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Thermodynamic Studies of Cu (II) complex of new bidentate Schiff base ligand type (NO) derived from Mebendazol

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Abstract

In the present work, the proceeding ligand as well as its complexes have been studied, via investigate the effects of the temperature within ranges over **(25º - 45º) C** and a variety of the concentrations on molar conductivity values from arrhenius law application. The limiting molar conductivity of Ligand **(L)** and **[M(L)₂Cl]Cl.H₂O** complex in different temperature was measured, by which decomposition constant and uniform molar conductivities are determined, However, thermo-dynamic parameters such as **(ΔH, ΔG and ΔS)** have been estimated and discussed. Results are shown that the value of the molar conductivity is increased with increaseing the temperature and decreased with increaseing the concentration by using **DMSO** solvent. The process of the dissociation is an exothermic process for the complex **(M⁺² = cu),** in addition to that, characterizing this prepared complex has been carried out through measuring the value of the melting point, **FTIR** spectra, **UV-Visible** spectra, and the measurements of the magnetic susceptibility, and later in comparison to the ligand and metal solutions.

Key words: complexcupper**,** Theromdynamic Measurments, 4-Aminoantipyrine**,** Mebendazol derivd, reaction kinetics

1. Introduction

The Schiff bases represent one of the significant ligand classes in the coordination chemistry and find wide-ranging applications in a variety of the areas. A new Schiff base, methyl (E)-(6-(((1,5 - di-methyl - 3-oxo -2phenyl-2, 3-di-hydro-1 H-pyrazol-4yl) imino) (phenyl) methyl) -1 H-benzo [d] imidazol-2yl) carbamate (L) was synthesized from mebendazol and 4-amino-antipyrine. Schiff base metal complexes have been produced from the metal ions of the MII = Cu in an alcoholic medium that has a molar ratio (M:L) (1:2). Complexes have the general composition of [Cu(L)2Cl] Cl.H2O[1-3]. The ligand as well as all of its complexes have been identified with the novel spectroscopic (UV_Vis, FT-IR, 1 HNMR, Mass spectroscopy, 13CNMR, and atomic absorption), besides elemental micro-analysis, measurements of the magnetic susceptibility, chloride content, thermal analyses, and molar conductance. Besides the evaluation of their biological activities towards 2 types of the bacterial and one fungus type. Nowadays, the chemists are quite focused upon Schiff base that has been derived from the heterocyclic ring with the compounds of the carbonyl, due to the fact that it is a significant special center of the attraction in a wide range of the fields, such as the biological clinical, pharmacological and analytical fields [4-5].

Coordinating those donor ligands with transition ions gives the complexes of a variety of the geometries and those complexes are commonly applied in the physical reactions[6], In fact, Schiff base metal complexes have an important impact the development of the coordination chemistry , Produced Schiff base metal complexes may play an important role of the models to understande the physical systems [7-9]. Schiff bases of the forms of 4-amino-antipyrine vary by the use of various aldehyde/ketone types, and they have been reported as superior reagents in the pharmacological, biological, analytical and clinical applications, they're enhanced through the complexation with the ions of the transition metals [10].

Moreove, Mebendazol derivatives have been utilized in azo-colorant synthesis that has been used in the analytical chemistry for the spectro-photometric determination of the metal ions. The aim of this study was for measuring the molar conductivity at different temperatures with range over (25o to 45) oC using a different concentration of DMSO solvent, and taking under consideration variations as well as results of the present study[11].

This study had exhibited that by increasing the concentration, the value of the molar conductivity is decreased.while, by increasing the temperature lead to increase the conductivity, By applying Arrhenius equation [12], that has been a possibility for explaining oure results which have been obtained, including stability of a ligand, its complex, as well as the fact that they emit heat energy.

Experiments
Ligand and complexes:

The Ligand as well as its cupper complex proceeding by [13], where all of the measurements that are needed by researcher have been made from the Mebendazol (MBZ) cupper(II) chloridedehydrate, ethanol, methanol and DMSO have been provided from the Aldrich company. The melting points for the prepared complexes have been measured with the use of the electro thermal (i.e. Stuart melting point device). Passed ammonia gas via (0.05mole) 6ml of the EtOH solution 2-hydroxyacetophenone, then, this mix has been under the glass bath. Yellow needle–like ligand crystals have been re-crystallized from the EtOH, followed by filtering and drying, 13C and 1H NMR have been recorded with the use of the UltraShield 300 MHz Switzerland at Al al-Bayt Univ., Jordan. The value of the melting point has been recorded with the use of the melting point meter KRUSS (A, KRUSSOPTRONIC). The spectra of the FTIR have been recorded as FTIR with the use of htee 3800 Shimadzu in ranging between (4,000 and 400cm-1) with the use of the (KBr) disc. The electronic spectra have been obtained with the use of the (UV160 Shimadzu) spectro-photometer at a temperature of 25 Co for 10M-3 M DMSO Solution. The value of the molar conductivity has been evaluated at a temperature of 25 Co for (10M-3M) with the use of the Philips PW, thermo-gravimetriv analysis (TGA) has been conducted with the use of the STA PT1000 Linseis co. /Germany which has been operated on through making the physical evaluations that are

represented by thermo-dynamic function values (i.e. ΔH, ΔG and ΔS).

Physical measurements:

The conductivity values has been evaluated in the DMSO and DMF solvents by using the digital conductivity meter of PHILIPS PW-9526 with 0.829cm-1 cell constant. A variety of the concentrations which ranged between (10-3 and 10-4) molar has been evaluated at 298.15K, 303.15K and 308.15 K.at a temperature range between (25o and 45o). In addition to that, concentrations that range from (0.10 to 0.5g/L) have been worked out. Specific molar conductivity has been obtained through the subtraction of solvent conductivity from solutions' conductivity. Molar conductivity value of ligand as well as its complex have been evaluated at a variety of the concentration and temperature values that range between (25o and 45) oC. The amounts of the metal in complexes has been determined through SHIMADZU AA680 atomic absorption/flame emission spectro-photometer in Ibn-Sina co. Based on results, it has been discovered that increasing concentration, conductivity is decreased, and the other way around according to the degree of the temperature, the higher the molar conductivity increased, and therefore, it has been concluded that it's the ligand and complex that exothermic process.

Synthesis of Schiff base ligand (L):

A 4-aminoantipyrine solution [0.20g, 1 mmole] in (10ml of the ethanol) has been added to (mebndazole) solution [0.29 g, 1mmole] in (10 ml of the ethanol) and 3 HBr 48% drops. This mix has been refluxed for a duration of (30hrs.) with the stirring. The orange colored solid mass that was formed throughout the pricess of the refluxing has been cooled to the temperature of the room, followed by filtering and washing with the ethanol and then it has been re-crystallized by the (methanol) for the purpose of getting a pure sample. Yield 78%, MP: (237o-240) oC, M.wt: 480.3gm/mol (C27H24N6O3). As it has been depicted in scheme1 Fig(1,2).
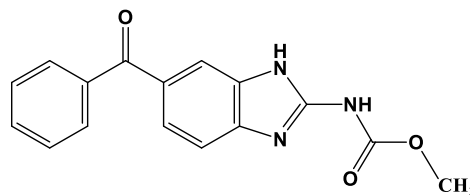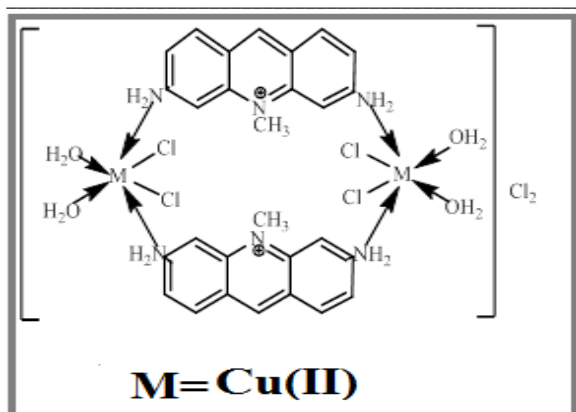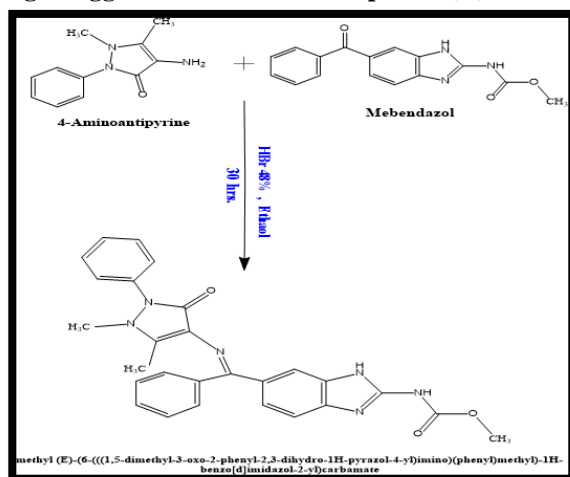

Fig 1.Strcture of mebendazol

Fig.2 suggested structure of complex cu(II)

Scheme1. **Synthesis role of the new Schiff base (L).**

Synthesis of Schiff base complex:
Synthesis of other complex:
Each of hot EtOH solution (10mL) of (0.170 1g,1mmole) of Cu(II) resoectyvely and solution of hot methanol (15mL) of (L) (0.960g, 2 mmole) have been mixed in a round flask with constantly stirring, this mix has been refluxed for a period of 3 hrs. at a temperature of **(70ºC),** A colored complexes has been then it has been precipitated, filtered and washed a number of times with the cool ethanol.

Result and Discussion
 Characterization of ligand (L):
The I.R. spectrum for (L):
Fig3, shown the strong band at 1645cm-1 is an indication of the fact that carbonyl group's stretching frequency υ(C=O) of 4AAP ring. However, a new band at a value of 1635cm1 associated with imine (C=N) stretching frequency [14]. The band at the value of 1357cm-1 have been assigned to υ(C-N) and band at (1,597) may be referring to υ(C=N)stretching of the MBZ. υ(N-N) stretching frequency of 5 member ring had emerged at (1,082). The appearance of the iminic band and disappearance of the carbonyl (C=O) band of the MBZ in the spectrum of the ligand and the

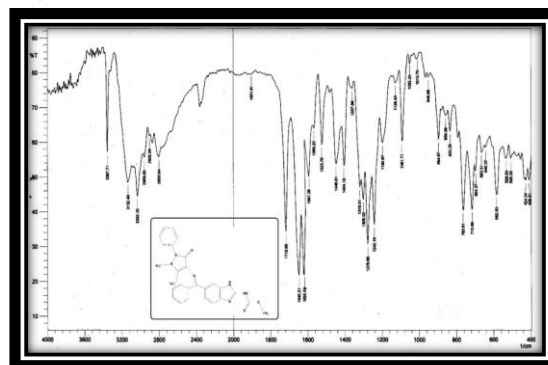disappearance of the amino group (NH2) band in ligand, is confirming Schiff base ligand's formation [15].

Fig. (3): FTIR spectra of ligand (L)
The electronic spectrum date of (L):
In this study, there have been two high peaks of the absorption, the first one at 263nm 38023cm–1 has been a result of the electronic transition π→π*, the other one has been observed at 319nm 31348cm-1 and has been a result of the π→π* electronic transition [16], 1H-NMR The data of the electronic spectrum of (L): had shown two high peaks of absorption, the first one has been at 263nm 38023cm–1 has been a result of the electronic transition π→π*, the other one emerged at 319nm 31348cm-1 has been a result of the from π→π* electronic transition [16] 1H-NMR spectrum for a ligand L: In solution, it has been noted that intra-molecular hydrogen bond between hydrogen of N-H groups and oxygen of carbonyl group had taken place. Such phenomenon was confirmed by NMR spectra. 1HNMR spectrum for (L), in the DMSO-d6 displayed. Broaden hump signal at (δH=11.72-12.34) ppm 2H is a result of altered process of the hydrogen bonding had happened between (N-H) group protons and ion pairs of carbonyl group's oxygen atoms. The signal broadness might be associated with the bonding of the hydrogen (N–H…..O) [17]. Resonance levels at the chemical shifting (δH= 7.49 -7.73) ppm (Ar–H) have been found to be assignable to the aromatic ring protons. Those protons' appearances as multi result from the mutual coupling. Signal at the chemical shifting (δH=3.78ppm) returns to the protons group (CO2CH3)[18]. Sharp singlet signals at the values of (δH= 3.18ppm & 2.49ppm) equivalent to 6 protons (6 H, S) has been a result of methyl group protons. The shown chemical shift spectrum at (δH= 2.56 and 3.39) ppm which is known as DMSO solvent, and water molecules' presence in solvent respectively. The 13 CNMR spectrum of (L) in the DMSO-d6 solvent illustrates chemical shifting at the range (δ= 114.05-138.38) ppm that has been assigned to the atoms of the aromatic carbon. Chemical shift values at (δ=167.55ppm) that result from atom of carbonyl carbon (C18). Chemical shifting at the value of (δ=160.39ppm) which resulted from imine carbon atom (C2) (130). Chemical shifting at (δ=154.33ppm) which results from atom of carbonyl carbon (C 10).

Chemical shifting at the value of (δ=150.37 ppm) which results from (C19), whereas chemical shifting at the value of (δ=149.37 ppm) which results from (C3). Chemical shifting at (δ=110.78 ppm) which results of (C17). Chemical shifting at the value of (δ=52.62ppm) assigned to the carbon atom of methoxy group (C1). Chemical shifting at (δ=33.05ppm & 14.29ppm) which has been assigned to carbon atoms of the methyl group (C21, 20) respectively [19]. Mass spectrum of (L) has been illustrated in Fig3. Molecular ion peak for ligand has been noticed at m/z = 480.40 (M)+ for $C_{27}H_{19}N_5O_3S$; needs = 480.52. Other peaks that have been detected at m/z = 450.10-77.10 which is corresponding to $[C_{26}H_{22}N_6O_2]+$-$[C_6H_5]+$. The proposed mass segmentations of (L) has been illustrated in scheme2.
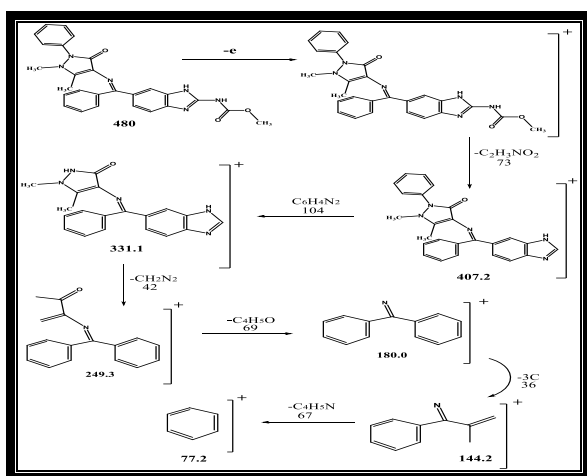

Scheme (2): Suggested mass fragmentation of Schiff base (L).

Thermal analyses of [Cu(L)₂Cl]Cl.H2O:

Thermo-gram for the **[Cu(L)₂Cl]Cl.H2O** has been illustrated by Fig4. In TGA [20] curve, peak value that has been detected at 252.48ºC has been associated with the associated loss of (Cl,Cl, H2O, H2O, N2, H2 and 2CH4) portions, (det. = 3.308mg, 15.036 %; calc. = 3.311mg). The 2nd step at 378.28ºC which has been an indication of (CO, C3H5) fragment loss, (obs. = 1.358mg, 6.173%; calc. = 1.351mg). The 3rd step at the temperature of 595.58ºC has been associated with (C13H11N2, H2) segment loss, (obs. = 3.864mg, 17.566 %; calc. = 3.865 mg). The final compound residue which has been observed higher than 598ºC has been assigned to (CuC35H20N8O5), (det. = 13.469mg, 61.223 %; calc. = 13.47mg). The curve of the DSC analysis verified peaks at the temperatures of 96.40, 135.40, and 200.70, 595.5ºC indicate process of endothermic de-composition. The peaks that has been observed at temperature degrees of 268.20, 447.10 and 400.50ºC have been associated with the processes of the exothermic decomposition. The endothermic as well as the exothermic peaks could be indicating the organic ligand combustion in argon atmosphere. The last endothermic peak could be signifying breaking of the metal-ligand bond [21,22]
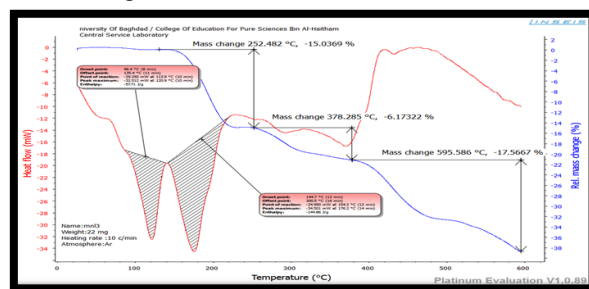
Fig. (4): (DSC and TGA) thermo-gram of the [Cu(L)2(H2O)Cl]Cl.H2O

RESULTS AND DISCUSSION:

CHEMISTRY.:

From FT- IR spectra of prepared complexes The detected value of the band at (1635cm-1) that has been assigned to azomethine group υ(N=C) stretching frequency of free ligand, the band has been shifted to a lower level of the frequency at range a range of (1620cm-1 to 1629cm-1) in the spectra of all of the complexes that have been prepared, such shifting to lower level of the frequency could be a result of involved azomethine group's nitrogen atom in a coordination with metal ions as well as the de-localization of the electronic density of the metal to ligand (π–system)[23], (HOMO→LUMO), where:.

The band at the value of (1645cm-1) stretching vibration that indicates υ C=O for 4AAP ring of the free ligand, has been shifted to a higher range of the frequencies (1650cm-1 to 1660cm-1) in spectra of all of the complexes, which show that coordination between this group's oxygen atom (C=O) and the metal ions was happened depicted in Fig.5,6.

FT-IR spectra of all of the complexes that have been prepared had shown broad band at a scope of (3446cm-1 to 3342cm-1), which could be a result of υ(O-H) of the hydrated molecules of the water in the complex's molecular formula. Those observations in infra-red spectra of ligand (L) as well as it's complexes are an indication of the fact that ligand is coordinating with the ions of the metal: Cu(II), through the (C=O) group oxygen atom of 4AAP ring. The data of the TGA of **[Cu(L)₂Cl]Cl.H2O** has been in agreement with their molecular formula [24] that has been listed in Table1.

Thermo-dynamics study:

Effects of various concentration values on the molar conductivity

The values of molar conductivity of a ligand (L) and it complex **[Cu(L)₂Cl]Cl.H2O** have been obtained in DMSO solvent at a variety of the concentration and temperature values, and as has been listed in **table2.**
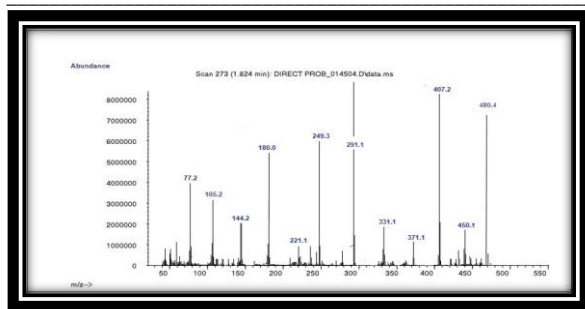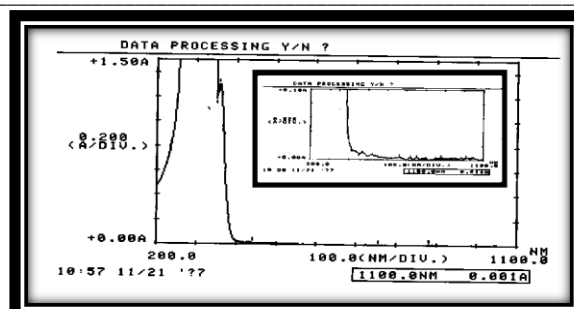
Fig. (5): Mass spectrum of (L).

Fig.(6) Electronic spectra of [Cu(L)$_2$Cl]Cl.H$_2$O in 10^{-3}M.

Table1: Physical and analytical data of the ligand and complex.

	Empirical formula	M.wt g/mol.	Yield %	Colour	mp. ºC	Micro-analysis found, (Calc.) %					Λ_m S.cm^2.mole^{-1}
						C	H	N	Metal	Cl	
1	[L]	480.52	79	Orang	237-240	66.89 (67.49)	4.80 (5.03)	17.11 (17.49)	- -	- -	-
2	[Cu^{II}C$_{54}$H$_{48}$N$_{12}$O$_6$Cl$_2$].H$_2$O	1,113	83	Dark brown	152-155	58.07 (58.22)	4.2 (4.49)	14.98 (15.09)	5.66 (5.75)	6.19 (6.38)	21.60

Table2: shows values of conductivity of (L) in (DMSO) solvent. Under a variety of the concentration and temperature values.

L

25C			30C		
C (g/L)	C(M)	S (mho)	C (g/L)	C(M)	S (mho)
0.10	4.57E-04	8.80E07	0.10	4.57E-04	1.10E07
0.20	1.00E-04	1.27E06	0.20	1.00E-04	1.32E07
0.30	1.40E-03	1.84E06	0.30	1.40E-03	2.45E07
0.40	1.85E-03	2.00E06	0.40	1.85E-03	2.60E07
0.50	2.30E-03	2.50E06	0.50	2.30E-03	2.96E07
35C			**40C**		
C (g/L)	C(M)	S (mho)	C (g/L)	C(M)	S (mho)
0.10	4.57E-04	1.25E07	0.10	4.57E-04	1.62E07
0.20	1.00E-04	2.15E07	0.20	1.00E-04	2.37E07
0.30	1.40E-03	2.40E07	0.30	1.40E-03	3.44E07
0.40	1.85E-03	3.10E07	0.40	1.85E-03	3.82E07
0.50	2.30E-03	3.57E07	0.50	2.30E-03	4.49E07

45C		
C (g/L)	C(M)	S (mho)
0.10	4.57E-04	1.70E-07
0.20	1.00E-04	2.81E-07
0.30	1.40E-03	3.75E-07
0.40	1.85E-03	4.52E-07
0.50	2.30E-03	5.15E-07

Table3: shows values of the conductivity of the complex [Cu(L)$_2$Cl]Cl.H2O in the DMSO solvent, under a variety of the concentration and temperature degrees

[Cu(L)₂Cl]Cl.H2O

| 25C			30C		
C (g/L)	C(M)	S	C (g/L)	C(M)	S
0.10	1.95E04	8.46E-08	0.10	1.95E-04	2.10E08
0.20	3.67E04	1.30E-07	0.20	3.67E-04	3.08E08
0.30	5.52E04	1.51E-07	0.30	5.52E-04	3.81E08
0.40	7.30E04	1.75E-07	0.40	7.30E-04	4.45E08
0.50	9.18E04	1.95E-07	0.50	9.18E-04	4.82E08
35C			**40C**		
C (g/L)	C(M)	S	C (g/L)	C(M)	S
0.10	1.95E04	4.51E-08	0.10	1.95E-04	7.52E08
0.20	3.67E04	6.95E-08	0.20	3.67E-04	1.30E07
0.30	5.52E04	8.81E-08	0.30	5.52E-04	1.75E07
0.40	7.30E04	1.14E-07	0.40	7.30E-04	2.09E07
0.50	9.18E04	1.25E-07	0.50	9.18E-04	2.49E07
45C					
C (g/L)	C(M)	S			
0.1	1.95E-04	9.89E-08			
0.2	3.67E-04	1.75E-07			
0.3	5.52E-04	2.54E-07			
0.4	7.30E-04	3.27E-07			
0.5	9.18E-04	4.14E-07			

Figure (7) (8) (9) (10) illustrates reduction of molar conductivity value of ligand (L) as well as its complex [Cu(L)2Cl]Cl.H2O the final concentration values of natural solution in line with electrolyte solutions' behaviours. Poor for the ligand.
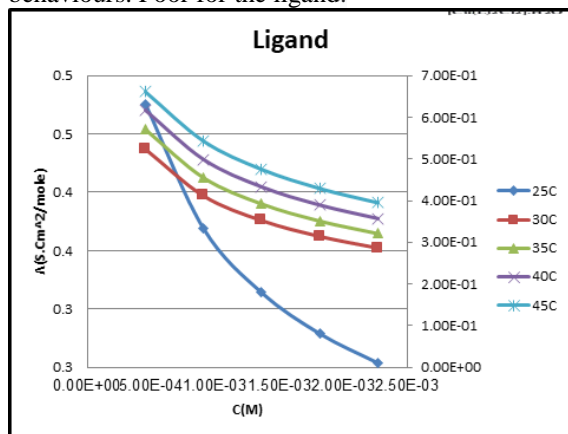
**Fig (7): shows reduction of values of the molar conductivity of (L) through the increase in solution concentration and at a variety of the temperature degrees.**
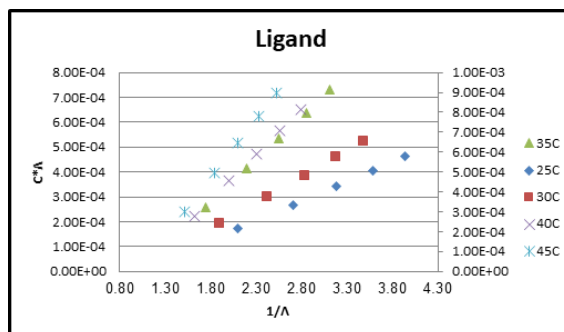
Fig (8): shows the correlation of the concentration with reciprocal of the ligand (L) conductivity with the increase in the concentrations of the solution with a variety of the temperature degrees
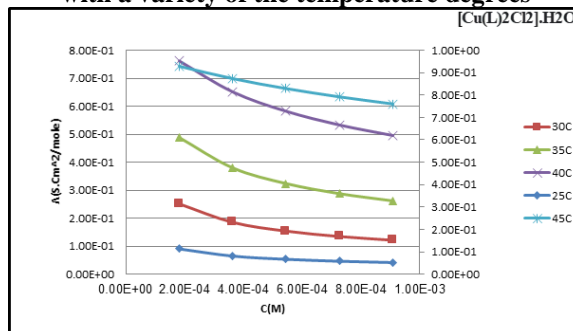
Fig (9): shows molar conductivity reductions of complex [Cu(L)₂Cl]Cl.H2O with increasing the solution's concentration And at a variety of the temperature degrees
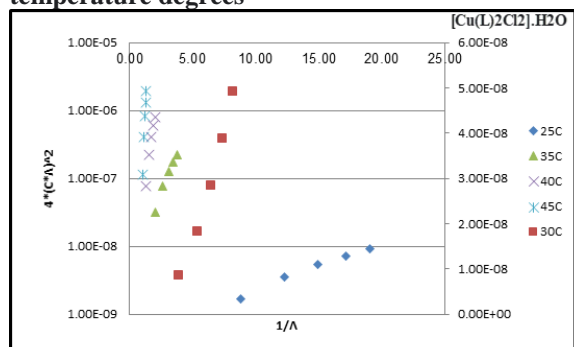
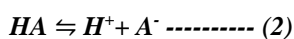

Fig (10): Shows correlation of the concentration to molar conductivity reciprocal of complex [Cu(L)₂Cl]Cl.H2O through the increase of solution concentration with a variety of the temperature degrees

The effects of the degree of the temperature on the level of the molar conductivity:

Concerning effects of the temperatures on the of the conductivity measurment [25], it has been observed that the two systems increased molar conductivity value with the increase in the temperature, and based on what has been stipulated by Arrhenius equation [26,27], of conductivity: -

$$e^{-Ea/RT} \text{ ---------- } (1) = \Lambda$$

The constant of hydrolysis equilibrium (L) as well as its complex **[Cu(L)₂Cl]Cl.H2O** have been obtained by fundamental relations of the dissociation and complex of both ligand solutions as below:

$$HA \leftrightharpoons H^+ + A^- \text{ ---------- } (2)$$

C 0 0

c(1-ᾳ) ᾳc ᾳc

$$K_L = \frac{\alpha^2 C}{1-\alpha} \quad \text{----------}(3)$$

$$\alpha = \frac{\Lambda}{\Lambda_o} \quad \text{------- (4)}$$

$$K_L = \frac{\left(\frac{\Lambda}{\Lambda_o}\right)^2 C}{1 - \frac{\Lambda}{\Lambda_o}} \quad \text{----------(5)}$$

And linear form has been adopted for the extraction of K_L and o values for the ligand has been: -

$$\Lambda C = \Lambda^2_o K_L \cdot (1/\Lambda) - \Lambda_o K_L \text{ ---------- } (6)$$

As this relationship's slope = $\Lambda^2_o K_L$
And relationship is intersected = $\Lambda_o K_L$

Where those constants' values were given in **Table4.** **Table4** shows specific molar conductivity values Λ_O as well as the value of the arinus constant for every ligand (**L**) as well as its complex **[Cu(L)₂Cl]Cl.H2O** at the absolute value of the temperature.

T(K)	L	[Cu(L)2Cl]Cl.H2O		
	K	Λ_0	K	Λ_0
298	2.66497E-06	83.722	9.5E-08	31.517
303	2.89845E-06	98.412	3.8E-07	55.213
308	3.14264E-06	120.452	1.3E-06	72.143
313	3.26753E-06	144.115	5.45E-06	92.188
318	3.6230E-06	171.630	1.7E-05	120.314

$$K_{coplx} = \frac{4 \alpha^3 C^3}{C(1-\alpha)} = \frac{4 \alpha^3 C^2}{(1-\alpha)} \quad \mathbf{7}$$

$$K_{coplx} = \frac{4\left(\frac{\Lambda}{\Lambda_o}\right)^3 C^2}{1 - \frac{\Lambda}{\Lambda_o}} \cdot \left(\frac{\Lambda_o}{\Lambda}\right)^3 \quad 8$$

$$K_{coplx} = \frac{4 \Lambda^3 C^2}{\cdots} \quad 9$$

$$4(\Lambda C)^2 = \left(K_{coplx}\Lambda_o^3 \left(\frac{1}{\Lambda}\right) - K_{coplx} \Lambda_o^2\right) \quad 10$$

The final formula [28] is linear **[Cu(L)₂Cl]Cl.H2O** de-composition relationship form, where through the plotting of 4 (ΛC) 2 on y-axis (Y) vs. ((1/Λ)) on x-transformer (X), a straight line has been obtained, that is:

$$\textbf{Intersection} = \frac{K_{coplx} \Lambda_o^2}{}$$

$$\textbf{Slope} = K_{coplx}\Lambda_o^3$$

Therefore, (Λ₀) values and constant of complex decomposition have been obtained from where values have been listed in table4.

It has been noted in Table4 that (Λ₀) values for (**L**) are generally low, and in particular, through comparing them to (Λ₀) values for weak electrolyte materials in the aqueous solutions, as a result of dissolved proton's transport mechanism in the DMSO, which has no compatibility with the mechanism of proton transport. In the aqueous solutions, specific molar connection value (Λ₀) of lycand solution (**L**) and at a variety of the temperature degrees is higher compared to that of complex **[Cu(L)₂Cl]Cl.H2O** and this is because: -

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Even though the proton's specific molar conductivity value (Λ_0) is low (because of solvent difference), it is still high in comparison with others, as a result of a small proton size as well as its small mass (i.e. the low intrinsic inertia). Which is why, specific molar conductivity (Λ_0) of the ligand solutions **(L)** that has been considered one of the weak acids. It has been found larger compared to that of the **[Cu(L)₂Cl]Cl.H2O** complex. Regarding constant values of **(L)** as well as its complex **[Cu(L)₂Cl]Cl.H2O**, it has been noticed that in a case of the ligand **(L)** they have been within usual limits of the constants of the weak acid dissolution and differences of solvent didn't result in changing that nature as a result of considered substance (DMSO) polarity. Concerning the complex **[Cu(L)₂Cl]Cl.H2O**, even though it's has low values, it has been considered high in the case where it has been compared to corresponding constants of the decomposition in the aqueous solutions.

Thermo-dynamic functions:

Thermo-dynamic functions[29] of ligand **(L)** and its complex **[Cu(L)₂Cl]Cl.H2O** degradation have been obtained through following fundamental correlations:

$$\Delta G = - RT \, LnK \quad \text{------------(11)}$$

$$LnK = (1/T) \times (-\Delta H/R) + (\Delta S/R) \quad \text{-------------(12)}$$

While through the plotting of equation **(12)** (LnK) vs. (1 / T), the result is a straight line with a slope of ($-\Delta H / R$) as well as its intersection (S / R), as has been listed in **Table5.**

Table5. Shows entropy, enthalpy, and free energy values of **(L)**.

L			
T(K)	Δ H(J/mole)	Δ S(J/mole.K)	Δ G(J/mole)
298	14203.10	-51.120	41700.8
303			42131.3
308			42421.8
313			42692.3
318			45422.8

Table6: shows entropy, enthalpy, and free energy values for the complexes **[Cu(L)2Cl2].H2O**

[Cu(L)2Cl2].H2O			
T	ΔH(J/mole)	Δ S(J/mole.K)	Δ G(J/mole)
298	320000.00	640	50130
303			46290

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308			41440
313			31590
318			28740

Where it has been noticed in Table5 and Table6 that decomposition processes of **(L)** as well as its complex **[Cu(L)₂Cl]Cl.H2O** emit heat [26], however, for complexes it's considerably higher compared to that for ligand, as a result of the complexes being highly stable, due to the fact that they're structures. Highly stable claw toroid.

Concerning (ΔS) value, it has been noted that it's negative for **(L)** hydrolysis procedure, whereas it's positive for complex **[Cu(L)₂Cl]Cl.H2O**[17] and has high value. Which results from the fact that ligand **(L)** decomposition includes transforming it to the ionic groups with the tendency of increasing regularity of solvent molecules that are around ions, which results from the decomposition and thereby, total system entropy (ΔS) reduces upon the decomposition.

Conclusions:

As it has been shown by observing this study and depending upon results that obtained molar conductivity from Arinus' law's application, the thermo-dynamic parameters such as (ΔH, ΔS, and ΔG), magnetic moment, spectroscopic which are included (FT-IR,UV-Vis and atomic absorptions for ligand **(L)** and for the complexes that have been prepared **[Cu(L)₂Cl]Cl.H2O** add too while the (¹H-NMR and 13CNMR) was anily measured for the only for ligand, the points below have been obtained:-

1- The Schiff base **(L)** behaves as bi-dentate ligand by 1 imine group's nitrogen atom and oxygen atom of C=O group of 5-member ring with central metal ions: Cu(II) forming complex with the general molecular representation: **[Cu(L)₂Cl]Cl.H2O**

2- Results have shown that the value of the molar conductivity is increased with the increase in the temperature and decreased with the increase in the concentration through using solvent (DMSO).

3- In Future ligand and complex biology we can be studies.

4- In Future, nano-materials can be mixed with the both ligand as well as the complexes for observing the changes that will obtain the results.

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