

ANTIBACTERIAL AND ANTIFUNGAL ACTIVITIES OF COBAL AND NICKEL COMPLEXES OF SHIFF BASE

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ABSTRACT

Schiff base complexes of cobalt and nickel were synthesized through a condensation reaction between salicylaldehyde and 2-amino-3-methylpyridine in the presence of the metal chlorides of Co(II) and Ni(II). The compounds were characterized using melting point/decomposition temperature, solubility, magnetic measurements, conductivity, FT-IR, and elemental analysis. Orange-yellow, dark blue, and brown colours were observed for the Schiff base and its complexes. Melting point/decomposition temperatures of 120°C, 212°C, and 222°C were recorded. Both the Schiff base and the metal complexes were soluble in water, methanol, ethanol, and DMSO, but only slightly soluble in other solvents. The electrical conductivity values obtained were 16.5 and 10.7 $\Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$, indicating that the synthesized complexes are non-electrolytes. Effective magnetic moments of 3.9 BM and 1.28 BM suggest an octahedral geometry for the complexes. The IR spectrum revealed a band at 1581 cm^{-1} , indicating the formation of the azomethine (C=N) group and confirming the formation of the Schiff base. This band shifted to higher frequencies, 1610 cm^{-1} and 1618 cm^{-1} , indicating complex formation. Bands observed at 755 cm^{-1} for M–N and 618 cm^{-1} for M–O in the spectra of the complexes support coordination of the Schiff base to the respective metals. The CHN elemental analysis data showed good agreement between the experimental and calculated values, suggesting a 1:2 metal-to-ligand ratio. In vitro antimicrobial screening of the Schiff base and its metal complexes against the test organisms *Escherichia coli*, *Streptococcus pneumoniae*, and *Aspergillus niger* using the well diffusion method, showed that the compounds are potential antibacterial and antifungal agents.

Keywords: Metals Complexes antibacterial, antifungal, Schiff base

INTRODUCTION

Schiff bases are versatile ligands which are synthesized from the condensation of primary amines with carbonyl groups. These compounds are very important in medicinal and pharmaceutical fields because of their wide spectrum of biological activities. Most of them show biological activities such as antibacterial, antifungal as well as antitumor activity. Transition metal complexes derived from the Schiff base ligands with biological activity have been widely studied (Arulmurugan et al 2010). In recent years, the chemistry of coordination compounds displays rapid development in diverse disciplines due to the possible biological applications of these new compounds. Metal chelates play an essential role in the chemistry of living organisms and a large number of metal proteins and other metal complexes of biological importance (Sevil Toroglu, et al 2009).

MATERIALS AND METHODS

Materials

All reagents and solvents used for this research were of analytical grade and were purchased from Sigma Aldrich and

Merck and were used without further purification the melting point was recorded on hot stage gallen kamp melting point apparatus. the infrared spectra was recorded using Agilent carry 630 FT-IR spectrometer in the frequency range of 400-4000 cm^{-1} . The magnetic susceptibility was obtained at room temperature using magnetic susceptibility balance MK1 Sherwood. Conductivity measurement was carried out using Jan way conductivity meter 401 and elemental analysis was carry out using perkin elmer elemental analyser CHNS/ analyser 2400

Methods

Synthesis of Schiff Base

Exactly 0.05mol (6.106.7ml) of Salicylaldehyde was mixed with 0.05mol (5.407g,6ml) of 2-amino-3-methylpyridine in 50 cm^3 of ethanol. The mixture was heated under reflux at 60°C-70°C for 3hours and the solid product formed was separated by filtration, purified by recrystallization from ethanol, washed with ethanol, and then dried in desiccators over calcium chloride (CaCl_2) for 18hrs. (Abubakar *et al.*, 2020).

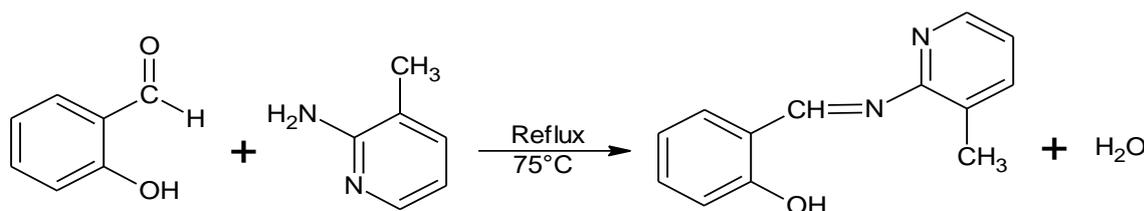


Figure 1: – {€} – [(3-MethylPyridin-2-yl) imino] Methyl} phenol

Synthesis of Schiff Base Complexes

An aqueous solution of hydrated Cabal (II) chloride (0.01 mol, 1.39839g) in 10 cm³ ethanol was added to an ethanolic solution of the prepared Schiff base ligand (0.02mol, 4.24g) the mixture was refluxed at 60°C-70°C for 3hours. The precipitated complex formed was separated by filtration recrystallized and washed with ethanol and dried in a desiccator over calcium chloride (CaCl₂) for 18hrs. The same procedure was used for the synthesis of Cr (ii) Co (II), Ni and Zn (II) complexes (Uba *etal*, 2020).

Antibacterial and Antifungal Screening

The sterilized medium (Gillespie, 1994), autoclaved at 121 °C for 15 min, was inoculated with a microbial suspension (5 ×

10⁻⁵ CFU/mL) adjusted to the Joseph McFarland turbidity standard. The inoculated medium was poured into a Petri dish to a depth of 3–4 mm. Three wells were prepared, each containing different concentrations (250, 500, and 1000 ppm in dimethyl sulfoxide) of the Schiff base and its metal(II) complexes.

The plates were pre-incubated for 1 h at room temperature and then incubated at 37 °C for 24 h and 48 h for antibacterial and antifungal activity, respectively. Streptomycin (100 ppm) and Dress Force (100 ppm) served as standards. After the incubation period, the plates were examined for zones of inhibition, which were measured in millimeters, following Govindaraj et al. (2015).

RESULTS AND DISCUSSION**Table 1: Physical Properties and Analytical Data of Schiff Base and its Metal (II) Complexes**

Compound	Color	Melting point	Decomposition Temperature (°C)	Percentage Yield (%)
Ligand	Orange yellow	120		77
[CoL ₂ Cl ₂]	Dark blue		212	72
[NiL ₂ Cl ₂]	Brown		222	68

Table 2: Solubility of Schiff Base and Its Metal (II) Complexes

Compound	Water H ₂ O	Ethanol CH ₃ CH ₂ OH	Methanol CH ₃ OH	DMSO (CH ₃) ₂ SO	Chloroform CHCl ₃	Acetone CH ₃ COCH ₃
Ligand	S	S	S	S	SS	SS
[CoL ₂ Cl ₂]	S	S	S	S	SS	SS
[NiL ₂ Cl ₂]	S	S	S	S	SS	SS

Table 3: Magnetic Susceptibility of Metal (II) Complexes

Compound	Magnetic susceptibility (cm ³ g ⁻¹)	Molar magnetic susceptibility (cm ³ mol ⁻¹)	B.M(μ _{eff})	Magnetism
[CoL ₂ Cl ₂]	1.14 x 10 ⁻⁹	6.3 x 10 ⁻⁵	3.9	Paramagnetic
[NiL ₂ Cl ₂]	1.227x 10 ⁻⁹	6.8 x 10 ⁻⁵	1.28	Paramagnetic

Table 4: The Infrared Spectral Data of Schiff Base and its Metal (II) Complexes

Compound	ν(OH) cm ⁻¹	ν(C-O) cm ⁻¹	ν(C=N)cm ⁻¹	ν(M-N)cm ⁻¹	ν(M-O)cm ⁻¹
Ligand	3335	1201	1581		
[CoL ₂ Cl ₂]	3251	1121	1610	755	618
[NiL ₂ Cl ₂]	301	1112	1618	755	618

Table 5: Conductivity Measurement of Complexes in DMSO Solution (1x10³mol dm⁻³)

Compound	Concentration (mol ⁻¹ dm ⁻³)	Specific conductance Ohm ⁻¹ cm ⁻¹	Molar conductance Ohm ⁻¹ cm ² mol ⁻¹
[CoL ₂ Cl ₂]	1 x 10 ⁻³	16.5x10 ⁻⁶	16.5
[NiL ₂ Cl ₂]	1 x 10 ⁻³	10.7x10 ⁻⁶	10.7

Table 6: Elemental Analysis Data of Schiff base and its Metal (II) Complexes

Compound	C	%Cal. (found) H	N
Ligand	73.55 (73.40)	5.70 (5.75)	13.21 (13.20)
[CoL ₂ Cl ₂]	56.74 (56.20)	4.33 (4.30)	10.11 (10.05)
[NiL ₂ Cl ₂]	56.77 (56.70)	4.37 (4.30)	10.11 (10.03)

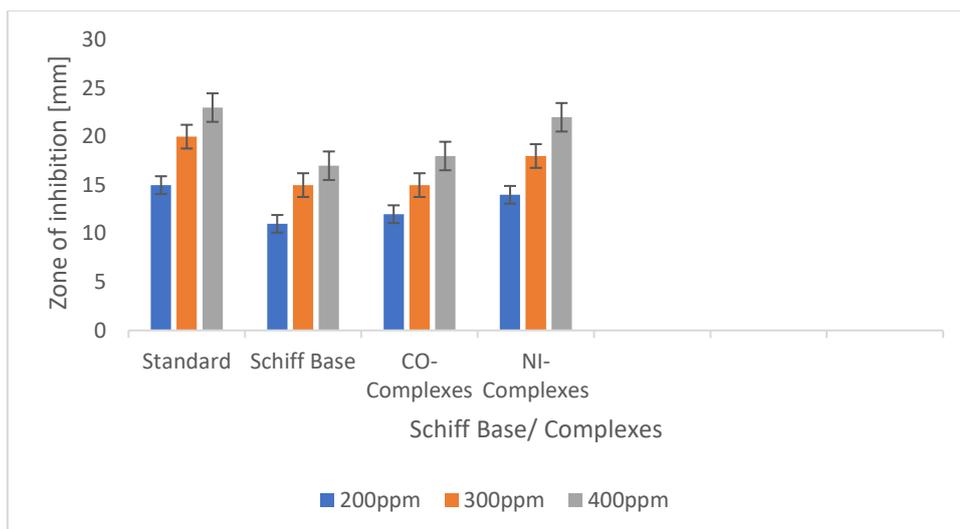


Figure 1: Sensitivity Test for Antibacterial Activity of Schiff base and its Metal (II) Complexes against Clinical Isolate (*Escherichia Coli*) using Well Diffusion Method

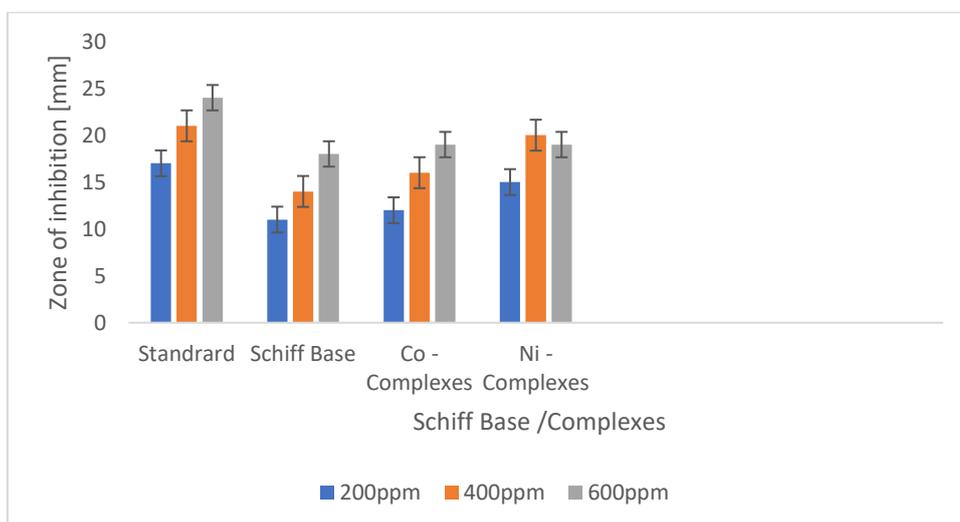


Figure 2: Sensitivity Test for Antibacterial Activity of Schiff base and its Metal (II) Complexes against Clinical Isolate (*Streptococcus pneumoniae*) using Well Diffusion Method

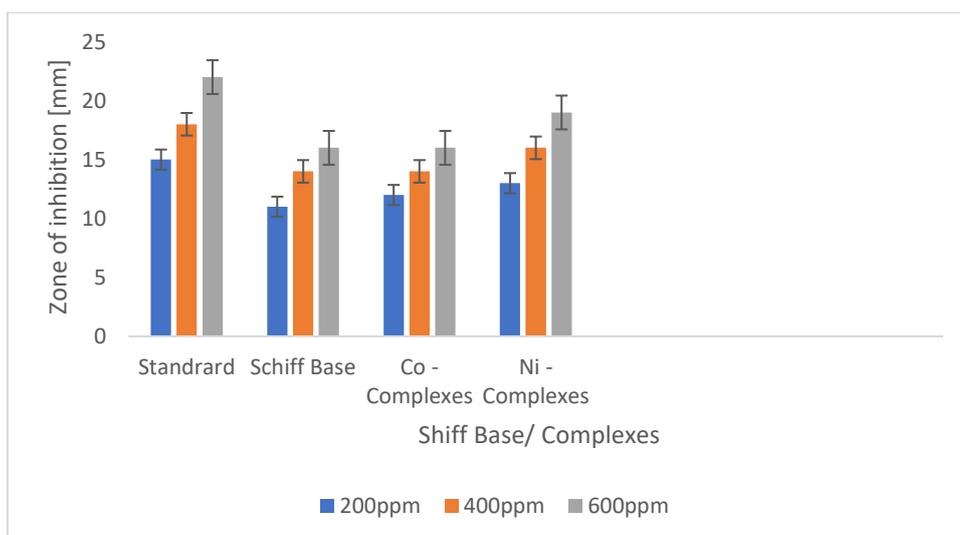


Figure 3: Sensitivity Test for Antifungal Activity of Schiff base and its Metal (II) Complexes against Clinical Isolate (*Aspergillus Niger*) using Well Diffusion Method

Discussion

The condensation of Salicylaldehyde with 2-amino-3-methylpyridine afforded an orange-yellow Schiff base ligand. Complexation with cobalt(II) and nickel(II) ions yielded dark-blue and brown products, respectively. The intense colour changes observed after coordination are consistent with ligand-field effects arising from d-d electronic transitions within the metal centres.

The melting/decomposition temperatures were 120 °C for the ligand and 212 °C and 222 °C for the cobalt(II) and nickel(II) complexes, respectively. The higher thermal stability of the complexes compared with the free ligand can be attributed to increased molecular weight and stronger intermolecular interactions in the coordinated species, in agreement with previous reports. Both the ligand and its complexes are non-hygroscopic solids and remain stable to air and light under ambient conditions.

Solubility behaviour depended strongly on solvent polarity and the nature of bonding within the compounds. Tests performed in methanol, ethanol, dimethyl sulfoxide (DMSO), water, chloroform, and acetone showed good solubility in DMSO, methanol, ethanol, and water, but only slight solubility in acetone and chloroform. The enhanced solubility in polar media supports the presence of polar functional groups capable of favorable solute-solvent interactions. Comparable trends have been documented for related Schiff base systems.

Infrared spectra of the free ligand displayed a broad band at 3335 cm⁻¹ attributable to ν(O-H). This band shifted upon complex formation, indicating deprotonation and participation of the phenolic oxygen in coordination. The phenolic ν(C-O) vibration observed at 1201 cm⁻¹ in the ligand moved to lower frequencies (1121 and 1112 cm⁻¹) in the complexes, further supporting metal-oxygen bond formation. The azomethine ν(C=N) band at 1581 cm⁻¹ shifted to 1610 cm⁻¹ for the cobalt complex and 1618 cm⁻¹ for the nickel analogue, consistent with coordination through the imine nitrogen. Additional bands in the far-IR region around 755 cm⁻¹ and 618 cm⁻¹, absent in the ligand, are assignable to ν(M-N) and ν(M-O) vibrations, confirming chelation.

Molar conductance measurements in 10⁻³ M DMSO gave values of 16.5 and 10.7 Ω⁻¹ cm² mol⁻¹ for the cobalt(II) and nickel(II) complexes, respectively, indicating non-electrolytic behaviour. Magnetic susceptibility data at room temperature afforded effective magnetic moments of 3.9 BM for the nickel complex and 1.28 BM for the cobalt complex, revealing paramagnetic species compatible with high-spin octahedral environments. In contrast, the zinc analogue exhibited diamagnetism, as expected for a d¹⁰ configuration. Overall, the magnetic data fall within the typical range reported for octahedral geometries.

Elemental (CHN) analysis showed good agreement between calculated and experimental values. The results support a ligand formula of C₁₃H₁₂N₂O and a 1:2 metal-to-ligand stoichiometry for the complexes, giving C₂₆H₂₄N₄O₂ around the metal centre.

Antibacterial activity

The ligand and its metal(II) complexes were evaluated in vitro at concentrations of 200, 400, and 600 ppm against *Escherichia coli* and *Streptococcus pneumoniae*, with Ciprofloxacin used as the reference drug. The free ligand produced inhibition zones of 11–18 mm for *E. coli* and 11–17 mm for *S. pneumoniae*. Upon chelation, activity increased markedly. This enhancement can be rationalized by π-electron delocalization and partial sharing of the metal charge with donor atoms, which increases lipophilicity and facilitates penetration through microbial membranes. Activity rose with

increasing concentration. Among the complexes, the nickel derivative displayed superior potency compared with the cobalt analogue, although both remained less active than the standard drug. The variation in efficacy highlights the metal-dependent nature of biological responses.

Antifungal activity

Antifungal screening against *Aspergillus Niger* employed Ketoconazole as control. The ligand showed moderate inhibition (11–16 mm) but was consistently less active than the metal complexes. Nickel again exhibited the strongest effect (13–19 mm), followed by cobalt (12–16 mm). As observed in the antibacterial study, inhibition increased with concentration, yet the activities of all synthesized compounds were lower than that of the reference antifungal agent (15–22 mm).

CONCLUSION

In conclusion, the Schiff base and its metal complexes were synthesized and characterized, and their in vitro antimicrobial screening against the test organisms (*Escherichia coli*, *Streptococcus pneumoniae*, and *Aspergillus niger*) showed that they are potential antibacterial and antifungal agents.

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