

# Cinnamaldehyde Schiff Base Derivatives: A Short Review

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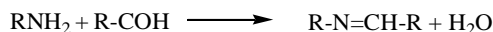
**Abstract:** Schiff bases are aldehyde or ketone like compounds in which the carbonyl group is replaced by an imine or azomethine group. They are widely used for industrial purposes and also exhibit a broad range of biological activities. This short review compiles the Schiff base derivatives of cinnamaldehyde and the most their applications.

**Key word:** Schiff base, Cinnamaldehyde, Derivatives

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## I. INTRODUCTION

Schiff bases (also known as imine or azomethine), named after Hugo Schiff [1], was reported in the 19th century by Schiff(1864). Since then a variety of methods for the synthesis of imines have been described. The classical synthesis is when any primary amine condenses with a carbonyl compound [2], under specific conditions(for example, azeotropic distillation), according to the following equation:



Structurally, a Schiff base is a nitrogen analog of an aldehyde or ketone in which the carbonyl group (C=O) has been replaced by an imine or azomethine group (Figure. 1).

Aromatic aldehydes, especially with an effective conjugation system, form stable Schiff bases, whereas those aliphatic aldehydes are unstable and readily polymerize. Schiff base ligands with aldehydes are formed more readily than with ketones. Schiff bases have very flexible and different structures. A wide range of Schiff base compounds and their metal complexes have been prepared and their behavior studied because these compounds have very flexible and diverse structures [3].

Schiff bases generally are bi-, tri- or tetra- dentate chelate ligands and easily react with almost all transition metal ions and form very stable complexes with them. Their chemical and physical properties in various fields such as preparative uses, identification, or protection, and determination of aldehydes or ketones, purification of carbonyl or amino compounds, or protection of these compounds in complex or sensitive reactions have been studied by various workers [4][5].

## II. BIOLOGICAL ACTIVITIES

Cinnamaldehyde is an aromatic aldehyde and main component of bark extract of cinnamon<sup>6</sup>. The main advantage of cinnamaldehyde is that direct contact is not required for being active as antimicrobial. Cinnamaldehyde has been shown to be active against a range of forborne pathogens bacteria<sup>7</sup>. Nontoxic doses of cinnamaldehyde and cinnamaldehyde derivatives have previously been reported to potentiate the cell-inactivating effect of cis-diamminedichloroplatinum(II) in human NHIK 3025 cells in culture<sup>8</sup>. It has found that cinnamaldehyde and  $\alpha$ -chlorocinnamaldehyde potentiated the cell-inactivating effect when used simultaneously with cis-Diamminodichloroplatinum(II) without increasing the amount of cell-associated platinum<sup>9</sup>.

Nowadays, the increasing microbial resistance to antibiotics in use necessitates the search for new compounds with potential effects against pathogenic bacteria. The most spectacular advances in medicinal chemistry have been made

when heterocyclic compounds played an important role in regulating biological activities. many Schiff bases are known to be medicinally important and are used to design medicinal compounds. Nitro and halo derivatives of Schiff bases are reported to have antimicrobial and antitumor activities [10]. Antimicrobial and antifungal activities of various Schiff bases have also been reported [11]. Fungi toxicity of some Schiff bases have investigated by Sahu *et al.* [12]. Gawad *et al.* reported high antimicrobial activities of some Schiff bases [13]. Many Schiff bases are known to be medicinally important and are used to design medicinal compounds [14]. Cinnamaldehyde is a well-established natural antimicrobial compound. It is probable for cinnamaldehyde to react with amino acid forming Schiff base adduct in real food system. The main advantage of cinnamaldehyde is that direct contact is not required for being active as antimicrobial. Cinnamaldehyde has been shown to be active against a range of food borne pathogens bacteria. Wei *et al.* have prepared some adducts by the direct reaction of amino acids with cinnamaldehyde at room temperature. Their antimicrobial activities were evaluated with benzoic acid as a reference. Both cinnamaldehyde and their adducts were more active against three microbial strains at low pH. They were more active than benzoic acid at the same conditions, also [15]. Parekh and co-workers have synthesized Schiff bases derived from 4-aminobenzoic acid and cinnamaldehyde. They were screened as potential antibacterial agents against a number of medically important bacterial strains [16]. They concluded that different response of the synthesized Schiff bases arise because of their structural differences and are also solvent dependent. Srikar *et al.* used *p*-dimethyl amino cinnamaldehyde to form desired Schiff base, which used for quantitative estimation of Sparfloxacin in bulk and pharmaceutical dosage forms [17]. The antibacterial activities of chitosan and the Schiff base derived from chitosan and cinnamaldehyde were investigated by Xia and co-workers [18]. The results indicate that the antibacterial activity of the Schiff base is stronger than that of chitosan. It was found that antibacterial activity increases with the increase of Schiff base concentration.

### III. AS CORROSION INHIBITOR

An interesting application of Schiff bases is their use as an effective corrosion inhibitor which is based on their ability to spontaneously form a monolayer on the surface to be protected [19]. Schiff bases have been found to possess more inhibitor efficiency than their constituent carbonyls and amines [20]. Schiff bases derived from condensation reaction of cinnamaldehyde with 2-aminophenol and cinnamaldehyde with phenylene diamine studied as inhibitor for corrosion of carbon steel in acidic media 0.5 N HCl by Mohammad Qasim Mohammad. The results indicated that these Schiff bases inhibited the corrosion efficiently. Some authors have attributed these considerably stronger inhibition efficiencies to the presence of unoccupied  $\pi^*$ - orbitals in the Schiff base molecules, which enable electron back donation from the metal d-orbitals and thereby stabilize the existing metal-inhibitor bond, which is not possible with the constituent amines [21].

### IV. MISCELLANEOUS APPLICATIONS

Complexes of cinnamalideneamino-s-triazoles have received very little attention as compared to complexes of Schiff bases derived from salicylaldehyde or 2-hydroxy-1-naphthaldehyde and s-triazoles. Sen *et al.* synthesized and characterized Co(II), Ni(II), Cu(II), and Zn(II) complexes of monofunctional bidentate Schiff bases derived from cinnamaldehyde and s-triazoles.

Schiff base polymers with a system of conjugated  $-C=C-$  and  $-C=N-$  bonds in their main chain are of considerable interest due to their thermal stability similar to polyamides and their using as solid stationary phase for gas chromatography [22], their semiconductor properties [23], mechanical strength, electrochemical and nonlinear optical properties [24], and useful catenation ligand, where the coordination polymeric Schiff bases are extensively studied [25]. Schiff base polymers are produced by the polycondensation of diamines with various dicarbonyl compounds [26]. Khuhawar *et al.* synthesized and characterized Schiff base polymers derived from 4,4'-methylenebis(cinnamaldehyde) with various diamines [27].

Due to various applications of silver(I) complexes, for example as reagents in organic and inorganic synthesis [28], in photography or electrochemical silver plating [29], and as free radical scavengers in industrial processes [30], these complexes have received considerable attention in recent years [31]. Limited work related to the silver(I) complexes with mixed ligands. Amirnasr *et al.* have synthesized and determined crystal structure of two mixed ligand silver(I) complexes,  $[Ag(ca_2en)(PPh_3)(X)]$ , where  $ca_2en$  = is a bidentate Schiff base that prepared from cinnamaldehyde and ethylenediamine, and  $X = N_3$  and  $SCN$  [32].

Tricarbonyl( $\eta^4$ -1,3-diene)iron complexes have found many useful applications in organic synthesis [33]. Although a large number of these compounds have been reported and their activity investigated [34], less is known of the corresponding heterodynes compounds. In such compounds, which may be regarded as derived from the basic butadiene unit by the replacement of one or more of the carbon atoms by the oxygen or nitrogen, the possibility arises that the lone pair of electrons of the heteroatom is involved with the metal-ligand bond [35]. The 1-aza-1,3-butadienes and their tricarbonyl complexes are readily available by condensation of cinnamaldehyde with the corresponding arylamine followed by complexation with the ennacarbonyl-di-iron. Jarrahpour *et al.* have synthesized the 1-(2-aminopyridine)-4-phenyl-1,3-diene and 1-(3-aminopyridine)-4-phenyl-1,3-diene as heterodynes for iron carbonyl complexes [36]. Knölker *et al.* have reported that ( $\eta^4$ -1-aza-1,3-butadiene)tricarbonyliron complexes are highly efficient for the transfer of the tricarbonyliron fragment [37].

Cyclometallation reactions are well-established for many of the metals in the periodic table, especially where the metallation has occurred at an aromatic carbon atom [38]. However examples involving cyclometallation of  $sp^2$  carbon atoms from non-aromatic substrates are much less common. Asamizu *et al.* react  $\text{PhCH}_2\text{Re}(\text{CO})_3$  with 1,4-diaryl-1-azabutadienes to give cyclometallated ( $\eta^2$ -(C,N)-azabutadiene) $\text{Re}(\text{CO})_4$  with the substituted derivatives ( $\eta^1$ -(C,N)-azabutadiene) $\text{Re}(\text{CO})_3$  (figure 2).

The substituted product was shown by NMR and X-ray crystal structure analysis to be an inseparable mixture of isomers differing in the conformation of the  $\eta^1$ -ligand about the N=C bond. Reaction of this complex with phenyl acetylene gave  $\eta^3$ -(1,2,4-triphenyl-1-aza-cyclohexadienyl) $\text{Re}(\text{CO})_3$  [39].

The crystal structure and properties of copper(I) complexes with multidentate ligands has a growing interest in recent years [40], for their potential applications in metallosupramolecular assemblies [41], bioinorganic chemistry [42] and catalysis [43]. Morshedi *et al.* have designed and prepared tetradentate  $\text{N}_2\text{S}_2$  donor Schiff base ligand with using of cinnamaldehyde. They have studied the coordination chemistry of their copper(I) complexes [44]. Khalaji and Welter react N,N'-bis( $\beta$ -phenyl-cinnamaldehyde)-1,2-diiminoethane (Phca2en) with a mixture of CuI and  $\text{AgNO}_3$  to yields the mononuclear  $[\text{Cu}(\text{Phca2en})_2][\text{AgI}_2]$  complex. The X-ray crystallography showed that this complex consists of a  $[\text{Cu}(\text{Phca2en})_2]^+$  cation and a  $[\text{AgI}_2]^-$  anion. Phca2en acts as a bidentate ligand coordinating via two N atoms [45].

Bolz *et al.* prepared Schiff bases with multiple binding sites for supramolecular assemblies by condensation of *para*-nitro- and *para*-N,N-dimethylaminocinnamaldehyde with 1,3-dimethyl- and 1-butyl-5-aminobarbituric acid [46]. The investigation of *keto-enol* tautomerism of synthesized Schiff bases by FTIR spectroscopy confirmed that in the solid state this compounds exist only in the *enol* form (figure 3).

In all sighted species, the absorption of light by the *cis* – retinal Schiff base rhodospin results in the *cis* – *trans* isomerization of its chromophore as an important step [47]. Under different conditions, *p*-substituted cinnamaldehyde undergo a variety of different photoprocesses including *cis* – *trans* isomerization [48]. The photobehavior of rhodospin is dependent on molecular environment [49]. Kanthimiathi and Dhathathreyan have studied the photoreaction of monolayers synthesized Schiff bases derived from condensation reaction of *p*-nitro cinnamaldehyde with ethylene diamine and *o*-phenylene diamine at air /water interface (compounds **1** and **2**) [50] (figure 4).

Choloroform solution of compound **1** undergoes *cis* – *trans* isomerization on irradiation of white light while compound **2** does not under photolytic conditions. The photolysis of **1** and **2** in *Langmuir-Blodgett* films (LB films) transferred to quartz plates form dimmers.

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#### REFERENCES

- [1] Schiff H., *Justus Liebigs Ann Chem*, 1864; 131(1): 118-9
- [2] Bell S S C, Conklin GL. *Childress S J, J. Am. Chem. Soc.* 1963; 85: 2868
- [3] a) Hakimi M, Takjoo R, Erfaniyan V, Schuh E, Mohr F, *Transition Met. Chem.* 2010;35 (8): 959-965; b) Hakimi M, Vahedi H, Rezvaninezhad M, Schuh E, Mohr F, *J. Sulfur Chem.* 2011;32 (1): 55-61; c) Hakimi M, Kukovec B, Minoura M, *J. Chem. Crystallogr.*

- 2012;42 (3): 290-294; d) Mehta B H, Vengarlekar V P, Asian J. Chem. 1999; 11: 397; e) Raman N, Muthuraj V, Ravichandran S, Kulandaisamy A, Proc. Indian Acad. Sci. 2003; 115: 161
- [4] a) Krylov AI, Stolyarov BV, Zh. org. khim. 1978; 14: 2224; b) Issa YM, Omar MM, Abdel-Fattah HM, Soliman AA, J. Indian Chem. Soc. 1996; 73: 55
- [5] a) Shetye SS (late), Mayadeo MS, Hexameshwar NB, Asian J. Chem. 1999; 11: 1379; b) Miao R, Shuoling L, Rudong Y, Lau Y, Wenbing Y, Indian J. Chem. Sec. 2003; 42: 318
- [6] Holley RA, Patel D, Food Microbiology. 2005; 22: 273–292
- [7] a) Amalaradjou MAR, et al., Food Microbiology. 2010; 27: 841–844; b) Becerril R, Gómez-Lus R, Goñi P, López P, Nerin C, Analytical and Bioanalytical Chemistry. 2007; 388: 1003–1011; c) Guillier L, Nazer AI, Dubois-Brissonnet F, Journal of Food Protection. 2007; 70: 2243–2250
- [8] Dornish JM, Pettersen EO, Oftebro R, Cancer Res. 1989; 49: 3917
- [9] Dornish JM, E. Pettersen O, Oftebro R, Cancer Res. 1989;49:3917
- [10] Chaudhari TD, Subnis SS, Bull. Haskine Inst. 1986; 4: 85
- [11] a) Shah S, Vyas R, Mehta RH, J. Indian Chem. Soc. 1992; 69: 590; b) Raman N, Kulandaisamy A, Shunmugasundaram A, Jayasubramaniam K, Transition Met. Chem. 2001; 26 : 131; c) Sari N, Arslan S, Logoglu E, Sakiyan I, G. U. J. Sci. 2003;16: 283
- [12] Sahu K, Behera RK, Pathaik RC, Nayak A, Behera GB, Indian J. Chem. 1979; 18B: 557
- [13] Abdul-Gawad M, Issa YM, Abd-Alhamid SM, Egypt J. Pharm. Sci. 1993; 34: 219
- [14] a) Chakraborti SK, Kumar De B, J. Indian Chem. Soc. 1973; 137; b) Rao S, Mittra AS, J. Indian Chem. Soc. 1978;420; c) Khan SA, Siddiqui AA, Bhatt S, Asian J. Chem. 2002; 14: 1117
- [15] Wei Q, Xiong J, Jiang H, Zhang C, Ye W, Int. journal of Food Microbiology. 2011; 150: 164
- [16] Parekh J, Inamdar P, Nair R, Baluja S, Chanda S, J. Serb. Chem. Soc. 2005; 70 (10): 1155
- [17] Srikar A, K. Channabasavaraj P, Dharmamoorthy G, Valmiki N, Chinnappa C, Venu Babu T, J. Pharm.Sci. & Res. 2009;1(2): 13
- [18] Xiao X, Jiang-tao W, Jie B, Journal of Chemical Engineering of Chinese Universities04, 2010
- [19] Quan Z, Chen S, Li Y, Cui X, Corros. Sci. 2002; 44 : 703
- [20] a) Chitra S, Parameswari K, Int.J.Electrochem.Sci. 2010; 5: 1675-1697; b) Bilgic S, Cabiskan N, J. Appl. Electrochem. 2001; 31: 79
- [21] Mohammad MQ, Journal of Barash Researchers, 2011; 37(48)
- [22] Grunes R, Sawondy W, J. Chromatogr. 1985; 122: 63–9
- [23] Kenney CN, Chem Ind.1960;880–4
- [24] Orazzhanova L, Yashkarova MG, Bimendina LA, Kudaibergenov SE, J. Appl. Polym. Sci. 2003; 87 (5): 759–764
- [25] a) Sawodny W, Reiderer M, Urban E. Inorg Chim Acta. 1978; 29: 63–8; b) Patel MN, Patel MM, Cassidy PE, Fitch JW. Inorg Chim Acta. 1986; 118:33–5; c) Bottino FA, Finchiario P, Libertini PE, Reale A, Recca A, Inorg Nucl Chem Lett, 1980; 16: 417–21; d) Patel MN, Patil SH. J Macromol Sci Chem A. 1982; 18(4):521–33; e) Wang R, Wang Y, Li S. Gaofenzi Tonghaa. 1998; 1:33–40
- [26] a) GF. Dalelio, JV. Grivello, RK. Schoenig, TF. Huemmer, J Macromol Sci Chem A. 1979, 1, 1161–249; b) Delman AD, Stein AA, Simms BB, J. Macromol Sci Chem A. 1967; 1: 147–78; c) Goodwin HA, Bailor JC, J Am Chem Soc. 1961;83: 2467–71; d) Marvel CS, Tarkey N, J Am Chem Soc. 1958; 80: 32–835; e) El-Sayed Mansour ME, Kaseem AA, Nour Elgin H, El- Torkhy AA, Macromol Rep A. 1991; 28: 103–9; f) Khuhawar MY, Channer AH, Macromol Rep. 1995; 32: (Suppl. 4), 523–30; g) Sawodny W, Reiderer M, Urban E, Inorg Chim Acta.1978; 29: 63–8; h) Patel MN, Patel MM, Cassidy PE, Fitch JW. Inorg Chim Acta. 1986; 118: 33–5; i) Destris Pasini M, Pelizzi C, Porzio W, Predieri G, Vignali C, Macromolecules. 1999; 32(2): 353–60; j) Khuhawar MY, Channer AH, Shah SW, Eur Polym J. 1998; 34: 133–5
- [27] Khuhawar MY, Shah A, M. Mughal A, chinese journal of polymer science, 2007; 4: 399
- [28] Mehrotra R, Bohra R, Metal Carboxylates, Academic Press, London. 1983
- [29] Xue G, Dong J, Sun Y, Langmuir. 1994; 10: 1477
- [30] a) Henry P.M, Adv. Organomet. Chem. 1975;13: 363; b) Cohen H, Meyerstein D, Inorg. Chem. 1986; 25:1505; c) Gollstein S, Czapski G, Cohen H, Meyerstein D, Inorg. Chem. 1992; 31: 5670; d) N Navon, Golub G, Cohen H, Meyerstein D, Organometallics. 1995; 14: 5670
- [31] a) Mehrotra R, Bohra R, Metal Carboxylates, Academic Press, London, 1983; b) Xue G, Dong J, Sun Y, Langmuir. 1994; 10: 1477; c) Henry PM, Adv. Organomet. Chem. 1975;13: 363; d) Cohen H, Meyerstein D, Inorg. Chem. 1986; 25: 1505; e) Gollstein S, Czapski G, Cohen H, Meyerstein D, Inorg. Chem. 1992; 31: 5670; f) Navon N, Golub G, Cohen H, Meyerstein D, Organometallics. 1995; 14: 5670; g) Berners-Price SJ, Sadler PJ, Coord. Chem. Rev. 1990; 15: 1; h) Berners-Price SJ, Johnson RK, Mirabelli CK, Faucette LF, McCabe FL, Sadler PJ, Inorg. Chem. 1987; 26: 3383; i) Berners-Price SJ, Brevard C, Sadler PJ, Inorg. Chem. 1986;26: 3383
- [32] Amirmasr M, Khalaji AD, Falvello LR, Solar T, Polyhedron. 2006; 25: 1967
- [33] Pearson AJ, Acc. Chem. Res. 1980;13: 463; Kn61ker HJ, Synlett 1992; 371
- [34] Coates GE, Wade K., in Organometallic Compounds, Methuen,London, 1969; 2: 65
- [35] a) Dieck HT, Bock H, Chem. Comm. 1968; 678; b) Maywald F, Eilbracht P, Synlett. 1996;380-382; c) Wrackmeyer B, Seidel G, Koster R, Magnetic Resonance in Chemistry, 2000; 38 (7):520-524; d) Kuramshin AI, Kuramshina EA, Cherkasov RA, Russ. J. Org. Chem. 2005;41 (5): 649-655
- [36] Jarrahpour AA, Esmailbeig AR, Adabi A, Molbank, 2006; M457
- [37] Knölker H, Goesmann H, Gonser P, Tetrahedron Letters; 1996;37 (36):6543-6546
- [38] a) Bruce MI, Angew. Chem., Int. Ed., 1977; 16: 73; b) Main L, Nicholson BK, Adv. Metal-Org. Chem., 1994;3:1;c) Ryabov AD, Chem. Rev., 1990; 90:403;d) Omae I, Coord. Chem. Rev., 2004; 248: 995
- [39] Asamizu T, Nielsen JL, Nicholson BK, J. Organometal. Chem., 2010; 695: 96
- [40] a) Gennari M, Lanfranchi M, Cammi R, Pellinghelli MA, Marchio L, Inorg. Chem. 2007; 46: 10143; b) Chou CH, Yeh WY, Lee GH, Peng SM, Inorg. Chim. Acta. 2006; 359: 4139; c) Glockle M, Hubler K, Kummerer HJ, G. Denninger, Kaim W, Inorg. Chem. 2001; 40:2263; d)

- Panja S, Chowdhury S, Drew MGB, Datta D, *Inorg. Chem. Commun.* 2002; 5: 304; e) Jia WL, McCormick T, Tao Y, Lu JP, Wang S, *Inorg. Chem.* 2005; 44: 5706
- [41] Zhou XH, Wu T, Li D, *Inorg. Chim. Acta.* 2006; 359: 1442; f) Bell ZR, Harding LP, Ward MD, *Chem. Commun.* 2003; 2432; g) Paul R I, Argent SP, Jeffery JC, Harding LP, Lynam JM, Ward MD, *Dalton Trans.* 2004; 3453; h) Ronson TK, Adams H, Ward MD, *Eur. J. Inorg. Chem.* 2005; 4533; i) Tavacoli S, Miller TA, Paul RL, Jeffery JC, Ward MD, *Polyhedron.* 2003; 22: 507
- [42] Kretzer RM, Ghiladi RA, Lebeau EL, Liang HC, Karlin KD, *Inorg. Chem.* 2003; 42:3016
- [43] Solomon EI, Jones PM, Maj JA, *Chem. Rev.* 1993; 93: 2623
- [44] Morshedi M, Amirnasr M, Slawin AMZ, Woollins JD, *Polyhedron.* 2009;28:167
- [45] Khalaji AD, Welter R, *Inorganica Chemica Acta.* 2006; 359: 4403
- [46] Bolz I, May C, Spange S, *Arkivoc.* 2007; 3: 60
- [47] a) Wald G, *Annu. Rev. Biochem.* 1953; 22: 497; b) Stryer L, *Annu. Rev. Neurosci.* 1986; 9:87
- [48] Zeng F, Zimmermann SC, *Chem. Rev.* 1997; 97: 1681
- [49] a) Whitten DG, *J. Am. Chem. Soc.* 1974;96:594; b) Weis LD, Evans TR, P. Weermakers A, *J. Am. Chem.Soc.* 1968; 90:6109
- [50] Kanthiamathi M, Dhathathreyan A, *Chemical Physics Letters*, 2003;367: 193