SYNTHESIS, STRUCTURAL STUDY AND ANTIBACTERIAL ACTIVITY OF SOME NEW COMPLEXES WITH 2-N(4-N,N-DIMETHYL BENZYLIDEN)-5-(P-IODO PHENYL)-1,3,4-THIODIAZOLE WITH Cr (III), Mn (II), and Cd (II) IONS

Sh.R. Bakir[*], T.A.A. Kareem[**] and M.F. Alias[*]
[*] Department of Chemistry, College of Science for Women, University of Baghdad.
[**] Chemical Search and Petrochemical Department, Ministry of Scientific and Technology, Baghdad-Iraq.

Abstract

A new Schiff base 2-N(4-N,N-dimethyl benzyliden)-5-(p-Iodo phenyl)-1,3,4-thiodiazol and its metal complexes with Cr(III), Mn(II), and Cd (II) ions , were synthesized . The prepared complexes were identified and their structural geometries were suggested by using flame atomic absorption technique, FT-IR and Uv-vis Spectroscopy, in addition to Magnetic Susceptibility and Conductivity measurements .Different bonding and structural behavior were revealed through the study of the coordination chemistry of the metal complexes of the ligand. The nature of bonding between the metal ion and the donor atoms of the ligand were demonstrated through the calculated of Racah parameter and the other ligand field parameters which were calculated by using suitable Tanaba-Sugano-diagrams .Structural geometries of these compounds were also suggested in gas phase by using theoretical treatments, using Hyper chem-6 program for the molecular mechanics and semi-empirical calculations. The heat of formation (ΔH_f°) and binding energy (ΔE_b)for the free ligand and it's metal complexes were calculated by PM3 methods.

The antibacterial activity for the ligand and its metal complexes were studied against two selected microorganisms (***Staphylococcus aureus***) as gram positive and (***Pseudomonas aeruginosa***) as gram negative.

Introduction

Schiff bases offer aversatile and flexible series of ligands capable to bind with various metal ions to give complexes with suitable properties for many applications[1]. The way that ligand coordinate to the metal ion is effected by the type and oxidation state of the metal ion in addition to the ligand structure [2]. A great deal of work concerning metal complexes of imine were concentrated on the cobalt(III) complexes [3], that are used as reversible of oxygen carrier or a model for vitamin B_{12}-Co-enzyme, the attention is also extended to Fe(II) complexes which are included in hemoglobin found in some biological systems [3].

Many complexes of Schiff base have proven to be antitumer and have carcinostatic activities[4,5]. On the other side. They have a great importance in the biological reactive like visual process [6], and in the reaction that involves removing the amine group by enzyme effect and some B_6-catalysed reaction [7]. The biological activity of imine is attributed to the formation of stable chelates with transition metals present in the cell [8] .

Experimental

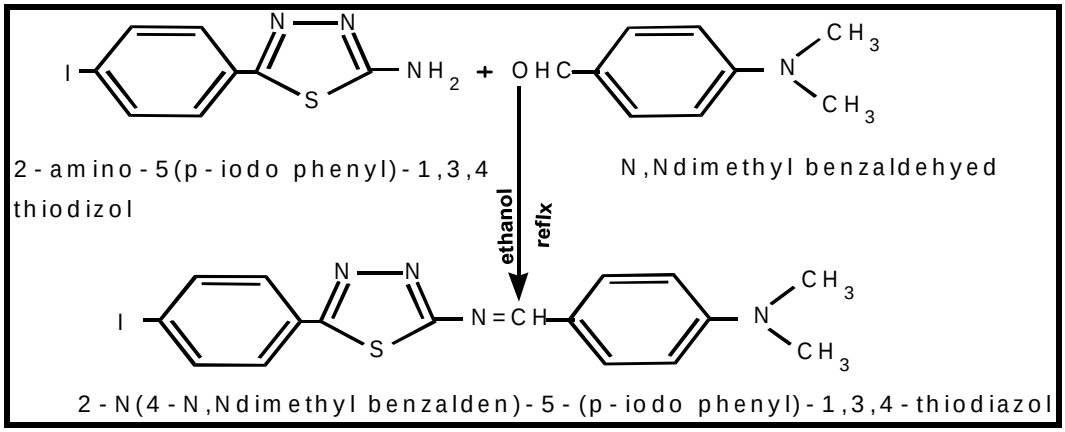
Material, physical measurement and analysis. All chemicals were of highest purity used as received. Melting points were recorded on Gallen Kamp melting point apparatus and were uncorrected .FTIR spectra were recorded using FTIR 8400 Shimadzu in the rang of (4000-200)cm^{-1} and samples were measured as CsI disc.Electronic spectra were obtained using (Uv-160) Shimadzu Spectrophotometer at room temperature using ethanol as a solvent. The metal conte nt was estimated using Atomic Absorption Shimadzu AA670 Spectrophotometer.

Conductivity measurement were obtained using (WTW) conductometer, these measurements were obtained in DMSO using concentration 10^{-3} M at 25°C. Magnetic Susceptibility measurement was obtained at 25 °C in the solid state, applying Faraday's method using Bruker BM6 instrument.

Preparation of ligand :

The method that used to prepare 2-amino -5(p-iodo phenyl)-1,3,4-thiodiazol (AI) was prepared according to reported method [9]. The Schiff base (L) was prepared according to the following :

(0.05 mol, 5.17g)of(AI) of was dissolved in (15) ml absolute ethanol and (3.7g, 0.05 mol) N,N dimethyl bezyldehyde dissolved in (10) ml in the same solvent were mixed and added to AI, with drop of glacial acetic acid, the reaction mixture was refluxed for 4hours, the mixture was cooling at room temperature, then left over night in a refrigerator, the separated solid was filtered and crystallized from ethanol .The physical properties of the (L) were listed in the Table (1). The structure formula of the ligand may be suggested as in the following scheme.



Preparation of the complexes

One general procedure was adopt, as following. The salt of ($CrCl_3.6H_2O$,$Cd(NO_3)_2.4H_2O$, $MnCl_2.4H_2O$). were dissolved in ethanol and added to an ethanolic solution of Schiff base in (1:1)for cadmium complexe and (1:2) for chromium and magnesium complexes molar ratio with stirring . The mixture was heated under reflux for 3hours .during this period the precipitation was completed. The precipitate was collected by filtration, washed with ethanol and dried under vacuum. All these complexes were analyzed by using different available techniques, the physical properties of these compounds are listed in Table (1) .

Bacteriological Activity

Bactericidal activity of the ligand and it's complexes of chromium, manganese and cadmium were evaluated against representative gram-positive and gram-negative bacteria by agar-plate method [10]. All the compounds were prepared freshly by dissolving them in DMSO to obtaine a final concentration of 5mM and10mM. All bacteria were cultivated in nutrient agar . The results obtained are shown in Table (6) .

Theoretical Treatment

Computational Chemistry

Today,advances in software have produced programs that are easily used by any chemist. Hyper Chem-6 program is known for its quality,flexibility and ease of use,it offers ten semiempirical methods[11, 12a]. Some of then have been devised specifically for the description of inorganic chemistry as well, and generally good for predicting molecular geometry and energetics.They can be used for predicting vibration modes and transition structures [12b].

In the present work, parameterization method 3(PM3) was used for the calculation of heat of formation and binding energy for all metal complexes. PM3 is more popular than other Semi empirical methods due to the availability of algorithms and more accurate than with other methods.PM3\TM is an extension of the PM3 method to include d orbitals for use with transion metals [12c]. It has been parameterized primarily for organic

molecules and certain transition metals listed below:
Ti,Cr,Mn,Co,Ni,Cu,Zn,Zr,Mo,Ru,Rh,Pd,Cd, Hf,Ta,W,Hg

Results and Discussion

Infrared Spectroscopic Study

The IR spectral data of the ligand and all complexes are listed in Table (2). There is no appreciable change took place in the absorption of υ(Ar-N) mode and the stretching of (NCS) moiety in the monomer complexes, which excludes of the the possibility of nitrogen atom participation in coordination for all prepared compounds.

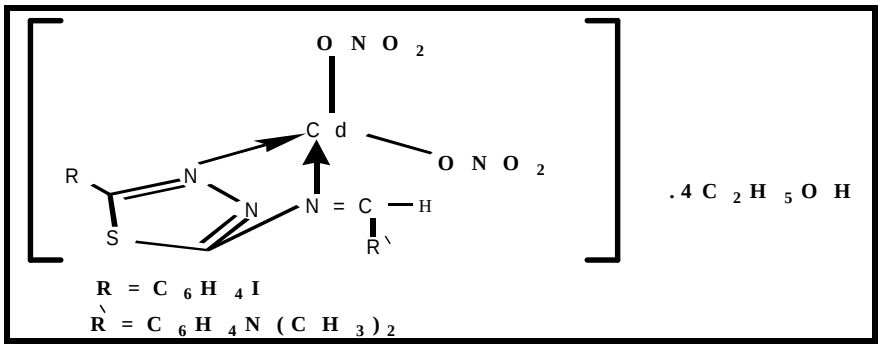
Further more there is a change in the frequency and intensity of the υC=N and υN-N bands, this behavior refers to coordinate modes of the ligand through nitrogen of is methane and nitrogen moiety of the thiodazole ring. These observatios were further supported by appearance frequencies of υM-N, υM-O and υM-Cl respectively [13, 14].

Electronic Spectroscopic Study

CdL_1 Complex

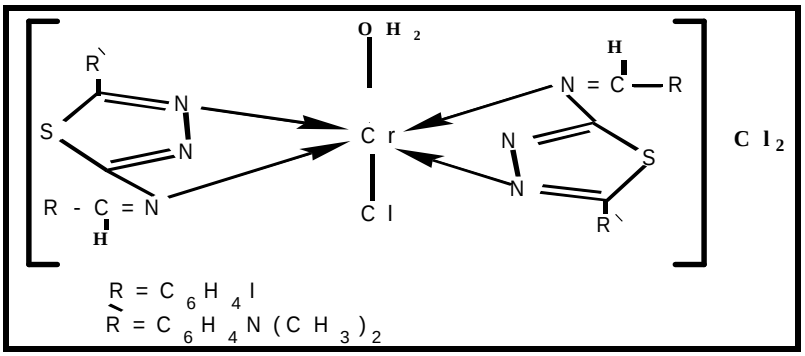
Since the Uv-visible spectrum of d^{10} ion do not furnish a lot of informations, so some shifting and change in the shape of the bands were compared with these of the ligand, therefore apossible geometry around the ion can be suggested considering the metal analysis, FTIR spectra and magnetic moment taking in account the available structures reported in the literature [15-17].

The magnetic susceptibility measurements appeard that the compound is a diamagnetic and molar conductivity measurement showed that the complex was non ionic. From the previous data, the structure of the complex can be suggested as tetrahedral geometry as follows:



CrL_1 Complex

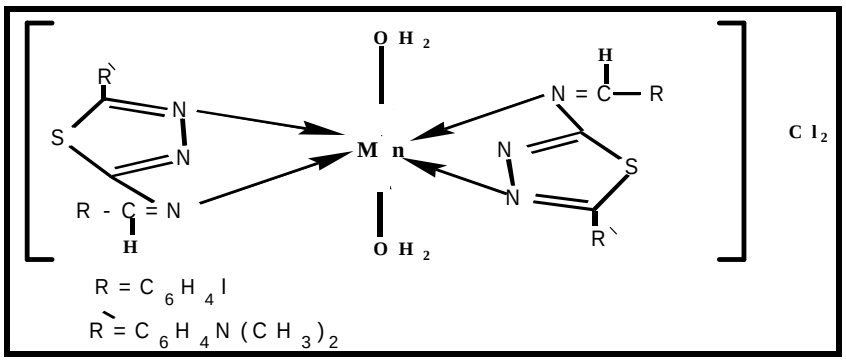
The spectrum of Cr(III) complex in ethanol showed three bands at 15.384, 23.353 and 27.777 cm^{-1} were assigned as belonging to transition $^4A_2g \rightarrow {}^4T_2g$, $^4A_2g \rightarrow {}^4T_1g$ and $^4A_2g \rightarrow {}^4T_{1g(P)}$. The values of ligand field (10Dq) was calculated using Tanaba-Sugano diagram for d^3configuration, the different ligand field parameter β, B\ have been calculated using the same diagram. All results are listed in Table (3). The magnetic susceptibility and molar conductivity indicate this complex to be octahedral, and to be conducting. According to these results and spectroscopy study in addition to analysis the suggested structure is :



MnL_1 Complex

The spectrum of This complex showed a series of very weak and some narrow bands, this expected because only sextet term of d^5configuration in octahedral stereochemistry is the ^6A_1g, there can be no spin allowed transition [18,19], and these bands were assigned to$^6A_1g \rightarrow {}^4T_1g_{(G)}$, $^6A_1g \rightarrow {}^4T_2g_{(G)}$ and $^6A_1g \rightarrow {}^4A_1g + {}^4Eg_{(G)}$ respectively[18].

The value of ligand field, Racah parameter and β have been calculated using Tanaba-Sugano diagram for d^5 system [20,21], magnetic moment of solid state was (5.8) B.M and, showed a high spin around manganese (II) [19, 22], Conductivity measurements showed the complex to be ionic, Table (3). From the above data the proposed structure is:



Theoretical Study

The vibration spectra of the starting material and Schiff base (L) were calculated [23]. The theoretically calculated wave numbers showed some deviation from the experimented values. These deviation are generally accepted in theoretical calculation. The deviation or errors occurs the calculated frequencies are due to several factors of these are :

1-Hartree-Fock Theory (HFT) .

2-There are coupling between vibrational models.

Electrostatic potential (E.P) :

Electrostatic potential of free ligand was calculated and plotted as 2D contour to investigate the reactive sites[24]of the molecules Fig.(3), and one can interpret the stereochemistry and rates of many reaction involving soft electrophiles and nuclephiles interims of properties of frontier orbitals (HOMO and LUMO). Overlap between the HOMO and LUMO is a governing factor in many reaction. The H and L values were plotted as 2D contour to get more in formation about these molecules. The results of calculation showed that the LUMO of transition metal ion prefer to react with the HOMO of nitrogen atom of Schiff base and nitrogen of the ring thiodazole ligand [25].

Optimized Geometries Energy of Metal Complexes for Schiff Base :

A theoretically probable structures of metal complexes with Schiff base have been calculated to search the most probable model building stable structure, these shapes Fig. (4) shows the calculated optima geometries for (L) and it's metal complexes. The result of PM3 method of calculation in gas phase for the binding energies and heat of formation of Cr(III), Mn(II) and Cd(II), these are describe in Table (4).

The results reflected that the complexes of imine exhibited to be more stable than the donor chelating ligand, this difference in stability of complexes might be related to the chelating effect.

Bactericidal Activity :

As results from the study of antimicrobial of the prepared compound Schiff base, and it's metal complexes, Table (6), the following points were concluded

1-The results reflected that the donor base, showed that there is no significant activity against ***Pseudomonas aeruginosa*** and ***Staphylococcus aureus*** bacteria when we used high and low concentrations.

2-The results of antibacterial activities of manganese complex, showed that there is no effect towered the studied bacteria, when we used high and low concentrations, while, chromium complex exhibited antibacterial towered ***Staphylococcus aureus*** bacteria when we use two concentrations.

3-The study of antibacterial activities revealed that the d^{10} configuration, cadmium complex, exhibited highly signification activity against the studied bacteria rather than that observed for any of the reminded complexes.

4-Biological evaluations of considerable number of these compounds have been maintained, and they were found to exhibit the expected synergic effect of activity, this attributed to the impact of the compound and the metal present in these complexes.

Table (1)
Physical data for the ligand and their metal complexes.

Comp.	colour	m.p/c°	Yield%	Atomic Abs. found(cal.)	Suggest molecular formula
L	Yellowish orange	212	70.0	—	$C_{17}H_5N_4SI$
CrL	Greenish brown	188d	56.0	5.65 (5.16)	$[CrL_2Cl(H_2O)]Cl_2$
CdL	Yellow	167d	71.5	13.55 (13.2O)	$[CdL(NO_3)_2].4C_2H_5OH$
MnL	brown	112	59.8	5.08 (5.27)	$[MnL_2(H_2O)_2]Cl_2$

d: decomposed point.

Table (2)
The most diagnostic FT-IR bands for the ligand and its metal complexes(cm^{-1}).

Comp. / Frequency	L	CrL	CdL	MnL
υ(N=C) iso	1666	1650	1655	1650
υNCS	1056 1110	1056 1118	1060 1110	1060 1114
υCSC	1157	1157	1160	1160
υCS	771	772	775	770
υC=N ring	1596 1519	1597 1510	1600 1512	1604 1512
υNCN	1373	1373	1373	1373
υN-N	1440	1450	1465	1463
υAr-N	1319	1320	1319	1320
υM-N	—	495	450	489
υM-O	—	—	—	420
υM-Cl	—	380	382	—
υNO_2	—	—	1542	—
δH_2O	—	827	—	827

Table (3)
Electronic spectra, conductance and magnetic moment, for Metal complexes of imines.

Comp.	CrL	CdL	MnL
Band cm^{-1}	15.3884 23.252 27.777	32.240 29.020	10.373 19.807 26.178
Assignment	$^4A_2g \rightarrow {}^4T_2g$ $^4A_2g \rightarrow {}^4T_1g$ $^4A_2g \rightarrow {}^4T_1g_{(P)}$	ILCT	$^6A_1g \rightarrow {}^4T_1g_{(G)}$ $^6A_1g \rightarrow {}^4T_2g_{(G)}$ $^6A_1g \rightarrow {}^4A_1g + {}^4Eg_{(G)}$
B	918		860
B\	805		725
β	0.876		0.845
10Dq	15313		8831.5
15 B\	16407		10875
*μeff.*BM	3.10	0.0	5.80
*μ*s. cm^{-1}	78.0	26.0	72.0

ILCT : Internal Ligand Change Transfer.

Table (4)
Conformation energetic in ($KJ.Mol^{-1}$) for imines and its metal complexes.

Conformation	PM3	
	ΔH_f°	ΔE_b
AI	1160.200247	-1994.6289
L	157.010082	-4073.5669176
CrL	-168.109631	-9905.255601
CdL	-96.153202	-7932.122511
MnL	-105.63905	-46521.01393

Table (5)
Comparison of experimental and theoretical vibrational frequencies for the starting material and imine.

Symb.	AI	L
υNH_2	(3309,3290)* (3545,3489)** (-7.1,-6.4)***	—
υ(C= N) iso	—	(1666.03)* (1775.3)** (-6.1)***
υNCS	(1045,1116)* (1031,1230)** (13,-10.2)***	(1056.9,1110.9)* (1077.03,1127.08)** (-1.9,-1.4)***
υN-N	(1463)* (1412)** (3.4)***	(1440)* (1452)** (-0.8)***
υCSC	(1178)* (1204)** (-2.2)***	(1157.2)* (1186.5)** (-2.5)***
υCS	(769)* (735)** (4.4)***	(771)* (793.6)** (-2.9)***
υNCN	(1392)* (1328)** (2.2)***	(1373.2)* (1330.8)** (3.08)***
υAr-N	—	(1319.2)* (1328)** (-0.6)***

Where:
: Experimental frequency
****: Theoratical frequency***
*****: Error % due to main difference in the experimental measurements and theoretical treatments of vibrational spectrum***

Table (6)
Antibacterial activities for Schiff base and its complexes.

Comp.	(+)*Staphylococcus aureus*		(-)*Pseudomonas aeruginosa*	
	5mM	10mM	5mM	10mM
L	-	-	-	-
CrL	+	+	-	-
MnL	-	-	-	-
CdL	+	++	+++	++++

(-) = No inhibition = inactive
(+) = (0.4-1) mm = slightly active
(++) = (1-1.6) mm = moderately active
(+++) = (1.6-2.2) mm = active
(++++) = (2.2-2.8) mm = highly active

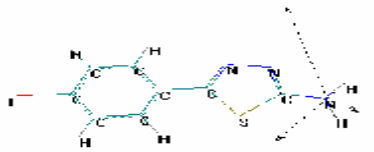
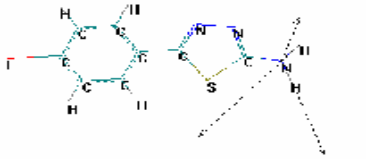
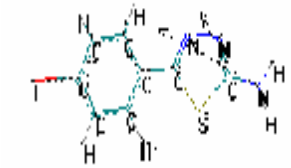
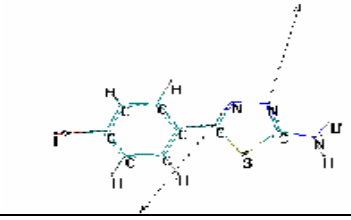
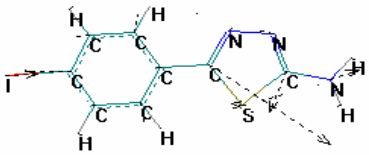
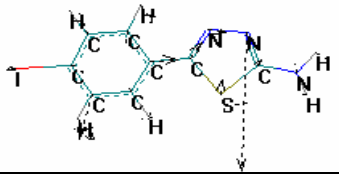
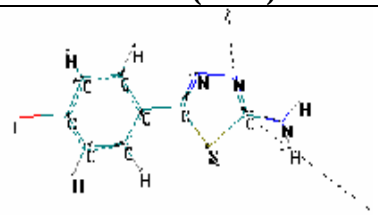
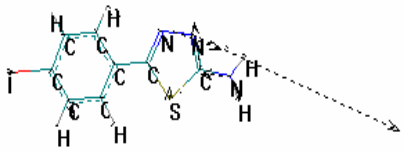
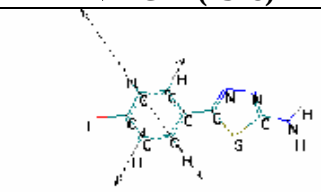
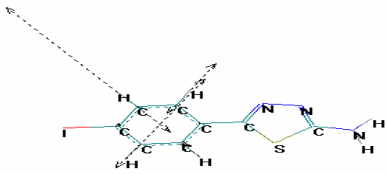
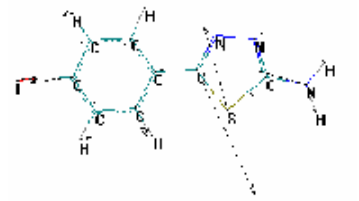
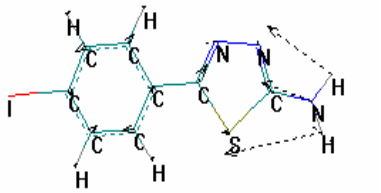
	
$\nu_{asy}NH_2$ (3545.31)	**$\nu_{sym}NH_2$(3489.40)**
	
νC-N (796.33)	**νN-N (1412.68)**
	
ν C-S-C(1204)	**ν NCS (1031.01)**
	
νN-C-N (1328)	**νN-C-S (1230.12)**
	
ν_{sym} C-H (3035.85)	**ν_{asy}C-H(3071.37)**
	
νC-S(735.63)	**δN-H (1509.79)**

Fig. (1) : The Calculated Vibrational Frequencies of AI.

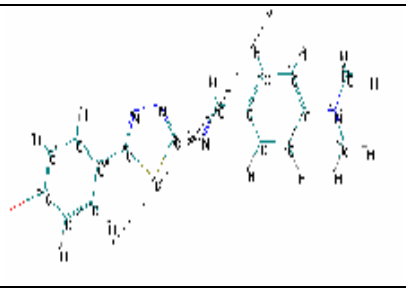
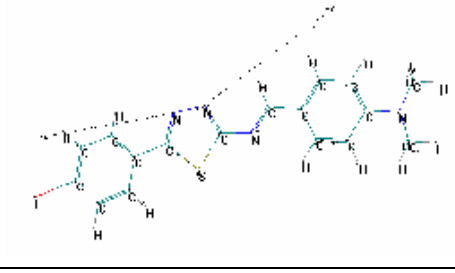
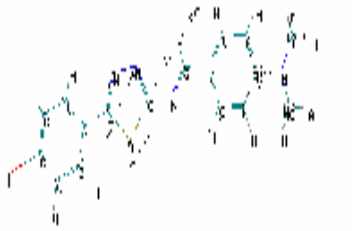
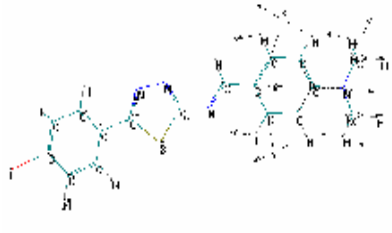
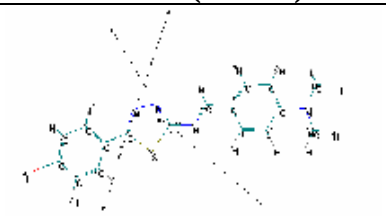
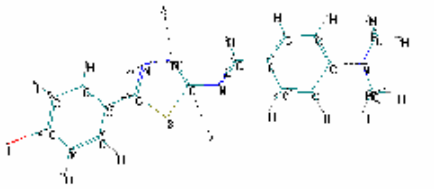
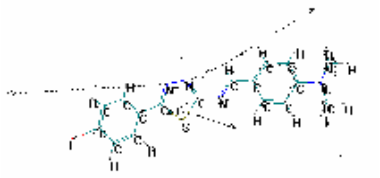
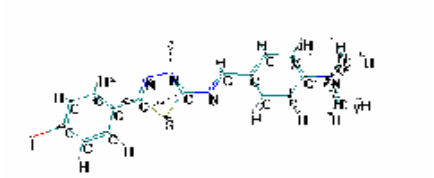
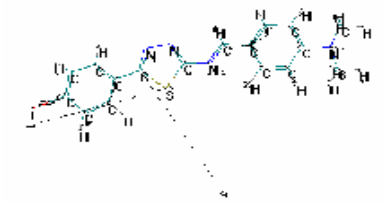
	
ν C=Niso(1775.3)	**νN-N (1452.33)**
	
ν N-C-N (1330.85)	**ν Ar-N (1328.32)**
	
νC=Nring(1566.72)	**ν C=Nring (1490.08)**
	
νN-C-S (1127.08)	**νN-C-S(1077.08)**
	
ν C-S-C(1186.57)	**νC-S (700.5)**

Fig. (2) : The Calculated Vibrational Frequencies of lmine.

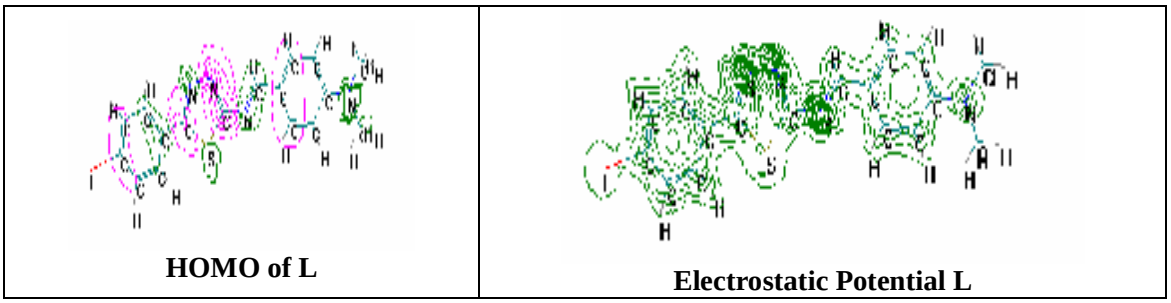


Fig. (3) : HOMO and Electrostatic Potential as 2D Contours for L.

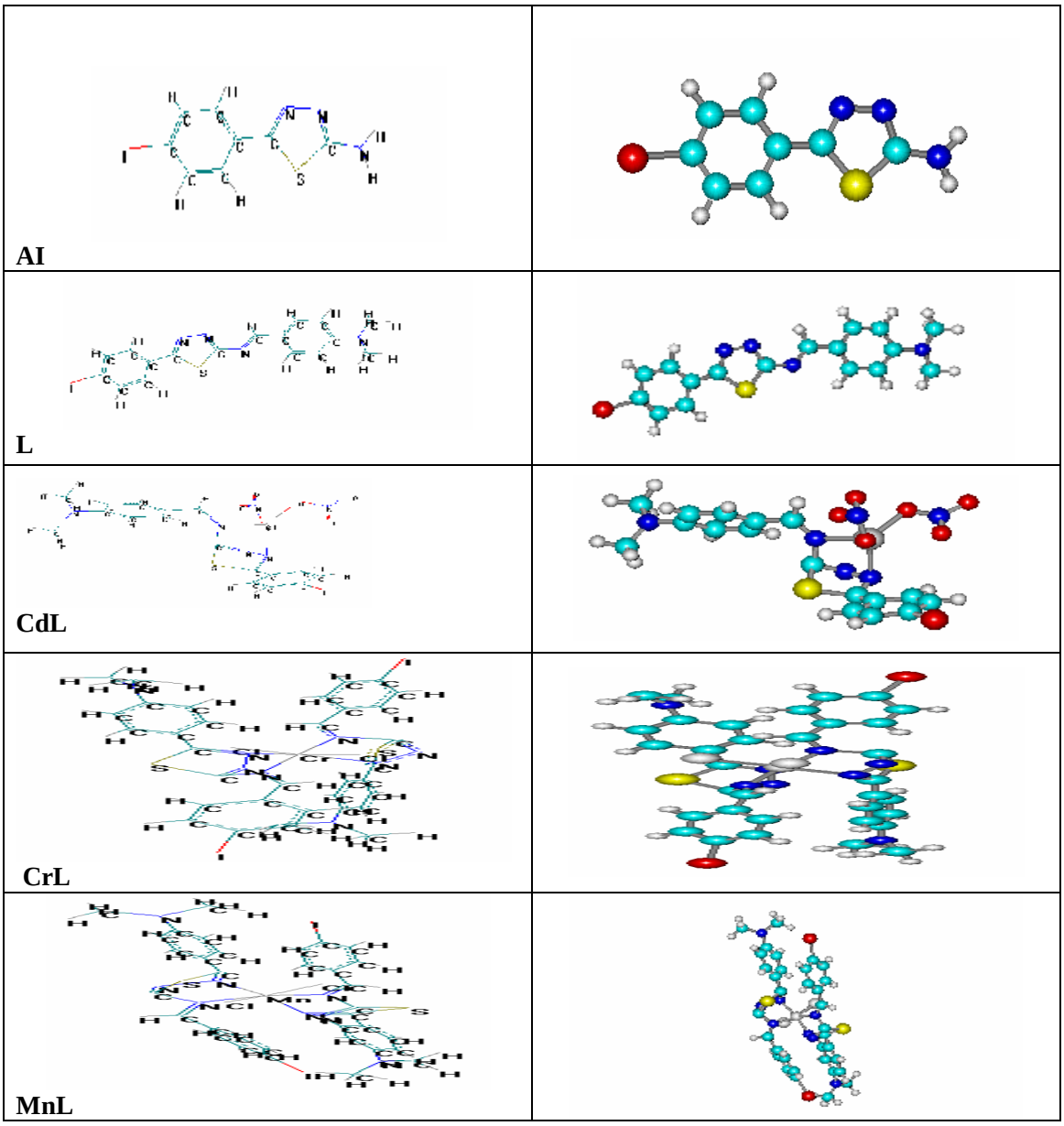


Fig. (4) : Conformational Structure of AI, L and their Complexes.

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الخلاصة

تم تحضير الليكاند N,N-4)N-2 ثنائي مثيل بنزيدين)5-بارا ايودو فنيل)-4,3,1-ثايوديازول ومعقداتة مع الايونات Cd(II), Mn(II) و Cr(III). تم تشخيص وتعيين الشكل الهندسي المقترح للمركبات المحضرة بأستخدام الاجهزة الطيفية، الاشعة تحت الحمراء والاشعة فوق البنفسجية- المرئية والامتصاص الذري اللهبي بالاضافة الى قياس الحساسية المغناطيسية والتوصيل الكهربائي لها .بهذا اتضح عدد من الخصائص التركيبية والسلوكية عند دراسة المعقدات المحضرة وكذلك تم حساب معامل راكاح والمجال الليكاندي بأستخدام مخططات تانابا- سوكانو المناسبة التي ساعدت على ايضاح طبيعة التآصر بين الفلز المركزي وذرات الليكاند المانحة .

أجريت معالجة تكوين المعقدات نظرياً في الطور الغازي بأستخدام برنامج(Hyper chem6) بتطبيق الميكانيك الجزيئي والشبة التجريبي في الحساب وذلك بأستخدام الدالة PM3 ، لحساب حرارة التكوين (ΔH_f°) وطاقة الترابط (ΔE_b) وبدرجة حرارة 298 كلفن لليكاند ومعقداته المحضرة. تم تقويم الفعالية المضادة للبكتريا لليكاند ومعقداته واختير نوعان من البكتريا (***Staphylococcus aureus***) موجبة الصبغة و (***Pseudomonas aeruginosa***) سالبة الصبغة لهذا الغرض.