

Preparation, Characterization and Antibacterial Studies of New 2-(naphthalene-2-yl)-2-(naphthalene-2-ylamino) Acetonitrile Ligand with Some Metal Ions

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Abstract

In the present work, the synthesized a series of metal ions complexes of [Cr(III), Fe(III), Mn(II), Co(II), Ni(II), Cu(II), Zn(II), Cd(II) and Hg(II)] from new bidentate 2-(naphthalene-2-yl)-2-(naphthalene-2-ylamino) acetonitrile ligand (L) which prepared from 2-naphthaldehyde and naphthalene-2-amine in the presence of KCN and alcoholic medium. These compounds were characterized by using several techniques FT-IR, UV-Visible spectrophotometer, magnetic susceptibility, thermal gravimetric analysis (TGA), elemental analysis, molar conductivity, ¹H-NMR, as well as atomic absorption. From the spectral studies, an octahedral monomer structure was proposed for all complexes. The nature of the complexes formed in ethanolic solution has been studied following the molar ratio method and the result recorded [1:2] [M:L] ratio. Some complexes were found to be non-electrolyte and others were found to be weak electrolyte in ethanol. Biological activities of the free ligand and its metal complexes have been tested against a number of microorganisms in order to assess their antimicrobial properties.

Keywords: Acetonitrile, bidentate ligand, 2-naphthaldehyde, naphthalene-2-amine.

Introduction

The reaction of primary or secondary amines and an aldehyde or ketone with the present of cyanide ion forms aminonitriles. α -Aminonitriles are important intermediates for the synthesis of a wide variety of amino acids, amides, diamines and nitrogen-containing heterocycles [1]. Ligands and its transition metal complexes have been of great interest to research workers since seventies of the last century. At that time it was found that pyridine complexes show activity against leukemia [2]. Three-component reaction of aldehydes, amines and cyanide, known as the Strecker reaction. The classical Strecker reaction provides one of the most efficient methods for the synthesis of α -aminonitriles since 1850 when Adolph Strecker interact an aldehyde, an amine and hydrogen cyanide [1]. The addition of cyanide to imines provides a direct route for the synthesis of α -aminonitriles. Some of the α -aminonitrile derivatives like 1-amino-4-phenylnaphthalene-2-carbonitrile have been postulated to have high fungistatic activity even stronger than the activity of the commercial fungicide – Kaptan [3]. α -aminonitriles are useful intermediates for the synthesis of amino acids [4,5] and nitrogen-containing heterocyclic such as thienopyrimidine derivatives which have antibacterial and antifungal activities higher

than the corresponding antibacterial ampicillin and antifungal nystatin [6-8]. Moreover, among many other applications, they are readily hydrolyzed to diamines, which are of interest as ligands for Platinum (II) complexes with potential antitumor properties [9, 10]. Several modifications of the Strecker reaction have been reported using a variety of cyanating agent such as α -trimethylsiloxynitriles and under various reaction conditions [11, 12]. Complexes with dinitrogen N₂ ligand are of interest not only in theoretically but also from a practical point of view. They have found application as antitumor activity [13], antibacterial activity [14] and antiviral activity in agriculture field [15]. α -aminonitriles have often been used as chelating ligands through two nitrogen atoms in the field of amino coordination chemistry. This is one of a few studies to obtain a new coordination field of α -aminonitrile compounds as ligands and their interactions with transition metal ions.

Experimental

Chemical used

All the starting materials were commercially available. 2-naphthaldehyde, naphthalene-2-amine, metal salts CrCl₃.6H₂O, FeCl₃.6H₂O, CoCl₂.6H₂O, MnCl₂.4H₂O, NiCl₂.6H₂O, CuCl₂.2H₂O, ZnCl₂ CdCl₂.2H₂O,

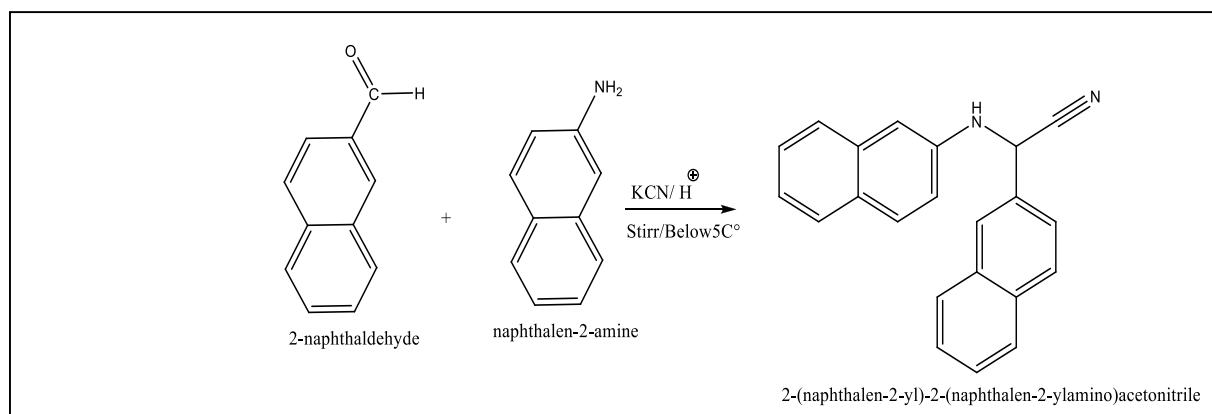
and HgCl_2 (BDH), Glacial acetic acid and potassium cyanide, (BDH), Ethanol, absolute ethanol, p-toluene sulphonic acid, ammonium hydroxide, sodium hydroxide sulfuric acid, chloroform, ethyl acetate, petroleum ether (30-60) and KBr (Fluka).

Instrumentation

The infrared spectra of the ligand and the complexes were recorded on SHIMADZU 8300 FTIR Spectrophotometer as KBr disk. Electronic absorption spectra were recorded on 1800-UV SHIMADZU. Atomic absorption technique was used to determine the metal contents of the complexes using Phoenix-986 Spectrophotometer. Molar conductivity was used to measure the conductivity of the complexes (10^{-3} M) at room temperature in freshly ethanol using (CDM 83) Digital conductivity meter. Elemental micro analysis for carbon, hydrogen and nitrogen elements were carried out at the Euro: (EA) Elemental analyzer. $^1\text{H-NMR}$ spectra of the ligand and Co (II) complex were recorded in DMSO using NMR Spectrometer 400 MHZ (Avance III Broker), Germany. Thermal gravimetric analyses (TGA) were recorded in SETARAM D350 analyzer. The magnetic properties were measured using Auto Magnetic susceptibility Balance (Sherwood Scientific). Melting points were measured using a Stuart SMP30 Digital Melting Point. The chlorine content determined gravimetrically.

Preparation of ligand (L)

The ligand (L) was prepared as follows [17-19]: 2-naphthaldehyde (0.156 g, 1 mmol) was added to (20 ml) glacial acetic acid, p-toluene sulphonic acid was added in very small portion as catalyst, followed by addition of (0.143 g, 1 mmol) of naphthalene-2-amine. The pH was adjusted to about 4 by addition of concentrated sulfuric acid drop wise to obtain Schiff base which stirred for 30 min. Potassium cyanide (2 mmol) was added to the mixture and kept under stirring for 4 days. The reaction mixture was poured into ice and then made slightly alkaline with ammonium hydroxide solution. The solid precipitate which formed was filtered, washed with water and air dried. The presence of nitrile group in the prepared α -aminonitrile was indicated by treating few amount of the sample with 10% sodium hydroxide solution, the liberation of ammonia after hydrolysis of nitrile group, which was detected by wet red litmus paper, indicating the presence of nitrile group. Purity of the obtained compound was checked by TLC, using chloroform and ethyl acetate (1:1) as eluent. The product color was dark brown and the yield percentage was (88.5%) and the melting point was ($187\text{-}189^\circ\text{C}$). The condensation reaction to prepare the new ligand was clarified below:

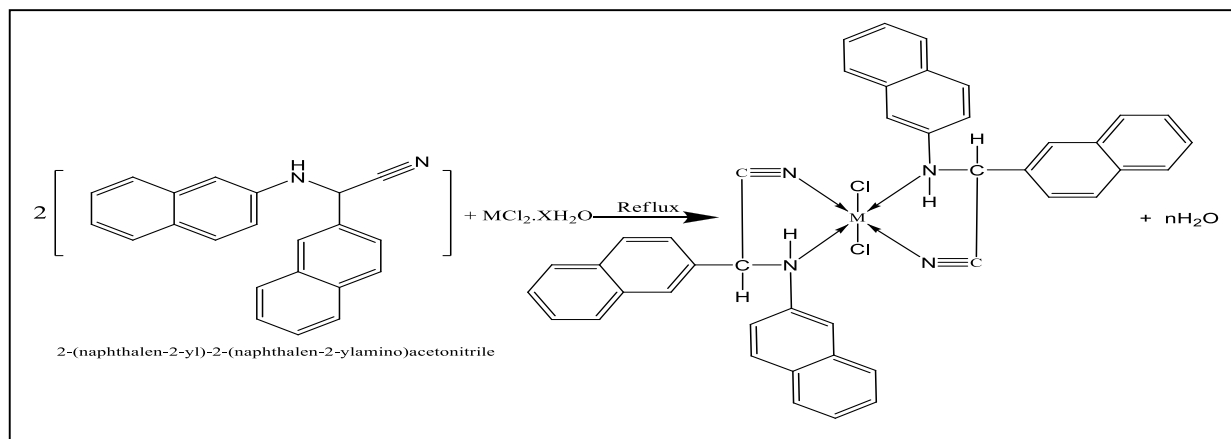


Preparation of Complexes

All complexes were prepared by the reaction of (0.616 g, 2 mmol) of (L) with (1mmol) of metal chloride (0.267 g, 0.198 g, 0.270 g, 0.238 g, 0.238 g, 0.171 g, 0.136 g, 0.219 g and 0.272 g for $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$,

$\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$, $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$, $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$, $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$, $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, ZnCl_2 , $\text{CdCl}_2 \cdot 2\text{H}_2\text{O}$ and HgCl_2 , respectively) dissolved in (20 ml) absolute ethanol and refluxed with stirring under anhydrous conditions using Na_2SO_4 (anhydrous) for 24 hours. The obtained

complexes were collected after evaporation of ethanol and triturated with petroleum ether (30-60 °C) then filtered and the products were left in the desiccators to be dried under silica gel. The yield percentage of the complexes were (79.6, 84.2, 75.7, 76.3, 86.6, 79.8, 77.3, 82.5 and 87.3) % respectively as shown in Table (1). The general reaction was clarified below:



Results and Discussion

The carbon, hydrogen, nitrogen and metal content data alongside the melting points, percentage and colors, of the ligand and the prepared complexes are shown in Table (1).

FT-IR spectra

In order to study the binding mode of the ligand to metal ion in the complexes, the IR spectrum of the free ligand was compared with those of the corresponding metal ion complexes. Selected vibrational bands of the ligand and its metal ion complexes and their assignments are listed in Table (2). The infrared spectrum of the ligand shows a band at 3328 cm^{-1} which assigned to $\nu(\text{N-H})$ vibration. In the spectra of all the metal ion complexes this band shows shifts to high frequencies (3345-3379) cm^{-1} . These changes indicate that the (N-H) takes part in the coordination. The band related to $\delta(\text{N-H})$ deformation of the ligand appeared at 1616 cm^{-1} , this band was shifted in the spectra of the complexes (1634, 1645, 1659, 1652, 1658, 1648, 1637 and 1655) cm^{-1} , respectively [20-21]. This gave further indication that the ligand was coordinated with metal ions through the nitrogen atom of α -amino group and thus supports the complexes formation.

The band at 2241 cm^{-1} which was assigned to the $\nu(\text{C}\equiv\text{N})$ stretching vibration of (C \equiv N) group of the ligand [L] was shifted in the spectra of complexes towards to lower frequencies as shown in Table (2) which indicates the linkage of (C \equiv N) group from nitrogen atom of the cyanide group. Other weak bands have been observed in the region (432-490) cm^{-1} which are absent in the free ligand, can be assigned to $\nu(\text{M-N})$ vibrations [20, 21].

$^1\text{H-NMR}$

The $^1\text{H-NMR}$ spectrum of the ligand [L] showed three peaks; The first one at $\delta(3.89 \text{ ppm})$, which corresponded to the (-N-H) proton, the second peak appeared at $\delta(5.36 \text{ ppm})$ which corresponded to the (-CH-C \equiv N) proton and the last peak appeared at $\delta(6.52-7.69 \text{ ppm})$ which corresponded to the aromatic protons [22]. The spectrum of the Zn (II) complex was also similar to that of the ligand. The signal of (N-H) of the ligand was shifted in this complex by 0.44 ppm and the signal of (-CH-C \equiv N) was shifted in this complex by 0.14 ppm, this gave an indication for complex formation [22].

Molar Conductance Data

The molar conductance of (10^{-3}M) of all the prepared complexes was measured in absolute ethanol at room temperature. The values of the molar conductance of the complexes Co (II), Mn (II), Ni (II), Cu (II), Zn (II) Cd (II) and Hg (II) were relatively low, they were lie in the range of $(13.7-17.2) \Omega^{-1}.\text{cm}^2.\text{mol}^{-1}$, these values indicated that these complexes were non electrolytes, this mean that all the chloride anions are coordinated to the metal ion (inside the coordination sphere) [23,24], while the molar conductance values of the complexes Cr (III) and Fe (III) were lie in the range of $(33.8-38.3) \Omega.\text{cm}^2.\text{mol}^{-1}$, these values indicated that, these two complexes were weak electrolytes, so that for these two complexes two chloride anions were coordinated to the metal ion, leaving the other chloride anion outside the coordination sphere [25]. The values of molar conductance of the complexes are shown in Table (3).

Molar Ratio Method

The absorption spectra were measured for many mixed solutions containing (1 ml) of the metal ion salt in the optimum concentration, and variable volumes of the ligand solution in the same concentration. M:L ratio was obtained by plotting the relation between the mole ratio in the X-axis and absorbance in the Y-axis. The intercept of the two straight lines represent the M:L ratio, it was (1:2).

Magnetic Moment

The Cr (III) complex has a magnetic moment value of 3.88 B.M was in accordance with those having octahedral structure. The Fe (III) complex shows a magnetic moment value 5.54 B.M was in accordance with those having octahedral structure. The Cu (II) complex shows a normal magnetic moment of 1.71 B.M observed for a d^9 system with an unpaired electron [24]. The Ni (II) complex with a magnetic moment of 2.90 B.M reveals a spin free octahedral configuration [23]. The magnetic moment of 4.20 BM for the Co (II) complex suggested a high spin octahedral arrangement [23]. The Mn (II) complex has a magnetic moment 5.60 B.M, as expected for high spin octahedral geometry [23]. The Zn (II), Cd (II) and Hg (II) complexes are

diamagnetic as expected for a d^{10} configuration [23, 25].

Electronic Spectra

The electronic absorption spectra of the ligand and its metal in complexes were recorded at room temperature using absolute ethanol as the solvent. The solid state electronic spectra of the ligand and the complexes display the absorption bands listed in table 3. The ligand shows two bands, the first band at 39683 cm^{-1} is due to intra ligand $\pi \rightarrow \pi^*$ and the second band located at 33333 cm^{-1} is due to. On complexation, these bands are shifted to higher wavelengths, suggesting coordination of the uncharged dinitrogen N_2 of the ligand to the metal ion. The spectra of the complex Cr (III) ion showed four bands observed at 9242, 13477, 17391 and 25773 cm^{-1} respectively these bands may be assigned to the transitions ${}^4\text{A}_{2g} \rightarrow {}^2\text{T}_{2g}+{}^2\text{E}_g$, ${}^4\text{A}_{2g} \rightarrow {}^4\text{T}_1(\text{F})$ and ${}^4\text{A}_2 \text{ g} \rightarrow {}^4\text{T}_1(\text{P})$ respectively[26]. The spectra of the complex Fe (III) ion showed two bands observed at 18820 and 22124 cm^{-1} , respectively, these bands may be assigned to the transitions ${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{2g}(\text{G})$ and ${}^6\text{A}_{1g} \rightarrow {}^4\text{A}_{1g}+{}^4\text{E}_g$. [27]. The Mn (II), Zn (II), Cd (II) and Hg (II) complexes do not show any d-d transitions but display charge transfer bands at 21459, 20576, 24390 and 25510 cm^{-1} , respectively. The cobalt (II) complex showed several electronic spectra; some of them related to the ligand only, while the others related to the metal ion. These spectra may be characterized as follows: absorption at wavelength 245 nm is assigned to the $\pi \rightarrow \pi^*$ transition in the aromatic rings within the ligand. Absorption at 275 nm is assigned to the $n \rightarrow \pi^*$ transition from the (non-bonding electrons) which are available on the ligand nitrogens N_2 . The $d \rightarrow d$ transition which were confined to the d orbital of the metal ion are exhibited in three spectra; indicating in an octahedral geometry around the Co (II) ion, the first one did not show up due to its low energy and it will be calculated theoretically through the Tanabe-Sugano diagrams [28,29]. The second absorption occurs at 616 nm, and this is equivalent to the absorption band at 16223 cm^{-1} ; and the third absorption occurs at 561 nm which is again equivalent to the band at 17835 cm^{-1} . All the above absorption are

related to the following transitions; $\nu_1 = {}^4T_{1g}(F) \rightarrow {}^4T_{2g}(F)$, $\nu_2 = {}^4T_{1g}(F) \rightarrow {}^4T_{1g}(P)$ and $\nu_3 = {}^4T_{1g}(F) \rightarrow {}^4A_{2g}(F)$.

The value of (ν_1) has been calculated from Tanabe-Sugano diagrams [29]; where the value of Racah inter-electronic repulsion parameter (B'), needs to be obtained first, which was 580 cm^{-1} , and then using the following relationship ($15B = \nu_3 + \nu_2 - 3\nu_1$) to determined the value of ν_1 . The value of ν_1 has been calculated accordingly and found to be 8453 cm^{-1} which is equivalent to the wavelength 1183 nm ; which is not in the visible area anymore. The electronic spectrum of Ni (II) complex exhibits two bands in the region 23095 and 16077 cm^{-1} which are assigned to the ${}^3A_{2g}(F) \rightarrow {}^3T_{1g}(P)$ (ν_3), ${}^3A_{2g}(F) \rightarrow {}^3T_{1g}(F)$ (ν_2) transitions, respectively, indicating in an octahedral geometry around the Ni (II) ion. The (ν_1) ${}^3A_{2g}(F) \rightarrow {}^3T_{2g}(F)$, transition is expected to appear at large wavelength, therefore it could not be observed, it will be calculated theoretically through the Tanabe-Sugano diagram [29]. The value of (ν_1) has been calculated from Tanabe-Sugano diagrams; where the value of Racah inter-electronic repulsion parameter (B'), needs to be obtained first, which was 630 cm^{-1} , and then using the following relationship ($15B = \nu_3 + \nu_2 - 3\nu_1$) to determined the value of ν_1 . The value of ν_1 has been calculated accordingly and found to be 9907 cm^{-1} which is equivalent to the wavelength 1009 nm ; which is not appear in the visible area. The spectrum of Ni (II) complex also exhibits a charge transfer band at 25400 cm^{-1} . The electronic spectrum of Cu (II) complex displays three bands at 14493 , 22727 and 24991 cm^{-1} corresponding to the following transitions: ${}^2B_{1g} \rightarrow {}^2A_{1g} (d_x^2-y^2 \rightarrow d_z^2)$, (ν_1), ${}^2B_{1g} \rightarrow {}^2B_{2g} (d_x^2-y^2 \rightarrow d_{zy})$, (ν_2) ${}^2B_{1g} \rightarrow {}^2E_g (d_x^2-y^2 \rightarrow d_{zy}d_{yz})$, (ν_3), respectively. Therefore, the Cu (II) complex may be considered to possess a tetragonal geometry around the copper ion [30, 31]. Though three transitions are expected in this case, they are very close in energy and often appear in the form of one broad band envelope [31]. The spectrum also exhibits a band at 25575 cm^{-1} , which is assigned to a charge transfer band.

Thermal Analysis

The data of thermal study of the prepared complexes are listed in Table (4). All the prepared complexes showed a similar thermal behavior as they showed that the thermal decomposition of the complexes passes through three stages; the first stage of mass loss was attributed to the loss of water of hydration which took place at a temperature range of $(50-150) ^\circ\text{C}$. It is hard at this point to differentiate between the coordinated water and the uncoordinated (lattice water) from the thermograms [33,34]. All the experimental mass losses were in good agreement with the calculated ones as it is shown in Table (4). The second stage is the dissociation and decomposition of the chloride at temperatures depending on bond energies, which results in a temperature range of $(100-200) ^\circ\text{C}$. The last mass loss recorded was between the range of $(160 - 390) ^\circ\text{C}$ after that, a region of thermal stability was observed up to more than $(800 ^\circ\text{C})$ and was identified as the oxide of the corresponding metal ions which are known to be very stable even at very high temperatures [32-35].

Antibacterial Activity of the Prepared Compounds

The biological activity of the prepared ligand and the metal ion complexes were studied against selected types of micro organisms with include of *Staphylococcus aureus*, *Bacillus subtilis* (Gram positive), *Escherichia Coli* and *Pseudomonas aerugin* (Gram negative) in agar diffusion method, which is used (DMSO) as solvent. Agar diffusion method involves the exposure of the zone of inhibition toward the diffusion of micro organisms on agar plate. The plates were in cubated for (24) hrs. at $(37 ^\circ\text{C})$. The solvent (DMSO) showed no activity against the tested bacteria, while some of prepared complexes showed good results. Table (5) shows the inhibition zones of the ligand and the prepared complexes. The inhibition zones were measured in (mm) and compared to the inhibition zone of broad spectrum antibiotic. All the complexes and the ligand showed activity against the gram positive (*Staphylococcus aureus*). Some complexes showed no activity against the gram negative

bacterium (*Escherichia coli*), which can cause disease. Some complexes showed activity against the gram negative bacterium (*Pseudomonas*). This bacterium is known for its resistance to most of the developed antibiotics and is known to be the major cause of many health issues and infections [36-38]. The Tetracycline (gram positive control) showed activity against the gram positive bacterium (*Staphylococcus aureus*), the inhibition zone is 16.8 mm. Some other complexes showed activity against the gram positive bacterium (*Staphylococcus aureus*) which is a bacterium that causes staphylococcal food poisoning, found in the environment (soil, water and air) and is also found in the nose and on the skin of humans [149]. Complexes [Mn(II), Ni(II) Cu(II), Zn(II) and Cd(II) complexes as well as the ligand showed activity against the gram positive bacterium (*Bacillus subtilis*) which has been used for genetic and biochemical studies for several decades, and is regarded as paradigm of Gram-positive endospore-forming bacteria [38-40].

Conclusion

A series of complexes of [Cr (III), Fe (III), Mn (II), Co (II), Ni (II), Cu (II), Zn (II), Cd (II) and Hg (II)] with new bidentate 2-(naphthalene-2-yl)-2-(naphthalene-2-ylamino) acetonitrile ligand have been prepared and characterized. The bidentate ligand (N2) was forming octahedral structures as shown in Fig.(1 and 2).

Table (1)

Elemental analysis and some physical properties of the ligand (L) and the prepared complexes.

<i>Formula</i> <i>M.wt. (gm/mol)</i>	<i>Yield</i> <i>%</i>	<i>Color</i>	<i>M.P.</i> <i>(°C)</i>	<i>C %</i> <i>Cal.</i> <i>(found)</i>	<i>H %</i> <i>Cal.</i> <i>(found)</i>	<i>N %</i> <i>Cal.</i> <i>(found)</i>	<i>M %</i> <i>Cal.</i> <i>(found)</i>	<i>Cl%</i> <i>Cal.</i> <i>(found)</i>
C ₂₂ H ₁₆ N ₂ 308	88.5	Dark Brown	187-189	85.71 (84.89)	5.19 (6.05)	9.09 (9.44)	-----	-----
[CrL ₂ Cl ₂].Cl.3H ₂ O 828.5	79.6	Gray	218-220	63.73 (65.34)	4.59 (4.52)	6.76 (6.88)	6.28 (6.18)	12.85 (12.67)
[FeL ₂ Cl ₂].Cl.3H ₂ O 832.35	84.2	Light red	230-233	63.43 (63.26)	4.57 (4.60)	6.73 (6.65)	6.70 (7.3)	12.80 (13.03)
[MnL ₂ Cl ₂].2H ₂ O 777.94	75.7	Yellow Orange	192-195	68.49 (67.72)	4.63 (4.58)	7.20 (6.89)	7.06 (7.23)	9.13 (9.35)
[CoL ₂ Cl ₂].2H ₂ O 781.93	76.3	Dark Brown	219--221	66.01 (65.96)	4.75 (4.80)	7.00 (6.93)	7.37 (7.45)	8.88 (8.94)
[NiL ₂ Cl ₂].2H ₂ O 781.69	86.6	Chocolate Brown	192-195	67.55 (67.88)	4.61 (4.54)	7.16 (7.51)	7.51 (7.72)	9.08 (9.37)
[CuL ₂ Cl ₂].2H ₂ O 786.55	79.8	Orange	210-212	67.13 (67.40)	4.58 (4.62)	7.12 (7.28)	8.08 (8.34)	9.03 (9.22)
[ZnL ₂ Cl ₂].2H ₂ O 788.38	77.3	Light Brown	223-225	67.58 (67.37)	4.57 (4.47)	7.10 (7.02)	8.29 (8.14)	9.01 (8.96)
[CdL ₂ Cl ₂].2H ₂ O 835.41	82.5	Medium Brown	226-229	63.78 (63.90)	4.31 (4.28)	6.70 (6.58)	13.46 (13.32)	8.50 (8.41)
[HgL ₂ Cl ₂].2H ₂ O 923.59	87.3	Brownish Yellow	187-189	57.69	3.90	6.06	21.72	7.69

Table (2)
Characteristic infrared absorption bands of ligand (L) and the prepared complexes.

Molecular Formula	ν_{N-H} cm^{-1}	ν_{C-H} Aromatic cm^{-1}	ν_{C-H} aliphatic cm^{-1}	$\nu_{C\equiv N}$ cm^{-1}	δ_{N-H} cm^{-1}	ν_{C-N} cm^{-1}	ν_{M-N} cm^{-1}
C ₂₂ H ₁₆ N ₂	3328	3026	2981	2241	1616	1125	-----
[CrL ₂ Cl ₂].Cl.3H ₂ O	3368	3029	2940	2187	1634	1114	488
[FeL ₂ Cl ₂].Cl.3H ₂ O	3345	3031	2982	2189	1645	1110	490
[MnL ₂ Cl ₂].2H ₂ O	3357	3029	2965	2176	1659	1222	465
[CoL ₂ Cl ₂].2H ₂ O	3348	3028	2988	2171	1652	1092	487
[Ni] ₂ Cl ₂ .2H ₂ O	3379	3024	2980	2173	1658	1110	491
[CuL ₂ Cl ₂].2H ₂ O	3368	3025	2976	2193	1648	1098	484
[ZnL ₂ Cl ₂].2H ₂ O	3355	3033	2991	2198	1637	1108	472
[CdL ₂ Cl ₂].2H ₂ O	3361	3027	2979	2177	1655	1102	474
[HgL ₂ Cl ₂].2H ₂ O	3358	3026	2983	2179	1643	1107	432

Table (3)
Electronic spectra, spectra parameters, molar conductance, magnetic susceptibility and suggested stereo chemical of ligand (L) and the prepared complexes.

Molecular formula	λ nm	$\bar{\nu}$ cm^{-1}	Assignment	$\Omega^{-1}cm^2 mol^{-1}$	Magnetic moment $\mu_{eff} B.M$	suggested geometry
C ₂₂ H ₁₆ N ₂	252 300	39683 33333	$\pi \rightarrow \pi^*$ $n \rightarrow \pi^*$	-----	-----	-----
[CrL ₂ Cl ₂].Cl.3H ₂ O	265 290 742 575 488	37736 34483 13477 17391 20492	Ligand Field Ligand Field $^4A_{2g} \rightarrow ^2T_{2g} + ^2E_g$ $^4A_{2g} \rightarrow ^4T_1(F)$ $^4A_{2g} \rightarrow ^4T_1(P)$	38.3	3.95	octahedral
[FeL ₂ Cl ₂].Cl.3H ₂ O	260 295 531 452	38462 33900 18820 22124	Ligand Field Ligand Field $^6A_{1g} \rightarrow ^4T_{2g}(G)$ $^6A_{1g} \rightarrow ^4A_{1g} + ^4E_g$	33.8	4.98	octahedral
[MnL ₂ Cl ₂].2H ₂ O	251 278 466	39841 35971 21459	Ligand Field Ligand Field L \rightarrow M (CT)	15.7	5.09	octahedral geometry
[CoL ₂ Cl ₂].2H ₂ O	245 275 1183 616 561	40816 36363 8453* 16223 17835	Ligand Field Ligand Field $^4T_{1g}(F) \rightarrow ^4T_{2g}(F)$ $^4T_{1g}(F) \rightarrow ^4T_{1g}(P)$ $^4T_{1g}(F) \rightarrow ^4A_{2g}(F)$	17.1	3.96	octahedral
[NiL ₂ Cl ₂].2H ₂ O	255 281 394 1009 622 433	39216 35587 25400 9907* 16077 23095	Ligand Field Ligand Field C.T $^3A_{2g}(F) \rightarrow ^3T_{2g}(F)$ $^3A_{2g}(F) \rightarrow ^3T_{1g}(F)$ $^3A_{2g}(F) \rightarrow ^3T_{1g}(P)$	17.2	3.78	octahedral
[CuL ₂ Cl ₂].2H ₂ O	260 285 390 690 440 405	38462 35088 25575 14493 22727 24991	Ligand Field Ligand Field C.T $^2B_{1g} \rightarrow ^2A_{1g}$ $^2B_{1g} \rightarrow ^2B_{2g}$ $^2B_{1g} \rightarrow ^2E_g$	16.5	1.79	Distorted octahedral
[ZnL ₂ Cl ₂].2H ₂ O	287 247 486	34843 40486 20576	Ligand Field Ligand Field L \rightarrow M (CT)	14.1	Dia.	octahedral
[CdL ₂ Cl ₂].2H ₂ O	292 260 410	34247 38462 24390	Ligand Field Ligand Field L \rightarrow M (CT)	13.7	Dia.	octahedral
[HgL ₂ Cl ₂].2H ₂ O	283 245 392	35357 40650 25510	Ligand Field Ligand Field L \rightarrow M (CT)	15.8	Dia.	octahedral

*Calculated value

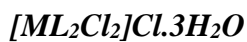
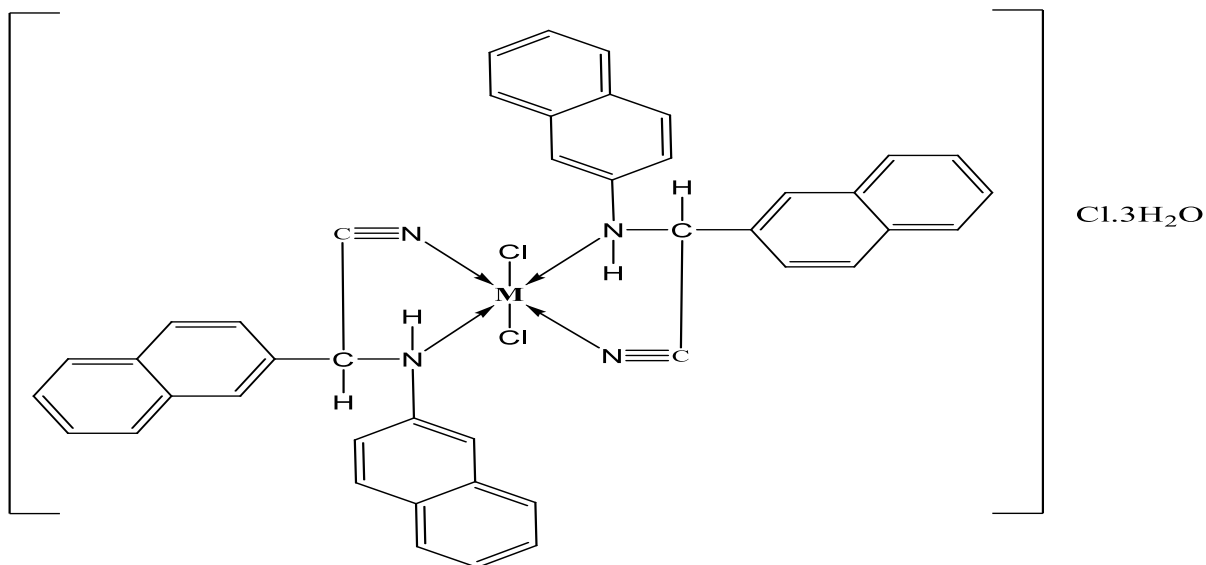
Table (4)
Thermal decomposition data for the prepared complexes.

Molecular Formula M.wt (gm/mol)	Step	Temp. range of decomposition °C	Suggested formula of resultant compound	Mass loss %	
				Calculated	Found
[CrL ₂ Cl ₂]Cl.3H ₂ O 828.5	1	70-112	[CrL ₂ Cl ₂]Cl	6.52	6.44
	2	112-180	[CrL ₂]	12.85	12.72
	3	180-375	Cr ₂ O ₃	74.35	74.09
[FeL ₂ Cl ₂]Cl.3H ₂ O 832.35	1	65-140	[FeL ₂ Cl ₂]Cl	6.49	6.33
	2	140-190	[FeL ₂]	12.80	12.68
	3	190-365	Fe ₂ O ₃	74.01	73.89
[MnL ₂ Cl ₂].2H ₂ O 777.94	1	65-130	[MnL ₂ Cl ₂]	4.63	4.59
	2	130-170	[MnL ₂]	9.13	9.02
	3	170-390	MnO ₂	79.18	78.95
[CoL ₂ Cl ₂].2H ₂ O 781.93	1	55-100	[CoL ₂ Cl ₂]	4.50	4.39
	2	100-160	[CoL ₂]	9.08	8.98
	3	160-380	Mix of CoO and Co ₃ O ₄	78.78	78.88
[NiL ₂ Cl ₂].2H ₂ O 781.69	1	50-105	[NiL ₂ Cl ₂]	4.61	4.53
	2	105-175	[NiL ₂]	9.08	9.00
	3	175-380	NiO	78.80	78.63
[CuL ₂ Cl ₂].2H ₂ O 786.55	1	50-115	[CuL ₂ Cl ₂]	4.58	4.49
	2	115-200	[CuL ₂]	9.03	8.98
	3	200-385	CuO	78.32	78.21
[ZnL ₂ Cl ₂].2H ₂ O 788.38	1	60-130	[ZnL ₂ Cl ₂]	4.67	4.62
	2	130-190	[ZnL ₂]	9.06	8.93
	3	190-370	ZnO	78.13	78.45
[CdL ₂ Cl ₂].2H ₂ O 835.41	1	60-140	[CdL ₂ Cl ₂]	4.31	4.25
	2	140-195	[CdL ₂]	8.50	8.35
	3	195-360	CdO	73.74	73.83
[HgL ₂ Cl ₂].2H ₂ O 923.59	1	50-150	[HgL ₂ Cl ₂]	3.90	3.84
	2	150-190	[HgL ₂]	7.69	7.59
	3	190-380	HgO	66.70	66.42

Table (5)

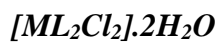
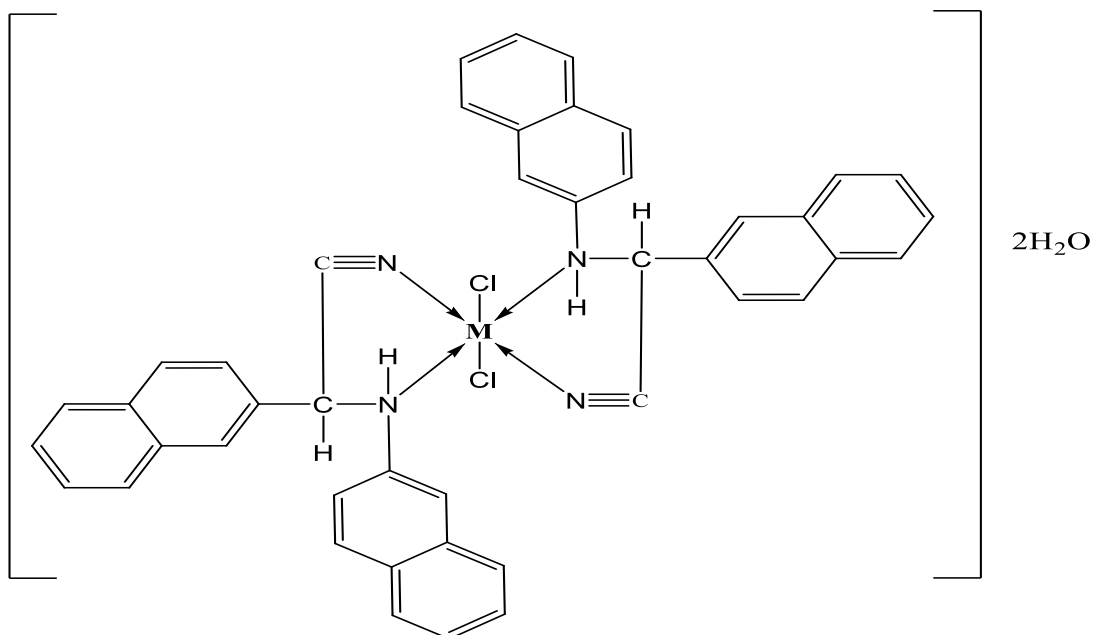
The antibacterial activity of the ligand and its metal ion complexes against the tested bacteria.

Compound	Inhibition zone zone (mm) <i>Escherichia coli</i>	Inhibition zone zone (mm) <i>Pseudomonas aeruginosa</i>	Inhibition zone zone (mm) <i>Staphylococcus aureus</i>	Inhibition zone zone (mm) <i>Bacillus subtilis</i>
DMSO	-----	-----	-----	-----
Tetracycline	19.3	7.2	16.8	-----
C ₂₂ H ₁₆ N ₂	9.3	10.9	13.7	9.6
[CrL ₂ Cl ₂]Cl.3H ₂ O	7.8	9.4	12.3	-----
[FeL ₂ Cl ₂]Cl.3H ₂ O	-----	23.2	10.6	contaminated
[MnL ₂ Cl ₂].2H ₂ O	6.7	-----	13.7	-----
[CoL ₂ Cl ₂].2H ₂ O	-----	contaminated	11.2	11.4
[NiL ₂ Cl ₂].2H ₂ O	8.2	-----	10.5	13.2
[CuL ₂ Cl ₂].2H ₂ O	-----	-----	7.4	12.3
[ZnL ₂ Cl ₂].2H ₂ O	7.8	20.8	8.5	10.9
[CdL ₂ Cl ₂].2H ₂ O	-----	-----	7.9	8.3
[HgL ₂ Cl ₂].2H ₂ O	contaminated	-----	6.2	-----



[Di Chloro-bis {2-(naphthalene-2-yl)-2-(naphthalene-2ylamino) acetonitrile} Chrome or Iron (III)]Chloride (3) Hydrate

Fig.(1) The proposed structure of the complexes, where M = Cr(III) or Fe(III).



[Di Chloro-bis {2-(naphthalene-2-yl)-2-(naphthalene-2ylamino) acetonitrile} Manganese, Cobalt, Nickel, Copper, Zinc, Cadmium or Mercury (II)] (2) Hydrate

Fig.(2) The proposed structure of the complexes, where M = Mn(II), Co(II), Ni(II), Cu(II), Zn(II), Cd(II) and Hg(II).

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الخلاصة

تضمنت هذه الدراسة تحضير وتشخيص مجموعة من معقدات بعض ايونت العناصر ثلاثية التكافؤ (Cr(III) و Fe(III) وثنائية التكافؤ (Mn(II) و Co(II) و Ni(II) و Cu(II) و Zn(II) و Cd(II) و Hg(II) من تفاعل الليكاند ثنائي السن ٢-(نفتالين-١٢-yl)-٢-(نفتالين-١٢-yl)امينو) اسيتونتريل الذي حضر من تفاعل ٢-نفتالالديهايد مع ٢-امينو نفتالين بوجود سيانيد البوتاسيوم في محلول كحولي. حضرت المعقدات من خلال معاملة الليكاند مع املاح العناصر بنسبة مولية [2:1] ملح: ليكاند] وشخصت المعقدات من خلال قياس درجة الانصهار و التحليل الدقيق للعناصر و مطيافية الامتصاص الذري ومطيافية الاشعة تحت الحمراء و الاطيف الالكترونية و بروتون الرنين النووي المغناطيسي والتحليل الحراري والتوصيلية المولارية والقياسات المغناطيسية. طبقاً للبيانات التي تم الحصول عليها تم اقتراح الاشكال الهندسية المحتملة لهذه المعقدات على انها ثمانية السطوح. بعض المعقدات كانت غير الكتروليتية والبعض الآخر وجدت بشكل الكتروليت ضعيف. تمت دراسة الفعالية البايولوجية لليكاند و للجميع المعقدات المحضرة.