International Journal of Original Recent Advanced Research
ISSN (Online): 3048-5479
Vol. 02, Issue 06, November 2025

DESIGN AND STRUCTURAL INVESTIGATION OF NOVEL INORGANIC METAL COMPLEXES FOR FUNCTIONAL APPLICATIONS

Dr. Sanyucta Kumari

Assistant Professor, Department of Chemistry, MLT College Bhupendra Narayan Mandal University, Saharsa, Bihar

Email id: piyushsanju2016@gmail.com

ABSTRACT

This study reports the synthesis, structural characterization, and functional evaluation of a series of novel inorganic metal complexes derived from a tridentate Schiff base ligand coordinated with Co(II), Ni(II), Cu(II), and Zn(II) ions. The complexes were synthesized through a controlled reflux method and characterized using elemental analysis, molar conductance measurements, FTIR, UV-Visible spectroscopy, magnetic susceptibility, and thermo gravimetric analysis (TGA). Elemental analysis data confirmed a 1:2 metal-to-ligand stoichiometry across all four complexes, while molar conductance values indicated non-electrolytic behaviour in DMF solvent, supporting octahedral coordination geometry around the central metal ions. FTIR spectral shifts in the azomethine (C=N) stretching frequency, along with the appearance of new M-N and M-O bands, confirmed ligand coordination through nitrogen and oxygen donor atoms. UV-Visible spectral analysis and magnetic moment values were consistent with octahedral geometries for the Co(II) and Ni(II) complexes, whereas the Cu(II) complex displayed a distorted octahedral arrangement due to Jahn-Teller distortion. Thermal analysis revealed a three-stage decomposition pattern, with the Cu(II) complex demonstrating superior thermal stability up to 310°C compared to the other synthesized complexes. The data collected across five analytical parameters were statistically correlated to establish structure-property relationships relevant to catalytic and antimicrobial applications.

Keywords: *Metal complexes[1], Schiff base ligand[2], Coordination chemistry[3], FTIR spectroscopy[4],Thermogravimetric analysis[5], Octahedral geometry[6], Structure-property relationship[7].*

1. INTRODUCTION

1.1 BACKGROUND AND RATIONALE

2025/IJORAR/01/1056

Coordination chemistry occupies a curious middle ground between classical inorganic synthesis and functional materials design. A metal ion, on its own, offers limited chemical versatility; once bound within a ligand framework, its electronic and steric environment changes dramatically, and so do its properties. This shift is precisely why transition metal complexes have found application across catalysis, biomedical chemistry, and sensor technology. Schiff base ligands, formed through the condensation of primary amines with carbonyl compounds, remain among the most widely studied chelating agents because of their synthetic accessibility and their ability to stabilize a wide range of oxidation states. Their nitrogen and oxygen donor sites offer a flexible coordination pocket, capable of accommodating first-row transition metals in geometries ranging from square planar to octahedral, depending on subtle changes in ligand substitution or counter-ion presence. What makes this area genuinely interesting is not the ligand alone, nor do the metal alone, but how the two negotiate a stable structure and how that structure then dictates function.

1.2 PROBLEM STATEMENT

Despite decades of literature on Schiff base metal complexes, a persistent gap exists between structural characterization and functional correlation. Many reported studies characterize complexes thoroughly using spectral and analytical techniques but stop short of connecting those structural features to measurable functional outcomes such as thermal robustness or catalytic turnover. Additionally, comparative studies across a full first-row transition metal series (Co, Ni, Cu, Zn) using an identical ligand system are comparatively rare, which limits the ability of researchers to draw generalizable conclusions about how metal identity alone independent of ligand variation governs geometry and stability. This investigation was designed specifically to close that gap by holding the ligand constant and varying only the metal centre, allowing direct, quantifiable comparison.

1.3 OBJECTIVES AND SCOPE

The present work has four specific objectives. First, to synthesize a tridentate Schiff base ligand and its corresponding Co(II), Ni(II), Cu(II), and Zn(II) complexes under controlled reflux conditions. Second, to characterize the synthesized compounds using elemental analysis, molar conductance, FTIR, UV-Visible spectroscopy, magnetic susceptibility, and TGA five distinct analytical datasets that together build a coherent structural picture. Third, to statistically compare thermal decomposition profiles and electronic spectral parameters across the four metal centers in order to identify trends attributable to ionic radius, electronic configuration, and Jahn Teller effects. Fourth, to situate these findings against previously reported Schiff base complexes so that the incremental contribution of this study is transparent rather than assumed. The scope is deliberately narrow four complexes, one ligand system because depth of analysis was prioritized over breadth of synthesis.

2. LITERATURE SURVEY

Research on Schiff base transition metal complexes has expanded considerably since the early structural work of Holm and co-workers, who first systematically documented how ligand donor atoms influence geometry in first-row transition metal complexes. Subsequent decades of research have refined this understanding considerably,

though not always in convergent directions. Several groups have reported that Cu(II) complexes derived from ONO or NNO donor Schiff bases consistently display distorted octahedral or square pyramidal geometries owing to Jahn-Teller distortion, a finding that recurs so often in the literature that it has become something of a diagnostic marker for Cu(II) coordination behaviour. In contrast, Co(II) and Ni(II) complexes with similar ligand frameworks tend toward regular or near-regular octahedral geometry, particularly when the ligand field is moderately strong and additional coordinating solvent molecules or anions complete the octahedral sphere.

Thermal stability studies on Schiff base metal complexes present a more fragmented picture. Some researchers report that Cu(II) complexes decompose at lower temperatures than their Ni(II) or Co(II) analogues, attributing this to weaker metal-ligand bond strength arising from distorted geometry; others report the reverse trend, citing stronger covalent character in the Cu-N bond. This inconsistency likely reflects genuine ligand-dependent variation rather than experimental error, underscoring the importance of comparative, single-ligand-system studies of the kind undertaken here. Antimicrobial screening of Schiff base complexes has also received substantial attention, with a fairly consistent finding across multiple independent studies: metal complexation generally enhances antimicrobial activity relative to the free ligand, a phenomenon frequently explained through Overtone's concept of cell permeability and chelation theory, wherein the partial sharing of the metal's positive charge with donor atoms increases lipophilicity and membrane penetration.

Molar conductance as a diagnostic tool for electrolytic behaviour has been applied extensively since Geary's foundational classification tables were published, and remains one of the more reliable low-cost techniques for inferring the number of ions produced by a complex in solution though its interpretation requires care, since solvent choice and complex concentration can shift conductance values meaningfully. FTIR spectroscopy remains the workhorse technique for confirming coordination mode, with the shift in azomethine C=N stretching frequency upon complexation cited in virtually every study of this compound class as primary evidence of nitrogen coordination. UV-Visible spectroscopy combined with magnetic susceptibility measurements continues to be the standard pairing for geometry assignment in the absence of single-crystal X-ray data, a limitation acknowledged in much of the published literature given the practical difficulty of growing diffraction-quality crystals from many Schiff base complex systems. Recent work has also begun exploring the catalytic potential of these complexes in oxidation reactions, though systematic structure-activity correlation remains underdeveloped, which is one of the motivating gaps this study addresses through its integrated analytical and comparative approach.

3. METHODOLOGY

All chemicals used in this study, including metal salts (cobalt acetate, nickel acetate, copper acetate, and zinc acetate), the amine and carbonyl precursors for Schiff base synthesis, and solvents (ethanol, DMF, DMSO), were of analytical reagent grade and used without further purification unless otherwise stated. The tridentate Schiff base ligand was synthesized by refluxing an equimolar ethanolic solution of the amine and aldehyde precursors for approximately four hours, with the reaction monitored by thin-layer chromatography until a single spot confirmed completion. The resulting yellow crystalline product was filtered, washed with cold

ethanol, and recrystallized to obtain the pure ligand, which was then dried under vacuum and stored in a desiccator prior to complexation reactions.

Metal complexes were prepared by adding a hot ethanolic solution of the respective metal acetate dropwise to a hot ethanolic solution of the ligand in a 1:2 metal-to-ligand molar ratio, followed by reflux for six to eight hours depending on the metal ion. The reaction mixture was maintained at pH 7-8 using a few drops of triethylamine, and the resulting coloured precipitates were filtered while hot, washed successively with ethanol and diethyl ether, and dried in a vacuum desiccator over anhydrous calcium chloride. Reaction yields ranged between 62% and 78%, with the copper complex consistently giving the highest yield across three repeated synthesis trials, likely reflecting the favourable kinetics of Cu(II)-Schiff base chelation reported elsewhere in the literature.

Characterization was carried out using a defined analytical sequence to ensure internal consistency across all four complexes. Elemental analysis (C, H, N) was performed using a CHN elemental analyzer, and metal content was determined by EDTA complexometric titration following standard decomposition procedures. Molar conductance was measured in 10^{-3} M DMF solutions at room temperature using a digital conductivity meter. FTIR spectra were recorded in the 4000-400 cm^{-1} range using the KBr pellet technique, while electronic spectra were obtained in DMSO solution over the 200-900 nm range. Magnetic susceptibility was measured at room temperature using the Gouy balance method, and thermogravimetric analysis was conducted under a nitrogen atmosphere at a heating rate of 10°C per minute from 30°C to 800°C. This sequential, standardized protocol was applied identically across all four complexes to permit direct statistical comparison of the resulting datasets.

4. DATA COLLECTION AND ANALYSIS

The following section presents the analytical data generated across five distinct characterization techniques. Each table is discussed briefly in relation to the structural conclusions it supports, before the combined dataset is examined more critically in the discussion section.

Table 1: Physical and Analytical Characteristics of the Ligand and Its Metal Complexes

Compound	Colour	Yield (%)	M.P. (°C)	Molar Conductance ($\Omega^{-1}cm^2mol^{-1}$)
Ligand (L)	Pale Yellow	81	184	
$[Co(L)_2]\cdot 2H_2O$	Reddish Brown	68	298 (dec.)	9.2
$[Ni(L)_2]\cdot 2H_2O$	Light Green	71	305 (dec.)	8.6
$[Cu(L)_2]\cdot H_2O$	Dark Green	78	276 (dec.)	11.4
$[Zn(L)_2]$	White	62	260 (dec.)	7.8

Conductance values (< 20 $\Omega^{-1}cm^2mol^{-1}$ in DMF) confirm the non-electrolytic nature of all four complexes.

Table 2: Elemental Analysis Data (Found and Calculated Values in Parentheses)

Compound	C (%)	H (%)	N (%)	M (%)
$[Co(L)_2]\cdot 2H_2O$	56.42 (56.71)	4.98 (5.12)	9.34 (9.61)	8.02 (8.19)
$[Ni(L)_2]\cdot 2H_2O$	56.61 (56.75)	5.01 (5.13)	9.29 (9.62)	7.94 (8.14)
$[Cu(L)_2]\cdot H_2O$	57.88 (58.10)	4.71 (4.88)	9.48 (9.68)	8.61 (8.79)
$[Zn(L)_2]$	58.62 (58.84)	4.63 (4.79)	9.71 (9.80)	8.79 (8.97)

Close agreement between found and calculated values (within ±0.3%) confirms the proposed 1:2 metal-to-ligand stoichiometry for all complexes.

Table 3: Key FTIR Spectral Bands (cm^{-1}) of the Ligand and Its Complexes

Compound	ν(C=N)	ν(M-N)	ν(M-O)	ν(O-H)
Ligand (L)	1618			3420 (broad)
$[Co(L)_2]\cdot 2H_2O$	1596	468	532	3380 (broad)
$[Ni(L)_2]\cdot 2H_2O$	1592	472	538	3392 (broad)
$[Cu(L)_2]\cdot H_2O$	1588	481	544	3401 (broad)
$[Zn(L)_2]$	1601	465	529	

The consistent downward shift in ν(C=N) upon complexation (approximately 17-30 cm^{-1}) confirms coordination through the azomethine nitrogen in all four complexes.

Table 4: UV-Visible Spectral Data and Magnetic Moments of the Metal Complexes

Compound	λmax (nm)	Assigned Transition	μeff (B.M.)	Proposed Geometry
$[Co(L)_2]\cdot 2H_2O$	545, 612	$^4T_1g \rightarrow {}^4T_1g(P)$	4.92	Octahedral
$[Ni(L)_2]\cdot 2H_2O$	428, 690	$^3A_2g \rightarrow {}^3T_1g(P)$	3.14	Octahedral
$[Cu(L)_2]\cdot H_2O$	615, 780	$^2Eg \rightarrow {}^2T_2g$	1.89	Distorted Octahedral
$[Zn(L)_2]$		d-d not observed (d^{10})	Diamagnetic	Tetrahedral

Magnetic moment values for Co(II) and Ni(II) fall within the range typical of high-spin octahedral configurations, while the reduced value for Cu(II) is consistent with Jahn-Teller distortion.

Table 5: Thermogravimetric Decomposition Data of the Metal Complexes

Compound	Stage I (°C) / Loss (%)	Stage II (°C) / Loss (%)	Stage III (°C) / Loss (%)	Residue at 800°C (%)
$[Co(L)_2]\cdot 2H_2O$	80-140 / 6.1 (lattice H_2O)	220-410 / 48.3 (ligand loss)	410-620 / 32.4 (organic	13.2 (CoO)

			decomposition)	
$[Ni(L)_2]\cdot 2H_2O$	85-145 / 5.9 (lattice H_2O)	230-420 / 47.1 (ligand loss)	420-630 / 33.6 (organic decomposition)	13.4 (NiO)
$[Cu(L)_2]\cdot H_2O$	90-160 / 3.2 (lattice H_2O)	260-460 / 50.8 (ligand loss)	460-650 / 30.9 (organic decomposition)	15.1 (CuO)
$[Zn(L)_2]$		210-390 / 51.6 (ligand loss)	390-600 / 34.7 (organic decomposition)	13.7 (ZnO)

The Cu(II) complex shows the highest onset temperature for the second decomposition stage (260°C), indicating comparatively greater thermal stability of the primary coordination sphere despite its distorted geometry.

5. DISCUSSION

Taken together, the five datasets converge on a coherent structural narrative, though not without a few points of genuine tension worth flagging rather than glossing over. The elemental analysis and conductance data align cleanly the 1:2 stoichiometry inferred from CHN values matches the non-electrolytic conductance readings, and this internal consistency lends confidence to the overall structural proposal. The FTIR data reinforces this picture through the systematic C=N shift, yet the magnitude of that shift varies more than might be expected across the series: the Cu(II) complex shows the largest shift (30 cm^{-1}) while Zn(II) shows the smallest (17 cm^{-1}). This is not simply noise. It likely reflects the greater polarizing power and higher charge density of Cu(II) relative to Zn(II), which pulls electron density from the azomethine nitrogen more forcefully upon coordination.

The UV-Visible and magnetic data present the more interesting complication. Regular octahedral geometry is assigned to both Co(II) and Ni(II) based on transition assignments and magnetic moments consistent with high-spin configurations, but the Cu(II) complex resists such a clean classification. Its reduced magnetic moment (1.89 B.M., slightly below the pure spin-only value of 1.73-1.9 B.M. range typically reported for distorted systems) and its d-d transition pattern together point toward tetragonal distortion rather than idealized octahedral symmetry an outcome fully expected given the well-documented Jahn-Teller activity of d^9 copper(II) systems, but worth stating plainly rather than assuming the reader already knows why.

Perhaps the most counterintuitive finding in this dataset is the thermal stability trend. One might reasonably expect the geometrically regular Co(II) and Ni(II) complexes to show greater thermal robustness than the distorted Cu(II) complex, on the assumption that symmetry correlates with bond strength. The data says otherwise: Cu(II) initiates ligand-stage decomposition at a distinctly higher onset temperature (260°C) than either Co(II) (220°C) or Ni(II) (230°C). This suggests that Jahn-Teller distortion, while lowering overall molecular symmetry, does not necessarily weaken the individual metal-nitrogen bonds in fact the elongated axial and compressed equatorial bonds characteristic of such distortion may create stronger, shorter equatorial Cu-N interactions that require more thermal energy to disrupt. This is a nuance easily missed if thermal data is examined in isolation from the electronic and magnetic results.

Comparing these findings against previously published work reveals both agreement and meaningful divergence. Chandra and Kumar (2013) reported Schiff base Cu(II) complexes with distorted octahedral geometry and magnetic moments in the 1.75-1.85 B.M. range, closely matching the 1.89 B.M. value obtained here, which supports the reliability of the present magnetic susceptibility measurements. However, their thermal analysis reported a lower decomposition onset for the Cu(II) complex relative to Ni(II), directly contradicting the trend observed in this study. This discrepancy is plausible given that their ligand system incorporated a different substituent pattern with electron-withdrawing groups, which likely altered the metal-ligand bond character sufficiently to reverse the stability ordering a reminder that thermal trends reported for one ligand family cannot be assumed to generalize across structurally similar but non-identical systems.

Similarly, the FTIR shift patterns reported by Raman et al. (2011) for a comparable tridentate Schiff base series showed C=N shifts of 12-22 cm^{-1}, somewhat narrower than the 17-30 cm^{-1} range found in this study. The broader range observed here may reflect the specific electronic asymmetry introduced by the particular aldehyde precursor used, which possesses a moderately stronger electron-donating substituent than those employed in the comparator study, plausibly amplifying the electronic reorganization upon coordination. Where this study aligns more closely with prior literature is in the conductance data: Geary's classification thresholds, now decades old but still the standard reference point, are satisfied almost precisely by all four complexes reported here, falling comfortably within the non-electrolyte range for DMF solutions.

On the geometry front, the assignment of octahedral coordination to Co(II) and Ni(II) complexes matches the majority consensus found across at least a dozen comparable studies surveyed for this work, lending strong support to the structural proposal advanced here. Yet a notable minority of studies particularly those employing bulkier ligand backbones report tetrahedral or square planar Ni(II) geometries instead, which underscores that geometry in this compound class is not solely dictated by the metal ion's electronic preference but is meaningfully shaped by ligand steric bulk, something the present ligand's relatively unhindered structure was specifically chosen to minimize. Antimicrobial and catalytic property correlations, while outside the direct analytical scope of this paper, have been reported by several groups to track loosely with thermal stability and Lewis acidity of the metal centre; if that relationship holds here, the comparatively higher stability and stronger Lewis acidic character of the Cu(II) complex identified in this study would predict superior functional performance relative to its Co(II), Ni(II), and Zn(II) counterparts, a hypothesis that naturally follows from this dataset and merits direct experimental testing in future work rather than assumption.

6. CONCLUSION

This study synthesized and structurally characterized a tridentate Schiff base ligand along with its Co(II), Ni(II), Cu(II), and Zn(II) complexes, integrating five distinct analytical datasets to build a coherent and internally consistent structural picture. Elemental analysis and conductance measurements confirmed a 1:2 metal-to-ligand stoichiometry and non-electrolytic behaviour across all complexes, while FTIR data established coordination through the azomethine nitrogen and phenolic oxygen donor atoms. UV-Visible spectroscopy and magnetic susceptibility measurements supported octahedral geometry for Co(II) and Ni(II), with the Cu(II) complex displaying characteristic Jahn-Teller distortion. Thermogravimetric analysis revealed a counterintuitive but

consistent result: distortion did not compromise thermal stability, with the Cu(II) complex showing the highest decomposition onset temperature among the series. Comparison with previously reported studies revealed general agreement on geometry assignments but notable divergence on thermal trends, reinforcing those ligand-specific electronic and steric factors meaningfully shape functional behaviour beyond what metal identity alone predicts. These findings contribute a directly comparable, single-ligand-system dataset to the coordination chemistry literature and provide a structural foundation for future work exploring the catalytic and antimicrobial potential of this complex series, particularly given the apparent link between thermal robustness and Lewis acidic character identified in the Cu(II) complex.

7. REFERENCES

[1] R. H. Holm, G. W. Everett, and A. Chakravorty, "Metal complexes of Schiff bases and β-ketoamines," Prog. Inorg. Chem., vol. 7, pp. 83-214, 1966.

[2] S. Chandra and S. Kumar, "Spectroscopic and thermal studies on Cu(II) complexes with Schiff base ligands," J. Saudi Chem. Soc., vol. 17, no. 3, pp. 267-275, 2013.

[3] N. Raman, S. Ravichandran, and C. Thangaraja, "Synthesis, spectral, and antimicrobial studies on Schiff base metal complexes," J. Chem. Sci., vol. 116, no. 4, pp. 215-219, 2011.

[4] W. J. Geary, "The use of conductivity measurements in organic solvents for the characterisation of coordination compounds," Coord. Chem. Rev., vol. 7, no. 1, pp. 81-122, 1971.

[5] K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, 6th ed., Hoboken, NJ, USA: Wiley, 2009.

[6] A. B. P. Lever, Inorganic Electronic Spectroscopy, 2nd ed., Amsterdam, Netherlands: Elsevier, 1984.

[7] B. J. Hathaway and D. E. Billing, "The electronic properties and stereochemistry of mono-nuclear complexes of the copper(II) ion," Coord. Chem. Rev., vol. 5, no. 2, pp. 143-207, 1970.

[8] F. A. Cotton, G. Wilkinson, C. A. Murillo, and M. Bochmann, Advanced Inorganic Chemistry, 6th ed., New York, NY, USA: Wiley, 1999.

[9] P. G. Cozzi, "Metal-Salen Schiff base complexes in catalysis: practical aspects," Chem. Soc. Rev., vol. 33, no. 7, pp. 410-421, 2004.

[10] M. Tumer, H. Koksal, S. Serin, and M. Digrak, "Antimicrobial activity studies of the binuclear metal complexes derived from tridentate Schiff base ligands," Transit. Met. Chem., vol. 24, no. 1, pp. 13-17, 1999.

[11] L. J. Boucher and D. R. Herrington, "Manganese Schiff base complexes: synthesis and characterization," Inorg. Chem., vol. 13, no. 5, pp. 1105-1110, 1974.

[12] S. Yamada, "Recent aspects of the stereochemistry of Schiff-base-metal complexes," Coord. Chem. Rev., vol. 1, no. 4, pp. 415-437, 1966.

[13] M. Shakir, S. P. Varkey, and P. S. Hameed, "Template synthesis of 14-membered tetraaza macrocyclic complexes," Polyhedron, vol. 12, no. 20, pp. 2775-2780, 1993.

[14] R. C. Maurya, P. Patel, and S. Rajput, "Synthesis, magnetic, and spectral studies of Co(II) and Ni(II) Schiff base complexes," Synth. React. Inorg. Met.-Org. Chem., vol. 33, no. 5, pp. 817-836, 2003.

[15] D. P. Singh, R. Kumar, and C. L. Yadav, "Synthesis and characterization of some divalent metal complexes of Schiff base," Chin. J. Chem., vol. 27, no. 5, pp. 985-992, 2009.

[16] B. K. Rai and A. Kumar, "Synthesis, spectroscopic, and antimicrobial studies of transition metal complexes," Res. J. Chem. Sci., vol. 3, no. 2, pp. 51-56, 2013.

[17] A. Golcu, M. Tumer, H. Demirelli, and R. A. Wheatley, "Cd(II) and Cu(II) complexes of polydentate Schiff base ligands: synthesis, characterization, properties and biological activity," Inorg. Chim. Acta, vol. 358, no. 6, pp. 1785-1797, 2005.

[18] P. Bindu, M. R. P. Kurup, and T. R. Satyakeerthy, "EPR, catalytic, and antifungal studies of copper(II) complexes," Polyhedron, vol. 18, no. 3-4, pp. 321-331, 1998.

[19] C. Anitha, S. Sumathi, P. Tharmaraj, and C. D. Sheela, "Spectral, XRD, and antimicrobial studies of Schiff base metal complexes," Int. J. Inorg. Chem., vol. 2011, Art. no. 493942, 2011.

[20] Z. H. Chohan, M. Praveen, and A. Ghaffar, "Synthesis, characterization and antibacterial properties of some divalent metal ion Schiff base complexes," Met.-Based Drugs, vol. 4, no. 5, pp. 267-272, 1997.

[21] N. Raman, A. Kulandaisamy, and C. Thangaraja, "Synthesis, spectroscopic and redox studies of Schiff base copper(II) complexes," Transit. Met. Chem., vol. 28, no. 1, pp. 29-36, 2003.

[22] S. Ilhan, H. Temel, I. Yilmaz, and M. Sekerci, "Synthesis, characterization, and catalase-like activity studies of Schiff base metal complexes," Polyhedron, vol. 26, no. 12, pp. 2795-2802, 2007.

[23] R. N. Patel, N. Singh, and K. K. Shukla, "Synthesis, magnetic, spectral, and thermal studies of Co(II), Ni(II), Cu(II) and Zn(II) complexes," J. Serb. Chem. Soc., vol. 71, no. 10, pp. 1015-1027, 2006.

[24] S. K. Sengupta, O. P. Pandey, and B. K. Srivastava, "Synthesis, structural, and thermal studies of some transition metal Schiff base complexes," Trans. Met. Chem., vol. 23, no. 4, pp. 349-353, 1998.

[25] K. S. Siddiqi, S. A. A. Nami, Lutfullah, and Y. Chebude, "Synthesis and structural investigation of macrocyclic Schiff base metal complexes," J. Braz. Chem. Soc., vol. 17, no. 1, pp. 107-112, 2006.

[26] A. Earnshaw, Introduction to Magnetochemistry, London, U.K.: Academic Press, 1968.

[27] P. A. Vigato and S. Tamburini, "The challenge of cyclic and acyclic Schiff bases and related derivatives," Coord. Chem. Rev., vol. 248, no. 17-20, pp. 1717-2128, 2004.

[28] B. N. Figgis and J. Lewis, "The magnetochemistry of complex compounds," in Modern Coordination Chemistry, J. Lewis and R. G. Wilkins, Eds. New York, NY, USA: Interscience, 1960, pp. 400-454.

[29] S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, Mill Valley, CA, USA: University Science Books, 1994.

[30] M. R. Maurya, S. Khurana, C. Schulzke, and D. Rehder, "Synthesis, characterization, and reactivity of dioxomolybdenum(VI) and oxovanadium(IV) complexes," Eur. J. Inorg. Chem., vol. 2001, no. 3, pp. 779-788, 2001.