IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 5, September 2026
Impact Factor: 8.2

Green Synthesis and Characterization of Mn (II), Fe (II) and Co (II) Complexes of a Cinnamaldehyde-Derived N, S-Donor Schiff Base

Sanjay R. Pawar
Department of Chemistry
Shri Siddheshwar Mahavidyalaya, Manjalgoan, Beed, Maharashtra, India
pawarsanjayr@gmail.com

Abstract: *A series of transition-metal complexes of a cinnamaldehyde-derived Schiff base were synthesized using a green microwave-assisted synthetic approach. The Schiff-base ligand, 2-[(E)-3-phenylallylideneamino]benzenethiol, was obtained from the condensation of cinnamaldehyde with 2-aminothiophenol and was subsequently used as a ligand for the preparation of Mn(II), Fe(II), and Co(II) complexes. Microwave irradiation at a power of 750 W was employed to facilitate the synthesis, providing rapid and efficient heating and reducing the reaction time compared with conventional heating methods [1]. The microwave-assisted approach offers a convenient and efficient route for the preparation of the ligand and its metal complexes with reduced processing time and improved synthetic efficiency. The synthesized ligand and its metal complexes were characterized by elemental analysis, Fourier-transform infrared (FT-IR) spectroscopy, and UV–Visible spectroscopy. Changes in the characteristic azomethine and thiol-related vibrational bands of the ligand upon complexation were investigated to establish the probable coordination behavior of the ligand. Electronic spectral data were used to examine the electronic properties of the complexes. The study demonstrates the applicability of microwave irradiation as a rapid green-assisted approach for the synthesis of transition-metal complexes of a cinnamaldehyde-derived Schiff base and highlights the role of metal coordination in modifying the spectroscopic and potentially biological properties of the ligand.*

Key Words: Cinnamaldehyde; Schiff base; o-aminothiophenol; transition-metal complexes; manganese; iron; cobalt; microwave-assisted synthesis; green synthesis;

I. INTRODUCTION

Schiff bases constitute an important class of compounds in coordination chemistry because of their facile synthesis and their ability to coordinate a wide variety of metal ions. They generally contain an azomethine functional group, –CH=N–, which can act as an effective donor site for metal coordination. The incorporation of additional donor atoms such as sulfur can produce multifunctional ligands capable of forming stable metal complexes.

Cinnamaldehyde is an attractive aldehyde precursor for Schiff-base synthesis because its conjugated phenyl-substituted α, β-unsaturated structure can impart interesting electronic and biological properties to the resulting compounds. 2-Aminothiophenol contains both amino and thiol functionalities and therefore provides a convenient route to N, S-containing Schiff bases.

In our previous work, a Schiff base was synthesized from cinnamaldehyde and 2-aminothiophenol using a green synthetic protocol. The synthesized compound was identified as 2-[(E)-3-phenylallylideneamino] benzenethiol and characterized using spectroscopic techniques [1]. The present work represents a continuation of this study and focuses on the coordination chemistry of this previously reported ligand with Mn (II), Fe (II), and Co (II) ions.

Copyright to IJARSCT
www.ijarsct.co.in
DOI: 10.48175/IJARSCT-40645

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 5, September 2026 Impact Factor: 8.2

Transition-metal complexes of Schiff bases have attracted considerable attention because metal coordination can alter the electronic structure, polarity, solubility, and biological behavior of the parent ligand [2]. In particular, Mn, Fe and Co complexes provide an interesting series for comparative investigation [3].

The objective of the present investigation was therefore to synthesize Mn (II), Fe (II) and Co (II), complexes of the previously reported cinnamaldehyde-derived Schiff base using a green approach and to characterize the resulting compounds by elemental analysis, FT-IR, and UV–Visible spectroscopy.

II. MATERIALS AND METHODS

2.1 Chemicals and reagents

Cinnamaldehyde and 2-aminothiophenol were used for the preparation of the Schiff-base ligand as described in our previous work. Appropriate analytical-grade metal salts of Mn (II), Fe (II) and Co (II) were used for complex preparation.

The metal salts selected for the present investigation were:

- Manganese(II) chloride tetrahydrate, $MnCl_2 \cdot 4H_2O$
- Iron(II) chloride tetrahydrate, $FeCl_2 \cdot 4H_2O$
- Cobalt(II) chloride hexahydrate, $CoCl_2 \cdot 6H_2O$

2.2 Preparation of the Schiff-base ligand

The Schiff-base ligand was prepared according to our previously published green synthetic procedure involving the condensation of cinnamaldehyde with 2-aminothiophenol. The product obtained was 2-[(E)-3-phenylallylideneamino]benzenethiol [1].

The previously reported ligand was purified and dried before being used for complexation reactions.

2.3 Green synthesis of metal complexes

The Schiff-base ligand was dissolved in ethanol and treated with the appropriate metal salt solution in the required stoichiometric ratio. The reaction mixture was subjected to microwave irradiation at 750 Watt [4] [5]. The fine color change indicates formation of complex. After completion of the reaction, the mixture was cooled and the resulting complex was isolated by filtration. The product was washed repeatedly with ethanol to remove unreacted ligand and inorganic impurities and was subsequently dried to constant mass.

The measurement of melting point of each metal complex was carried out on digital melting point apparatus and was recorded.

The resulting complexes were designated as ML2, where L represents 2-[(E)-3-phenylallylideneamino]benzenethiol.

2.4 Elemental analysis

Elemental analysis was performed to determine the percentage composition of carbon (C), hydrogen (H), nitrogen (N), and sulfur (S) in the synthesized Schiff-base ligand and its metal complexes. The analyses were carried out using a Heraeus CHN Elementar Vario EL-III elemental analyzer [6]. Accurately weighed and dried samples were used for the measurements. The experimental percentages of C, H, N, and S obtained for each compound were compared with the corresponding theoretical values calculated from the proposed molecular formulas. The close agreement between the experimental and calculated values provided supporting evidence for the proposed compositions of the synthesized compounds. Elemental analysis was also used in conjunction with FT-IR and UV–Visible spectroscopic data to assess the formation of the metal complexes.

Elemental analysis is presented in table 1.

Physical properties of metal complexes are presented in table 2.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 5, September 2026
Impact Factor: 8.2

2.5 FT-IR spectroscopy

FT-IR spectra of the Schiff base and its metal complexes were recorded in the range of approximately 4000–400 cm^{-1} using an FT-IR spectrophotometer. The characteristic vibrational frequencies of the ligand were compared with those observed for the metal complexes to investigate changes associated with metal coordination [7].

Particular attention was given to the azomethine ν(C=N) vibration and vibrations associated with the sulfur-containing functional group. [8]

The results of the IR study of three complexes has been presented in table 3.

2.6 UV–Visible spectroscopy

The UV-Visible spectra of the complexes were recorded in DMSO in the range 200-800 nm at room temperature.

The metal complexes exhibited absorption bands at [400-800] nm. Changes in the position and intensity of these bands compared with the free ligand, indicate modification of the electronic environment upon coordination. The observed spectral features were used together with the elemental and FT-IR results to discuss the probable coordination behavior of the ligand.

III. RESULTS AND DISCUSSION

3.1 Elemental Analysis and Physical characteristics

The synthesized Mn(II), Fe(II), and Co(II) complexes were subjected to elemental analysis for carbon, hydrogen, nitrogen and sulfur using a Heraeus CHN Elementar Vario EL-III elemental analyzer. The experimentally obtained C, H, N and S values showed good agreement with the theoretically calculated values for the proposed molecular formulations. The analytical results therefore provide supporting evidence for the proposed 2:1 ligand-to-metal stoichiometry and the formation of the corresponding metal complexes. Minor differences between the calculated and experimental values may be attributed to experimental uncertainty, sample purity, or the presence of small amounts of solvent/moisture in the isolated products.

Table 1. Elemental analytical data of the Schiff base and metal complexes

Sr.No.	Compound	Empirical Formula	C (%) Cal./Found	H (%) Cal./Found	N (%) Cal./Found	S (%) Cal./Found
1	L	$[C_{15}H_{13}NS]$	75.28/75.12	5.47/5.39	5.85/5.78	13.40/13.31
2	MnL2	[Mn(C15 H13 NS)2Cl2]	59.61/58.5	4.34/4.0	4.63/4.4	10.61/10.1
3	FeL2	$[Fe(C_{15}H_{13}NS)_2Cl_2]$	59.52 /58.4	4.33 /4.0	4.63/4.2	10.59/10.3
4	CoL2	[Co(C15H13NS)2Cl2]	59.22/58.0	4.31/3.9	4.60/4.6	10.54/10.70

The synthesized metal complexes were obtained as solid products. The colour and physical appearance of the complexes differed from those of the free Schiff base, suggesting changes in the electronic environment following coordination.

Table 2. Physical properties of the synthesized metal complexes

Sr. No.	Metal Complex	Colour	Yield (%)	M.P. (°C)
1	[Mn(C15 H13NS)2Cl2]	Pale Yellow	80	220
2	$[Fe(C_{15}H_{13}NS)_2Cl_2]$	Reddish Brown	78	230
3	$[Co(C_{15}H_{13}NS)_2Cl_2]$	Green	82	225

3.2 FT-IR spectral studies

IR spectral studies of Mn(II) metal complex:

The band appeared at 1615 cm-1 corresponds to azomethine (C=N) stretching, whereas same azomethine band was observed at 1620-1640 cm-1 in the spectrum of ligand. Band appeared at 3252 cm-1 indicates the aromatic (C-H) stretching in complex, whereas same stretching was observed at 3100 cm-1 in the spectrum of ligand. The vibration observed at 1469 cm-1 is due to aromatic (C=C) stretching. The characteristic band appeared at 470 cm-1 confirms the

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 5, September 2026 Impact Factor: 8.2

coordination of azomethine and metal ion. Disappearance of S-H band in the complex was attributed to coordination through deprotonated sulfur.

IR spectral studies of Fe(II) metal complex:

The FT-IR spectrum of the synthesized Fe(II) complex (Fe-L_2) showed characteristic vibrational bands at 1630, 3230, 1480 and 490 cm^{-1}, which were assigned to ν(C=N), ν(C–H), ν(C=C), and ν(Fe–N), respectively. The observed ν(C=N) band at 1630 cm^{-1} indicates the presence of the azomethine group, while the band at 490 cm^{-1} is attributed to the formation of a Fe–N bond. The changes in the characteristic vibrational frequencies compared with the free Schiff-base ligand indicate modification of the ligand environment upon complex formation. These spectral observations provide supporting evidence for coordination of the Schiff-base ligand with the Fe(II) ion through the azomethine nitrogen.

IR spectral studies of Co(II) metal complex:

The FT-IR spectrum of the synthesized Co(II) complex (Co-L_2) exhibited characteristic absorption bands at 1590, 2850, 1550 and 550 cm^{-1}, which were assigned to ν(C=N), ν(C–H), ν(C=C), and ν(Co–N), respectively. The ν(C=N) band at 1590 cm^{-1} indicates the presence of the azomethine group and its change relative to the free Schiff-base ligand suggests involvement of the azomethine nitrogen in coordination. The band at 550 cm^{-1} is tentatively assigned to ν(Co–N), providing further evidence for Co–N bond formation. The observed changes in the characteristic vibrational frequencies indicate coordination of the Schiff-base ligand with the Co(II) ion.

The azomethine ν(C=N) bands shifted to lower frequencies upon complexation, supporting coordination through azomethine nitrogen. The aromatic ν(C–H) stretching vibrations were remain largely unaffected. The thiol ν(S–H) vibration disappeared due to coordination through sulfur. New low-frequency bands appeared for ν(M–N) vibrations for Mn, Fe and Co complexes. Overall, the observed shifts in ν(C=N) with the appearance of M–N bands, would support coordination of the Schiff base through the N, S donor atoms.

Table 3. IR Spectral data of Metal Complexes

Sr. No.	Complex	ν (C=N)	ν (C-H)	ν (C=C)	ν (M-N)
1	Mn-L2	1615 cm-1	3252 cm-1	1469 cm-1	470 cm-1
2	Fe-L2	1630 cm-1	3230 cm-1	1480 cm-1	490 cm-1
3	Co-L2	1590 cm-1	2850 cm-1	1550 cm-1	550 cm-1

3.3 UV–Visible spectral studies

Electronic spectrum of Mn(II) complex

The electronic spectrum of Mn(II) complex exhibits weak bands in the visible region, which may be assigned to the spin-forbidden transitions 6A1g(S) →4T1g(G), 6A1g(S) →4T2g(G) and 6A1g(S) →4Eg(G) respectively. The weak nature of these bands is characteristic of the high-spin d5 Mn(II) ion. On the basis of the electronic spectral features and six-coordinate environment, an octahedral geometry is consistent to Mn(II) complex.

Electronic spectrum of Fe(II) complex

The electronic absorption spectrum of Fe(II) complex, recorded in DMSO over the 200–800 nm range, exhibits weak absorption bands around 680 nm (14,706 cm^{-1}) and 520 nm (19,231 cm^{-1}), which may be attributed to spin-forbidden d-d transitions of the high-spin Fe(II) ion. An additional relatively intense band around 400 nm (25,000 cm^{-1}) may be assigned predominantly to ligand-centered/charge-transfer transitions. The observed electronic spectral features, together with N, S-donor coordination environment, are consistent with octahedral geometry around the Fe(II) center.

Electronic spectrum of Co(II) complex

The electronic spectrum of Co(II) complex exhibits three characteristic absorption bands at approximately 700 nm (14,286 cm^{-1}), 550 nm (18,182 cm^{-1}), and 450 nm (22,222 cm^{-1}), which may be assigned to the 4T1g(F)→4T2g(F), 4T1g(F)→4A2g(F) and 4T1g(F)→4T1g(P) transitions, respectively. These transitions are consistent with a high-spin Co(II), d7 configuration in an octahedral ligand field. The electronic spectral data, together with the FT-IR results, supports the octahedral geometry of the Co(II) complex.

Table 4. Electronic spectral data of Metal complexes

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 5, September 2026 Impact Factor: 8.2

Sr. No.	Metal Complex	Frequencies Nm/cm⁻¹	Transitions	Expected Geometry
1	Mn-L2	550/18182 500/20000 450/22222	6A1g(S) →4T1g(G) (v1) 6A1g(S) →4T2g(G) (v2) 6A1g(S) →4Eg(G) (v3)	Octahedral
2	Fe-L2	680/14706 520/19231 400/25000	5T2g→3T1g (G) 5T2g→3T2g (G) LMCT / ligand-centered transition	Octahedral
3	Co-L2	700/14286 550/18182 450/22222	4T1g(F)→4T2g(F) (v1) 4T1g(F)→4A2g(F) (v2) 4T1g(F)→4T1g(P) (v3)	Octahedral

IV. CONCLUSION

The present investigation demonstrates a microwave-assisted approach for the synthesis of Mn(II), Fe(II), and Co(II) complexes of 2-[(E)-3-phenylallylideneamino]benzenethiol. Irradiation at 750 W enabled efficient complex formation and offered a convenient alternative to prolonged conventional heating. Elemental analysis, FT-IR, and UV–Visible spectroscopic studies provided complementary evidence for the proposed compositions and coordination of the Schiff-base ligand to the metal centers. The observed spectral changes, particularly those associated with the azomethine and sulfur-containing groups, supported the involvement of the donor sites in metal coordination. The electronic spectral characteristics were consistent with the proposed coordination geometries of the complexes. Thus, the study establishes the feasibility of microwave-assisted synthesis of these Mn(II), Fe(II), and Co(II) Schiff-base complexes and provides a useful basis for further investigation of their structural and biological properties.

. REFERENCES

[1] Pawar, S. R. Green Synthesis of a Schiff Base from Cinnamaldehyde and 2-Aminothiophenol. International Journal of Scientific Research in Science and Technology 2025, 12(17), 46–48. https://doi.org/10.32628/IJSRST
[2] Gabano E, Ravera M. Microwave-assisted synthesis: Can transition metal complexes take advantage of this “green” method? Molecules. 2022;27(13):4249. doi:10.3390/molecules27134249.
[3] Bargujar S, Ratnani S, Jain R. A comprehensive review on the synthesis and applications of Schiff base ligand and metal complexes: A comparative study of conventional heating, microwave heating, and sonochemical methods. Inorganic Chemistry Communications. 2023;158:111464. doi:10.1016/j.inoche.2023.111464.
[4] Hassan AM, Said AO, Heakal BH, Younis A, Aboulthana WM, Mady MF. Green synthesis, characterization, antimicrobial and anticancer screening of new metal complexes incorporating Schiff base. ACS Omega. 2022;7(36):32418–32431. doi:10.1021/acsomega.2c03911.
[5] A. K. Singh, et al., “A review on various green methods for synthesis of Schiff base ligands and their metal complexes,” Results in Chemistry, 6 (2023) 101153. https://doi.org/10.1016/j.rechem.2023.101153
[6] Yernale, N. G. et al. Synthesis, Characterization, Antimicrobial, DNA Cleavage, and In Vitro Cytotoxic Studies of Some Metal Complexes of Schiff Base Ligand Derived from Thiazole and Quinoline Moiety. Bioinorganic Chemistry and Applications, 2014, Article 314963.
[7] Ommenya, F. W., et al. “Synthesis, Characterization and Antibacterial Activity of Schiff Base, 4-Chloro-2-{(E)-[(4-Fluorophenyl)imino]methyl}phenol Metal (II) Complexes.” Journal of Chemistry, 2020, Article 1745236.
[8] Khalaf, R. N., Faheim, A. A., Ibrahim, S. S., El-Shafiey, Z. A., Saleh, H. M. “Structural Elucidation and Theoretical DFT Studies of Novel Schiff Base Metal Complexes Derived from 2-Aminothiophenol.” Green and Sustainable Chemistry.