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Synthesis, Theoretical Study, and Biological Evaluation of Some Metal Ions with Ligand "Methyl -6-[2-(4-Hydroxyphenyl) -2-((1-Phenylethylidene) Amino) Acetamido] -2,2-Dimethyl-5—Oxo-1-Thia-4-Azabicyclo [3.2.0] Heptane-3-Carboxyylate

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Abstract:

Schiff base (methyl 6-(2- (4-hydroxyphenyl) -2- (1-phenyl ethyl ideneamino) acetamido) -3, 3-dimethyl-7-oxo-4-thia-1-azabicyclo[3.2.0] heptane-2-carboxylate)Co(II), Ni(II), Cu (II), Zn (II), and Hg(II)] ions were employed to make certain complexes. Metal analysis M percent, elemental chemical analysis (C.H.N.S), and other standard physico-chemical methods were used. Magnetic susceptibility, conductometric measurements, FT-IR and UV-visible Spectra were used to identified. Theoretical treatment of the generated complexes in the gas phase was performed using the (hyperchem-8.07) program for molecular mechanics and semi-empirical computations. The (PM3) approach was used to determine the heat of formation (ΔH˚f), binding energy (ΔEb), and total energy (ET) for ligands and metal complexes at 298 ^{O}K. To explore the reactive sites of the compounds, the electrostatic potential of the ligand (L) was computed. PM3 was used to calculate the vibrational frequencies of the ligand (L) and its metal complexes, which were then compared to experimental data. The antibacterial activity of (L) and its metal complexes against three harmful microorganisms were examined: *Staphylococcus aureus* (gram positive), *Echerchia coli* (gram negative), and *Candida albicans*.

Keywords: Antimicrobial activity, DFT-PM3 Methods Theory, Schiff base complexes, Transition Metal ions

Introduction:

Biological activity of Schiff base and its complexes have been discovered. Antifungal, antibacterial, antimalarial, antipyretic, larvicidal, and antiviral activities are among the qualities understudy. In addition to biological activities, Carbonylation, hydroformylation, reduction, oxidation, epoxidation, and hydrolysis, as well as corrosion and enzyme inhibition, all use Schiff base metal complexes as catalysts, as well as polymers[1-3]

Amoxicillin is a semisynthetic penicillin derivative that is active against Gram positive and, to a lesser extent, Gram negative bacteria. 6-[D(-) Amino-p- hydroxypenyl) acetamido] peninillanic acid or -amino-p- hydroxyl benzyl penicillin is its nomenclature, according to penicillin.

Amoxicillin belongs to the penicillin group of antibiotics. Due to their particular bacterial toxicity, they are a very significant class of B-lactamic antibiotics used in therapy. All B-lactamic antibiotics have a number of probable donor sites and are known to interact efficiently with a variety of metal ions and organometallic moieties, resulting in complexes, according to coordination chemistry[4,5].

Metals have an esteemed place in medicinal chemistry, most antibiotics do not need metal ions for their biological activities, but there are a number of antibiotics that require metal ions to function properly, such as bleomycin. Streponigrin and bacitracin drugs have gained recognition, and they are more effective than pure drugs[6], this is due to the fact that metal ions can interact with many different kinds of biomolecules including DNA, RNA, proteins and lipids rendering their unique and specific bioactivities[7]. This work describes the process of synthesizing a new Shiff -imine ligand

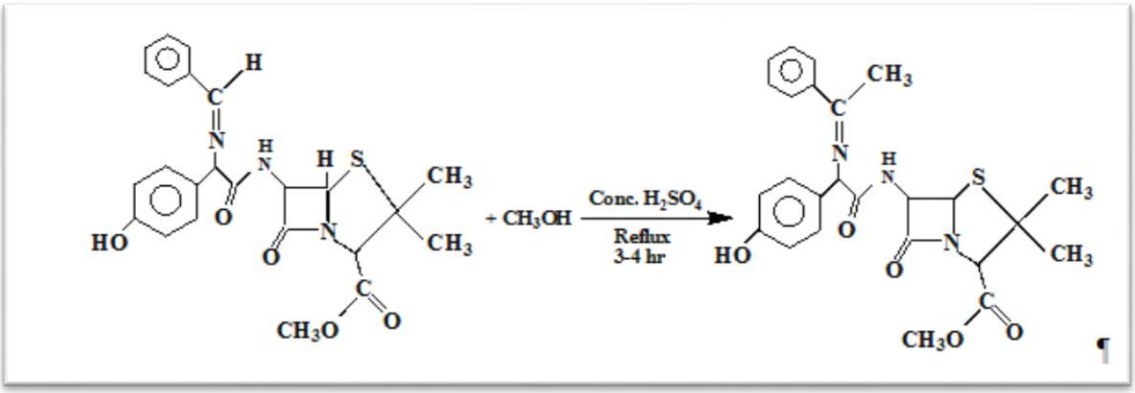
along with its Cu(II), Co (II) , and Ni (II), Zn (II) coordination compounds. The new synthesized compounds have been characterized by means of some spectral procedures. Biological activities of compounds have been tested by using three bacterial types.

Materials and Methods:

All metal salts used in this work were obtained from Fluka ($CoCl_2.6H_2O$, $NiCl_2.6H_2O$, $CuCl_2.2H_2O$, $ZnCl_2.6H_2O$, $HgCl_2$). Uv-Vis 1600A Shimadzu was used to record the electronic spectra at wave length range of 190-1100 nm. A Shimadzu 8400 Fourier Infrared Transform Spectrophotometer with a wave number range of 4000-200 cm^{-1} was used to measure FTIR. A Perkin Elmer 500 Atomic Absorption Spectrophotometer was used to conduct the metal analysis. Conductivity Meter 220 with Gallencamp was used to calculate the molar conductivity in ethanol as a solvent at room temperature, M.F.B-600.01 was used as a melting device. Magnetic susceptibility balance model MSB-MKT was used for magnetic moment measurement.

Preparation of the Ligand

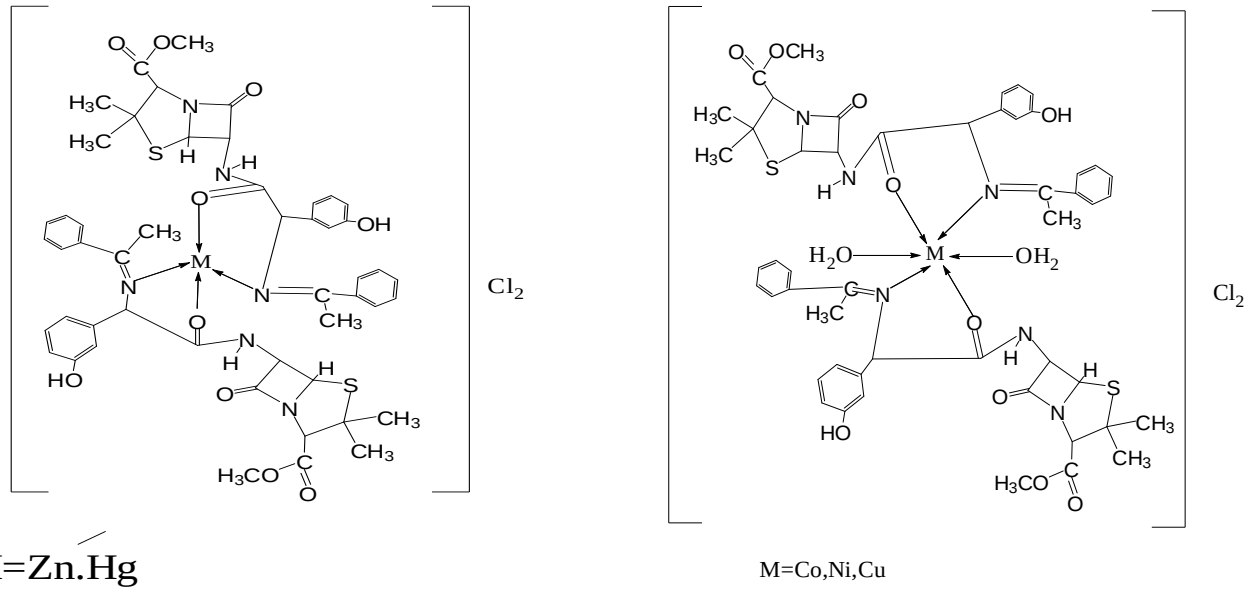
In a round bottom flask, a mixture of (0.05) mole was placed (150 ml). 6-[2-(benzyl ideneamino)2-(4-hydroxy phenyl)actamido] 6-[2-(benzyl ideneamino)2-(4-hydroxy phenyl) actamido] 6-[2-(benzyl ideneamino)2-(4-hydroxy phenyl) actamido] methyl-6-[2-(benzyl ideneamino)2-(4-hydroxy phenyl)actamido] 2,2-dimethyl-5-oxo-L-thio-4-azabicyclo[3.2.0] heptan-3-carboxylate containing more than 100% methanol (150 ml)and (3) drops of sulfuric acid concentration. The mixture was refluxed in a water bath (40-50) ^{O}C for (3-4) hours. After that, the mixture was chilled before being poured onto crushed ice. It was filtered, dried, and recrystallized using ethanol-derived precipitate[8] as shown in Scheme 1.



Scheme 1. 3,3-dimethyl-7-oxo-4-thia-1-azabicyclo[3.2.0]heptane-2-carboxylate synthesized from methyl6-(2-(4-hydroxyphenyl)phenylethylideneamino)acetamido) (L).

Preparation of the Complexes

(0.236 g $CoCl_2.6H_2O$, 0.237 g $NiCl_2.6H_2O$, 0.170 g $CuCl_2.2H_2O$, 0.152 g $ZnCl_2.6H_2O$, 0.17 gm $HgCl_2$) (1 mmole) were dissolved in 10 ml ethanol for each one and mixed with (0.93 g ligand) (2 mmole), diluted in 15 ml ethanol and refluxed for 3 hours. The colorful precipitates were filtered, then washed in hot ethanol and dried in a two-hour oven at 60 degrees Celsius as shown in Scheme 2.



Scheme 2. Suggested Structure for the Prepared Complexes

Results and Discussion:

Table. 1 summarizes the physical features of the complexes. The complexes were soluble in organic solvents and stable at room temperature. For prepared compounds, the molar ratio is (1:2) M: L.

Table 1. The ligand's and its complexes' physicochemical properties

Compounds	Elemental and metal analysis Found , (Cal.) %					M.P	Color	%	*µs cm^{-1}*
	C	H	N	S	M	^{O}C		Yield	
$C_{25}H_{27}N_3O_5S$ (L)	61.22 (60.31)	6.12 (6.00)	8.72 (7.19)	6.11 (6.02)	---	210	Yellow	77	---
$CoC_{50}H_{58}N_6O_{12}S_2Cl_2$	56.62 (55.46)	5.11 (4.89)	6.99 (7.63)	5.44 (5.89)	5.22 (5.77)	198	Greenish Blue	84	72.8
$NiC_{50}H_{60}N_6O_{13}S_2Cl_2$	52.83 (51.99)	4.33 (5.24)	7.22 (7.88)	5.22 (5.76)	5.11 (5.13)	220 d.	Light Green	79	88.32
$CuC_{50}H_{58}N_6O_{12}S_2C_{l2}$	51.77 (50.97)	5.40 (5.33)	7.86 (7.90)	5.73 (5.98)	5.88 (5.98)	1170 d.	Green	81	81.43
$ZnC_{50}H_{58}N_6O_{12}S_2Cl_2$	54.77 (53.88)	5.36 (5.44)	7.55 (7.75)	5.32 (5.44)	6.03 (5.98)	215	Yellow	90	89.4
$HgC_{50}H_{58}N_6O_{12}S_2Cl_2$	53.66 (52.87)	5.33 (5.32)	7.65 (7.32)	5.88 (5.97)	--- ---	225	Yellow	86	81.90

d= decomposition degree

Infrared Spectra

At 1731 and 1681 cm^{-1}, the ligand has two bands that correspond to the carbonyl of amide and β- lactam, respectively[9] Fig 1. In all compounds, the amide group's carbonyl was moved to a lower wave number, yielding in bands at (435-470) cm^{-1}, which is attributed to the M-O band[10].

The β - lactam band has remained unchanged, indicating that the oxygen atom in this group is not involved in complicated coordination of these complexes. At 1628 cm^{-1}, the ligand's third band corresponds to the imine (C=N) group[11], this band was shifted to lower frequency about (17-32) cm^{-1} in all complexes indicating that azomethane moiety is involved in the complex formation Fig 2 FTIR for L-Co complex.

In all complexes, this band changed to a lower frequency, indicating that azomethane is involved in their creation. The appearance of a new band ranging from (540-575) cm $^{-1}$ in all complexes to the M-N bond[12] supports the coordination of this group through nitrogen atoms. Table 2 contains a list of other bands.

Table 2. The most important diagnostic FT-IR bands for the L and its metal complexes

Comp.	ν NH	ν C=N	ν C=C	ν C-N	ν C=O est. B. lactm. Amide	ν C-H Alp.& Arom	ν M-N	ν M-O	Others
L	3250	1650	1583	1371	1762	3061	---	----	Phenalic
			1510		1731	2970			3523
					1681	2895			
L-Co	3242	1633	1589	1368	1760	3323	534	462	Brond band
			1505		1731	2970			3400
					1671	2922			ϭ744
L-Ni	3245	1624	1595	1377	1764	3068	572	451	Brond band
			1500		1730	2970			ϭ746
					1666	2931			
L-Cu	3244	1618	1588	1368	1760	3176	542	435	Brond band
			1516		1729	2972			3499
					1656	2931			ϭ742
L-Zn	3235	1625	1587	1370	1760	3023	544	445	Brond band
			1509		1730	2970			3489
					1666	2930			ϭ750
L-Hg	3234	1623	1590	1377	1760	2025	554	450	Brond band
			1507		1370	2971			3490
					1654	2932			ϭ750

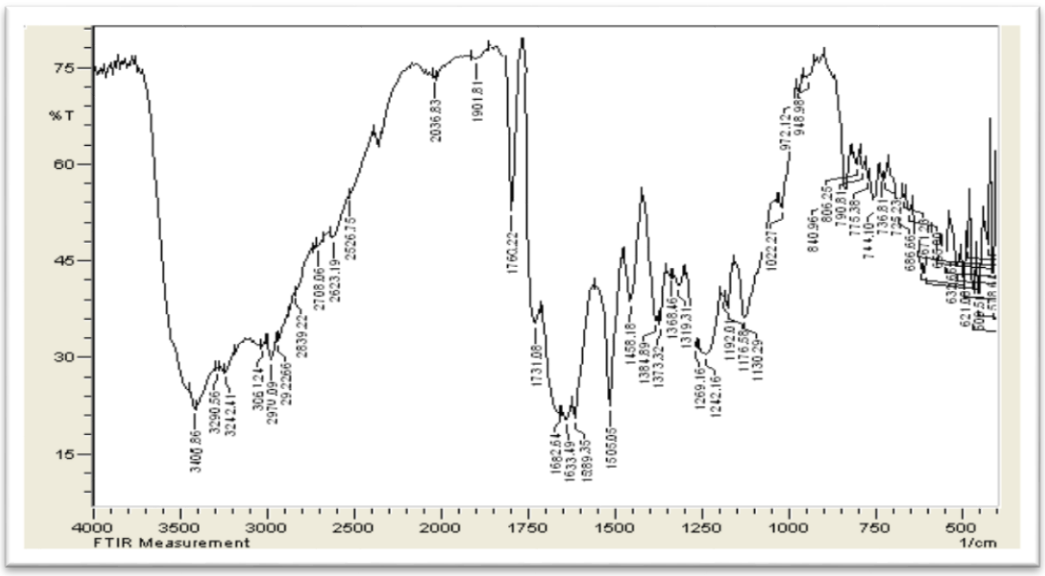
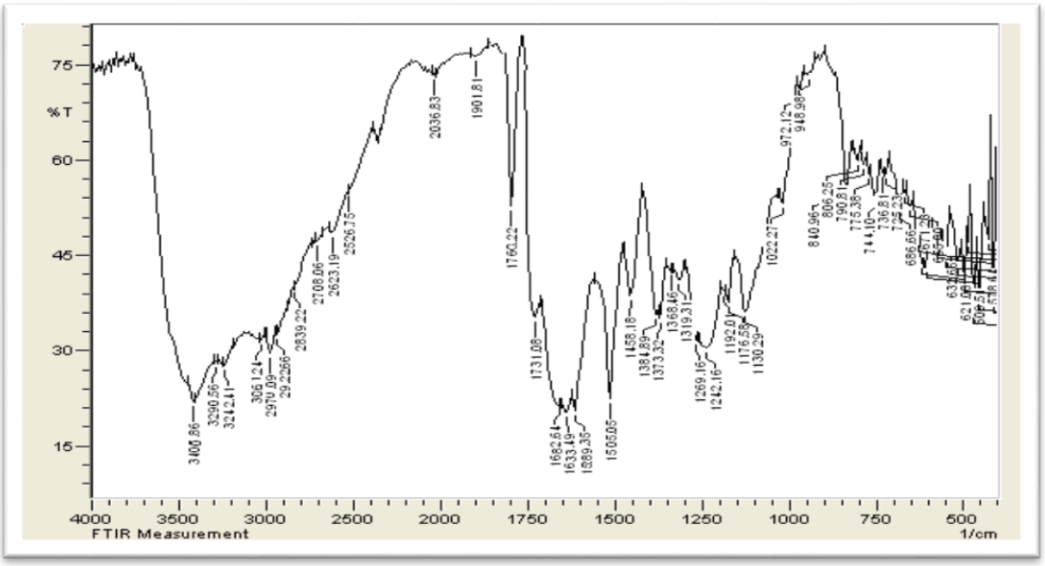


Figure 1. FTIR spectrum of L



Figur 2. FIIR spectrum for L- Co Complex

Uv-Visible Spectra

The electronic spectra of the synthesized ligands showed several peaks between 200-400 nm which were assigned to n→π*and π→ π*transitions to the C-O, C-N, and C=C transition respectively Fig3. The spectra helped us to expect the suggested geometry according to the shape and number of observed peaks [13]

For L-Co complex showed three bands in the wave number (10537, 19921, 23991) cm^{-1} respectively for oh geometry. Table 3 shows the absorption bands and their assignments Fig4.

L-Ni complex showed three bands in the wave number (96993, 14749, 26178) cm-123, L-Cu complex has two bands (12453, 23984) cm-1.

L-Zn and L-Hg with d^{10} electronic configuration were not expected to show (d-d) electronic transition because of the filled (d) orbital[14,15], this complex did not show clear band in the visible region.

Table 3. Electronic Spectra data and their probable assignments, magnetic moment data of the L and new prepared complexes

Comp.	λ max nm	Ύ cm^{-1}	Assignment	B° cm^{-1}	Dq/ B	B` cm^{-1}	B	10Dq cm^{-1}	μ_{eff} B.M.
L	241 277 345	41493 36101 28985	π-π* (C=C) n-π*(CO,CN)	-----	----	-----	----	----	---
L-Co	949 501 416	10537 19921 23991	$^4T_1g \rightarrow {}^4T_2g$ $^4T_1g \rightarrow {}^4T_1g$ $^4T_1g \rightarrow {}^4A_2g$	970	1.3	820	0.84	1066	4.63
L-Ni	973 651 360	10330 15361 27777 (cal.)	$^3A_2g \rightarrow {}^3T_2g$ $^3A_2g \rightarrow {}^3T_1g_{(F)}$ $^3A_2g \rightarrow {}^3T_1g_{(P)}$	1035	1.21	788.6	0.761	9699	3.01
L-Cu	803 416	12453 23984	$^2Eg \rightarrow {}^2T_2g$ Charge Transfer	-----	------	-----	-----	------	1.77
L-Zn	248 322	40266 30.994	π-π* Charge Transfer	-----	-----	-----	----	-----	Dia
L- Hg	334	29877	Charge Transfer	---	-----	-----	----	----	Dia

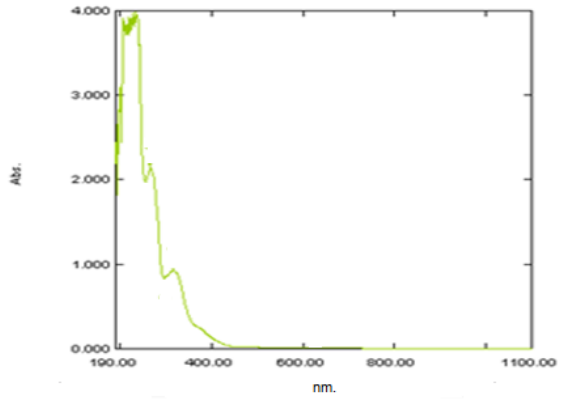


Figure 3. Uv-Visble spectra for L

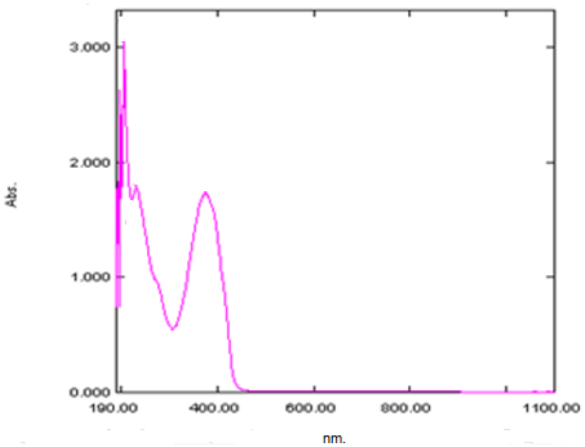


Figure 4. Uv-Visble spectra for L-Co complex

Antibacterial and Antifungal Activities

Human and animal pathogenic microbes cause a variety of diseases. The discovery of Chemotherapeutic drugs has a critical role in regulating and preventing such diseases. Microorganisms can acquire resistance to these chemotherapeutic drugs, and resistant strains pose a significant difficulty in the treatment of microbial illnesses. Searching for new antimicrobial agents becomes something very necessary. As a result, much effort has been expended in the search for novel antibiotics or molecules with a good antimicrobial activity that could be exploited as chemotherapeutic drugs[15].

The antibacterial effectiveness of the synthesized compounds was examined in vitro against two pathogenic bacteria species in this study: Antifungal *Candida albicans*, as well as Gram positive (*Staphylococcus aureus*) and Gram negative (*Escherchia coli*) bacteria. Furthermore, as shown in Table 4, the presence of metal ions in the complexes affects the final biological screening in vitro in a variety of ways.

Table 4. Staphylococcus aureus, Escherichia coli, and Candida albicans are all affected by the ligand and its metal complex. in the (5 & 10 mM).

Comp.	*Staphylococcus aureus*		*Escherichia Coli*		*Candida albicans*	
	5mM	**10mM**	**5mM**	**10mM**	**5Mm**	**10mM**
L	+	++	++	+	+	+
L Co	+++	+++	+	++	+	++
L Ni	-	+	++	++	+	++
L Cu	+	+	+	-	-	+
L Zn	+	+	_	_	-	+
L Hg	+	+	+	-	-	-
EtOH	-	-	-	-	-	-

(-) no signification.
(+) slight significant zone of which (5-10 *mm*).
(++) moderated significant zone of which (11-20 *mm*).
(+++) highly significant zone of which (> *20 mm*).

Computational Chemistry

Computational chemistry is one of the chemical applications to solve chemical problems using mathematical applications based on molecular shape (sample molecular) .To build a molecular model accurately based on the electronic build method that relies on quantum mechanics , you must increase the storage capacity and increase the processor speed ,so another method (semi-empirical method) was introduced to resolve this problem by introducing experimental spectral values for the purpose of speeding up the calculation calendar style treatment[16, 17].

Theoretical Energies and Dipole Moment

The program Hyperchem-8.07 is used to compute the heat of formation ($\Delta H°_f$), binding energy (ΔE_b), and dipole moment (μ) for ligands and their formed complexes using semi-empirical and molecular mechanic approaches PM3, DFT methods, in addition to calculating some identification vibration in IR spectra and molecular orbital HOMO and LUMO for ligand[18], Figs. 5,6 . A comparison of experimental and theoretical vibrational frequencies for ligand and their complexes are shown in Table 6. While the heat of formation (ΔH°f), binding energy (ΔEb), and dipole moment (μ) for 1- ((dicyclohexylamino) methyl)-3-(1,5- dimethyl-3-oxo-2-phenyl-2,3-dihydro-1H-pyrzol-4-ylimino) indolin-2-one and all produced complexes are shown in Table 5 the results revealed that all complexes are stable.

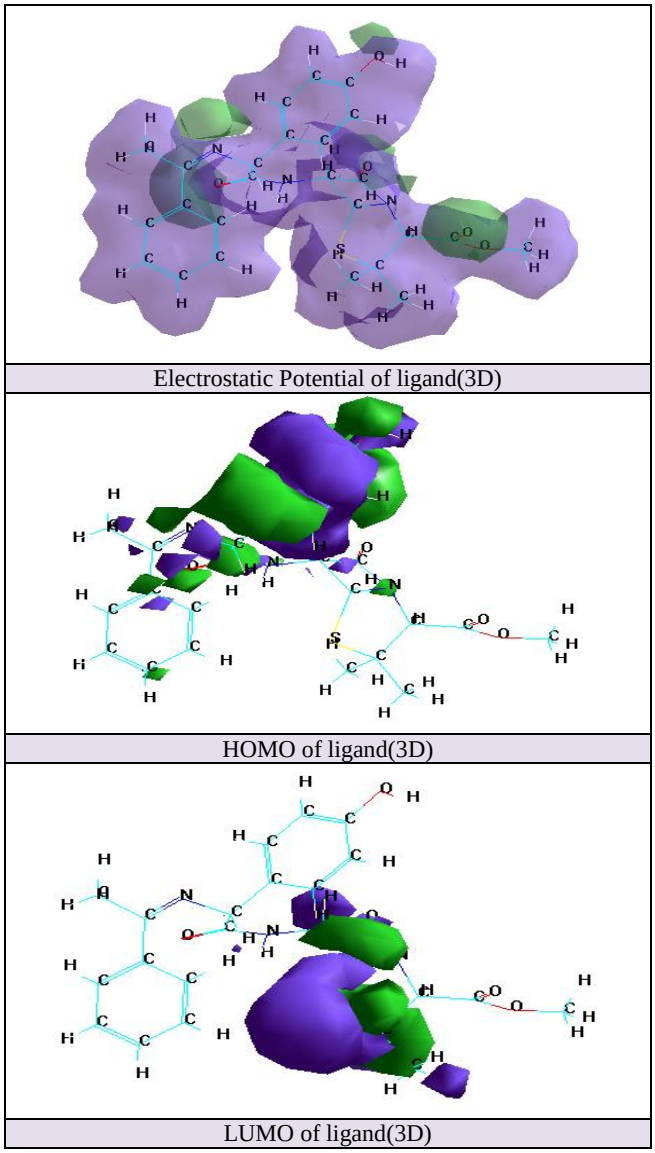


Figure 5. Electrostatic Potential and HOMO and LUMO as 3D counters for ligand.

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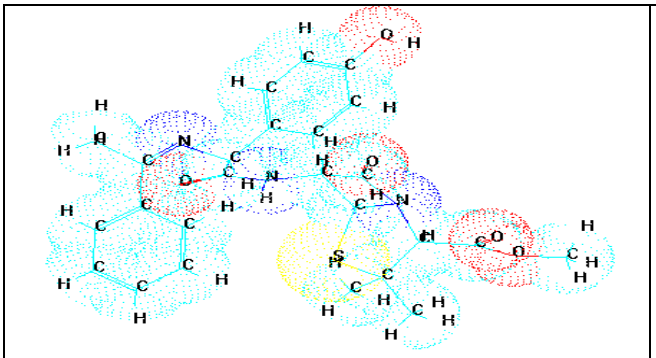
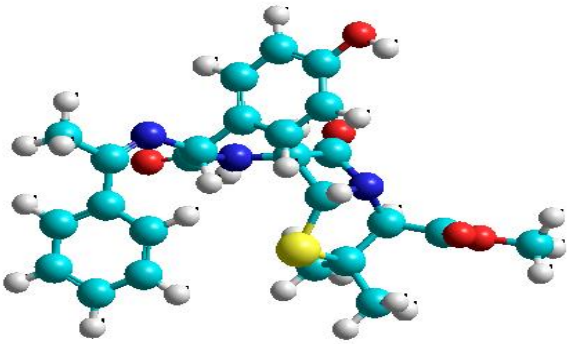
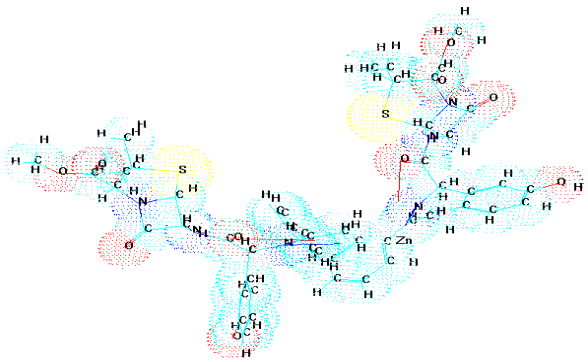
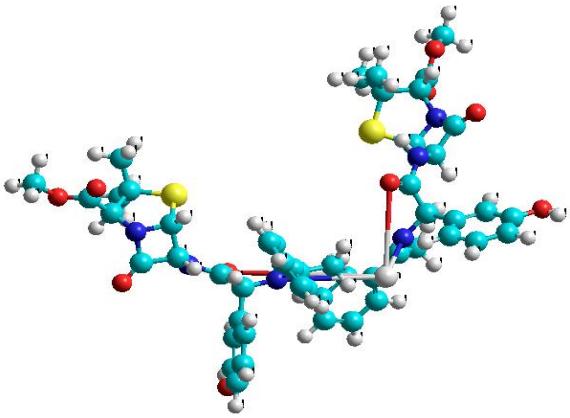


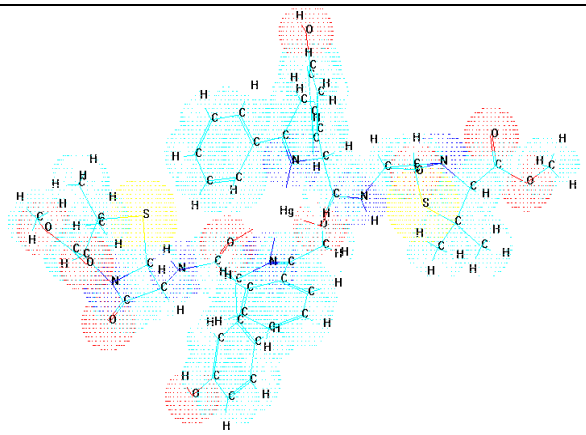
L



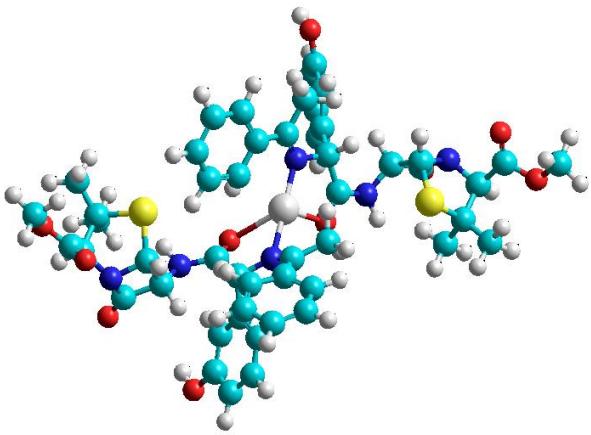


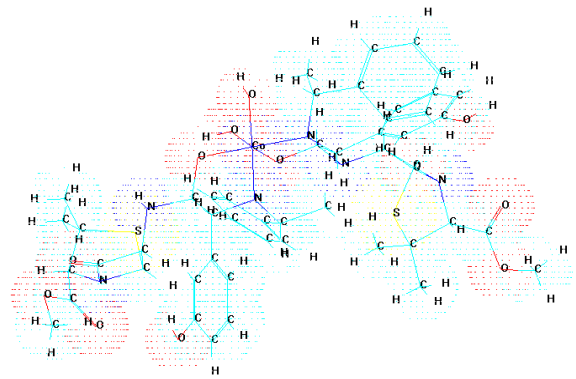
ZnL



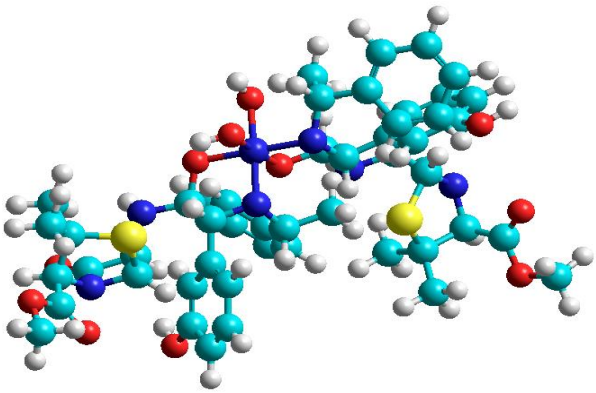


HgL





CoL



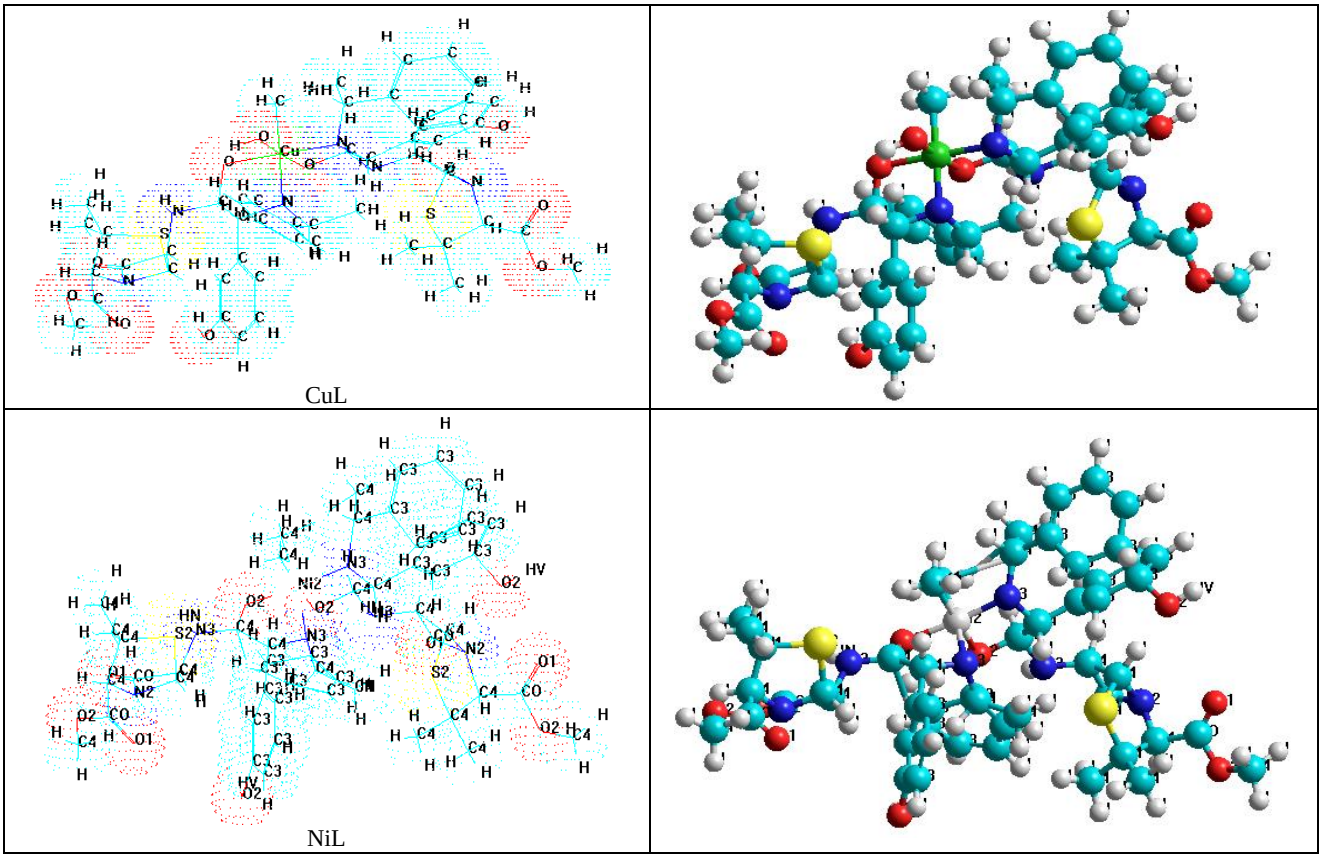


Figure 6. The Most Probable Model Building Stable Structure of Ligand and its Metal Complexes.

Computational Details

Hyper-chem8.07 was used to accomplish the current quantum chemistry computations the energy of the highest occupied molecular orbital and other molecular characteristics (E_{HOMO}),the lowest empty molecular orbital's energy (E_{LUMO}). The molecule's energy gap (E= E_{LUMO} – E_{HOMO}), dipole moment (μ), and total energy (ET) were calculated. The reactivity parameters were then calculated using the conceptual framework of DFT[19-22]. So, the chemical potential μ_p is defined as Eq.1:

$\mu_p = \left(\frac{\partial E}{\partial N}\right)_{v(r)} = -\chi$ 1 Where μp is the chemical potential, E is the total energy, N is the number of electrons, ν(r) is the external potential of the system and χ is the global electro negativity. The global hardness is given by Eq.2:

$\mu_p = \left(\frac{\partial 2E}{\partial N2}\right)_{v(r)}$ 2 Using the Koopmans theorem and the finite difference approximation. The global electronegativity d the global hardness is given by Eqs.3-8 respectively:

$\chi = \frac{(I+A)}{2} \approx -\frac{(EHomo+ELumo}{2}$ 3

$\eta = \frac{(I-A)}{2} \approx \frac{ELumo-EHomo}{2}$ 4 Eq.5 can be used to calculate global softness, which is the reciprocal of global hardness.: $S = \frac{1}{\eta}$ 5

The ionization potential is the negative of E_{HOMO} Equation 6:

I = -E Homo 6. The electron affinity is the negative of E_{LUMO} Equation 7: $A = -E$Lumo 7

The electrophilicity index ω[23] is defined as: $\omega = \frac{\mu 2p}{2\eta}$ 8

According to the definition, this index measures a chemical species' propensity to accept electrons. Good electrophile behavior is indicated by a high electrophilicity index value, whereas good nucleophile behavior is indicated by a low electrophilicity index value[24].

Quantum Chemistry Study

The calculated quantum chemical parameters are displayed in Table 5.

Table5. Quantum Chemical Parameters of Ligand.

Descriptor	Value	Descriptor	Value
E_{HOMO}(eV)	-9.3254	I(eV)	**9.3254**
E_{LUMO}(eV)	-0.3850	A(eV)	**0.3850**
$\Delta E_{(gap)}$(eV)	8.9404	μ(Debye)	**4.452**
Total Energy(Kcal/mol)	-127247	η(eV)	**4.4702**
ΔE_b(Kcal/mol)	-6483	H^o_f(Kcal/mol)Δ	**-101**
$S(eV)^{-1}$	0.2237	Ω	**2.6367**
X(eV)	4.8552	TE(a.u)	**-202.7816**

Table 6. Theoretical and Experimental Vibrational Frequencies (cm-1) for Ligands and Their Metal Complexes

Comp.	ν NH	ν C=N	ν C=C	ν C-N	ν C=O est. B. lactm. Amide	ν C-H Alp.	ν M-N	ν M-O
L	*3250	*1650	*(1583-1510)	*1371	*(1762-1731-1680)	*(3061-2970-2895)	---	----
	**3348	**1632	**(1562-1538)	**1384	**(1776-1711-1690)	**(3057-2930-2849)		
	***2.93	*** -1.10	***(-1.34-1.82)	***0.94	***(0.79-1.17-0.59)	***(-0.13-1.37-1.61)		
L-Co	*3242	* 1633	*(1589-1505)	*1368		*(3323-2970-2922)	*534	*462
	**3432	**1600	**(1590-1500)	**1360	*(1760-1731-1671)	**(3340-2977-2930)	**530	**465
	***0.55	***- 2.06	***(0.06-0.33)	***-0.59	**(1770-1700-1680) ***(0.56-1.82-0.54)	***(0.51-0.24-0.27)	***-0.75	***0.65
L-Ni	*3245	* 1624	*(1595-1500)	*1377	*(1764-1730-1666)	*(3068-2970-2931)	*572	*451
	**3190	**1615	**(1587-1552)	**1375	**(1780-1719-1615)	**(3098-2955-2937)	**580	**451
	***-1.72	***- 0.55	***(-0.50-3.35)	***-0.15	***(0.89-0.64-3.16)	***(0.97-0.51-0.20)	***1.38	***0
L-Cu	*3244	*1618	*(1588-1516)	*1368	*(1760-1729-1656)	*(3176-2972-2931)	*542	*435
	**3266	**1629	**(1590-1529)	**1370	**(1766-1700-1666)	**(3170-2966-2900)	**548	**434
	***0.67	***0.68	***(0.13-0.85)	***0.15	***(0.34-1.71-0.60)	***(-0.19-0.20-1.07)	***1.09	***-0.23
L-Zn	*3235	* 1625	*(1587-1509)	*1370	*(1760-1730-1666)	*(3023-2970-2930)	*544	*445
	**3169	**1613	**(1587-1535)	**1361	**(1761-1710-1606)	**(3029-2977-2941)	**546	**462
	***-2.08	*** -0.74	***(0-1.69)	***-0.66	***(0.06-1.17-3.74)	***(0.20-0.24-0.38)	***0.37	***3.68
L-Hg	*3234	*1623	*(1590-1507)	*1377	*(1760-1370-1654)	*(2025-2971-2932)	*554	*450
	**3278	**1618	**(1591-1505)	**1381	**(1760-1381-1618)	**(2055-2984-2944)	**555	**450
	***1.34	***-0.31	***(0.06-0.13)	***0.29	***(0-0.29-2.22)	***(1.46-0.44-0.41)	***0.18	***0

*Experimental frequencies
**Theoretical frequencies
***Error %

Table 7. bond length of a new Cefaxime derivative Druq.

Bond	Actual (Aº)	Optimal(Aº)	Bond	Actual (Aº)	Optimal(Aº)
C(36)-H(61)	1.113	1.113	N(11)-C(33)	1.45	**1.45**
C(36)-H(60)	1.113	1.113	C(12)-S(32)	1.815	**1.815**
C(36)-H(59)	1.113	1.113	C(31)-C(8)	1.337	**1.42**
C(35)-H(58)	1.113	1.113	C(30)-C(31)	1.337	**1.42**
C(35)-H(57)	1.113	1.113	C(29)-C(30)	1.337	**1.42**
C(35)-H(56)	1.113	1.113	C(28)-C(29)	1.337	**1.42**
C(33)-H(55)	1.113	1.113	C(27)-C(28)	1.337	**1.42**
C(31)-H(54)	1.1	1.1	C(8)-C(27)	1.337	**1.42**
C(30)-H(53)	1.1	1.1	C(4)-O(26)	1.208	**1.208**
C(29)-H(52)	1.1	1.1	C(22)-O(25)	1.355	**1.355**
C(28)-H(51)	1.1	1.1	C(24)-C(1)	1.337	**1.42**
C(27)-H(50)	1.1	1.1	C(23)-C(24)	1.337	**1.42**
O(25)-H(49)	0.972	0.972	C(22)-C(23)	1.337	**1.42**
C(24)-H(48)	1.1	1.1	C(21)-C(22)	1.337	**1.42**
C(23)-H(47)	1.1	1.1	C(20)-C(21)	1.337	**1.42**
C(21)-H(46)	1.1	1.1	C(1)-C(20)	1.337	**1.42**
C(20)-H(45)	1.1	1.1	N(5)-H(19)	1.012	**1.022**
C(17)-H(44)	1.113	1.111	C(15)-O(16)	1.338	**1.338**
C(17)-H(43)	1.113	1.111	C(12)-H(14)	1.113	**1.113**
C(17)-H(42)	1.113	1.111	C(2)-C(4)	1.509	**1.509**
C(9)-H(41)	1.113	1.113	C(10)-O(13)	1.208	**1.208**
C(7)-H(40)	1.113	1.113	C(12)-C(9)	1.523	**1.523**
C(7)-H(39)	1.113	1.113	N(11)-C(12)	1.45	**1.45**
C(7)-H(38)	1.113	1.113	C(10)-N(11)	1.369	**1.369**
C(2)-H(37)	1.113	1.113	C(9)-C(10)	1.4584	**1.509**
O(16)-C(17)	1.402	1.396	N(5)-C(9)	1.45	**1.46**
C(15)-O(18)	1.208	1.208	C(6)-C(8)	1.337	**1.503**
C(33)-C(15)	1.509	1.509	C(6)-C(7)	1.497	**1.497**
C(34)-C(36)	1.523	1.523	N(3)-C(6)	1.26	**1.26**
C(34)-C(35)	1.523	1.523	C(4)-N(5)	1.369	**1.369**
S(32)-C(34)	1.6943	1.815	C(2)-N(3)	1.47	**1.47**
C(33)-C(34)	1.523	1.523	C(1)-C(2)	1.497	**1.497**

Table 8. Dihedral angles of a new Cefaxime derivative Druq.

Bond	Actual (deg.)	Optimal(deg.)	Bond	Actual (deg.)	Optimal(deg.)
C(36)-H(61)	1.113	1.113	C(7)-H(38)	1.113	**1.113**
C(36)-H(60)	1.113	1.113	C(2)-H(37)	1.113	**1.113**
C(36)-H(59)	1.113	1.113	O(16)-C(17)	1.402	**1.396**
C(35)-H(58)	1.113	1.113	C(15)-O(18)	1.208	**1.208**
C(35)-H(57)	1.113	1.113	C(33)-C(15)	1.509	**1.509**
C(35)-H(56)	1.113	1.113	C(34)-C(36)	1.523	**1.523**
C(33)-H(55)	1.113	1.113	C(34)-C(35)	1.523	**1.523**
C(31)-H(54)	1.1	1.1	S(32)-C(34)	1.6943	**1.815**
C(30)-H(53)	1.1	1.1	C(33)-C(34)	1.523	**1.523**
C(29)-H(52)	1.1	1.1	N(11)-C(33)	1.45	**1.45**
C(28)-H(51)	1.1	1.1	C(12)-S(32)	1.815	**1.815**
C(27)-H(50)	1.1	1.1	C(31)-C(8)	1.337	**1.42**
O(25)-H(49)	0.972	0.972	C(30)-C(31)	1.337	**1.42**
C(24)-H(48)	1.1	1.1	C(29)-C(30)	1.337	**1.42**
C(23)-H(47)	1.1	1.1	C(28)-C(29)	1.337	**1.42**
C(21)-H(46)	1.1	1.1	C(27)-C(28)	1.337	**1.42**
C(20)-H(45)	1.1	1.1	C(8)-C(27)	1.337	**1.42**
C(17)-H(44)	1.113	1.111	C(4)-O(26)	1.208	**1.208**
C(17)-H(43)	1.113	1.111	C(22)-O(25)	1.355	**1.355**
C(17)-H(42)	1.113	1.111	C(24)-C(1)	1.337	**1.42**
C(9)-H(41)	1.113	1.113	C(23)-C(24)	1.337	**1.42**
C(7)-H(40)	1.113	1.113	C(22)-C(23)	1.337	**1.42**
C(7)-H(39)	1.113	1.113	C(21)-C(22)	1.337	**1.42**
C(20)-C(21)	1.337	1.42	S(32)-C(34)-C(36)-H(61)	-172.906	**1.369**
C(1)-C(20)	1.337	1.42	C(35)-C(34)-C(36)-H(59)	-56.4533	**1.47**
N(5)-H(19)	1.012	1.022	C(35)-C(34)-C(36)-H(60)	-176.417	**1.497**
C(15)-O(16)	1.338	1.338	C(35)-C(34)-C(36)-H(61)	63.5471	**1.42**
C(12)-H(14)	1.113	1.113	C(33)-C(34)-C(35)-H(56)	-180	**1.42**
C(2)-C(4)	1.509	1.509	C(33)-C(34)-C(35)-H(57)	60.0364	**1.022**
C(10)-O(13)	1.208	1.208	C(33)-C(34)-C(35)-H(58)	-59.9996	**1.338**
C(12)-C(9)	1.523	1.523	S(32)-C(34)-C(35)-H(56)	-73.3444	**1.113**
N(11)-C(12)	1.45	1.45	S(32)-C(34)-C(35)-H(57)	166.692	**1.509**
C(10)-N(11)	1.369	1.369	S(32)-C(34)-C(35)-H(58)	46.656	**1.208**
C(9)-C(10)	1.4584	1.509	C(36)-C(34)-C(35)-H(56)	53.3278	**1.523**
N(5)-C(9)	1.45	1.46	C(36)-C(34)-C(35)-H(57)	-66.6358	**1.45**
C(6)-C(8)	1.337	1.503	C(36)-C(34)-C(35)-H(58)	173.3282	**1.369**
C(6)-C(7)	1.497	1.497	C(12)-S(32)-C(34)-C(33)	-46.6803	**1.509**
N(3)-C(6)	1.26	1.26	C(12)-S(32)-C(34)-C(35)	-164.233	**1.369**
C(4)-N(5)	1.369	1.369	C(12)-S(32)-C(34)-C(36)	78.1999	**1.47**
C(2)-N(3)	1.47	1.47	N(11)-C(33)-C(34)-S(32)	61.3229	**1.497**
C(1)-C(2)	1.497	1.497	N(11)-C(33)-C(34)-C(35)	178.8757	**1.42**
C(15)-O(16)-C(17)-H(42)	-180	1.42	N(11)-C(33)-C(34)-C(36)	-63.5573	**1.42**
C(15)-O(16)-C(17)-H(43)	-60.0364	1.42	C(8)-C(6)-C(7)-H(38)	-179.59	**1.022**
C(15)-O(16)-C(17)-H(44)	59.9996	1.022	C(8)-C(6)-C(7)-H(39)	-62.0374	**1.338**
N(11)-C(33)-C(15)-O(16)	-122.549	1.338	C(8)-C(6)-C(7)-H(40)	55.5296	**1.113**
N(11)-C(33)-C(15)-O(18)	57.4513	1.113	C(2)-N(3)-C(6)-C(7)	-60.9463	**1.509**
C(34)-C(33)-C(15)-O(16)	122.5487	1.509	C(2)-N(3)-C(6)-C(8)	56.6065	**1.208**
C(34)-C(33)-C(15)-O(18)	-57.4513	1.208	C(2)-C(4)-N(5)-C(9)	174.1735	**1.523**
H(55)-C(33)-C(15)-O(16)	0	1.523	C(2)-C(4)-N(5)-H(19)	52.4534	**1.45**
H(55)-C(33)-C(15)-O(18)	180	1.45	C(20)-C(1)-C(2)-N(3)	-66.6334	**1.369**
C(33)-C(34)-C(36)-H(59)	180	1.369	C(20)-C(1)-C(2)-C(4)	174.7226	**1.509**
C(33)-C(34)-C(36)-H(60)	60.0364	1.509	C(20)-C(1)-C(2)-H(37)	-47.4832	**1.46**
C(33)-C(34)-C(36)-H(61)	-59.9996	1.46	C(24)-C(1)-C(2)-N(3)	-166.57	**1.503**
S(32)-C(34)-C(36)-H(59)	67.0935	1.503	C(24)-C(1)-C(2)-C(4)	74.786	**1.497**
S(32)-C(34)-C(36)-H(60)	-52.8702	1.497	C(24)-C(1)-C(2)-H(37)	61.3425	**1.369**

Conclusions:

The new Schiff base ligand and its metal complexes were successfully synthesized and characterized. Physio-chemical and spectroscopic approaches were used to determine the mode of bonding and overall structure of the complexes. The Hyperchem-8.07 program has been used to predict

the structural geometries of all compounds in gas-phase using PM3 program to calculate physical parameter (ΔE & ΔH). The free ligand (L) and its metal complexes showed a significant antibacterial activity. All complexes were found to be more effective than the free ligand.

Authors' declaration:

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission for re-publication attached with the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee in University of Baghdad.

Authors' contributions statement:

S.S. devised the project, the main conceptual ideas and proof outline. Z.A. worked out almost all of the technical details, and performed the numerical calculations for the suggested experiment. N.J. worked out the bound for quantum mechanics, with help from S.S verified the numerical results by an independent implementation. S.S and Z.A. proposed the experiment in discussions with N.J. and wrote the manuscript.

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تحضير ودراسة نظرية، تقييم بيولوجي لبعض أيونات المعادن باستخدام مركب "ميثيل -6- [2- (4- هيدروكسي فينيل) -2 - ((1-فينيل إثيليدين) أمينو) إستاميدو] -2،2-ثنائي ميثيل-5-أوكسو -1 -ثيا-4-أزاباي سيكلو [3.2.0] هيبتان-3-كربوكسيلات

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الخلاصة:

قاعدة شيف (ميثيل 6- (2- (4-هيدروكسيفينيل) -2- (1-فينيل إيثيل إدينيامينو) أسيتاميدو) -3، 3-ثنائي ميثيل-7-أوكسو-4-ثيا-1-أزابيسيكلو [3.2.0] هيبتان -2- كاربوكسيلات. تم استخدام أيونات العناصر و(Hg (II) , (Zn(II) (II , Cu (II) , Co (II), Ni (II)] لتحضير المعقدات . تم استخدام بنسبة تحليل المعادن M والتحليل الكيميائي للعناصر (CHNS)، وغيرها من الطرق الفيزيائية والكيميائية القياسية. تم استخدام القابلية المغناطيسية وقياسات الموصلية و FT-IR والأطياف المرئية للأشعة فوق البنفسجية لتحديدها. تم إجراء المعالجة النظرية للمعقدات المحضرة في الطور الغازي باستخدام برنامج (hyperchem-8.07) للميكانيكا الجزيئية والحسابات شبه التجريبية. تم استخدام طريقة (PM3) لتحديد حرارة التكوين ($\Delta H^{\circ}f$)، وطاقة الربط (Eb)، والطاقة الكلية (ET) للروابط والمجمعات المعدنية عند 298 K. لاستكشاف المواقع التفاعلية للمركبات، تم حساب القيم الكهروستاتيكية للرابط (L). تم استخدام PM3 لحساب ترددات اهتزازات (ligand L) ومعقداته المعدنية ، والتي تمت مقارنتها بعد ذلك بالبيانات التجريبية. تم فحص النشاط المضاد للبكتيريا (L) ومركباته المعدنية ضد ثلاثة كائنات دقيقة ضارة: *Staphylococcus aureu*s (إيجابي الجرام) ، *Echerchia coli* (سلبي الجرام) ، و *Candida Albicans*.

الكلمات المفتاحية: الفعالية البيولوجية، ,معقدات قواعد شف ,ايونات العناصر الانتقالية ,طريقة PM3 وDFT.