Synthesis and Structural Investigation of Some Transition Metal Complexes Derived from Assembled NO Donor Lewis Base of 6,7-Dimethyl-Quinoxaline-2,3-dione

Mahmoud Najim Abid Al-jibouri¹, Araf Ismael Jabbar² and Ahmad H.Ismail³

AL- Mustansiriyah University, College of Science, Department of Chemistry¹,³
Al-Anbar Education, Ministry of Education²

Corresponding author e-mail: mahmoudnajim71@yahoo.com¹

Abstract

The synthesis of a new ligand (Z)-3-((2-aminoethyl)imino)-6,7-dimethyl-3,4-dihydroquinoxalin-2(1H)-one containing quinoxaline and aliphatic ethylene moiety subunits is described. The reaction of 6,7-dimethylquinoxaline-2,3(1H,4H)-dione with ethylenediamine in glacial acetic acid as catalyst leads to the isolation of the free ligand (L), which is a Lewis base precursor. The new transition metal complexes of (L) ligand were prepared and characterized by elemental analysis and spectroanalytical techniques. The new poly dentate L Schiff base was formed upon condensation of 6,7-dimethylquinoxaline-2,3(1H,4H)-dione with ethylenediamine in glacial acetic acid as catalyst. The free ligand was fully identified with the help of elemental analyses, mass spectra, H NMR and FTIR spectra. The direct reactions of methanolic ligand (L) with the salts of manganese(II), cobalt(II), nickel(II), copper(II), zinc(II), cadmium(II) and vanadium(IV) resulted in colored precipitated which have been characterized by elemental analyses, magnetic susceptibility, molar conductivity measurements and FTIR and UV-Visible spectroscopy. The metal to ligand ratios data concluded that all structures of complexes were in 1:1 ratio with octahedral geometry for all complexes except that nickel(II) was square planner. The compounds were characterized by physical and spectroscopic measurements which indicated that the ligand is probably acting as a tridentate ON₂ chelating agent.

Keywords: Metals complexes of quinoxaline, Poly dentate ligands, quinoxaline-2,3-dione complexes.

Introduction

Transition metal complexes containing quinoxaline moiety have been of considerable interest in terms of structural chemistry and biological function [1-3]. This field has undergone spectacular growth during the past years and extensive work has been carried out in many areas [4,5]. This growth has largely been due to the synthesis of multi dentate Schiff bases and the complexes such ligands form with metal ions. The coordination chemistry of quinoxaline-2,3-dione including transition elements are attractive due to their importance in organo metallic and bio-inorganic applications [6]. The unexpected condensation of 2-acetylpyridine with 1,2-phenylenediamine have interested in synthesis of tri dentate N₃ donor Schiff bases which strongly bonded to bivalent metal ions [5]. The transition metal complexes of a multidentate Schiff base bis(N-salicylene)-2,3-dihydrazino-1,4-quinoxaline have prepared and elucidated their structures with he single crystal method[7]. The mononuclear complexes of platinum group metals containing quinoxaline donor ligands have received considerable attention towards their photochemical and biological properties[8]. As continuous synthesis of metal chelates of
quinoxaline complexes, we recently prepared, characterized and evaluated the antimicrobial activity transition metal complexes with tetra dentate Schiff base derived from quinoxaline-2, 3-dione and diethylene triamine [9]. As well as the tri dentate Schiff base derived from thiosemicarbazide with Mn(II),Co(II),Ni(II),Cu(II) and Zn(II) have elucidated with 1HNMR, mass spectra as well as their biological activity have been interested in pharmaceutical industry [10,11].

In the present work, the metal complexes of manganese(II), cobalt(II), nickel(II), copper(II), zinc(II), cadmium(II) and vanadium(IV) of neutral tere dentate Schiff base (Z)-3-((2-aminoethyl)imino)-6,7-dimethyl-3,4-dihydroquinoxalin-2(1H)-one have prepared and fully characterized with the help of NMR,IR,UV-Visible spectra as well as the mass spectra and magnetic moment measurements assisted in the elucidation the structure of the prepared complexes.

Experimental

1. Instrumentation

Elemental analyses (C.H.N.S) of the Schiff base L and its complexes were determined using Carlo-Erba 1106 Elemental analyzer. The UV-Visible spectra of complexes solutions were recorded in ethanol and DMF solvents using Shimadzu spectrometer in the range (200-800) nm. The 1H NMR spectra of the free ligand have scanned on Bruker 400 MHz spectrometer in DMSO-d6 solvent (Al-Yarmouk University, Jordan). The Fourier transform infrared spectra(FTIR) of the prepared complexes were recorded in KBr and CsI discs on Shimadzu FT-IR 8400 spectrometer at the laboratories of Chemistry department, college of science, Mustansirya university, Iraq. The molar conductance measurements were made on Hanna conductivity bridge type Pt-electrode with a cell constant of 1.0 cm−1 value. The content of metal in their solid complexes were determined on Shimadzu A.A-670 spectrometer at Laboratories of Ibn-Cina general company for researches, ministry of industry. The magnetic susceptibility measurements for the solid complexes were done on Sherewood Magnetic balance via Farady’s method at service laboratory of chemistry department, college of science, Mustansiriyah University.

2. Materials

All the chemicals were purchased from Sigma-Aldrich and Alfa companies and used as received. Solvents like methanol and ethanol were distilled by using standard distillation procedure. The 6,7-dimethylquinoxaline-2,3(1H,4H)-dione was prepared according to the method reported in literature [7], Scheme(1).

![Scheme 1. Preparation of 6,7-dimethyl-quinoxaline-2,3-dione](image)

2.1. Synthesis of (Z)-3-((2-aminoethyl)imino)-6,7-dimethyl-3,4-dihydroquinoxalin-2(1H)-one

About 6,7-dimethylquinoxaline-2,3(1H,4H)-dione (1.91 gm, 10 mmole) in 50 ml of hot ethanol was added to 10 ml of ethylenediamine with stirring then refluxed the mixture on water bath for 6 hours. The yellow compound which separated was removed by filtration, washed with
amounts of ethanol and diethyl ether and dried in a desiccator over anhydrous MgSO₄ powder, scheme (2). The physical properties, spectral data and elemental analyses are shown as below.

Scheme 2. Synthesis of ligand L

Yield: 75%.
M.p.: 290-292 °C.
Rf = 0.72 (ethanol:cyclohexane, v:v, 3:1).
FT-IR (KBr, v, cm⁻¹): 3400 (-NH-), 1683 (C=O), 1588 (-C=N), 2930-2855 (-NH- pyrazole ring).
1H NMR (400 MHz, DMSO-d₆, δ, ppm): 2.22 (s, 3H, J = 8.22 Hz, CH₃-Ar), 3.41 (m, 4H, J=6.90, CH₂-CH₂), 6.82 (s, 1H, J = 4.90 Hz, HN-C=O), 7.50-7.74 (m, 2H, J=6.33 Hz, Ar-H), 7.92 (s, 1H, HN-C=O).
MS (m/z (%)) = 232 (100) [M+1]. 230 (60) [M+], 201 (40) [M-2CH₃].

2.2. Synthesis of the Mn(II),Co(II),Ni(II),Cu(II),Zn(II), Cd(II) and V(IV) complexes

About 10 mmoles of metal chlorides (MnCl₂·6H₂O, CoCl₂·6H₂O,NiCl₂·6H₂O, CuCl₂·6H₂O, CdCl₂, ZnCl₂ and VOSO₄·5H₂O) in 25 ml of hot methanol was added with stirring to an ethanolic solution of the ligand L (10 mmoles, 0.231 gm) then refluxed on water bath for 2-3 hours and the turning of colors solutions followed by TLC in order to optimize the completion of reaction so after keeping for several hours at room temperature, a green to pale green precipitates of complexes were separated by filtration and dried on pellets of anhydrous CaCl₂ in desiccator. However, the nickel(II) and cadmium(II) complexes were prepared in the same method described above except that the time of reaction needed 5 hours with removing the solvent under reduced pressure. The table (1) shows the physical properties and elemental analyses of the prepared compounds. The light blue complex of [VOL SO₄] was prepared by the same way with using of VOSO₄·5H₂O salt in DMF medium.

Results and discussion

The cobalt (II) copper (II) and vanadyl (IV) complexes are dark green. The cadmium (II) and zinc (II) complexes are white off. They are air stable solids, soluble in DMSO and DMF, slightly soluble in methyl cyanide and insoluble in methanol and water. The elemental analyses agree well with a 1:1 metal-to-ligand stoichiometry for all the complexes (Table 1). The conductivity values of the complexes measured in DMSO and DMF at room temperature fall in the range expected for neutral complexes [12], suggesting that no chloride ion is not coordinated to the metal ion. However, the nickel complex was electrolyte in 1:1 ratio which agrees well with its suggested formula [NiLCl] Cl. H₂O.

The molecular ion at M⁺=191 of 100% relative intensity for mass spectra of the 6,7-dimethylquinoxalin-2,3(1H,4H)-dione [A] support its proposed formula dione C₁₀H₁₀N₂O₂ whereas the peaks in low relative intensity at 176 and 160 may be ascribed to cleavage of –
methyl groups in the lactam form, Figure(1). However, the mass spectra of the free ligand, Figure(2) showed the absorption at 233 with relative intensity 80% which is attributed to the molecular ion of C_{12}H_{16}N_{4}O_{2}. As well as the other peaks appeared in the 201 and 217 may be assigned to the fragmentations of methyl and amino moieties respectively[13].

The infrared spectrum of the ligand, Figure(3) shows sharp bands at 3300 cm\(^{-1}\) and 1683 cm\(^{-1}\), which are assigned to the stretching vibrations corresponding to HN-C=O moiety, respectively [10]. A broad band in the region 3400 cm\(^{-1}\) is due to (NH) [14,15]. A medium band at 1588 cm\(^{-1}\) is attributed to the C=N of pyrazine and pyridine rings [14]. As well as the medium bands in the regions 2967-2950 cm\(^{-1}\) is assigned to aliphatic C-H moiety which confirms the condensation of amino groups with the carbonyl of pyrazine compound. The (N–N) vibration in the complexes was found at lower frequencies (930–955 cm\(^{-1}\)) in comparison with the free ligand (970 cm\(^{-1}\)), this shows clearly that both the nitrogen of imine –C=N- and –NH\(_2\)-are involved in coordination [19] with the central metal ions. The IR spectra of all complexes show downward shift in the frequency of –C=O and –C=N- in comparison with the free ligand, L. This is indicating coordination through oxygen and nitrogen, respectively [16,17]. There is a little change in the intensity and shape of –NH\(_2\) vibration and this is good proof for drift of lone pair on nitrogen atom of free –NH\(_2\)- toward the empty orbital of the central metal ion[20]. It is found that the upward shift in (C- N) of pyrazine and pyridine. This is attributed to cleavage of hydrogen bonding with the respective centers in the ligand during complexation. Hence it may be concluded that in these complexes, the ligand is behaving as a terdentate ONN donor through the exocyclic oxygen -C=O and the terminal nitrogen of –C=N- and the nitrogen's of NH (ring) are not involved in coordination. The characteristic V=O is observed at 925 cm\(^{-1}\) in oxvanadium(IV) complex [18]. The weak to medium bands in the fingerprint regions especially belonged to the coordinated bonds M-N and M-O were appeared in the 480-540 and 410-450 cm\(^{-1}\) respectively [19].

Further evidence for the formation of the ligand and some of its complexes was explained from H NMR spectra which provide diagnostic tool for the positional and elucidation of the protons. Assignment of the signals related to resonance of protons attached to phenyl moiety was observed in the region 7.30 ppm whereas the –NH- protons of lactam group was displayed at 10.55 ppm as singlet peak, these absorptions agree well with the literature survey[10,13] of the ring closure of 3,4-dimethyl-1,2-phenylenediamine with hydrated oxalic acid to afford [A] derivative. The figure (4) exhibits the de shielded resonance protons of –HN-C=O in the region 7.92 ppm as singlet peak and the singlet peak in the regions 2.22-3.41 ppm can be assigned to spin spin coupling of aliphatic –CH\(_2\)-CH\(_2\)- moiety then indicates the condensation of –NH\(_2\)-group from one side with one mole of the 6,7-dimethylquinoxalin-2,3(1H,4H)-dione. Furthermore, the peaks of aromatic Ar-H protons were observed in the region 7.50-7.74 ppm. The appearance of singlet peak at 6.28 ppm can be ascribed to the free H\(_2\)N-CH\(_2\)-, then act good proof for condensation of ethylenediamine with [A] derivative in 1:1 molar ratio.

The data of UV-Visible spectra for the ligand and its complexes solutions in DMF and ethanol are recorded in Table 3. The solution of ligand in ethanol displays two spin-allowed transitions in the regions 222 and 323 nm which is characteristic of chromophores-C=N-,C=C- and -C=O related to benzoypyrazine moiety [15].The pale colored solution of manganese(II) complex showed weak peak at 375 nm and other of high intensity at 320 nm, these may be assigned to d-d and MLCT respectively [20,21].The cobalt(II) complex exhibited spin-allowed
d-d transitions at 822 and 612 nm that are assigned to the \( ^4T_1g \rightarrow ^4T_2g(F) \) and \( ^4T_1g \rightarrow ^4A_2g(F) \), respectively, which is typical for octahedral Co(II) complexes [20]. At the same way, the electronic spectra of nickel(II) complex in DMF at 480 and 388 nm are assigned to \( ^1A_1g \rightarrow ^1B_1g \) and \( ^3A_1g \rightarrow ^1B_2g \) respectively [22] thus ascribing the square planer structure around Ni(II) ion. The distorted octahedral copper(II) complex showed \( ^2Eg \rightarrow ^2T_2g \) transition as broad band at 560 nm supporting it’s expected geometry [21]. As well as the weak intensity bands for vanadyl(IV) complex in DMF in the regions 677, 400 and 290 nm may be attributed to \( ^2A_1g \rightarrow ^2T_2g \), \( ^4A_1g(F) \rightarrow ^2T_1g \) and O2- to V(IV) charge transfer of V=O moiety [22] respectively and these transitions agree well with the suggested octahedral geometry around vanadium(IV) ion. The magnetic moments recorded for all solid complexes fall in the expected octahedral geometry and the increasing in the value of magnetic moment for cobalt(II) complex to 4.76 BM could be assigned to orbital contribution[23]. However the diamagnetic properties of nickel(II) complex gives strong proof for square planer structure[23].

**Conclusions**

The condensation of ethylenediamine with 6,7-dimethylquinoxaline-2,3-(1H,4H)-dione leads to form poly dentate Schiff base (Z)-3-((2-aminoethyl)imino)-6,7-dimethyl-3,4-dihydroquinoxalin-2(1H)-one which was fully characterized on the basis of elemental analyses and other spectral methods like NMR and Mass spectra. The solid complexes of Mn(II),Co(II),Ni(II),Cu(II),Zn(II),Cd(II), and VO(IV) were prepared in 1:1 mole ratio with [MLCl2(H2O)2] where M=Mn(II),Co(II),Cu(II),Zn(II) and Cd(II),[VOL]SO4 and [NiLCl]Cl. The octahedral geometry was proposed for all complexes except the square planer was concluded for diamagnetic nickel complex. The data obtained from elemental analyses, electronic spectra and magnetic susceptibility agree well with the expected formula and symmetry of complexes, Scheme 3.

![Scheme 3. Geometrical structure of the prepared complexes](image)

**References**
[1]. R.S.Dikonda, V.A.Parupalli, J.L. Vuppalapati, Structural elucidation of manganese(II), iron(III), cobalt(II), nickel(II), copper(II) and zinc(II) complexes of a new multidentate dihydrazino quinoxaline derivative, Trans.Met.Chem.19(1994)75-77.

[2]. K.Spyridoula, G.Achilleas, P.Sofia, P.P.Spyros, S.B.Ian, H.Nick, Preparation, structural and physical studies of mercury(II) halide complexes with N,N-chelating bi heteroaromatic ligand 2-(2-pyridyl)quinoxaline, Inorg. Chimica Acta 227(1994)129-136.

[3]. K.Spyridoula, G.Achilleas, K.Agathopoulos, K.George, 1:1 Metal complexes of 2-(2-pyridyl)quinoxaline, a ligand unexpected formed by the reaction between 2-acetylpyridine and 1,2-phenylenediamine, Inorg.Chimica Acta 207(1993) 255-258.

[4]. S.Sanglipandi, S.Dipankar, B.Kaushik, K.Werner, S.R.Joshi, A.K.Chandra, K.R.Mohan, Synthesis, structure, antibacterial studies and DFT calculations of arene ruthenium, Cp Rh, Cp Ir and tricarbonylrhenium metal complexes containing 2-chloro-3-(3-(2-pyridyl)pyrazolyl)quinoxaline ligand, Inorg.Chim.Acta 441(2016)95-108.

[5]. V. K. Naveen, K. R. Vidyanand, B. N. Kirasur, H. H. Mallinath, Transition metal complexes of thiosemicarbazones with quinoxaline hub: an emphasis on antidiabetic property, Med.Chem.Res.21(2012)663-671.

[6]. Sandhaya Rani, D. Ph.D. Thesis "synthesis and structural studies of transition metal compounds derived from multidentate 2,3-Distrubited Quinoxalines", submitted to Osmania university (1995).

[7]. Deleuze M.C, Moarbess, G., Khier S., David N., Gayraud P. S., Bressolle F., Pinguet F., Bonnet P.A. "New imidazo [1, 2-a]quinoxaline derivatives: synthesis and in vitro activity against human melanoma". Eur J Med Chem.44(2009) 3406–3411.

[8]. Sindhu, R.C.V. "Heterocycles derived from Quinoxalines and Mucobromic acid", Cohn university, Department of applied chemistry (1998).

[9]. Anil Kumar B.S.P., Madhav, B.; Harsha, K.; Nageswar, Y. V. D. Quinoxaline synthesis in novel tandem one-pot protocol, Tetrahedron Lett.52(2011) 2862-2865.

[10]. D. Sandhya Rani, R. Jagatage "Synthesis and Structural Studies of first row transition metal complexes of a new bi-ambidentate heterocyclic ligand" Indian J.Chem. 38A.(1999) 385-387.

[11]. Mahmoud Aljibouri M.N., Saad Mohammad, Synthesis, Characterization and Biological Activity of Chromium(III), Manganese(II), Cobalt(II), Nickel(II), Copper(II) and Zinc(II) Complexes with New Schiff Base Derived from 6-methylquinoxaline-2, 3(1H,4H)-dione and DiethylenetriamineInt.J.Pure&Appl.Chem.2015,6(4),147-159.

[12]. Mahmoud, N. Aljibouri, Saad Mohammad, Synthesis and characterization of manganese(II), cobalt(II), nickel(II), copper(II) and zinc(II) complexes with new Schiff base derived from 6,7-dimethyl-quinoxaline-2,3(1H,4H)-dione and thiosemicarbazide, Eur.J.Chem.2015,6(1),44-47.
[13]. Geary, J.W. The use of conductivity measurements in organic solvents for the characterization of coordination compounds, Coord. Chem. Rev. 7(1971)781–122.

[14]. Suja, N.R."Studies on Some Supported Co(II), Ni(II) and Cu(II) Complexes of o-Phenylenediamine and Schiff bases Derived from 3-Hydroxyquinoxaline-2-carboxaldehyde" PhD thesis, Cochin, University of Science and Technology (2002).

[15]. Arun, V. Synthesis and characterization of new transition metal complexes of Schiff bases derived from 3-hydroxyquinoxaline-2-carboxaldehyde and application of some of these complexes as hydrogenation and oxidation catalysts. PhD thesis, Cochin University of Science and Technology (2009).

[16]. W. H Sean., Y. Li, W. Xiaoping, G. R. Michael, New osmium cluster compounds containing the heterocyclic ligand 2,3-bis-(diphenylphosphino)quinoxaline (dpq): Ligand isomerization and crystal structures of dpq, the isomeric clusters Os3(CO)10(dpq), and HOs3(CO)9[m-2,3-PhP(h1-C6H4)(Ph2P)quinoxaline], J. Organomet. Chem. 696 (2011) 1432-1440.

[17]. Nakamoto, K. Infrared and Raman Spectra of Inorganic and Coordination Compounds, 3rd ed., Wiley, New York, 1997.

[18]. D.N. Satyanarayana, Electronic Absorption Spectroscopy and Related Techniques, Universities Press: Hyderabad (2001). mbidentate ligand containing quinoxaline moiety, Spectrochimica Acta A: Molec. Biomolec. Spec. 74(2009)52-57.

[19]. Songa, Q.X. W. Ya-Wen, Z. Jiang, L. Wei-Sheng, T. Min-Yu Synthesis and spectroscopic properties of lanthanide nitrate complexes with a new amide-based quinoxaline-2,3-dione ligand, Electr. Chem. Acta, 68(2007)701-704.

[20]. Chellaian, D.C. Johnson J., Spectral characterization, electrochemical and anticancer studies on some metal(II) complexes containing tridentate quinoxaline Schiff base, Spectrochimica Acta A: Molec. Biomolec. Spec. 127(2014)396-404.

[21]. Lever, A.B. Inorganic electronic spectroscopy" Elsevier Publishing Company, New York (1968).

[22]. Figgis, B.N. J. Lewis, Modern Coordination Chemistry, Interscience Inc., New York, 1960.

[23]. Cotton, F.A. Wilkinson, G.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, 6th edition, John Wiley & Sons(1999).

[24]. Langdon, J. Hallet, A.J. Jack, D. Croke, D.A. Ward, D. Platts, J.A. Simon, P.J. Using substituted cyclometalated Quinoxaline ligands to Finely the Luminescence properties on complexes, Amer. Chem. Soc. (2013), 52(1), 448-456.
Table (1). The elemental analysis of ligand and its metal complexes

| Compounds | Found(Calc.)% | C% | H% | N% | S, Cl% | Metal |
|-----------|---------------|----|----|----|--------|-------|
| L         | 63.15 (62.88) | 5.29 | 24.35 | 14.77 | 12.89 |       |
| [VOLSO₄(H₂O)] | 36.92 | 4.22 | 14.44 | 8.11 |       |       |
| [MnLCl₂(H₂O)] | 38.11 | 5.33 | 14.80 | 18.66 | 15.01 |       |
| [CoLCl₂(H₂O)] | 36.77 | 3.99 | 13.90 | 15.82 | -      |       |
| [NiLCl₂Cl.H₂O] | 37.11 | 4.66 | 14.33 | 17.99 | 15.08 |       |
| [CuLCl₂(H₂O)] | 37.66 | 4.22 | 14.67 | 18.33 | 15.08 |       |
| [ZnLCl₂(H₂O)] | 35.22 | 3.95 | 13.77 | 16.96 | -      |       |
| [CdLCl₂(H₂O)] | 33.35 | 2.99 | 5.90 | 12.33 | 25.01 |       |

Table 2. FT-IR absorptions of the ligand and its template metal complexes in cm⁻¹.

| Compound          | νNH  | νC=O | νC=N | νC-H | νN-N  | νM–N  | νM–O  | νM-Cl |
|-------------------|------|------|------|------|-------|-------|-------|-------|
| L                 | 3400 (br) | 1683(s) | 1550 (s) | 3010,2962 (m) | 970(m) | -     | -     | -     |
| [VOLSO₄(H₂O)]     | 3500(br) | 1660(s) | 1570(w) | 3090,2977 | 955 | 450 | 430,930(s) | -     |
| [MnLCl₂(H₂O)]     | 31390(br) | 1640 | 1690 (s) | 3050,2966 | 960 | 520 | 436 | 275 |
| [CoLCl₂(H₂O)]     | 3300 | 1660 | 1605 (s) | 3010,2987 | 944 | 530 | 430 | 322 |
| [NiLCl₂Cl.H₂O]    | 3235 | 1650 | 1580 (s) | 3010,2983 | 962 | 522 | 477 | 316 |
| [CuLCl₂(H₂O)]     | 3369 | 1639 | 1612 (s) | 3010,2966 | 955 | 500 | 480 | 310 |
| [ZnLCl₂(H₂O)]     | 3300 | 1679 | 1611 (s) | 3010,2980 | 943 | 515 | 450 | 297 |
| [CdLCl₂(H₂O)]     | 3480(br) | 1675(s) | 1535(m) | 3100(w),2976 | 935 | 465(w) | 424(w) | 312(w) |

s =strong, m=medium,br=broad, w=weak.

Table 3. The electronic spectra and molar conductance of the prepared complexes

| Compound          | UV-visible, λ (nm) | μ (BM) | Λm(S.mol⁻¹.cm⁻¹) | Geometry |
|-------------------|--------------------|--------|------------------|----------|
| L                 | 222, 323           | -      | -                | -        |
| [VOLSO₄(H₂O)]     | 677,400,290        | 1.70   | 18               | Octahedral |
| [MnLCl₂(H₂O)]     | 575, 325(CT)       | 5.75   | 22               | Octahedral |
| [CoLCl₂(H₂O)]     | 822,612,265(CT)    | 4.76   | 50               | Octahedral |
| [NiLCl₂Cl.H₂O]    | 480, 388,222       | 0.00   | 30               | Square planer |
| [CuLCl₂(H₂O)]     | 560, 390,215       | 1.65   | 31               | Octahedral |
| [ZnLCl₂(H₂O)]     | 245,370(CT)        | 0.00   | 21               | Octahedral |
| [CdLCl₂(H₂O)]     | 205,355(CT)        | 0.00   | 17               | Octahedral |

* Λm = molar conductance was measured in DMF solutions, CT=charge transfer bands.
Figure (1). Mass spectrum of derivative [A]

Figure (2). Mass spectra of ligand L

Figure (3). IR spectrum of ligand in KBR disc

Figure (4). $^1$HNMR spectrum of ligand in $d_6$-DMSO solvent