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Synthesis and characterization of Mn(II),Co(II),Ni(II),Cu(II) and Zn(II) complexes with heterocyclic ligands and evaluation of its biological activity

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ABSTRACT

Solid phase one-pot multicomponent reaction was used of heterocyclic compounds due to its supreme properties starting from three component mixture of piperonal binzil, p-phenylene diamine and ammonium acetate which was synthesized through reflux for 6 hours to afford 1-N(p-aminophenyl)-2-(piperonyl-5-yl) -5-hydroxy-4,5-diphenyl-2H-imidazole, which then converted to N-(4-(2-(benzo-1,3-dioxol-5-yl)-4,5-diphenyl-2,5-dihydro-1H-idazol-1-yl)phenyl) benzamide through its reaction with benzoyl chloride in the presence of triethylamine as a base catalyst.

Further the Mn(II), Co(II), Ni(II), Cu(II) and Zn (II) complexes were synthesized by direct reaction of the above ligand with metal chlorides in (1:1) or (2:1) (Ligand:metal) molar ratio in ethanolic medium.

The prepared complexes were characterized by elemental analysis, spectral studies (FTIR., UV/vis), ^{1}H-NMR measurement, conductivity measurements, magnetic measurement and electronic spectra values indicate the presence of tetrahedral and octahedral geometric around the metal ions and the study of inhibiting effect on the growth of different types of bacteria which are strains *staphylococcus aurous* and *Klebsiella pneumoniae*. The results indicate that the compound (4) has a great effect on different types of bacteria compared to the rest of the complexes, which gave a higher effectiveness rate.

Keyword: Ammonium acetate, reflux, ethanolic medium, diphenyl, characterized**.**

INTRODUCTION

Heterocyclic ligands are known as organic cyclic compounds whose ring contains a heterogeneous atom in addition to a carbon atom, such as oxygen, sulfur, nitrogen, silicon, and phosphorus. They are either three-ring, four-ring, penta-ring, or six-ring. Among these types, the heterocyclic pentacyclic ligands are the most common and important, especially when used in the preparation of a wide range of compounds that have high effectiveness in the pharmaceutical and medical fields (Kerru *et al*., 2020).

Imidazole compounds were prepared in many different ways, but the first to discover and prepare them was the scientist Hattzesh in the year 1858 AD (Debus, 1858). He used dicarbonyl compounds in the presence of ammonia and aldehyde compounds to give the tri-substituted imidazole. This reaction was the first step in discovering multi-component reactions used to prepare heterocyclic compounds, including imidazole, as many of its derivatives were later prepared in different and diverse ways. Among them is the preparation of substituted imidazoles fused with heterogeneous hexagonal rings by the scientist Sisko and his group in (1998). He used Schiff's rules to replace them with heterocyclic compounds. The homologs are saturated and the cyanide compounds are replaced by an aromatic ring (Shama and Pathak, 2010; Sharma *et al*., 2013).

The researcher Mosad (Mosad *et al*., 2022) and his assistants were able to prepare the ligand 2-{(2-[(2,3-dihydroxy-benzylidene)-amino]-6-oxo-1H-purine-9-yl) methoxy} ethyl-2-amino-3-mehyl butanoate. After the ligand was identified by spectroscopic methods, and preparing complexes by reacting the above ligand with some transition elements (Cr(III), Mn(II), Co(II), Ni(II), Cu(II), Zn(II)). Then the complexes that were prepared were characterized by physical and spectroscopic methods and it was found that the complexes have an octahedral structure, while the zinc complex It is a triangular pyramid.

The researcher Hadi (Hadi *et al.*, 2024) and his assistants were able to prepare the ligands (picolinohydrazide), (nicotinohydrazide), and (isonicotinohydrazide) and then react them with a number of transition elements, they determined the behavior of the ligand and how it bonds with metals using a number of spectroscopic methods and physicochemically, as it showed the behavior of the ligand in a three-stranded form and its coordination with the central atom through the donor atoms (O, N, O).

Therefore, in this research we prepared some new heterocyclic ligands, and prepare complexes with the ligand, we used 1.4 Phenylenediamine, which acts as metal binders within large rings that resemble DNA, as well as their complexes with metal ions Cu(II), Ni(II), Zn(II), Co(II), Mn(II), and then studying the effect of bacteria on ligands and some of the complexes.

EXPERIMENTAL

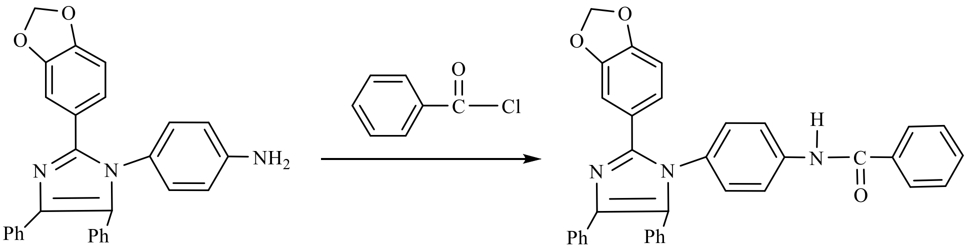
All chemical were of reagent grade, purchased from commercial source (BDH and Fluka).

Physical characterization

Infrared spectra were recorded on a Bruker-ATR-FT-IR. spectrophotometer in the 400-4000 cm^{-1} range (Germany origin). Elemental analyses (C, H, N) were carried out using micro analytical techniques on elemental (CHN) Analyzer LCHN-ALO Labtrone, UK. Metal content was determined spectrophotometrically using AA670 atomic absorption. Conductivity measurements were carried out (conductivity mater/Leitfahigketitsme Bgerat) (Cond3110) on 10^{-3} M solution of the complexes in DMSO using conductivity meter PCM3 Jenway at ambient temperature. The electronic spectra were recorded on a Shimadzu UV-visible spectrophotometer UV-160 for 10^{-3} M solution of complexes in DMSO at 25ºC. H-NMR measurement was recorded on a Bruker Bio spin GmbH (400MHz) Turkish origin. The magnetic susceptibility of the prepared complexes was measured at a temperature of 25 °C using the (Gouy method), the measurements were made using an electronic device (Sherwood Scientific MKI Magnetic susceptibility balance). The elements were determined spectrophotometrically using an atomic absorption spectrometer Analytik Jena Model Nova AA 350, Turkish origin.

1- Preparation of the ligands (L)

In a 100ml glass conical flask equipped with a magnetic stirrer, dissolve (0.02mol, 8.64g) of (4-(2-(benzo-1,3-dioxol-5-yl)-4,5-diphenyl-2,5-dihydro-1H-imidazol-1-yl) aniline) in absolute ethyl alcohol (20ml) with the addition of (3 drops) of triethylamine as a basic catalyst, then add benzoyl chloride (0.05mol, 9.27g) of meta-nitrobenzoyl chloride or (0.05mol, 7.02g) of benzoyl chloride), gradually and continue stirring for (30 minutes), then the reaction mixture rises for (3 hours), cool and pour it into ice water (10ml) and stir well to complete the precipitation process. The resulting sediment is filtered, washed several times with water (5 x 5 ml) and recrystallized using absolute ethyl alcohol.



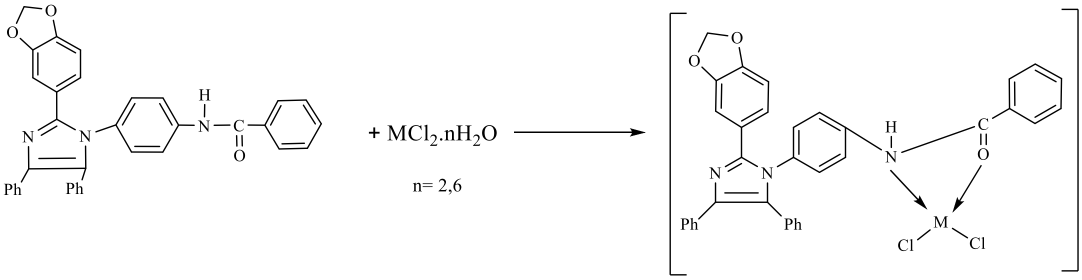
(L)

Preparation of the complexes [M(L)Cl$_2$], M=Mn(II), Co(II), Ni(II),Cu(II), and Zn (II)

Using the general method for preparing manganese complex.

The complex is prepared by adding (0.01mol, 1.96 g) ($MnCl_2.4H_2O$) dissolved in (15ml) absolute ethanol to the ligand (L) (0.01mol, 5.65g) in (5ml) absolute ethanol in a (100ml) circular flask equipped with a magnetic stirrer, then the reaction mixture is stirred for (3 hours) with continuous stirring until the precipitate is obtained. The formed precipitate is separated by filtration, washed with ether, and dried under vacuum pressure for several hours.

In the same way, the rest of the complexes are prepared, as the salts used are (0.01mol, 2.38g) of ($CoCl_2.6H_2O$), (0.01mol, 1.70g) of ($CuCl_2.2H_2O$), and (0.01mol, 2.37g) of ($NiCl_2$. $6H_2O$) and (0.01mol, 1.36g) of $ZnCl_2$.

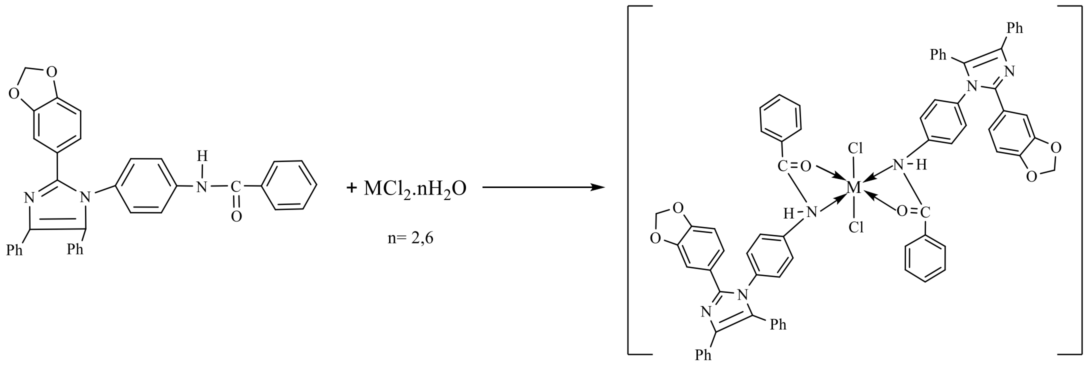


2- Preparation of the Complexes [M(L)$_2$Cl$_2$], M=Mn(II), Co(II), Ni(II),Cu(II), and Zn (II)

Using the general method for preparing manganese complex.

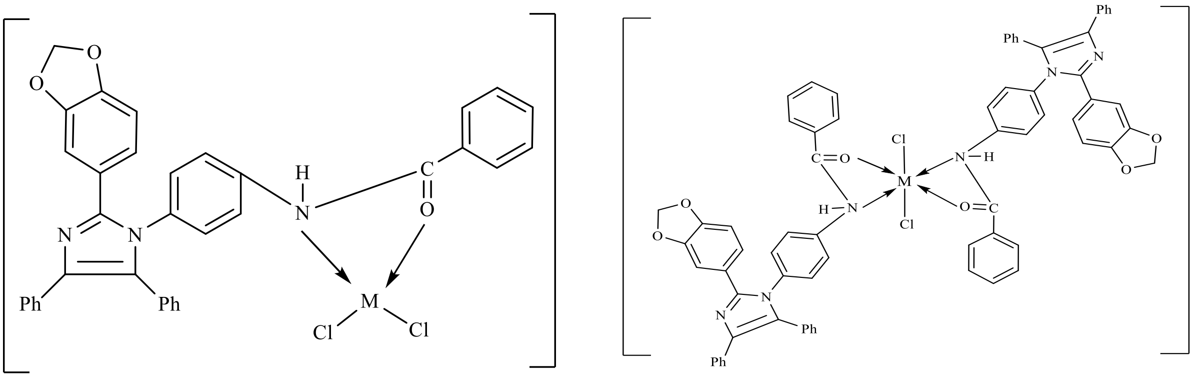
The complex is prepared by adding (0.01mol, 1.96g) ($MnCl_2.4H_2O$) dissolved in (15ml) absolute ethanol to the ligand (L) (0.02mol, 11.62g) and the solute as well. With (5ml) absolute ethanol in a circular flask with a capacity of (100ml) equipped with a magnetic stirrer, then the reaction mixture is stirred for (3 hours) with continuous stirring until the precipitate is obtained. Then the formed precipitate is separated by filtration, washed with ether, and dried under vacuum pressure for several hours.

In the same way, the rest of the complexes are prepared, as the salts used are (0.01mol, 2.38g) of ($CoCl_2.6H_2O$), (0.01mol, 1.70g) of ($CuCl_2.2H_2O$) and (0.01mol, 2.37g) of ($NiCl_2$. $6H_2O$) and (0.01mol, 1.36g) of $ZnCl_2$.



RESULTS AND DISCUSSION

The synthesized ligand (L) (scheme 1) forms 10 stable complexes with Mn(II), Co(II), Ni(II), Cu(II) and Zn(II) in (1:1) and (2:1) molar ratio (L:M). All the complexes soluble in most organic solvent and stable in dry air and their melting points ranged from 203 to 286°C.The results obtained from analytical as well as the physical properties of the compounds were recorded in (Table 1). The analytical data of the complexes fit in with suggested formula [$M(L)Cl_2$] and [$M(L)_2Cl_2$]. The value of molar conductance of complexes in DMF and DMSO indicates that L complexes are (1:1) and complexes are (2:1) were nonelectrolytes. The suggested structure of the prepared complexes is shown in Fig. (1).



(a) **(b)**

Fig. 1: Suggested structure of: (a) [$M(L)Cl_2$] (b) [$M(L)_2Cl_2$] complexes. M=Mn(II), Co(II), Ni(II), Cu(II), Zn(II)

Table 1: Physical properties of the prepared ligands and their complexes

Seq.	compound	Color	M.Wt.	m.p (°c)	Yield %	Analysis, found (calc.) %				(Λ) $cm^2.ohm^{-1}.mol^{-1}$
						C	H	N	M	
L	$C_{35}H_{25}N_3O_2$	Pale ashen	520.12	239-242	68	8.07 (8.01)	4.99 (4.83)	80.82 (80.20)	----	---
1	$[Mn(L)Cl_2]$	Ashen	644.95	230^d	87	65.18 (55.78)	3.87 (2.94)	6.51 (6.21)	8.51 (7.34)	12
2	$[Co(L) Cl_2]$	Dark ashen	648.95	275^d	97	64.77 (62.19)	3.85 (4.93)	6.47 (5.86)	9.08 (8.77)	15
3	$[Ni(L) Cl_2]$	Pale ashen	648.71	229^d	79	64.80 (54.33)	3.85 (4.56)	6.47 (5.41)	9.04 (8.59)	17
4	$[Cu(L) Cl_2]$	Pale yellow	653.56	266^d	80	64.32 (66.03)	3.82 (4.93)	6.42 (6.33)	9.72 (9.45)	18
5	$[Zn(L)Cl_2]$	Ashen	655.40	294^d	91	64.14 (65.53)	3.81 (3.51)	6.41 (5.98)	9.97 (9.02)	11
6	$[Mn(L)_2Cl_2]$	Pale ashen	1164.07	293^d	79	72.22 (71.98)	4.29 (3.88)	7.21 (6.58)	4.71 (3.85)	33
7	$[Co(L)_2Cl_2]$	Bluish grey	1168.07	273^d	84	71.97 (65.77)	4.28 (4.95)	7.19 (6.21)	5.04 (4.89)	30
8	$[Ni(L)_2Cl_2]$	Dark ashen	1222.77	229^d	86	68.75 (67.97)	4.08 (4.95)	6.87 (6.48)	4.79 (4.06)	38
9	$[Cu(L)_2Cl_2]$	Dark yellow	1172.68	296^d	78	71.69 (70.39)	4.26 (4.95)	7.16 (6.51)	5.41 (4.91)	12
10	$[Zn(L)_2Cl_2]$	Pale ashen	1174.52	278^d	80	71.58 (70.86)	4.25 (4.01)	7.15 (6.45)	5.56 (4.27)	10

d= decomposition temperature

^{1}H-NMR spectra:

The ^{1}H- NMR spectra of L were registered in DMSO – d^6 solvent and the ^{1}H- NMR assignments for the compound are presented in (Table 2) and Fig. (2) (Srivastava *et al.*, 2010).

Table 2: The ^{1}H-NMR data of the ligand

	ς(ppm)	Assignment
L	10.67	NH(s,1H)
	6.02-6.03	CH_2-piperonal(s,2H)
	6.87-6.89	Ph-piperonal (m,3H)
	7.18-8.76	2phenyl ring (m,10H)

s=singlets, m=mu ltiplets

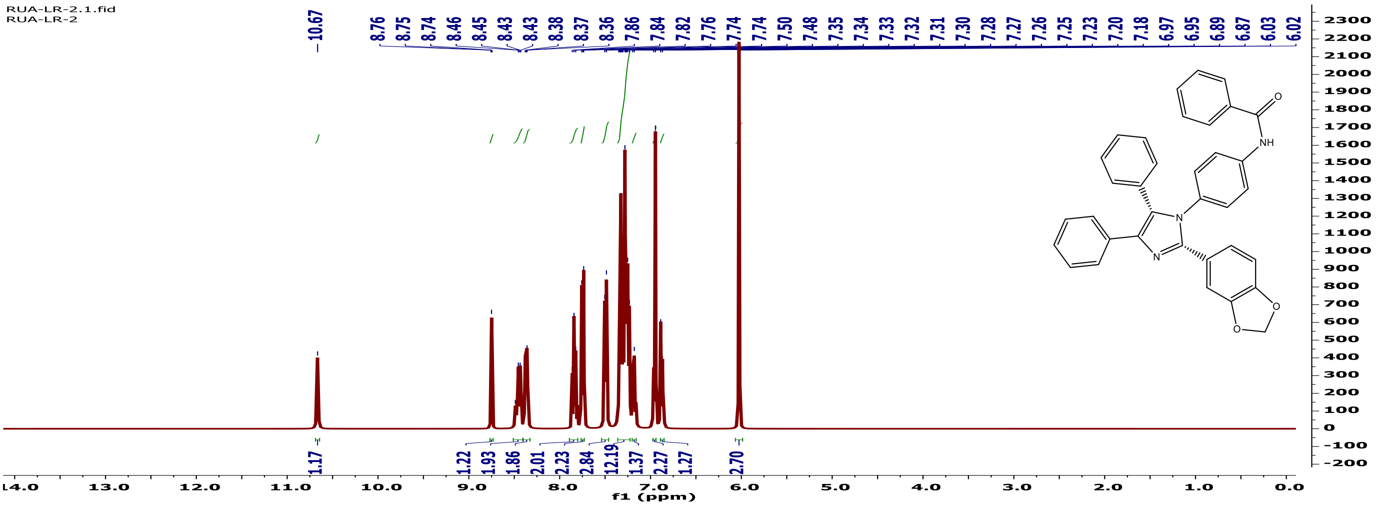


Fig. 2: ^{1}H-NMR spectra of L.

IR- spectra

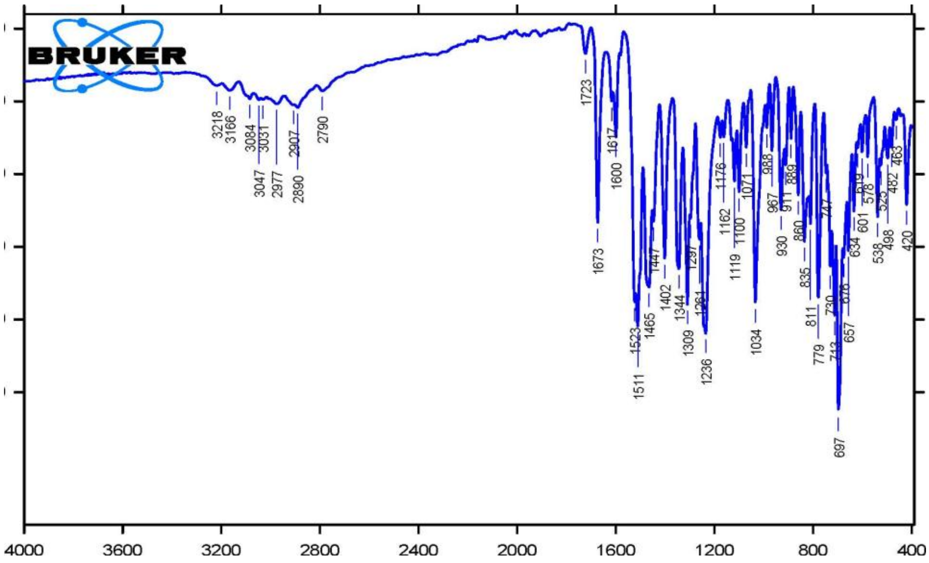
IR spectral study was tried for all prepared compounds. The type of binding of ligand and metal can be established by IR spectra. The band at (3218) cm^{-1} in IR spectra of L supported the formation of ν(NH). (Keypour *et al*., 2002).

There was a band received for ν(C-N) at 730 cm^{-1}. This band shift to higher or lower frequency in the spectrum complexes (Elmali *et al*., 2005). Which indicates participation of nitrogen atom of the imidazole group in bonding. A distinctive package appeared at (1673 cm^{-1}), due to the ν(C=O) (Giusti and Peryronel, 1981). The infrared spectrum of the prepared complexes showed absorption bands at higher or lower frequencies. This is due to the coordination of the oxygen atom with the metal ion, and this agrees with what was previously published (Souza *et al*., 1995).

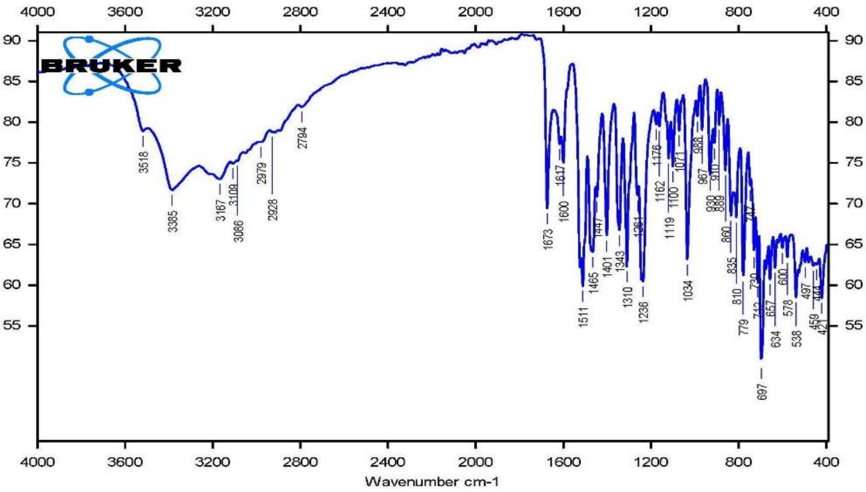
On the other hand, on the spectrum of all complexes new bands were appeared (459-497) cm^{-1} and (517-579) due ν(M-N) and ν(M-O) for (1:1) and (2:1) spontaneously stretching vibration (Aranha *et al*., 2016). ν(M-Cl) band is not registered because this band below to the spectrophotometer limits. This discussion suggested that L coordinates to metal in tetradentate and octahedral fashion O-M-N. The results were mentioned in the following (Table 3) and shown in Fig. (3).

Table 3: Personalized IR bands of L and their complexes

NO.	Compounds	ν (C-N)	ν (NH)	ν(M-N)	ν(M-O)	ν(C=O)
L	$C_{35}H_{25}N_3O_3$	1511	3218	---	---	1673
1	$[Mn(L)Cl_2]$	1512	3335	476	579	1671
2	$[Co(L)\ Cl_2]$	1511	3385	459	578	1673
3	$[Ni(L)\ Cl_2]$	1512	3345	482	578	1674
4	$[Cu(L)\ Cl_2]$	1512	3341	462	578	1673
5	$[Zn(L)Cl_2]$	1512	3164	482	579	1675
6	$[Mn(L)_2Cl_2]$	1511	3373	497	538	1672
7	$[Co(L)_2Cl_2]$	1511	3352	497	538	1673
8	$[Ni(L)_2Cl_2]$	1511	3319	497	517	1674
9	$[Cu(L)_2Cl_2]$	1512	2972	482	579	1674
10	$[Zn(L)_2Cl_2]$	1512	3171	483	539	1672



(a)



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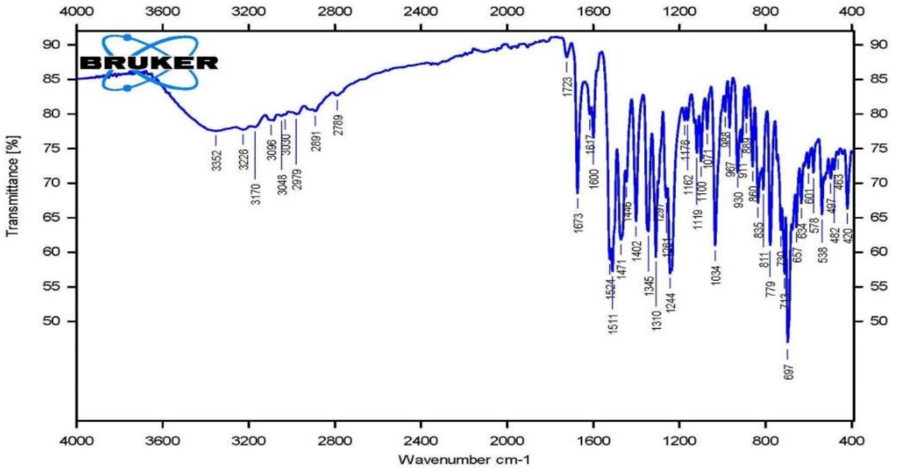
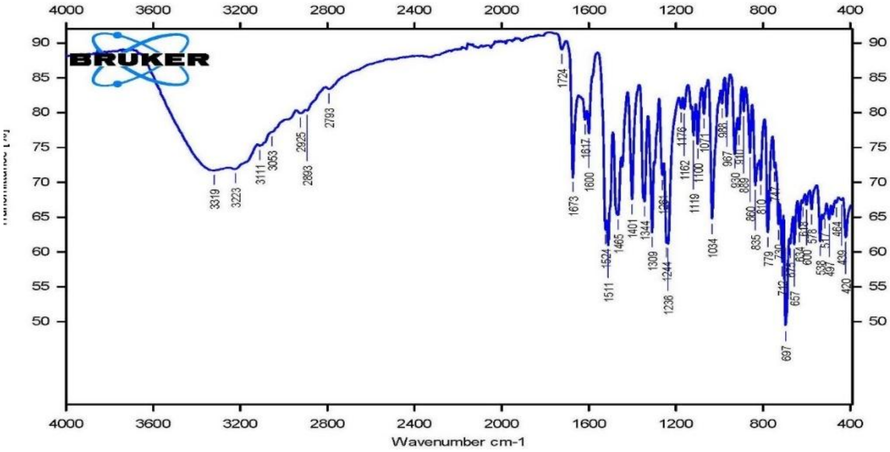


(C)



(D)

Fig. 3: The IR spectrum of (a)L, (b)[Co(L)Cl$_2$, (c)[Co(L)$_2$Cl$_2$], (d)[Ni(L)$_2$Cl$_2$].

Ultraviolet visible (UV):

The electronic spectra are very useful in elucidating structure, the results of measurement are specified in (Table 4).

The electronic spectra of Mn(II) complex (1) shown no prominent absorption that could be assigned for d-d transition. The d-d transition in Mn(II) tetrahedral environment are spin-forbidden but no longer parity forbidden, these transition are ~100times stronger, therefore structure of the prepared Mn(II) complex were proposed depending on the data of other measurements namely (Lana, 2022). While the complex (6) it showed absorption band (19803)cm^{-1}, (24532) cm^{-1} and (27336) cm^{-1}, these bands agree with the octahedral structure. (Rakhi, and Shelly, 2011; Chandra *et al.*, 2009).

In Co (II) complex (2) the electronic spectra exhibits one transition ν_3 $^4A_2(F) \longrightarrow {}^4T_1(P)$ consisting of two humps located at (14218) cm^{-1}, the splitting of this band is expected due to distortion of Jahn-Teller type of the tetrahedral structure in the excited state (Saleem *et al.*, 2011), the other two bands ν_1 and ν_2 are below the spectrophotometer limits. While the complex (7) it's showed bands at 10452, 16321 and 20431 cm^{-1}, these observation indicating an octahedral geometry around Co(II) ions (Jayaseelan *et al.*, 2011).

In Ni(II) complex (3) electronic spectra show a band ν_3 at (14870) cm^{-1} due to $^3T_1(F) \longrightarrow {}^3T_1(P)$ transition in tetrahedral geometry (Kulkarni *et al.*, 2012) the other two bands ν_1 and ν_2 are located in the lower section of the spectra, below the spectrophotometer limits. While the complex (8) show three bands at the region (11789), (13890) and (24790), this show that the Ni(II) ions having an octahedral geometry (Douglas *et al.*, 1999).

In the electronic spectrum of Cu(II) complex (4) a wide band was seen at (11768) cm^{-1} attributed to $^2T \longrightarrow {}^2E$ transition which is comparable with complex having tetrahedral structure (Ray *et al.*, 2003). While the complex (9) showed abroad absorption band at 15478 cm^{-1} and 17643 cm^{-1} arises from two or three d-d transition $^2B_1g\ ^2A_1g$, $^2B_1g \longrightarrow {}^2A_1g$, $^2B_1g \longrightarrow {}^2B_2g$ and $^2B_1g \longrightarrow {}^2Eg$ suggest that the Cu(II) ion exhibits octahedral geometry (Parihri *et al.*, 1999; Sahar *et al.*, 2018).

The electronic spectrum of Zn(II) complex (5,10) shows only a band at (35198 and 36095) cm^{-1} respectively which represents the charge transfer spectra. It can be concluded that complex (5) takes the tetrahedral geometry while complex (10) is octahedral geometry (Ray *et al.*, 2003).

Magnetic measurements

The magnetism of the prepared complexes was measured as follows:

It has been found practically that the value of the magnetic moment for manganese (II) complex (1) is (5.65 B.M) and this value is consistent with the tetrahedral structure of manganese (II) complex. (Lever, 1984; Al-Shaalan, 2011), while the complex (6) show a magnetic moments (5.85 B.M) which appreciably close to the calculated spin-only value for five unpaired electrons, and reveals a high spin state. and this value is consistent with the octahedral structure of manganese (II) complex (Cotton *et al.*, 1999).

The cobalt complex of the prepared ligands (2) gave magnetic moments (4.75 BM), and this value is consistent with the tetrahedral structure. (Nicholls, 1973), while the magnetic moment of complex (7) is (4.59) and this value is consistent with the octahedral structure of coblt(II) complex (Rasha and Haidar, 2020; Khalid and Haider, 2015)

Nickel complexes (3) showed magnetic moment (4.03B.M) and this value generally agree with nickel (II) complex that have a tetrahedral shape (Patel and Ikekwere, 1981). The practical values were high due to the presence of the orbital contribution. while the magnetic moment of complex (8) is (3.60) and this value is consistent with the octahedral structure of nickle (II) complex (Khalid and Shaimaa., 2017; Hassan *et al.*, 2015).

The copper (II) complexes (4) gave magnetic moment (2.63B.M) in agreement with the electronic spectra, it was shown that it agrees with copper (II) complex that have a tetrahedral shape. While the magnetic moment of complex (9) is (1.78) and this value is consistent with the octahedral structure of copper (II) complex (Al-adilee *et al.*, 2021).

The Zn(II) complexes are expected to be diamagnetic and their geometry is most probably similar to the Co(II), Ni(II) and Cu(II) complexes based on the rest of results for the other measurements particular the results of metal content and IR spectra. (Nabeel and Farah, 2012).

Table 4: UV spectra and magnetic moments of compounds

No	**Compounds**	**Absorption bands**	**Transition**	**Band maxima λ cm^{-1}**	**μ_{eff} (B.M.)**
1	$[Mn(L)Cl_2]$	---	---	35971	5.65
2	$[Co(L)\ Cl_2]$	14218	$^4A_2(F) \rightarrow {}^4T_1(P)$	37231	4.75
3	$[Ni(L)\ Cl_2]$	14870	$^3T_1(F) \rightarrow {}^3T_1(P)$	37981	4.03
4	$[Cu(L)\ Cl_2]$	11768	$^2T_2 \rightarrow {}^2E$	36231	1.93
5	$[Zn(L)Cl_2]$	---	---	35198	---
6	$[Mn(L)_2Cl_2]$	19803 24532 27336	$^6A_1g \rightarrow {}^4T_1g(^4G)$ $^6A_1g \rightarrow {}^4A_1g(^4G)$ $^6A_1g \rightarrow {}^4Eg(^4D)$	35976	5.85
7	$[Co(L)_2Cl_2]$	10452 16321 20431	$^4T_1g(F) \rightarrow {}^4T_2g(F)$ $^4T_1g(F) \rightarrow {}^4A_2g(F)$ $^4T_1g(F) \rightarrow {}^4T_1g(p)$	36891	4.59
8	$[Ni(L)_2Cl_2]$	11789 13890 24790	$^3A_2g(F) \rightarrow {}^3T_2g(F)$ $^3A_2g(F) \rightarrow {}^3T_1g(F)$ $^3A_2g(F) \rightarrow {}^3T_1g(p)$	35971	3.60
9	$[Cu(L)_2Cl_2]$	15478 17643	$^2B_1g \rightarrow {}^2A_1g$ $^2B_1g \rightarrow {}^2Eg$	35211	1.78
10	$[Zn(L)_2Cl_2]$	---	---	36095	---

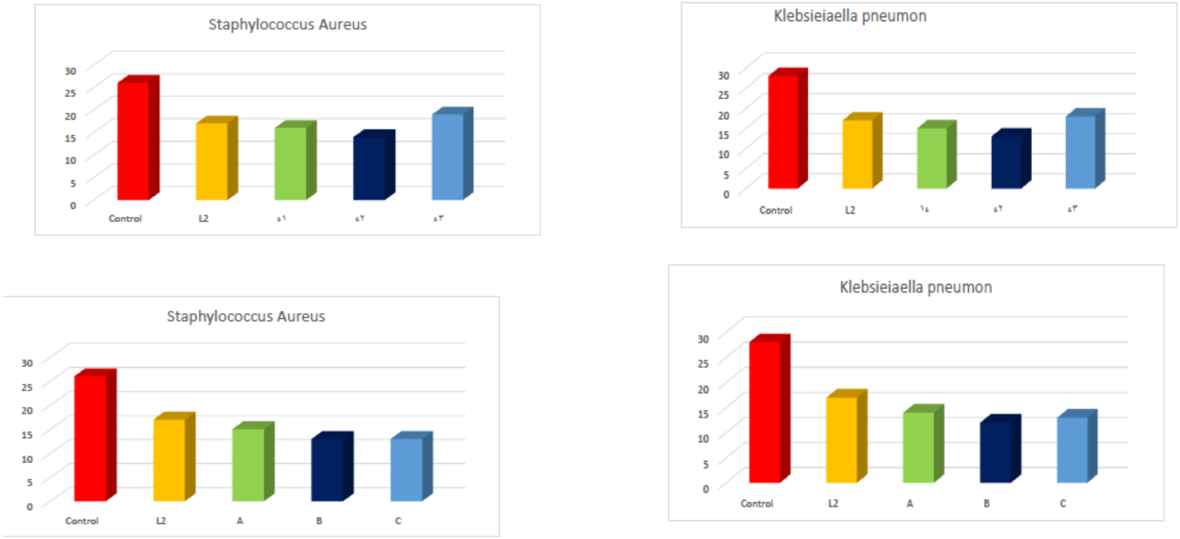
Antibacterial activity:

The agricultural medium was prepared with Hinton Mueller agar according to the instructions of the Indian company that classified the product. (38) grams of agar were dissolved in one liter of boiling distilled water, and the pH was equalized at 7.2 for the agricultural medium, then the solution was placed in the sterilizer (Autoclave) at a temperature of 121°C and under a pressure of 150 pounds/square inch for 15 minutes. After the solution reached a temperature of 50°C, the culture solution was poured into Petri dishes with a thickness of up to 2 mm per dish and left until it solidified, then placed for 24 hours inside an incubator at a temperature of 37°C to ensure that there was no contamination in the culture medium.

Evaluation of biological activity for the ligand and complexes was studied against selected types of G(+) bacteria staphylococcus aurous and G(-) bacteria *Klebsiella pneumoniae*. The obtained results have been tabulated and show in (Table 5) and Fig. (4) and graph (1) and compared with standard drug (Ciprofloxacin). The evaluation showed that the ligand and their complexes have an activity described as less than effective of ciprofloxacin against the bacteria which used in this research.

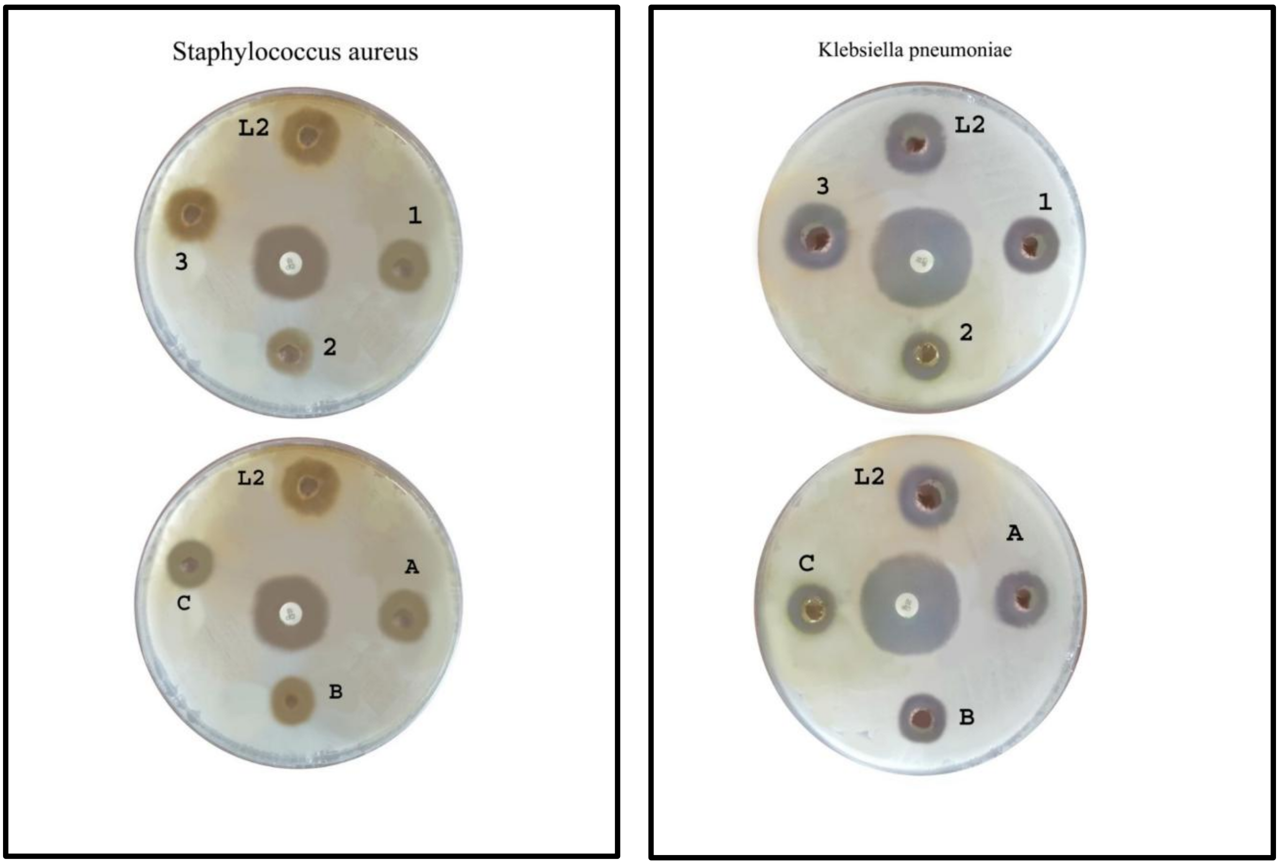
Table 5: The antibacterial activity of ligand and their complexes

No.complex	**symble**	**Compound**	***Staphylococcus aurous* (mm)**	***Klebsiella pneumoniae* (mm)**
L	L_2	$(C_{35}H_{27}N_3O_3)$	17	17
2	1	$[Co(L)\ Cl_2]$	16	15
3	2	$[Ni(L)\ Cl_2]$	14	13
4	3	$[Cu(L)\ Cl_2]$	19	18
7	A	$[Co(L)_2Cl_2]$	15	14
8	B	$[Ni(L)_2Cl_2]$	13	12
9	C	$[Cu(L)_2Cl_2]$	13	13
Control			18	25



(a) Staphylococcus aureus ***(b) Klebsiella pneumoniae***

Fig. 5: Antibacterial activity of compounds agents (a) *Staphylococcus aureus* (b) *Klebsiella pneumonia.*



Graph 1: Antibacterial activity of the compounds.

CONCLUSIONS

The ligands and their complexes were prepared and characterized by physio-chemical methods, in molar conductance of mononuclear Mn(II), Co(II), Ni(II), Cu(II) and Zn (II)were non-electrolytic in nature. The spectroscopic data of metal complexes with nitrogen and oxygen group of the ligand L. Hence all complexes have been in tetrahedral or octahedral structure and then studying the effect of bacteria on ligands and some of the complexes.

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تحضير وتشخيص معقدات Zn(II),Cu(II),Ni(II),Co(II),Mn(II) مع الليكاندات الحلقية غير المتجانسة وتقييم نشاطها البايولوجي

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الملخص

تم استخدام التفاعل متعدد المكونات ذو الوعاء الواحد في المرحلة الصلبة على نطاق واسع للحصول على المركبات الحلقية غير المتجانسة نظرًا لخصائصها الفائقة بدءًا من خليط مكون من ثلاثة مكونات وهي بيبرونيل بنزيل، بارا فينيلين ثنائي الامين وخلات الأمونيوم والتي تم تصنيعها من خلال التصعيد لمدة 6 ساعات, لتعطي 1-(4-امينو فنيل)-2-(2-بنزو -1،3 -اوكسالين -5-يل) 4،5 - ثنائي فنيل -5- ايميدازول، والتي يتم تحويلها بعد ذلك إلى (4-(2-(بنزو-1,3-اوكسالين-5-يل) -5,4-ثنائي فينيل إيميدازول-1-يل) - بنزامايد من خلال تفاعله مع كلوريد البنزويل في وجود ثلاثي إثيل أمين كمحفز أساسي.

بالإضافة الى ذلك، تم تحضير معقدات Mn(II)، Co(II)، Ni(II)، Cu(II) و Zn (II) عن طريق التفاعل المباشر للمركب المذكور أعلاه مع كلوريدات الفلز وبنسبة مولية (1:1) أو (2:1) (ليكاند : فلز) في الوسط الإيثانولي. شخصت المعقدات المحضرة بالتحليل الدقيق للعناصر والدراسات الطيفية (FTIR,UV/vis) وقياس ^{1}H-NMR وقياسات التوصيلية الكهربائية وقيم الأطياف الإلكترونية وقياسات المغناطيسية وقد اشارت إلى وجود تراكيب بهيئة رباعي السطوح وثماني السطوح حول أيونات الفلز. كما تم دراسة التأثير التثبيطي لبعض المعقدات المحضرة على أنواع مختلفة من البكتيريا وهي *staphylococcus aurous, Klebsiella pneumoniae* وقد أشارت النتائج إلى أن المركب (4) له تأثير كبير على أنواع مختلفة من البكتريا مقارنة ببقية المعقدات مما أعطى نسبة فعالية عالية.

الكلمات الدالة: خلات الامونيوم، تصعيد، وسط ايثانولي، ثنائي الفنيل، فلز.