal at 8.80 ppm is belong to (CH_3–C=NOH)[27]. The ^{13}CNMR spectra of the [LZnCl] Cl complex revealed a signal at 154.46 ppm belong for (-C=NOH). However, this signal is shifted to downfield upon complexation. The signal at 153.51 ppm is assigned to (-C=N-).

The signals at (128.45-140.84 ppm) range belong to (C_2,C_3,C_4,C_5,C_6,C_7 (aromatic). The signals at 23.23 ppm and 9.80 ppm are due to (CH_3-C=N-) and (CH_3–C=NOH) respectively[28]. All data are reported in Table (7).

Table (7). ^{13}CNMR data for the ligand and **[**LZnCl] Cl complex

Funct. Group	δ(ppm) Ligand	δ(ppm) (C_1) Complex
–C=N–OH	153.49	154.46
C=N–	152.53	153.51
C_2,C_3,C_4,C_5,C_6,C_7 (aromatic)	(127.51,128.28,139.90)	(128.45,129.25,140.84)
CH_3-C=N-	22.26	23.23
CH_3–C=N–OH	8.80	9.80

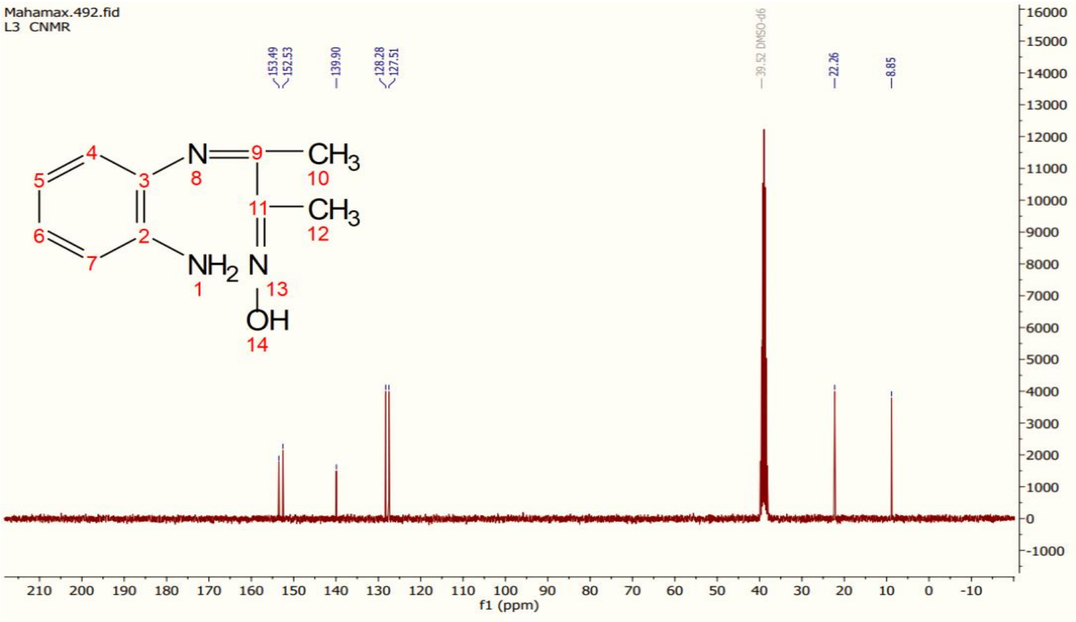


Figure 9.^{13}CNMR spectrum of the ligand

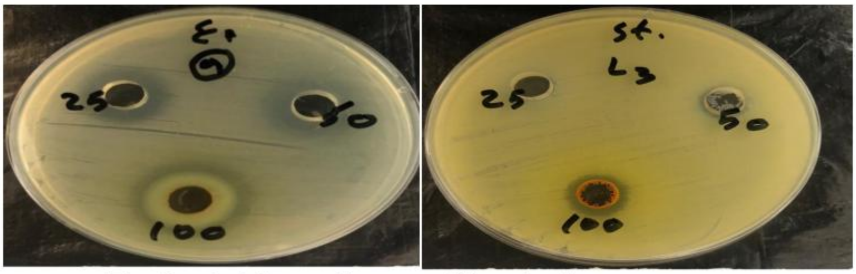
3.2. Biological Activity

The ligand and its complexes were assessed for their biological effects on two distinct bacteria strains, namely Staphylococcus aureus (G+) and Escherichia coli (G-), using DMSO concentrations of 100, 50, and 25 µg/ml. The results are presented in (Table 8) and illustrated in Figure (10). Analysis of the table indicates that at a concentration of 25 µg/ml, both the ligand and the $LNiCl_2$ complex exhibited no discernible biological activity against (*Staphylococcus aureus)* (G+). Similarly, at this concentration, the $LNiCl_2$ complex demonstrated no biological activity against (*Escherichia coli*) (G-). Conversely, all compounds exhibited biological activity at concentrations of 50 and 100 µg/ml against both bacterial strains, except for the $LNiCl_2$ complex, which showed no biological activity against (*Staphylococcus aureus*) at any concentration, Because it is neutral or non-ionic [29, 30].

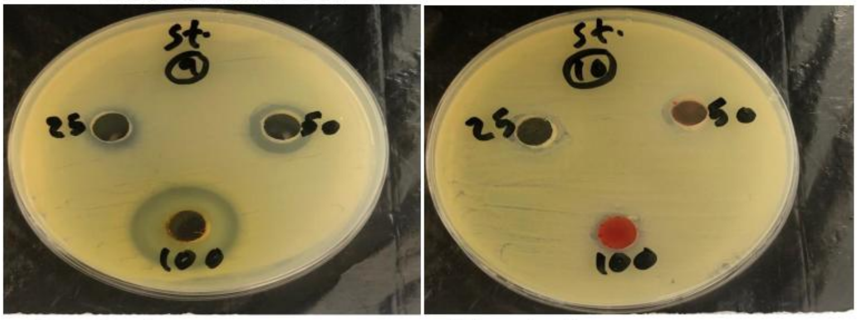
Table 8. Biological activity for prepared ligand and its complexes

Compound	Concentration (µg/ml)	Staphylococcus Aureus (G+)	Escherichia Coli (G-)
L	100	13	16
	50	11	15
	25	R	11
[LZnCl] Cl	100	23	25
	50	14	18
	25	12	16
$LNiCl_2$	100	R	16
	50	R	12
	25	R	R

Escherichia coli Escherichia coli



Escherichia coli Staphylococcus aureus



Staphylococcus aureus Staphylococcus aureus

Figure 10. Assessing the Antiviral Effectiveness for the Ligand and Its Complexes [C1, C2] Against Staphylococcus aureus and *Escherichia coli*

4. CONCLUSION

In this study, a newly synthesized Schiff base-oxime ligand, along with its zinc ($Zn^{2+)}$ and nickel ($Ni^{2+)}$ complexes, were examined at appropriate ratios. Various analytical techniques, including magnetic susceptibility, molar conductivity, IR spectroscopy, nuclear magnetic resonance (NMR) with ^{13}C and ^{1}H, ultraviolet-visible spectroscopy, and mass spectroscopy, were employed to analyze the complexes. The results obtained validated several structural characteristics. The amine-oxime ligand and its metal complexes exhibited activity ranging from moderate to good against two distinct bacterial species investigated in this study. Proposed geometric configurations revealed the Zn^{2+} complex to have a tetrahedral structure and the Ni^{2+} complex to possess a square planar geometry.

ACKNOWLEDGEMENTS

I extend my sincere thanks and gratitude to everyone who contributed to the preparation of this research

REFERENCES

[1] N. T. Dhokale, "A Novel Co (Ii) Metal Complexes Of N, O Donor Salicyloyl Pyrazole Oxime Schiff Bases: Synthesis, Spectroscopic Studies And Antimicrobial Evaluation," Indian Journal of Chemistry-Section A (IJCA), vol. 60, no. 11, pp. 1437-1442, 2021.

[2] I. Issa, M. Al-Jeboori, and J. Al-Dulaimi, "Formation of binuclear metal complexes with multidentate Schiff-base oxime ligand: synthesis and spectral investigation," Ibn Al-Haitham Journal For Pure And Applied Science, vol. 24, no. 2, 2017.

[3] B. K. Singh, P. Mishra, and B. S. Garg, "Nickel (II) complexes of new polydentate carboxyamide: spectroscopic, kinetics of thermal decomposition and X-ray powder diffraction studies," Transition metal chemistry, vol. 32, pp. 603-614, 2007.

[4] E. L. Chang, C. Simmers, and D. A. Knight, "Cobalt complexes as antiviral and antibacterial agents," Pharmaceuticals, vol. 3, no. 6, pp. 1711-1728, 2010.

[5] C. Yenikaya, M. Kaya, and I. Demir, "Synthesis of a imine vic-dioxime ligand and its Ni (II), Co (II), Cu (II) complexes," Asian Journal of Chemistry, vol. 20, no. 7, p. 5651, 2008.

[6] S. A. Khan, K. Priti, and A. K. Pramanik, "Studies of magnetic, electrical conductance and spectral behaviour of complexes of divalent Nickel with bis-(2, 6-diacetyl pyridine monoxime) 1, 2-di-iminobenzene."

[7] A. H. Osman and A. A. Aly, "Photooxidation von Bis (ethylxanthato) nickel (II) mit aromatischen Stickstoffheterocyclen enthaltenden Liganden in Chloroform," Monatshefte für Chemie/Chemical Monthly, vol. 123, pp. 309-314, 1992.

[8] N. M. Hosny, R. Ibrahim, and A. A. El-Asmy, "Spectral, thermal, optical and biological studies on (E)-4-[(2-hydroxyphenyl) imino] pentan-2-one and its complexes," Journal of the Serbian Chemical Society, vol. 81, no. 1, pp. 57-66, 2016.

[9] B. Dede, F. Karipcin, and M. Cengiz, "Novel Schiff bases with oxime groups and their homo-and heteronuclear copper (II) complexes," Collection of Czechoslovak Chemical Communications, vol. 72, no. 10, pp. 1383-1397, 2007.

[10] T. Sardohan-Koseoglu, E. Kir, and B. Dede, "Preparation and analytical application of the novel Hg (II)-selective membrane electrodes based on oxime compounds," Journal of colloid and interface science, vol. 444, pp. 17-23, 2015.

[11] E. Canpolat, A. Aglamis, H. Sahal, and M. Kaya, "Some Transition Metal Complexes of NO Type Schiff Base," Preparation and Characterization: Science Journal (CSJ), vol. 37, pp. 1300-1949, 2016.

[12] S. Sarkar et al., "Synthesis, structure and catalytic activities of nickel (II) complexes bearing N4 tetradentate Schiff base ligand," Journal of Molecular Structure, vol. 1160, pp. 9-19, 2018.

[13] M. S. Kasare, P. P. Dhavan, B. L. Jadhav, and S. D. Pawar, "Synthesis of Azo Schiff Base Ligands and Their Ni (II), Cu (II) and Zn (II) Metal Complexes as Highly-Active Antibacterial Agents," ChemistrySelect, vol. 4, no. 36, pp. 10792-10797, 2019.

[14] B. M. C. D. from Amino, "Journal of Chemical, Biological and Physical Sciences."

[15] O. A. El-Gammal, F. S. Mohamed, G. N. Rezk, and A. A. El-Bindary, "Structural characterization and biological activity of a new metal complexes based of Schiff base," Journal of Molecular Liquids, vol. 330, p. 115522, 2021.

[16] H. Kargar et al., "Binuclear Zn (II) Schiff base complexes: Synthesis, spectral characterization, theoretical studies and antimicrobial investigations," Inorganica Chimica Acta, vol. 530, p. 120677, 2022.

[17] K. Nakamoto, "Infrared spectra of inorganic and coordination compounds," (No Title), 1970.

[18] S. A. Khan, K. Priti, and A. K. Pramanik, "Synthesis and characterisation of some complexes of Cu (II) with schiff base ligand derived from Bis-(2, 6-diacetyl pyridine monoxime) 1, 2-di-iminobenzene."

[19] A. P. Lever, "Inorganic electronic spectroscopy," Studies in physical and theoretical chemistry, vol. 33, 1984.

[20] F. A. Cotton, G. Wilkinson, C. A. Murillo, and M. Bochmann, Advanced inorganic chemistry. John Wiley & Sons, 1999.

[21] K. J. AL-Adilee, A. K. Abass, and A. M. Taher, "Synthesis of some transition metal complexes with new heterocyclic thiazolyl azo dye and their uses as sensitizers in photo reactions," Journal of Molecular Structure, vol. 1108, pp. 378-397, 2016.

[22] G. A. Bain and J. F. Berry, "Diamagnetic corrections and Pascal's constants," Journal of Chemical Education, vol. 85, no. 4, p. 532, 2008.

[23] J.-i. Ueda, T. Ozawa, M. Miyazaki, and Y. Fujiwara, "Activation of hydrogen peroxide by copper (II) complexes with some histidine-containing peptides and their SOD-like activities," Journal of inorganic biochemistry, vol. 55, no. 2, pp. 123-130, 1994.

[24] A. Ramadan and M. El-Naggar, "Synthesis, characterization and demonstration of superoxide dismutase-like activity of copper (II) chloride, bromide, nitrate, thiocyanate, sulphate, and perchlorate complexes with 2-methyl-amino pyridine," Journal of inorganic biochemistry, vol. 63, no. 2, pp. 143-153, 1996.

[25] A. Kahraman and G. İrez, "The Synthesis of N-(2-Methylpyridyl) diaminoglyoxime Derivates and the Formation of Their Nickel (II) and Palladium (II) Complexes," Synthesis and Reactivity in Inorganic and Metal-Organic Chemistry, vol. 26, no. 1, pp. 79-91, 1996.

[26] E. Canpolat and M. Kaya, "Studies on mononuclear chelates derived from substituted Schiff-base ligands (part 2): synthesis and characterization of a new 5-bromosalicyliden-p-aminoacetophenoneoxime and its complexes with Co (II), Ni (II), Cu (II) and Zn (II)," Journal of Coordination Chemistry, vol. 57, no. 14, pp. 1217-1223, 2004.

[27] A. Bilgin and Y. Gök, "Synthesis and characterization of a new dioxime and its cobalt (III) complexes as vitamin B12 models," Synthesis and Reactivity in Inorganic and Metal-Organic Chemistry, vol. 31, no. 9, pp. 1717-1730, 2001.

[28] S. Serin, "New vic-dioxime transition metal complexes," Transition Metal Chemistry, vol. 26, no. 3, pp. 300-306, 2001.

[29] N. T. Dhokale and A. V. Nagawade, "Antimicrobial Studies On Novel Ni (Ii) Metal Complexes With Salicyloyl Pyrazole Oximes: Synthesis And Characterization," Journal of Advanced Scientific Research, vol. 11, no. 04, pp. 255-261, 2020.

[30] A. M. Mansour, "Pd (ii) and Pt (ii) complexes of tridentate ligands with selective toxicity against Cryptococcus neoformans and Candida albicans," RSC advances, vol. 11, no. 63, pp. 39748-39757, 2021.

Mahmood Rafid Mahmood is A graduate student in the Department of Chemistry at the College of Education for Pure Sciences, University of Diyala. He obtained his Bachelor's degree in 2017 from the Department of Chemistry, College of Education for Pure Sciences, University of Karbala, and is employed by the Ministry of Education as a teacher. He can be contacted at email: mahmoodrafid3@gmail.com.

Abdul Salam Abdul Kareem Abdul Rahman is a Professor at the College of Education for Pure Science, University of Diyala, Iraq. He received a B.Sc. degree in Chemistry Science from the University of Baghdad and an M.Sc. degree from Essex University, UK . He holds a PhD degree in College of Education Ibn Al-Haitham, At The University Of Baghdad. His research areas are inorganic materials, Its characterization and biological effectiveness studies. He has published several scientific papers in national, and international conferences and journals. He can be contacted at email: **drsalam.chem58@gmail.com**.