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Synthesis, Spectral Investigations, and Biological Studies for Some Metal Complexes of Schiff Base Derived From Isoniazid

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Abstract:
This study synthesized six metal complexes of a new Schiff base ligand. Through multiple techniques the ligand [L´] N'-(4-hydroxy-3, 5-dimethoxy benzylidene) isonicotinohydrazide ($C_{15}H_{15}N_3O_4$) and its metal complexes [Cr (III), Mn (II), Zn (II), Cd (II), Hg (II), and Pb (II)] were characterized, techniques including [FT-IR, UV-Vis, ^{1}H-NMR, and ^{13}C-NMR] spectroscopy, micro elemental analysis (C.H.N.), molar conductivity measurements, melting point determination, chloride content analysis, and magnetic susceptibility evaluation. The results showed that the metal complexes formed have the formula [Cr (L´)$_2$Cl$_2$] Cl, and [M (L´)$_2$Cl$_2$], where M = (Mn, Zn, Cd, Hg, and Pb) (II) and [L´]=N'-(4-hydroxy-3,5-dimethoxybenzylidene)isonicotinehydrazide.
The coordination of metal ions, based on spectroscopic analysis, which involves the (N-O) donor atoms from the nitrogen atom of the iminic group and the oxygen atom of the carbonyl group, suggested that the six complexes possess a six-coordinated octahedral structure. In addition, the enzymatic activity of the ligand [L´] and its complexes was investigated. The enzymatic activity study demonstrated distinct inhibition profiles for the ligand and its metal complexes. The biological efficiency of the complexes was tested on fungi *Candida albicans* and other microorganisms, including Gram-positive bacteria such as *Staphylococcus aureus* and *Enterococcus spp*, in addition to negative-

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gram bacteria such as *E. coli* and *Pseudomonas aeruginosa*, using the disc diffusion method. The results showed that the complexes exhibited higher antimicrobial activity than the free ligand. These observations suggest that these metal complexes have good potential for the design of new antioxidant and antimicrobial agents.

Keywords: Schiff base, Isoniazid, Transition metal complexes, AST, Antimicrobial study

Note: The research is based on a master's thesis

Introduction

Organic compounds containing the azomethine (>C=N-, also known as an imine) functional group were originally called “Schiff bases.” Chemist Hugo Schiff first synthesized these compounds using a straightforward condensation reaction (a process where two molecules combine with the loss of a small molecule, like water) of primary amines with aldehydes or ketones (Raczuk *et al*., 2022). Hydrazones are an important class of medicinal compounds due to their wide range of therapeutic applications (Teixeira *et al*., 2025). Indeed, isoniazid inhibits the synthesis of mycolic acids, which are involved in cell wall construction and thus affect bacteria (Heysell & Mpgama, 2020). Schiff base complexes are appealing as a key model for understanding how main-group and transition-metal complexes bond to other substances because they exhibit a wide variety of structures Nidhi *et al.*, 2025). Transition metals complexes have paved the way for the exploration and findings of a variety of metal complexes in the last few years (El-Lateef *et al*., 2024). Previous research has shown that nitrogen atoms in the conjugated bridge (C=N) of compounds derived from Schiff bases have a strong coordination capacity for transition-metal ions (Gomathi *et al*., 2025). Complexes of transition metals with donor atoms nitrogen and oxygen are recognized for their efficacy as stereospecific catalysts for oxidation, reduction, bioactivity, and other organic and inorganic transformations chemistry (Sukhorukov, 2025), which is regarded have a wide fields in biological applications, as anti-depressants, antimicrobial (Zahid, 2022), antitumor (Li *et al*., 2003). They have received considerable attention in the literature due to their

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interesting physicochemical properties and broad applications across various fields of science. In this paper, we report the results of our investigation, including prepared, structure analysis, and biologically studies of the [L´] ligand and its complexes.

Materials and Methods

All analytical reagents and chemicals were supplied by BDH, Sigma Aldrich, Loba Chemie, and Glentham. The melting points were determined using an electro thermal digital apparatus and were subsequently corrected with the Stuart SMP30. FT−IR spectra were documented by a Shimadzu model 4800S spectrophotometer in the range of (4000−400) cm^{-1}. UV-visible spectra were obtained using a Shimadzu 160 ultraviolet spectrophotometer. (^{1}H, ^{13}C) NMR spectra of the ligand were recorded on a DMX-500 Bruker 300 MHz spectrometer. The molecular weight was found by using LC-MS. Conductivity measurements were recorded using an Inolab Multi 740 and a WTW 82362.

Experimental

Synthesis of N'-(4-hydroxy-3, 5-dimethoxy benzylidene) isonicotinohydrazide

Schiff base [L´] ligand prepared by the condensation of the solution of isoniazid (isonicotinohydrazide) (0.137 g, 0.001mol) dissolved in 10 ml of ethanol absolute. This solution was added to an acidified mixture containing drops of glacial acetic acid gradually, with (0.182 g, 0.001mol) 4-hydroxy-3,5-dimethoxy benzaldehyde in dissolved 10 ml of absolute ethanol. The mixture was refluxed for 8hours. The resulting yellow precipitate was filtered, washed by ethanol absolute, dried at room temperature, finally recrystallized from the hot absolute ethanol. The ligand [L´] purity detected by using TLC silica gel as the stationary phase, hexane and ethyl acetate as the mobile phase, with a yield of approximately the product was in percentage71%, melting point (228 −230) °C. The preparation reaction of the ligand [L´] showed in Schem1.

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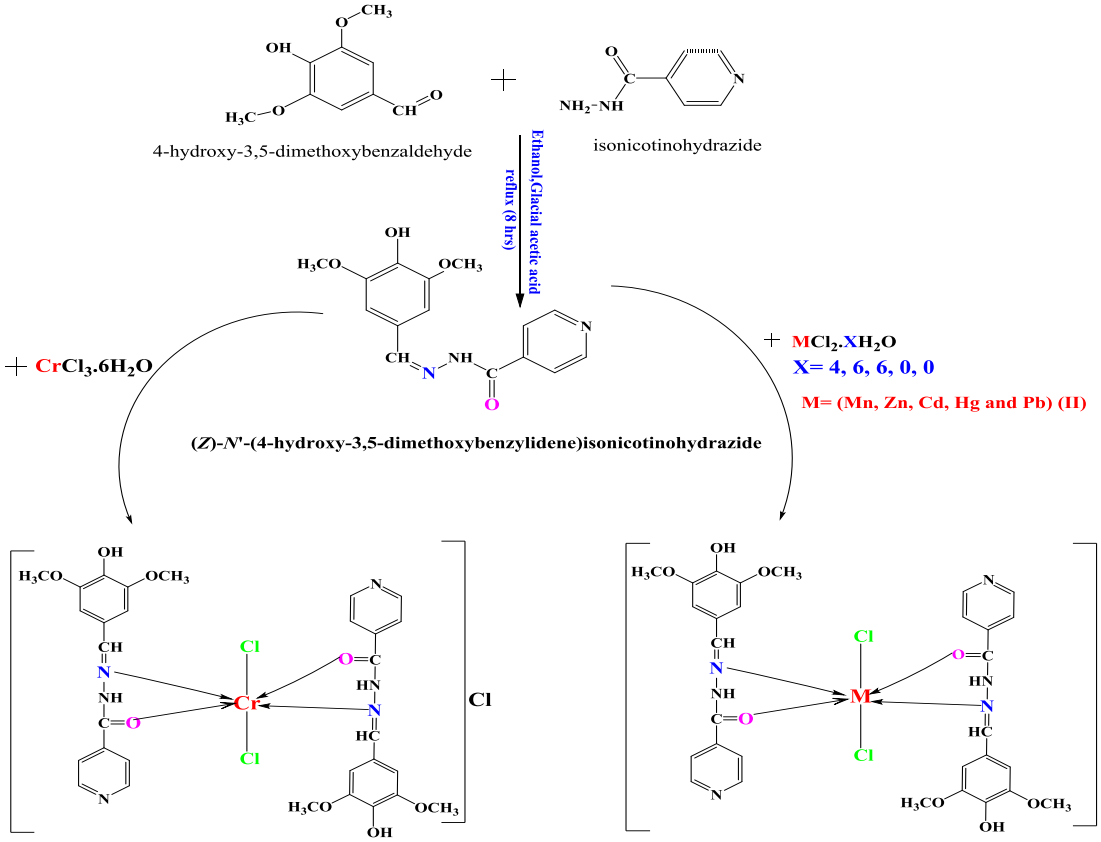
Synthesis of [L´] metal complexes

The metal complexes were prepared from ligand [L´] and six transition metal ions. The procedure involves dissolving two moles of ligand [L´] (0.602g, 2.00mmol) were dissolved in absolute ethanol and after that, one mole of metal salts, $CrCl_3 \cdot 6H_2O$ (0.266 g, 1.00mmol), $MnCl_2 \cdot 4H_2O$ (0.198 g, 1.00mmol), $ZnCl_2$ (0.136 g, 1.00mmol), Cd Cl_2 (0.220 g, 1.00mmol), $HgCl_2$ (0.272 g, 1.00mmol) and $PbCl_2$ (0.177 g, 1.00mmol) were added. The mixture was refluxed for 4 hours. The formation of the metal complex was followed by changing in the solutions color. The resultant products were filtered, washed with ethanol, and air-dried at room temperature. The preparation reaction of the metal complexes was illustrated in Scheme 1.



Schem1: The preparation ligand [L´] and the proposed structures of newly prepared metal complexes

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Characterization

The physical properties including melting points, color, yield%, elemental microanalysis of [L´] and its complexes are summarized in the Table1

Table1: Characterization of the produced compounds

Molecular formula	Molecular weight g/mol	Melting points °C or Dec.	The color	Yield %	Element micro analysis found (calc.) %				
					C	H	N	M	Cl
$C_{15}H_{15}N_3O_4$ [L´]	301.17	228-230	yellow	71	59.31 (59.71)	4.78 (4.98)	13.88 (13.94)	—	—
[Cr(L´)$_2$Cl$_2$]Cl $C_{30}H_{30}N_6O_8Cl_3Cr$	760.5	263-265	orange	82	46.96 (47.33)	3.91 (3.94)	11.12 (11.04)	6.81 (6.83)	13.98 (14.00)
[Mn(L´)$_2$Cl$_2$] $C_{30}H_{30}N_6O_8Cl_2Mn$	728	214 Dec.	yellow	79	49.38 (49.45)	4.11 (4.12)	11.49 (11.53)	7.53 (7.55)	9.69 (9.75)
[Zn(L´)$_2$Cl$_2$] $C_{30}H_{30}N_6O_8Cl_2Zn$	738	278-280	Light brown	65	48.77 (48.78)	4.05 (4.06)	11.33 (11.38)	8.76 (8.80)	9.60 (9.62)
[Cd(L´)$_2$Cl$_2$] $C_{30}H_{30}N_6O_8Cl_2Cd$	785.4	283 Dec.	orange	75	45.80 (45.83)	3.79 (3.81)	10.70 (10.69)	14.22 (14.26)	9.00 (9.03)

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$[Hg(L')_2Cl_2]$ $C_{30}H_{30}N_6O_8Cl_2Hg$	873.5	270 Dec.	Light yellow	86	41.20 (41.21)	3.40 (3.43)	9.60 (9.61)	23.00 (23.01)	8.10 (8.12)
$[Pb(L')_2Cl_2]$ $C_{30}H_{30}N_6O_8Cl_2Pb$	880	251 Dec.	orange	54	40.88 (40.90)	3.38 (3.40)	9.53 (9.54)	23.51 (23.52)	8.10 (8.06)

Calc. =calculated, Dec. =decomposition

Results and Discussion

^{1}H-Nuclear Magnetic Resonance spectrum of the ligand [L´]

The solvent DMSO d_6 was used to record the ^{1}H- NMR of the ligand [L´]. Chemical shift at (δ H=11.98 ppm) corresponds to the proton signal (N-H) of isoniazid (Frazão de Faria *et al*., 2021). Chemical shift at (δ H=11.96 ppm) assigned to (O-H) phenolic group (Buczek *et al*., 2025). At (δ H=9.01 ppm) the singlet signal indicates the azomethine proton (Preethi *et al*., 2018). A spectrum returns the signal regarding the proton for aromatic rings at (δ H 6.81 - 8.90) ppm. The sharp singlet signals at (δ H 3.73 and 3.82) ppm belong to the (OCH_3) group (Safronov *et al*., 2023). A spectrum revealed chemical shift in (δ H 2.49- 2.50) ppm indicating to dimethyl sulfoxide- d_6. They are presented in Table2 and Figure 1

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Table2: ^{1}H – NMR in DMSO and chemical shift in ppm (δ) for the ligand [L´]

Ligand	Functional group	δ(ppm)
$C_{15}H_{15}N_3O_4$ [L´]	N-H isoniazid 7	11.98 (1H,s)
	O-H phenolic 2	11.96 (1H,s)
	(N=CH) imine 6	9.01 (1H,s)
	Ar-H 4,5,8,9,10,11	(6.81-8.90) (6H,s,m)
	$-OCH_3$ 1 $-OCH_3$ 3	3.73 (3H,s) 3.82 (3H,s)
	HDO	3.39
	DMSO	(2.49-2.50)

S = singlet, m = multiplet

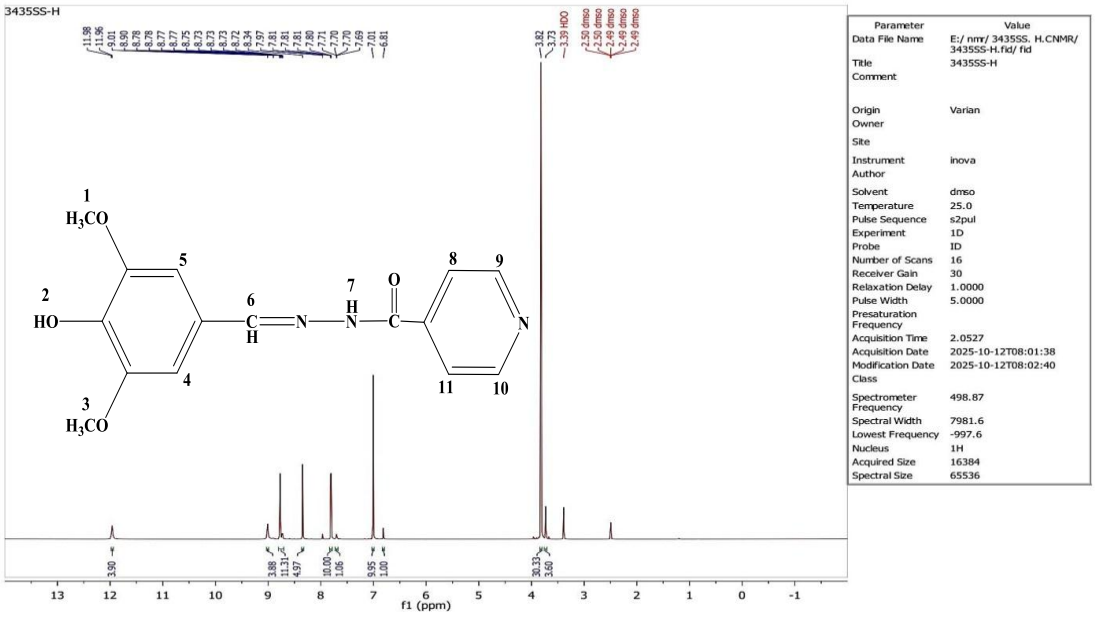

Figure1: ^{1}H–NMR of [L´] ligand

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^{13}C- Nuclear Magnetic Resonance spectrum of the ligand [L´]

The ^{13}C- NMR for ligand [L´] in di methyl sulfoxide- d_6 revealed the chemical shift in the range (δ = 161.86ppm) assigned to the carbon atom for carbonyl group C=O (C_{10}) (Saleh *et al.*, 2021)The chemical shift of carbon atom of azomethine in δ =150.74 ppm (C_9) (Sambasevam *et al.*, 2013). The chemical shift appeared at 150.12ppm, 149.83ppm (C_3, C_5) due to C─OCH_3. The chemical shift at δ 148.58 ppm due to C─OH (C_4), the chemical shifts appeared at δ 105.23ppm- δ 141.13ppm are ascribed to carbon atoms of aromatic ring. Chemical shift at δ=56.47 ppm assigned to ─OCH_3 group (C_1, C_2). The spectrum data is illustrated in Table 3 and Figure 2

Table3: ^{13}C-NMR in DMSO-d_6 of [L´]

Ligand	Functional groups	δ(ppm)
$C_{15}H_{15}N_3O_4$ [L´]	C=O C_{10}	161.86
	(N=CH) imine C_9	150.74
	C -OCH_3 $C_{3,5}$	150.12,149.83
	C -OH C_4	148.58
	Ar- C 6,7,8,11,12,13,14,15	(105.23-141.13)
	-OCH_3 C $_{1,2}$	56.47
	DMSO	(39.42-40.42)

S= singlet, m= multiplet

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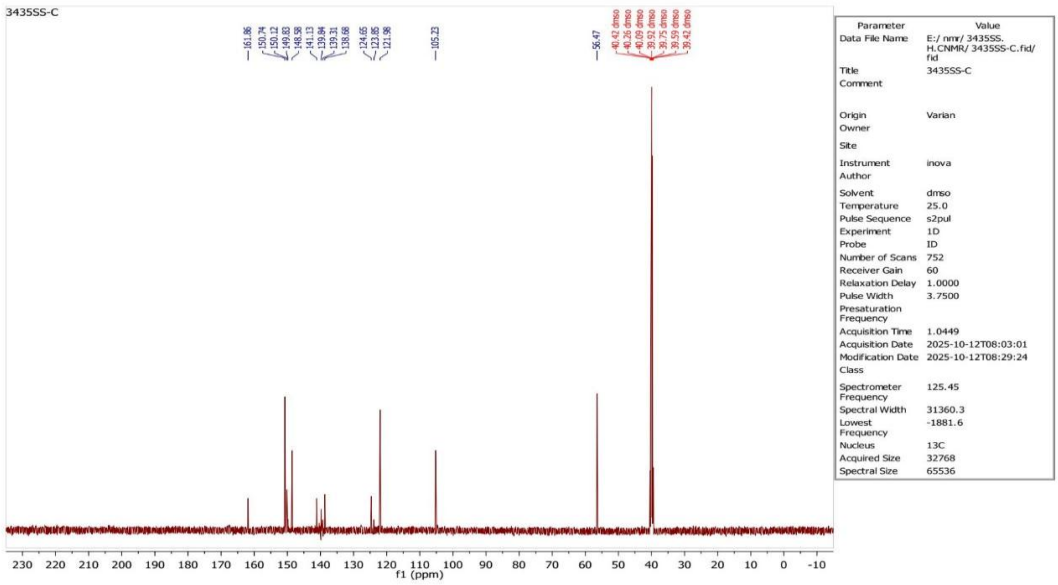

Figure2: ^{13}C –NMR of ligand [L´]

FT-IR spectra of ligand [L´] and its complexes

The IR Spectrum for ligand [L´] showed a band at (3178) cm^{-1} belongs to the frequency of (N-H). A strong band absorbed at (1649) cm^{-1} that for to the υ (C=O) group of INH (isoniazid) (Poggi *et al*., 2013). At υ (1581) cm^{-1} the band assigned to the stretching frequency for azomethine group υ (C=N) for the ligand [L´]. The bands at (1510) cm-1 and (3072) cm^{-1} can be assigned to (C=C) aromatic and (C-H) stretching frequencies respectively (Kindness *et al*., 1990). υ (C=N) for Schiff base's vibration frequency was moved to the higher or the lower frequencies in the complexes. The stretching vibration corresponding to υ (C=O) for ligand [L´] was changed to a higher or lower frequency at the range (1614 - 1720) cm^{-1} in complexes spectra. The reason of this change is attributed to the coordination of the carbonyl oxygen atom (C=O) with metal ions (Mahmoud & Hassan, 2017). New bands were observed at the range (536- 582) cm^{-1} and (467- 499) cm^{-1} were ascribed to υ (M-N) and υ (M-O) respectively for complexes (Nakamoto, 2006), FT-IR data illustrated in Table 4.

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Table4: Infrared spectra data for [L´] and its complexes

Compounds	υ (N-H) δ (N-H) group cm^{-1}	υ (C=O) cm^{-1}	υ (C=N) cm^{-1}	υ (N-N) cm^{-1}	υ(M-N) cm^{-1}	υ(M-O) cm^{-1}	υ (C=C) Ar. cm^{-1} υ (C-H) Ar. cm^{-1} υ (C-H) Aliph. cm^{-1}
$C_{15}H_{15}N_3O_4$ [L´]	3178(br)	1649 (s)	1581(s)	1060 (s)	___	___	1510 (s) 3072 (br) 2967(br),2848(br)
[Cr $(L´)_2Cl_2$]Cl	3415(br) 1557(sh)	1667 (s)	1578(s)	1064(m)	545(m)	467(m)	1549(s) 3060(m) 2944(m),2842(br)
[Mn $(L´)_2Cl_2$]	3369(br) 1582 (s)	1643 (m)	1614(m)	1067(m)	536(w)	482 (s)	1515(s) 3070(m) 2960(w), 2840(w)
[Zn $(L´)_2Cl_2$]	3343(s) 1544(s)	1614 (s)	1583(s)	1069(s)	555(s)	477(br)	1544(s) 3089(br) 2966(m),2841(m)
[Cd $(L´)_2Cl_2$]	3360(br) 1572(s)	1720(s)	1679(s)	1069(s)	552(br)	499 (s)	1548(s) 3066(br) 2875(sh,2983(sh))
[Hg $(L´)_2Cl_2$]	3502(s) 1546(s)	1638(s)	1586(s)	1057(s)	553(s)	495(s)	1512(s) 3067(s) 2848(m),2971(m)
[Pb $(L´)_2Cl_2$]	3200(br) 1600(sh)	1669(m)	1638(s)	1059(s)	582(s)	499(s)	1584(s), 3054(br) 2938(br),2844(br)

s. =strong, sh. =shoulder, m. = medium, br. =broad

Electronic spectrum and magnetic properties of the ligand [L´] and complexes

The measurements of magnetic susceptibility incorporated with electronic spectrum data in order to investigate the complexes structure. The effective magnetic moments (μ_{eff}) measured at room temperature 300K for the complexes, as illustrated in Table 5. The electronic spectra of [L´] and its complexes was recorded at the wavelength range (200- 800) nm in DMSO solution. UV- visible spectrum of the yellow solution for the synthesized [L´] ligand showed a pair of peaks at (251 nm, 39411 cm^{-1}) and (363 nm, 27548 cm^{-1}), which may be assigned to the ($\pi \rightarrow \pi^*$), (n→

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π*) (Vinusha *et al.*, 2019). These transitions shifted to lower frequencies in the spectra of the complexes with various coordination of ligand with metal ions. Peaks detected in the spectrum of Cr (III) at (340 nm, 299411 cm^{-1}) were assigned to the ligand field transition. The peak at (481 nm, 20790 cm^{-1}) due to (^4A_2g (F) → ^4T_1g(F)) transition. The computed value of (μ_{eff}) was detected at (4.21) B.M inside the limits for the predicted octahedral geometry range (Hadi *et al.*, 2021). The complex of Mn (II) spectrum showed one peak at the visible region (480 nm, 20833 cm^{-1}) and (727 nm,3755 cm^{-1}) assigned to (^6A_1g(F) →^4T_2g(G)), (^6A_1g(F) →^4T_2g(G)) respectively. The magnetic moment was measured at 5.40 B.M., around Mn (II) the ligand field concluded an octahedral geometry (Hamaguchi *et al.*, 2024). The electronic spectra of Zn (II), Cd (II), Hg (II) and Pb (II) complexes showed shifted bands compared with the free ligand [L´] which are due to charge transfer (C.T.).

Table5: UV-Vis data, Molar conductance, μ_{eff} , and suggested geometries for [L´] and its complexes

Compound	λ nm	ῡ cm^{-1}	ε max mol-^{1}.L.cm	Transitions	$\Lambda_{M\ (DMSO)}$ $S.cm^2.mol^{-1}$	(μ_{eff}) (B.M) suggested Geometry structure
$C_{15}H_{15}N_3O_4$ [L´]	251 363	39840 27548	1885 111	π → π* n→ π*	———	———
[Cr(L´)$_2$Cl$_2$]Cl	340 481	29411 20790	1201 763	Intra- ligand $^4A_2g_{(F)}$→$^4T_1g_{(F)}$	33.10	4.21 Octahedral
[Mn (L´)$_2$Cl$_2$]	347 480 727	28818 20833 13755	1209 70 56	Intra- ligand $^6A_1g_{(F)}$→$^4T_2g_{(G)}$ $^6A_1g_{(F)}$→$^4T_1g_{(G)}$	13.31	5.40 Octahedral
[Zn (L´)$_2$Cl$_2$]	338 435	29585 22988	668 153	Intra- ligand MLC.T	7.88	0.00 Octahedral
[Cd (L´)$_2$Cl$_2$]	334 430	29940 23255	1356 160	Intra- ligand MLC.T	11.50	0.00 Octahedral
[Hg (L´)$_2$Cl$_2$]	336 475	29761 21052	747 122	Intra- ligand MLC.T	14.15	0.00 Octahedral
[Pb (L´)$_2$Cl$_2$]	337 460	29673 21739	1110 250	Intra- ligand MLC.T	5.77	0.00 Octahedral

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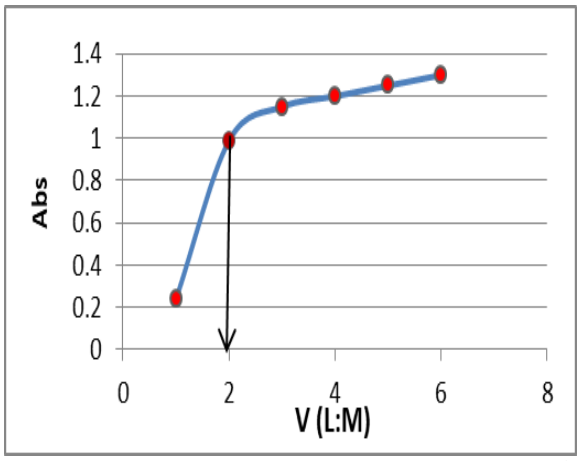
Studying of complexes formation in solution molar- ratio method

The molar-ratio method was used to determine the metal-ligand ratio in the complex solution. This method carried out using the well-established spectrophotometric technique (Abdullah, 2016). Ethanol was used as a solvent in my study. A series of solutions containing a constant amount of metal and various amounts of ligand concentration ($2x10^{-3}$ M) was prepared. The absorbance was measured at (λ Max) for the complex. The relationship between absorbance and the [L] / [M] ratio was plotted, with the metal fixed and the ligand concentration varied in the presence of an ethanoic solution. A plot would show absorbance increasing with the addition of the ligand until the point where the [L] / [M] ratio is 2. This indicates a complex with stoichiometry (L: M) (2:1) complexes for Cr (III) as shown in Figure3.



V (L:M)	Abs
0.5:1	0.24
1:1	0.99
3:1	1.29
4:1	1.32
5:1	1.3

Figure3: molar- ratio slop for $[Cr (L')_2Cl_2] Cl$

Enzyme activity (AST activity)

Human serum (AST activity) measured by using the colorimetric method (Geies & Abdelazim, 2021). The ligand's enzymatic activity and its metal complexes, as well as the kinds of inhibition percentages, were determined by contrasting the activity in the presence and absence of inhibition under identical conditions according to the following equation (Hussein et al., 2020), data illustrated in Table 6

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$$\% \textbf{ inhibition} = 100 - \frac{\textbf{the activity with inhibitor}}{\textbf{the activity without inhibitor}} * 100$$

Table6: The enzyme activity on [L´] and its complexes

Compounds	Inhibition conc. (M)	AST Activity (IU/L)	% Inhibition
Control	zero	360	—
$C_{15}H_{15}N_3O_4$ [L´]	10^{-2}	260	27.8
	10^{-4}	275	23.6
	10^{-6}	300	16.7
	10^{-8}	335	6.9
$[Cr_{(}L´_{)2}Cl_2]Cl$	10^{-2}	202	38.4
	10^{-4}	305	15.3
	10^{-6}	340	5.6
	10^{-8}	360	0
$[Mn_{(}L´_{)2}Cl_2]$	10^{-2}	77	78.6
	10^{-4}	200	44.4
	10^{-6}	310	13.8
	10^{-8}	335	6.9
$[Zn_{(}L´_{)2}Cl_2]$	10^{-2}	177	50.9
	10^{-4}	265	26.4
	10^{-6}	350	2.8
	10^{-8}	360	0
$[Cd_{(}L´_{)2}Cl_2]$	10^{-2}	285	20.8
	10^{-4}	340	5.6
	10^{-6}	360	0
	10^{-8}	360	0
$[Hg_{(}L´_{)2}Cl_2]$	10^{-2}	88	75.6
	10^{-4}	133	63
	10^{-6}	340	5.6
	10^{-8}	335	7
$[Pb_{(}L´_{)2}Cl_2]$	10^{-2}	120	66.6
	10^{-4}	310	13.8
	10^{-6}	350	2.8
	10^{-8}	360	0

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The anti-bacterial and anti-fungal activity of ligand [L´] and its complexes

The activity of the synthesized ligand [L´]and its complexes was tested against chosen species of microorganisms, including the G+ bacteria like *Staphylococcus aureus* and *Enterococcus spp*, and the G- bacteria like *E. coli* and *Pseudomonas aeruginosa* (Tavares *et al.*, 2020), and anti-fungal activity against *Candida albicans* in agar (Paz *et al*., 2023). Compounds dissolved in DMSO to provide 10^{-3} mg/ml concentration. The dissolved samples were used to determine the exposure zone of inhibition on Agar plates for the diffusion of microorganisms. At 37 °C, the plates were cultured for 24 hours. The inhibition zones of bacteria around the samples are shown in Table7 and Figure4.

Table7: The effect of prepared ligand [L´] and its complexes against *candida albicans*, gram-negative bacteria and gram-positive bacteria

Compounds	Inhibition zone diameter (mm) at concentration 10^{-3}M				
	Candida albicans	G- bacteria		G+ bacteria	
		E.coli	*pseudomonas aeruginosa*	*Staphylococcus aureus*	*Enterococcus Spp*
Amoxicillin	25.4	26	23.4	27.2	28.6
$C_{15}H_{15}N_3O_4$ [L´]	0	0	14	0	12
$[Cr_{(}L´_{)2}Cl_2]Cl$	0	14	13	14	15
$[Mn_{(}L´_{)2}Cl_2]$	13	15	20	15	20
$[Zn_{(}L´_{)2}Cl_2]$	20	16	14	18	15
$[Cd_{(}L´_{)2}Cl_2]$	0	0	15	12	12
$[Hg_{(}L´_{)2}Cl_2]$	17	15	19	24	15
$[Pb_{(}L´_{)2}Cl_2]$	0	0	0	0	17

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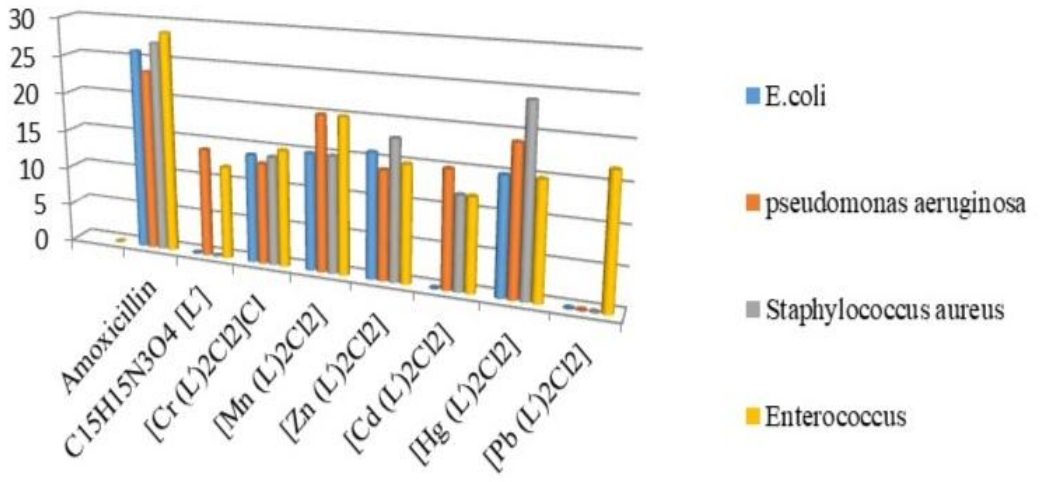

Figure4: The plotting of antimicrobial activity of prepared ligand [L´] and its complexes against the negative and positive gram bacteria

Conclusion

The present study demonstrated that the condensation of isonicotinohydrazide with 4-hydroxy-3,5-dimethoxybenzaldehyde resulted in the formation of a new bidentate ligand coordinated through the nitrogen and oxygen atoms of the azomethine. Spectroscopic analysis indicated that metal ions coordinated with the ligand through the (N, O) donor atoms, specifically the nitrogen atom of the imine group and the oxygen atom of the carbonyl group. The analysis suggested that the resulting complexes possess an octahedral geometry. Furthermore, the investigation of enzyme activity revealed that the inhibitory concentration was below (10^{2-}) M for the metal ions Mn (II), Zn (II), Cd (II), Hg (II), and Pb (II). In vitro studies showed that the Mn (II) complex exhibited activity against fungi and against Gram-positive (G+) and Gram-negative (G-) bacteria, outperforming both the ligand itself and other synthesized complexes. These findings suggest that the Mn (II) complex holds potential for therapeutic applications.

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تحضير، دراسة طيفية و بيولوجية لبعض المعقدات الفلزية لقاعدة شف المشتقة الآيزونيازيد

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مستخلص البحث:

تم في هذه الدراسة تحضيرستة معقدات فلزية لليكاند قاعدة شف جديدة. وباستخدام تقنيات متعددة، تم تشخيص الليكاند [L´] (N'-(4-hydroxy-3, 5-dimethoxy benzylidene) $C_{15}H_{15}N_3O_4$ isonicotinohydrazide) ومعقداته الفلزية [Cr (III)، Mn (II)، Zn (II)، Cd (II)، Hg (II)، Pb (II)]، وشملت هذه التقنيات مطيافية الأشعة تحت الحمراء بتحويل فورييه، والأشعة فوق البنفسجية المرئية، والرنين النووي المغناطيسي للبروتون[1]، والرنين النووي المغناطيسي للكربون[13]، والتحليل الدقيق للعناصر، وقياسات التوصلية المولارية، وتحديد نقطة الانصهار، وتحليل محتوى الكلوريد، وتقييم الحساسية المغناطيسية. أظهرت بيانات النتائج أن المركبات الفلزية المتكونة لها الصيغة $Cr(L´)_2Cl_2]Cl$ و$[M(L´)_2Cl_2]$، حيث M = (Mn, Zn, Cd, Hg، وII) (Pb) و[4]-N' = L´-هيدروكسي-5،3-ثنائي ميثوكسي بنزيليدين) أيزونيكوتين هيدرازيد. بناءً على التحليل الطيفي لليكاند الذي يشمل ذرات مانحة (N-O) من ذرة النيتروجين في مجموعة الإيمين وذرة الأكسجين في مجموعة الكربونيل، يشير تنسيق الليكاند أيونات المعادن إلى أن المركبات الستة تمتلك بنية ثمانية السطوح سداسية التناسق. إلى جانب ذلك، دُرست فعالية الإنزيم تجاه الليكاند [L´] ومركباته. أظهرت دراسة الفعالية الإنزيمية أنماط تثبيط متباينة ليكاند ومركباته الفلزية. تم اختبار الكفاءة البيولوجية للمركبات في المختبر على فطر المبيضة البيضاء (*Candida albicans*) وكائنات دقيقة أخرى، بما في ذلك بكتيريا موجبة الغرام مثل المكورات العنقودية الذهبية (*Staphylococcus aureus*) وأنواع من المكورات المعوية (*Enterococcus spp*)، بالإضافة إلى بكتيريا سالبة الغرام مثل الإشريكية القولونية (*E.coli*) والزائفة الزنجارية (*Pseudomonas aeruginosa*)، باستخدام طريقة انتشار القرص. أظهرت النتائج أن المركبات أبدت نشاطًا مضادًا للميكروبات أعلى من الليجاند الحر. تشير هذه النتائج إلى أن هذه المركبات الفلزية تمتلك إمكانات جيدة لتصميم عوامل جديدة مضادة للأكسدة ومضادة للميكروبات.

الكلمات المفتاحية : قاعدة شف، الآيزونيازيد ، معقدات الفلزات الانتقالية، AST ، دراسة مضادات الميكروبات.

ملاحظة : هل البحث مستل من رسالة ماجستير نعم√: