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RESEARCH ARTICLE

Preparation, Characterization, and Biological Evaluation of New Schiff Base Ligand and their Complexes with iron(II), cobalt(II), nickel(II) and Copper(II) ions

Mohammed Hamid Said

College of Science for Woman -University of Babylon-Iraq.

Abstract

In the present work a new schiff base ligand was prepared by reaction of 6-amino penicillinic acid with 5-chlorosalicyldehde. The new ligand was characterized by using various techniques UV/ Visible, FT IR , Mass spectral ,^{1}H NMR, and ^{13}C NMR , It was also preparing four new complexes by interaction of ligand with transition metals ions (Fe^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}) and characterized by UV/ Visible, FT IR, Magnetic moment and molar conductance. Ligand shows tridentate behavior demonstrated by the presence of three effective groups and complexes have taken octahedral form. The biological effectiveness was measured for ligand and coordination complexes against two types of bacteria (Staphyllococcus aureus and Pseudomonas aeruginosa) showed good effectiveness.

Keyword: *β-Lactam, Schiff base, 6.Amino Penicillinic, and tridentate ligand.*

Introduction

Schiff base was prepared in 1864 by researcher Hugo Schiff by Interaction of primary amines with carbonyl compounds (aldehydes and ketones), Rules can be named schiff base by other names such as Azomethene and Anils and Imines [1]. In general, the schiff base prepared from aldehydes has a faster reaction than those prepared from ketones [2]. The reason is that aldehydes have a lower Steric hindrance impairment than ketones. Also the compounds produced from aldehydes are also high stability stabilizers with metals in various oxidation states [3, 4].

Schiff base was used in Various fields, have been used in industry [5, 7] and agriculture [8,9] also used in the pharmaceutical and pharmaceutical industries [10,11] Where the most important role of Schiff base rules was with the beginnings of pharmacologic action of antibiotics by employing ß-Lactam compounds [12]. Lactam antibiotics is an important class of antibiotics containing the ß-lactam ring, the first preparation of ß-lactam compounds was in 1907 by researcher Hemann Staudinger [13,14] Many of the compounds of Schiff base containing ß-Lactam ring have an effective Anticancer effect because they contain effective groups such as azumethin group, ß-lactam and carbonyl [15,16]. This study focused on the preparation of ß-Lactam complexes with a number of elements of the first transitional series, such as iron, cobalt, nickel and copper, and study their biological effectiveness.

Experimental

All chemicals used were reagent grade (Sigma Aldrich, B.D.H, C.D.H. and S.L. Company)

Preparation of Schiff base ligand

The Ligand were synthesized by dissolving (2.16g,0.01mole) 6-Amino Penicillinic acid in absolute ethanol (basic medium), then it added to (1.06g, 0.01mole) of 5-Chloro-Salicyldehyde of climb thermally for 12hrs then it filtered out put formed , dried and recrystallization from absolute ethanol.

Preparation of Complexes

The complexes were prepared in a M:L ratio 1:2 by dissolving 0.608g , 0.001mole of Schiff base ligand in 15 ml ethanol absolute, then it added to (0.2151g, 0.2379g, 0.2377g and 0.170g) 0.001 mole of $FeCl_2.6H_2O$, $CoCl_2.6H_2O$, $NiCl_2.6H_2O$ and $CuCl_2.2H_2O$ respectively.

The mixture was refluxed for 30min, and then filtered, dried and recrystallization from absolute ethanol.

Biological Activity

Disk Diffusion Method was applied for evaluation of the inhibitor ability of the original ligand and its complexes in the biological activity of the most active plantation of the bacteria (Staphylococcus aureus, pseudomonas aeruginosa).

Table1:Data ligand and complexes show chemical and physical characterizations

Compound symbol	M.wt	M .p°C	Color
L	355	141-143	Brown
Fe $[L]_2$	740.39	165-167	Light Brown
Co $[L]_2$	733.69	130-132	Light Green
Ni $[L]_2$	791.93	132-134	Light Brown
Cu$[L]_2$	738.54	147-149	Light Green

Results and Discussion

Infrared Spectra

FTIR spectrum includes appearance extensive of vibration Pack low density at 3295 cm^{-1}. This pack because of the vibration of hydroxyl group, Also note other Pack low density to ν (C-H) aromatic at 3084 cm^{-1}.While the ß-Lactam group appeared at a frequency of 1732 cm^{-1}. The band was set in 1629cm^{-1} to stretch vibration of υ (-CH = N-) azomethene complexation, the Bands of (ß-Lactam and azomethene) group shifted to a higher frequency in all spectra of complexes [17]. The emergence of new bands between the frequencies (443-557) in the prepared spectrum of the complexities denote get of coordination , and the change in location and shape of the spectrum bunds for hydroxyl, isomethine and lactam groups indicates that the metal is consistent with these groups [18, 19]. The FTIR frequencies of free ligand and complexes are reported in Table 2, Figures 1 and 2 show a spectrum of free ligand and copper complex.

Table 2: FTIR Data of Schiff Base Ligand and Metal Complexes

Compound	ν(OH)	$\nu(C\text{-}H)_{alph.}$	$\nu(C\text{-}H)_{arm.}$	ν(C=O) Lactam	(C=N) Azomethene	M-N M-O
L	3295	2974	3084	1732	1629	-
Fe $[L]_2$	3379	2974	3070	1740	1635	532 455
Co$[L]_2$	3232	2974	3070	1741	1635	550 443
Ni $[L]_2$	3236	2976	3064	1742	1631	554 440
Cu$[L]_2$	3190	2976	3064	1740	1635	557 451

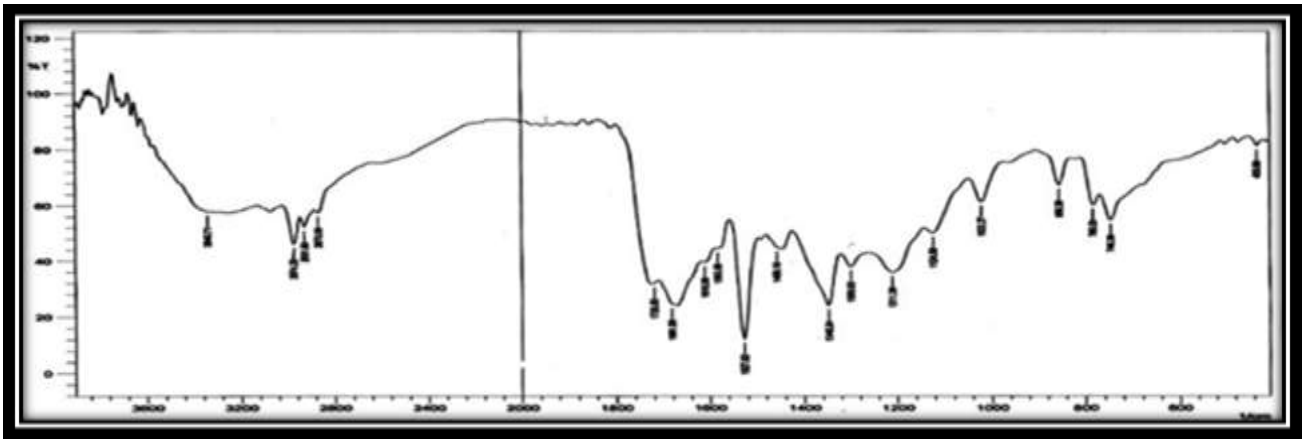


Fig. 1: FTIR Spectra of Ligand

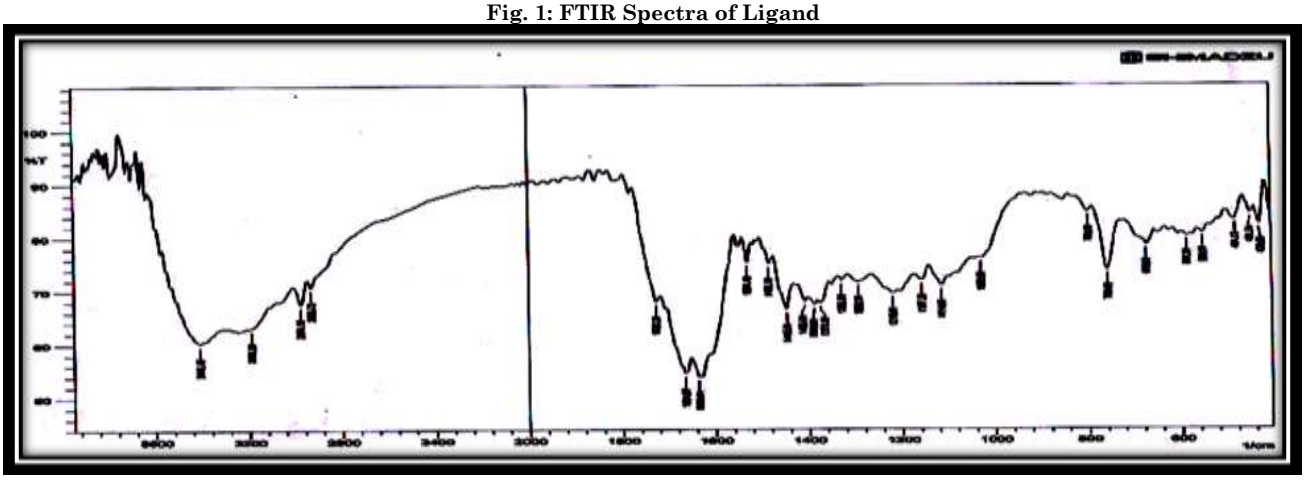


Fig. 2: FTIR Spectra of Copper (II) Complex

Electronic Spectra

The electron spectrum of ligand and complexes in DMSO solution was measured between 200-1100 nm at room temperature. The UV-Visible spectra of free ligand include two absorption bands at wavelength 262 nm and 325 nm. The first transmission due to transition electron to π-π* (aromatic ring) and the second transition due to transmission electron n-π* (azomethene group) respectively [20, 22].The spectra of the complexes were compared with the ligand spectrum. A change was observed in the absorbent peaks by the disappearance of the absorption peaks and the emergence of new absorption packs through which the complications could be extracted. Reported data UV-Vis of ligand and complexes in Table 3 and Figures 3 and 4 shows a Uv-Vis spectrum of free ligand and copper complex.

Table3: Electronic Spectra Data of Schiff Base Ligand and Metal Complexes

Complexes	Absorption Band nm λ_{max}	Assignment
L	262,325	π-π*, n-π*
$Fe[L]_2$	466,424	C.T
$Co[L]_2$	429	C.T
$Ni[L]_2$	409	C.T
$Cu[L]_2$	418,287	C.T

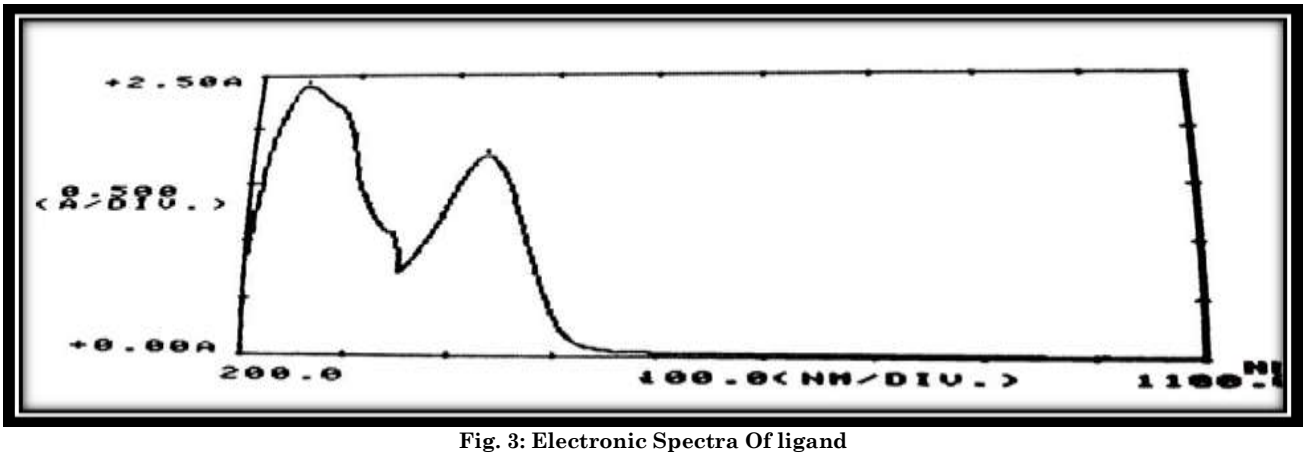


Fig. 3: Electronic Spectra Of ligand

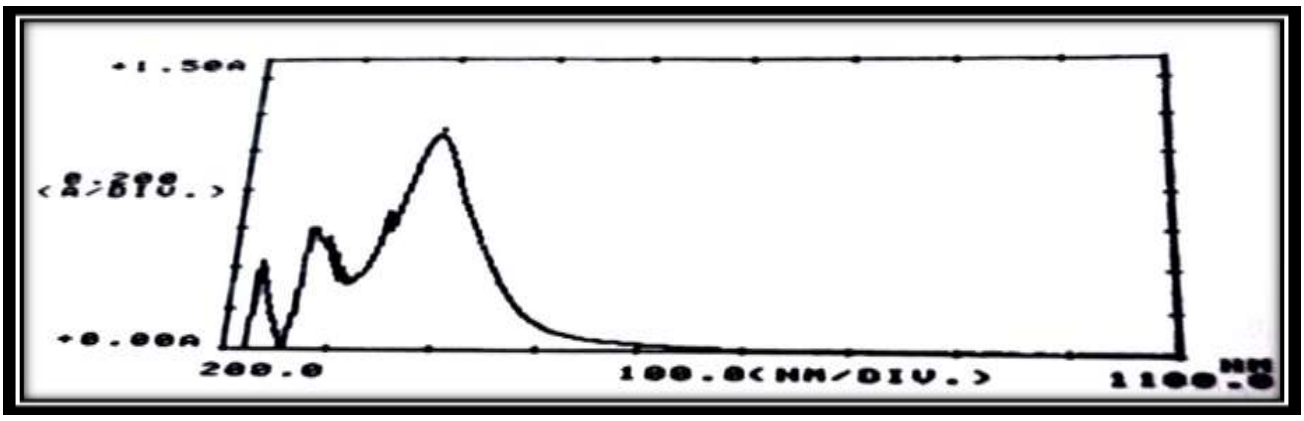


Fig. 4: Electronic Spectra of Copper (II) Complex

Mass Spectrum

The ligand mass spectrum showed the highest peak at 355 z /(m). This peak is attributed to the ion of the parent molecule, which compatible with the molecular formula is proposed to a ligand, and record the spectrum other peaks appear consistent with the literature [23, 24]. Figure.5 shows the proposed fragmentation of ligand process. The general pattern of fragmentation for ligand is summarized in Scheme1.

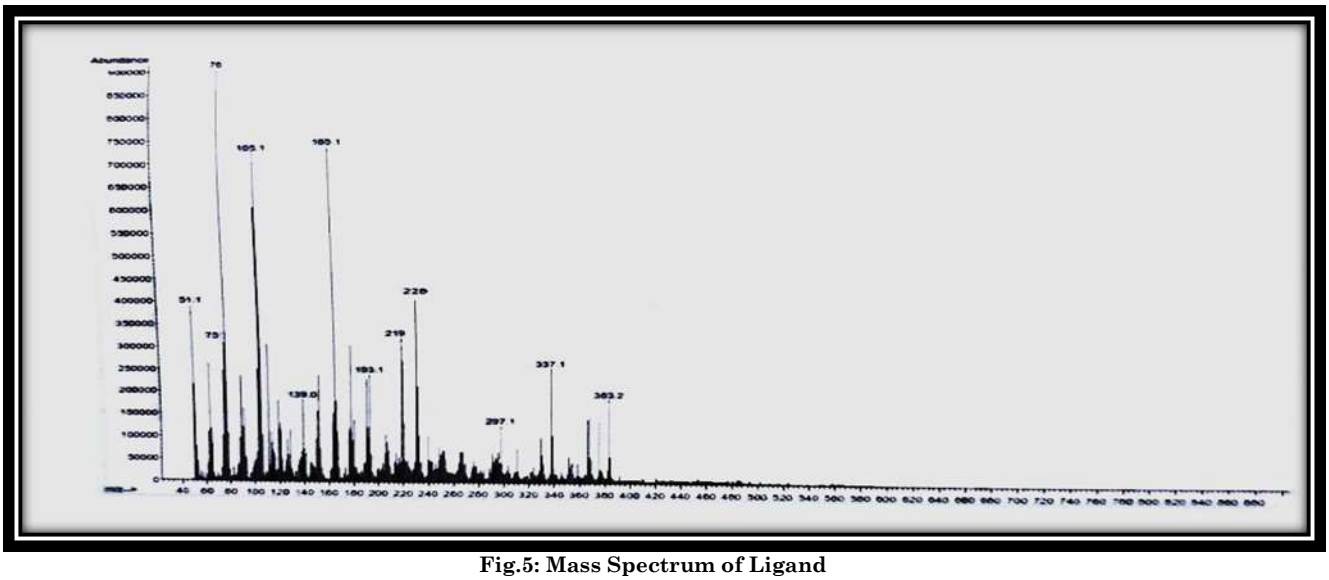
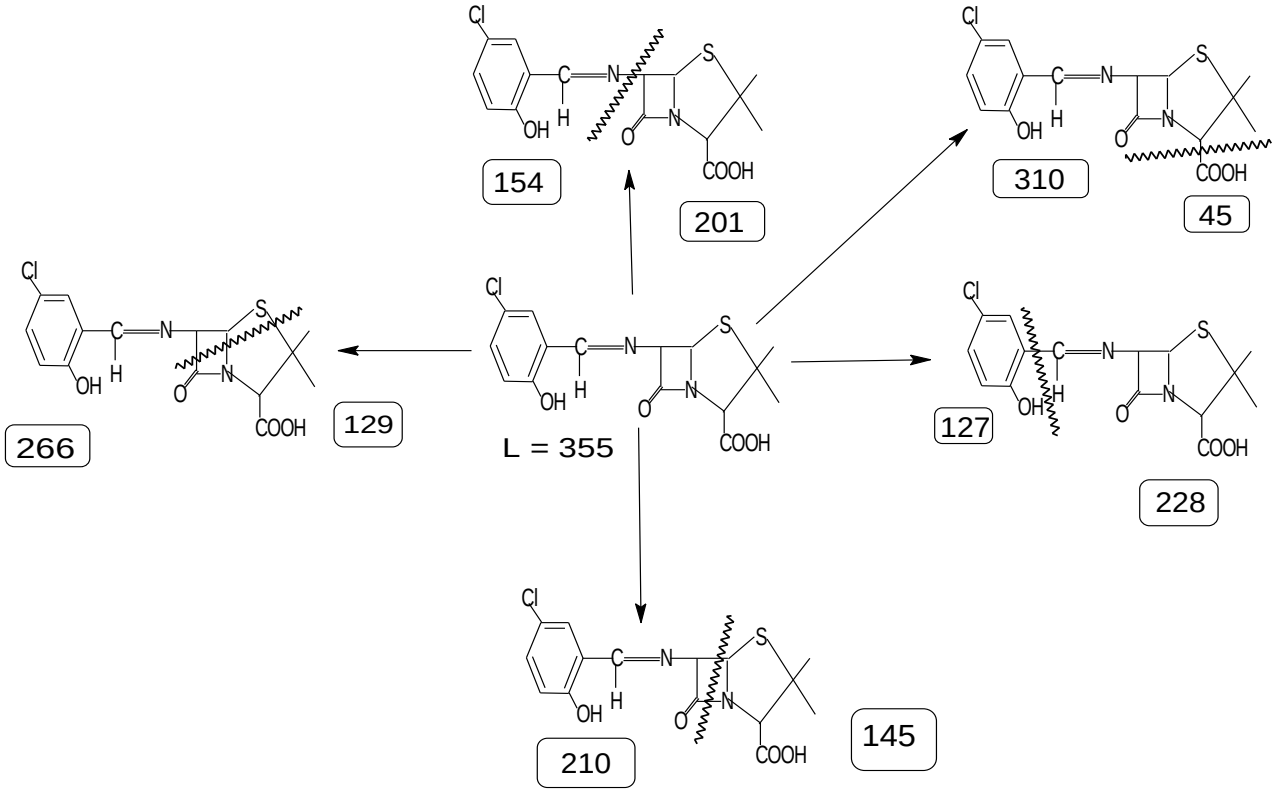


Fig.5: Mass Spectrum of Ligand



Scheme 1: Fragmentation Pattern of Ligand

^{1}H-NMR Spectra of the Ligand

The ^{1}HNMR spectra are used to determine the type of hydrogen in the free ligand and the complexes, on the other hand, to determine the ligand structure, finally to take advantage of it in the case of displacement or disappearance of these peaks in the spectra of complexities to investigate the participation of these groups in the process of consistency. The ^{1}HNMR spectrum for the ligand (Schiff base) in the DMSO-d^{6} solvent appearance a different peaks in the Figure 6. The signal at (δ 8.6) ppm was assigned for singlet due one proton of -CH = N reached in ligand. The signal obtained in the range (δ 7.2-7.8), the other signals from ^{1}H-NMR of the ligand were shown in Table 4.

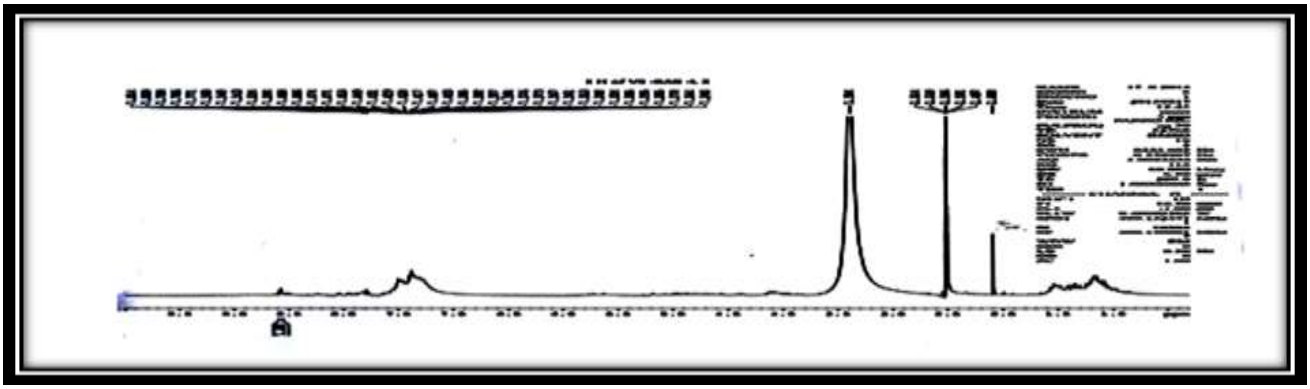


Fig.6: ^{1}H-NMR Spectrum of Ligand

Table4: Proton Nuclear Magnetic Resonance Spectra of The Schiff Base Ligand

Compound	^{1}HNMR
L	CH3(1.5ppm,S, 6H)
	Aromatic(7.2-7.8ppm ,m,5H)
	Azomethene(8.6ppm,S,H)
	CHN(4.1ppm,d,H)
	CHCO(4.3ppm,d,H)
	DMSO (3.5,2.5ppm)

^{13}C-NMR Spectra of the Schiff Base Ligand

The ^{13}C-NMR spectrum for the ligand base is recorded in DMSO-d^{6}.The ^{13}C-NMR spectrum showed the peak of azomethane carbon at (δ 153) ppm. The peak appearance at (δ180) ppm is due to the C = O group of the lactam ring. Carbon atoms in the phenyl ring have shown a different peak in (δ 124, 130, 124, 130, 116, 168) ppm [25, 26]. Figure 7 and Table 5 shows the data of ^{13}C-NMR for ligand.

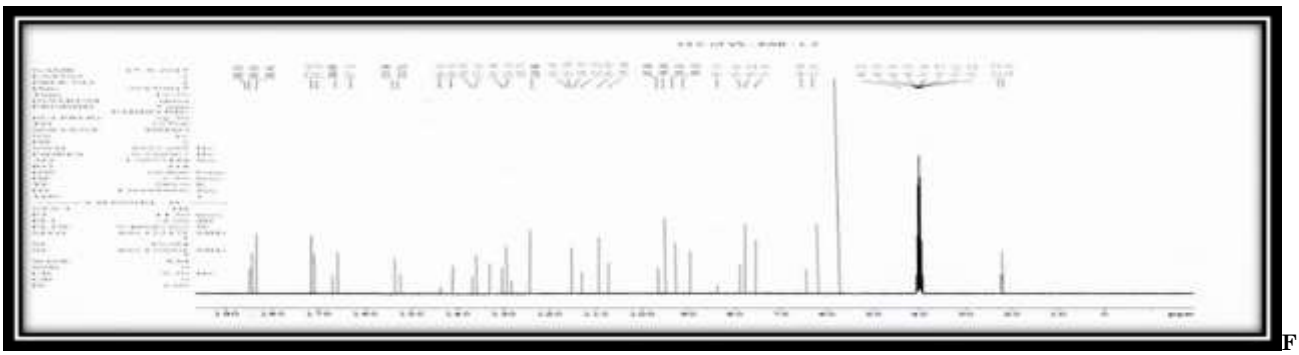


Fig.7: ^{13}C-NMR Spectrum of Ligand

Table5: Carbon Nuclear Magnetic Resonance Spectra of the Schiff Base Ligand

Compound	^{13}C-NMR
L	(aromatic) 124 ,130 ,124 ,130 ,116 ,168 (azomethene) 153 (COOH) 167 (CH_3) 25 (CH)79 (β-Lactam CO) 180 (CH)64 (CHN)76 (CHCO)62

Magnetic Susceptibility and Molar Conductivity for Coordination Complexes

The magnetic susceptibility measurements of the complexes include calculation of both magnetic and atomic susceptibility as well as molecular sensitivity and comparison with theoretical values. The molecular conductivity of the complexes was limited between 5.6-7.4 ohm^{-}.cm^{2}.mole. This result is consistent with the literature [27,28], which was reached to form the vacuum of these complexes and was found to be of octahedral shape as for molar connectivity every complexes recipe is ionic (neutral) and the Table 6 shows the magnetic sensitivity and results of molecular conductivity of the complexes of this ligand.

Table 6: Magnetic moments and Molar Conductivity data of Schiff base ligand and metal complexes

Complexes	Magnetic moment	Molar Conductivity	Geometry
Fe [L]	Diamagnetic	5.8	Octahedral
Co[L]	4.0	8.2	Octahedral
Ni[L]	3.01	8.5	Octahedral
Cu[L]	1.7	5.9	Octahedral

Anti-Bacterial Activity

The complexes prepared with Fe, Co, Ni and Cu were studied against the biological activity of two type of bacteria (Streptococcus Facials and Proteus mirabilis) at concentrations 1×10^{-6}, 1×10^{-5}, 1×10^{-4}, 1×10^{-3} (M) and compared with the inhibitory effect of ligand (L).The ligand and its complexes were applied on the plantation of *Staphylococcus aureus* as shown in Figure 8 and Table 7.

Table 7: Vital effect of Ligand and Complexes in Vital Work of bacterial Staphylococcus aureus

Concentration (M)	Compound Symbol				
	L	= Fe Zn[L]	Co[L]	Ni[L]	Cu[L]
1×10^{-6}	-	-	-	-	-
1×10^{-5}	-	+	+	+	-
1×10^{-4}	-	++	+	++	-
1×10^{-3}	+	+++	+++	+++	+++

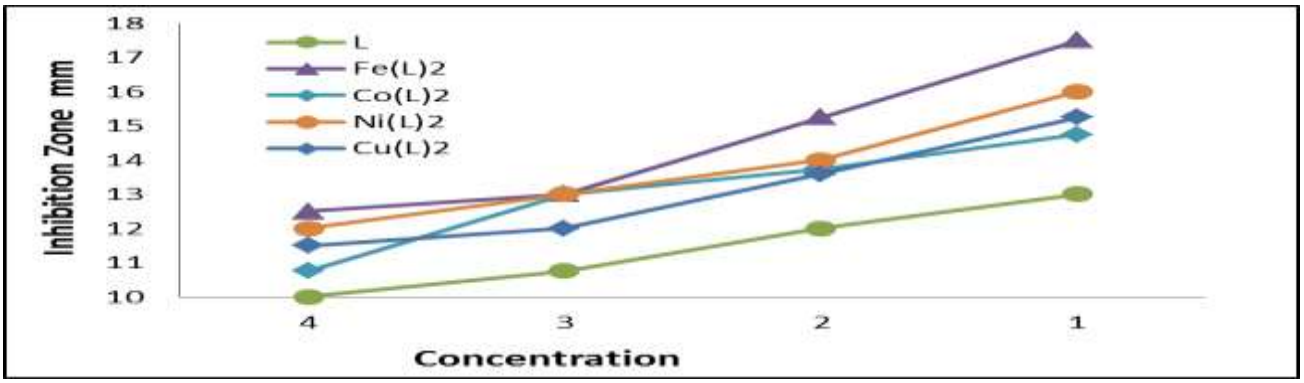


Fig.8: Effect of Original Ligand (L) and Its Four Complexes In The Biological Activity of The of Staphylococcus aureu Bacteria

The complex of Iron illustrated the highest inhibitory effect among the four complexes, on the other hand results of the inhibition ability of the cobalt, nickel and Copper complexes were so convergent at the four examined concentrations. Figure 9 exposes the ability of inhibition data for the ligand and its complexes at they applied in the plantation of Proteus mirabilis, the complex of iron were illustrated the highest inhibitory effect followed by the complexes of cobalt then nickel respectevily, while complex of copper demonstrated approximate inhibitory effects at different concentrations, as shown in Table 8.

Table8: Vital Effect of the Ligand and Complexes in The Biological Activity of Pseudomonasaeruginosa

Concentration (M)	Compound Symbol				
	L	Fe [L]	Co[L]	Ni[L]	Cu[L]
1×10^{-6}	-	-	-	-	-
1×10^{-5}	-	+	-	-	-
1×10^{-4}	-	++	++	++	++
1×10^{-3}	+	+++	+++	+++	+++

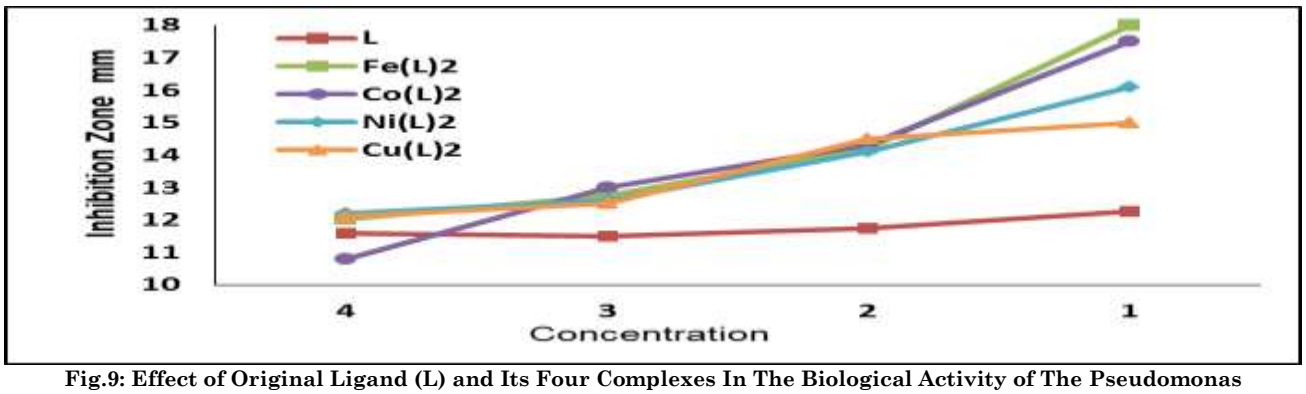
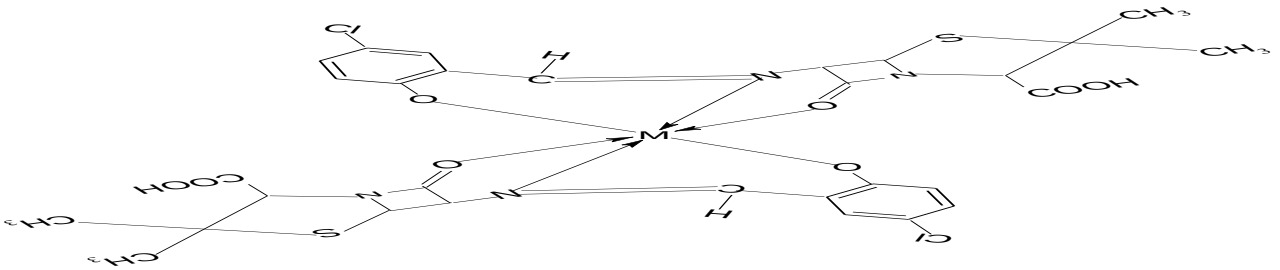


Fig.9: Effect of Original Ligand (L) and Its Four Complexes In The Biological Activity of The Pseudomonas

Conclusions

The prepared ligand and it's complexes illustrated a good inhibitory ability towards the varieties bacteria (Staphyllococcus aureus and Pseudomonas aeruginosa) so, the prepared compounds could be good alternatives to the common drugs which are used in treatment of ulcers.



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