

Synthesis, spectroscopic and antimicrobial studies of new Cr(III), Co(II), Ni(II) and Cu(II) Schiff base complexes

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Abstract

Complexes of the 8-((furan-2-ylmethylene)amino)naphthalene-1-amine, Schiff base ligand with the metal ions, Cr(III), Co(II), Ni(II) and Cu(II) have been prepared and characterized by elemental analyses, IR, ¹H NMR, UV-visible, magnetic moment, molar conductance and thermal analysis. The complexes are found to have the formulae [CrLCl(H₂O)₃]Cl₂.3H₂O, [CoL₂(H₂O)₂]Cl₂.3H₂O, [NiL(H₂O)₂]Cl₂.4H₂O and [CuL(H₂O)₂]Cl₂.2H₂O. The conductance of complexes is measured and revealed their electrolytic nature. Thermal analysis and thermodynamic parameters of the complexes were investigated and indicated the presence of hydrated water molecules. The antimicrobial activity is assayed in vitro against two fungi and four bacteria species.

Keywords: Complexes; Spectral; thermal analysis ; biological activity

1. Introduction

Schiff bases are condensation products of primary amine and aliphatic or aromatic carbonyl compounds with the general formula (RCH=N-R), that makes the Schiff base a stable imine. The linkage azomethine group contains a pair of π electrons bonded between carbon and nitrogen (-CH=N-). In addition, the nitrogen atom present in the azomethine group has a lone pair of electron and this adds distinct properties to this group. Schiff bases derived from aromatic amines and aromatic aldehydes have a wide variety of applications in many fields, eg., biological [Tadavi et al., 2018; Diab et al., 2017; Daravath et al., 2018; Jia et al., 2017], heterogeneous catalyst [Esmaeilpour et al., 2014], oxidation of alkanes [Buvaylo et al., 2017], catalytic applications [Park et al., 2018; El-Megharbel et al., 2016] and

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photoluminescent properties [Burlov et al., 2018; Gao et al., 2018].

This paper focuses on the structural study of four new Ni(II), Cu(II), Co(II) and Cr(III) complexes with 8-((furan-2-ylmethylene)amino)naphthalene-1-amine, **L** using IR, ^1H NMR, molar conductance, and thermal analysis measurements. The biological activities of the parent Schiff base and its metal complexes are reported and compared with reference standard antibiotic drugs.

2. Experimental

2.1. Methods and materials

All chemicals and solvents used in these analyses are of analytical grade and used without further purification. IR measurements (KBr pellets) are recorded using a Perkin-Elmer spectrophotometer model 1430, in the range of 400-4000 cm^{-1} . ^1H NMR spectra are recorded with Bruker 500 MHz spectrometer using CDCl_3 with TMS as internal standard. Elemental analysis of the ligand and its metal complexes are carried out using Perkin-Elmer elemental analyzer. The melting points of the complexes are determined using an Electrothermal 9200. Molar conductance of the complexes is measured in DMF (1×10^{-3} M) at 25 °C, by using Jenway 4010 conductivity meter. Mass spectrometry measurements of the solid ligand and its complexes (70 eV, EI) are carried out on a JEOL JMS-AX 500 spectrometer. Magnetic moments are measured by Guoy method on a Sherwood magnetic susceptibility balance. The electronic spectra are measured on a Shimadzu 3101 pc spectrophotometer. Thermogravimetric analyses (TG and DTG) are carried out under a nitrogen atmosphere with a heating rate of 10 °C/min. using a Shimadzu DT-50 thermal analyzer. PXRD is performed at ambient temperature on Philips X'pert multipurpose $\{\text{K}\alpha 1(1.54056 \text{ \AA})$ radiation with an intensity weighted average of $(\text{K } \alpha \text{ ave}) 1.54184 \text{ \AA}\}$ as the radiation sources. The diffraction patterns are recorded at room temperature in the range $2\theta = 10-80^\circ$ with a continuous scan mode.

2.2. Synthesis of the Schiff base ligand (L)

An ethanolic solution of 1,8-diaminonaphthalene (3 g, 0.01 mol) is mixed with methanolic solution of 2-furancarboxaldehyde (1.8 g, 0.01 mol). The mixture is stirred with heating at 40 °C for 3 hours. On cooling, a brown precipitate is isolated, filtered off, washed

several times with ethanol, ether and subsequently dried over anhydrous CaCl_2 in a desiccator. The product is produced in 75% yield.

2.3. Preparation of the metal complexes

The preparation of the complexes have been carried out by dissolving the metal salt in 10 ml of ethanol then is added slowly to magnetically stirred ethanolic solution of the Schiff base. The reaction mixture is refluxed for three hours. The resulting solution is concentrated by evaporation and the precipitate is isolated, washed with hot petroleum ether several times and then left to dry at room temperature.

2.4. Biological studies

In vitro antibacterial activity studies are carried out by using the standardized disc-agar diffusion method. The ligand and its complexes are tested against two local Gram positive bacterial species (*Streptococcus pneumoniae* and *Bacillus subtilis*) and two local Gram negative bacterial (*Pseudomonas aeruginosa* and *Escherichia coli*) on nutrient agar medium (NA). Also, the antifungal activities are tested against two local fungal species (*Aspergillus fumigatus* and *Candida albicans*) on Sabouraud Dextrose Agar (SDA) medium. Amphotericin B, Ampicillin, and Gentamicin are used as standard references for Gram-positive & Gram-negative bacteria and fungi, respectively served as positive controls. The concentration of the test samples (1 mg/ml in DMSO) is introduced in the respective wells. The plates are then incubated at 37 °C and 25 °C for bacteria and fungi, respectively. Generally, the antimicrobial agent diffuses in the agar medium and inhibits the germination and growth of the test microorganism and then the diameters of inhibition zones are measured in millimeter, after 24 hrs for bacteria and 48 hrs for fungi as an indicator for antimicrobial activity and the obtained results are represented as no activity, low activity, intermediate activity and high activity.

3. Result and discussion

The Ligand and its Cr(III), Co(II), Ni(II) and Cu(II) complexes are prepared by the reaction of the metal ions with the neutral bidentate Schiff base, 8-((furan-2-ylmethylene)amino)naphthalene-1-amine, (L). These complexes are characterized by several analytical and spectroscopic techniques. Several efforts made to develop single crystal of complexes suitable for crystal analysis are failed due to their poor solubility in common

organic solvents. Some physical and analytical data of the ligand and its complexes are shown in **Table(1)**.

Table.1. Physical and analytical data of the metal complexes

Compound	Color	Elemental analysis, Found (Calcd.)			M.Wt. Found ^(a) (Calcd)	Molar conductance ($\Omega^{-1}\text{mol}^{-1}\text{cm}^2$)
		C%	H%	N%		
L	Light	76.6	5.2	11.6	236.273	-
C₁₄H₁₃NO	brown	(76.3)	(5.1)	(11.8)		
[CrLCl(H ₂ O) ₃]Cl ₂ .3H ₂ O	Dark	35.4	4.8	5.0	502.719	131
Cr[C₁₅H₂₄N₂O₇Cl₂]	brown	(35.8)	(4.8)	(5.6)		
[CoL ₂ (H ₂ O) ₂]Cl ₂ .3H ₂ O	Brown	51.8	(4.5)	7.8	692.460	180
Co[C₃₀H₃₂N₄O₆.Cl₂]		(52.0)	(4.9)	(8.1)		
[NiL(H ₂ O) ₂]Cl ₂ .4H ₂ O	Brown	38.5	5.2	5.5	373.970	169
Ni[(C₁₅H₂₄N₂O₇.Cl₂)]		(38.0)	(5.1)	(5.9)		
[CuL(H ₂ O) ₂]Cl ₂ .2H ₂ O	Black	40.2	4.8	6.3	442.789	171
Cu[C₁₅H₂₀N₂O₅Cl₂]		(40.7)	(4.6)	(6.3)		

^(a)Found values obtained from mass spectra data.

3.1. Mass spectra

Mass spectra data of Schiff base ligand, L and its complexes are showed a well-defined parent peak at $m/z = 237 [P^+]$ confirming the molecular formula of the ligand, L. The molecular formula of Cr[C₁₅H₂₄N₂O₇Cl₂], (FW = **502.719** g mol⁻¹, $m/z = 503$, Co[C₃₀H₃₂N₄O₆.Cl₂], (FW = 692.460 g mol⁻¹, $m/z = 693$, Ni[(C₁₅H₂₄N₂O₇.Cl₂], (FW = 373.970 g mol⁻¹, $m/z = 374$ and Cu[C₁₅H₂₀N₂O₅Cl₂], (FW = 442.789 g mol⁻¹, $m/z = 443$ corresponding to the parent molecular ion peak $[p]^+$.

3.2. IR spectra studies

The IR spectrum (KBr disk, cm⁻¹) of the ligand L showed symmetric and asymmetric stretching bands at 3345 cm⁻¹ & 3309 cm⁻¹ corresponded to NH₂ group [Nakamoto, 1986]. Furthermore, the IR spectrum displayed stretching bands at 1632 and 1243 cm⁻¹ due to the azomethine group (C=N), C-O-C moieties, respectively [Ali et al., 2015]. The IR spectra of the complexes revealed strong $\nu(C=N)$ stretching frequencies in the range 1620-1641 cm⁻¹ with

shift with respect to that of the free ligand [Zhang, et al., 2017; Abdel Aziz, et al., 2017]. These results indicated the coordination of the metal atoms to the ligand via the azomethine nitrogen atom in the complexes. Moreover, the IR spectra showed $\nu(\text{NH}_2 \text{ or/and } \text{H}_2\text{O})$ broad stretching frequency bands in the range $3355\text{-}3441 \text{ cm}^{-1}$. These results may suggest the presence of coordinated and / or hydrated water molecules in the reported complexes. The coordinated water molecules can be confirmed by TG-DTG analysis as will be discussed later. Moreover, there are band in the range $1231\text{-}1225 \text{ cm}^{-1}$ referred to stretching vibrations of C-O-C bond of furan moiety in the spectra of complexes with the proper shift with respect to the corresponding one in the free ligand L. This indicates the coordination of the oxygen atom of furan moiety to metal in complexes. In addition, non-ligand stretching vibrations are appeared in the IR spectra of the complexes in the ranges $525\text{-}512 \text{ cm}^{-1}$ and $473\text{-}470 \text{ cm}^{-1}$. These bands are referred to $\nu(\text{M-O})$ and $\nu(\text{M-N})$ stretching vibrations, respectively, confirming the coordination of the oxygen atom of the furan moiety and the nitrogen atom of the azomethine group to the metal in complexes(**Table 2**)

Compound	IR spectra (cm^{-1})*				
	$\nu(\text{OH})$ (OH_2)	$\nu(\text{C=N})$	$\nu(\text{C-O-C})$ (furan)	$\nu(\text{M-O})$	$\nu(\text{M-N})$
L	3344- 3309 (b)	1632 (m)	1243 (w)	-	-
[CrLCl (H_2O) ₃]Cl ₂ .3H ₂ O	3378 (b)	1641 (m)	1231(w)	525 (w)	473 (w)
[CoL ₂ (H_2O) ₂]Cl ₂ .3H ₂ O	3388 (b)	1630 (m)	1231 (w)	535 (w)	471 (w)
[NiL(H_2O) ₂]Cl ₂ .4H ₂ O	3355 (b)	1640 (m)	1225 (w)	525 (w)	472 (w)
[CuL(H_2O) ₂]Cl ₂ .2H ₂ O	3441 (b)	1620 (s)	1225 (w)	512 (w)	470 (w)

Table 2.Most important IR spectral bands of the Ligand and its complexes (cm^{-1}).

* m, medium; w, weak; b, broad.

3.3. ¹H NMR spectroscopy

The ¹H NMR spectrum of the Schiff base ligand in DMSO **Fig. (1)** displayed singlet at 10.69 ppm referred to NH₂ protons and another singlet at 7.93 ppm corresponded to CH=N proton [Iftikhar, et al., 2018]. Further, the ¹H NMR spectrum of the ligand showed multiplet signals at 6.23-7.52 ppm referred to aromatic protons.

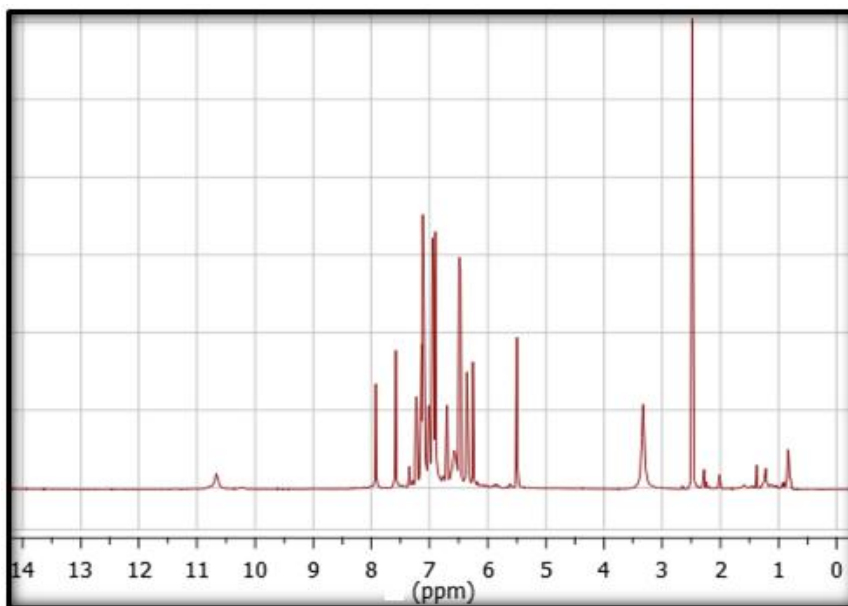


Fig.1. ^1H NMR spectrum of Schiff base ligand

3.4. Electronic and magnetic moment measurements

The electronic spectrum of the ligand has been recorded in DMSO at room temperature (**Table (3) Fig (2)**). The absorption spectrum of the Schiff base ligand exhibited two bands at 252 nm and 329,340 nm assignable to $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ transitions for the electrons on benzene rings and the C=N chromophore, respectively [**Olalekan et al., 2016**]. These bands are shifted due to the coordination of azomethine to the metal ions. The electronic spectra of the prepared complexes exhibit new band around (402-456) nm refer to charge transfer (C.T) transitions and d-d transitions are not observed [**Abo-Aly et al., 2015**]. These bands are shifted due to the coordination of azomethine to the metal ions.

The magnetic moment value of Co(II) complex has been found to be 4.7 BM corresponding to three unpaired electrons within the range of high spin octahedral complex of Co(II) ion [**Radha et al., 2018**]. The magnetic moment of Ni(II) complex is measured and equals 3.88 B.M., which lie in the range of tetrahedral compounds (3.2– 4.1 B.M.) [**Abou-Hussein & Linert, 2015**]. The effective magnetic moment of chromium complex showed a value of 3.61 BM indicating a high spin d^3 electronic configuration. The copper(II) complex showed magnetic moment value of 1.70 BM. with d^9 electronic configuration which is consistent with tetrahedral geometry [**Beyazit et al., 2016**]. From spectroscopic data and magnetic measurements, it could be concluded that the ligand is coordinated to the metal center in Cr(III) complex forming octahedral geometry with 1:1 ratio (ligand : metal) through

oxygen atom of furan moiety and nitrogen atom of imine group while in Co(II) complex, the cobalt atom was surrounded by two

Table 3.The UV-Vis of the ligand and its complexes

Compound	UV-Vis data		
	λ_{\max} (nm)		
	$\pi \rightarrow \pi^*$	$n \rightarrow \pi^*$	CT
Ligand	252	329, 340	-
[CrLCl(H ₂ O) ₃]Cl ₂ .3H ₂ O	272	327	420
[CoL ₂ (H ₂ O) ₂]Cl ₂ .3H ₂ O	273	312	456
[NiL(H ₂ O) ₂]Cl ₂ .4H ₂ O	279	342	425
[CuL(H ₂ O) ₂]Cl ₂ .2H ₂ O	258	310	402

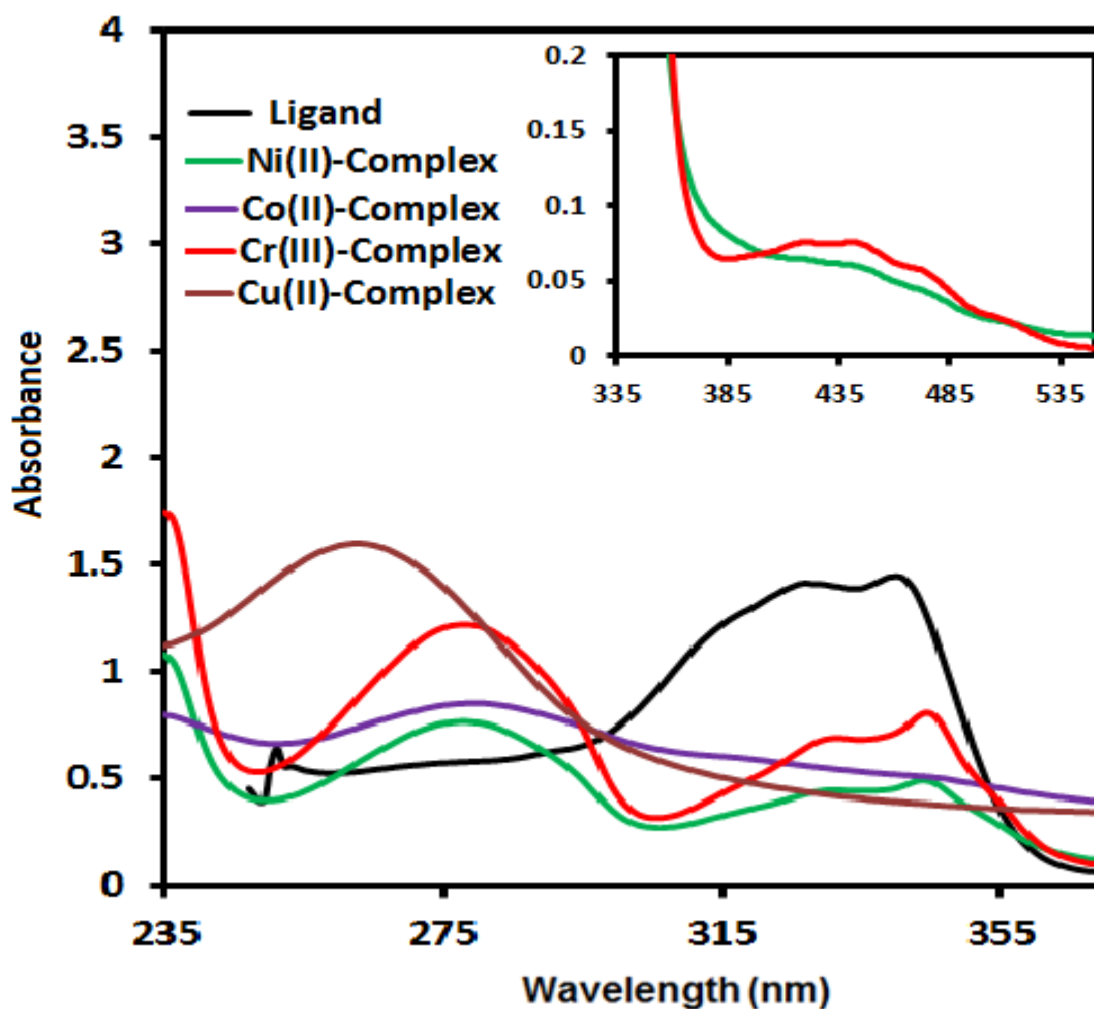


Fig.2.The UV-Vis spectra of synthesized ligand and its complexes

ligand moieties with four donating groups;with oxygen atom of furan group and nitrogen atom of imine group.Ni(II) and Cu(II) complexes are probably presented in a tetrahedral shape withone metal : one ligand where the metal ion is coordinated with ligand through two positions; azomethine nitrogen and furan oxygen in addition to water molecules.

3.5. Thermal analyses and kinetic studies

The thermal studies of the ligand and complexes are carried out using thermogravimetry (TG) and differential thermogravimetry (DTG) techniques. The TG data of the reported ligand and its complexes are listed in **Table (4)** and plotted as shown in **Fig.(3)**.

Table 4. Thermogravimetric data of the metal complexes

Compound	Stage	Temp. range (°C)	Mass loss (%)		Evolved moiety	Residue (%) Found (Calcd.)
			Found	Calcd.		
L	I	30–157	7.21	6.80	NH ₃	
	II	157-277	87.71	87.96	C ₄ H ₄ O+CH≡N+C ₉ H ₄	No residue
	III	277-611	5.08	5.24	C	
[CrLCl(H ₂ O) ₃]Cl ₂ .3H ₂ O	I	48-121	10.03	10.75	3H ₂ O (hyd)	
	II	121-463	25.13	25.25	3H ₂ O(coord)+2HCl	½Cr ₂ O ₃ ; 15.78 (15.12)
	III	463-793	49.06	48.88	½O ₂ +C ₁₅ H ₁₂ N ₂ O+½C I ₂	
[CoL ₂ (H ₂ O) ₂]Cl ₂ .3H ₂ O	I	25-132	12.98	13.01	3H ₂ O(hyd.) and 2H ₂ O(coord.)	
	II	132-402	10.44	10.54	2HCl	
	III	402-701	34.00	34.13	C ₁₅ H ₁₂ N ₂ O	CoO; 10.83 (10.82)
	IV	701- 1000	31.75	31.50	C ₁₅ H ₁₀ N ₂	
[NiL(H ₂ O) ₂]Cl ₂ .4H ₂ O	I	25-136	21.95	22.80	4H ₂ O(hyd.)+ 2 H ₂ O(coord.)	
	II	136-290	20.90	21.29	N ₂ +2HCl	NiO; 16.25 (15.76)
	III	290-690	40.90	40.15	C ₁₅ H ₁₀	
[CuL(H ₂ O) ₂]Cl ₂ .2H ₂ O	I	40-229	16.59	16.28	2H ₂ O(hyd.)+ 2H ₂ O(coord.)	CuO; 17.4 (17.96)
	II	229-988	66.01	65.76	C ₁₅ H ₁₂ N ₂ +Cl ₂	

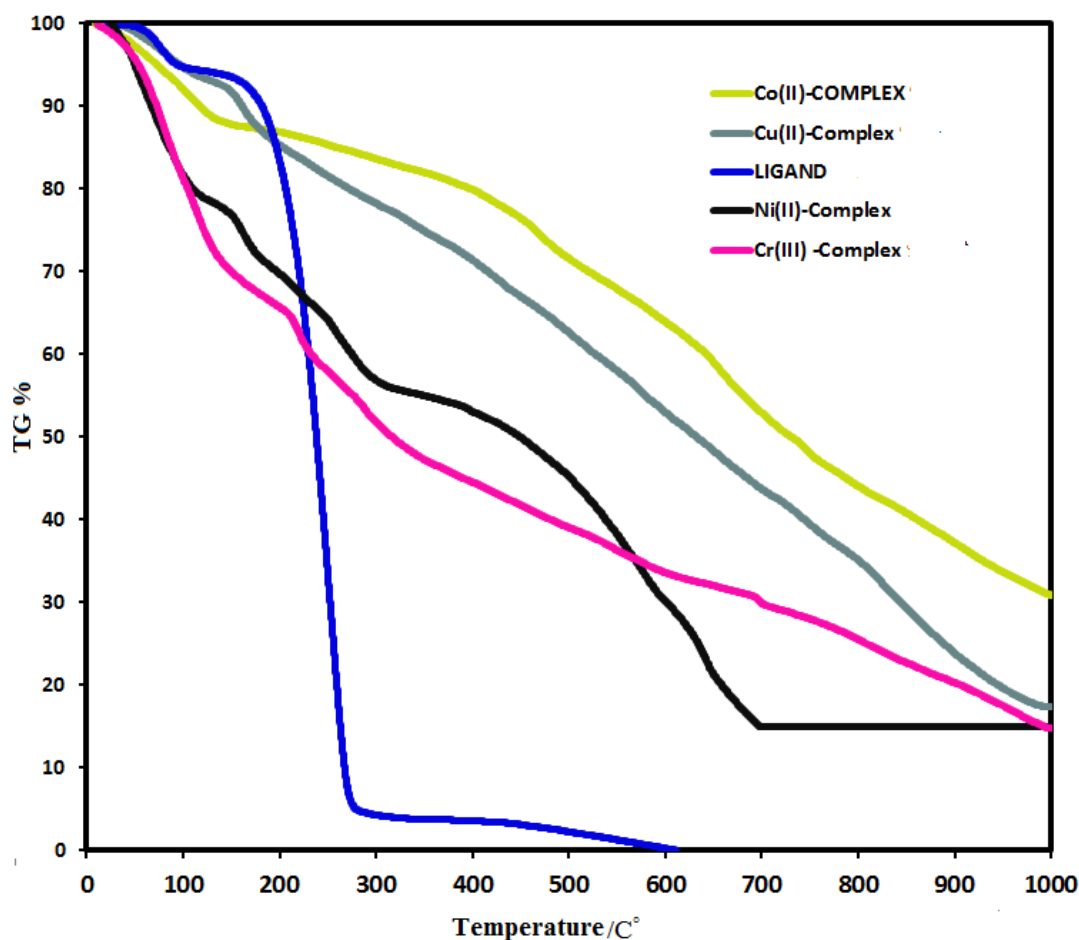


Fig.3. TG-thermogram of ligand and its complexes

The TG and DTG plots of $[\text{CrLCl}(\text{H}_2\text{O})_3]\text{Cl}_2 \cdot 3\text{H}_2\text{O}$ displayed three resolved and well-defined decomposition steps in the temperature range 48-793 °C. The first decomposition step occurred in the temperature range 48-121 °C, with a net weight loss of 10.03%, (calc. 10.75%) could be due to the elimination of three H_2O molecules confirming the presence of three hydrated water molecules in the complex. The second decomposition step occurred in the temperature range 121-463 °C with a net weight loss of 25.13 % (calc. 25.25%) was due to the loss of a $3\text{H}_2\text{O}(\text{coord})+2\text{HCl}$ moieties. On the other hand, the third decomposition step (463-793°C, 49.06%) (calc. 48.88%) was due to the elimination of $\frac{1}{2}\text{O}_2+\text{C}_{15}\text{H}_{12}\text{N}_2\text{O}+\frac{1}{2}\text{Cl}_2$ species to leave metallic residue of $\frac{1}{2}\text{Cr}_2\text{O}_3$. The TG plots of $[\text{CoL}_2(\text{H}_2\text{O})_2]\text{Cl}_2 \cdot 3\text{H}_2\text{O}$ complex $[\text{CoL}_2(\text{H}_2\text{O})_2]\text{Cl}_2 \cdot 3\text{H}_2\text{O}$ [M.wt.=692.460] exhibited four well-defined and non-overlapping decomposition steps. The first decomposition step occurred in the temperature range 25-132°C, with a net weight loss of 12.98 (13.01%), probably due to elimination of three hydrated water molecules and two coordinated water molecules. The

second decomposition step occurred in the temperature range 132-402 °C with a net weight loss of 10.44 (10.54 %) may be due to the elimination of two HCl molecules. The third decomposition step occurred in the temperature range 402-701 °C, with a net weight loss of 34.00 (34.13 %), probably due to elimination of C₁₅H₁₂N₂O. Moreover, the final decomposition step happened in the temperature range 701-1000 °C, with a net weight loss of 31.75 (31.50 %), probably due to elimination of C₁₅H₁₀N₂ to give, finally, the residue CoO (10.83%). The TG and DTG plots of the [NiL(H₂O)₂]Cl₂·4H₂O, Ni[(C₁₅H₂₄N₂O₇Cl₂)]₂ complex displayed three decomposition steps in the temperature range 25-690 °C. The first decomposition step occurred in the temperature range 25-136 °C with a net weight loss of 21.95% (calc; 22.80%) corresponded to the elimination of four hydrated and two coordinated water molecules. On the other hand, the second decomposition peak occurred in the temperature range 136-290 °C with a weight loss of 20.90 % (calc; 21.29%) corresponded to the decomposition of N₂+2HCl. In addition, a third decomposition step (290-690 °C, 40.90%) was due to the elimination of C₁₅H₁₀ species to give finally NiO solid residue (16.25). The [CuL(H₂O)₂]Cl₂·2H₂O complex is found to be thermally decomposed in two well-defined steps in the temperature range 40-988 °C. In the first decomposition step occurred in the temperature range 40-229 °C with a net weight loss of 16.59% (calc; 16.28%) and corresponded to the elimination of two hydrated and two coordinated water molecules. The second decomposition step (388-528 °C, 30.69 %) was due to the elimination of two C₉H₆NS₂ species. The third decomposition peak occurred in the temperature range 229-988 °C (weight loss 66.01%) could be due to the elimination of a C₁₅H₁₂N₂+Cl₂ moieties to leave CuO as a residue.

The thermodynamic activation energy (E^*), enthalpy (H^*), entropy (S^*) and Gibbs free energy change (G^*) of decomposition processes of complexes are evaluated graphically by utilizing the Coats-Redfern relation [Coats & Redfern, 1964]

$$\log \left[\frac{\log(W_{\infty} / (W_{\infty} - W))}{T^2} \right] = \log \left[\frac{AR}{\phi E^*} \left(1 - \frac{2RT}{E^*} \right) \right] - \frac{E^*}{2.303RT}$$

Where W is the mass loss up to temperature T , W_{∞} is the mass loss at the completion of the decomposition reaction, ϕ is the heating rate and R is the gas constant. As the value of $(1 - 2RT/E^*) \cong 1$, the plot of the left-hand side of Coats-Redfern equation against $1/T$ gives a straight line with slope $E^*/2.303R$ and intercept = $\log(AR/\phi E^*)$. E^* is calculated from the slope then the Arrhenius constant, A , could be obtained from the intercept. The other kinetic

parameters; (S^*), (H^*) and (G^*) are calculated and tabulated in **Table (5)**. The kinetic parameters are calculated using the following equations:

Table 5. Thermodynamic data of the thermal decomposition of the ligand and its complexes

Compound	Steps	Decomposition Temp. range °C	DTGA peak °C	A (s ⁻¹)	ΔH* (KJ/mol)	ΔS* (J/mol)	ΔG* (KJ/mol)	E* (KJ/mol)	R ²
L	I	30-101	71	9.96×10 ⁴	50.37	-99.09	57.47	50.96	0.99
	II	148-272	254	18.9×10 ³	49.99	-161.74	91.15	52.11	0.95
[CrLCl(H ₂ O) ₃]Cl ₂ .3H ₂ O	I	48-121	82	58.97×10 ⁷	82.01	-21.05	89.50	84.97	0.95
	II	158-305	238	7	8.20	-250.42	136.23	12.45	0.96
[CoL ₂ (H ₂ O) ₂]Cl ₂ .3H ₂ O	III	405-608	491	88 84×10 ⁷	12.56	-259.65	211.12	18.93	0.96
	I	25-117	61	25.09×10 ⁴	31.10	-128.48	39.03	31.61	0.98
[NiL(H ₂ O) ₄]Cl ₂ .3H ₂ O	I	25-122	60	9.6×10 ⁵	45.15	-117.09	52.20	45.65	0.95
[CuL(H ₂ O) ₂]Cl ₂ .2H ₂ O	I	34-126	71	6.56×10 ²	24.52	-179.13	37.32	25.12	0.98
	II	126-181	152	1.99×10 ³	32.67	-176.18	59.53	33.94	0.98

$$S^* = 2.303 \left(\log \frac{Ah}{kT} \right) R$$

$$H^* = E^* - RT$$

$$G^* = H^* - TS^*$$

Where (h) and (k) are Planck's and Boltzman constants, respectively. The activation energies, E*, of decomposition are found to be in the range 20-215 kJ mol⁻¹ reflecting the thermal stability of the complexes. This behavior corresponded to the covalent character of the complexes [Hatakeyama & Liu, 1998; Ali et al, 2015]. On the other hand, the negative values of S* reveal more ordered activated complex and lower rate for the decomposition reactions than normal ones [Mohamed et al, 2006].

3.6. Biological activity studies

Antimicrobial agents are one of the major advances in medical science. However, the wide spread use of the traditional drugs leads to microorganism resistance. So, it is important to develop new classes of antimicrobials, to overcome the drug resistance [Dwyer & Mellor, 1964]. Transition metal complexes have been vastly studied and some have shown significant biological activity due to their strong ability to bind proteins and nucleic acids [Smith et al, 2017; Li et al, 2015]. The Schiff base ligand 8-((furan-2-ylmethylene)amino)naphthalene-1-amine, L, and its Cr(III), Co(II), Ni(II) and Cu(II) complexes were screened against the

bacterial stains *B. subtilis*, *S. aureus*, *E. coli*, *P. aeruginosa* and the fungal stains *A. flavus* and *C. albicans* and compared with known antibiotics: ampicillin as antibacterial agents and Amphotericin B as antifungal agents.

It is clear that, the ligand and its complexes exhibit significant activity against bacterial stains. This may be due to the presence of the imine group which may be one of the reasons for the biocidal action of both the ligand and metal complexes. Furthermore, the results indicated that some complexes have higher activity than the ligand and the cobalt(II) and nickel(II) complex have the highest antibacterial and antifungal activity than other complexes. According to this study, it could be concluded in general that the metal ion in complexes improves the antimicrobial activity compared to the free ligand **L**. The higher activity of the complexes than the free Schiff base ligands can be explained by the cell permeability concept [Deamer et al., 1999] and Tweedy's chelation theory [Tweedy, 1964]. According to the cell permeability concept, the metal ions can hardly pass through the membrane surrounding the cell due to the high polarity of such ions. On chelation, the polarity of the metal ions can be reduced to a greater extent as a result of the overlap of the ligand and metal ion orbitals leading to a partial sharing of the positive charge of the metal ion with donor groups. In addition, the lipophilicity of complexes is improved as the π -electron delocalization over the whole chelating ring increases. Accordingly, the penetration of the complexes into lipid membranes will be enhanced and then blocking the metal binding sites in the enzymes of microorganisms [Singh, 2008] (Figs.4-5)

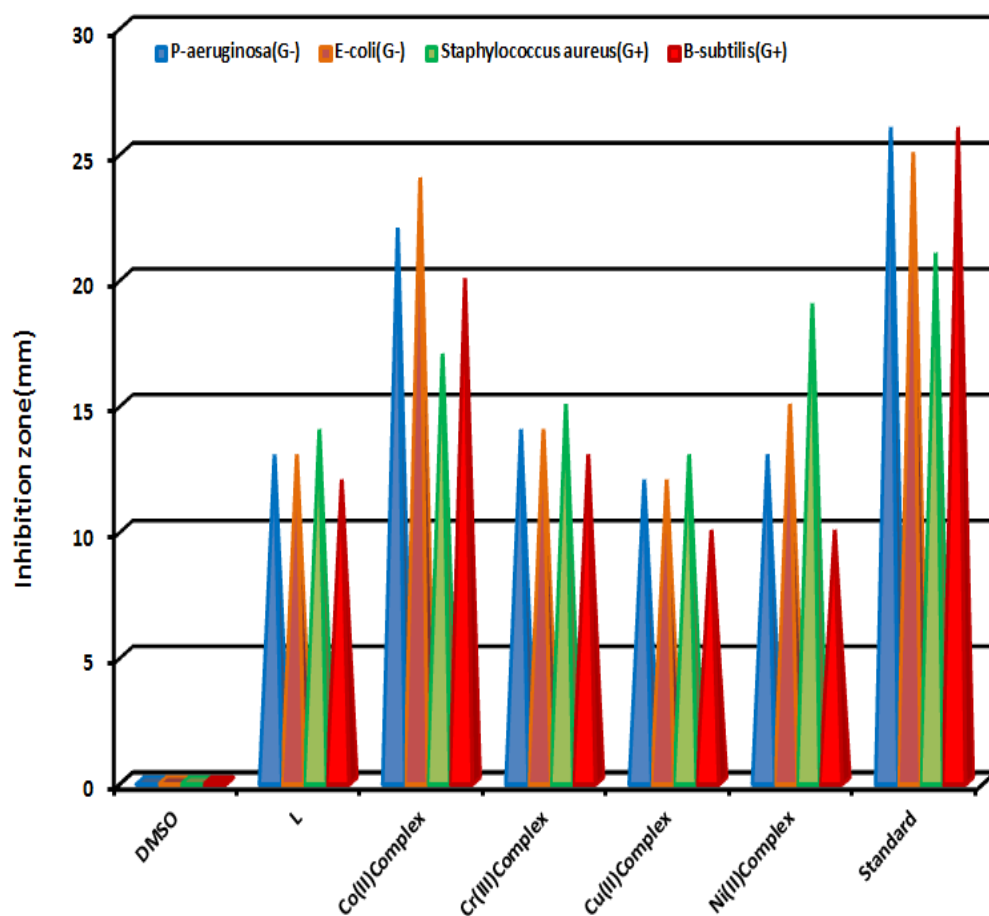


Fig.4. Bioactivity of the ligand and its metal complexes against the bacteria species

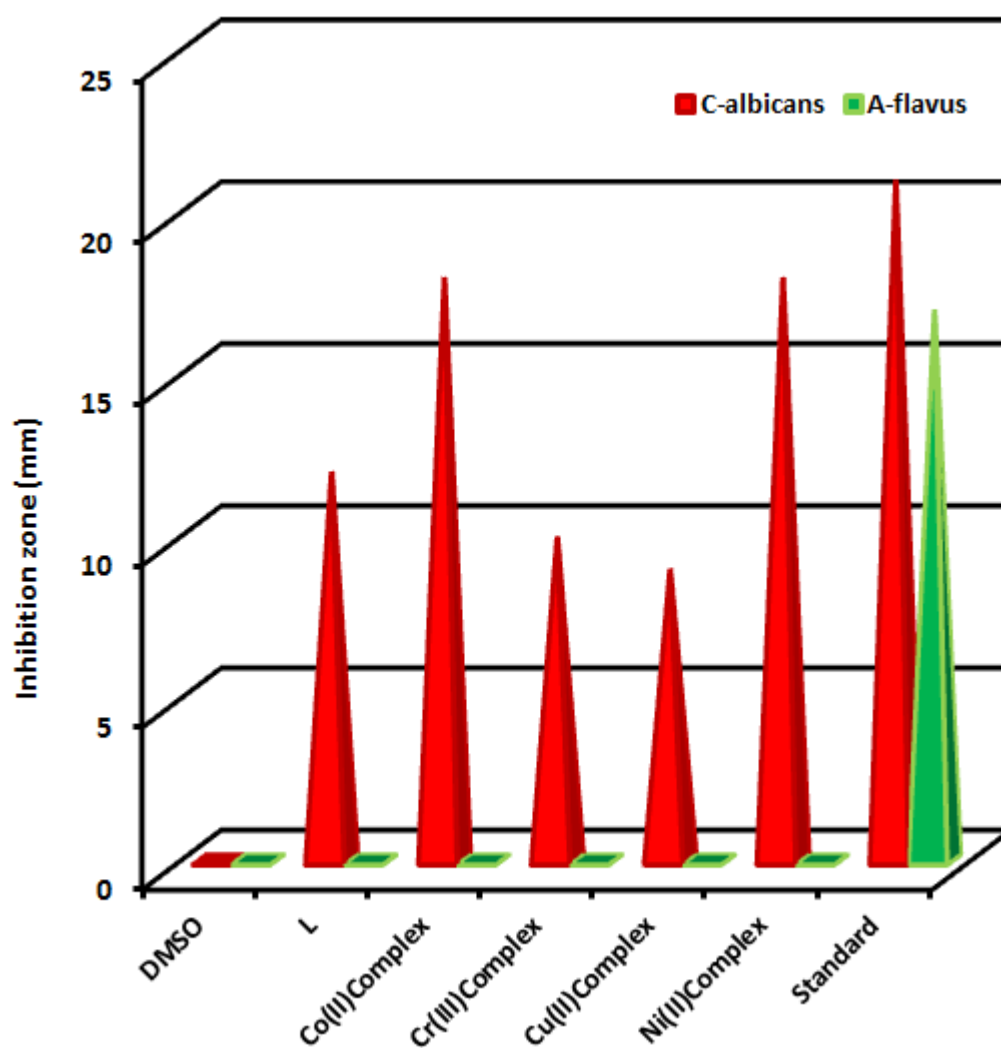


Fig.5. Bioactivity of the ligand and its metal complexes against the fungi species

Conclusion

A novel series of four mononuclear complexes are synthesized and characterized by elemental analysis, TGA/DTA, spectral analysis like ^1H NMR, electronic spectra, FT-IR and Mass Spectrometry. The results support the suggested structure of metal complexes. The studies suggested the coordination of the Schiff base (L) to metals as bidentate ligand. Thermal studies indicated high stability complexes. Furthermore, the novel complexes exhibited considerable antibacterial activity.

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المخلص باللغة العربية

" تحضير، توصيف طيفي ومضاد ميكروبي لبعض متراكبات قواعد شيف Cr(III), Co(II), Ni(II)

"Cu(II)

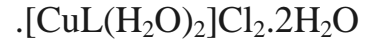
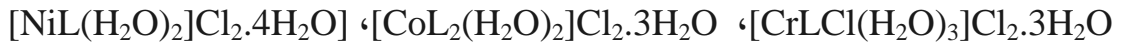
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تم تحضير متراكبات قاعدة شيف ٨ - (فيوران - ٢ - بيل ميثيلين)نفثالين)-١- أمينو مع أيونات المعادن لكل من: الكروم (III)، الكوبلت (II)، النيكل (II) و النحاس (II) وتم توصيف المركبات بالطرق الاتية: التحليل العنصري ، الأشعة تحت الحمراء ، اشعة الرنين المغناطيسي ، الأشعة فوق البنفسجية والمرئية ، القياسات المغناطيسية ، والتحليل الحراري. تم اقتراح الصيغ الكيميائية للمركبات كالاتي:



تم قياس التوصيل الكهربى للمركبات واتضح انها موجودة فى صورة متاينة. كما تم تعيين خطوات التفكك الحرارى وحساب المعاملات الديناميكية الحرارية للمتراكبات، كما تم اختبار النشاط المضاد للميكروبات في المختبر ضد نوعين من الفطريات وأربعة أنواع من البكتيريا.