INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD)
© 2026 IJNRD | Volume 11, Issue 2, February 2026 | ISSN: 2456-4184 | IJNRD.ORG

# SCHIFF BASES AND THEIR POSSIBLE MEDICINAL APPLICATIONS

**DR SHYAM KUMAR MEENA, DR YOGESH KUMAR**

Associate Professor Department of Chemistry Government College Dholpur

Associate Professor Department of Chemistry, shri kalian Rajkiya kanya mahavidyalaya, Sikar

## Abstract

Schiff base represents a category of organic compounds in which a nitrogen atom with a double bond maintains its stereochemistry. The long history of Schiff base has been fascinating chemists to explore its new dimension by generating optimal analogs with their therapeutic effects to serve the humankind. Schiff base coupled with metals evolves as a new stable molecule with their therapeutic indication as antifungal, antibacterial, anticancer or antiproliferative agents. Fusion of Schiff base with heterocyclic compounds like pyrazole or imidazole moieties conjointly crop different molecular entities with antifungal properties. Similarly, the amalgamation of Schiff base with benzene derivatives yields a new molecule with high antibacterial properties. However, further structural optimization may showcase other antimicrobial activities to prove this molecular entity as a potential druggable candidate. Apart from these, the well-known Schiff base anticancer and antiproliferative properties of this molecular entity are being explored. Schiff base, however, is suspected of causing cancer and can cause severe eye discomfort.

**Keywords**

Schiff base, Medical condition, Microorganism, Broad spectrum, Molecular entity

## INTRODUCTION

Schiff bases are ligands that have a There are imines in the RC group (−RC = N–) created by reacting primary amines (R–$NH_2$) with compounds containing a carbonyl group (RCOR′). The R and R′ groups can be there are either alkyls or aryls. The range of services provided by Schiff bases is extensive alternatives that can substitute for and be suitable for bridged N, N′, or unbridged. Generally, a Schiff base consists of donor atoms. The presence of oxygen can be associated with NO or $N_2O_2$ substituted by nitrogen, it can also be present in a molecule containing sulphur or selenium. [1]

Schiff bases are used in a variety of applications because of their coordinative solid ability such as liquid–liquid extraction [2-4] metal cations are transported through liquid membranes 5 reactions with organometallic reagents in an asymmetric manner to aldehydes 6 and reactions of Diels-Alder that are asymmetric [7]. Reactions associated with condensation of aldehydes and amines as a result, Schiff bases are formed. In addition to their established antibacterial and antifungal properties, Schiff bases

exhibit a broad spectrum of biological activities, including anti-diabetic, tumor-preventative, anti-proliferative, cancer-preventative, anticorrosive, and anti-inflammatory effects [8-11]. Hugo Schiff, a German chemist, first described it.

"The products are obtained by reacting Anions of primary origin with Carbonyl compounds, those were discovered in 1864 [12], the term" The Schiff's' base "was derived from his name. As defined by the International Union of Chemical Sciences, Schiff bases are nitrogen compounds that contain hydrocarbyl groups that are $R_2C = NR'$ ($R' + H$). Analogous to azomethines, there is a wide use for them [13]. Schiff bases are crucial in building complicated structures with transition metal ions due to a common feature [14]. These bases act as multiple electron donor ligands, like amines, amides, and phosphines [15]. The coordination of electron-donating ligand atom with d-block metal ions "This process allows for the stabilization and modulation of the metal ion's reactivity". "This is particularly beneficial for higher oxidation state metal ions. Auxiliary ligands are Schiff bases, as they modify the reactivity of transition states and the structure of metal ions at the center of the complex. Without irreversible transformations, unlike reactive ligands [16]. A Schiff base with an azomethine moiety directly attached to a benzene ring contributes to intra molecular resonance-stabilized hydrogen bonds. And positively affects the molecule's thermodynamic stability. Overall, Schiff bases play a crucial role in complex formation with transition metal ions, the metal's environment can be manipulated in terms of both steric and electronic fields; the process mentioned above results in the stabilization and regulation of the metal ion's reactivity [17].

In Schiff bases, hydroxyl groups are incorporated into the structure, which makes them effective at protecting against free radicals. Numerous studies have been performed to investigate the antioxidant characteristics of Schiff base ligands [18] and their corresponding ruthenium and nickel complexes. Inhibitor and therapeutic agents can also be made from these ligands and metal complexes by substituting for biomolecules. AChE, BChE, and GST enzymes are strongly inhibited by some Schiff base complexes [19]. For instance, Ru (II) inhibits cholinesterase enzymes. SB-stabilized hydrogels, particularly for tissue engineering, may be helpful in biomedical fields. As they prevent chemical diffusion and sustain drug delivery, they have been employed in engineering and medical applications [20]. Nanoparticles with Schiff base (SB) functionalization have important applications in nanoscience, particularly pharmaceuticals. NPs and Schiff bases in the nanocomposite contain a variety of functional groups that help retard microorganism growth An AgNPs functionalized SB was synthesized by Elemike et al. (2016), which were then screened against various bacteria. It has been shown that the nanomaterial destroys biomolecules such as DNA, RNA, and proteins [21].

In addition to being dyes and pigments, Schiff bases can serve as catalysts, intermediates of organic synthesis, and polymer stabilizers [22]. In Schiff bases, A primary amine ($R_3$-$NH_2$) condenses the carbonyl group [C = O]", Aldehydes or ketones are converted into nitrogen analogues. The azomethine group has therefore been substituted with an imine [$R_2$-$R_1$-C = N-$R_3$]. There are various types of aryls, alkyls, heteroaryls, and cycloalkyls. These molecules are uniquely biologically active due to the amine groups in Schiff bases [23].

## SIGNIFICANT ROLE OF SCHIFF BASES IN THE VARIOUS FIELDS

- **In the biological area-**

Several industrial applications can be found for Schiff bases, according to research. In addition, they possess many physiological properties [24], in addition to antianxiety and antipyretic properties, anti-inflammatory properties, antibacterial properties [25], and antiproliferative properties are present. These Schiff base compounds have garnered significant scientific interest due to their straightforward synthetic procedures and capacity to form metal complexes. Salicylaldehyde and diamine Schiff bases have been used to synthesize $N2O_2$ metallic complexes. M(Salen) I, a metalized N, N'-bis (salicylamide)-1,2-ethylenediamine, is one of the most well-known electrically and catalytically active members of this class. Several other compounds with similar properties have also been studied [26], such as "M(salophen)" II, "M(Salpn)" III, and "M(Salen-Me4)" IV. The stereo-electronic structure of Schiff bases makes them an attractive ligand because almost all transition metals can be complexed with them [27]

An organic compound belonging to the Schiff base family is called a Schiff base. Various metallic ions and geometries in various oxidation states can form complexes with them as multifunctional ligands. There are complexes formed between d-block metals and lanthanides when these bases are present. Physicochemical and pharmaceutical applications are attracted to metallic Sulphonamide Ligand complexes [28]. Fossil fuels are being exploited at an increasing rate. Environmental degradation has been caused by fossil fuels. Sustainable development is crucial for addressing this issue. As a means of supplementing sequential energy, renewable energy is needed. Researchers and engineers are paying more attention to solar energy as a renewable energy source. An example of renewable energy is a photovoltaic device, which converts solar energy directly into electricity. By combining organic materials with environmentally friendly materials, organic photovoltaic devices provide electricity at low cost, are easily reproducible, non-toxic, and biodegradable, which are prerequisites for their success [29].

- **In organic chemistry -**

A ketogenic tautomer isomerism at the C = N double bond is caused by ortho-hydroxy groups. Biochemistry, catalysis, sensors, and water treatment are just some uses for Schiff bases based on chitosan (CBSs). Polysaccharides such as chitosan are naturally derived from crustaceans, mollusks, insects, and fungi in the ocean. The antitumor, antiulcer, immune stimulating, antidiabetic, antioxidant, and antibacterial properties of chitosan are well documented. There have also been studies of chitosan and its derivatives. In wastewater, they act as adsorbents and remove heavy metal ions. Heavy metal ions can be determined with Schiff base-functionalized nanoparticles. Using an SB ligand, core–shell magnetic nanoparticles ($Fe3O_4.SiO_2$) have also been reported for removing uranium. Resistance to antimicrobials can be combated by nanoparticles. Schiff bases possess a number of important properties and are used in a variety of applications

- **In coordination chemistry**

Its chelating activity makes the tetradentate ligand attractive to researchers. Their many unique biological properties are attributed to the nitogen present in their imine groups (C = N). Inorganic biochemistry, catalysis, magnetism, medical imaging, and sensors depend heavily on metal-sales compounds [30-34]. As well as NLO devices [35,] solar cells building motifs, and blocks, they have also been used for nonlinear optical devices. Various compounds can be synthesized from metal ions by forming complexes with them. As a metal ion coordinator, azamethine nitrogen coordinates with them [36]. The oxidation states and coordination geometry of these metal complexes have been studied extensively. Some of these studies have represented advancements in inorganic biochemistry and catalysis [37-38]. A number of chemicals rely on copper because it is biologically essential. Since copper's biological characteristics are well understood, its coordination chemistry has been extensively studied. Biological and supramolecular systems have successfully used copper complexes based on Schiff bases [40-41]. Schiff-base complexes have received extensive scientific research attention in recent decades, particularly in biology, where they exhibit antimicrobial, redox, catalytic, and antioxidant properties. The complexes have also been used to produce new compounds with extraordinary properties and structures [42].

- **Application in various fields**

It is highly desirable to pursue further investigations into Schiff base ligands and their complexes in this area as a result of their versatility in biological, analytical, and industrial applications. It is briefly discussed here how Schiff bases, specifically thiosemicarbazones, and their complexes are used in a range of applications:

- **Schiff base as anticancer agents**

There are large numbers of people affected by cancer globally, and it causes substantial mortality [43], and therefore urgent attention and action are needed. It is common for cancer cells to resist drugs that are aimed at fighting cancer, and these drugs are not effective against cancer cells. In order to prevent cancer, new antitumor agents need to be developed that have the ability to inhibit specific target proteins [44] as well as to be less harmful. Bioenergetic drugs are particularly important in this context because they can stop the production of ATP and disrupt the biosynthetic pathway that is crucial to cancer cell proliferation [45]. Reduced NADH is fed into the electron transport chain by the enzyme ubiquinone oxidoreductase. Inhibiting complex I in cancer cells can attenuate the proton motive force and mitochondrial respiratory rate, leading to a reduction in tricarboxylic acid cycle activity and metabolite levels, ultimately leading to decreased cellular ATP production.

This cellular response, also known as aerobic glycolysis, is associated with the Warburg effect, which allows cancer cells to maintain ATP production when mitochondrial respiration is impaired. The inability to reroute metabolic flux can result in a depletion of cellular ATP when hexokinase is inhibited, which catalyzes the first step in glycolysis. Due to oxidative stress, cancer cells fail to produce enough ATP, resulting in reactive oxygen species production. The mitochondrial membrane potential becomes dysfunctional in these cases due to activation of AMP-protein kinases (AMPK). When AMPK is phosphorylated, it becomes activated. Inhibiting transcription of gluconeogenic genes and mTOR, as well as arresting cell cycle progression, which may contribute to their antibacterial activity.

In an effort to address the detrimental impacts stemming from the inhibition of the mitochondrial respiratory complex I and hexokinase on the cellular energy status, new and effective anticancer drugs are being developed, which have been shown to reduce the global consumption of ATP and induce oxidative stress in the cells. Some clinical observations have shown a reduction in cancer cell growth progression due to a reduction in proliferation in proliferating cells. The cells may undergo apoptosis once they compensate for their reduced energy status. Schiff base compounds containing heterocyclic moieties, such as quinazolinones, indoles, and azomethine groups, have attracted considerable interest in the realms of medicinal and pharmaceutical research due to their promising applications. There are several biologically active compounds, both natural and synthetic, which use quinozolinone and indole as scaffolds for their pharmacophoric properties. The compounds associated with these compounds are highly effective antimalarials, antimicrobials, anticonvulsants, and anticancer agents.

- **Schiff base as oxygen binding**

As a result of their various biological implications, coordination compounds containing Schiff bases are gaining interest. Schiff bases have garnered significant attention as potential new therapeutic agents for combating various diseases, including bacterial and fungal infections, as well as cancers, inflammatory conditions, and viral infections. These compounds have demonstrated promising biological activities in these areas. Additionally, scientists study the metal ion binding sites of metalloproteins as well as their metabolism in living systems.

## Conclusion

Over the period of time Schiff base has been exploring for its essential antimicrobial properties. Significance of Schiff base in it's antimicrobial properties could be truly attributed to it's occupancy of space in three dimensional space with rigid bulky side groups with the possible interaction to the biological species. Schiff bases are used in a variety of domains, including biological, industrial, and coordination chemistry. Antifungal properties of specific compounds in comparison to fluconazole yield reasonable minimum inhibitory concentrations against the variety of the bacterial strains tested. Anti-cancerous and anti-proliferative properties of Schiff bases are not fully explored yet several efforts are being made globally to fully understand the underlying mechanism to provide an effective diagnosis to this disease, which devour millions of life annually.

## References

1. R.W. Laye- The chemistry of imines Chem. Rev., 63 (5) (1963), pp. 489-510.

2. R. Fiammengo, C.M. Bruinink, M. Grego-Calama, D.N. Reinhoudt -Noncovalent secondary interactions in Co (II)Salen complexes: O2 binding and catalytic activity in cyclohexene oxygenation*J.* Organomet. Chem., 67 (24) (2002), pp. 8552-8557.

3. W.A. Zoubi, N.A. MohannaMembrane sensors based on Schiff bases as chelating ionophores – A reviewSpectrochim. Acta Part A: Mol. Biomol. Spectroscopy, 132 (2014), pp. 854-870.

4. W.A. Zoubi, F. KandilSynthesis of Macrocyclic Schiff Bases Based on Pyridine-2,6-Dicarbohydrazide and their use in metal cations extraction *Org.Chem.*, 1 (1) (2012).

5. W.A. Zoubi Solvent extraction of metal ions by use of Schiff bases J. Coord. Chem., 66 (13) (2013), pp. 2264-2289.

6. W.A. Zoubi, F. Kandil, M.K. ChebaniSynthesis of New N, N′-bis (2-amino thiophenol)-α, α′-bis (5-bromocarboxylidene phenoxy) xylene and their Liquid Membrane Transport of Copper Cations *Sep. Sci. Technol.*, 48 (3) (2013), pp. 501-507.

7. E.C. Niederhoffer, J.H. Timmons, A.E. Martell Thermodynamics of oxygen binding in natural and synthetic dioxygen complexes. Chem. Rev., 84 (2) (1984), pp. 137-203.

8. N.H. Patel, H.M. Parekh, M.N. Patel Synthesis, characterization, and biological evaluation of manganese (II), cobalt (II), nickel (II), copper (II), and cadmium (II) complexes with monobasic (NO) and neutral (NN) Schiff bases. Transit. Met. Chem., 30 (1) (2005), pp. 13-17.

9.Y.J. Thakor, S.G. Patel, K.N. PatelSynthesis, characterization and biocidal studies of some transition metal complexes containing tetra dentate and neutral bi dentate Schiff base, J. Chem. Pharm. Res., 2 (5) (2010), pp. 518-525.

10. R. Ramesh, P.K. Suganthy, K. NatarajanSynthesis, Spectra, and Electrochemistry of Ru (III) Complexes with Tetradentate Schiff Bases. Synth. React. Inorg. Met. - Org. Chem., 26 (1) (1996), pp. 47-60.

11. K.I. Shivakumar, Shashidhar, P.V. Reddy, M.B. HalliSynthesis, spectral characterization, and biological activity of benzofuran Schiff bases with Co (II), Ni (II), Cu (II), Zn (II), Cd (II), and Hg (II) complexes. J. Coord. Chem., 61 (14) (2008), pp. 2274-2287.

12. H. SchiffMittheilungen aus dem Universitätslaboratorium in Pisa: Eine neue Reihe organischer Basen Justus Liebigs Annalen der Chemie, 131 (1) (1864), pp. 118-119.

13. G.P. Moss, P.A.S. Smith, D. TavernierGlossary of class names of organic compounds and reactivity intermediates based on structure (IUPAC Recommendations 1995) Pure Appl. Chem., 67 (8–9) (1995), pp. 1307-1375.

14. R.H. Holm, K. Swaminathan Studies on Nickel (II) complexes. III. Bis- (N-aryl salicylaldimine) complexes. Inorg. Chem., 1 (3) (1962), pp. 599-607.

15. G.C. Percy, D.A. ThorntonN-aryl salicylaldimine complexes: Infrared and PMR spectra of the ligands and vibrational frequencies of their metal (II) chelates. J. Inorg. Nucl. Chem., 34 (11) (1972), pp. 3357-3367.

16. M. Stradiotto, R.J. LundgrenLigand design in metal chemistry In Wiley eBooks (2016).

17. I. Król-Starzomska, A. Filarowski, M. Роспенк, A. Koll, C. МеликоваProton Transfer Equilibria in Schiff Bases with Steric Repulsion. Chem. A Eur. J., 108 (11) (2004), pp. 2131-2138.

18. M. Azam, I. Warad, S. Al-Resayes, M. Shakir, M.F. Ullah, A. Ahmad, F.H. Sarkar A novel Ru (II) complex derived from hydroxydiamine as a potential antitumor agent: Synthesis and structural characterization. Inorg. Chem. Commun, 20 (2012), pp. 252-258.

19. N. Turan, K. Buldurun, R. Adigüzel, A. Aras, F. Türkan, E. BursalInvestigation of spectroscopic, thermal, and biological properties of FeII, CoII, ZnII, and RuII complexes derived from azo dye ligand. J. Mol. Struct., 1244 (2021), Article 130989.

20. N.B. Singh, A.B.H. Susan, R.G. Chaudhary Emerging applications of nanomaterials. Materials research foundations, 141 (2023).

21. E.E. Elemike, E.O. Dare, I.D. Samuel, J.C. Onwuka2-Imino-(3,4-dimethoxybenzyl) ethanesulfonic acid Schiff base anchored silver nanocomplex mediated by sugarcane juice and their antibacterial activities. J. Appl. Res. Technol., 14 (1) (2016), pp. 38-46.

22. T. Thirunavukkarasu, E. Ramachandran, K. Natarajan, H.A. Sparkes, S.I. Al-Resayes, M. AzamA study on the applications of 3-amino quinoline complexes of Pd (II) as catalysts for the Suzuki-Miyaura coupling of aryl halides in aqueous and organic media. Polyhedron, 230 (2023.

23. S. Sutradhar, D. Das, P. Sarkar, B.N. GhoshSynthesis, structure, and solution behavior of trimethyl platinum (IV) iodide complexes of 3-chloropyridine. Polyhedron, 229 (2023).

24. S.I. Al-Resayes, M. Azam, A. Trzesowska-Kruszynska, R. Kruszynski, S.M. Soliman, R.K. Mohapatra, Z. KhanStructural and Theoretical Investigations, Hirshfeld Surface Analyses, and Cytotoxicity of a Naphthalene-Based Chiral Compound. ACS Omega, 5 (42) (2020), pp. 27227-27234.

25. M. Azam, S.I. Al-Resayes, G. Velmurugan, P. Venuvanalingam, J. Waglerc, E. Krokec Novel uranyl(vi) complexes incorporating propylene-bridged salen-type $N_2O_2$-ligands: a structural and computational approach. Dalton Trans., 44 (2015), pp. 568-577.

26. M. Azam, S.I. Al-Resayes, A. Trzesowska-Kruszynska, R. Kruszynski, P. Kumar, S.L. Jain Seven-coordinated chiral uranyl (VI) salen complex as effective catalyst for C–H bond activation of dialkyl anilines under visible light Polyhedron, 124 (2017) (2017), pp. 177-183.

27. M. Azam, S.I. Al-Resayes Phenoxy-bridged binuclear Zn (II) complex holding salen ligand: Synthesis and structural characterization. J. Mol. Struct., 1107 (2016), pp. 77-81.

28. X. Wang, G. Ding, Y. Duan, Y. Zhu, G. Zhu, M. Wang, X. Li, Y. Zhang, X. Qin, C. HungA novel triphenylamine-based bis-Schiff bases fluorophores with AIE-Activity as the hydrazine fluorescence turn-off probes and cell imaging in live cells. Talanta 217 (2020).

29. J.C. Berrones-Reyes, B.M. Muñoz-Flores, A.M. Cantón-Díaz, M.A. Treto-Suárez, D. Páez-Hernández, E. Schott, X. Zárate, V.M. Jiménez-PérezQuantum chemical elucidation of the turn-on luminescence mechanism in two new Schiff bases as selective chemosensors of Zn2+: synthesis, theory and bioimaging applications. RSC Adv., 9 (53) (2019), pp. 30778-30789.

*30* Q.T. Nguyen, P.N.P. Thi, V.T. Nguyen Synthesis, characterization, and in vitro cytotoxicity of unsymmetrical tetradentate Schiff base CU(II) and FE(III) complexes. Bioinorg. Chem. Appl., 2021 (2021), pp. 1-10.

31. C. Freire, M. Nunes, C. Pereira, D.M. Fernandes, A.F. Peixoto, M. Rocha Metallo (salen) complexes as versatile building blocks for the fabrication of molecular materials and devices with tuned properties. Coord. Chem. Rev., 394 (2019), pp. 104-134.

32. J.C. Pessoa, I. CorreiaSalan vs. salen metal complexes in catalysis and medicinal applications: Virtues and pitfalls. Coord. Chem. Rev., 388 (2019), pp. 227-247.

33. G. Yuan, H. Jiang, L. Zhang, Y. Liu, Y. CuiMetallosalen-based crystalline porous materials: Synthesis and property. Coord. Chem. Rev., 378 (2019), pp. 483-499.

34. G. Consiglio, I. Pietro Oliveri, S. Failla, S. Di Bella on the Aggregation and Sensing Properties of Zinc (II) Schiff-Base Complexes of Salen-Type Ligands.
Molecules, 24 (13) (2019), p. 2514.

35. P. Matozzo, A. Colombo, C. Dragonetti, S. Righetto, D. Roberto, P. Biagini, S. Fantacci, D. Marinotto A Chiral Bis(salicylaldiminato) zinc (II) Complex with Second-Order Nonlinear Optical and Luminescent Properties in Solution.
Inorganics (Basel), 8 (4) (2020), p. 25.

36. S.V.S. Babu, K.K. Rao, Y. LeeSynthesis, Characterization, Luminescence and Dna Binding Properties of Ln (Iii)-Schiff Base Family. J. Chil. Chem. Soc., 62 (2) (2017), pp. 3447-3453.

37.L. Leoni, A.D. CortThe supramolecular attitude of Metal–Salophen and Metal–Salen complexes. *Inorganics (Basel)*, 6 (2) (2018), p. 42.

38. N. Novoa, C. Manzur, T. Roisnel, S. Kahlal, J.Y. Saillard, D. Carrillo, J. Hamon Nickel (II)-Based Building Blocks with Schiff Base Derivatives: Experimental Insights and DFT Calculations. Molecules, 26 (17) (2021), p. 5316.

39. S. Kumar, D.N. Dhar, P.N. SaxsenaApplications of metal complexes of Schiff bases-A review. J. Scient. Ind. Res., 68 (2009), pp. 181-187.

40.Z. Afsan, T. Roisnel, S. Tabassum, F. Arjmand. Bioorg. Chem., 94).

41. H. Kargar, R. Behjatmanesh-Ardakani, V. Torabi, A. Sarvian, Z. Kazemi, Z. Chavoshpour-Natanzi, V. Mirkhani, A. Sahraei, M.N. Tahir, M. Ashfaq Novel copper (II) and zinc (II) complexes of halogenated bidentate N, O-donor Schiff base ligands: Synthesis, characterization, crystal structures, DNA binding, molecular docking, DFT and TD-DFT computational studies. Inorg. Chim. Acta, 514 (2021).
42. More, P.G. Joshi, Y.K. Mishra, P.K. KhannaMetal complexes driven from Schiff bases and semicarbazones for biomedical and allied applications: a review Mater. Today, Chem., 14 (2019).
43. M. Von Meyenfeldt Cancer-associated malnutrition: An introduction. Eur. J. Oncol. Nurs., 9 (2005), pp. S35-S38.

44. A.A. Noser, M. El-Naggar, T. Donia, A.H. Abdel Monsef Synthesis, in silico and in vitro assessment of new quinazolinones as anticancer agents via potential AKT inhibition. Molecules, 25 (20) (2020), p. 4780.

45. S. Andrzejewski, P.M. Siegel, J. St-PierreMetabolic profiles associated with metformin efficacy in cancer. Front. Endocrinol., 9 (2018),