Rafidain Journal of Science
https://rsci.uomosul.edu.iq
Vol. 35, No. 1, pp. 94-107, 2026 (March)

Synthesis and characterization of Some Transition Metals complexes with N-(4-phenylthiazol-2-yl) benzamide and evaluation of its biological activity

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p-ISSN: 1608-9391
e -ISSN: 2664-2786

Article information

Received: 27/7/2025
Revised: 15/9/2025
Accepted: 25/9/2025

DOI: 10.33899/rsci.v35i1.61996

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ABSTRACT

For the synthesis of the new N-(4-phenylthiazol-2-yl) benzamide ligand, 4-phenylthiazol-2-amine, and benzoyl chloride in a 1:1 molar ratio was condensed in ethanol with ammonium acetate. For creating the Zn (II), Ni (II), Mn (II), and Co (II) complexes, the above-mentioned ligand was directly reacted with metal chlorides in an ethanolic medium at a molar ratio 1:1 and 2:1 (Ligand: Metal). Determination of the elemental composition of a substance, spectral studies. The produced complexes were characterized using (FTIR, UV/visible), Proton-NMR and conductivity. The findings demonstrated octahedral and tetrahedral geometric availability linked to the central ion, along with an inhibitory effect on the growth of various bacterial strains, such as *Escherichia coli*, *Staphylococcus aurous*, *Bacillus*, and *Klebsiella pneumonia*. Complex (9) with the structure $[Cu(L)_2Cl_2]$ has a higher effect on different bacterial species than the other complexes, which had a lower effectiveness rate, according to the results.

Keyword: Triazole, complexes, transition metal, *Staphylococcus aurous.*

INTRODUCTION

Thiazoles are a class of heterocyclic compounds with the molecular formula (C3H3NS) that are distinguished by their distinctive aromatic pentagonal ring structure. Thiazoles in their unbound state are a pale-yellow liquid at room temperature. The thiazole nucleus is an essential structural element of vitamin B, underscoring the heterocyclic moiety's significance in biology. Thiazoles are essential for the controlled production of carbene entities in synthetic chemistry. This is done by conjugating them with transition metals to create metal-thiazole complexes, which act as catalysts in significant catalytic processes like benzoin condensation and the Stetter reaction. Thiazoles and transition metals can be strategically combined to produce precise free carbene species and give the resulting catalytic properties, which advances synthetic methods in organic chemistry (Ali and Sayed, 2021; Alrazzak, 2018).

The researcher Jafar (Jafar *et al*.,2016) and his assistants were able to prepare the ligand bis-[2-amino-4-phenyl-5-thiazolyl] disulfide. The [CoL] and [ClCuHL] complexes of the ligand were prepared and the products were further investigated by UV-Vis that confirmed the formation of desired complex in a 1:1 molar ratio, Then the complexes that were prepared were characterized by physical and spectroscopic methods and it was found that the complexes have an octahedral structure.

In chemistry, thiazole is heterocyclic ring of nitrogen and sulfur atoms is very important. Numerous heterocyclic compounds with antibiotic, antibacterial, anticancer, anti-inflammatory, and anticonvulsant qualities contain it. Thiazoles are essential heterocyclic rings with five members that exhibit a variety of activities. The thiazole derivatives fall into one of three categories: synthetic, semisynthetic, or natural. The thiazole molecules are aromatic and have some dienic character, according to molecular orbital techniques. Thiazole and its derivatives are widely used in a variety of chemical, biological, and therapeutic applications, which makes them a desirable subject for chemists and scientists to study. (Gartel & Kandel, 2008). Free thiazole has a boiling point that falls between (116-118) °C. Thiazole is distinguished by its pale-yellow liquid state, flammability, and pyridine-like scent. One electron pair associated with the sulfur atom delocalized and formed a six-electron symbol system, which is responsible for its aromatic properties. Furthermore, the strong aromaticity of the thiazole protons is demonstrated by proton nuclear magnetic resonance, where each thiazole ring proton's chemical shift value ranges from 7.27 to 8.77 ppm. The evaluated density of π-electrons shows that the substitution by electrophiles predominantly targets the C5 carbon, followed by C4. Conversely, the C2 position is where nucleophilic substitution occurs (Abdu-Rahem et al., 2021). The drugs of thiazole-containing compounds, also known as thiazole derivatives, are diverse and include antipsychotic, analgesic, anticancer, antiallergic, antihypertensive, antibacterial, anti-inflammatory, antimalarial, and antifungal qualities. Because they are incorporated into the structural frameworks of approved medications, thiazole-based scaffolds are crucial, underscoring their clinical significance. Moreover, the fact that these thiazole-containing complexes are essential components of more than 70 experimental medications suggests the thiazole-derived compounds are still being investigated and may have therapeutic uses in pharmaceutical research and development. Thiazoles or compounds containing them are therefore useful as pharmacological agents in a variety of ways, making them an efficient nucleus. (Rajiani and Ismail, 2019; Srivastava *et al*., 2010) antipsychotic, antibiotics, anticancer, allergy-suppressing, hypertension-controlling, inflammation-reducing, antimalarial, and antifungal agents. More than 70 experimental drugs contain these complexes. Despite its enormous medical significance, there are very few reviews in the literature. Over time, this complexes antiviral properties have been thoroughly investigated, yielding compounds with nM-range activity. Nevertheless, there isn't a comprehensive analysis of the range of antiviral activities displayed by this scaffold (Srivastava *et al.*, 2010).

Experimental

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

Physical characterization

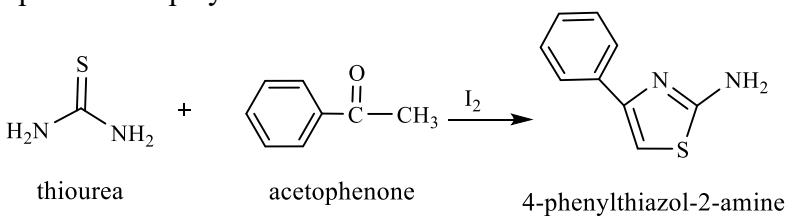
A Bruker-ATR-FT-IR spectrophotometer was employed to obtain IR spectra within the 400-4000 cm^{-1} region. Using elemental (CHN) Analyzer LCHN-ALO Labtrone, micro analytical

techniques were used to perform elemental analyses of carbon, hydrogen, and nitrogen). Atomic absorption was executed using an AA670 instrument to determine the metal content. Room temperature conductivity measurements were taken with the aid of a PCM3 Jenway conductivity meter involving 10^{-3} M complex solutions in DMSO (Conductivity Measuring Device: Leitfähigkeitstismessgerät Cond3110). The complexes' electronic spectra analyzed with a Shimadzu UV-160 Ultraviolet-Visible spectrophotometer in 10^{-3} molar DMSO solution maintained at 25 °C.

^{1}H- NMR spectral measurements were conducted on a 400 MHz Bruker BioSpin GmbH spectrometer. Magnetic susceptibility measurements of the complexes were conducted at 25 °C using the Gouy method with a Sherwood Scientific MK Magnetic Susceptibility Balance. Additionally, an Analytik Jena Model Nova AA 350 atomic absorption spectrometer was also employed for further determination of metal content.

1: Preparation of the compound (4-phenylthiazol-2-amine) (Abedi-Jazini *et al*., 2018)

Using a 100 ml glass conical vessel Connected to a glass condenser in the solid phase, (0.12g,0.1 mol) acetophenone are mixed with (0.07 g,0.1 mol) of thiourea and in the presence of iodine (0.25g,0.1 mol) as a selective catalyst, the reaction mixture is put in a sand bath for 2 hours, at a temperature of 150 °C. Then it is cooled and added to the liquid matter formed (25 ml) of diethyl ether with continuous stirring until a thick precipitate is formed, which is filtered and washed well using the same solvent. Then the formed precipitate is dissolved in hot water and hot filtered. The isolated filtrate is neutralized using concentrated ammonia solution to complete the process of precipitating the desired product, which is filtered, dried, and its physical constants are measured all the above discussion preparation displays in.

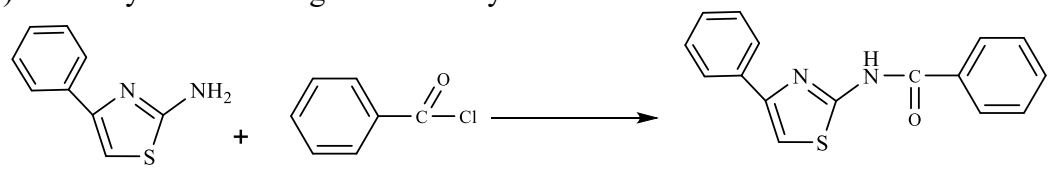


thiourea acetophenone 4-phenylthiazol-2-amine

Scheme (1): Preparation of the compound(4-phenylthiazol-2-amine)

2: Preparation of the ligand N-(4-phenylthiazol-2-yl) benzamide (L)

Using a 100 ml glass conical vessel and a magnetic stirrer, dissolve (0.17 g, 0.1 mol) of 4-phenylthiazol-2-amine in absolute ethyl alcohol (20 ml) with the addition of (3 drops) of triethylamine as a basic catalyst, then add (0.14g, 0.1 mol) of benzoyl chloride, gradually and continue stirring for (30 minutes), then the reaction mixture rises for (3 hours), cools down, then pour into 10 ml of ice-cold water and stir to complete precipitation. Filter the precipitate and wash with water (5 × 5 ml) and recrystallized using absolute ethyl alcohol.



N-(4-phenylthiazol-2-yl)benzamide

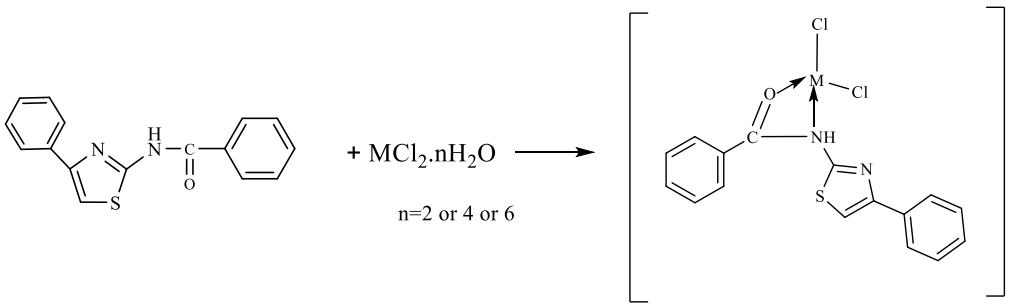
Scheme (2): Preparation of the ligand

3: Preparation of the Complexes [M(L)Cl_2], M=Mn (II), Co (II), Ni (II), Cu (II), and Zn (II)

Following the standard procedure for the preparation of manganese complex, the preparation of the complex involves the addition of (0.001 mol, 0.19 g) ($MnCl_2.4H_2O$), dissolved into (15 ml) absolute ethanol to the ligand (L) (0.001 mol, 0.28 g) in (5 ml) absolute ethanol in a (100 ml) 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 (0.001 mol, 0.23 g) of ($CoCl_2.6H_2O$), (0.001 mol, 0.17 g) of ($CuCl_2.2H_2O$), and (0.001 mol, 0.23 g) of ($NiCl_2.6H_2O$) and (0.001 mol, 0.13 g) of $ZnCl_2$.

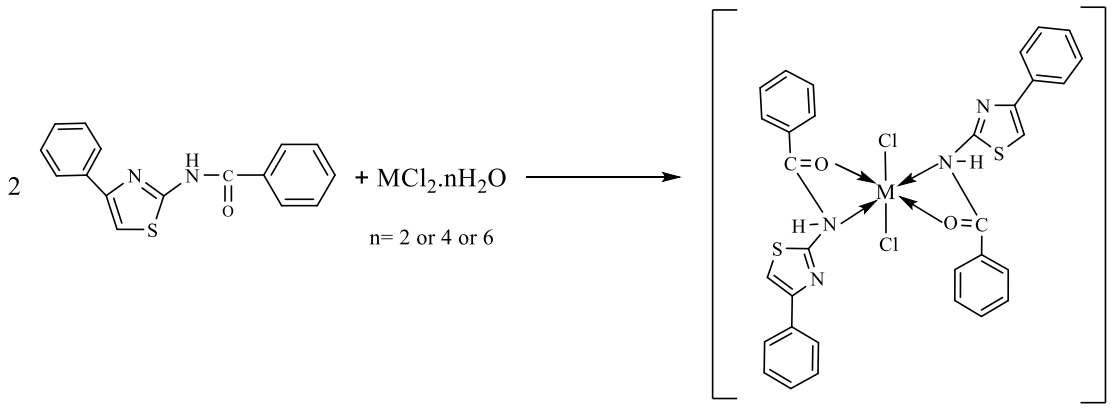


Scheme (3): Preparation of the complexes $[M(L)Cl_2]$

4: Preparation of the Complexes $[M(L)_2Cl_2]$, M=Mn (II), Co (II), Ni (II), Cu (II), Zn (II)

Following the standard procedure for the preparation of manganese complex, the preparation of the complex involves the addition of (0.001 mol, 0.19g) ($MnCl_2.4H_2O$) dissolved using 15 ml absolute ethanol before mixing with the ligand (L) (0.002 mol, 0.56 g) and the solute as well. With (5 ml) absolute ethanol in a circular flask with a capacity of (100 ml) fitted with a magnetic stirrer, then the mixture is stirred continuously for 3 hours until the precipitate is obtained. The resulting precipitate is filtered, rinsed with ether, and vacuum-dried for several hours.

In the same way, the rest of the complexes are prepared, as the salts used are ($CoCl_2.6H_2O$), ($CuCl_2.2H_2O$), ($NiCl_2.6H_2O$) and $ZnCl_2$.

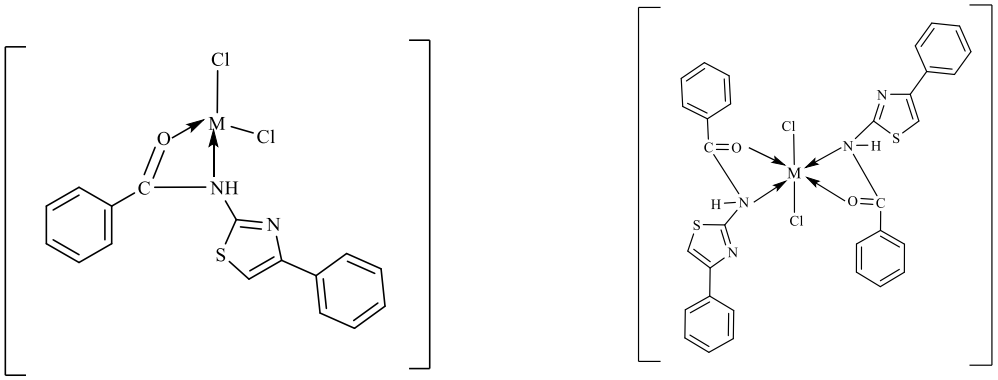


Scheme (4): Preparation of the complexes $[M(L)_2Cl_2]$

RESULTS AND DISCUSSION

Ten stable complexes result from the coordination of the synthesized ligand N-(4-phenylthiazol-2-yl) benzamide (scheme 1) with Mn (II), Co (II), Ni (II), Cu (II), and Zn (II) in (1:1) and (2:1) molar ratios (L:M). These complexes exhibited melting points in the range of 139–198°C, and they were all chemically stable in the absence of moisture and soluble in the majority of Organic-phase solvents. The physical characteristics of the compounds and the analytical results were

documented in Table 1. $[M(L)Cl_2]$ and $[M(L)_2Cl_2]$ are the suggested formulas that fit the complexes' analytical data. According to the complexes' values of molar conductance recorded in DMF solvent, all complexes' nonelectrolytes. The prepared complexes' proposed structure is displayed in (Fig1).



(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.	Comp.	Colors	M.Wt. Kg/mol	m.p (°c)	Yield %	Analysis CHNS, practically (theoretically)%					(Λ) $cm^2.ohm^{-1}.mol^{-1}$ (DMF)
						C	H	N	S	M (Mn,Co, Ni,Cu,Zn)	
4-phenylthiazol-2-amine	$C_9H_8N_2S$	Pale-yellow	176.24	126	94	61.34 (59.96)	4.58 (3.99)	15.90 (15.05)	18.19 (15.84)	---	---
N-(4-phenylthiazol-2-yl) benzamide	$C_{16}H_{12}N_2OS$	Yellowish white	280.35	118-123	93	68.55 (67.03)	4.31 (4.21)	9.99 (10.01)	11.44 (11.62)	---	---
1	$[Mn(L)Cl_2]$	Pale white	406.18	198[d]	89	47.31 (47.40)	2.98 (2.80)	6.90 (6.50)	7.89 (7.49)	13.53 (13.39)	15
2	$[Co(L)Cl_2]$	Blue	410.18	183[d]	88	46.85 (46.04)	2.95 (2.50)	6.83 (6.33)	7.82 (7.42)	14.37 (14.50)	11
3	$[Ni(L)Cl_2]$	Pale green	409.94	177[d]	97	46.88 (46.98)	2.95 (2.60)	6.83 (6.72)	7.82 (7.31)	14.32 (14.30)	18
4	$[Cu(L)Cl_2]$	Blake	414.79	139[d]	89	46.33 (46.32)	2.92 (2.62)	6.75 (6.19)	7.73 (7.53)	15.32 (15.24)	15
5	$[Zn(L)Cl_2]$	white	416.63	152[d]	88	46.13 (46.15)	2.90 (2.84)	6.72 (6.86)	7.70 (7.89)	15.96 (15.83)	19
6	$[Mn(L)_2Cl_2]$	Pale white	686.53	170[d]	89	55.98 (55.02)	3.52 (3.09)	8.16 (8.22)	9.34 (9.21)	8.00 (8.09)	25
7	$[Co(L)_2Cl_2]$	Green	690.52	186[d]	90	55.66 (55.44)	3.50 (3.42)	8.11 (8.19)	9.29 (9.26)	8.53 (8.49)	16
8	$[Ni(L)_2Cl_2]$	Pale yellow	690.28	144[d]	93	55.68 (55.71)	3.50 (3.43)	8.12 (8.10)	9.29 (9.19)	8.50 (8.48)	18
9	$[Cu(L)_2Cl_2]$	Blake	695.14	167[d]	91	55.29 (55.36)	3.48 (3.08)	8.06 (7.98)	9.22 (9.20)	9.14 (9.10)	21
10	$[Zn(L)_2Cl_2]$	White	696.97	164[d]	69	55.15 (55.22)	3.47 (3.40)	8.04 (8.12)	9.20 (9.29)	9.38 (9.32)	20

d= decomposition temperature

^{1}H-NMR spectra:

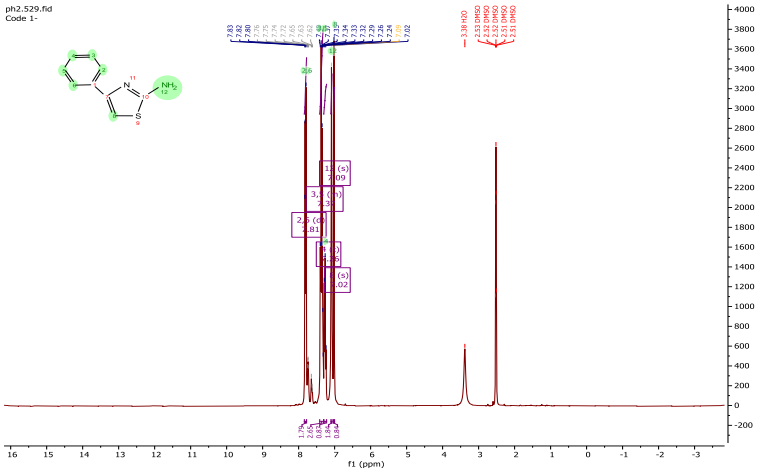
The ^{1}H NMR spectrum of the formation of 4-phenylthiazol-2-amine and N-(4-phenylthiazol-2-yl) benzamide observed by peak ratios in the ^{1}H-NMRspectra which was taken using DMSO-d6 solvent show the following important signals in (ppm) unit. For (A) δ (7.09) due to NH_2 protons, at

δ (7.02) due to CH-thiazole protons and δ (7.26-7. 81) for aromatic protons, while the (L) show δ (9.27) indicate to NH protons and δ (7.31) for CH-thiazole proton, Finlay a multiple at δ (7.39 – 8.00) due to phenyl ring (Table2) (Srivastava *et al.*,2010).

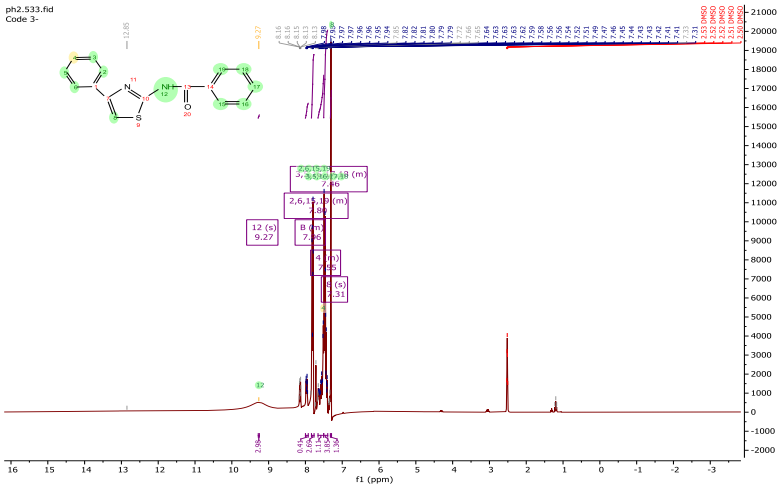
Table 2: The ^{1}H-NMR data of the 4-phenylthiazol-2-amine and N-(4-phenylthiazol-2-l) benzamide

Symbol	The name	ς(ppm)	Assignment
A	4-phenylthiazol-2-amine	7.09	NH_2(m,2H)
		7.02	CH-thiazole(s,1H)
		7.26-7. 81	Phenyl ring (m,3H)
L	N-(4-phenylthiazol-2-yl) benzamide	9.27	NH (s, 1H)
		7.31	CH-thiazole(s,1H)
		7.39 – 8.00	Phenyl ring (m,10H)

s=singlets, m=mu ltiplets



(a)



(b)

Fig 1: ^{1}H-NMR Spectral Data of the (a) A ,(b) (L) .

IR- spectra

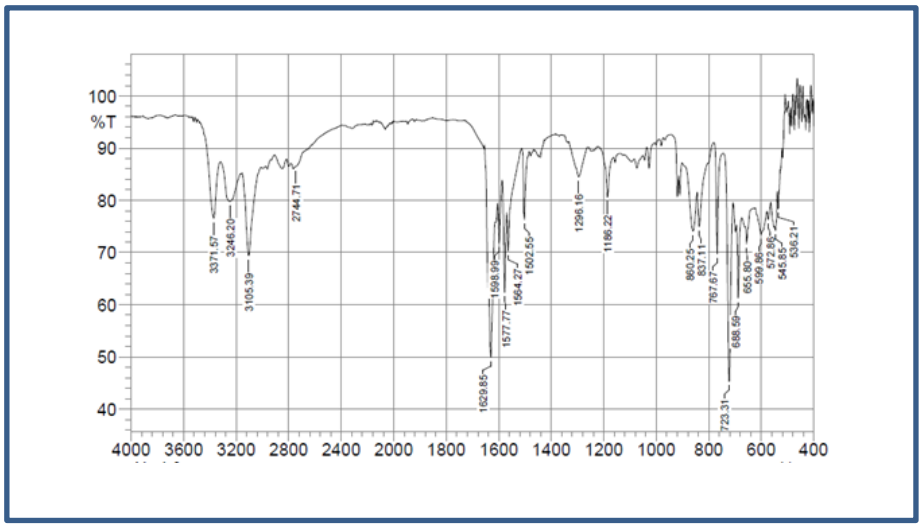
All prepared compounds were subjected to an IR spectral analysis.IR spectra can be used to determine the kind of ligand-metal binding. The development of ν(NH) was validated through the band at (3246) cm^{-1} in the ligand IR spectra (Keypour *et al*.,2002).

A band for ν(C-N) at 723 cm^{-1} was received. In the spectra of the complexes, this band shift occurs to a higher or lower frequency (Celal *et al.*, 2005). which shows that the imidazole group's nitrogen atom is involved in the bonding process. The ν(C=O) caused a unique package to emerge at (1629 cm-1) (Giusti and Peyronel, 1981). Absorption bands at higher or lower frequencies were visible in the prepared complexes' infrared spectrum. This correlates with what was previously published and is caused by the Bonding interaction between the oxygen atom and the metal ion (Moltved and Kepp, 2019).

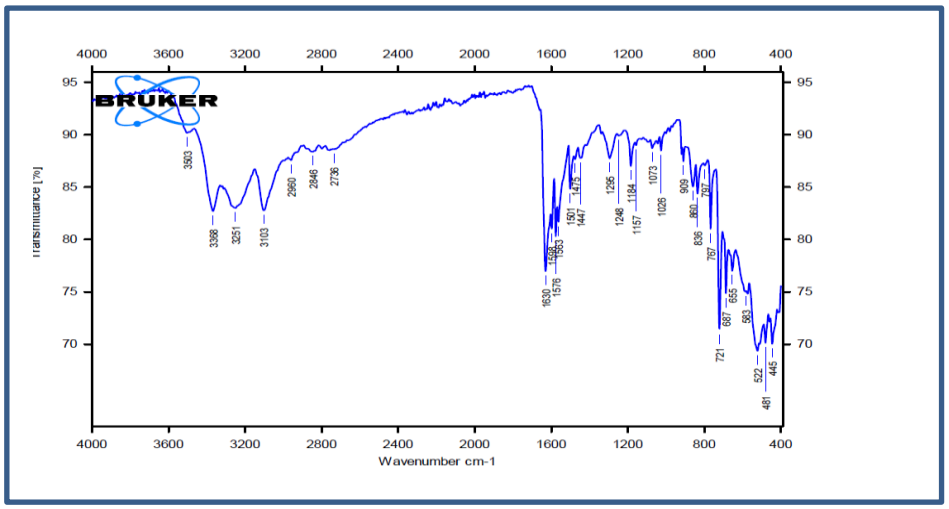
However, due to ν (M-N) and ν (M-O) for (1:1) and (2:1) spontaneously stretching vibrations, new bands appeared on the spectrum of all complexes (480-483) cm-1 and (510-563) (Shokohi-pour *et al.*, 2016). Since the ν (M-Cl) band is below the spectrophotometer limits, it is not registered. According to this discussion, ligand coordinates to metal in the octahedral and tetradentate fashions O-M-N. The findings were displayed in Fig. 2 and referenced in Table (3).

Table 1. Distinctive IR Spectral Features of the Ligand and their Complexes.

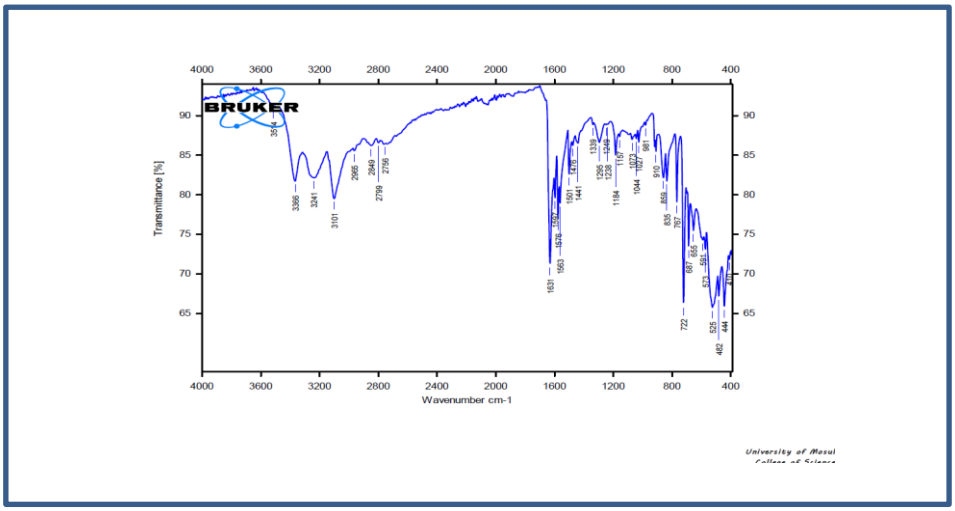
No.	Compound	ν asy(NH)	ν (C-N)	ν(C=O)	ν (M-O)	ν (M-N)
A	$C_9H_8N_2S$	3433	713	--	---	---
L	$C_{16}H_{12}N_2OS$	3371	723	1629	---	---
1	$[Mn(L)Cl_2]$	3486	722	1630	526	481
2	$[Co(L)Cl_2]$	3367	721	1628	524	482
3	$[Ni(L)Cl_2]$	3503	721	1630	522	481
4	$[Cu(L)Cl_2]$	3406	690	1623	563	480
5	$[Zn(L)Cl_2]$	3358	722	1626	536	481
6	$[Mn(L)_2Cl_2]$	3368	722	1631	527	482
7	$[Co(L)_2Cl_2]$	3367	721	1631	510	481
8	$[Ni(L)_2Cl_2]$	3514	722	1631	525	482
9	$[Cu(L)_2Cl_2]$	3367	722	1630	529	483
10	$[Zn(L)_2Cl_2]$	336	722	1626	537	482



(a)



(b)



(c)

Fig 2: The IR spectrum of (a)L, (b)$[Ni(L)Cl_2$, (c)$[Ni(L)_2Cl_2]$

Ultraviolet visible (UV):

The results of the measurement are listed in (Table 4), and the recorded electronic transitions are very helpful in clarifying structure.

The Mn (II) complex (1)'s electronic spectra did not exhibit any noticeable absorption that could result from d-d electronic transitions. Since the d-d electronic transition within the tetrahedral field of Mn(II) is approximately 100 times stronger than the spin-forbidden but the transition is now parity-allowed, the structure of the Mn(II) complex was inferred using data obtained from other characterization techniques (IR, Conductivity and Magnetic moment), specifically (Rasheed, 2022). The octahedral structure is supported by the absorption bands (19761)cm^{-1}, (25437)cm-1, and (26983)cm^{-1} that were observed in complex (6) (Abu El-Reash *et al*, 2013).

The electronic absorption spectra of the Co (II) complex (2) show a single transition, $4A_2(F)$ $^4T_1(P)$ ν_3, which is composed of two humps at (14328) cm^{-1}. The observed band is expected to split because of the distortion of the Jahn-other two bands, ν_1 and ν_2, are below the limits of the spectrophotometer. According to (Jafar *et al.*, 2016), the complex (7) displayed bands at 10502, 16423, and 20511 cm^{-1}, which suggest an octahedral geometry surrounding Co(II) ions.

A band ν_3 at (14788) cm^{-1} is present in Ni (II) complex (3) electronic spectra because of the $^3T_1(F) \longrightarrow {}^3T_1(P)$ transition in tetrahedral geometry (Kulkarni *et al.*, 2012). The other two bands, ν_1 and ν_2, are situated at the lower end of the spectral range, below the measurable range of the spectrophotometer. However, complex (8) displays three bands at (11869), (13769), and (24642), indicating that the Ni(II) ions exhibit an octahedral coordination geometry (Abu El-Reash *et al.*, 2013).

Cu(II) complex's (4) electronic spectrum displayed a wide band at (11675) cm^{-1} that was ascribed to the $^2T_2 \longrightarrow {}^2E$ transition. This band is similar to complexes with tetrahedral structures (Mahadev *et al*., 2018). A band of absorption at 15365 cm^{-1} and 17768 cm-1 was observed in complex (9) and is caused by two or three d-d transitions. The Cu(II) ion appears to have octahedral geometry, according to $^2B_1g \longrightarrow {}^2A_1g$, $^2B_1g \longrightarrow {}^2B_2g$, and $^2B_1g \longrightarrow {}^2Eg$ (Nagesh and Mruthyunjayaswamy, 2015; Mahmood *et al.,* 2020).

Only one band, representing the charge transfer spectra, is visible in the Zn(II) complex (5,10) electronic spectrum at (35901 and 35097) cm^{-1}, respectively. This indicates that complexes have an octahedral geometry, whereas complex (5) has a tetrahedral geometry (Hassan *et al.,* 2015).

Magnetic Measurements

The magnetism of the prepared complexes was measured as follows:

Practical research has revealed that the magnetic moment for manganese (II) complex (1) is 5.58B.M., which is in agreement with the complex's tetrahedral structure. However, the complex (6) exhibits a high spin state and a magnetic moment (5.79 B.M.) that is noticeably near the computed Spin-only magnetic moment corresponding to five unpaired electrons. and this value is in line with the manganese (II) complex's octahedral structure (Cotton *et al.*, 1999; Hassan *etal*.,2018).

Magnetic moments of 4.60 BM were obtained from the cobalt complex of the prepared ligands (2), and this value is in agreement with the tetrahedral structure. (Nicholls, 1973); however, complex (7) magnetic moment is 4.57, which is in line with the cobalt (II) complex's octahedral structure (David *et al.*, 2025).

The magnetic moment of nickel complexes (3) was 4.02 B.M., which is generally consistent with the tetrahedral shape of nickel (II) complexes (Patel and Ikekwere, 1981). Because of the orbital contribution, the practical values were high. The octahedral structure of the nickel (II) complex is consistent with the magnetic moment of complex (8), which is 3.58 (Alshamsi *et al*., 2015).

The magnetic moment of the copper (II) complexes (4) was 2.62B.M. It was demonstrated that it agrees with the tetrahedral copper (II) complex in accordance with the electronic spectra. However, complex (9) has a magnetic moment of 1.73, which is in line with the copper (II) complex's octahedral structure (Al-adilee *et al*., 2021).

Zn^{+2} complexes are projected to exhibit diamagnetic behavior and their structural arrangement is expected to resemble that of the Ni(II), Co(II), and Cu(II) complexes, as evidenced by the metal composition analysis and infrared spectral data (Abdljabar and Tariq, 2024).

Table 4: UV spectra and magnetic moments of compounds

No	Compounds	Absorption bands	Transition	Band maxima λ cm^{-1}	μ_{eff} (B.M.)
1	$[Mn(L)Cl_2]$	---	---	36342	5.58
2	$[Co(L)\ Cl_2]$	14328	$^4A_2(F) \rightarrow\ ^4T_1(P)$	36872	4.60
3	$[Ni(L)\ Cl_2]$	14788	$^3T_1(F) \rightarrow\ ^3T_1(P)$	37868	4.02
4	$[Cu(L)\ Cl_2]$	11675	$^2T_2 \rightarrow\ ^2E$	35734	2.62
5	$[Zn(L)Cl_2]$	---	---	35901	---
6	$[Mn(L)_2Cl_2]$	19761 25437 26983	$^6A_1g \rightarrow\ ^4T_1g(^4G)$ $^6A_1g \rightarrow\ ^4A_1g(^4G)$ $^6A_1g \rightarrow\ ^4Eg(^4D)$	35795	5.79
7	$[Co(L)_2Cl_2]$	10502 16423 20511	$^4T_1g(F) \rightarrow\ ^4T_2g(F)$ $^4T_1g(F) \rightarrow\ ^4A_2g(F)$ $^4T_1g(F) \rightarrow\ ^4T_1g(p)$	36791	4.57
8	$[Ni(L)_2Cl_2]$	11869 13769 24642	$^3A_2g(F) \rightarrow\ ^3T_2g(F)$ $^3A_2g(F) \rightarrow\ ^3T_1g(F)$ $^3A_2g(F) \rightarrow\ ^3T_1g(p)$	36321	3.58
9	$[Cu(L)_2Cl_2]$	15365 17768	$^2B_1g \rightarrow\ ^2A_1g$ $^2B_1g \rightarrow\ ^2Eg$	36478	1.73
10	$[Zn(L)_2Cl_2]$	---	---	35097	---

Antibacterial activity

Hinton Mueller agar was used to prepare the agricultural medium in accordance with the guidelines provided by the Indian company that classified the product. After dissolving 38 grams of agar in one liter of boiling distilled water and bringing the pH of the agricultural medium to 7.2, the mixture was put in an autoclave at 121°C and 150 pounds per square inch of pressure for 15 minutes. When the solution reached 50°C, the culture solution was transferred into Petri dishes up to 2 mm thick each, allowed to solidify, and then the samples were incubated at 37°C for 24 hours to make sure the culture medium was free of contaminants.

The ligand and complexes' biological activity was assessed against specific strains of the G(+) bacteria *Bacillus*, *Staphylococcus aurous* and the G(-) bacteria *Klebsiella pneumonia, E. coli.* The results obtained have been tabulated and displayed in Table 5, Figure 3, and Graph 1. According to the results, the complexes' ligand activity against the bacteria used in this study was deemed to be less than effective.

Table 5: The antibacterial activity of ligand and their complexes

No. complex	Compound	*Klebsiella pneumoniae (mm)*	*Bacillus (mm)*	*Staphylococcus aurous (mm)*	*E. coli (mm)*
1	$[Mn(L)Cl_2]$	19	20	---	---
2	$[Co(L)\ Cl_2]$	23	23	---	---
3	$[Ni(L)\ Cl_2]$	19	20	---	---
4	$[Cu(L)\ Cl_2]$	11	18	---	---
6	$[Mn(L)_2Cl_2]$	---	---	32	28
7	$[Co(L)_2Cl_2]$	---	---	33	30
8	$[Ni(L)_2Cl_2]$	---	---	34	29
9	$[Cu(L)_2Cl_2]$	---	---	38	26
Control	L	14	25	29	26

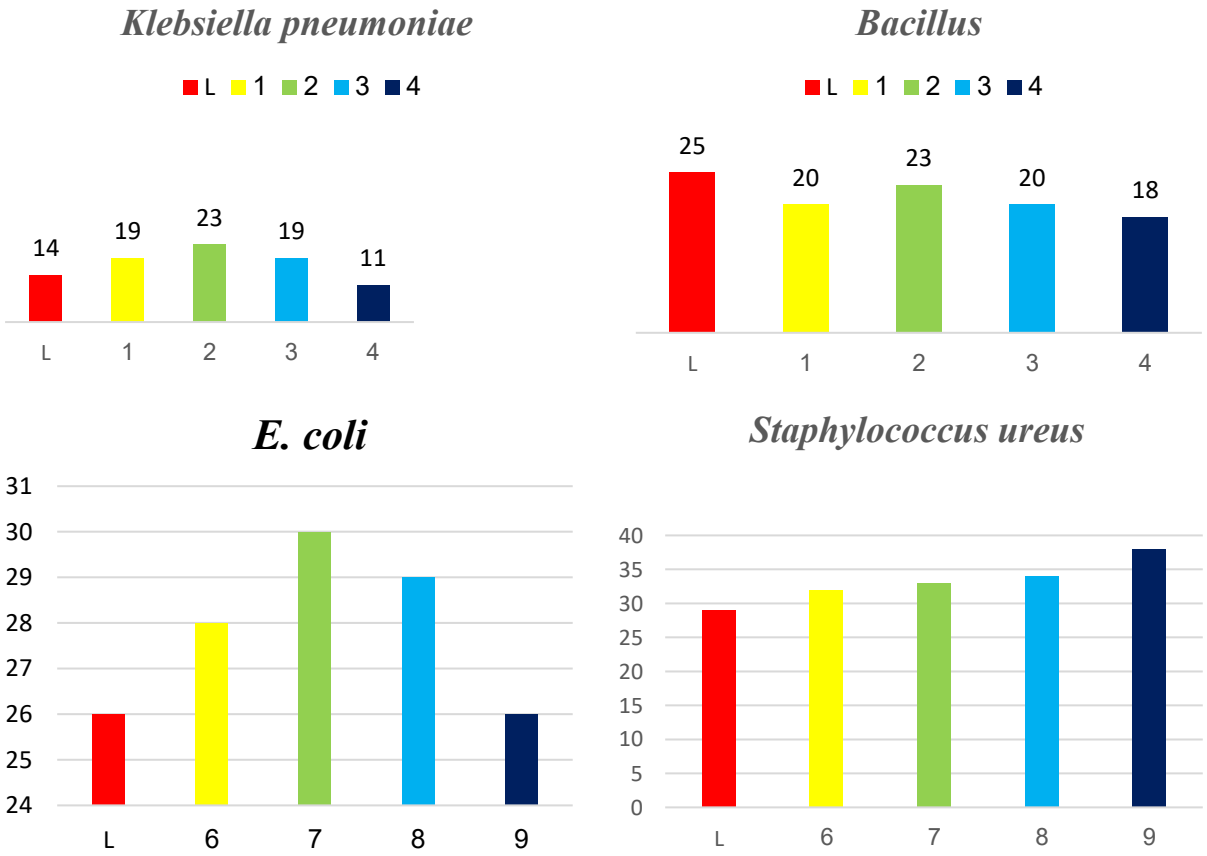
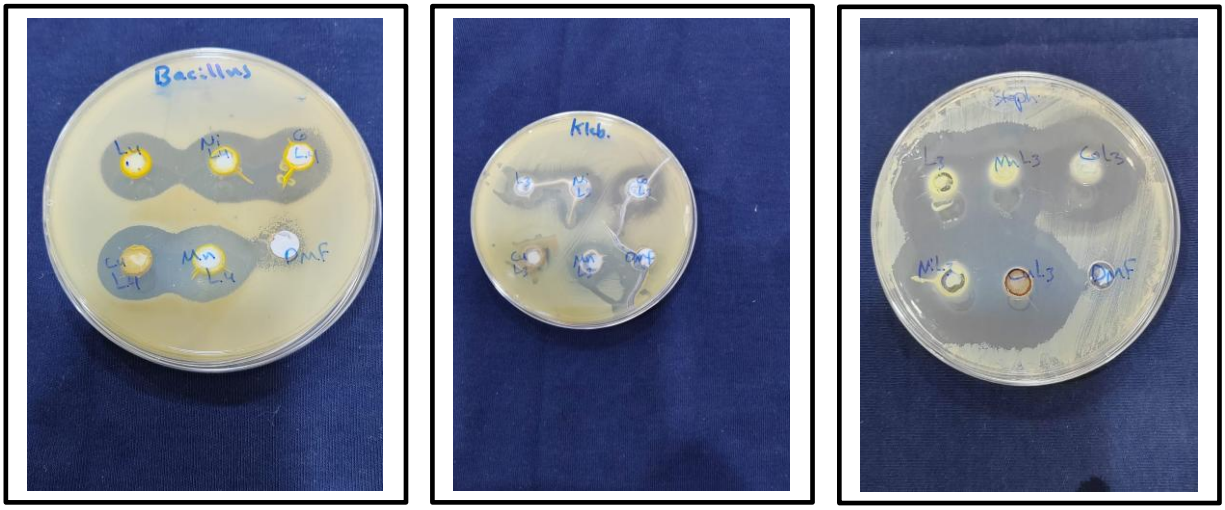


Fig (3): The antibacterial activity of the studied compounds



Graph (1): Antibacterial activity of the compounds

CONCLUSIONS

Using physio-chemical techniques, the ligands along with their corresponding complexes were synthesized and analyzed. The measured conductance per mole of mononuclear Mn(II), Co(II), Ni(II), Cu(II), and Zn(II) was non-electrolytic. The spectroscopic data of metal complexes containing the ligand L's nitrogen and oxygen groups. Because of this, all complexes have tetrahedral or octahedral structures, and the impact of bacteria on ligands and some of the complexes has been studied.

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تحضير وتشخيص معقدات بعض العناصر الانتقالية مع N–(4 –فينيل ثيازول–2–يل) بنزاميد وتقييم نشاطها البيولوجي

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الملخص

لتحضير الليكاند N-(4 - فينيل ثيازول-2-يل) بنزاميد الجديد، تم تكثيف 4–فينيل ثيازول–2–أمين، وكلوريد البنزويل في الإيثانول بنسبة مولارية 1:1 مع أسيتات الأمونيوم. ولتكوين معقدات(Mn(II)، Co(II)، Ni(II)، Cu(II)، وZn(II))، يتم تفاعل الليكاند المذكور أعلاه مباشرةً مع كلوريدات الفلزات في وسط إيثانولي بنسبة مولارية 1:1 أو 2:1 (ليكاند: فلز). تم استُخدم التحليل العنصري، والدراسات الطيفية (FTIR، UV/vis)، وقياسات الرنين المغناطيسي النووي أحادي الهيدروجين، وقياسات الموصلية، وقيم الأطياف الإلكترونية لتشخيص المعقدات المُحضرة. فقد أظهرت النتائج وجود شكل هندسي رباعي السطوح وثماني السطوح حول أيونات الفلز، كما تم دراسة التأثير التثبيطي لبعض المعقدات المحضرة على أنواع مختلفة من البكتيريا، وهي , *Bacillus Staphylococcus aurous*, *Klebsiella pneumonia, Ecoli.* . وفقًا للنتائج، كان للمركب (9) ذو الصيغة $[Cu(L)_2Cl_2]$ تأثير أكبر على مختلف أنواع البكتيريا مقارنة مع المركبات الأخرى، والتي كانت ذات فعالية أقل.

الكلمات الدالة: التريازول، معقدات، فلز انتقالي، *Staphylococcus aurous*.