

Synthesis, Characterization, And Study of Anti-Bacterial Properties of Ni (II) Schiff Base Complexes Derived from Benzaldehyde and Diphenylamine

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Abstract: The present study deals with the synthesis of an N-phenylbenzal-diphenylamine Schiff base derived from Benzaldehyde and Diphenylamine. This Schiff base is formed by the condensation of Benzaldehyde and diphenylamine. Schiff bases are known for their diverse biological and coordination properties due to the presence of an azomethine group. The Ni (II) complex of this SB was obtained through refluxing the SB with the metal salt in ethanol. Both the SB and complexes were confirmed via spectroscopic and physicochemical analyses. The UV-Vis spectra of Ni-bis-N-phenylbenzal-diphenylamine chloride complexes consistently showed absorption bands around 291.4 nm. These complexes exhibited strong antibacterial activity against *Escherichia coli* in disc diffusion tests. UV-Vis spectroscopy aided their synthesis and characterization. These results highlight the significant antimicrobial potential of Schiff base metal complexes.

Keywords: Schiff Base, Dimethyl sulfoxide, UV-Vis spectroscopy, *Escherichia coli*, Antimicrobial

I. Introduction

In the year 1864, a German chemist named Hugo Schiff achieved the creation of Schiff base (SB). His method involved taking primary amines and aldehydes and bringing them together in a chemical reaction known as condensation ^[1]. Schiff base (SB) is a chemical described as $R_1R_2C=NR_3$. Here's the breakdown: R_1 is a flat, ring-shaped group known as an aryl. R_2 is just a single hydrogen atom. And R_3 can be either another aryl group or a more chain-like group called alkyl. Schiff bases that have these aryl groups (the ring shapes) are more stable and easier to create in the lab. If they have alkyl groups instead (the chains), they are usually less stable ^[2]. So, ever since the mid-1800s, Schiff bases (SBs) and how they interact with metals have become quite popular among scientists, Jorgensen and Werner. SBs and their metal buddies function in the area of coordination chemistry ^[3]. The development of Schiff base (SB) complexes, along with their chelation Properties and stereochemistry, is explained and extensively studied ^[4].



Figure 1: Preparations of Schiff Base

The condensation of an aldehyde or ketone with a primary amine produces a Schiff base. This transformation is accelerated by heat and requires a catalytic trace of acid or base. The synthesis is reversible; hydrolysis, promoted by acidic or basic conditions, will break the Schiff base down into its original amine and carbonyl precursors. ^[5]

In coordination chemistry, Schiff bases have shone as incredibly adaptable ligands. They're excellent at grabbing onto metal ions because of the nitrogen atom in their azomethine group, which helps them form stable, ring-like structures. The study of Schiff base metal complexes extends beyond structural characterization as researchers continue to explore their potential applications. These complexes hold promise in the development of novel catalysts for intricate chemical reactions and the design of metal-based drugs with reduced side effects, thereby offering a broad spectrum of possibilities. ^[6]

This study focuses on creating Ni(II) Schiff base complexes. Then thoroughly examined the ligand itself and the resulting metal complexes using a variety of physicochemical and spectroscopic techniques to understand their properties. The antibacterial properties of all compounds were evaluated against *Escherichia coli* ^[7].

Schiff bases and their metal complexes have wide-ranging biological applications. This makes them incredibly promising candidates for more in-depth study. ^[8]

II. Materials and Methods

For this research, we utilized Benzaldehyde (C_6H_5CHO), Diphenylamine ($C_{12}H_{11}N$), Nickel chloride ($NiCl_2$), Ethanol, Methanol, Dimethyl Sulfoxide (C_2H_6OS), and Nutrient Agar Media. All reagents and solvents were of analytical grade.

III. Methods:

The condensation method was employed to synthesize SB and its metal complexes, while the antibacterial activities of these compounds were assessed using the agar well diffusion technique.

Synthesis of Schiff Base:

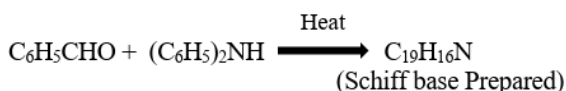
First, diphenylamine (about 1.69 g in 10 ml C₂H₅OH) and Benzaldehyde (1.06 g) are reacted with ethanol (10 ml), both are mixed in a necked flask and heated for about 10 to 15 minutes after the flask is put in ice to form N-phenylbenzal-diphenylamine. This compound was solidified. After isolation, the products were purified by washing with ethanol and subsequent recrystallization.

Synthesis of Nickel (II) Complexes of a Novel Schiff Base Ligand

Synthesis of the nickel complex with SB involved mixing equimolar ethanolic solutions of nickel chloride and SB. The solution was refluxed for 10 minutes and then cooled in an ice bath to promote solidification. The precipitated product was washed with ethanol and recrystallized to yield the pure complex. The chemical reaction is illustrated.

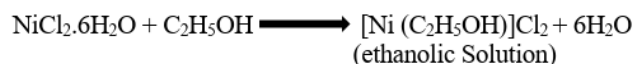
Chemical reaction of two different compounds

1. Formation of Schiff base Chemical Reaction

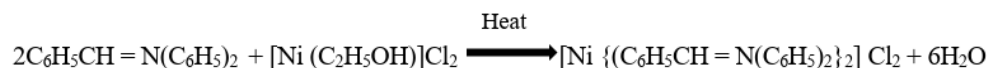


2. Formation of Complex with the help of Schiff base chemical Reaction

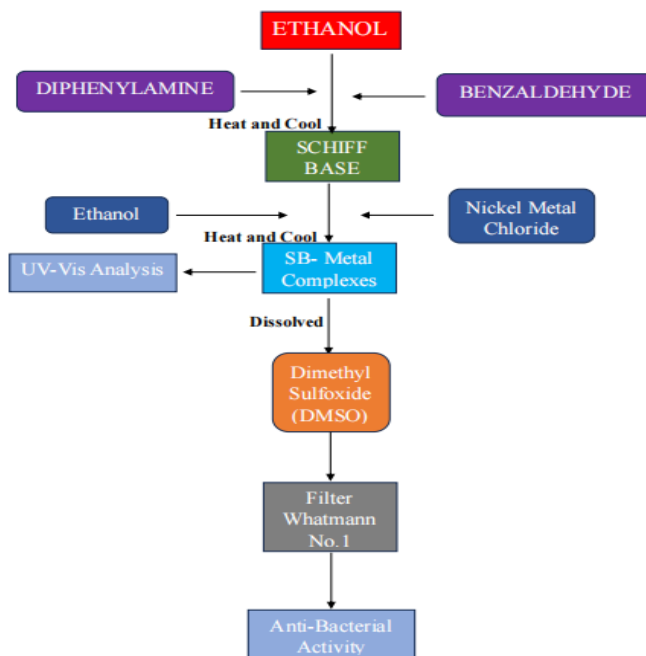
I. Nickel Chloride dissolved in Ethanol



II. Chemical reaction of nickel complex synthesis with SB



The overall Approach followed throughout this Study



Characterization of Ni Schiff Base complexes

The characterization of Ni-bis-N-phenylbenzal-diphenylamine chloride complexes is effectively performed using analytical techniques, including UV-Visible spectroscopy. For assessing the optical properties of these complexes, UV-Visible spectroscopy is an indispensable tool. It functions by measuring the degree of light absorption or reflection by the sample, which elucidates critical parameters such as the size, geometry, and bandgap energy of the complexes.

The interaction of Ni (II) Schiff base complex with UV light induces an electronic excitation, whereby electrons are transferred from the valence band to the conduction band. This phenomenon is evidenced by a characteristic absorbance peak at a specific wavelength. The energy associated with this peak is equivalent to the band gap energy, which is a fundamental and identifying property of Ni (II) Schiff base.

Characterization of Ni (II) Schiff base complex using UV-VIS Spectroscopy

The electronic absorption spectra for the ligand and its derived complexes were acquired on a double-beam UV-Vis spectroscopy 2205 instrument at ambient temperature. The Uv-vis absorption peak is 291.2 nm. The spectral data, collected from 200-800 nm, were analyzed to identify the characteristic d-d and ligand-metal charge transfer bands. ^[9]

Anti-Bacterial Screening: Media and Methods

The antimicrobial activity of the Ni-bis-N-phenylbenzal-diphenylamine chloride complexes was determined through a sensitivity assay. Sterile nutrient agar was prepared and aseptically dispensed into sterile Petri dishes, allowing for solidification at ambient temperature.

The Petri dishes were labelled with the bacterial isolates and the specific locations of the wells containing the various test concentrations of 100 μ L, 200 μ L, 300 μ L, and 400 μ L for Ni (II) complexes. A standard inoculum of 0.1 mL, derived from each isolate, was uniformly spread onto the surface of the dried nutrient agar using a sterile glass spreader. Aliquots of the metal (II) complexes were subsequently introduced into the designated wells within the respective Petri dishes. **For bacterial assays**, Incubation of the Petri dishes occurred at 37°C for 24 hours. Subsequently for bacterial assays, the Petri dishes were incubated occurred at 37°C for 24 hours. Following incubation, the degree of sensitivity was determined by measuring the radius of the visible zones of inhibition, to the nearest millimeter, for each isolate and test concentration. The data were then recorded ^[10].

IV. Result and Discussion

Our journey began with the synthesis of a Schiff base (SB), a molecule we crafted by carefully reacting Benzaldehyde with diphenylamine (N-phenylaniline) in a precise amount. Following this, we moved on to form its metal complexes by introducing various nickel metal salts to our newly created Schiff base.

Graph 1: UV-Vis Spectra of Metal-Ligand

The ligand exhibits two UV-Vis absorption bands: a $\pi \rightarrow \pi^*$ transition at 291.2 nm and an $n \rightarrow \pi^*$ transition at 324.8 nm. Upon complexation with metal ions, the following changes are observed:

Bathochromic shift of the $n \rightarrow \pi^*$ band: The 324.8 nm band shifts to longer wavelengths, indicating successful coordination through the lone pair electrons involved in the $n \rightarrow \pi^*$ transition.

Appearance of d-d transitions: New absorption bands appear in the 645.2-647.4 nm range, characteristic of d-d electronic transitions within the metal center, confirming complex formation.

Observed color change: This visual is further supports the formation of metal complexes. ^[11]

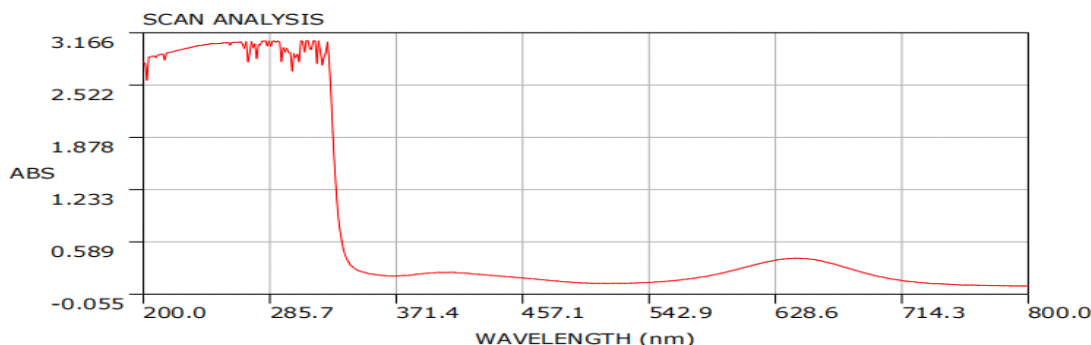


Table 1: UV-Vis peak of Metal-ligand

S. No.	Wavelength (nm)	Absorbance
1.	291.2	3.065
2.	324.8	3.051
3.	410.0	0.214
4.	645.2	0.388

Interpreting UV-Vis Spectra of Metal Complexes

The electronic spectrum of the Ni(II) Schiff Base ligand reveals two key absorption features:

291.2 nm (λ max, A=3.065): This strong absorption band is attributed to a $\pi \rightarrow \pi^*$ transition. This typically involves the excitation of electrons within the conjugated system of the C=N (azomethine) group and the benzene ring. The high intensity indicates a highly allowed transition due to extensive electron delocalization.

~400 nm (shoulder): A weaker, less defined absorption appearing as a shoulder at approximately 400 nm is assigned to an $n \rightarrow \pi^*$ transition. This corresponds to the excitation of a non-bonding electron (lone pair, likely from the nitrogen of the C=N group) to an antibonding π^* orbital. The lower intensity is characteristic of this type of transition, which is often less probable due to symmetry or orbital overlap constraints.

Study of Antimicrobial Activity

The synthesized compounds were dissolved in DMSO at a 1:10 ratio to evaluate the biological activity of the Nickel (II) Schiff base (SB) metal complexes. Following an incubation period of 24 hours at 37°C, the inhibition zone (IZ) Radius was measured visually. *E. coli* was used as the positive control (PC).

Study of Synthesized Compounds for Antibacterial Activity Against *Escherichia coli*.

We investigated the anti-bacterial impact of our synthesized compounds using an adapted agar well diffusion method. Specifically, we challenged them against the *Escherichia coli* bacterial strain. For each compound, 10 milliliters were directly placed onto a solid growth medium already seeded with the bacterial inoculum. Following a 24-hour incubation period at 37°C, we then precisely measured the zone of growth inhibition with a ruler to quantify their effectiveness.



Figure 1: Inhibition zone formed when Nickel (II) Schiff bases metal complexes against *Escherichia coli*,

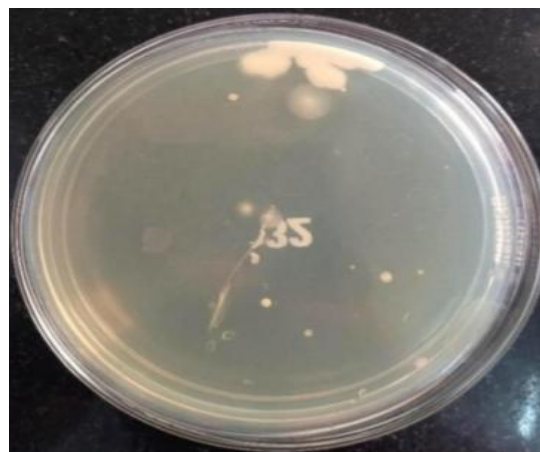
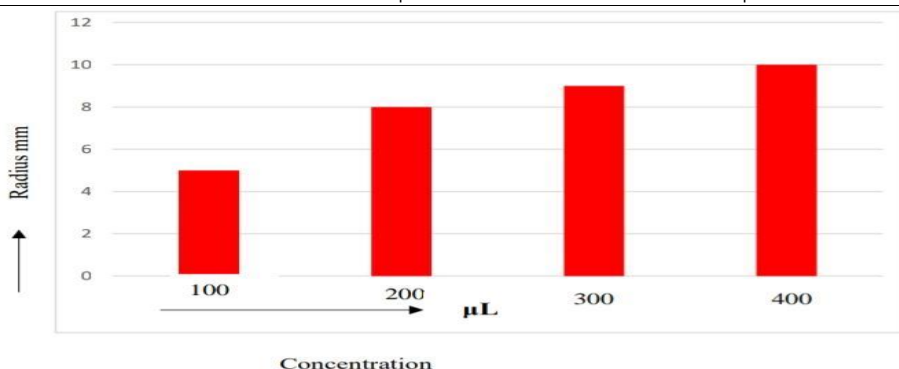


Figure 2: Control without metal complexes

The complete results are compiled in Table 2. It's worth noting that both the initial ligand and the resulting complexes were tested against two distinct bacterial species, including *E. coli*, and their respective outcomes are provided.

Table 2: Inhibition Zone IZ of synthesized complexes against *E. coli*

<i>Escherichia Coli</i>			
S. No	Concentration of Complexes in μ L	Radius of IZ in (mm)	Positive control
1.	100	5	1 mm
2.	200	8	
3.	300	9	
4.	400	10	



Graph 2: This Bar graph tells us that according to our inhibition zone concentration.

The inhibition zone (IZ) analysis revealed that the nickel complex exhibited the highest anti-bacterial activity *Escherichia coli*.

V. Conclusion

Our study successfully demonstrate the synthesis, characteristics, and germ-fighting abilities of a specific Schiff base, which we synthesized from Benzaldehyde and diphenylamine. We also explored its complexes with nickel (II). Using a range of spectroscopic techniques, we confidently confirmed that our Schiff base 'ligand' effectively binds to the nickel ion. we put the Schiff base and its metal complexes to the test against different micro-organisms. The anti-bacterial result revealed a clear concentration-dependent inhibition against *E.coli*. To ensure we have successfully created these compounds with nickel (II), we relied on detailed elemental analysis and various spectroscopic methods, including UV-Vis spectroscopy. The UV-Vis spectra of these new complexes consistently showed absorption bands around 291.4 nm. Through our anti-bacterial assessments, particularly by looking at how large their inhibition zones were, we found that the Schiff base metal complexes had a much greater impact. Simply put, they showed stronger antibacterial effects than just the Schiff base on its own or the basic metal salts. This improvement in activity suggests that these metal complexes could serve as effective anti-bacterial agents. Especially Ni (II) complexes showed moderate inhibition against *Escherichia coli*, respectively. These findings highlight the potential of Schiff base metal complexes.

References:

- Schiff, H. (1864). Mittheilungen aus dem Universitäts laboratorium in Pisa: eine neue Reihe organischer Basen. Justus Liebigs Annalen der Chemie, 131(1), 118- 119.
- Hine, J. and Yeh, C.Y., 1967. Equilibrium in formation and conformational isomerization of imines derived from isobutyraldehyde and saturated aliphatic primary amines. Journal of the American Chemical Society, 89(11), pp.2669-2676.
- Pfeiffer, P., Hesse, T., Pfizner, H., Scholl, W. and Thielert, H., 1937. Innere Komplexsalze der Aldimin- und Azoreihe. Journal für Praktische Chemie, 149(8-10), pp.217-296.
- Hariharan, M. and Urbach, F.L., 1969. Stereochemistry of tetradentate Schiff base complexes of cobalt (II). Inorganic Chemistry, 8(3), pp.556-559.
- Cimerman, Z., Miljanić, S. and Galić, N., 2000. Schiff bases derived from aminopyridines as spectrofluorimetric analytical reagents. Croatica Chemica Acta, 73(1), pp.81-95.
- Adaji, M. U., Iorungwa, M. S., & Salawu, O. W. (n.d.). Characterization of Schiff base ligand and its metal complexes. IntechOpen. <https://doi.org/10.5772/intechopen.114182>
- Kassim, K., & Hamali, M. A. (2018). Green synthesis and antimicrobial studies of Ni(II) and Zn(II) dinuclear Schiff base complexes. International Journal of Engineering & Technology, 7(3.11), 237–240.
- Bala, U. (2022). Synthesis, characterization, and antimicrobial activities of Schiff base complexes of Co(II) and Cu(II) derived from salicylaldehyde and diphenylamine. Scholars International Journal of Chemistry and Material Sciences, 5(1), Article 002. <https://doi.org/10.36348/sijcms.2022.v05i01.002>
- Abdullahi, B. L., & Aliyu, H. N. (2025). Synthesis, characterization, and antimicrobial activity of Ni (II) and Cu (II) complexes with schiff base derived from pyrrole-2-carboxaldehyde and thiosemicarbazide. *Proceedings of the Nigerian Society of Physical Sciences*, 2, 176. <https://doi.org/10.61298/pnspsc.2025.2.176>
- Bukhari, I. H., Arif, M., Nazir, F., Riaz, M., Aslam, N., & Ain, Q. U. (n.d.). Synthesis, characterization, and antimicrobial studies of Schiff base transition metal complexes of Cr(II), Mn(II), Co(II), Ni(II), Zn(II), and Cd(II) derived from cefadroxil. International Journal of Pharmaceutical Chemistry. <https://doi.org/10.7439/ijpc>
- Uba. B., Muhammad, C., Uba, A., Amali, A.M. (2020). Synthesis, characterization, Antibacterial and Antifungal Activities of Schiff Base Complexes of Ni (II) and Cu (II) derived from 2,2-hydroxy-1-naphthaldehyde and 4-aminophenol. IAR J. Pharm, 1(1) 1-5