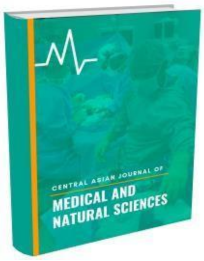

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Article

Synthesis, Characterization, Antibacterial and Antioxidant Of New 3,3'- ((1E,1'E) - ((4H-1,2,4-Triazole-3,5- Diyl) Bis (Azaneylylidene)) Bis (Methaneylylidene)) Diphenol With Some Transition Metal Ions

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Abstract: Triazole-based compounds are widely studied due to their diverse biological properties, including antimicrobial and antioxidant activities. Schiff base derivatives of triazoles have garnered attention for their potential coordination with transition metals, enhancing their pharmacological efficacy. While several triazole-based ligands have been synthesized, their structural elucidation, biological evaluation, and coordination with metal ions such as Co(II) and Cu(II) require further exploration to establish their full therapeutic potential. Knowledge Gap: Limited studies provide a detailed correlation between the spectroscopic characteristics, antioxidant capacity, and antibacterial effects of newly synthesized triazole Schiff bases and their transition metal complexes. This study aims to synthesize a novel Schiff base derived from 4H-1,2,4-triazole-3,5-diamine and 3-hydroxybenzaldehyde, characterize its structure using various spectroscopic methods, and evaluate its antioxidant and antibacterial activities, both as a free ligand and in complexation with Co(II) and Cu(II) ions. Structural characterization confirmed the formation of a Schiff base with successful coordination to metal ions in a 1:1 stoichiometry. The ligand demonstrated moderate antioxidant activity, with lower DPPH scavenging efficiency than ascorbic acid. Antibacterial testing revealed moderate inhibitory effects against Klebsiella and E. coli, with enhanced activity in the metal complexes. This study introduces a novel triazole-derived Schiff base and its Co(II) and Cu(II) complexes, supported by comprehensive spectroscopic and biological analyses. The results suggest that metal complexation can improve the biological activity of Schiff base ligands, indicating potential applications in the development of new antimicrobial and antioxidant agents.

Keywords: Triazole, Heterocyclic, Antioxidant, Antibacterial

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1. Introduction

Triazoles are five-membered heterocyclic compounds consisting of three nitrogen and two carbon atoms [1]. They exist in two forms of tautomerism 1,2,4-triazole and 1,2,3-triazole, be based on positions of the nitrogen atoms, as illustrated in Figure 1 [2]. The triazole ring is featured in the structure of numerous biological active classes, including Many biological active classes contain a triazole nucleus, including anticancer [3], [4], antiviral [5], anti-inflammatory [6], [7], antiepileptic [8], anticonvulsant [9], antidepressant [10], antidiabetic [11], antianxiety [12], antitubercular [13], antimicrobial

[14], antibacterial [15], antifungal [16], [17], antimalarial [18], and antioxidant [19], [20], [21]. Additionally, several triazole compounds are commercially marketed as medication [22]. The structures of triazole have such a high therapeutic potential therefore they can link to the enzymes and receptors through weak bonding such as ion-dipole, hydrophobic influence, hydrogen bonds and Van der Waals assess [23]. As research on triazole compounds expands.

Figure 1. Triazoles.

2. Materials and Methods

2.1 Materials and Instruments

All solvents and reagents which used in this work were analytical grade and obtained from commercially reliable sources. The chemicals' purity was determined using (TLC) on Merck silica gel. Electro thermal IA9300 melting point equipment. The Shimadzu FTIR 8400s was used to capture infrared spectra, and the data was given in wavenumbers (cm-1). Bruker Advance NMR spectrometer with frequencies of 300 MHz.

2.2. Synthesis of Ligand (L)

The ligand was synthesized according to the reporte [24] in literature her. The ligand was synthesized by reflux heating a admixture (0.01 mol, 0.99 g) of [4H-1,2,4-triazole-3,5-diamine] with (0.01 mol, 1.22 g) of (3-hydroxybenzaldehyde) and add drops of acetic acid to ethanol for (3 hours), using TLC to monitor the progress of the reaction. Allow the mixture to cool . The product precipitate was filtered off and crystallized from ethanol. The synthesis scheme is depicted in Scheme 1.

2.3. Synthesis of The Complexes

(0.01 mol) of the ligand has been solved in 25 ml of ethanol and mixed with (0.005 mol) of Co(II) (M1) and Cu(II) (M2) chloride. This mixture had been refluxed for 4 hours, and the end result had been filtrated and washed by water then crystallized from ethanol [24]. The synthesis scheme is illustrated in Scheme 2.

3. Results and Discussion

The synthesized Schiff bases was outlined in Scheme (1), the ligand derived from (3,5-diamino-4H-1,2,4-triazole) , (3-hydroxybenzaldehyde) is colored crystalline solids. The purity of the structure of the title chemical was validated using spectral data and elemental analysis. All spectral and analytical results were in accordance with the specified structures, for all complexes, the elemental anatomy shows a (1:1) ligand- metal stoichiometry shown at Tabel 1.

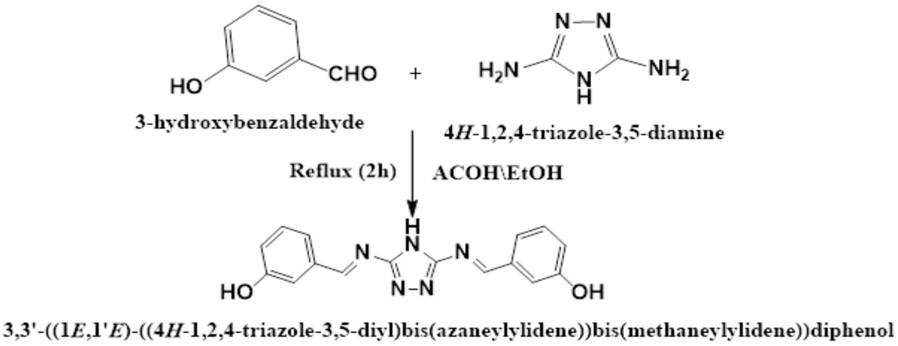

Figure 2. Scheme 1.

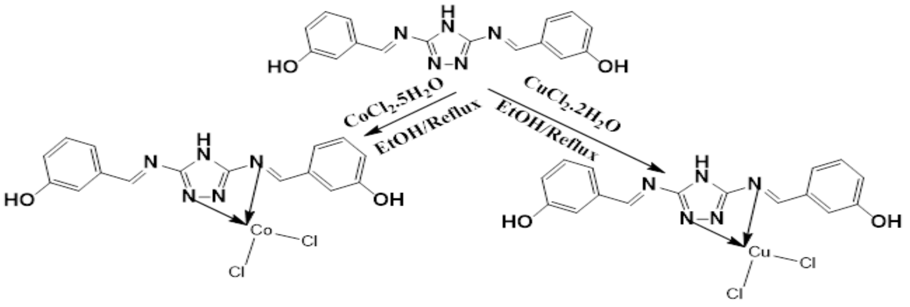

Figure 3. Sheme 2.

Table1. Show The Analytical and Physical date For The Substances.

Compound	Colure	Elemental analysis			M% found (Calc)
		C% found (calc)	H% found (calc)	N% found (calc)	
$C_{16}H_{13}N_5O_2$(L)	Yellow	61.89(62.53)	5.12(4.26)	23.45(22.79)	
[CO(L)Cl_2]	Olive green				4.72(13.48)1
[Cu(L)Cl_2]	Brown				15.63(14.82)

3.1 FTIR Spectrum

The FTIR spectrum showed at Fig 2, 3 and 4 clear absorption bands were detected at (3455) ,(3053), (3026), (1665) cm-1 for v (OH) , v (N-H), v (CH) aromatic, v(C=N) azomethine groups respectively .while (1613) cm-1 due to (C=N) in triazole ring, (1591) cm-1 for v (C=C) group, (1328 , 1239) cm-1 due asy and sy v(C-N-C) group respectively, The azomethine group was shifted to a lower frequency (1525-1593 cm-1) when complex formation, confirming that the nitrogen atom of the azomethine group coordinated with the metal ion in all complexes. The appearance of a band in the range (475–515) cm-1 in complexes which confirmed the coordination, the spectrum assigned to ν(M-N) vibrations [24]. FT-IR data of the synthesized compounds were gathered in the Table 2, as shown in Figure 4, 5, and 6.

Table 2. FT-IR Data of The Compounds.

Comp.	ϒ (O-H)	ϒ (N-H)	ϒ (C-H) Aromatic	ϒ (C=N) Azomethane	ϒ (C=N) Triazole Ring	ϒ (C=C)	ϒ (M-N)
L	3455	3053	3026	1665	1613	1591	
Co(L)Cl_2	3452	3042	3012	1643	1592	1568	478
Cu(L)Cl_2	3319	3060	3010	1642	1572	1538	554

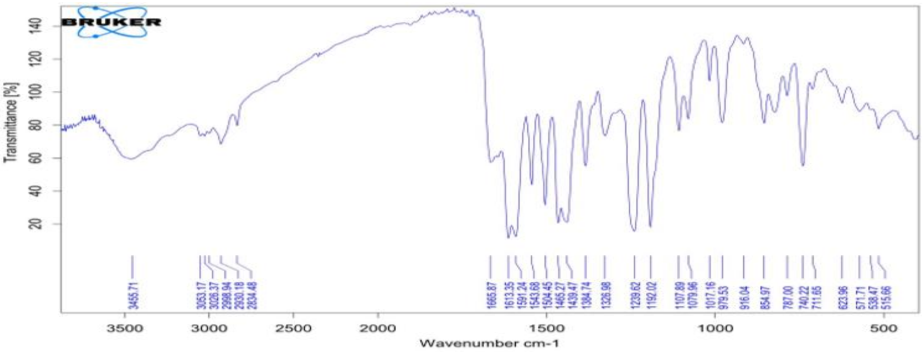

Figure 4. lR Spectra of L

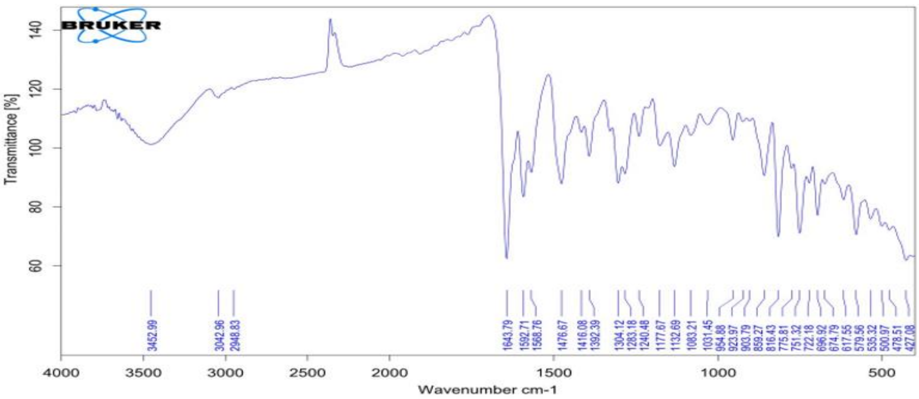

Figure 5. lR Spectra of M1.

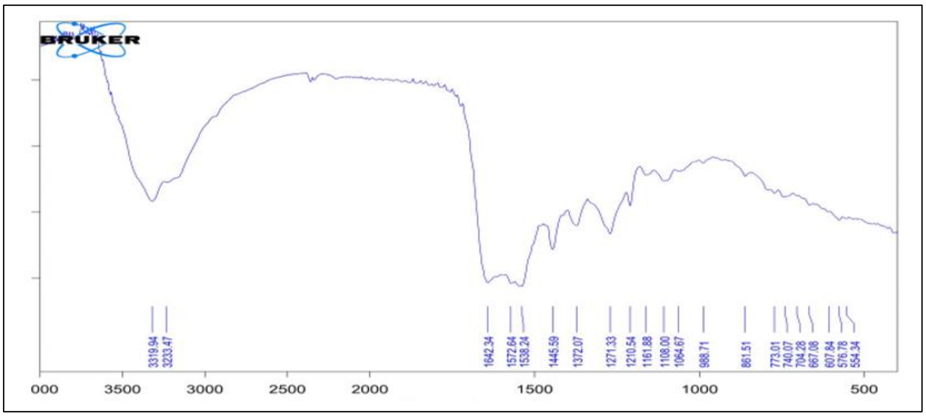

Figure 6. lR Spectra of M2.

3.2 1H- NMR and 13C- NMR Spectrum

1H-NMR of the (L) shows a peak at δ [(14.34) ppm, singlet, due to the (NH)] proton in the triazole ring [25], and a singlet signal at δ (11.20) ppm, indicating the (OH) phenolic proton. The azomethine proton generates a singlet peak at δ (9.41) ppm, multi peak at δ (6.84-7.37) ppm are assigned for aromatic protons. An additional two peak at (2.51 and 3.39) ppm is attributable to protons of DMSO and water, respectively, as seen in Figure 7. 13C NMR spectrum

13C NMR spectrum of (L) showed two peaks at (166.47 and 163.53) ppm that were attributed to azomethine (C=N) oxo group carbon and (C=N) in triazole ring respectively, signal at (157.94) ppm for the carbon of (C-OH) phenolic group,the signals of aromatic carbons in the ring were observed in the range of (119.70-157.94) ppm as shown in Figure 8.

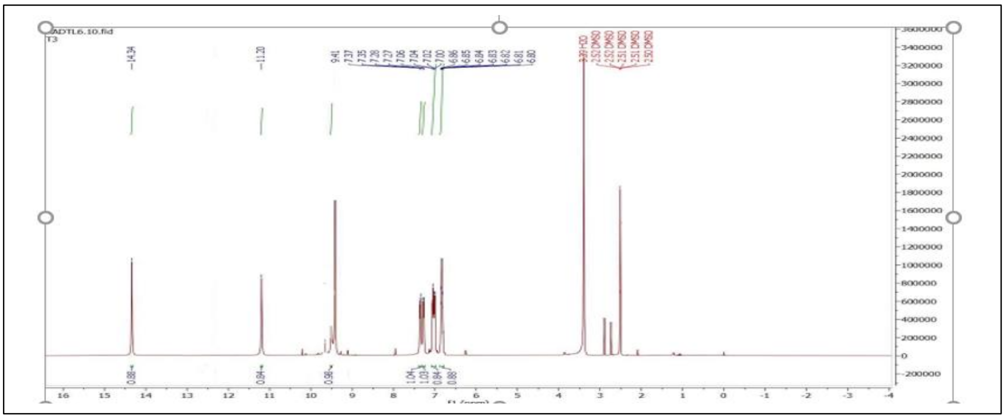

Figure 7. 1H-NMR spectra of L.

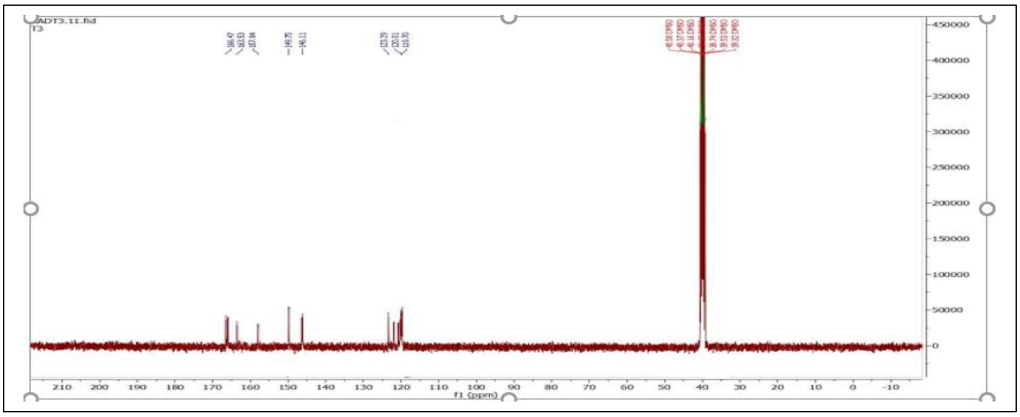

Figure 8. 13C-NMR spectra spectra of L.

3.3 Mass Spectra

Mass spectrum (MS) results validate the structure of the produced 1,3,4-triazole derivative ligand, as depicted in Scheme (3) and Figure 9. (MS) pectra for the ligand revealed a peak at (307 m/z) due to the ligand's molecular ion [C16H13N5O2]+ and a peak at (73 m/z) for the [C2H7N3] base peak, with the additional fragment peaks depicted in scheme(3). The mass of the Co(II) complex appeared a molecular ion peak at (437 m/z) for [Co(L)Cl2], as shown in fig. (8), and the mass of the Co(II) complex revealed a peak at (441 m/z) for a molecular ion of [Cu(L)Cl2], as shown in Figure 12.

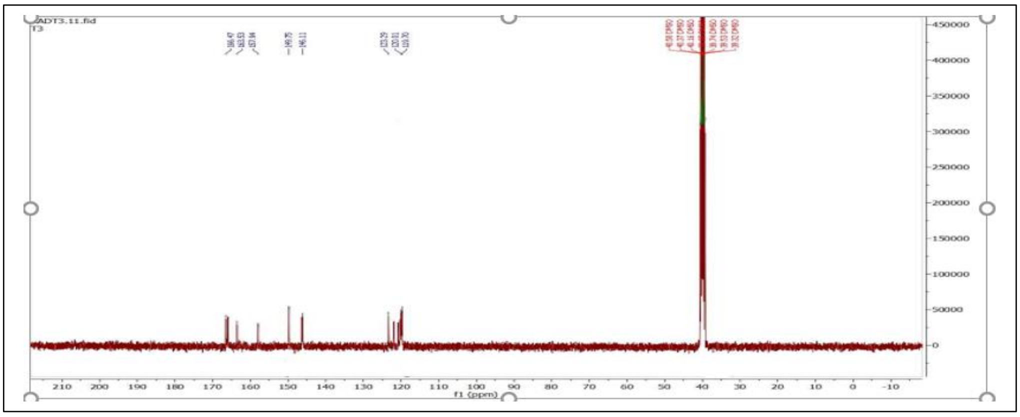

Figure 9. MS spectra of L.

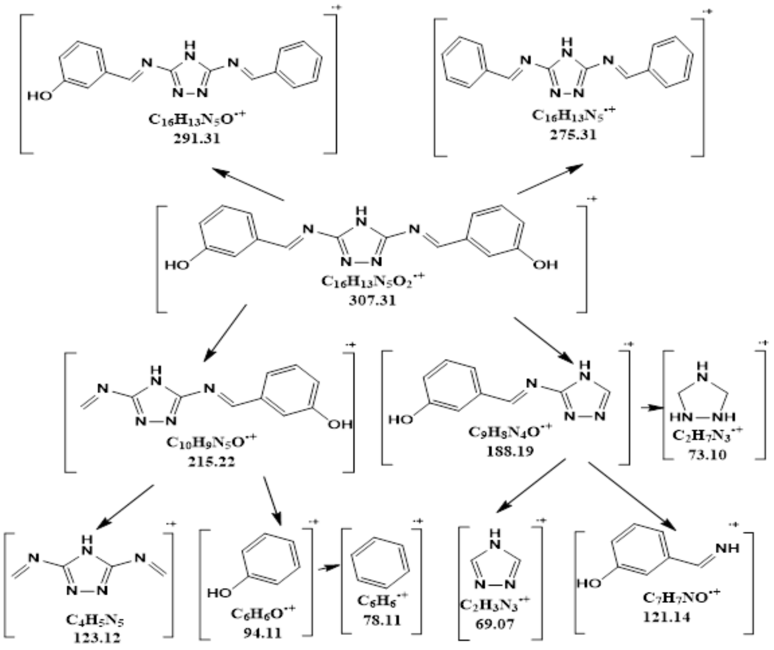

Figure 10. Scheme: Fragmentation of L.

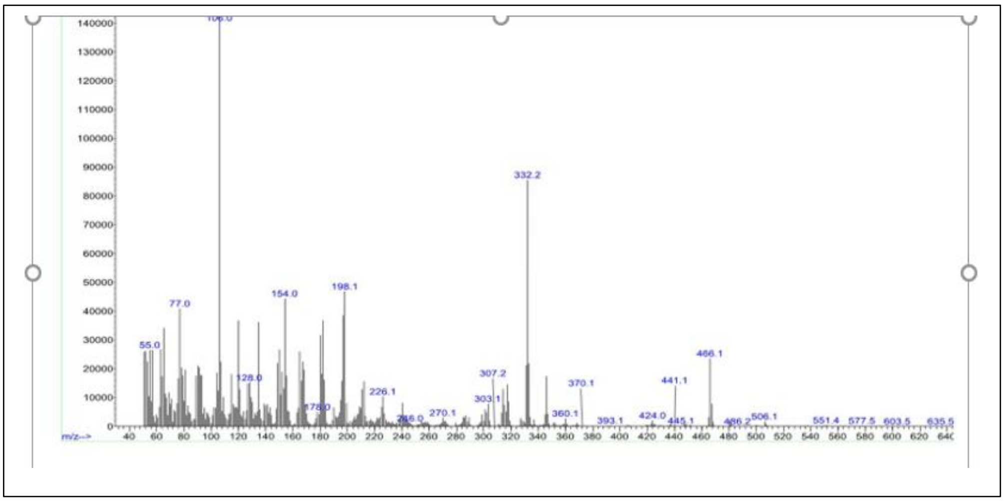

Figure 11. MS Spectra of M1.

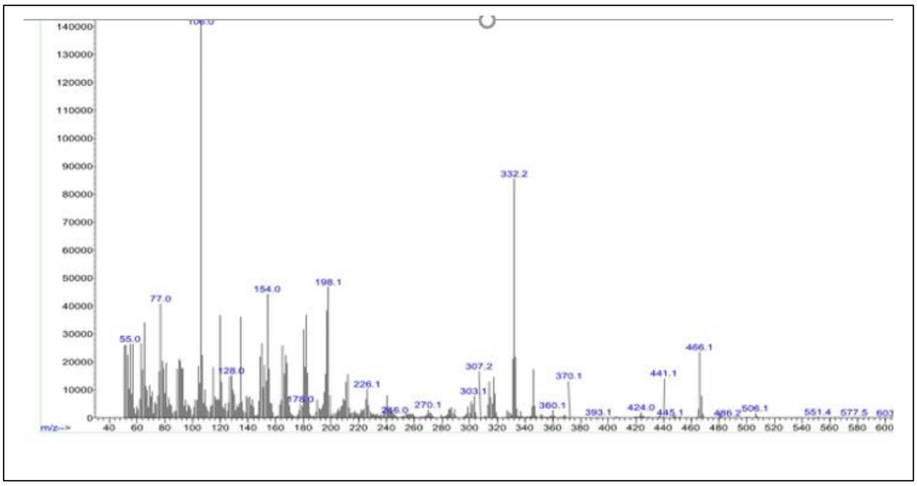

Figure 12. MS Spectra of M2.

3.4 Conductivity Measurements

The molar conductance of Co(II) and Cu(II) complex in 10−3M DMSO was determined at 25°C. The complexes had conductance values below (18-22) Ohm−1·cm2·mol−1] indicating that they are no electrolytes.

3.5 Evaluation of Antioxidant Activity.

The evaluation activity of the free radical scavenging (DPPH) is a classic test in antioxidant activity research. One milliliter of a solution contained 102 μg of the ligand in ethanol. Then, it was combined with an equivalent concentration of (DPPH) solution,The produced solution steady for incubation at (25 °C) for (30-60) minutes. The decreases in the concentration of (DPPH) solution were assessed using the absorbance at (517) nm. The test was compared by using the ascorbic acid (vitamin C) as an internal standard instead of the ligand. Using [26]. The percentage scavenging of (DPPH) solution of each test chemical was determined from the absorbance of the negative control. The ligand has lower antioxidant activity than vitamin C, as indicated in Table 3 and Figure 13. The ligand contains hydrogen atoms, which can be provided. DPPH creates a violet/ purple coular in an ethanol solution that turns to a yellow coular in the existence of antioxidants.

Table 3. Scavenging Activity Data of The Ligand

Concentrationμg mL^{-1}	**Scavenging % (Mean±SD)**	
	Ascorbic Acid	**Ligand**
200	81.2±2.6	41.51±4.7
100	73.81±1.4	28.60±2.13
50	66.08±1.5	24.46±0.50
25	52.73±1.25	21.21±4.31
12.5	22.03±12.41	15.02±1.11

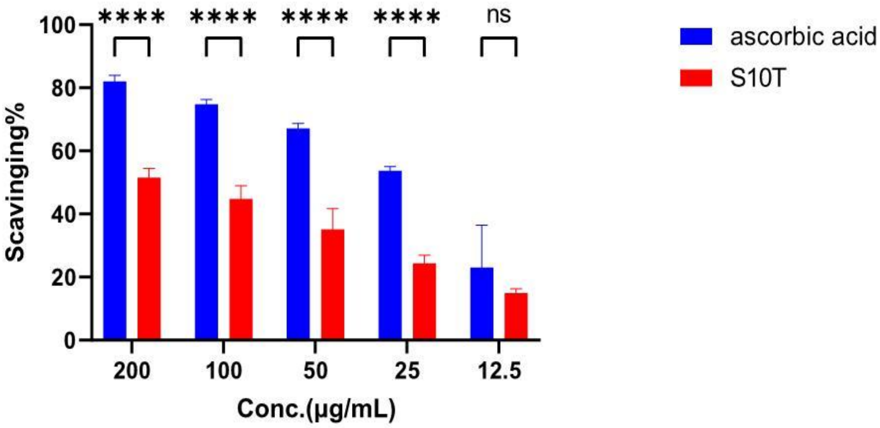

Figure 13. Scavenging Activity of L.

3.6 Antibacterial Activity Test

The test was carried out using the disc diffusion method. The synthesized compounds were evaluated against strain-negative (bacteria Escherichia coli) and strain-positive (bacteria klebsilla) (Table 4). Whatman no.1 filter paper disc with a diameter of 5mm was autoclaved at 121°C for 15 minutes. The sterile discs were impregnated with various chemicals (800µg each disc), see Figure 14. The plates of agar were injected uniformly with 00°µL from each culture of examined microorganisms. The impregnated disc was put on the medium at a suitable spacing To achieve good dispersion, the plates were incubated for one hour at 5°C, before being transferred to an incubator for 24 hours [27] at 37°C. An inhibitory zone induced by various chemicals on microorganisms were studied.

Table 4. Antibacterial Data (Zone Of Inhibition In Mm) of Ligand and Co(II) and Cu(II) Complexes.

No.	**Type**	**L1**	**$[CoLCl_2]$**	**$[CuLCl_2]$**
1	*klebsiella*	11	6	9
2	*E.coli*	13	12	18

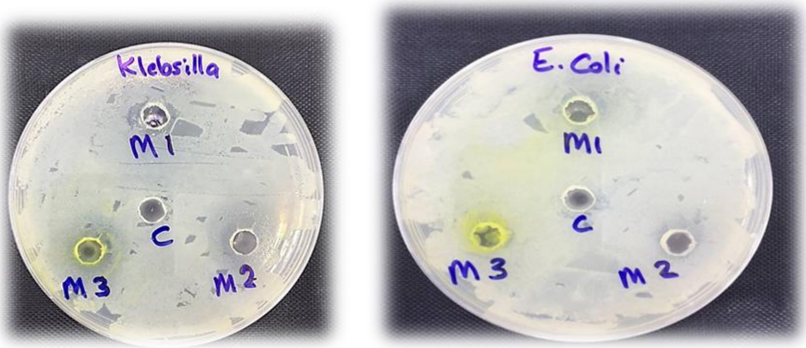

Figure 14. Antibacterial of The Ligand And Its Complexes With Cobalt And Copper Ion.

3.7 Molecular Electrostatic Potential (MEP)

(MEP) is a useful descriptor of assessing evidence on the reactivity of molecule. (MEP) surfaces indicate for the shape, location,neutral electrostatic potentials and magnitude of positive, negative,. This information explains the relationship between the molecular structure and reactivity to nucleophilic and electrophilic attack, see Figure 15, 16, 17, and 18 shows that the highest negative electron potential is the ideal place for electrophilicity. Attacks are displayed in red [28]. Using (Hyper Chem 8.0) program and semi-empirical theoretical with the PM3 method to appraisal the optimization of the molecular structure of the ligand and complexes, the geometric structure is appears as square planar for the cobalt complex and tetrahedral for the copper complex, with coordination occurring between a metal and nitrogen atoms [29].

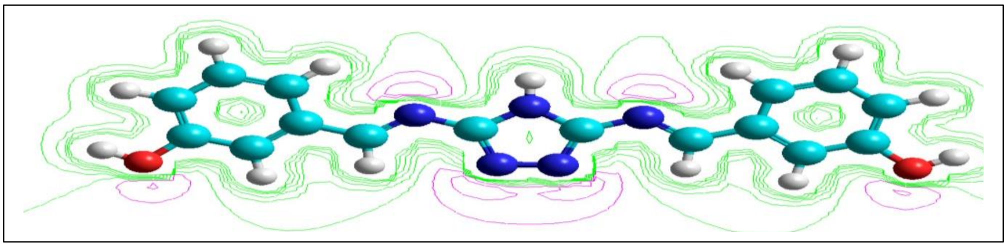

Figure 15. Molecular Electrostatic Potential (MEP) as Contours for The Ligand

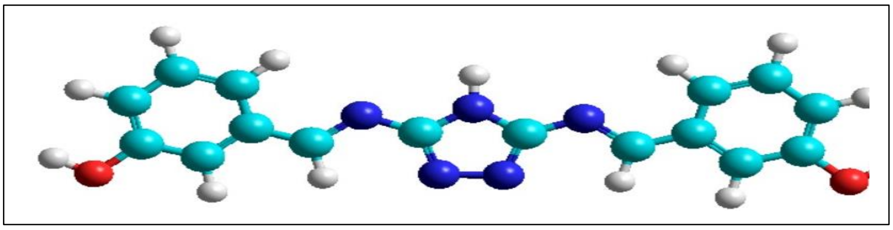

Figure 16. Geometry of L

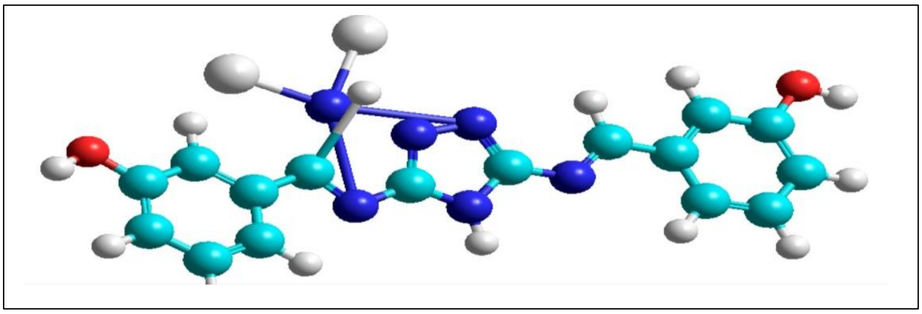

Figure 17. The geometries of the M1

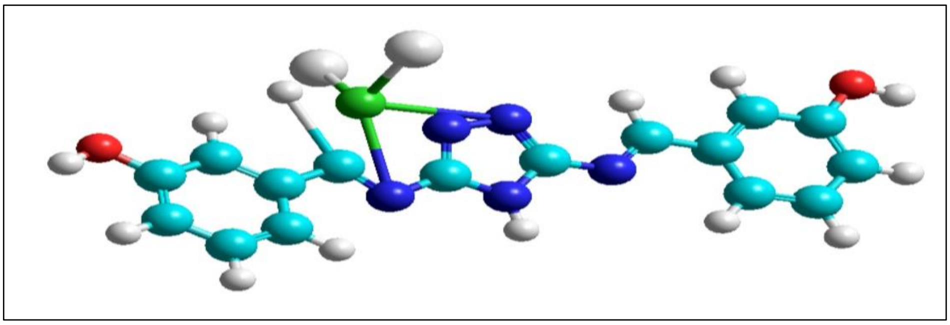

Figure 18. The geometries of the M2.

4. Conclusion

Schiff base Ligand and its Complexes were synthesized and characterized by different experimental techniques such as elemental analysis, FTIR, 1HNMR and mass spectroscopy, The antibacterial screening of the ligand and the complexes against four bacterial strains. The synthesized compounds showed moderate antibacterial activities, the ligand showed significant antioxidant activity.

REFERENCES

[1] C. H. Zhou and Y. Wang, "Recent Researches in Triazole Compounds as Medicinal Drugs," *Curr. Med. Chem.*, vol. 19, no. 2, pp. 239–280, 2012, doi: 10.2174/092986712803414213.

[2] X. Peng, M. CGX, and Z. CH, "Recent Developments in Azole Compounds as Antibacterial and Antifungal Agents," *Bentham Science Publishers*, pp. 1963–2010, 2013.

[3] A. K. Zaid, "Synthesis, Characterization, and Computational, Biological Studies of Four-membered Cyclic Amides 2-azetinones," *J. Chem. Health Risks*, vol. 12, no. 4, pp. 665–674, 2022.

[4] A. K. Zaid, "Synthesis, Characterization, and Computational Study of Novel Thiazolidinone Derivatives Containing the Indole," *J. Med. Chem. Sci.*, vol. 6, pp. 346–354, 2023.

[5] N. Agouram, "1,2,3-triazole derivatives as antiviral agents," *Med. Chem. Res.*, vol. 32, no. 12, pp. 2458–2472, 2023, doi: 10.1007/s00044-023-03154-3.

[6] S. M. Li, J. Y. Chou, S. E. Tsai *et al.*, "Synthesis and anti-inflammatory activity evaluation of NO-releasing furoxan/1,2,4-triazole hybrid derivatives," *Eur. J. Med. Chem.*, vol. 257, p. 115496, 2023, doi: 10.1016/j.ejmech.2023.115496.

[7] M. J. Vaishnani, S. Bijani, M. Rahamathulla *et al.*, "Biological importance and synthesis of 1,2,3-triazole derivatives: a review," *Green Chem. Lett. Rev.*, vol. 17, no. 1, 2024, doi: 10.1080/17518253.2024.2307989.

[8] X. Deng, H. Sun, and B. G. M. Youssif, "Editorial: Pharmaceutical insights into the triazoles: Recent advances," *Front. Chem.*, vol. 11, 2023, doi: 10.3389/fchem.2023.1149133.

[9] B. Kaproń, J. J. Łuszczki, A. Płazińska *et al.*, "Development of the 1,2,4-triazole-based anticonvulsant drug candidates acting on the voltage-gated sodium channels," *Eur. J. Pharm. Sci.*, vol. 129, pp. 42–57, 2019, doi: 10.1016/j.ejps.2018.12.018.

[10] A. Kanwal, U. Afzal, M. Zubair, M. Imran, and N. Rasool, "Synthesis of anti-depressant molecules via metal-catalyzed reactions: a review," *RSC Adv.*, vol. 14, no. 10, pp. 6948–6971, 2024, doi: 10.1039/D3RA06391G.

[11] S. K. Avula, S. Ullah, S. A. Halim *et al.*, "Meldrum-Based-1H-1,2,3-Triazoles as Antidiabetic Agents: Synthesis, In Vitro α-Glucosidase Inhibition Activity, Molecular Docking Studies, and In Silico Approach," *ACS Omega*, vol. 8, no. 28, pp. 24901–24911, 2023, doi: 10.1021/acsomega.3c01291.

[12] K. N. Ankali, J. Rangaswamy, M. Shalavadi, N. Naik, and G. K. Naik, "Synthesis and Molecular Docking of novel 1,3-Thiazole Derived 1,2,3-Triazoles and In vivo Biological Evaluation for their Anti anxiety and Anti inflammatory Activity," *J. Mol. Struct.*, vol. 1236, p. 130357, 2021, doi: 10.1016/j.molstruc.2021.130357.

[13] R. D. Bakale, S. M. Sulakhe, S. L. Kasare *et al.*, "Design, synthesis and antitubercular assessment of 1,2,3-triazole incorporated thiazolylcarboxylate derivatives," *Bioorg. Med. Chem. Lett.*, vol. 97, p. 129551, 2024, doi: 10.1016/j.bmcl.2023.129551.

[14] S. Saffour, A. A. AL-Sharabi, A. E. Evren, M. Y. Cankiliç, and L. Yurttaş, "Antimicrobial activity of novel substituted 1,2,4-triazole and 1,3-thiazole derivatives," *J. Mol. Struct.*, vol. 1295, p. 136675, 2024, doi: 10.1016/j.molstruc.2023.136675.

[15] R. Reddyrajula, U. Etikyala, V. Manga, and U. K. Dalimba, "Discovery of 1,2,3-triazole incorporated indole-piperazines as potent antitubercular agents: Design, synthesis, in vitro biological evaluation, molecular docking and ADME studies," *Bioorg. Med. Chem.*, vol. 98, p. 117562, 2024, doi: 10.1016/j.bmc.2023.117562.

[16] S. Sadeghian, L. Emami, A. Mojaddami *et al.*, "1,2,4-Triazole derivatives as novel and potent antifungal agents: Design, synthesis and biological evaluation," *J. Mol. Struct.*, vol. 1271, p. 134039, 2023, doi: 10.1016/j.molstruc.2022.134039.

[17] Z. Kazeminejad, M. Marzi, A. Shiroudi, S. A. Kouhpayeh, M. Farjam, and E. Zarenezhad, "Novel 1,2,4-Triazoles as Antifungal Agents," *Biomed Res. Int.*, vol. 2022, p. 4584846, 2022, doi: 10.1155/2022/4584846.

[18] L. Ravindar, S. A. Hasbullah, K. P. Rakesh, and N. I. Hassan, "Triazole hybrid compounds: A new frontier in malaria treatment," *Eur. J. Med. Chem.*, vol. 259, p. 115694, 2023, doi: 10.1016/j.ejmech.2023.115694.

[19] P. Berwal, S. Rohilla, N. Mathur, and K. Rani, "Synthesis, Molecular Docking, and Biological Evaluation of Novel Indole--triazole Conjugates," *Curr. Drug Discov. Technol.*, vol. 21, 2024, doi: 10.2174/0115701638295739240222074426.

[20] A. Pachuta-Stec, "Antioxidant Activity of 1,2,4-Triazole and its Derivatives: A Mini-Review," *Mini-Rev. Med. Chem.*, vol. 22, no. 7, pp. 1081–1094, 2022, doi: 10.2174/1389557521666210401091802.

[21] R. Matta, J. Pochampally, B. N. Dhoddi, S. Bhookya, S. Bitla, and A. G. Akkiraju, "Synthesis, antimicrobial and antioxidant activity of triazole, pyrazole containing thiazole derivatives and molecular docking studies on COVID-19," *BMC Chem.*, vol. 17, no. 1, p. 61, 2023, doi: 10.1186/s13065-023-00965-8.

[22] Z. Xu, S. J. Zhao, and Y. Liu, "1,2,3-Triazole-containing hybrids as potential anticancer agents: Current developments, action mechanisms and structure-activity relationships," *Eur. J. Med. Chem.*, vol. 183, p. 111700, 2019, doi: 10.1016/j.ejmech.2019.111700.

[23] D. Dheer, V. Singh, and R. Shankar, "Medicinal attributes of 1,2,3-triazoles: Current developments," *Bioorg. Chem.*, vol. 71, pp. 30–54, 2017, doi: 10.1016/j.bioorg.2017.01.010.

[24] S. A. Deodware, U. B. Barache, U. B. Chanshetti *et al.*, "Newly synthesized triazole-based Schiff base ligands and their Co(II) complexes as antimicrobial and anticancer agents: Chemical synthesis, structure and biological investigations," *Results Chem.*, vol. 3, p. 100162, 2021, doi: 10.1016/j.rechem.2021.100162.

[25] A. T. A. Boraei, A. A. Sarhan, S. Yousuf, and A. Barakat, "Synthesis of a New Series of Nitrogen/Sulfur Heterocycles by Linking Four Rings: Indole; 1,2,4-Triazole; Pyridazine; and Quinoxaline," *Molecules*, vol. 25, no. 3, p. 450, 2020, doi: 10.3390/molecules25030450.

[26] Y. Ünver, S. Deniz, F. Çelik, Z. Akar, M. Küçük, K. Sancak, "Synthesis of new 1,2,4-triazole compounds containing Schiff and Mannich bases (morpholine) with antioxidant and antimicrobial activities," *J. Enzyme Inhib. Med. Chem.*, vol. 31, no. sup3, pp. 89–95, 2016, doi: 10.1080/14756366.2016.1206088.

[27] D. Zelelew, M. Endale, Y. Melaku, *et al.*, "Synthesis, Antibacterial, and Antioxidant Activities of Thiazolyl-Pyrazoline Schiff Base Hybrids: A Combined Experimental and Computational Study," *J. Chem.*, vol. 2022, p. 3717826, 2022, doi: 10.1155/2022/3717826.

[28] M. Farrokhnia, "Density Functional Theory Studies on the Antioxidant Mechanism and Electronic Properties of Some Bioactive Marine Meroterpenoids: Sargahydroquionic Acid and Sargachromanol," *ACS Omega*, vol. 5, no. 32, pp. 20382–20390, 2020, doi: 10.1021/acsomega.0c02354.

[29] P. Horlescu, D. Sutiman, C. S. Stan *et al.*, "New Complexes of 2-(1H-1,2,4-TRIAZOL-3-YL) PYRIDINE WITH Co(II), Cd(II), Rh(III) Ions: Synthesis, Structure, Properties and Potential Applications," *Environ. Eng. Manag. J.*, vol. 14, no. 2, pp. 389–397, 2015, doi: 10.30638/eemj.2015.040.