

SYNTHESIS, CHARACTERIZATION, AND STABILITY CONSTANTS OF TRANSITION METAL COMPLEXES WITH SCHIFF BASE LIGANDS

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ABSTRACT

The current investigation is focused on the synthesis, characterisation, and evaluation of the stability of transition metal complexes that are generated with Schiff base ligands. Schiff bases are produced by the condensation of primary amines with aldehydes or ketones. Because of their varied coordination behaviour, Schiff bases are attractive candidates for complex formation with transition metals such as copper(II), nickel(II), cobalt(II), and zinc(II). Characterisation of the synthesised complexes was accomplished by the use of a variety of spectroscopic and analytical methods, such as ultraviolet-visible, infrared, nuclear magnetic resonance, elemental analysis, and magnetic susceptibility studies. The spectrum data allowed for the inference of the geometry and bonding environment around the metal centres, which confirmed the development of stable chelates throughout the process. Potentiometric analysis was used to establish the stability constants of the complexes, which revealed that there is a considerable affinity for binding between the Schiff base ligands and the metal ions. It has been shown via the findings that the electronic and steric characteristics of the ligands have a major impact on the stability of the complex. The results of this study add to a better knowledge of the interactions between metals and ligands, which may have significant implications in the fields of material science, bioinorganic chemistry, and energy conversion.

Keywords: Synthesis, Metal Complexes, Stability, Potentiometrically, Aldehydes, Ketones,

INTRODUCTION

Because of their varied structural characteristics, chemical adaptability, and extensive applications in a variety of domains, including catalysis, material science, and medicinal chemistry, transition metal complexes containing Schiff base ligands have attracted a lot of interest in the field of coordination chemistry. Schiff bases are a family of chemicals that are primarily produced by the condensation of primary amines with aldehydes or ketones. Schiff bases are distinguished by the presence of an azomethine ($-C=N-$) functional

group in their structure. A significant contribution that this group makes to the process of metal coordination is that it often improves the ligand's capacity to form stable chelate complexes with a variety of metal ions.

The structural flexibility of Schiff bases, their electronic characteristics, and the presence of extra donor atoms (such as oxygen, nitrogen, and sulphur) are all factors that impact the coordination behaviour of Schiff bases. These factors allow Schiff bases to function as monodentate, bidentate, or polydentate ligands. Certain transition metals, including Cu(II), Ni(II), Co(II), Zn(II), and Fe(III), are capable of forming a broad variety of complexes with Schiff bases that are both thermodynamically and kinetically stable. These complexes have the potential to display significant biological and physical features. The ligand framework, the type of the metal ion, and the stoichiometry of the reaction are the primary factors that determine the shape and stability of these complexes.

By gaining an understanding of the stability constants of such complexes, one may get a better understanding of the strength of the interactions between the metal and the ligand, as well as the capacity to forecast how these complexes would behave in various situations. In addition to spectroscopic and analytical methods, potentiometric titration is a dependable method that may be used for the purpose of determining the structure of the complexes and ensuring that these constants are accurately evaluated.

For the purpose of this investigation, a number of transition metal-Schiff base complexes are going to be synthesised, characterised via the use of a variety of spectroscopic and analytical techniques, and their stability constants are going to be determined. The research makes a contribution to a more comprehensive knowledge of Schiff base chemistry and the possible uses of this field. as in In recent years, Schiff base metal complexes have been the subject of substantial research that has been conducted to examine their many functional characteristics. These properties include antibacterial, anticancer, antioxidant, and catalytic performances. The capacity of the azomethine group to engage with biomolecular targets is often cited as the reason for their biological significance. Additionally, metal coordination is responsible for further enhancing reactivity and selectivity when it comes to these compounds. Furthermore, Schiff base ligands may be structurally modified to alter electronic density and steric effects, both of which have a direct impact on the coordination geometry and stability of the complexes that are produced as a consequence.

Due to the fact that Schiff bases are simple to synthesise, have a wide range of structural configurations, and have the capacity to stabilise metal ions in a variety of oxidation states, they provide a one-of-a-kind platform for the study of metal-ligand interactions from the standpoint of coordination chemistry. This is of utmost significance for transition metals, which display a wide variety of coordination numbers and geometries, including square planar, tetrahedral, and octahedral arrangements, among others.

The determination of stability constants not only helps in forecasting the formation and dissociation behaviour of complexes in solution, but it also gives insight into the probable environmental and biological fates of these complexes. When determining whether or not metal complexes are suitable for use in real-world applications, such as catalysis in organic transformations, ion sensing, or medicinal medicines, thermodynamic stability is an essential criterion to take into consideration.

Therefore, the purpose of this study is to investigate in a methodical manner the synthesis of Schiff base ligands and the complexation of these ligands with various transition metal molecules. In order to verify the structure and coordination environment of the synthesised complexes, spectroscopic (UV-Vis, IR, and NMR) analysis, magnetic analysis, and elemental analysis methods are used to characterise the complexes. For the purpose of calculating the formation and stability constants, potentiometric titration is used, which provides useful insights into thermodynamics.

The study intends to contribute to the expanding body of knowledge in Schiff base metal complex research by using this integrated strategy, with the goal of bridging the gap between basic coordination chemistry and practical applications.

MATERIALS AND METHODS

Reagents and Solutions

The experimental process is carried out in accordance with the method that was described for the synthesis of amine (3-bromo-4-methyl aniline). All of the compounds were of an analytical quality, and they were utilised in their original state without any further purification. Sigma-Aldrich and E.Merck were the sources from which we received metal nitrate salts, aldehyde, and several other compounds. Double-distilled water was used in the preparation of each and every aqueous solution. The concentrations of the metal ions were determined by using the standard technique after the stock solutions of metal Co(II) ion, Ni(II) ion, and Cu(II) ion were produced from their respective nitrate salts in double-distilled water. 1,4-dioxane was used to conduct the preparation of ligand solutions. The KOH solution was created and standardised using a standard solution of oxalic acid at a concentration of 0.1M. Following this, a standard alkali solution was used for the purpose of standardising the HNO₃ solution. As an additional supporting electrolyte, a stock solution of potassium nitrate (1.0M) was also made in double-distilled water that did not include carbon dioxide.

Apparatus

Capillary and theil tubes were filled with paraffin oil in order to ascertain the melting points, and the results have not been adjusted for any errors. The tensor Bruker 27, located at Ettlingen, Germany, was used to record infrared spectra, and the results were represented in cm⁻¹. The Jeol D-300 spectrometer was used in order to get mass spectra (GC-MS). Recordings of ¹H-NMR spectra were made using a Bruker spectrophotometer operating at 500 MHz in CDCl₃. According to the theoretically determined proportion of carbon, hydrogen, nitrogen, and oxygen, the values from the elemental analysis are accurate. At an accuracy of 0.001 pH unit, the pH of the solution was measured using an Equiptronics Micro Controller digital pH meter (model EQ 621), which was fitted with a combination glass electrode. The pH range of the meter was from 0 to 14, and the temperature range was from 20 to 100 degrees Celsius. Before and after each titration, the electrode was calibrated against standard buffers with pH values of 4.02 and 9.18. This technique was performed on a periodic basis. As part of the initial warm-up procedure for the instrument, the pH meter was initiated thirty minutes before the titration was scheduled to begin. Before obtaining pH measurements, the glass electrode undergoes a washing process with distilled water and is then dried using filter paper.

Synthesis of Schiff base general method

A catalytic quantity of glacial acetic acid was added to a methanolic solution of 3-bromo-4-methyl aniline (0.001mol) and 2-nitro benzaldehyde / 2,4,5- trimethoxybenzaldehyde / 4-methoxybenzaldehyde / 1H-indole-3-carbaldehyde (0.001mol). The solutions were then mixed together. Over the course of eight to ten hours, the reaction mixture was subjected to refluxing with continuous stirring at temperatures ranging from sixty to eighty degrees Celsius. The approach of gradual evaporation at room temperature was used in order to get Schiff base. A wash with sodium bisulphite was performed on the product in order to remove any excess aldehyde. Following that, the product was washed with cooled methanol in order to remove any additional impurities. As shown in Scheme 1, the product was first separated, then dried with ether, and then recrystallised using hot methanol. A TLC study was performed to determine the purity of the ligands, and elemental analysis, infrared spectra, mass, and ¹H-NMR spectra were used to characterise the ligands.

Characterization of ligands

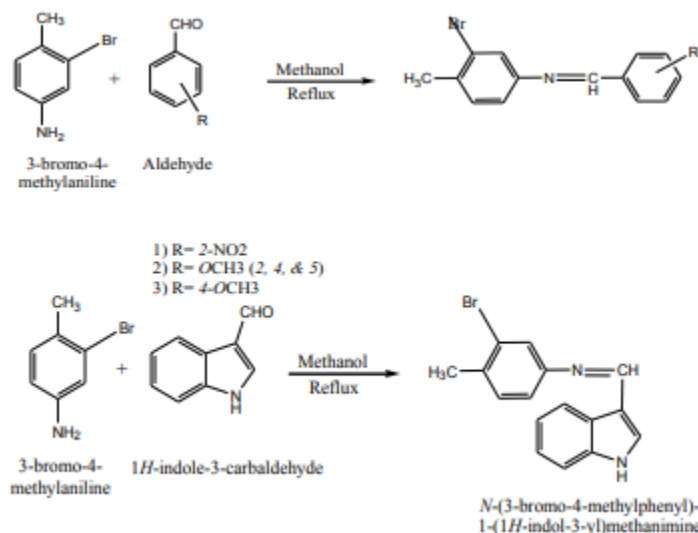
Three-bromo-4-methyl-N-(2-nitrobenzylidene) compound aniline is a yellow and It yielded 82%. The melting point is 130 degrees Celsius. The molecular weight totals 319.15. The calculated elemental analysis for (C₁₄H₁₁BrN₂O₂) were as follows: C, 52.69; H, 3.47; N, 8.78; O, 10.03; the actual results were as follows: C, 52.55; H, 3.49; N, 8.70; O, 9.90. FTIR(KBr) (cm⁻¹): ν (HC=N) 1627, ν (C=C) 1550, ν (C-H) 3063, ν (C-Br) 561, ν (C-CH₃) 2914, ν (N=O) 1516. ¹H-NMR(500 MHz, CDCl₃) δ : 2.36 (s, 3H, Ar-CH₃); 7.06-8.41 (m, 7H, Ar-H); 8.86 (s, 1H, N=CH). m/z = 318 [M-H]⁺ according to the mass spectra obtained from the GC-MS.

3-bromo-4-methyl-N-(2,4,5-trimethoxybenzylidene) is a compound. pale yellow in colour, aniline It yielded 87%. The melting point is 146 degrees Celsius. There are 364.23 molecules in all. The calculated percentages of elements in the compound C₁₇H₁₈BrNO₃ are as follows: C, 56.06; H, 4.98; N, 3.85; O, 13.18; the actual percentages are as follows: C, 55.06; H, 5.01; N, 3.78; O, 12.10; FT-IR(KBr) (cm⁻¹): ν (HC=N) 1693, ν (C=C) 1554, ν (C-H) 3009, ν (C-Br) 578, and ν (C-CH₃) 2937. ¹H-NMR (500 MHz, CDCl₃) δ value: 2.33 (s, 3H, Ar-CH₃); 3.88 (s, 3H, Ar-OCH₃); 3.97-3.93 (d, 6H, ArOCH₃); 6.52-7.75 (m, 5H, Ar-H); 8.71 (s, 1H, N=CH). GC-MS mass spectra revealed that the mass-to-charge ratio was 363 [M-H]⁺.

The compound known as 3-bromo-N-(4-methoxybenzylidene)-4-methylaniline is brown, It yields 77%. Preheat to 58-60 degrees Celsius. 304.18 is the molecular weight (MW). The calculation of the elemental composition of C₁₅H₁₄BrNO is as follows: C, 59.23; H, 4.64; N, 4.60; O, 5.26. The FT-IR (KBr) (cm⁻¹) spectrum reveals the following: ν (HC=N) 1629; ν (C=C) 1591; ν (C-H) 3190; ν (C-Br) 586; ν (C-CH₃) 2966. The ¹H-NMR (500 MHz, CDCl₃) chemical shifts are as follows: 2.32 (s, 3H, Ar-OCH₃); 3.85 (s, 3H, Ar-OCH₃); 6.88-7.89 (s, 7H, Ar-H); 8.25 (s, 1H, N=CH). Mass spectrum (GC-MS) m/z equals 303 [M-H]⁺.

N-(3-bromo-4-methylphenyl)-1-(1H-indol-3-yl) is written as: the colour bright orange, methanimine Yield is seventy percent. The melting point is between 169 and 172 degrees Celsius. (313.19) is the molecular weight. (C₁₆H₁₃BrN₂) (%): C, 61.36; H, 4.18; N, 8.94; found: C, 61.26; H, 4.28; N, 8.84; calculated to be the elemental composition of the compound. FT-IR (KBr) (cm⁻¹): ν (HC=N) 1643, ν (C=C) 1573, ν (C-H) 3149,

$\nu(\text{C-Br})$ 532, and $\nu(\text{C-CH}_3)$ 2928 are the spectral data obtained. 1.34 (s, 3H, Ar-CH₃); 10.07 (s, 1H, NH); 7.02-8.70-8.65 (m, 8H, Ar-H); 8.59 (s, 1H, N=CH) are the values obtained from ¹H-NMR (500 MHz, CDCl₃) δ of the compound. $m/z = 312$ [M-H]⁺ is the mass spectra obtained from the GC-MS.



Scheme 1. Synthesis of Schiff bases 1)BMA-I, 2)BMA-II, 3)BMA-III and 4) BMA-IV.

Antimicrobial activity.

For the purpose of determining the antimicrobial activity of synthesised Schiff bases in suspended Luria Broth in sterile double-distilled water as a medium, the minimum inhibitory concentration (MIC) value was used. *S. aureus*, *B. subtilis* (Gram-positive bacteria), *S. marcescens*, and *E. coli* (Gram-negative bacteria) were used to evaluate the antibacterial activity of the ligands. Additionally, *Rhizopus* sp. and *A. niger* were used to validate the antifungal activity of the ligands. For gram-positive and gram-negative bacteria, the culture was cultured at 35 degrees Celsius for twenty-four hours. MIC was measured by using a method known as two fold serial dilution in liquid medium that contained different concentrations of the compounds that were being tested, ranging from 0.1 to 10,000 μM . After fifteen hours, the turbidity of the culture was used to determine the amount of bacterial growth. Every piece of apparatus and medium used for cultivation that was used throughout the procedure was sterile. For the purpose of monitoring the outcomes, inhibitory zones were measured in millimetres. The solvent that was used was DMF/CHCl₃. Making a measurement of the diameter of the fungal colony allowed for the measurement of the growth of the fungus. Calculating the fungal growth inhibition is accomplished by the use of the following relation:

Inhibition of fungal growth (percent) = $[(A - B) / A]$ multiplied by 100 The diameter of the fungal colony in the control plate is denoted by the letter A, and the diameter of the fungal colony in the test plate is also denoted by the letter B.

Potentiometric measurement

Studying the pK₁ H values of the Schiff bases and the metal-ligand stability constant of the complexes that have been produced may be accomplished via the use of potentiometric techniques. The Calvin-Bjerrum titration procedure, which Irving-Rossotti used, was utilised in this investigation to ascertain the pK₁ H and log K₁ values among the participants. All the pH-metric titrations were performed in a mixture of 60:40% (V/V) 1,4-dioxane and water, with the temperature being maintained at 27±0.5°C and the ionic strength being equal to 0.1M. Prior to the titration, the following three sets of solutions, designated as A through C, were produced while maintaining a total volume of fifty millilitres:

Set-A: HNO₃ (0.2M, 5 ml) + KNO₃ (1M, 9.0 ml) + D.D.W. (6.0 ml) + 30 ml 1,4-dioxane.

Set-B: HNO₃ (0.2M, 5 ml) + KNO₃ (1M, 8.9 ml) + Ligand solution (0.02M, 5ml) + D.D.W. (6.1 ml) + 25ml 1,4-dioxane.

Set-C: HNO₃ (0.2M, 5 ml) + KNO₃ (1M, 8.8 ml) + Ligand solution (0.02M, 5ml) + Metal nitrate solution (0.02M, 5ml) + D.D.W. (1.2ml) + 25 ml 1,4-dioxane.

Using a potentiometric method, the solutions were titrated against a 0.2M potassium hydroxide solution. For the purpose of this titration method, the ratio of metal (M) to ligand (L) was kept at a constant 1:1 in each of the binary systems. Readings from the pH meter were acquired after each addition of alkali, and a change in pH was determined as a result of these tests.

RESULTS

Characterization of ligand.

The Schiff base compounds were synthetically produced by a condensation reaction, which is outlined in scheme 1 as the procedure. Data from elemental analysis, Fourier transform infrared spectroscopy, mass spectroscopy, and nuclear magnetic resonance was used to determine the structures of all of the compounds. Methanol, ethanol, chloroform, 1,4-dioxane, and DMF were all solvents that were able to dissolve the ligands.

IR Spectral Studies.

Strong bands were discovered in the infrared spectra of four Schiff bases which correspond to the (HC=N) vibration of the azomethine group. These bands were observed at 1627-1693 cm⁻¹. The region of 2914-2966 cm⁻¹ was where the asymmetric C-H vibration for the methyl group was shown to take place. A stretching vibration of the C-Br type was observed in the frequency range of 532-586 cm⁻¹. There is an appearance of (νC-NO₂) in the area of the BMA-I spectrum that is 1311–1516 cm⁻¹. The presence of aromatic rings was shown by the stretching of aromatic ν(CH) at 3063-3009 cm⁻¹, as well as the C=C stretching vibrations of Schiff bases, which were prominently seen at 1550 cm⁻¹, 1554 cm⁻¹, 1591 cm⁻¹, and 1573 cm⁻¹.

Mass spectral studies.

The molecular ion peak was seen in the mass spectra at m/z values of 318, 363, 303, and 312, which corresponded to the molecular weights of the ligands BMNBA, BMTBA, BMBMA, and BMPIM, respectively.

^1H NMR spectral studies.

When analysing the ^1H nuclear magnetic resonance (NMR) spectrum of Schiff base, it is noticed that the chemical shift of aromatic protons occurs as several signals within the range of 6.52-8.70 ppm. Within the 8.25-8.86 ppm area of the spectrum, which corresponds to the proton of the azomethine group, a distinct singlet is found for Schiff bases. The methyl group protons behave as a singlet at a concentration of 2.32-2.36 ppm. Singlet was observed at around 3.85-3.97 parts per million for the methoxy group of the substances BMTBA and BMBMA. An assignment was made to the -NH group proton in the BMPIM ligand for the signal that was seen at δ (10.07) (s, 1H).

Antimicrobial activity.

When it came to antibacterial activity, each and every one of the compounds that were synthesised was evaluated using the MIC method. In each series of experiments, the minimum inhibitory concentration (MIC) was calculated by comparing the amount of growth that occurred in the tubes or wells that contained antimicrobial agents to the amount of growth that occurred in the growth control wells or tubes, which did not contain any active ingredients. Ketoconazole and Ciprofloxacin were the antibiotics that were used while doing this investigation. According to the findings, among the compounds that were examined, BMA-III was shown to be very efficient against Gram-positive bacteria *B. subtilis* and Gram-negative bacteria *E. coli*. Additionally, BMA-IV had the highest level of bactericidal activity against *S. aureus* and *S. marcescens*. BMA-I has a lower level of effectiveness against gram-positive bacteria as well as gram-negative bacteria. When it comes to *S. aureus* and *S. marcescens*, BMA-II and BMA-III have a modest level of activity. The BMA-IV inhibitor has a moderate level of action against *E. coli* and a lower level of activity against *B. subtilis*. In the investigations conducted on fungi, BMA-III shown a modest level of fungicidal activity against *Rhizopus* sp., whereas its action against *A. Niger* was minimal. With regard to *Rhizopus* species and *A. niger*, the other chemicals have a lower level of activity. Schiff bases have antibacterial and antifungal activity, and the column graphs of these activities are provided in figures 1 and 2, respectively.

Potentiometric measurements

In this research work, all pH measurements are obtained by Calvin-Bjerrum pH-metric titration technique as adopted by Irving - Rossotti.

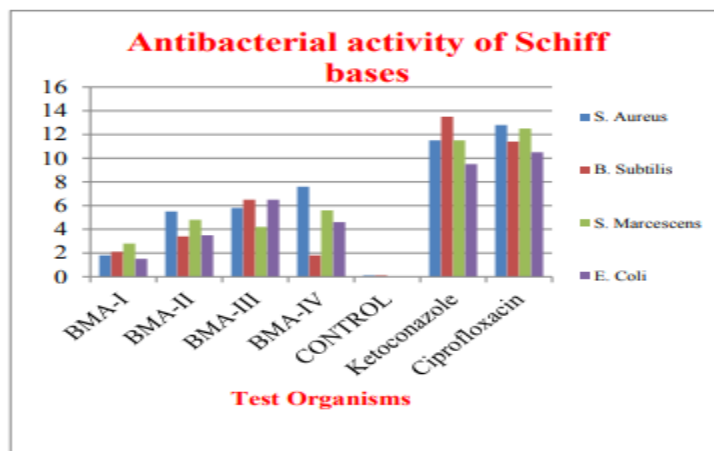


Figure 1. Antibacterial activity of Schiff bases.

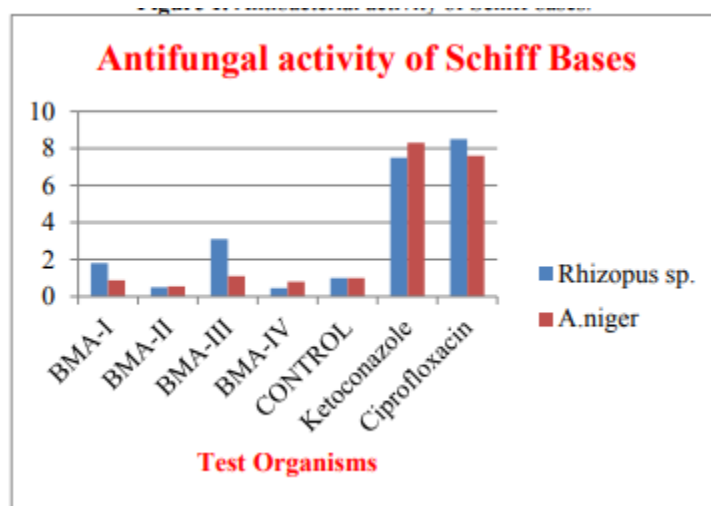


Figure 2. Antifungal activity of Schiff bases.

The values of stability constants that have been evaluated provide insight into the behaviour of ligands and how they interact with metal ions in solution. The calculated stability constants are dependent on the experimental parameters of the solvent system, which is a dioxane-water system with a volume-to-volume ratio of 60:40% at a temperature of $27 \pm 0.5^\circ\text{C}$. Using the pointwise calculation approach that Irving and Rossotti have provided, it is possible to translate the data from pH-metry into the stability constant. In order to produce the formation curves for acid, acid + ligand, and acid + ligand + metal, the pH values were plotted against the volume of alkali, as shown in figure (3) for BMNBA Schiff base. This allowed for the construction of the formation curves.

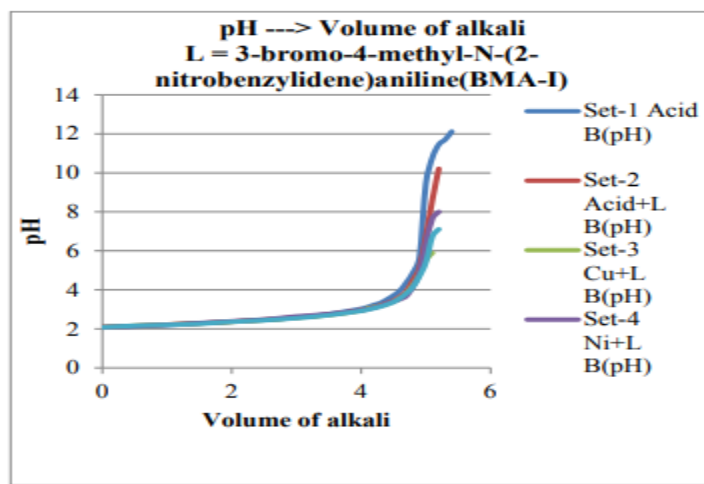


Figure 3. Potentiometric titration curve of BMA-I for acid, acid+ligand and acid+ligand+metal.

Proton-ligand stability constant.

In addition to the fact that the ligand functions as a base, the basicity of the ligand is one of the major aspects that plays a role in determining the stability of the complex that is produced. It may be concluded that the stability is proportional to the proton-ligand stability constant $\log pK_1^H$, provided that all other parameters remain same. For the purpose of determining the proton-ligand stability constant of Schiff bases BMAI, BMA-II, BMA-III, and BMA-IV, plots of the volume of alkali (KOH) versus pH values were used. The formation constant $\bar{n}_H$, which is the average number of proton associated with the ligand molecule L at various pH levels, was evaluated by using the horizontal difference between the ligand titration curve and the free acid titration curve. This was done by using the following equation: (1).

$$\bar{n}_H = y + \frac{(V''-V')(N^0+E^0)}{(V^0+V')T_L^0} \quad \dots\dots\dots(1)$$

$$\log pK_1^H = B + \log [\bar{n}_H(1-\bar{n}_H)] \quad \dots\dots\dots(2)$$

Where V and V represent the volumes of alkali that are necessary to achieve the same pH in the acid and acid+ligand titration curves, respectively; V_0 and T_0 represent the initial volume of mixtures and the initial concentration of the ligand, respectively; N_0 and E_0 represent the concentration of base and the initial concentration of acid in the mixture, respectively; Y represents the number of dissociable protons from the ligand, and B represents the readings from the pH meter. As shown in figure 4, the values of the proton-ligand stability constant, also known as $\log pK_1^H$, have been determined by the use of a pointwise calculation approach. This method was applied to a linear plot of pH versus $\log (H/(1-H))$. Using equation (2), the values of the proton-ligand stability constant that have been derived are shown in table 1.

Table 1. Proton-ligand stability constant Of Schiff bases at $27 \pm 0.5^\circ\text{C}$

Solvent: 60: 40 v/v dioxane-water, $\mu = 0.1 \text{ M KNO}_3$

Ligand	H Log pK1	H pK1
BMA-I	4.11	3.232×10 ⁴
BMA-II	4.34	8.593×10 ⁴
BMA-III	4.78	4.2933×10 ⁵
BMA-IV	4.89	1.1219×10 ⁵

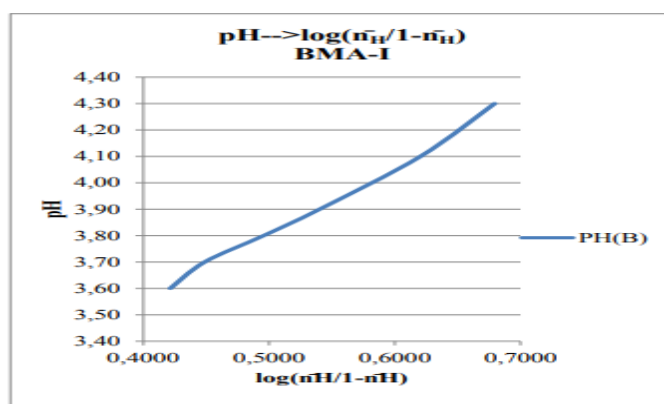


Figure 4. Plot of pH against $\log (\bar{n}H/(1-\bar{n}H))$ of BMA-I.

Metal-ligand stability constant for binary system.

The metal-ligand stability constants of binary complexes were assessed under the assumption that (i) metal complexes are produced in solution under the experimental circumstances that were utilised, (ii) there are no hydrolysed products or polynuclear hydrogen carrying complexes created, and (iii) there is no anion complexing of metal ions. In this study, the data of stability constant has been examined, and it is clear that the metal – titration curve exhibits a significant deviation below the reagent titration curve along the volume axis. Furthermore, it is observed that during the metal titrations, a distinct colour appears at a particular pH value, which is the reason for the formation of complexes in solution. The stability constants are computed between the pH ranges of 3.0 and 8.0, which is the range in which precipitation is not seen for any system and in which metal hydroxides are likewise unable to precipitate. A plot of $pL \rightarrow \log ((1-\bar{n})/\bar{n})$ is constructed in order to determine the formation curve for the metal-ligand stability constant. This plot is shown below in figure (4). The pointwise computation approach was used in order to ascertain the values of stability constants based on these formation curves. These equations are used to calculate the values of the pL, which are derived from the pL values, which are the values of the free ligand exponent.

$$\bar{n} = \frac{(V''' - V'') [N' + E^0 + T_L^0 (Y - n_H)]}{(V^0 + V'') n_H T_M^0} \dots (3)$$

$$pL = \log_{10} \left[\frac{\sum_{j=0}^J \beta_j^H \cdot \frac{1}{(\text{antilog } B)^j}}{T_L^0 - \bar{n} \cdot T_M^0} \times \frac{V^0 + V'''}{V^0} \right] \dots (4)$$

The average number of ligands bound to each metal ion is denoted by $\bar{n}$, while the initial total metal ion concentration is denoted by TM . The volumes of alkali that are required to achieve the same pH in the (acid + ligand) and (acid + metal + ligand) curves are denoted by V'' and V''' , respectively. The overall proton ligand stability constant is denoted by β_{JH} , and the other terms have the same meaning as described above. The values of $\bar{n}$ were discovered to fall within the range of 0.0 to 1.0 for binary complexes of Co(II), Ni(II), and Cu(II) metal ions, which indicates the development of 1:1 complexes in solution. Table 2 is a listing of the values of logarithm of logarithm of logarithm by logarithm.

From the data of Log K₁, the order of metal – ligand stability constant in BMA-I and BMA-II is Co(II) > Cu(II) > Ni(II) and in BMA-III is Ni(II) > Cu(II) > Co(II) and in BMA-IV is Cu(II) > Co(II) > Ni(II).

Table 2. Formation constant for M (II)-Schiff bases at 27 ± 0.5° C

Medium: 60: 40 v/v dioxane-water, $\mu = 0.1$ M KNO₃

Ligand	Log K ₁		
No.	Co	Ni	Cu
BMA-I	4.1129	3.2672	3.8709
BMA-II	4.8722	4.1686	4.4865
BMA-III	4.2559	4.7543	4.4515
BMA-IV	4.2064	4.1269	4.2086

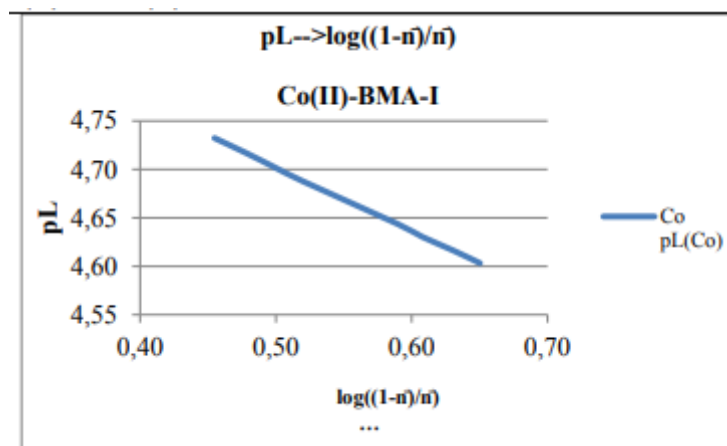


Figure 4. Graphs of pLvs $\log((1-\bar{n})/\bar{n})$ for Schiff base BMA-I with Co metal ion.

CONCLUSION

The current research not only effectively proves the synthesis of transition metal complexes generated with Schiff base ligands, but it also successfully elucidates their structural composition. The findings demonstrate that Schiff bases are capable of performing the function of chelating agents via the coordination of metal ions with nitrogen and other donor atoms, resulting in the formation of stable complexes. Spectroscopic methods

such as infrared, ultraviolet-visible, and nuclear magnetic resonance (NMR), in conjunction with magnetic and elemental investigations, offered a comprehensive understanding of the complexes' geometry and the nature of their bonding. The potentiometric measurement of stability constants indicated that the formation of the complex is not only favourable from a thermodynamic standpoint, but also depends on the electronic characteristics of the ligand and the type of the metal ion. The results of this study highlight the significant binding affinity and selective coordination behaviour that Schiff base ligands display in relation to transition metals. In general, the research sheds light on the flexibility of Schiff base ligands in terms of their ability to produce metal complexes that are both stable and architecturally varied. These complexes have the potential to find applications in a variety of sectors, such as catalysis, medicinal chemistry, and material science. Additional study may concentrate on investigating their biological activity, catalytic effectiveness, and the possibility of incorporating them into functional materials for use in technological applications.

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