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Ni(II) and Cu(II) Complexes of Halogenated Unsymmetrical Tetradentate Schiff Base: Synthesis, Spectral Characterization, and Appraisal of Antimicrobial and Antioxidant Properties

[1*]Abubakar Abdullahi AHMED, [1]Mohammed Baba FUGU, [1]Naomi Piyinkir NDAHI, [1]Ibrahim WAZIRI, [1]Ibrahim Mohammed WAKIL, [2]Hussaini Adam BARMA, [3]Yesufu Hassan BRAIMAH, and [4]Malik Abubakar YURARI

[1]Department of Pure and Applied Chemistry, Faculty of Physical Sciences, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria

[2]Department of Chemistry, Faculty of Science, Kashim Ibrahim University, Maiduguri, Borno State, Nigeria

[3]Department of Pharmaceutical Chemistry, Faculty of Pharmacy, University of Maiduguri, Maiduguri, Borno State, Nigeria

[4]Department of Chemistry, Faculty of Science, Yobe State University, Damaturu, Yobe State, Nigeria

***Corresponding author's Email:** abubakarabdullahiahmed28@gmail.com

ABSTRACT

Antimicrobial resistance (AMR) is one of the prime health crises bedeviling the world. The need to design a single compound capable of dual utility – as antioxidant and antimicrobial agent which will combat oxidative stress and AMR is a matter of great quest. Herein, a novel unsymmetrical Schiff base ligand (H_2L) was generated through a condensation reaction between 2-hydroxybenzaldehyde, 3-bromo-5-chlorosalicylaldehyde and *o*-phenylenediamine in ethanol under room temperature condition. Ni(II) and Cu(II) complexes were subsequently generated from reaction of the ligand with nickel(II) chloride and copper(II) chloride. These compounds were elucidated by the use of various techniques including ^{1}H NMR and ^{13}C NMR, FT-IR, HRMS, UV-visible spectroscopy, elemental analysis, molar conductance and magnetic susceptibility. The data confirmed the isolation of the ligand as unsymmetrical with the two C=N and OH groups coordinated to the metal ions, establishing four coordinate tetrahedral and square planar geometries for Ni(II) and Cu(II) complexes, respectively. Furthermore, the antimicrobial and antioxidant activities of the ligand and its complexes were evaluated by disc diffusion and DPPH techniques, respectively. The outcome unveiled the outperformance of the ligand H_2L over the complexes in antiradical efficacy but less than the standard vitamin C. The sequence of efficacy follows: vitamin C (0.004 µg/mL) > H_2L (0.036 µg/mL) > CuL (0.141 µg/mL) > NiL (no activity). In the antimicrobial assay, only CuL complex displayed activity with inhibition zone of 12 ± 0.00 mm against *Bacillus subtilis* and *Candida albicans* which corresponded to the activity index of 40.00 and 57.14 %, respectively.

Keywords: Unsymmetrical Schiff base, *o*-phenylenediamine, tetradentate, 3-Bromo-5-chlorosalicylaldehyde.

1.0 INTRODUCTION

In the past few years, coordination chemists and allied researchers have demonstrated great interest in metal-based compounds as a significant category of therapeutic agents with multifunctional potential for biological efficacies including antibacterial, antifungal, and antioxidant properties. Among the plethora ligand-types employed to ligate metal ions, Schiff bases are facile, ease-to-synthesize and stable chelate former (Boulechfar *et al.,* 2023; Felemban *et al.,* 2025). Schiff bases are classically characterized by the azomethine (C=N) possessing the nitrogen atom as binding site to the metal ion, and other heteroatoms bearing lone pairs to provide further coordination (Dağ, 2025; Mir and Banik, 2025).

Many studies have reported the antimicrobial abilities of Schiff base complexes with standout performance for Ni(II) and Cu(II) complexes, owing to the obstruction ability of cellular processes when interacted with bacterial cell walls (Al-Qadsy *et al.,* 2023; Saravanaselvam *et al.,* 2025). Recently, there have been communications of therapeutic properties of Schiff base

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complexes possessing NOON donor atoms. For instance, Sherif and co-workers (2021) described copper(II), nickel(II) and cobalt(II) complexes of Schiff bases obtained from the reaction of *o*-phenylenediamine with salicylaldehyde or *o*-vanillin. The antibacterial efficacy study revealed that the ligand L possessed moderate efficacy whereas the complexes displayed the highest efficacy. Similarly, Omar *et al.* (2025) described the synthesis of Cu(II), Zn(II), Fe(III) and Ru(III) chelates of a Schiff base derived from the reaction of 5-bromosalicylaldehyde and 4-nitro-1,2-diaminobenzene. According to the *in vitro* studies against bacteria and fungi strains, notable anti-pathogenic efficacy against the studied microbes. Moreover, the studied compounds displayed strong suppression of DPPH radical.

Motivated by the paucity of research works and efficacy of *o*-phenylenediamine-derived Schiff base with halogen substituents as therapeutic agents, we herein, reported unsymmetrical Schiff base derived from *o*-phenylenediamine, salicylaldehyde and 3-bromo-5-chlorosalicylaldehyde and then coordinated it to Ni(II) and Cu(II) ions to construct the corresponding complexes. The ligand and its metal complexes were assessed for antimicrobial and antioxidant efficacies.

2.0 Experimental

2.1 Materials and Methods

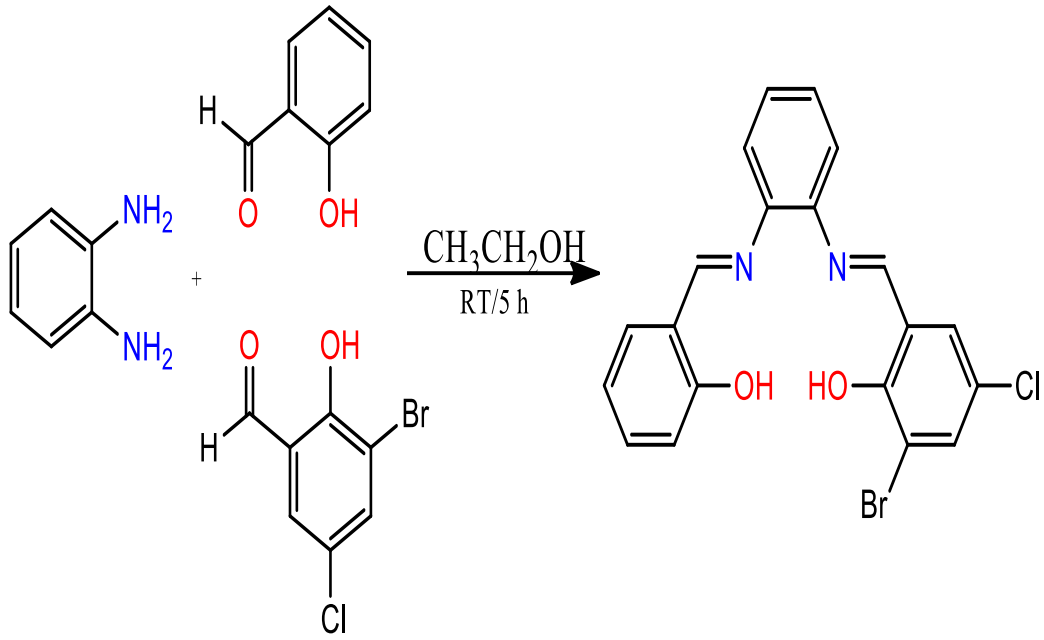
Analytical grade (AR) chemicals and solvents were purchased and utilized as received – salicylaldehyde (98 %, Merk), 3-bromo-5-chlorosalicyladehyde (98 %, Sigma-Aldrich), *o*-phenylenediamine (99.5 %, Sigma-Aldrich), ethylenediamine (98 %, LobaChemie. Pvt. Ltd, India), $NiCl_2.6H_2O$ and $CuCl_2.2H_2O$, ethanol, methanol, dichloromethane, acetonitrile, dimethylformamide and dimethylsulfoxide. Vario Elementar III microcube CHNS Analyser was employed to perform the elemental analysis. For metal content analyses, Spectro Arcos FSH12 Inductively-coupled Plasma Optical Emission (ICP-OES) Spectrometer was used. FT-IR spectra were run on a Nicolet iS5 FT-IR Spectrometer at the range of 4000-400 cm^{-1}. Bruker-500 MHz Spectrometer (500 MHz for ^1H and 125 MHz for ^{13}C) was used to obtain the ^1H and ^{13}C NMR spectra of the unsymmetrical Schiff bases ligands using DMSO-d_6 as a solvent and TMS as a reference. Mass spectra were recorded on a high-resolution mass spectrometry Waters Acquity UPLC Synapt G2HD machine. Room temperature magnetic susceptibility measurements was executed on a Sherwood MK1 Magnetic susceptibility balance with $Hg[Co(SCN)_4]$ as standard. Conductivities of 10^{-3} M solution of the complexes were measured in DMSO at 25 ◦C using a Hand-Held MP 33 Conductivity Meter.

2.2 Synthesis of the Unsymmetrical Schiff Base Ligand, H_2L

The unsymmetrical tetradentate Schiff base ligand was prepared by one-pot condensation approach (Priya *et al.*, 2024; Akbari *et al.*, 2024). Briefly, *o*-phenylenediamine (0.29 g, 2 mmol) in ethanol (15 mL) was added to an equimolar mixture of salicylaldehyde (0.21 mL, 2 mmol) and 3-bromo-5-chlorosalicylaldehyde (0.47 g, 2 mmol) each in ethanol (15 mL) that was obtained by stirring for 10 minutes in 50 mL reaction flask. The mixture was magnetically stirred at ambient temperature for 5 hours. The precipitate formed thereof was collected by gravity filtration, washed with methanol and desiccated over anhydrous $CaCl_2$. The equation for the reaction is depicted in Scheme 1.

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Scheme 1: Synthetic path for the unsymmetrical Schiff base ligand H_2L

H_2L; Colour: Bright orange, Yield: 640 mg, 75%. M. W.: 429.69 gmol^{-1}. Anal. Calcd for $C_{20}H_{14}BrClN_2O_2$: C, 55.90%; H, 3.28%; N, 6.52%. Found: C, 55.63%; H, 3.21%; N, 6.50%. ATR-FTIR (cm^{-1}): 3066.92 (O–H), 1621.67 (C=N), 1224.73 (C–O). ^{1} H NMR (400 MHz, DMSO-*d6*), δ (ppm): 12.943 (s, 1H, OH), 12.512 (s, 1H, OH), 8.997 (s, 1H, HC=N), 8.930 (s, 1H, HC=N), 7.785 (s, 1H, Ar-H^5), 7.781 (s, 1H, Ar-H^3), 7.722–7.534 (s, 2H, Sal-H), 7.520–6.983 (t, 2H, Sal-H), 6.983 (d, 2H, Ph-H), 6.968 (t, 2H, Ph-H). ^{13}C-NMR (125 MHz, DMSO-*d6*), δ (ppm)): δ 163.96 (1C, HC=N), 162.54 (1C, HC=N), 160.34 (1C, C–OH), 156.59 (1C, C–OH), 142.65 – 116.61 (Ar-C). HR-MS (m/z): 429.0004 [M + H]$^+$ (Cal. 429.0005).

2.3 Synthesis of Metal(II) Complexes

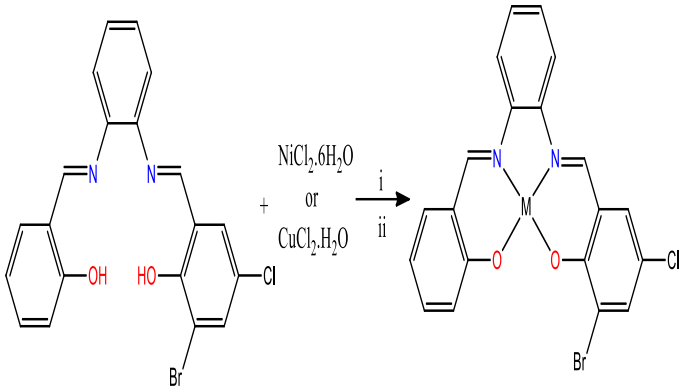
The metal salt ($NiCl_2.6H_2O$: 0.3 mmol, 0.07 g; $CuCl_2.2H_2O$: 0.3 mmol, 0.05 g) was dissolved in methanol (5 mL) and added to a stirring solution of the ligand H_2L (0.3 mmol, 0.13 g) in THF (10 mL). The mixture was refluxed for 4 h at 70 °C, whereupon product was formed. The product was separated by filtration, washed with THF and dried at room temperature (Pinchaipat *et al.*, 2024). The general reaction protocol is depicted in Scheme 2.

NiL: Colour: Reddish brown, Yield: 130 mg, 89%. Dec. Temp.: > 350 °C, M. W.: 489.37 gmol^{-1}. Anal. Calcd for [$C_{20}H_{12}BrClN_2O_2Ni$]: C, 549.39%; H, 2.49%; N, 5.76%, Ni, 12.07%. Found: C, 49.32%; H, 2.43%; N, 5.68%, Ni, 12.02%. ATR-FTIR (cm^{-1}): 1603.13 m (C=N), 1247.36 (C–O), 420.83 (Ni–O), 407.99 (Ni–N). Ω (DMSO) Scm^2 mol^{-1}: 0.0 μ (B. M.): 4.30.

CuL: Colour: Green, Yield: 120 mg, 81%. Dec. Temp.: 223 °C, M. W.: 491.22 gmol^{-1}. Anal. Calcd for [$C_{20}H_{12}BrClN_2O_2Cu$]: C, 48.90%; H, 2.46%; N, 5.70%, Cu, 12.94%. Found: C, 48.78%; H, 2.38%; N, 5.63%, Cu, 12.86%. ATR-FTIR (cm^{-1}): 3172.17 (O-H), 1620.39 (C=N), 1248.19 (C–O), 427.45 (Cu–O), 417.47 (Cu–N). Ω (DMSO) Scm^2 mol^{-1}: 0.020. μeff (B. M.): 2.18.

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Scheme 2: Synthesis of metal(II) complexes; i = CH_3COH/THF, ii = 70 ^{0}C, 4 h, M=Ni or Cu

2.4 Antioxidant Assay

The DPPH free radical scavenging method as in reported was employed by modifying the concentrations (Es-Sounni *et al.* 2024; Priya *et al.*, 2024). In a nutshell, 1.5 mL of each test compound in DMF at concentrations of 1.0, 0.5, 0.25, and 0.125 mg/mL was added to 1 mL of the ethanolic solution of DPPH (24 mg/L). Ascorbic acid was used as a standard reference. The % DPPH scavenging activity of the test compounds was computed using Equation reported therein. The inhibitory concentration needed to achieve 50 % of the maximum scavenging activity known as the IC_{50} value was computed using the linear regression plot of the concentrations of test compounds against % DPPH scavenging activity (Juyal *et al.*, 2024).

2.5 Antimicrobial Evaluation

The antimicrobial efficacies of the ligand and complexes were evaluated using the disc diffusion method. Paper discs concentrated with 10 µg/mL, 20 µg/mL and 30 µg/mL of the compounds in DMSO were utilized against *Staphylococcus aureus, Bacillus subtilis, Escherichia coli* and *Salmonella Typhi* as well as *Candida albicans* and *Aspergillus fumigatus* as described by (Mohapatra *et al.*, 2024).

3.0 RESULTS AND DISCUSSION

3.1 Physicochemical Properties

An unsymmetrical tetradentate Schiff base ligand (H_2L) was synthesized by one-pot condensation of salicylaldehyde, 3-bromo-5-chlorosalicylaldehyde and *o*-phenylenediamine at room temperature. The ligand was available as bright yellow powdery solid with quantitative yield of 75%. Ni(II) and Cu(II) complexes of the ligand were obtained as brownish and green solids with yield of 89 and 81% respectively, through interaction of equimolar ratios of THF-solutions of the unsymmetrical Schiff base ligands with Ni(II) and Cu(II) ions under reflux condition. They are air and photo-stable under ordinary condition and H_2L and CuL are soluble in DMF and DMSO but insoluble in common solvents while NiL shows slight solubility in both. The melting point of the unsymmetrical Schiff base was 238 ^{o}C whereas the Ni(II) and Cu(II) complexes showed >350 and 223 ^{o}C, respectively indicating their thermal stability (Tahmasbi *et al.,* 2023). The melting point of the precursor ligand was typically lower compared to that of the complexes, which is likely due to the increased molecular sizes and the presence of stronger dative covalent bonds between C–N–metal and ionic bonds between C–O–metal (Gavali *et al.,* 2024; Muzammil *et al.*, 2024). The molar conductance can be used to determine the degree of ionization of the complexes. The Ni(II) complex exhibited zero molar conductivity value while the Cu(II) complex showed low value of 0.020 $S^{-1}cm^2mol^{-1}$ which demonstrate their non-electrolytic property (Geary, 1971; Nasaruddin *et al.* 2022). The non-electrolytic nature avers the deprotonation of the phenolic OH through bonding as an oxygen

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anion with the metal(II) ions (Abbas *et al.*, 2024).

The micro-analytical data of the unsymmetrical Schiff base revealed excellent agreement with the theoretical values, confirming purity. Furthermore, the formation of the complexes with sufficient purity in 1:1 metal-ligand stoichiometry was evident from the data. The general molecular formulae of the complexes could be formulated as ML, where L is the deprotonated unsymmetrical Schiff base ligand H_2L, and M is Ni(II) or Cu(II) ion.

3.2. FTIR Spectral Study

The FTIR spectra are presented in Figures 1–3. In the IR spectrum of the unsymmetrical Schiff base ligand, H_2L, the vibrational frequency of υ(C=N) appeared as intense peak at 1621.67 cm^{-1}. This peak shifted to lower frequencies of 1603.13 and 1620.39 cm^{-1} in the spectra of NiL^2 and CuL complexes, respectively, indicating involvement of the nitrogen atom of the azomethine group in coordination. Ngounoue-Kamga *et al.* (2023) recorded an alike wavenumber of 1603 cm^{-1} for similar Ni(II) complex. These shifts could be attributed to the reduction in the electron density on nitrogen atom of the azomethine group due to the donation of its lone pair of electrons to the Ni(II) and Cu(II) metal centres (Oladipo and Luckay, 2024). The υ(O–H) vibration frequency of the H_2L appeared as a less intense band at 3066.92 cm^{-1}, which disappeared in the spectrum of NiL, inferring complexation through deprotonated phenolic OH. But in the case of CuL, a broad band due to moisture content was observed at 3172.17 cm^{-1}. Moreover, a supportive evidence is seen in the shift in the band due to υ(C–O) which appeared at 1224.73 cm^{-1} in the free H_2L to 1247.36 and 1248.19 cm^{-1} in the spectra of NiL and CuL complexes, respectively. The observed increase in the wavenumber could be attributed to the deprotonation of the phenolic hydroxyl (OH) moieties, resulting in an elevation in electron density within the bonding regions of C–O within the complexes (Jabbari *et al.,* 2024). The emergence of new non-precursor weak bands at 420.83 and 407.99 cm^{-1} assigned to υ(Ni–O) and υ(Ni–N) respectively; and 427.45 and 417.47 cm^{-1} assigned to υ(Cu–O) and υ(Cu–N), respectively is a confirmation of participation of oxygen and nitrogen atoms in coordination (Shukla *et al.*, 2020; Singh *et al.*, 2024).

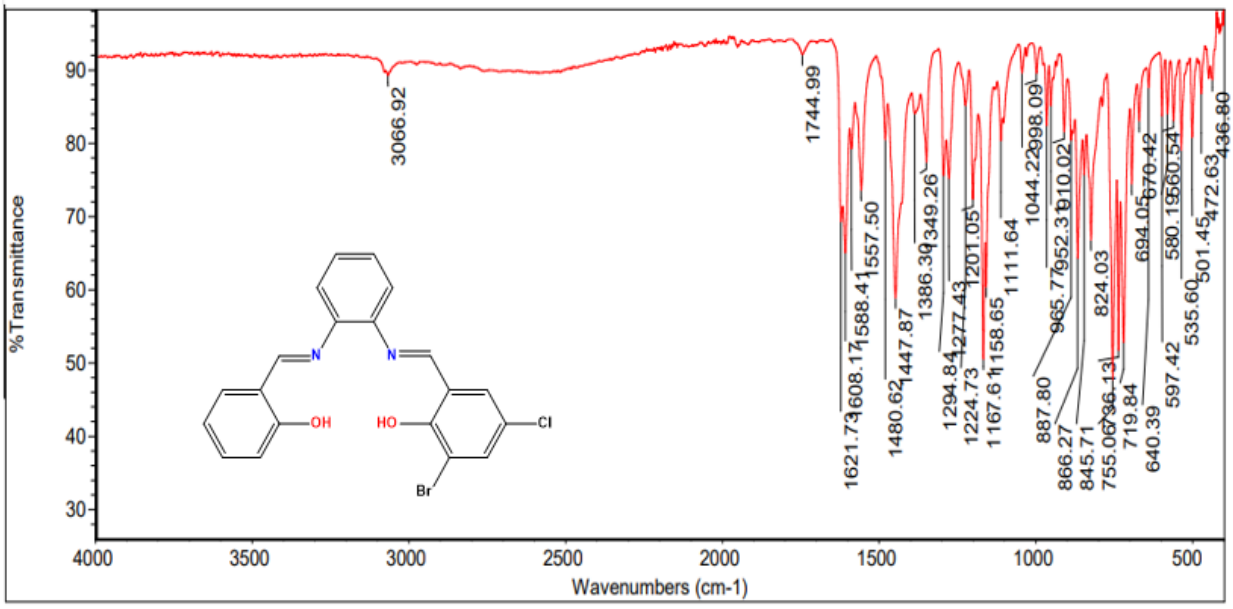


Figure 1: FTIR Spectrum of H_2L

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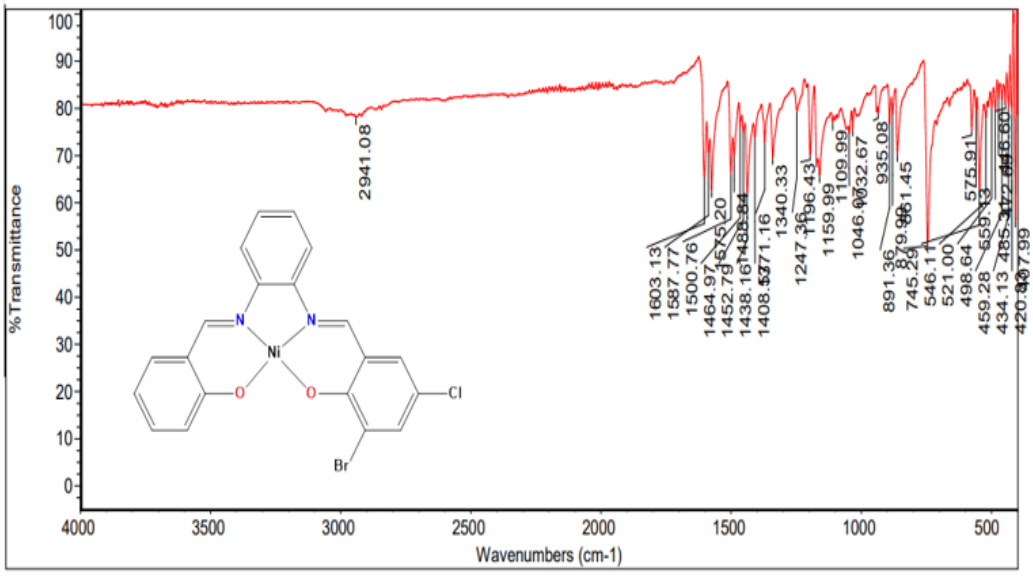


Figure 2: FTIR Spectrum of NiL

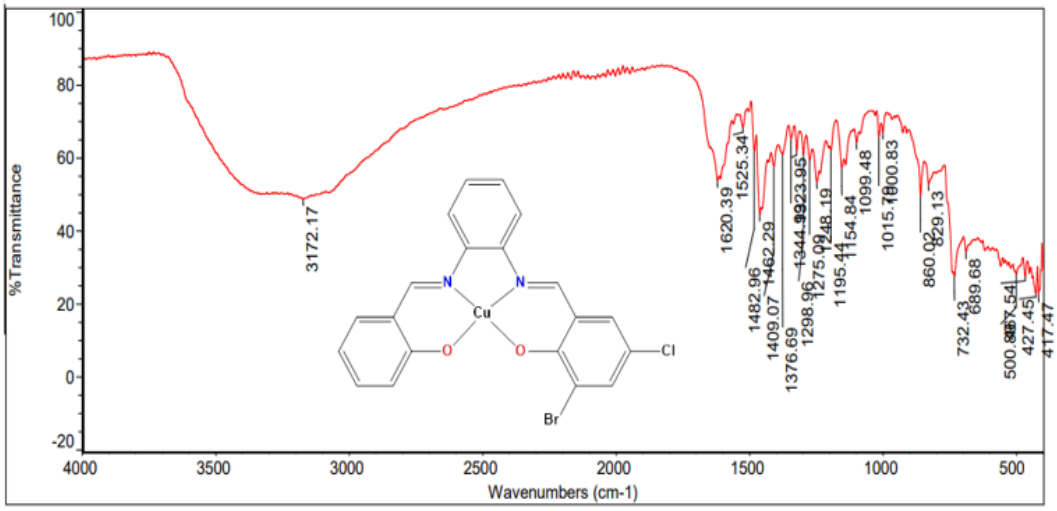


Figure 3: FTIR Spectrum of CuL

3.3 NMR Spectral Study of the Ligand, H_2L

The ^1H NMR spectrum of the unsymmetrical Schiff base H_2L displayed the expected resonance patterns consistent with the proposed structures (Figure 4). The presence of the azomethine proton resonance appearing at 8.997 and 8.930 ppm, assignable to the imine moiety $HC^7=N$ and $HC^{12}=N$ respectively in consonance with the work of Abdel-Rahman *et al.* (2021). The phenolic OH of the salicylaldehyde fragment appeared as a singlet at 12.512 ppm while that of the substituted salicylaldehyde was observed in more down field region (12.943 ppm) due to the presence of electron withdrawing group adjacent to it. The asymmetry of the ligand is lucidly reflected by the resonance patterns in the chemical shifts of the protons of the azomethine and phenolic OH. The two aromatic protons of the substituted salicylaldehyde ring gave rise to two singlet signals at 7.740 (s, 1H, H^5C=C-Cl) and 7.722 (s, 1H, H^3C=C-Cl) ppm. The magnetic inequivalence of the four aromatic protons of salicylaldehyde moiety is highlighted by four sets of multiplets observed at 7.722 – 7.755 (**H**^{17}C-C-OH), 7.534 – 7.711 (**H**^{14}C=C), (**H**^{16}C=CH) and (**H**^{15}C=CH), each integrated to one proton. Similarly, the protons of the phenyl ring showed a chemical shift at 6.983 (s, 2H, $H^{9,9'}$C=CH) and 6.968 ($H^{10,10'}$C=CH) ppm,

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with an integration of two protons each. Such range of chemical shifts has previously been reported for salophen ligand (Mahmud *et al.*, 2023).

Corroboratively, the ^{13}C NMR spectral data of H_2L (Figure 5) fully reproduce the features observed in ^{1}H NMR and support the interpretation outlined above, clearly demonstrating the unsymmetrical nature of the ligand. The two resonances featured in the downfield at 163.96 and 162.54 are due to the azomethine carbon (C^{7}=N) and (C^{12}=N) respectively. The occurrence of these signals in the downfield could be ascribed to the double bond character, electronegative nitrogen atom, and conjugation effect (Lawan *et al.*, 2025). The signal observed at 160.34 ppm is attributed to the phenolic carbon (C^{1} – OH) adjacent to the electronegative bromine atom while chemical shift at 156.59 is attributed to the phenolic carbon (C^{18}–OH) of the salicylaldehyde. Relative to the azomethine carbons, the aromatic carbon bearing the hydroxyl groups were observed in the upfield due to mesomeric effect of the hydroxyl group electron density (Lawan *et al.*, 2025). Furthermore, the resonance due to the two aromatic carbons appeared at 142.65 – 119.91 ppm representing all the aromatic carbons in the rings (Mahmud *et al.*, 2023).

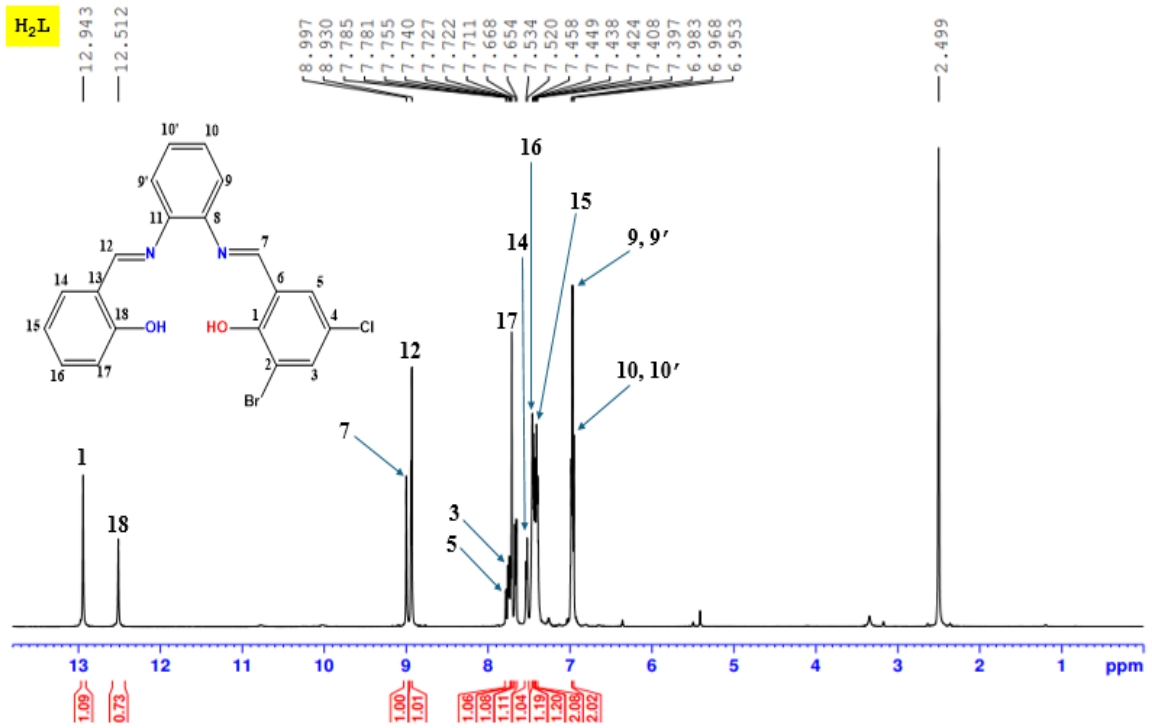


Figure 4: ^{1}H NMR of the Unsymmetrical Schiff Base Ligand H_2L

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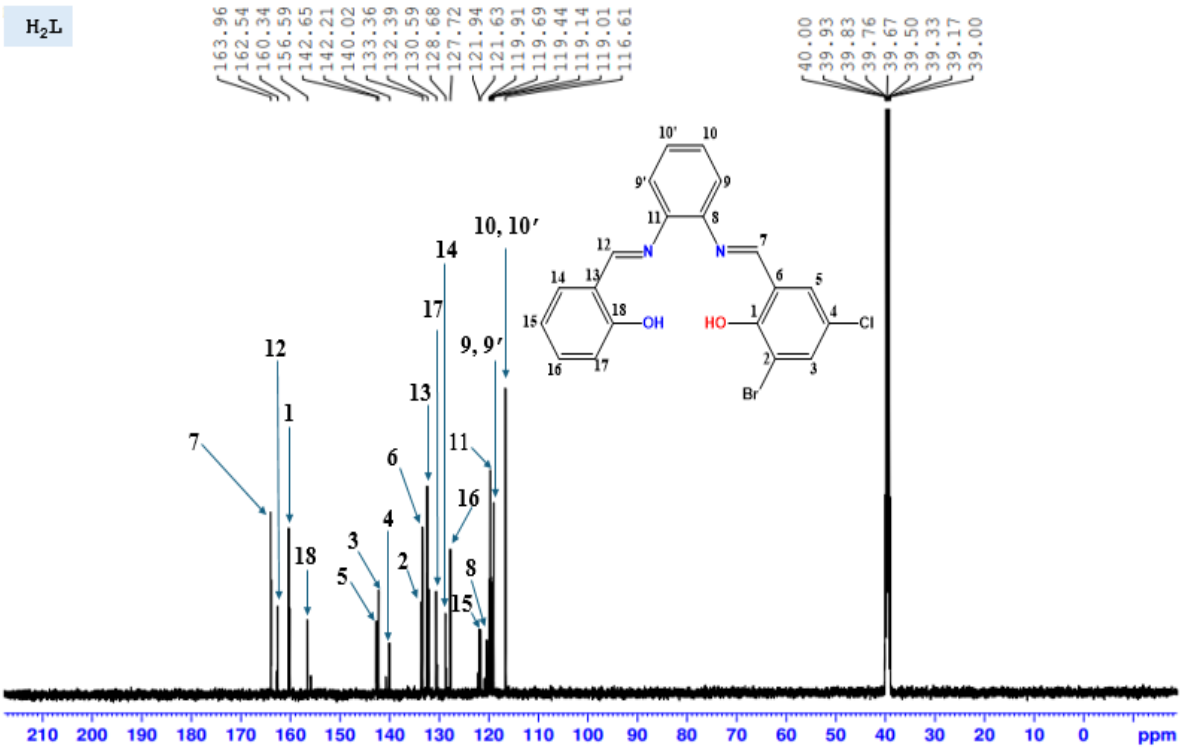


Figure 5: ^{13}C NMR of the Unsymmetrical Schiff Base Ligand H_2L

3.4 Mass Spectral Analysis of the ligand, H_2L

In the MS spectrum of the ligand H_2L (Figure 6), a molecular ion peak at *m/z* 429.0004 agreeable with the theoretical value of 429.0005 was observed, affirming the proposed formula. Similarly, peaks identified as [M+3H] and [M+5H] were observed at *m/z* 430.9985 and 432.9966, respectively. This isotopic cluster due to the presence of chlorine and bromine is in agreement with the theoretical values 431.0162 and 433.0318, respectively (Güngör and Nuralin, 2024).

3.5 Magnetic Moments Study

Magnetic moment (μ) is a measure of the degree of paramagnetic character in a compound (Hasan *et al.*, 2024). The Ni(II) complex displayed magnetic moment value of 4.30 B.M, which fall within the typical range for tetrahedral Ni(II) complexes (3.62 to 4.01 B.M). This value suggests the presence of two unpaired electrons in the Ni(II) complex consistent with the d^8 configuration (Kumar *et al.*, 2021; Al-Quaba *et al.,* 2024). In the case of the Cu(II) complex, the observed magnetic moment was 2.18 B.M. Irrespective of the geometry, the magnetic moments for copper complexes fall between 1.75 – 2.20 B.M. (Suja *et al.*, 2021). Therefore, these complexes are likely to possess a square planar geometry. Based on these data, the complexes exhibit four-coordinate tetrahedral and square planar geometries around the Ni(II) and Cu(II) ions respectively. From the combined data, the structures of the ligand and complexes are as shown in Schemes 1 and 2, respectively,

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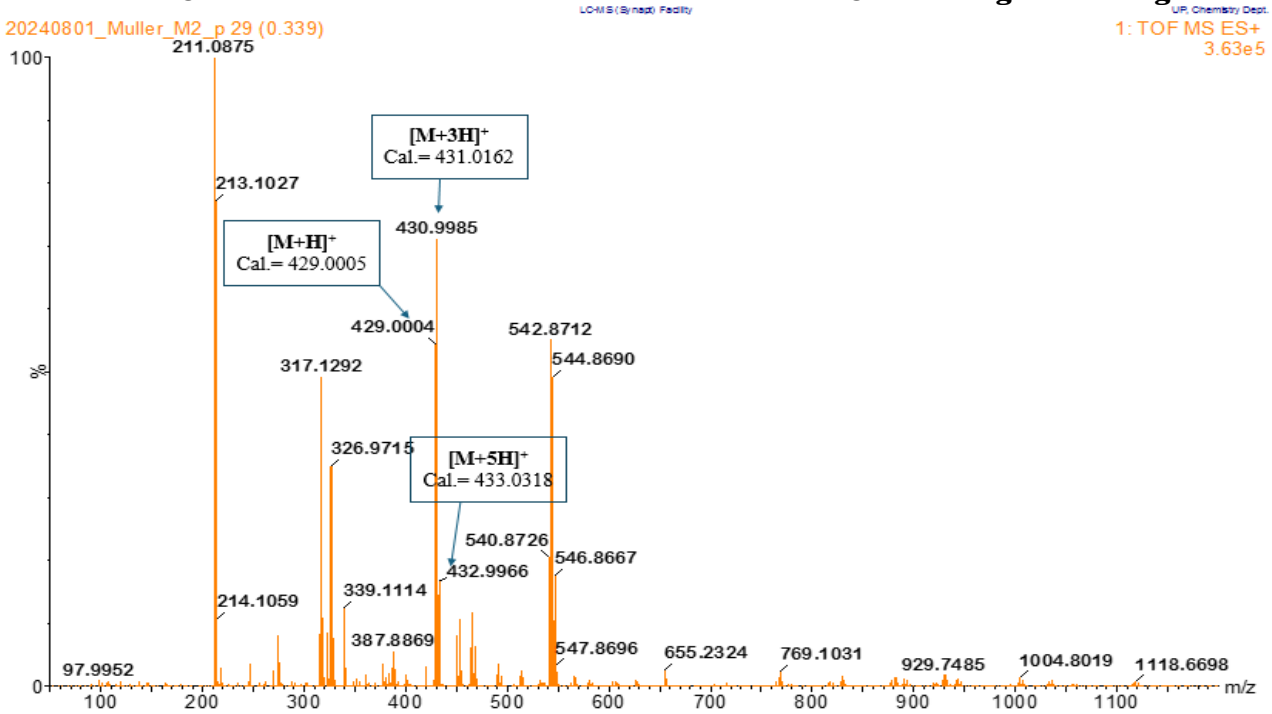


Figure 6: HRMS Spectrum of the Unsymmetrical Schiff Base Ligand H_2L

3.6 Antioxidant Analysis

The antioxidant efficacy of the unsymmetrical Schiff bases and their Ni(II) and Cu(II) complexes was assayed by the DPPH free radical scavenging technique. The results are expressed as percentage radical inhibition and IC_{50} values. Table 1 furnishes the antioxidant activity of the studied compounds cum vitamin C as positive reference standard. The ligands H_2L displayed average % radical inhibition and IC_{50} value of 78.58 % and 0.036 mg mL^{-1} respectively. The sequence of the antiradical activity follows: vitamin C (0.004 mg mL^{-1}) > H_2L (0.036 mg mL^{-1}) Fundamentally, the lower the IC_{50}, the more effective antioxidant efficacy of a substance (Singh *et al.*, 2024). The ligand possesses two electron-withdrawing groups (Br and Cl) in addition to the two phenol OH groups alongside a phenylene ring serving as source of electron for donation. Previously, Schiff bases with a halogen atom substituent in the para position have been reported to scavenge free radicals better than those whose halogen atom is substituted in the ortho position (Oladipo *et al.,* 2024). The proficiency order of the synthesized compounds and vitamin C in scavenging DPPH radical follows: vitamin C (0.004 mg mL^{-1}) > CuL (0.141 mg mL^{-1}) > NiL. The Ni(II) complex shows no free radical scavenging activity. Generally, solubility and stability of a Schiff base complex in a test medium can affect its antioxidant efficacy. If a complex is unstable or poorly soluble, as it is the case herein, it might not be able to effectively interact with free radicals, hence they exhibit inefficacy.

Table 1: Antioxidant Activity of the Schiff Bases and their Neat Metal(II) Complexes

Compound	Concentration ($mgmL^{-1}$)				%	IC_{50}
	0.125	0.250	0.500	1.000	Average	($mgmL^{-1}$)
	Scavenging activity % Inhibition					
H_2L	78.13	83.03	84.25	68.89	78.58	0.036
NiL	-13.75	-62.83	-145.52	-53.52	-	-3.213
CuL	108.27	95.17	98.28	85.32	92.92	0.141
Vitamin C	89.83	91.33	72.72	90.60		0.004

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3.7 Antimicrobial Activity

The inhibition efficacy of the unsymmetrical Schiff bases and their corresponding complexes was examined against six pathogens comprising two Gram-positive bacterial strains: *S. aureus, B. subtilis*, two Gram-negative strains: *E. coli, S. Typhi,* and two fungi strains: *C. albicans, A, fumigatus* using ciprofloxacin and fluconazole as positive controls and solvent dimethyl sulfoxide as a negative control. The results of the assessment are presented in Table 2. The screening results showed that, the ligand H_2L as well as its Ni(II) complex did not exhibit any inhibitory effect against any of the examined pathogenic strains. These findings are similar to earlier reports of antimicrobial activities of tetradentate N_2O_2 Schiff bases (Ilhan *et al.*, 2014; Vhanale *et al.*, 2019). The Cu(II) complex showed activity of 12.00 ± 0.00 and 8.00 ± 0.00 mm at the concentrations of 30 and 20 µg mL^{-1} respectively against *B. subtilis* and *C. albicans* apiece. The other studied pathogens maintained their inactivity even after complexation. Generally, the diameter of the inhibition zone is affected by the concentration of the test agent and its diffusion rate through the agar medium (Derafa *et al.*, 2024). The inactivity of the Ni(II) complex could be attributed to either poor solubility or inability of the compounds to diffuse into the microbial cell membrane and hence they become impaired to intervene with its bioactivity (Adam *et al.*, 2019).

The potency of the Cu(II) complex could be explained through chelation theory. The polar nature of the metals copper and nickel ions gets reduced when coordinated to the ligands. This results in delocalization throughout the aromatic ring, which subsequently cause heightened lipophilicity of the metal ions, enhancing their penetration into the lipid layers of cell membranes. This process interferes with cell respiration, resulting in disruption of protein synthesis and, as a result, organisms die (Derafa *et al.*, 2024).

Table 2: Antimicrobial Activity of the Schiff Bases and their Neat Metal(II) Complexes

Compounds	Conc. (µg/mL)	*S. aureus*	*B. subtilis*	*E. Coli*	*S. Typhi*	*C. albicans*	*A. fumigatus*
H_2L	30	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	20	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	10	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
NiL	30	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	20	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	10	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CuL	30	0.00 ± 0.00	12.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	12.00 ± 0.00	0.00 ± 0.00
	20	0.00 ± 0.00	8.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	8.00 ± 0.00	0.00 ± 0.00
	10	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
DMSO	30	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Ciprofloxacin	30	18.00 ± 0.00	30.00 ± 0.00	23.00 ± 0.00	21.00 ± 0.00	-	-
Fluconazole	30	-	-	-	-	21.00 ± 0.00	25.00±0.00

4. CONCLUSION

Two novel complexes of Ni(II) and Cu(II) obtained from unsymmetrical NOON-donor-type Schiff base ligand have synthesized. Various spectroscopic and analytical approaches were utilized to affirm the formation of the ligand and propose the chemical structures of the complexes. The

tetradenticity of the ligand was confirmed from the FT-IR spectral data with the phenolic OH and C=N functional groups being the dibasic sites of chelation. The non-electrolytic nature of the compounds was inferred on the basis of molar conductivity results. Magnetic moment values suggest the tetrahedral and square planar structure for Ni(II) and Cu(II) complexes respectively. The ligand and Ni(II) complex show notable antioxidant activity whereas Cu(II) complex exhibit enhanced antimicrobial efficacy against *B. subtilis* and *C. albicans*.

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