مجلة كلية التربية الاساسية
كلية التربية الاساسية – الجامعة المستنصرية
Journal of the College of Basic Education **Vol.31 (NO. 132) 2025, pp. 21-41**

Synthesis, spectroscopic and Biological Studies of New Metallic Chelates Derived from (E)-N'-(3,5-dimethoxybenzylidene)isonicotinohydrazide

Aya W. Al-Samarai[1], Mahmoud Najim Al-jibouri[2 *], Salam A.H.Al-ameri[3]
[2,3] *Department of Chemistry, College of Science, Mustansiriyah University, Baghdad-Iraq*
[1] *Ministry of Education, Alkarkh Third Education Directorate, Iraq*
* Correspondence author.
ayaawleed@uomustansiriyah.edu.iq
mahmoud_inor71@uomustansiriyah.edu.iq,
alamri_salam@yahoo.com

Abstract

Coordination compounds of Schiff base-based isonicotinic acid of transition metals has formed complexes of cobalt(II), nickel(II), copper(II) and zinc(II) utilizing new bi dentate ligands;HL namely as: and HL namely: (E)-N'-(3,5-dimethoxybenzylidene)isonicotinohydrazide. The two new ligands were synthesized by the condensation reaction of isoniazid with ethanolic solution of 3,5-dimethoxybenzaldehyde. The metal complexes were prepared and isolated in their solid state after adjusting the reaction conditions such as time reaction, mole ratios (M: L), and pH of the reaction medium. The synthesized isoniazid Schiff base and its metal complexes were fully characterized based on elemental analyses (C.H.N.S), metal content via FAAS, IR, UV-visible-NIR, NMR spectra, molar conductivity, and magnetic susceptibility measurements. The results revealed an octahedral geometry around cobalt (II), nickel (II), copper (II) ions in $[M (L) Cl_2 (H_2O)_2].2H_2O$ formula. According to result of biological activity, free ligands had little to no effect, while the majority of metal complexes, especially those of cobalt, demonstrated strong antibacterial and antifungal activity. The results of biological activity showed that cobalt (II) and copper (II) complexes were most effective than the free ligand, L and its nickel (II) complex against all microorganisms tested. The suggestion for these results has been assigning to the effect of less polarity and formation the coordination and covalence bonding in the metal complexes rather than the free ligand, beside the penetration of metal complexes the lipophilic layer of bacteria and fungi may be ascribed to chelation effect.

Keywords: Schiff bases of isoniazid, Isoniazid complexes, biological activity of isoniazid complexes.

1. Introduction

The coordination compounds derived from isoniazid Schiff bases [1-5] have been currently attracting much interest as potential therapeutic agents [6-7]. Recently, the use of iron (II) complexes of isoniazid as a non-enzymatically activated has been devoted by some of us and proposed as a possible remedy to replace the default enzymatic activation step [8]. Isonicotinic acid hydrazide has widely used as main drug in treatment of tuberculosis beside the combination with other drugs like pyrazinamide. The development of Schiff bases derived from isoniazid condensation with 3,5-dimethoxybenzaldehyde [10-15] have interested the scope of coordination chemistry applications especially in the modification of their separation in analytical chemistry methods like high performance liquid chromatography (HPLC) and other colorimetric methods [16-18]. Md.Ashraful and co-workers [19] have been investigating experimental and density functional theory for metal complexes of isoniazid Schiff base with respect to spectroscopic studies of IR, NMR, HPLC-MS and magnetic susceptibility measurements and the results afforded octahedral environment around cobalt (II), nickel (II) and copper (II) ions.

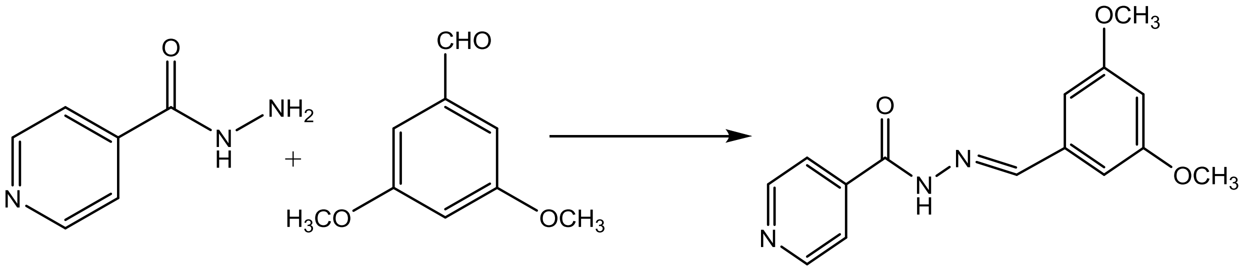
2. Experimental

2.1. Material and methods

The starting materials and solvents were purchased from Merck company used as received without further purification like isoniazid, 3,5-dimethoxybenzaldehyde . Melting points were recorded by a Stuart melting point SMP30 apparatus. FT- IR spectrum was recorded by a Shimadzu (FT-IR) model 4800 s spectrophotometer in the range (4000-400) cm^{-1}. The UV-Visible-NIR spectra of the prepared reagents with their metal complexes were recorded by Shimadzu UV-Vis 160 ultraviolet spectrophotometer in the range at (200-1100) nm at (10^{-3}) M in ethanol and DMF solvents. The percent of metals (cobalt, nickel and copper) in their solid complexes were determined by flame atomic absorption (F.A.A.S) on Shimadzu AA680G atomic absorption spectrophotometer at the laboratories of Ibn-Sina Company. Elemental analysis for the prepared Schiff base, L and their complexes were carried out by (C.H.N.S) calibration Linear Regression Euro EA elemental analysis. The suggested molecular weight of the free ligand and its metal complexes were measured by electron ionization mass spectroscopy on GC-MS (DIRECT PROBE) via ES technique. The NMR spectra of reagents in DMSO-d6 solvent were recorded on Bruker DMX- 500 spectrophotometer (400MH_Z). The molar conductance of complexes solutions in DMF solvent were determined at 283℃ using Jenway conductivity meter with a KCl reference salt bridge and platinum electrode. The effective magnetic moments of the solid complexes were measured on Auto magnetic susceptibility Balance in Mustansiriyah University, College of science, chemistry Department.

2.2. Synthesis of the (E)-N'-(3,5-dimethoxybenzylidene)isonicotinohydrazide

Dissolve (1.73 g, 0.01 mole) of isoniazid in 15 ml of absolute ethanol, stir in a water bath, add to it 1.67g, or the equivalent of 0.012 mole of glyoxalic acid, next, three drops of glacial acetic acid was added and keep on heating under reflux for 5 hours, then left at room temperature for several hours to get a pale yellow precipitate of the new Schiff base, HL. The recrystallization from hot methanol afforded dark yellow crystals, Chemical Formula: $C_{15}H_{15}N_3O_3$, M.P (195-197) C°, weight 2.32 g, Yield 75 %; TLC (ethyl acetate :chloroform, 3:1, *Rf* =0.72, Scheme (1).



Scheme (1) Synthesis of HL Schiff base

2.3. Synthesis of the metal complexes C1-C3

2.3.1. Cobalt (II) Complex C1

A solution of (0.286 g, 0.001 moles) in hot ethanol 20 mL was added to ethanol solution of $CoCl_2.6H_2O$ (0.237 g, 1mmole). The olive mixture at pH = 7.5 (adjusting by addition 5 drops of of 5% sodium hydroxide solution) was formed and then the reactants were refluxed for 90 minutes. Finally, the complex was separated from the filtrate, continuously washed with ether, and finally dried in air and oven for two hours, Chemical Formula: $C_{15}H_{19}CoN_3O_5$, M.P (270-273) C°, weight: 1.36 g, yield 72%.

2.3.2. Nickel (II) Complex C2

A solution of (0.286 g, 0.001 moles) in hot ethanol 20 mL was added to ethanol solution of $NiCl_2.6H_2O$ (0.237 g, 1mmole). The olive mixture at pH = 7.0 (adjusting by addition 5 drops of of 5% ammonia solution) was formed and then the reactants were refluxed for 60 minutes. Finally, the complex was separated from the filtrate, continuously washed with ether, and finally dried in air and oven for two hours, Chemical Formula: $C_{15}H_{19}NiN_3O_5$, M.P (280-282) C°, weight: 1.79 g, yield 70%.

2.3.3. Copper (II) Complex C3

HL (0.286 g; 0.001 moles) disbanded in 20 mL of hot ethanol to a mixture of $CuCl_2.2H_2O$ (0.171 g; 0.0012 mole) dissolved in 10 mL of hot ethanol. The reaction mixture was adjusted at pH in the range 8.0 by addition (1.5 ml) of 10% ammonia solution and the reactants were then stirred for 30 minutes on water bath. A green precipitate was formed and its yield equals about 95%. Weight 2.33 g. The resulting solid complex was obtained by filtration, washed continuously with diethyl ether, and then left to dry in a dryer over $CaCl_2$. Chemical Formula: $C_{15}H_{19}CuN_3O_5$, Decomposed at 300 C^o.

Table (1) Condition of preparation of metal complexes with HL

Metal chloride	Weight (g)	Weight of ligand (g)	Reaction conditions
$CoCl_2.6H_2O$	0.237	L=0.286	90 min / refluxed
$NiCl_2·6H_2O$	0.237	0.286	60 min / reflux
$CuCl_2.2H_2O$	0.171	0.286	30 min / stirred

2.4. Biological activity

The agar well diffusion method was used to detect the antibacterial activity of the prepared Schiff base, (E)-N'-(3,5- imethoxybenzylidene)isonicotinohydrazide and its metal complexes (C1,C2 and C3) against various pathogens, including two strains of gram-positive bacteria (*Staphylococcus aureus* and *Staphylococcus epidermidis*), two strains of gram-negative bacteria (*Escherichia coli* and *Klebsiella sp.)*, as well as against fungus such as *Candida albicans*, at the concentrations of 10^{-2} and 10^{-4} M according to chelation theory [22]. All of the bacterial isolates used in this study were grown in nutrient broth and incubated at 37C° for 18 to 24 hours. After the incubation period, 0.1 ml of each bacterial solution was applied to the nutrient agar surface and left for 24 hours at 37C°. A bacterial suspension with a moderate turbidity, which is approximately equivalent to $1.5x10^8$ CFU/mL when compared to the standard turbidity solution, was obtained by adding a single colony to a test tube containing 5 mL of normal saline. A portion of the bacterial suspension was carefully transferred and evenly distributed on Mueller-Hinton agar medium using a sterile cotton swab, and it was then allowed to sit for ten minutes. In the prior agar layer, three wells per plate with a diameter of five millimeters were created. After detaching the agar discs, a micropipette was used to add 50 µl of the synthesized compounds to each well. After an 18-hour period of incubation at 37C°, the diameter of the inhibitory zones on the plates was determined. The results were compared with those of common medications, such as fluconazole for Candida albicans, vancomycin hydrochloride for gram-negative bacteria, and exigent for gram-positive bacteria. As a control, DMSO was employed.

3. Results and Discussion:

3.1. Physical Properties and Elemental Analyses:

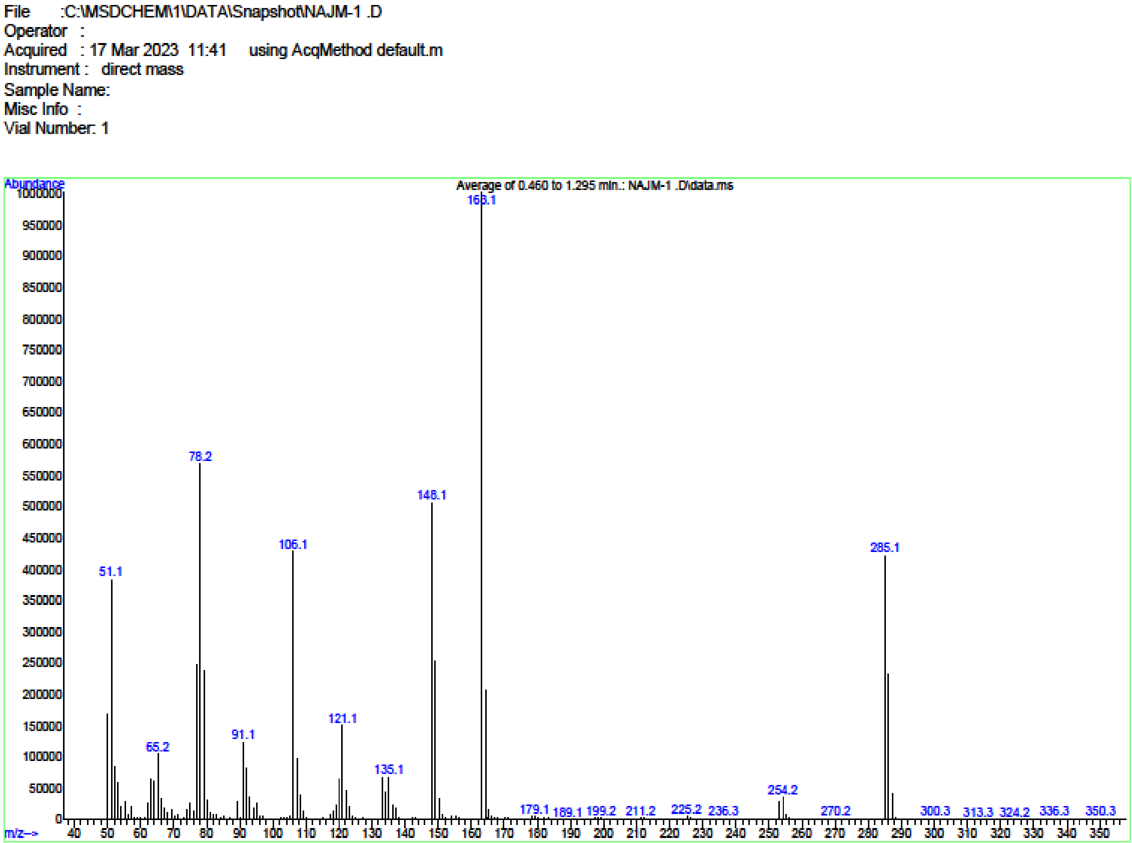
The interesting and wide spectrum researchers have been creating in the update years which they were involving the synthesis and clinical applications on isoniazid Schiff bases and their metal complexes [18, 20]. Therefore, efficacy works encouraged us in our project to synthesize new poly dentate ligands of isoniazid and their metal complexes with cobalt (II), nickel (II) and copper (II) and ions besides docking and biological activates. The new Schiff base of isoniazid HL was synthesized in their solid state after optimizing the conditions of reactions alcoholic solution of isoniazid with the 3,5-dimethoxybenzaldehyde. The new derivative of the chemical formulas $C_{15}H_{15}N_3O_5$ and its metal complexes were confirmed by elemental analyses and flame atomic absorption technique and the observed data are in well agreement of the calculated values. All the metal complexes are sparingly soluble in hot methanol and ethanol and they are soluble in DMSO and DMF solvents. The complexes solutions in DMSO showed molar conductance values in the region (12-25) $ohm^{-1}.cm^{2}.mole^{-1}$ indication neutral properties [21] of all complexes and their chemical structures are in well agreement with proposed chemical formula of $[M(L)Cl_2(H_2O)_2].H_2O$, M(II)=Cu and Ni whereas the suggested formula for cobalt(II) complex is $[CoCl_2(L)\ (H_2O)_2].2H_2O$, Table (1)

No.	General formula / color	M.wt (g/mol) Chemical Formula	M.P C^o	Micro Elemental Analysis (Calc.) Found				Metal content (Calc.) Found (M %)
				C%	H%	N%	S%	
L	$C_{15}H_{15}O_3N_3$ Yellow	285 $C_{15}H_{15}O_3N_3$	218-220	(63.15) 62.76	(5.26) 4.22	(14.70) 15.50	-	-
C1	$[Co(L)Cl_2(H_2O)_2]$ Pale green	450.3 $C_{15}H_{19}CoCl_2O_5N_3$	270-273	(39.51) 38.70	(4.17) 3.24	(9.22) 10.66	-	(12.78) 12.11
C2	$[Ni(L)Cl_2(H_2O)_2]$ Dark blue	450.3 $C_{15}H_{19}NiCl_2O_5N_3$	280-282	(39.90) 38.42	(4.22) 3.09	(9.32) 10.77	-	(12.94) 11.56
C3	$[Cu(L)Cl_2(H_2O)_2]$ Olive	455.5 $C_{15}H_{19}CuCl_2O_5N_3$	295 Dec.	(39.92) 38.20	(4.21) 3.89	(9.32) 10.22	-	(13.90) 12.88
M % = analyses by flame atomic absorption spectroscopy (FAAS), Dec=decomposed								

Table (1) Physical properties and elemental analyses of ligand and its complexes

3.1. Mass spectral studies

The MS spectra of the prepared Schiff base, (E)-N'-(3,5-dimethoxybenzylidene)isonicotinohydrazide exhibited molecular ions at at *m/z* =285.15and 309 respectively which are in agreement of their empirical structure of the product from the condensing isoniazid with 3,5-dimethoxybenzaldehyde [13, 15]. The cleavages of two methoxy moieties as weak points in the skeletal structure of the Schiff base was adopted from the high intense peaks at 254, 165 and 148. However the breaking down of pyridine ring was showed as low intense peak at m/e=121 with intensity equal to 22%. The molecular weight resulted from the MS spectrum is good agreement with other data of elemental analyses that supports the suggested chemical structure of the new ligand, Figure 1.

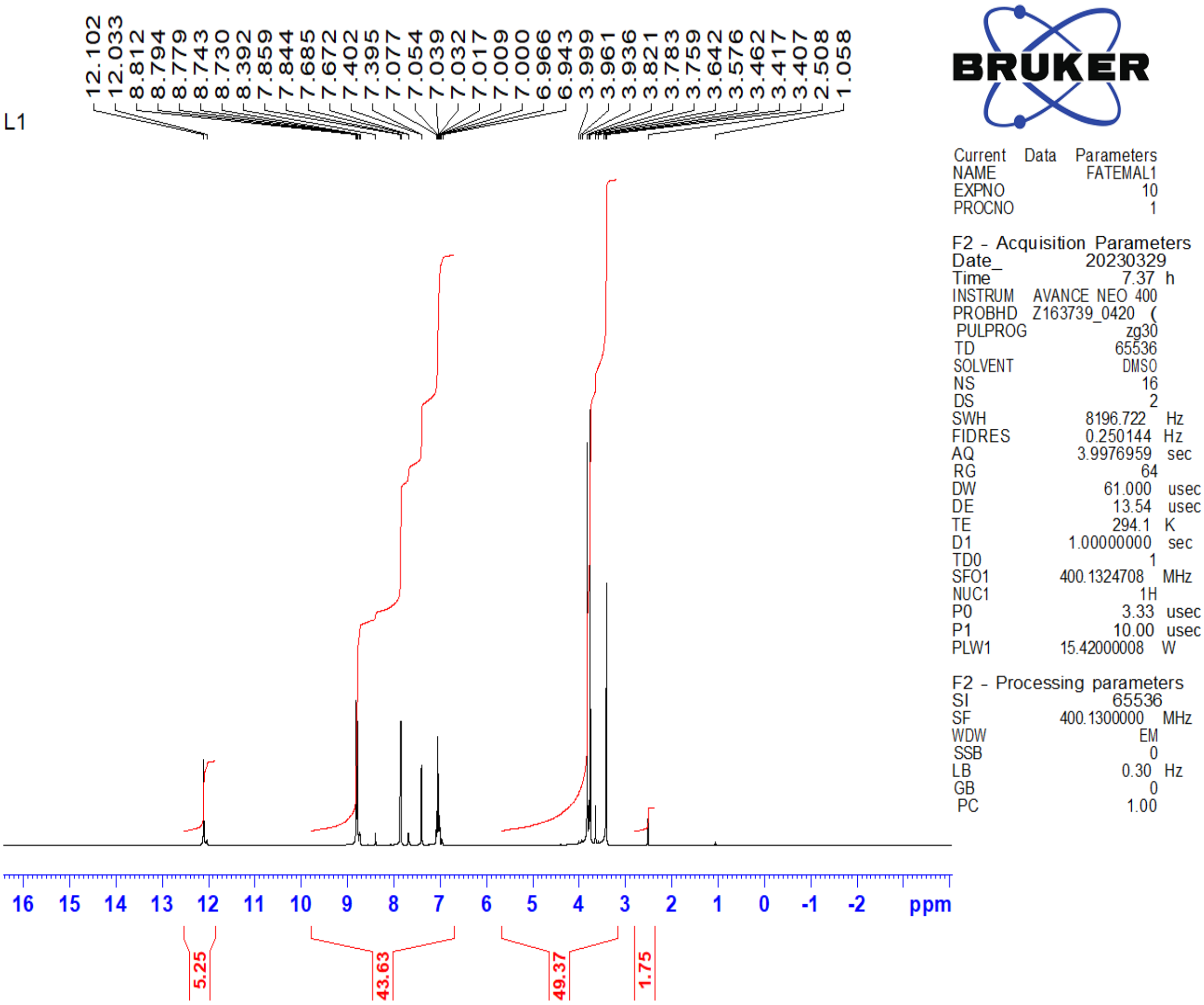


File :C:\MSDCHEM\1\DATA\Snapshot\NAJM-1 .D
Operator :
Acquired : 17 Mar 2023 11:41 using AcqMethod default.m
Instrument : direct mass
Sample Name:
Misc Info :
Vial Number: 1

Figure 1. MS spectrum of HL

3.2. NMR spectra

The H NMR spectrum of ligand showed singlet at δ = 12.10 ppm corresponding to the de shielded proton of –NH which is considered as tautomer with -OH. As well as the singlet peak at 8.18 ppm is consistent with the azomethine –CH=N- moiety revealing the condensation of carbonyl group of 3,5-dimethoxybenzaldehyde with the amino group of isonazid. The multiple peaks at around 6.90-7.78 ppm were corresponding to the aromatic protons of pyridine and trisubstituted aromatic ring rings respectively. As well as the singlet peaks appeared at around at 3.82-3.99 ppm are associated with the nuclear spin of aliphatic protons of –OCH_3 with area under peaks equal to six that is confirmation to the structure of the new Schiff base, Figure 2.



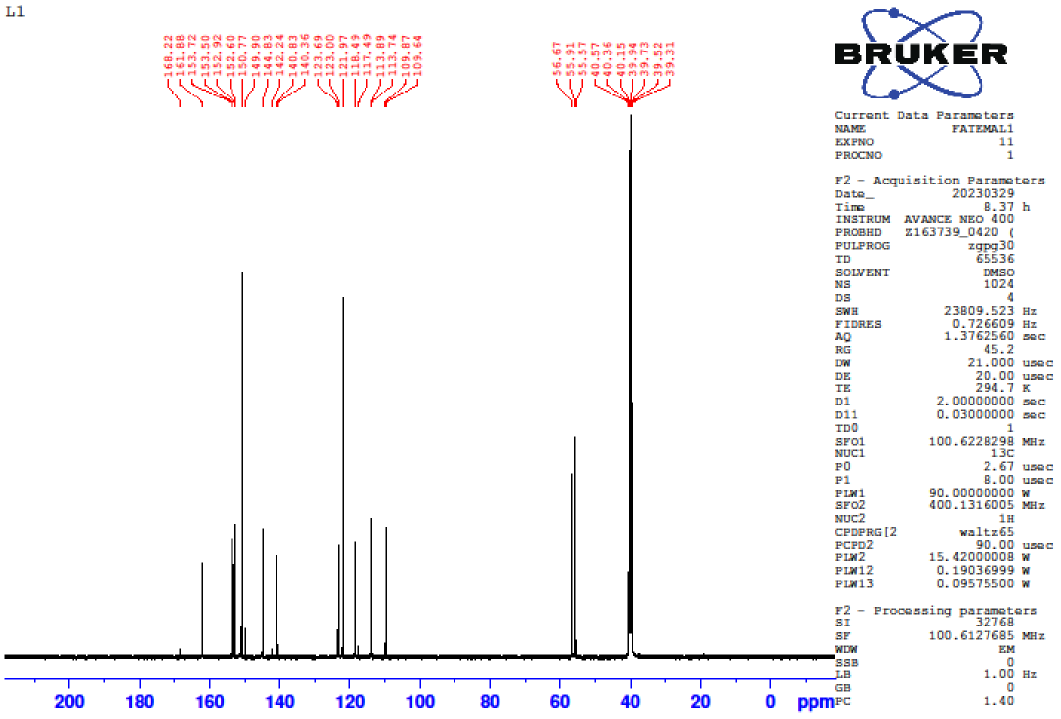
```
Current   Data   Parameters
NAME              FATEMAL1
EXPNO                   10
PROCNO                   1

F2 - Acquisition Parameters
Date_             20230329
Time                 7.37  h
INSTRUM    AVANCE NEO 400
PROBHD   Z163739_0420  (
PULPROG               zg30
TD                   65536
SOLVENT               DMSO
NS                      16
DS                       2
SWH               8196.722  Hz
FIDRES            0.250144  Hz
AQ               3.9976959  sec
RG                      64
DW                  61.000  usec
DE                   13.54  usec
TE                   294.1  K
D1              1.00000000  sec
TD0                      1
SFO1           400.1324708  MHz
NUC1                    1H
P0                    3.33  usec
P1                   10.00  usec
PLW1           15.42000008  W

F2 - Processing parameters
SI                   65536
SF             400.1300000  MHz
WDW                     EM
SSB                      0
LB                    0.30  Hz
GB                       0
PC                    1.00
```

Figure 2. ^{1}H-NMR spectrum of HL in DMSO-*d6* solvent

As well as the C-13 NMR spectrum of HL in DMSO-d6 showed variable absorptions at 168, 161,153 and 150 ppm which are consistent with –C=O, C=N- and C-N carbon atoms [10,15]. The carbon atoms of pyridine and phenyl ring were shown at 149, 144-140.3 and 123, 121, 119 and 117-109.64 respectively. However the spin of aliphatic methoxy groups are located at 55.57-56.67 ppm due to the effect of electron withdrawing atoms of oxygen [17], Figure 3.



```
Current Data Parameters
NAME              FATEMAL1
EXPNO                   11
PROCNO                   1

F2 - Acquisition Parameters
Date_             20230329
Time                  8.37 h
INSTRUM   AVANCE NEO 400
PROBHD    Z163739_0420 (
PULPROG             zgpg30
TD                   65536
SOLVENT               DMSO
NS                    1024
DS                       4
SWH              23809.523 Hz
FIDRES            0.726609 Hz
AQ               1.3762560 sec
RG                    45.2
DW                  21.000 usec
DE                   20.00 usec
TE                   294.7 K
D1              2.00000000 sec
D11             0.03000000 sec
TD0                      1
SFO1           100.6228298 MHz
NUC1                   13C
P0                    2.67 usec
P1                    8.00 usec
PLW1           90.00000000 W
SFO2           400.1316005 MHz
NUC2                    1H
CPDPRG[2           waltz65
PCPD2                90.00 usec
PLW2           15.42000008 W
PLW12           0.19036999 W
PLW13           0.09575500 W

F2 - Processing parameters
SI                   32768
SF             100.6127685 MHz
WDW                     EM
SSB                      0
LB                    1.00 Hz
GB                       0
PC                    1.40
```

Figure 3. ^{13}C-NMR spectrum of HL in DMSO-*d6* solvent.

3.3. IR Spectra of Ligands and their complexes:

The characteristic absorptions in the FT-IR spectrum of HL provided a clue to the condensation of isoniazid with 3,5-dimethoxybenzaldehyde, Figure 4. The IR spectrum of HL showed doublet band at (3304-3180) cm^{-1} and a strong band at around 1650 cm^{-1} which are indicative of υ (NH_2) and υ (-C=N-) respectively. Furthermore the medium band at around 2962 cm^{-1} is assigned to –C-H of methoxy moiety [18]. Up on comparison the IR spectra of all metal complexes, the lowering in frequencies of –C=O, -C=N- and C-N groups in the regions (1635-1640), (1570-1530) and (1370-1340) cm^{-1} revealed that the –C=O and HC=N- are the active sites in coordination with the cobalt (II), nickel (II) and copper (II) ions [19, 20]. Furthermore, the appearance of weak bands at around (550-495) and (425-400) cm^{-1} is strong evidence for formation of (M-N) and (M-O) coordination bonds [20] in the formed solid complexes. However, the broad absorptions at around (3400-3500) cm^{-1} beside the rocking of –O-H bonding for water molecules is strong confirmation for the stretching frequency of –O-H moiety for crystalline and coordinated water molecules respectively, Figure (5).

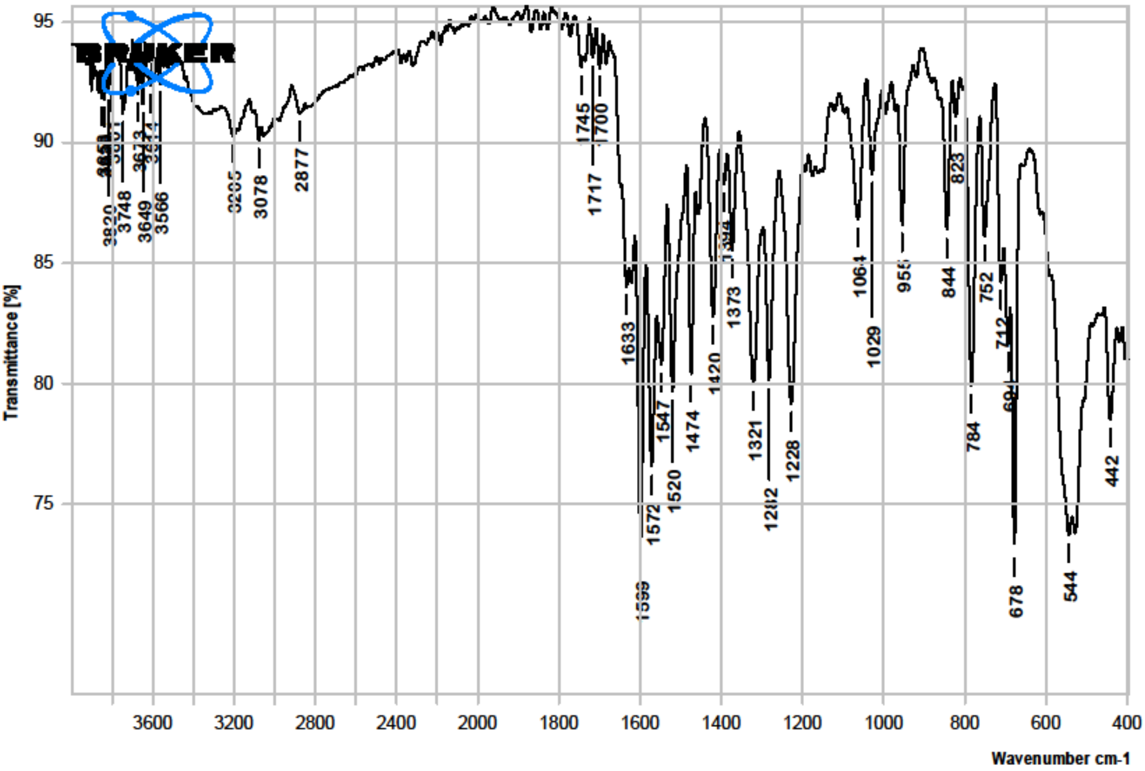


Figure 4. FT-IR spectrum of HL

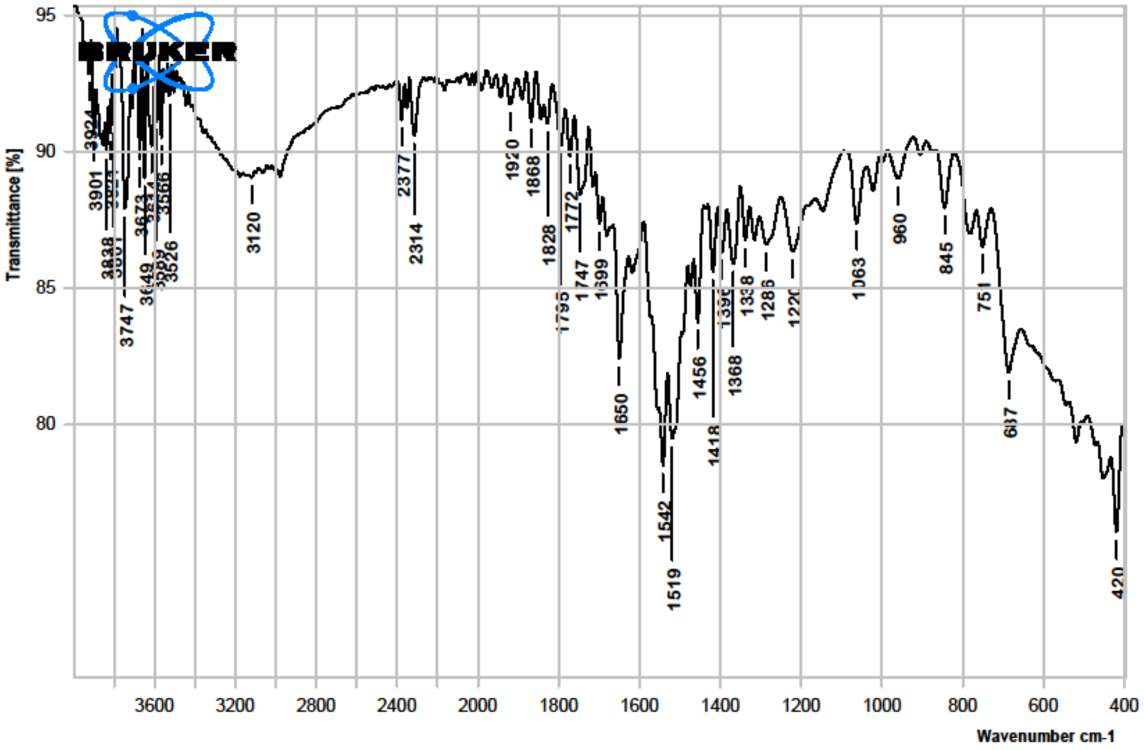
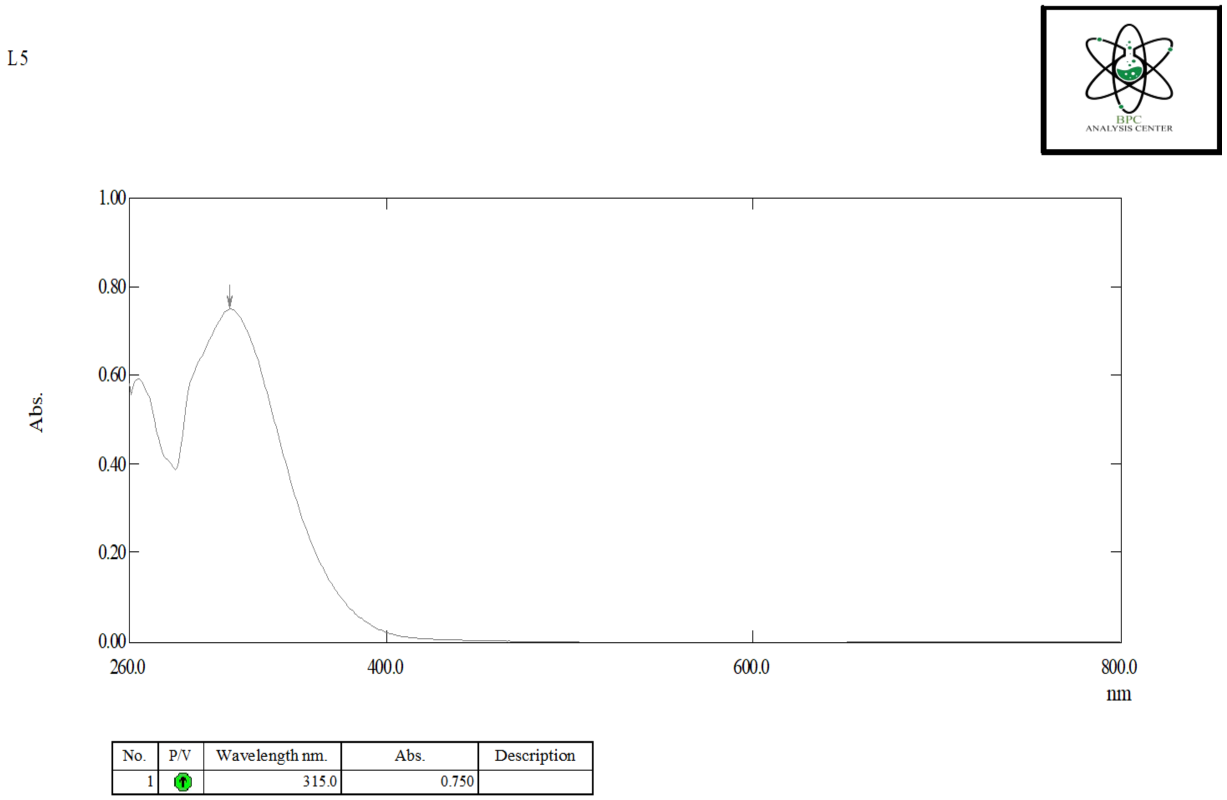


Figure 5. FT-IR spectrum of C2 complex

3.4 UV-Vis spectral data

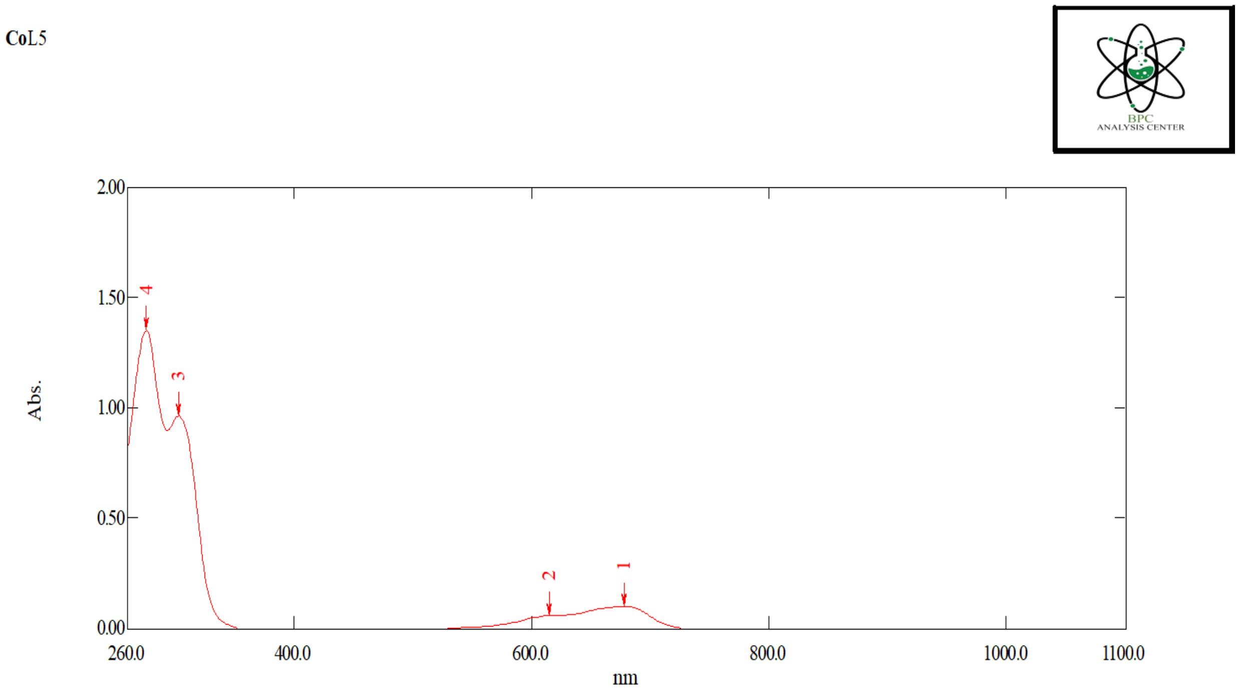
The studying of electronic spectrum for the metal complexes has been showing the strong evidence for the bonding of metal orbitals and ligand orbitals beside the conclusions the prediction the geometry of the prepared metal complexes. The appearance of bathochromic or hypochromic shifts in the UV spectrum of the ligand solution after chelation with the d-block metal ions have already caused from interaction their orbitals and the intensities and positions of the new observed peaks are related to the weak bands of (d-d) and high intense bands of charge transfers in both types of LMCT and MLCT. The main energy level diagrams that help the coordination chemistry researchers are described by two independent schemes Orgel diagrams which are applicable to weak field complexes and Tanabe –Sugano (or simply T-S) diagrams which are applicable to both weak field and strong field complexes [16,17]. The off white solution of, HL in ethanol recorded two bands at 338 nm, 29585 cm^{-1} and 265 nm, 37735 cm^{-1} which are assigned to π-π* and n-π* transitions respectively, Figure 6. The green solution of CoL in DMF displayed low intensity peaks at around;672 nm, 14880 cm^{-1} and 614 nm, 16286cm^{-1} which are attributed to the transition ${}^4T_{1}g\rightarrow{}^4T_{2}g$ (F) (ν_1) and ${}^4T_{1}g\rightarrow{}^4A_{2}g$ (F) (ν_2) respectively. As well as the high intensity peak at 323 nm, 30957 cm^{-1} is assigned to charge transfer ligand to metal charge transfer. The spin-allowed transitions in the visible region for cobalt(II) complex investigates the high-spin octahedral cobalt(II) complexes with ground term ^4F which it mainly splits to three microstates from the stable ground $^4T_1g(F)$, therefore the application of T-S diagram on UV-Visible spectrum of C1 leads to intercepts y_1, y_2 at E_1/B', E_2/B' to provide Racah parameter (B′) was found to be 635 cm^{-1} and the crystal field splitting energy 10Dq found to be 14750 cm^{-1}, indicating the high spin octahedral environment around Co(II) ion [22, 23]. The *Nephelauxetic* ratio (β) was calculated and found to be 0.88 indicating the high degree of interaction between s, p and d-orbitals of reagent; HL and metal ions with synergetic effect, hence inter electronic repulsion has been decreased during the process of chelation. The transition ratio ν_2/ν_1 gave value 1.35 providing further evidences for octahedral geometry for the Co (II) complex [18], Figure 7. The magnetic susceptibility of CoL in solid state was 4.75 BM is good proof for the presence of orbital contribution for the (t_2g^5 eg^2) and agrees well with the (L+S) of magnetic moment calculations. The pale green solution of C2 complex in DMF showed two spin-allowed transitions at around 678 nm, 14749cm^{-1} and 614 nm, 16288 cm^{-1} assigning to $^3A_2g \rightarrow {}^3T_2g$ (F) (ν_1) and $^3A_2g \rightarrow {}^3T_1g$ (F) (ν_2) respectively. However the intense absorption at 329 nm, 30359 cm^{-1} is already associated with LMCT band. The application of T-S diagram on electronic spectrum of C2 through the ratio ν_2/ν_1 found to be

1.201 which results in the values of y_1, y_2, x_1 intercepts at E_1/B', E_2/B' and Dq/B' was found to be 19, 22, 29 respectively, the calculation refer B' equal to 715 cm^{-1} and 10Dq equal to 715x19=13585 cm^{-1} indicating octahedral environment around nickel (II) ion [15-20]. As well as electron- electron repletion in $3d^8$ configuration was decreased through overlapping with thione and -C=N- groups, this was confirmed from synergetic effect found to be 0.95. The solid C2 complex recorded effective magnetic moment 3.20 BM which is associated with high-spin of (t_2g^6 eg^2) and in well agreement of its octahedral geometry. The pale green solution of C3 in DMF showed one weak shoulder band at 909 nm, 11013 cm^{-1} which is ascribed with 2Eg→ 2T2g transition. As well as the high intense peaks at 295nm, 33892cm^{-1} and 265 nm, 37735 cm^{-1} are assigned to CT and π-π* respectively. The copper (II) ion with the electronic configuration d9 has one unpaired electron in the 3d-shell. As well as the confirmation of z-out tetragon ally distortion was adopted from the elevation of its effective magnetic moment to 1.88 BM [21].



No.	P/V	Wavelength nm.	Abs.	Description
1	●	315.0	0.750	

Figure 6. UV-Vis spectral of HL



No.	P/V	Wavelength nm.	Abs.	Description
1	↑	678.0	0.097	
2	↑	615.0	0.056	
3	↑	303.0	0.962	
4	↑	276.0	1.352	

Figure 7. UV-Vis spectral of C1 complex

3.5. Biological activity

The biological activity of the free ligand and its metal complexes (CoL, NiL and CuL) was evaluated against a range of microorganisms, including Gram-positive bacteria (*Staphylococcus aureus and Staphylococcus epidermidis*), Gram-negative bacteria (*Escherichia coli and Klebsiella sp*.), and the fungus *Candida albicans*, using the agar diffusion method at two different concentrations (10^{-2} and 10^{-4} M) in Table (2), Figure (8-10). According cobalt complexes such as CoL have showed consistently the most effective against microorganisms tested, including *Candida albicans*, *Escherichia coli and Staphylococcus epidermidis*. Show NiL exceptional event with *Staphylococcus aureus*, this indicates the strength of its association with the bacterial cell wall in this strain. CuL showed the highest activity against Escherichia coli at concentrations of 10^{-4}, indicating its effectiveness as an antibiotic. It also showed good activity against *Staphylococcus aureus*, *Candida albicans*, *and Staphylococcus epidermidis*. It is worth noting that the free ligand (HL) and isoniazid showed weaker activity compared to the metal complexes, supporting the hypothesis that coordination with metals enhances the biological activity of the compounds. These results are agreement with the new studies that highlight on [18-22].

Microorganisms / Compound	**Conc.**	**Fungus**	**Gram negative bacteria**		**Gram positive bacteria**	
		Candida albicans	***Escherichia coli***	***Klebsiella sp.***	***Staphylococcus aureus***	***Staphylococcus epidermidis***
L	**10^{-2}**	-	-	11	-	12
	10^{-4}	-	-	12	-	12
CuL	**10^{-2}**	13	16	12	12	10
	10^{-4}	16	22	14	20	16
CoL	**10^{-2}**	15	13	13	12	9
	10^{-4}	25	16	14	15	16
NiL	**10^{-2}**	-	-	10	10	12
	10^{-4}	17	12	12	26	12
Isoniazid drug	**10^{-2}**	12	-	9	-	12
	10^{-4}	11	-	12	-	14

Table (2) The inhibition zones (mm) of anti-bacterial and anti-fung

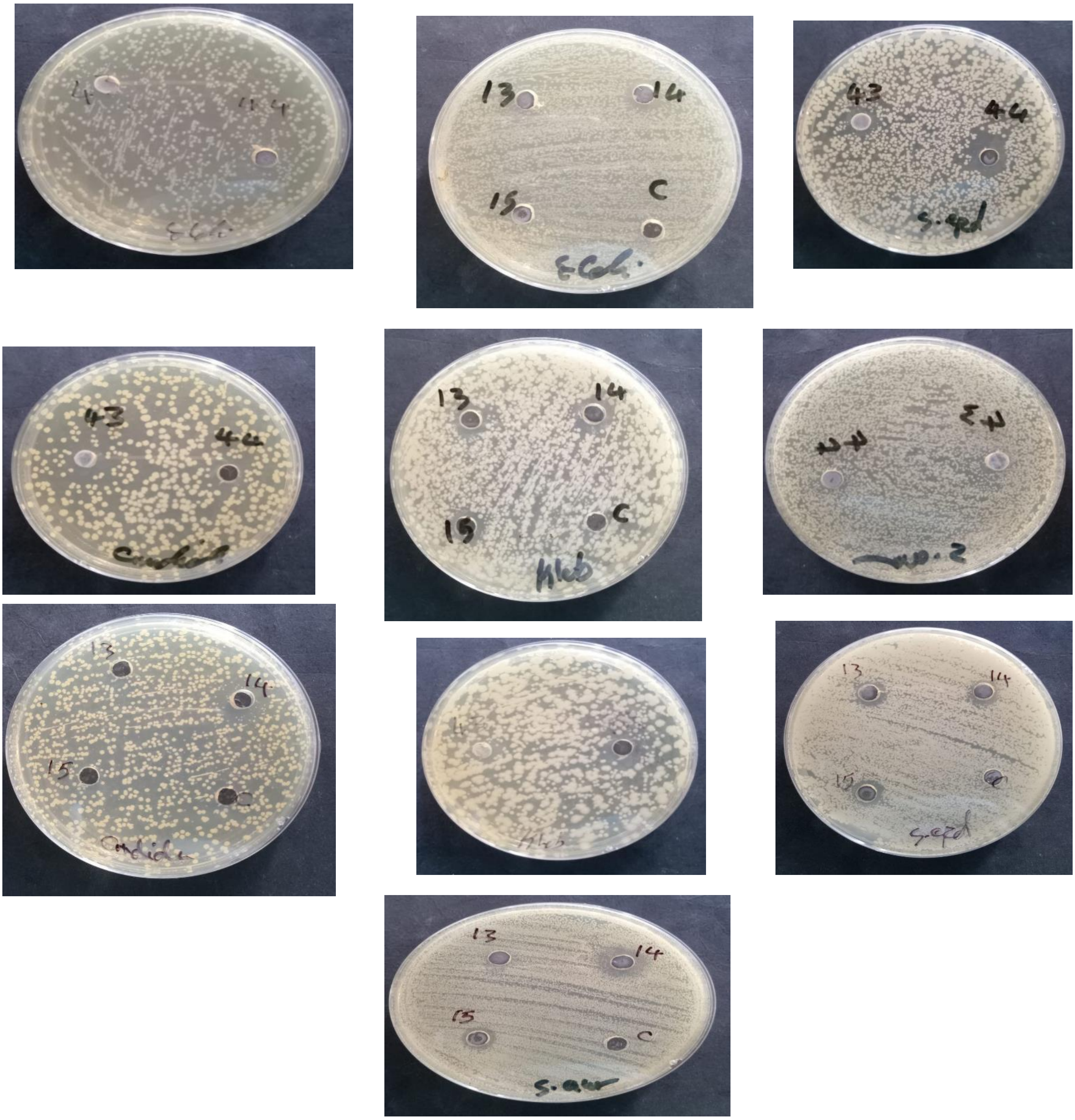


Figure 9. Inhibition zone of gram- positive and gram-negative bacteria with different concentration of L and its complexes Conc. (10^{-2}) M

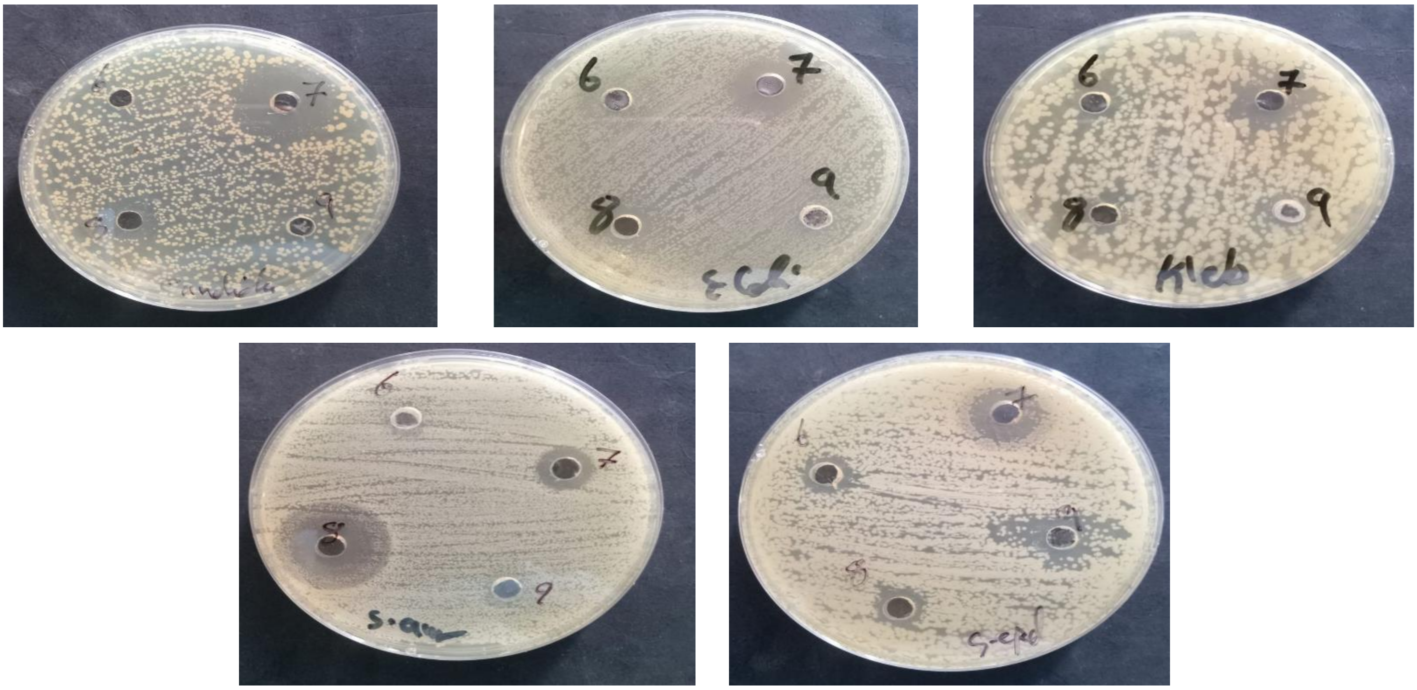
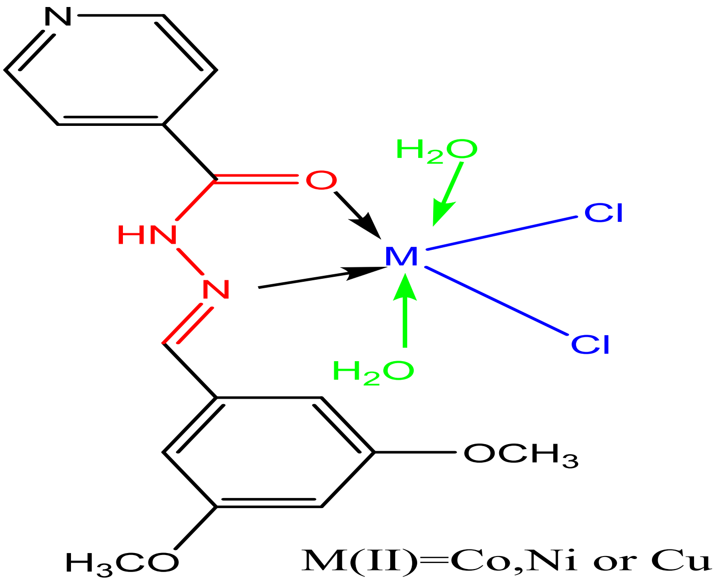


Figure 10. Inhibition zone of gram- positive and gram-negative bacteria with different concentration of L and its complexes Conc. (10^{-4}) M

4. Conclusion:

The observed data from micro-elemental analyses, UV-Visible spectra and magnetic moment measurements revealed that all synthesized complexes with HL are octahedral in chemical formula;[$M(L)(H_2O)_2Cl_2$], Scheme (2). Show these results that metal complexation plays a major role in enhancing the biological efficacy of Schiff base ligands. CoL, NiL, and CuL have promising antimicrobial properties, perform better than both the free ligand HL and the reference drug isoniazid thus highlighting their potential in pharmaceutical applications.



Scheme (2) Octahedral geometry of the prepared complexes $[M(L)Cl_2(H_2O)_2].nH_2O$

References

1. Heba Nassar, Moustafa H.M. Abou-El-Wafa, Hussin Elkik, Synthesis and characterization of some coordinated metal and charge transfer complexes of isonicotinic acid hydrazide ligand with 2-hydroxyacetophenonylidene, Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy: Vol. 309 No.123759 (2024).
2. Houssem Boulebd, Yasmine Zine, Imene Amine Khodja, Arif Mermer, Adem Demir, Abdelmadjid Debache, Synthesis and radical scavenging activity of new phenolic hydrazone/hydrazide derivatives: Experimental and theoretical studies, Journal Molecular Structure: Vol. 1249 No. 131546 (2022).
3. Dessie Ashagrie Tafere, Mamo Gebrezgiabher, Fikre Elemo, Taju sani, Tsegaye Belege Atisme, Tesfay G. Ashebr, Ibrahim Nasser Ahmed, Hydrazones, hydrazones-based coinage metal complexes, and their biological applications, RSC Advances: Vol. 15(8) No.6191-6207 (2025).
4. Hatice Gamze Sogukomerogullari, Eyüp Başaran, Reşit Çakmak, Muhammed Tılahun Muhammed, Senem Akkoc, Novel transition metal (II) complexes of hydrazones as potential antitumor agents: Synthesis, characterization, DFT computations, cytotoxic activities, molecular docking and simulation studies, Inorganica Chimica Acta: Vol. 581 No. 12263 (2025).
5. Hadi Kargar, Mehdi Fallah-Mehrjardi, Khurram Shahzad Munawar, Metal complexes incorporating tridentate ONO pyridyl hydrazone Schiff base ligands:

Crystal structure, characterization and applications, Coordination Chemistry Reviews: Vol. 501No. 215587 (2024).

6. Daniil N. Yarullin, Sofia O. Slavova, Evgeniya O. Abramova, Maksim N. Zavalishin, Peter M. Tolstoy, George A. Gamov, Elena V. Grachova, Conformer-specific differences in solid-phase emission of pyridoxal 5′-phosphate hydrazones containing heteroaromatic cycles, Optical Materials: Vol. 159, 116593 (2025).

7. Hadi Kargar, Mehdi Fallah-Mehrjardi, Muhammad Ashfaq, Khurram Shahzad Munawar, Muhammad Nawaz Tahir, Cis-dioxomolybdenum(VI) complex bearing tridentate ONO isonicotinoyl hydrazone Schiff base: Synthesis, characterization, crystal structure, and catalytic activity investigation for the oxidation of sulfides, Journal Molecular Structure: Vol. 1294(2) No.136458 (2023).

8. Khlood S. Abou-Melha, Transition metal complexes of isonicotinic acid (2-hydroxybenzylidene)hydrazide, Spectrochimica Acta Part A: Molecular & Biomolecular Spectr: Vol. 70(1). 162-170 (2008).

9. Hatice Gamze Sogukomerogullari, Eyüp Başaran, Reşit Çakmak, Muhammed Tılahun Muhammed, Senem Akkoc, Novel transition metal (II) complexes of hydrazones as potential antitumor agents: Synthesis, characterization, DFT computations, cytotoxic activities, molecular docking and simulation studies, Inorganica Chimica Acta: Vol. 581. 122634 (2025).

10.Sumaira Abbas, Imtiaz-ud-Din, Mehwish Mehmood, M. Khawar Rauf, S. Sikander Azam, Ihsan-ul Haq, M. Nawaz Tahir, Nousheen Parvaiz, Synthesis, structural characterization, and molecular docking studies of bioactive bismuth(III) complexes with substituted hydrazones, Journal of Molecular Structure: Vol. 1230 No. 129870 (2021).

11.Ahmed I. Khodair, Dalia R. Imam, Nabila A. Kheder, Asmaa M. Fahim, Ahmed A. El-Barbary, Synthesis, DFT investigation, molecular docking analysis, ADMET studies, and biological evaluation of a novel series of imidazolidinone derivatives as potential antimicrobial agents, Journal of Molecular Structure: Vol. 1322(4), 140586 (2025).

12.Sachin S. Wazalwar, Anita R. Banpurkar, Franc Perdih, Single crystal structure of 3-(2-(3-acetylphenyl)hydrazono)pentane-2,4-dione and molecular docking study with CYP450 members for anticancer molecular screening, Journal of the Indian Chemical Society: Vol.99(6), 100482 (2022).

13.Ali Akram Derardja, Lynda Golea, Rim Benali-Cherif, Dominique Luneau, Zina Boutobba, Youcef Boumedjane, Hassina Harkat, Synthesis, crystal structure, DFT calculations, Hirshfeld surface analysis and molecular docking

studies of a new manganese complex, Inorganic Chemistry Communications: Vol.146, 110198 (2022).
14. Verma, S., & Prasad, S. Molecular docking and dynamics studies of bioactive compounds targeting key enzymes in pathogenic microorganisms. Journal of Biomolecular Structure and Dynamics, Vol.41(3), 702–715 (2023). https://doi.org/10.1080/07391102.2022.2032765
15. Zhang, Y., Liu, H., & Wang, Y. Antibacterial performance of nickel and cobalt Schiff base complexes against resistant strains. Microbial Pathogenesis: Vol. 165, 105484 (2022). https://doi.org/10.1016/j.micpath.2022.105484
16. Shaaban, S., & Yousef, T. Synthesis, characterization, and antimicrobial activity of transition metal Schiff base complexes. Inorganic Chemistry Communications: Vol. 120, 108134 (2020). https://doi.org/10.1016/j.inoche.2020.108134.
17. Md. Ashraful Islam, Faria Tasnim, Md. Sajib Hossain, Md. Faruk Hossen, Md. Kudrat-E Zahan, Md. Ali Asraf, Experimental and computational insights into antibacterial and antioxidant properties of metal complexes with isoniazid-based Schiff base ligands, J. Molec. Struc: Vol.1324, 140916 (2025).
18. Mohammed, A., & Al-Omari, S. Evaluation of antibacterial properties of Cu(II) and Co(II) complexes with bioactive ligands. Journal of Coordination Chemistry: Vol. 76(6), 1014–1028 (2023). https://doi.org/10.1080/00958972.2023.2187415.
19. Nandini .B, . Amutha Selvi, Metal Complexes with Schiff Bases - A Review of their Antimicrobial Activities: A review. Bioinorganic Chemistry and Applications, 6632958 (2021). https://doi.org/10.1155/2021/6632958.
20. W.J. Geary, The use of conductivity measurements in organic solvents for the characterization of coordination compounds, Coord. Chem. Rev. : Vol. 7(1) (1971).
21. Alam, M., Khan, A. U., & Naqvi, A. Cobalt-based Schiff base complexes as potential antifungal agents: Mechanisms and therapeutic implications. Journal of Mycology and Medical Research: Vol. 31(2). No 109 (2021). https://doi.org/10.1016/j.jmmr..102345..
22. K. Jagadesh Babu, Dasari Ayodhya, Shivaraj, Comprehensive investigation of Co(II), Ni(II) and Cu(II) complexes derived from a novel Schiff base: Synthesis, characterization, DNA interactions, ADME profiling, molecular docking, and in-vitro biological evaluation, Res. Chem: Vol.6, No.101110 (2023).

مجلة كلية التربية الاساسية
كلية التربية الاساسية – الجامعة المستنصرية
Journal of the College of Basic Education Vol.31 (NO. 132) 2025, pp. 21-41

التحضير والدراسات الطيفية والحيوية لمخلبات معدنية جديدة مشتقة من (E) -N'- (3,5- ثنائي ميثوكسي بنزليدين) - بيريدين -4- كربوهيدرازيد

☐*آية وليد السامرائي[1]، محمود نجم الجبوري[2]، سلام عباس العامري[3]
قسم الكيمياء، كلية العلوم، الجامعة المستنصرية، بغداد – العراق [3،2]
وزارة التربية، مديرية تربية الكرخ الثالثة، العراق [1]
*البريد الإلكتروني للمؤلف المراسل:
ayaawleed@uomustansiriyah.edu.iq
mahmoud_inor71@uomustansiriyah.edu.iq
alamri_salam@yahoo.com

مستخلص البحث:

تم في هذا البحث تحضير معقدات تناسقية جديدة قائمة على قواعد شيف المشتقة من حمض الأيزونيكوتينيك لعناصر الفلزات الانتقالية: الكوبلت (II)، النيكل (II)، النحاس (II) والكوبلت (II)، باستخدام ليكاند ثنائي السن جديد هو (E) -N'- (3,5- ثنائي ميثوكسي بنزليدين)- بيريدين -4- كربوهيدرازيد. تم تحضير هذا الليكاند من خلال تفاعل تكاثف بين دواء الأيزونيازيد والألدهيد الأروماتي 3,5- ثنائي ميثوكسي بنزليدين في وسط كحولي. تم تحضير المعقدات المعدنية وعزلها في حالتها الصلبة بعد ضبط ظروف التفاعل مثل زمن التفاعل، النسب المولية (M:L) ، ودرجة الحموضة (pH) للوسط التفاعلي. وقد تم تشخيص الليكاند المحضَّر ومعقداته المعدنية باستخدام مجموعة من التقنيات الطيفية والتحليلية، شملت: التحليل العنصري(C.H.N.S) ، تقدير محتوى الفلز باستخدام الامتصاص الذري اللهبي(FAAS) ، مطيافية الأشعة تحت الحمراء(IR) ، الأشعة فوق البنفسجية-قريبة من تحت الحمراء (UV-Vis-NIR)، طيف الرنين النووي المغناطيسي(NMR) ، قياسات التوصيلية المولارية، وقياسات القابلية المغناطيسية. أظهرت النتائج أن جميع المعقدات المحضرة من فلزات الكوبلت (II)، النيكل (II)، والنحاس (II) تمتلك شكل ثُمانيّ السطوح (Octahedral) حول الذرة المركزية، وذلك بصيغة $[M(L)Cl_2(H_2O)_2]\cdot 2H_2O$ أما فيما يتعلق بالفعالية الحيوية، فقد أظهرت نتائج الاختبارات أن الليكاند الحر أبدى تأثيرًا ضعيفًا أو شبه معدوم ضد البكتيريا والفطريات، في حين أن معظم المعقدات الفلزية – وبالأخص معقدات الكوبلت – أظهرت نشاطًا مضادًا عاليًا للبكتيريا والفطريات. وقد وُجِد أن معقدات الكوبلت (II) والنحاس (II) كانت أكثر فعالية من الليكاند الحر ومعقد النيكل (II) ضد جميع الأنواع الميكروبية المختبرة. يمكن تفسير هذه النتائج بأن المعقدات الفلزية تمتاز بقطبية أقل مقارنة بالليكاند الحر، إلى جانب تكوين روابط تناسقية وتساهمية أكثر فعالية داخل المعقدات. كما أن قدرة المعقدات الفلزية على اختراق الطبقة الدهنية (الليبيدية) لجدران الخلايا البكتيرية والفطرية قد تُعزى إلى تأثير الخلب (Chelation effect)، مما يفسر ارتفاع نشاطها الحيوي.