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## Synthesis and characterization of some new metal complexes with 2-(2-(2-hydroxybenzylidene amino) ethyl) isoindoline-1,3-dione.

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### ABSTRACT

In this paper some new metal complexes of 2-[2-(2-hydroxybenzylidene amino)ethyl] isoindoline-1,3-dione with VO(II), Cr(III), Fe(III), Mn(II), Co(II), Ni(II), Cu(II), Zn(II) and Pd(II) were syntheses. The free Schiff base ligand and its metal complexes were characterized by physic-chemical spectroscopic techniques. The spectral data suggested that the 2-[2-(2-hydroxybenzylidene amino)ethyl] isoindoline-1,3-dione (new Schiff base ligand) as a neutral bidentate ligand is coordinated with the central metal ion through the nitrogen atom of azomethine group and oxygen atom of phenolic group except Pd (II). It is concluded that the Mn(II), Fe(III), Cu(II) and Zn(II) complexes have tetrahedral geometries. The Cr(III) and Co(II) complexes have octahedral geometries. The Ni(II) and Pd(II) complexes have square planar geometries, while the VO(II) complex has square pyramidal geometry.

**Keywords:** Metal Complexes, 2-(2-(2-Hydroxybenzylidene amino)ethyl)isoindoline-1,3-dione.

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## INTRODUCTION

Schiff bases of aliphatic aldehydes are unstable because they are readily polymerization while those of aromatic aldehydes are more stable because they are having the conjugation system [1]. The aryl group must be bonded to nitrogen atom of azomethine group to prevent these compounds from the decomposition or polymerization [2]. The azomethine groups of Schiff bases are aided to form stable metal complexes, especially if the amine and carbonyl compounds contain a second functional group sufficiently near the site of condensation to form five to six member chelate rings [3].

Schiff base complexes have attracted a wide attention due to their important role in analytical chemistry, organic synthesis, metallurgy, refining of metals, electroplating and photography [4]. The studies of the azomethine group is showed that the presence of a lone pair of electrons in an  $sp^2$  hybridized orbital of nitrogen atom of the azomethine group has great chemical and biological important [5]. Pfeiffer et al. have made a systematic study on Schiff base complexes [6]. The properties of these complexes depend on the nature of metal ion as well as on the nature of the ligands. There is interesting studies in the synthesis of Schiff base metal complexes because of their preparative convenience and using in different applications [7]. A review on metal complexes of Schiff bases by Holm et al shows that more than half of these prepared complexes were derived from salicylaldehyde [8]. Schiff base metal complexes derived from salicylaldehyde were first used by Pfeiffer et al [9]. The physical and biological properties of Schiff bases and their metal complexes are very important and directly related to the presence of intermolecular hydrogen bonding and the proton transfer equilibrium. This group is characterized by great biological activity and they play an important role in biological system [10].

## EXPERIMENTAL

### *Materials and measurements*

All the chemicals used in this work were of highest purity, were purchased from commercial source (BDH and Aldrich). The infrared spectra were recorded on Shimadzu IR prestige-21, single beam path laser, FTIR spectrophotometer in the  $4000-400\text{ cm}^{-1}$  range using KBr disc. The electronic spectra were carried out on a Shimadzu UV-Visible spectrophotometer UV-160 for  $10^{-3}\text{M}$  solution of the amic acid, Schiff base and its metal complexes in DMF, using (1.0cm) quartz cell at room temperature. Elemental microanalyses (C.H.N) were carried out using microanalysis techniques Euro Vector, model EA 3000 A origin: Italy. Metal content of the prepared complexes were determined using Nov AA350 flame atomic absorption spectrophotometer. Proton nuclear magnetic resonance spectrum was performed on Bruker Amx 400MHz spectrometer with tetramethylsilane (TMS) as an internal standard. The molecular ion of the prepared Schiff base ligand was carried out using mass spectrometer technique Shimadzu QP-2010. Thermal analysis of cobalt complex was performed on Perkin-Elmer Pyris Diamond DTA/TGA thermal system under helium atmosphere at a heating rate at  $20^\circ\text{C}/\text{min}$  in the ( $30-900^\circ\text{C}$ ) range. Conductivity measurements were carried out on  $10^{-3}\text{M}$  solution of the complexes in DMF using conductivity meter WTW at  $25^\circ\text{C}$ . The magnetic moments were carried out at room temperature on the solid state by Farady's method using Balance Magnetic Susceptibility Model MSB-MKT. Melting points were measurement on MSRS apparatus.

### *Synthesis of ethylenediaminephthalate.*

Phthalic anhydride (0.148 g, 0.001 mmole) was dissolved in absolute ethanol ( $10\text{ cm}^3$ ) with stirring. Ethylenediamine (0.06 g, 0.001 mmole) was dissolved in absolute ethanol ( $5\text{ cm}^3$ ) and added to the phthalic anhydride solution. The mixture solution was heated under reflux at temperature ( $60^\circ\text{C}$ ) for (20 min.). During this period, a white precipitate was formed. The white solid was collected by filtration and then washed with diethyl ether ( $2 \times 10\text{ cm}^3$ ) and then dried in oven at temperature  $60^\circ\text{C}$  for four hours, and then kept in desicator.

### **Synthesis of 2-[2-(2-hydroxybenzylidene amino) ethyl]isoindoline-1,3-dione.**

Ethylenediamine phthalate (0.19 g, 0.001 mmole) was dissolved in absolute ethanol (15 cm<sup>3</sup>) with stirring. Ortho hydroxybenzaldehyde (0.122 g, 0.001 mmole) was dissolved in absolute ethanol (5 cm<sup>3</sup>), and added to the ethylenediamine phthalate solution, and then three drops of glacial acetic acid were added. The mixture was heated with stirring under reflux at temperature (70°C) for 35 min. During this period the colorless solution turned to the yellow color solid was formed. The yellow solid was then collected by filtration, and then washed with ethanol and then dried in oven for six hours at temperature (60°C), and then recrystallized from absolute ethanol. The yellow powder collected by filtration and then dried in oven for five hours at temperature (60°C), m.p. = (116 - 118 °C)

### **Synthesis of metal complexes**

The metal salt CoCl<sub>2</sub>.6H<sub>2</sub>O, CuCl<sub>2</sub>.2H<sub>2</sub>O, MnCl<sub>2</sub>.4H<sub>2</sub>O, PdCl<sub>2</sub>, FeCl<sub>3</sub>, CrCl<sub>3</sub>.6H<sub>2</sub>O, ZnCl<sub>2</sub>, Ni(NO<sub>3</sub>)<sub>2</sub>.6H<sub>2</sub>O and VOSO<sub>4</sub> (0.23783 g, 0.001 mmole, 0.17045g, 0.001 mmole, 0.1978 g, 0.001 mmole, 0.1978g, 0.001mmole, 0.162204 g, 0.001 mmole, 0.2666 g, 0.001 mmole, 0.13631 g, 0.001 mmole, 0.29070 g, 0.001 mmole, 0.2943 g, 0.001 mmole, 0.5886g, 0.002 mmole, 0.5886g, 0.002 mmole, 0.2943g, 0.001 mmole, 0.8829g, 0.003 mmole, 0.5886g, 0.002 mmole, 0.2943g, 0.001 mmole, 0.2943g, 0.001 mmole) in ethanol (5cm<sup>3</sup>) was added to the clear solution of yellow Schiff base ligand (0.2943g, 0.001 mmole, 0.2943 g, 0.001 mmole, 0.5886g, 0.002 mmole, 0.5886g, 0.002 mmole, 0.2943g, 0.001 mmole, 0.8829g, 0.003 mmole, 0.5886g, 0.002 mmole, 0.2943g, 0.001 mmole, 0.2943g, 0.001 mmole) in ethanol (10cm<sup>3</sup>). The mixture was stirred and heated under reflux for two hours at temperature 80-90°C. The resulting precipitate was collected by filtration and then dried for three hours.

## **RESULTS AND DISCUSSION**

The ethylenediamine phthalate was synthesized by a condensation reaction of phthalic anhydride with ethylene diamine in 1:1 mole ratio the ethanol was used as a solvent. 2-[2-(2-hydroxybenzylideneamino)ethyl] isoindoline-1,3-dione synthesized by the reaction of ethylenediamine phthalate with orthohydroxy benzaldehyde under reflux in 1:1 mole ratio using ethanol as solvent. The metal complexes were prepared from the reaction of 2-[2-(2-hydroxybenzylideneamino) ethyl] isoindoline-1,3-dione with the metal salts in different mole ratio in ethanol as a solvent.

### **IR spectra**

The FTIR frequency of the amic acid, free Schiff base ligand and its complexes are summarized in table (1). The spectrum of the amic acid appears the absorption bands at 3379 and 3278 cm<sup>-1</sup> attributed to the (NH<sub>2</sub>) stretching vibration, the band at 3066 cm<sup>-1</sup> assigned to the (C-H) aromatic stretching vibration, the weak absorption band at 2931 cm<sup>-1</sup> assigned to (C-H) aliphatic stretching vibration. The two strong bands at 1627 and 1543 cm<sup>-1</sup> due to the stretching vibration of (C=O) and (C=C) respectively [11,12]. The weak absorption bands showed at 1111 and 1172 cm<sup>-1</sup> attributed to (C-O) and (C-N) stretching vibration respectively [13].

The FTIR spectrum of free Schiff base ligand, showed weak abroad absorption band at 3414 cm<sup>-1</sup> is due to the stretching vibration of (OH) because of the intermolecular hydrogen bonding [13]. The weak absorption bands at 3051 and 3008cm<sup>-1</sup> are attributed to (C-H) aromatic stretching vibration, the two absorption bands showed at 2900 and 2870 cm<sup>-1</sup> can be assigned to the (C-H) aliphatic stretching vibration of asymmetrical and symmetrical respectively. The ligand shows strong absorption bands at 1635, 1612cm<sup>-1</sup> and 1577 cm<sup>-1</sup> can be attributed to (C=O), (C=C) and (C=N) stretching vibration respectively, indicating the formation of the free Schiff base ligand product. The bands at 1199 cm<sup>-1</sup> due to the stretching vibration of (C-O) of phenolic group [14,15]. The band at 3414 cm<sup>-1</sup> in the spectrum of the ligand due to the stretching vibration of (OH), was shifted to lower or higher frequency with change in the shape and intensity were observed from these bands on complexation, while different in intensity were noticed. The significant may be result of coordination with the central metal ion for Mn(II), Cu(II), Co(II), Ni(II), Zn(II), Fe(III), VO(II) and Cr(III) complexes, while this band is absent in the Pd(II) complex which is indicated the deprotonation of phenol proton prior to and indicated the coordination of oxygen of the

phenolic with Palladium ion. The band of azomethine group in the ligand which is observed at  $1577\text{ cm}^{-1}$  was shifted to lower frequency in all the infrared spectra of complexes, this indicates the participation of the nitrogen atom of the azomethine group in coordination [16]. The bands at  $1595\text{ cm}^{-1}$ ,  $1631\text{ cm}^{-1}$ ,  $1627\text{ cm}^{-1}$ ,  $1600\text{ cm}^{-1}$  and  $1597\text{ cm}^{-1}$  due to the stretching vibration of (C=C) for the, Mn(II), Fe(III), Co(II), Ni(II), Cu(II), Zn(II) and Pd(II) complexes respectively and appeared shoulder bands at  $1600\text{ cm}^{-1}$  and  $1581\text{ cm}^{-1}$  is also due to the stretching vibration of (C=C) of VO(IV) and Cr(III) complexes respectively [4]. The IR spectrum of Co(II) complex has a weak band which showed at  $929\text{ cm}^{-1}$  can be assigned to the rocking vibration of (OH) of water which indicated the presence of coordinated water molecules with Cobalt ion in the complex [17], water molecules inside the coordination sphere was also identified by the thermal analysis. The IR spectrum of VO(II) complex has other three bands, the first is medium intensity at  $983\text{ cm}^{-1}$  can be attributed to the stretching vibration of (V=O) and the other weak intensities which observed at  $902\text{ cm}^{-1}$  and  $864\text{ cm}^{-1}$  which were attributed to the stretching vibration of (V-O) [18]. Other new band at  $1303\text{ cm}^{-1}$  and  $1199\text{ cm}^{-1}$  can be assigned to the stretching vibration of  $\text{SO}_4^{2-}$  [19].

In all the spectra of the prepared complexes the low frequency region observed new medium intensity bands around  $(513-597)\text{ cm}^{-1}$  and  $(416-497)\text{ cm}^{-1}$  can be assigned to the frequency of (metal-nitrogen) and (metal-oxygen) respectively. IR spectra of Schiff base and some its complexes are illustrated in figures 1 and 2.

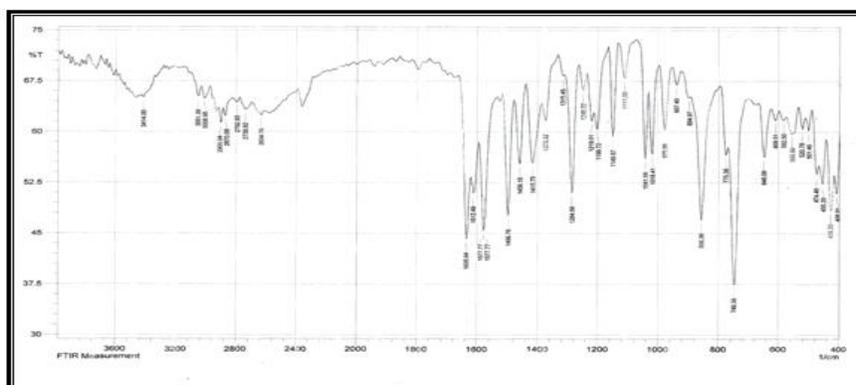


Figure 1: Infrared spectrum of Schiff base ligand (HL)

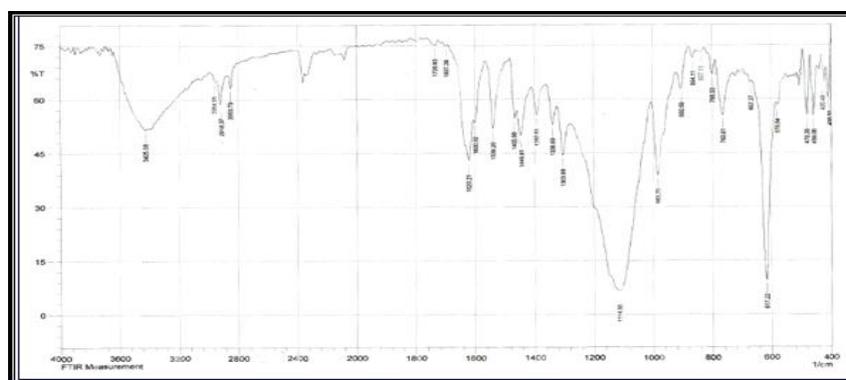


Figure 2: Infrared spectrum of  $[\text{VO}(\text{HL})(\text{SO}_4)]$  complex

### Thermal analysis

The thermo gravimetric analysis of Co(II) complex,  $[\text{Co}(\text{HL})(\text{H}_2\text{O})_2\text{Cl}_2]$  is used for the information on water of hydration which is present inside the coordination sphere of the central metal ion. The thermo gravimetric analysis of cobalt complex was carried out in the range  $(30-90^\circ\text{C})$ , using helium as inert gas in rate  $20^\circ\text{C}/\text{min}$ . The result which obtained from the thermal decomposition was in a good agreement with the calculated value. This is

summarized in the following decomposition fragmentations and as in figure 3. Weight loss in the range of (167-215°C) and in the range (245-312°C) were 5.302% (cal. 3.947%) and 3.907% (cal. 4.275%) which were corresponding to the loss of coordinated water molecules. The total weight loss 53.86% (cal. 57.431%) was corresponding to complete decomposition of ligand moiety around the metal ion and formation of Cobalt oxide.

- 1-  $C_{17}H_{18}Cl_2CoN_2O_5$  (460.17) (50-110°C) → H [0.931% Found (0.218% Cal.)]
  - 2-  $C_{17}H_{17}Cl_2CoN_2O_5$  (459.17) (167-215°C) → H<sub>2</sub>O [5.302% Found (3.947% Cal.)]
  - 3-  $C_{17}H_{15}Cl_2CoN_2O_4$  (441.15) (245-312°C) → H<sub>2</sub>O [3.907% Found (4.275% Cal.)]
  - 4-  $C_{17}H_{13}Cl_2CoN_2O_3$  (423.14) (332-389°C) → Cl [11.163% Found (8.808% Cal.)]
  - 5-  $C_{17}H_{13}ClCoN_2O_3$  (387.68) (443-530°C) → Cl [8.093% Found (9.659% Cal.)]
  - 6-  $C_{17}H_{13}CoN_2O_3$  (352.23) (737-892°C) → C<sub>4</sub>H<sub>4</sub> [16.744% Found (15.662% Cal.)]
  - 7-  $C_{17}H_9CoN_2O_3$  [46.14% Found (42.569% Cal.)]
- Total wt Loss = 53.86 % Found (57.431 % Cal.)

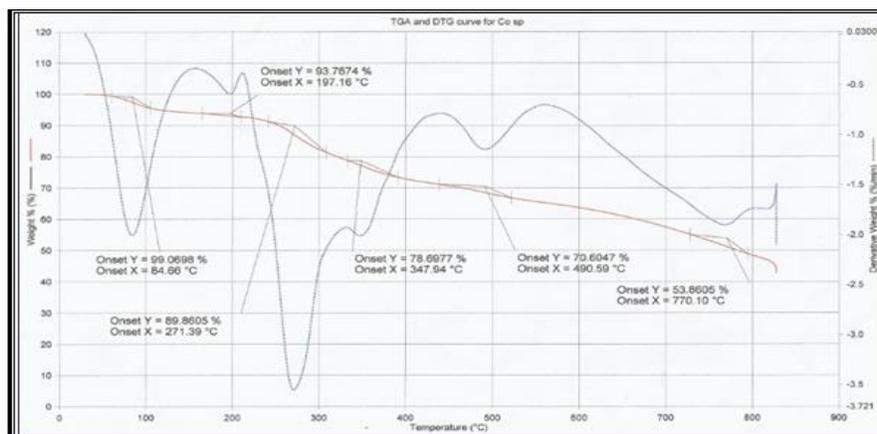
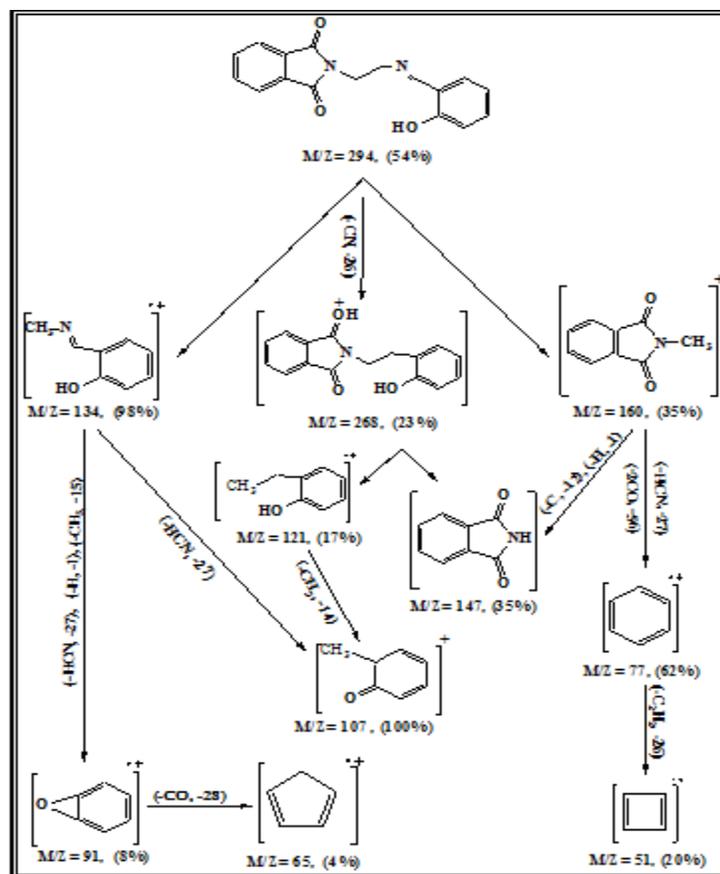


Figure 3: Thermo gravimetric analysis (TGA) curve [Co(HL)(H<sub>2</sub>O)<sub>2</sub>Cl<sub>2</sub>] complex

The magnetic moments of VO(II), Cr(III), Mn(II), Fe(III) and Cu(II) complexes were found to be 1.75, 3.87, 5.4, 5.92 and 1.63 B.M. respectively within the expected of spin only values, except of Co(II) complex appeared higher value was found to 5.01 B.M. due to the spin orbital contribution, the value of magnetic moment for Ni(II) and Pd(II) complexes was found to be zero, also of Zn(II) were found to be zero [20]. The microanalysis (CHN) for amic acid, ligand and its metal complexes are in a good agreement with the theoretical values, also the data of metal contents and anions of the complexes were in a good agreement. The results were illustrated in table 2.

<sup>1</sup>H-NMR spectrum indicated the singlet signal at  $\delta=13.36$  ppm in the spectrum of Schiff base ligand, was assigned to the proton hydroxyl phenolic group [21]. The singlet signal showed at  $\delta=12.96$  ppm, was attributed to the proton of azomethine group (CH=N) [22]. The multiplet a ranged between ( $\delta= 6.82-8.59$  ppm) were assigned to the aromatic protons of the ligand [22]. The triplate at  $\delta= 3.925$  ppm was attributed to (-CH<sub>2</sub>CH<sub>2</sub>-). The singlet signal appeared at  $\delta= 2.50$  ppm can be assigned to the solvent (DMSO). This spectrum was summarized in figure 4.





**Scheme 1: The fragmentation pattern of Schiff base from phthalic anhydride**

The electronic spectra data of amic acid, Schiff base ligand and its complexes are summarized in table 3. The electronic spectrum of VO(II) Complex, shows four absorption bands at 272 nm ( $36764 \text{ cm}^{-1}$ ), 314 nm ( $31847 \text{ cm}^{-1}$ ) and 607 nm ( $16474 \text{ cm}^{-1}$ ) were attributed to ( $\pi$ - $\pi^*$ ), charge transfer (C.T.) and (d-d) electronic transition type ( ${}^2B_{2g} \rightarrow {}^2B_{1g}$ ) and the fourth band at 350 nm ( $28571 \text{ cm}^{-1}$ ) attributed to ( ${}^2B_{2g} \rightarrow {}^2A_{1g}$ ), which is a good evidence for square pyramidal geometry around the VO(II) ion [24]. The spectrum of Cr(III) complex appeared five absorption bands, the first at 271 nm ( $36900 \text{ cm}^{-1}$ ) assigned to ( $\pi$ - $\pi^*$ ) electronic transition, the second band at 305 nm ( $32786 \text{ cm}^{-1}$ ) with higher molar extinction coefficient due to ( $n$ - $\pi^*$ ) electronic transition, the third band at 728 nm ( $13736 \text{ cm}^{-1}$ ) attributed to ( ${}^4A_{2g(F)} \rightarrow {}^4T_{2g(F)}U_1$ ) electronic transition, the fourth band at 399 nm ( $25062 \text{ cm}^{-1}$ ), can be assigned to charge transfer (C.T.) and ( ${}^4A_{2g(F)} \rightarrow {}^4T_{1g(F)}U_2$ ) while, third transition  $U_3$  calculated theoretically from using Tanabe-Sugano diagram for  $d^3$  system and found to be ( $28122.1 \text{ cm}^{-1}$ ) attributed to ( ${}^4A_{2g(F)} \rightarrow {}^4T_{2g(P)}$ ), electronic transition. The value of  $U_3$ , nephelauxetic factor  $\beta=0.90$  and Racah parameter  $B'=834.4 \text{ cm}^{-1}$  were estimated by fitting the ratio  $U_2/U_1$  to the Tanabe-Sugano diagram for octahedral  $d^3$  system, therefore suggested octahedral geometry around the chromium ion [25]. The spectrum of Mn(II) complex shows absorption band at 278 nm ( $35971 \text{ cm}^{-1}$ ) can be assigned to ( $\pi$ - $\pi^*$ ) electronic transition, the peak at 330 nm ( $30303 \text{ cm}^{-1}$ ) attributed to charge transfer (C.T.), the peak at 399 nm ( $25062 \text{ cm}^{-1}$ ) can be assigned to ( ${}^6A_1 \rightarrow {}^4A_1 + {}^4E_{(G)}$ ) and the peak at 469 nm ( $21321 \text{ cm}^{-1}$ ) can be assigned to (d-d) electronic transition type ( ${}^6A_1 \rightarrow {}^4T_{1(G)}$ ). These transitions were indicated the complex is tetrahedral geometry around the Mn(II) ion [26]. The spectrum of Fe(III) Complex appeared four peaks at 273 nm ( $36630 \text{ cm}^{-1}$ ), 346 nm ( $28901 \text{ cm}^{-1}$ ), 416 nm ( $24038 \text{ cm}^{-1}$ ) and 435 nm ( $22988 \text{ cm}^{-1}$ ) were attributed to ( $\pi$ - $\pi^*$ ), (C.T.), ( ${}^6A_1 \rightarrow {}^4A_1 + {}^4E_{(G)}$ ) and ( ${}^6A_1 \rightarrow {}^4T_{1(G)}$ ) electronic transition respectively, the electronic spectrum suggested a tetrahedral geometry around the Fe(III) ion [27]. The spectrum of Ni(II) complex exhibits a high intensity peak and high molar extinction coefficient at 272 ( $36764 \text{ cm}^{-1}$ ) and 330 nm ( $30303 \text{ cm}^{-1}$ ) can be assigned to ( $\pi$ - $\pi^*$ ) and (C.T.) respectively, the third

peak was appeared at 409 nm ( $24449\text{ cm}^{-1}$ ) was attributed to ( ${}^1A_{1g} \rightarrow {}^1A_{2g}$ ) and the fourth absorption shoulder exhibits a low intensity with low molar extinction coefficient was observed at 580 nm ( $17241\text{ cm}^{-1}$ ) due to ( ${}^1A_{1g} \rightarrow {}^1B_{1g}$ ) electronic transition. These transitions and the magnetic value (0.0 B.M.) were characterized to square planar geometry around the Ni(II) ion [28]. The spectrum of Cu(II) complex shows four peaks at 276 nm ( $36231\text{ cm}^{-1}$ ), 354 nm ( $28248\text{ cm}^{-1}$ ), 363 nm ( $27548\text{ cm}^{-1}$ ) and 574 nm ( $17421\text{ cm}^{-1}$ ) were attributed to ( $\pi-\pi^*$ ), ( $n-\pi^*$ ), (C.T.) and (d-d) transition type ( ${}^2T_2 \rightarrow {}^2E$ ) respectively, the magnetic moment value of the complex 1.63 B.M. which is in a good agreement with the calculated value, which confirmed the tetrahedral geometry around Cu(II) ion [29]. The spectrum of Co(II) complex shows five peaks at 272 nm ( $36764\text{ cm}^{-1}$ ), 350 nm ( $28571\text{ cm}^{-1}$ ), and 840 nm ( $11904\text{ cm}^{-1}$ ) corresponding to electronic transition of ( $\pi-\pi^*$ ), (C.T) and (d-d) transition type ( ${}^4T_{1g(F)} \rightarrow {}^4T_{1g(F)} \nu_1$ ) respectively, while the second transition  $\nu_2$  calculated theoretically from using Tanab-Sugano diagram for  $d^7$  system and found to be ( $23741.3\text{ cm}^{-1}$ ) attributed to ( ${}^4T_{1g(F)} \rightarrow {}^4A_{2g(F)}$ ). The values of Sugano diagram for  $d^7$  system by fitting the  $\nu_2/\nu_1$ , the peak at 390 nm ( $25641\text{ cm}^{-1}$ ) corresponding to ( ${}^4T_{1g(F)} \rightarrow {}^4T_{1g(P)} \nu_3$ ). This shows the presence in octahedral complex geometry for Co(II) ion [30]. The electronic spectrum of Zn(II) complex shows three absorption bands the first at 271 nm ( $36900\text{ cm}^{-1}$ ), the second at 316 nm ( $31645\text{ cm}^{-1}$ ) assigned to ( $\pi-\pi^*$ ) and ( $n-\pi^*$ ) electronic transition respectively, The third band attributed to the charge transfer (C.T) at 357 nm ( $28011\text{ cm}^{-1}$ ). The absence of the absorption peak in the range of visible region in the electronic spectrum of the Zinc complex was indicated no (d-d) electronic transition happened because of the electronic configuration ( $d^{10}$ -system), the complex has tetrahedral geometry around Zn(II) ion [28]. Finally, the spectrum of Pd(II) complex has four absorption bands at 271 nm ( $36900\text{ cm}^{-1}$ ), 305 nm ( $32786\text{ cm}^{-1}$ ), 394 nm ( $25380\text{ cm}^{-1}$ ) and 619 nm ( $16155\text{ cm}^{-1}$ ) corresponding to ( $\pi-\pi^*$ ), ( $n-\pi^*$ ), (C.T) and (d-d) electronic transition type ( ${}^1A_{1g} \rightarrow {}^1B_{1g}$ ) respectively, the complex has square planar geometry around Pd(II) ion [32].

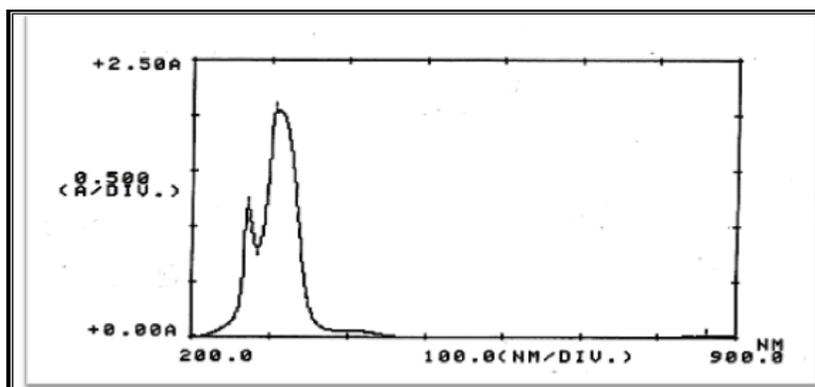


Figure 6: Electronic spectrum of 2-[2-(2-hydroxybenzylideneamino) ethyl] isoindoline-1,3-dione (Schiff base)

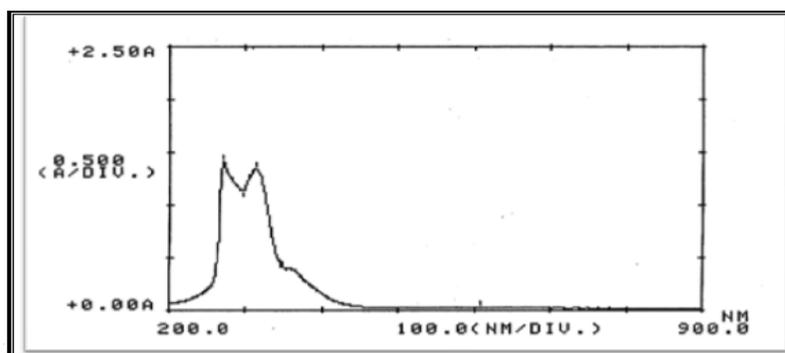


Figure 7: Electronic spectrum of  $[VO(HL)(SO_4)]$  complex

Table (1): FT-IR of amic acid, free ligand and its metal complexes in (cm<sup>-1</sup>)

Compounds	$\nu$ NH <sub>2</sub>	$\nu$ OH	$\nu$ C-H arom.	$\nu$ C-H aliph	$\nu$ C=O	$\nu$ C=C	$\nu$ C=N	$\nu$ C-O phen.	$\nu$ M-N	$\nu$ M-O	Other bands
Amic acid	3379 3278	-	3066	2931	1627	1543	-	-	-	-	-
Schiff base(HL)	-	3414	3051 3008	2900 2870	1635	1612	1577	1199	-	-	-
[VO(HL)(SO <sub>4</sub> )]	-	3425	3015	2954 2916	1620	1600	1539	1114	578	420	V=O = 983 V-O = 902, 864 SO <sub>4</sub> <sup>-2</sup> = 1303, 1199
[Cr(HL) <sub>3</sub> ].Cl <sub>3</sub>	-	3340	3055	2924 2854	1627	1581	1539	1041	513	416	-
[Mn(HL) <sub>2</sub> ].Cl <sub>2</sub>	-	3398	3020	2978 2908	1627	1600	1539	1045	594	424	-
[Fe(HL)Cl <sub>2</sub> ].Cl	-	3433	3020	2697	1627	1597	1539	1049	540	497	-
[Co(HL)(H <sub>2</sub> O) <sub>2</sub> Cl <sub>2</sub> ]	-	3398	3120	2954	1639	1600	1535	1060	597	424	(rocking) H <sub>2</sub> O aqua =929
[Ni(HL)(NO <sub>3</sub> ) <sub>2</sub> ]	-	3383	3078 3051	2977 2858	1624	1597	1531	1067	597	466	-
[Cu(HL)Cl <sub>2</sub> ]	-	3414	3051 3016	2954 2916	1651	1631	1531	1053	574	497	-
[Zn(HL) <sub>2</sub> ].Cl <sub>2</sub>	-	3375	3055 3020	2920 2850	1635	1595	1539	1033	536	435	-
[Pd(L) <sub>2</sub> ]	-	-	3016	2951 2912	1647	1627	1531	1053	570	451	-

arom. = aromatic

aliph. = aliphatic

phen. = phenolic

Table 2: Some analytical &amp; physical properties for the amic acid, Schiff base ligand and its metal complexes

Compounds	Mwt	formula	Color	Yield %	m.p °C	Microanalysis(Calc.) Exp							$\Delta(\mu\text{s}/\text{cm}^{-1})$	$\mu\text{eff. (B.M.)}$
						C	H	N	M	Cl	NO <sub>3</sub>	SO <sub>4</sub>		
Amic acid	190	C <sub>10</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>	White	67	123-125	(63.157) 62.26	(5.263) 5.728	(14.74) 14.465						
Schiff base(HL)	294.3	C <sub>17</sub> H <sub>14</sub> N <sub>2</sub> O <sub>3</sub>	Yellow	77	116-118	(69.38) 69.05	(4.76) 4.926	(9.524) 9.223						
[VO(HL)(SO <sub>4</sub> )]	457.31	C <sub>17</sub> H <sub>14</sub> N <sub>2</sub> O <sub>8</sub> SV	Gray	75	250 d	(44.64) 45.01	(3.06) 3.24	(6.13) 6.52	(11.14) 10.84			(21.2) 20.73	<b>12</b>	1.75
[Cr(HL) <sub>3</sub> ].Cl <sub>3</sub>	1041.27	C <sub>51</sub> H <sub>42</sub> Cl <sub>3</sub> CrN <sub>6</sub> O <sub>9</sub>	Yellowish-brown	78	122 d	(58.9) 60.02	(4.04) 3.67	(8.08) 8.656	(4.99) 4.92	(10.21) 11.96			<b>218</b>	3.87
[Mn(HL) <sub>2</sub> ].Cl <sub>2</sub>	714.45	C <sub>34</sub> H <sub>28</sub> Cl <sub>2</sub> MnN <sub>4</sub> O <sub>6</sub>	Dark-brown	83	280-282	(57.22) 58.059	(3.93) 3.326	(7.85) 7.333	(7.69) 7.32	(9.92) 8.92			<b>123</b>	5.4
[Fe(HL)Cl <sub>2</sub> ].Cl	456.5	C <sub>17</sub> H <sub>14</sub> Cl <sub>3</sub> FeN <sub>2</sub> O <sub>3</sub>	Dark-brown	76	288 d	(44.85) 44.22	(3.078) 3.311	(6.156) 6.44	(12.23) 12.73	(23.30) 22.19			<b>75.1</b>	5.92
[Co(HL)(H <sub>2</sub> O) <sub>2</sub> Cl <sub>2</sub> ]	460.17	C <sub>17</sub> H <sub>18</sub> Cl <sub>2</sub> CoN <sub>2</sub> O <sub>5</sub>	Brown	80	160-162	(44.35) 44.73	(3.91) 4.01	(6.1) 6.66	(12.81) 13.09	(15.41) 14.63			<b>10</b>	5.01
[Ni(HL)(NO <sub>3</sub> ) <sub>2</sub> ]	477	C <sub>17</sub> H <sub>14</sub> N <sub>4</sub> NiO <sub>9</sub>	Orange	80	193-195	(42.8) 43.15	(2.9) 2.09	(11.75) 12.09	(12.30) 13.40		(26.01) 26.77		<b>22</b>	diamagnetic
[Cu(HL)Cl <sub>2</sub> ]	428.7	C <sub>17</sub> H <sub>14</sub> Cl <sub>2</sub> CuN <sub>2</sub> O <sub>3</sub>	Dark-green	72	292d	(47.72) 49.08	(3.27) 4.11	(6.55) 7.03	(14.82) 13.46	(16.54) 17.08			<b>17</b>	1.63
[Zn(HL) <sub>2</sub> ].Cl <sub>2</sub>	724.9	C <sub>34</sub> H <sub>28</sub> Cl <sub>2</sub> N <sub>4</sub> O <sub>6</sub> Zn	Off-white	62	130 d	(56.40) 57.01	(3.87) 4.02	(7.74) 8.03	(9.02) 8.25	(9.78) 10.4			<b>163</b>	diamagnetic
[Pd(L) <sub>2</sub> ]	693	C <sub>34</sub> H <sub>26</sub> N <sub>4</sub> O <sub>6</sub> Pd	Yellowish-green	70	134-136	(59.1) 60.60	(3.76) 4.01	(8.11) 8.19	(15.36) 16.28	-			<b>12</b>	diamagnetic

Table (3): Electronic Absorption spectra data of amic acid, free ligand and its metal complexes

Complexes Suggested structure	$\lambda_{\max}$ (nm)	$\nu$ ( $\text{cm}^{-1}$ )	$\epsilon_{\max}$ $\text{Mole}^{-1}.\text{l}.\text{cm}^{-1}$	ABS.	Assignment
Amic acid	281	35587	2369	2.369	$\pi \rightarrow \pi^*$
Schiff base (HL)	271	36900	1193	1.193	$\pi \rightarrow \pi^*$
	305	32786	2061	2.061	$n \rightarrow \pi^*$
[VO(HL)(SO <sub>4</sub> )] Square pyramidal	272	36764	1414	1.414	$\pi \rightarrow \pi^*$
	314	31847	1340	1.340	C.T
	607	16474	25	0.025	${}^2B_{2g} \rightarrow {}^2B_{1g}$
	350	28571	1213	1.213	${}^2B_{2g} \rightarrow {}^2A_{1g}$
[Cr(HL) <sub>3</sub> ].Cl <sub>3</sub> Octahedral	271	36900	1230	1.230	$\pi \rightarrow \pi^*$
	305	32786	1732	1.732	$n \rightarrow \pi^*$
	355(cal.)	28122(cal)	1623	1.623	${}^4A_{2g(F)} \rightarrow {}^4T_{1g(P)}$
	399	25062	1452	1.452	C.T, ${}^4A_{2g(F)} \rightarrow {}^4T_{1g(F)}$
	728	13736	42	0.042	${}^4A_{2g(F)} \rightarrow {}^4T_{2g(F)}$
[Mn(HL) <sub>2</sub> ].Cl <sub>2</sub> Tetrahedral	278	35971	2295	2.295	$\pi \rightarrow \pi^*$
	330	30303	1154	1.154	C.T
	399	25062	679	0.679	${}^6A_1 \rightarrow {}^4A_1 + {}^4E(G)$
	469	21321	2426	2.426	${}^6A_1 \rightarrow {}^4T_1(G)$
[Fe(HL)Cl <sub>2</sub> ].Cl Tetrahedral	273	36630	709	0.709	$\pi \rightarrow \pi^*$
	346	28901	1057	1.057	C.T
	416	24038	708	0.708	${}^6A_1 \rightarrow {}^4A_1 + {}^4E(G)$
	435	22988	689	0.689	${}^6A_1 \rightarrow {}^4T_1(G)$
[Co(HL)(H <sub>2</sub> O) <sub>2</sub> Cl <sub>2</sub> ] Octahedral	272	36764	985	0.985	$\pi \rightarrow \pi^*$
	350	28571	507	0.507	C.T
	392	25641	460	0.46	${}^4T_{1g(F)} \rightarrow {}^4T_{1g(P)} \cup_3$
	422(cal.)	23741(cal.)	340	0.34	${}^4T_{1g(F)} \rightarrow {}^4A_{2g(F)} \cup_2$
	840	11904	2	0.002	${}^4T_{1g(F)} \rightarrow {}^4T_{2g(F)} \cup_1$
[Ni(HL)(NO <sub>3</sub> ) <sub>2</sub> ] Square planar	272	36764	1843	1.843	$\pi \rightarrow \pi^*$
	330	30303	1914	1.914	C.T
	409	24449	1444	1.444	${}^1A_{1g} \rightarrow {}^1A_{2g}$
	580	17241	31	0.031	${}^1A_{1g} \rightarrow {}^1B_{1g}$
[Cu(HL)Cl <sub>2</sub> ] Tetrahedral	276	36231	2091	2.091	$\pi \rightarrow \pi^*$
	354	28248	1712	1.712	$n \rightarrow \pi^*$
	363	27548	1792	1.792	C.T
	574	17421	72	0.072	${}^2T_2 \rightarrow {}^2E$
[Zn(HL) <sub>2</sub> ].Cl <sub>2</sub> Tetrahedral	271	36900	1212	1.212	$\pi \rightarrow \pi^*$
	316	31645	1258	1.258	$n \rightarrow \pi^*$
	357	28011	696	0.696	C.T
[Pd(L) <sub>2</sub> ] Square planar	271	36900	1014	1.014	$\pi \rightarrow \pi^*$
	305	32786	843	0.843	$n \rightarrow \pi^*$
	394	25380	315	0.315	C.T
	619	16155	7	0.007	${}^1A_{1g} \rightarrow {}^1B_{1g}$

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