IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Importance Of Schiff Base Metal Complexes

DR. SHYAM KUMAR MEENA, DR.YOGESH KUMAR

Assistant Professor, Department of Chemistry Government College Dholpur (Raj.)

Assistant professor, Department of Chemistry Shri Kalyan Rajkiya Kanya Mahavidyalaya, Sikar (Raj.)

Abstract -

Schiff bases are a vast group of compounds characterized by the presence of a double bond linking carbon and nitrogen atoms, the versatility of which is generated in the many ways to combine a variety of alkyl or aryl substituents. Compounds of this type are both found in nature and synthesized in the laboratory. For years, Schiff bases have been greatly inspiring to many chemists and biochemists. The carbon–nitrogen double bond present in the iminol tautomer is a typical element found in Schiff bases. In addition to the characteristics of the structure of these selected derivatives, and sometimes their classification, we presented selected literature items which, in our opinion, represent their importance in various fields well. Schiff bases have a wide range of biological activities, including antibacterial, antifungal, anti malarial, anti-inflammatory, anti proliferative, antiviral, and antipyretic. Schiff bases can be potential sources of antioxidants because they can donate electrons and protons. Schiff base complexes can be used as catalysts, such as in the oxidation of cyclohexene. Schiff bases are used in coordination chemistry because they can form stable complexes with metal ions. Schiff bases are used as dyes and pigments. Schiff bases are used as stabilizers for polymers.

Keywords: Schiff bases, hydrazides, Biological activities, Antioxidants, Dyes and pigments, Polymer stabilizers.

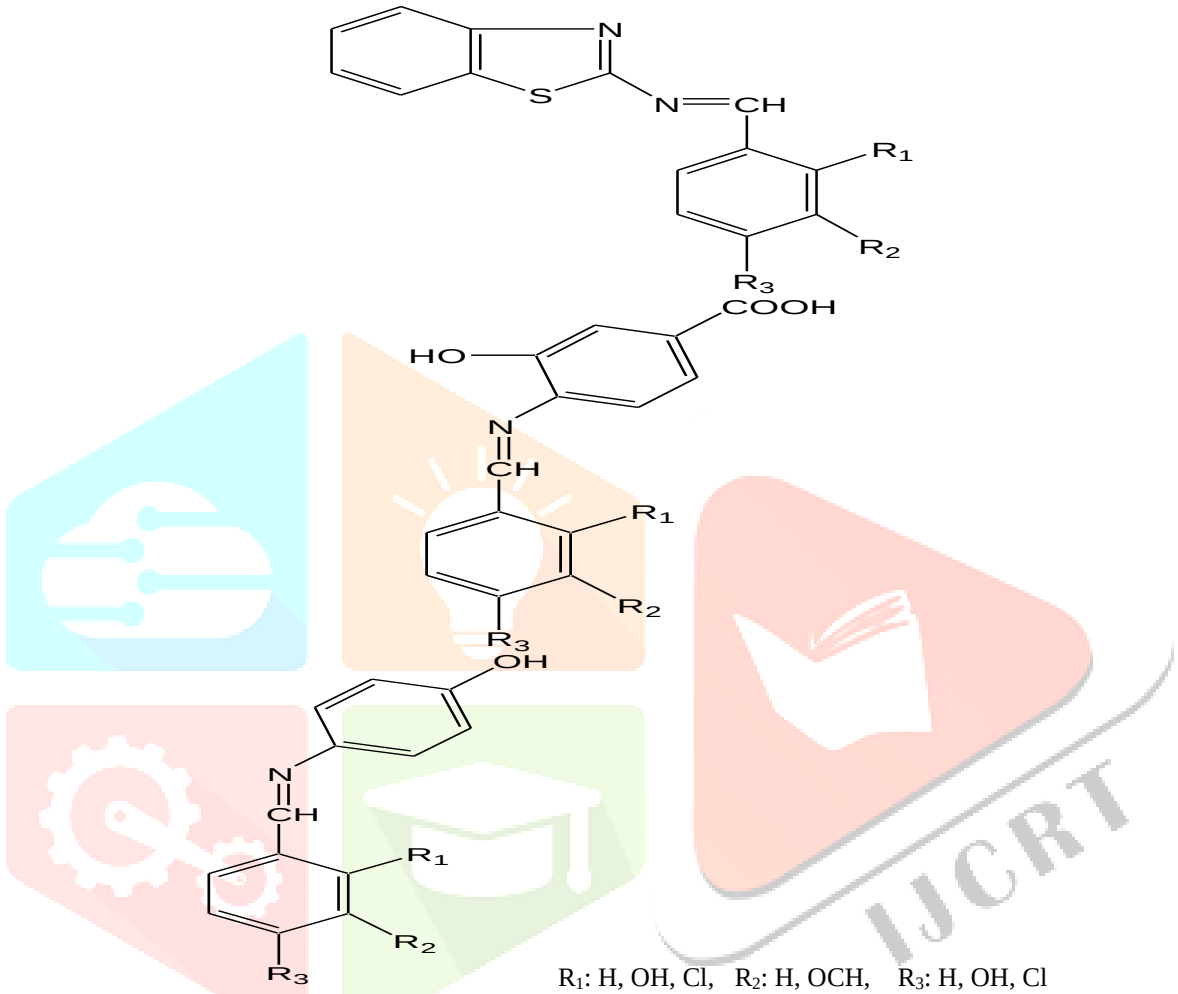
INTRODUCTION

Schiff bases are generally excellent chelating agents, [1-6] especially when a functional group like –OH or –SH is present close to the azomethine group so as to form a five or six membered ring with the metal ion. Versatility of Schiff base ligands and biological, analytical and industrial applications of their complexes make further investigations in this area highly desirable. The importance of Schiff base complexes for bioinorganic chemistry, biomedical applications, supramolecular chemistry, catalysis and material science, separation and encapsulation processes, and formation of compounds with unusual properties and structures has been well recognized and reviewed.

Schiff bases resulted from aromatic aldehydes ortho-substituted with a hydroxyl group have initially arouse the researchers' interest because of their ability to act as bidentate ligands for transitional metal ions[7-11]. Schiff bases of salicylaldehydes have also been reported as plant growth regulators[12] and antimicrobial[13] or antimycotic[14] activities. Schiff bases also show some analytical applications[15]. Schiff bases are active against a wide range of organisms for example; Candida Albicans, Escherichia coli Staphylococcus aureus, Bacillus polymxa, Trychophyton gypseum, Mycobacteria, Erysiphe graminis and Plasmopora viticola. 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.

A large number of different Schiff base ligands have been used as cat ion carriers in potentiometric sensors as they have shown excellent selectivity, sensitivity, and stability for specific metal ions such as Ag(II), Al(III), Co(II), Cu(II), Gd(III), Hg(II), Ni(II), Pb(II), Y(III), and Zn(II)[16-21]. Schiff bases have been studied for their important properties in catalysis[22]. They show catalytic activity in hydrogenation of olefins[23]. They find applications in bio mimetic catalytic reactions.

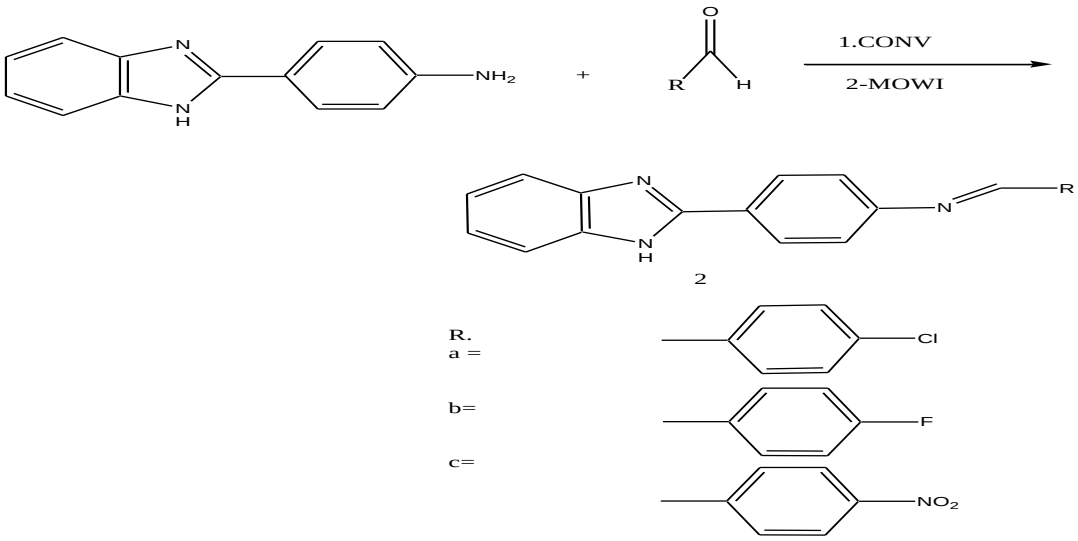
The Schiff bases synthesized from 2-amino-Benzthiazole, 4-amino-Salicylic acid and 4-aminophenol are shown in scheme 1.



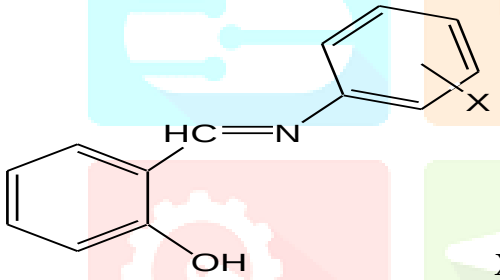
R_1: H, OH, Cl, R_2: H, OCH, R_3: H, OH, Cl

Literature survey shows that benzimidazole derivatives play a vital role in biological activities such as anti-diabetic[24], antimicrobial[25-26], antifungal[27], antiviral[28-29], antispasmodic[30], anticancer[31-32], anti-tumor[33], anti-hepatitis-C-virus[34], kinase inhibitor[35-36], analgesic[37], antipsychotic[38], antidepressant[39], anti-anxiety[40], antihypertensive[41], antiulcer[42] and anti-inflammatory[43]. On the other hand Schiff bases have an efficient antimicrobial[44] and antifungal activities[45]. Benzimidazoles can be prepared by the acid catalyzed reaction of aldehyde or ketone with amines[46].

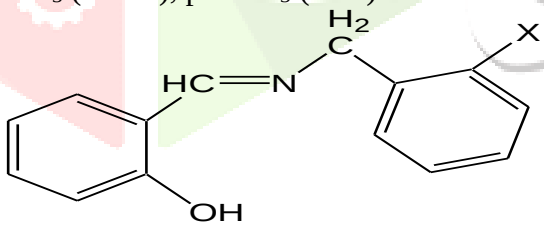
The preparations of the newly synthesized Schiff bases proceed via both conventional and microwave irradiation methods. The aim of using microwave irradiation technique is to study the efficiency of Green Chemistry for synthesizing Schiff bases, also decreasing the reaction time and increasing the yield. Anticancer evaluation in vitro have been screened for the newly synthesized products against human Cancer cell lines; [Co rectal cancer cell line HCT116, human liver cancer cell line HepG2 and human Ovarian cancer cell line A2780], the results showed that the compounds 2a, 2b, 2c are more potent comparing with the standard drugCK0106023. The molecular docking is performed and analyzed with Molecular Operating Environment program (MOE)



Schiff bases are ligands frequently used in coordination chemistry. Although they have been used for a long time, characterization of Schiff bases by mass spectrometry (MS) are less than expected in the literature. In some studies, mass spectrums of Schiff bases and complexes were performed with Fast Atom Bombardment (FAB) and Electro spray ionization (ESI) methods that indicate the molecular ion peak, at recent times. In these studies, characterizations of metal complexes of Schiff bases were reported. A number of studies about Schiff bases and method were reported in between 1970 and1991. Schiff bases were synthesized and ionized by 20,40,60,70,100 and 140 eV electrons using Direct Inlet. The obtained m/z values were evaluated[47-58].
Molecular structures of prepared Schiff bases can be seen in Fig 1.

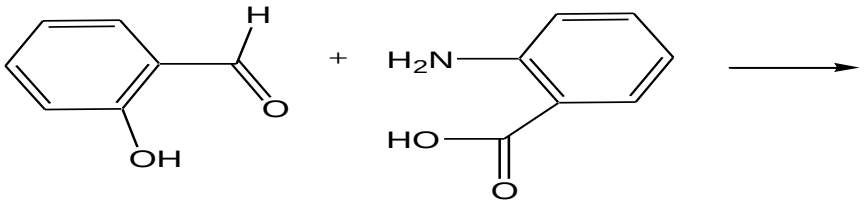


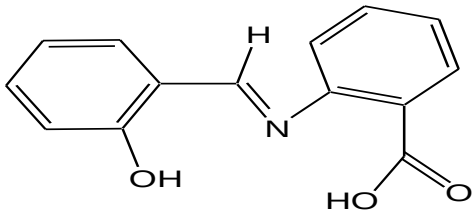
X= H (I), o-F (II), m-F (III), p-F (IV), o-Cl (V), m-Cl (VI), p-Cl (VII),o-Br (VIII), m-Br (IX), p-Br (X),o-I (XI), m-I (XII), p-I (XIII) ,o-OH (XIV), m-OH (XV), p-OH (XVI), o-OCH_3 (XVII), m-OCH_3 (XVIII), p-OCH_3 (XIX)



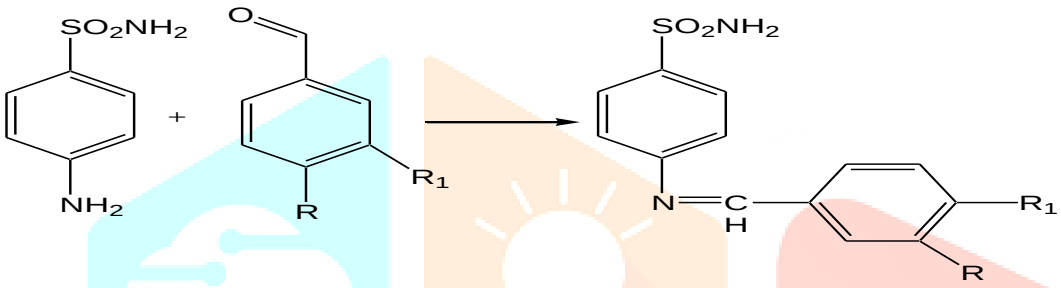
X=-H, -OH

Schiff bases have number of applications viz., preparative use, identification, detection and determination of aldehydes or ketones, purification of carbonyl or amino compounds, or protection of these groups during complex or sensitive reactions. Ugras et al[59] have reported the synthesis, complexation, antifungal and antibacterial activity studies of a new macro cyclic Schiff base .Preparation, physical characterization and antibacterial activity of Ni (II) Sciffbase complex was reported by Morad et al[60] (Scheme 2).

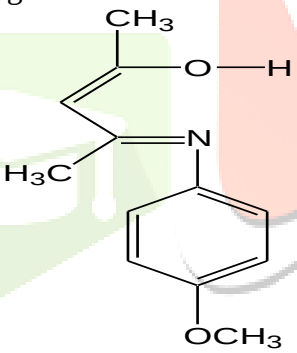




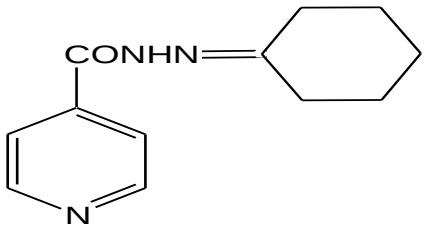
Baluja *et al* [61] have studied the biological activities of the following Schiff base (**Scheme 9**) and metal complexes.



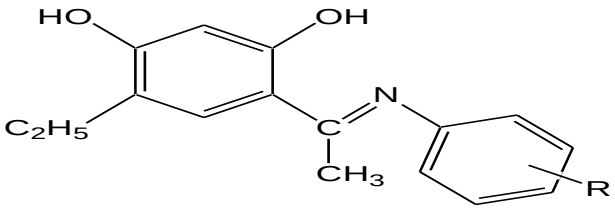
Synthesis, characterization and electrochemical behavior of Cu (II), Co (II), Ni (II) and Zn (II) complexes derived from acetyl acetone and p-anis dine was reported by Raman and coworkers[62]. These authors have observed that the complexes synthesized by them show fairly good antimicrobial activity.



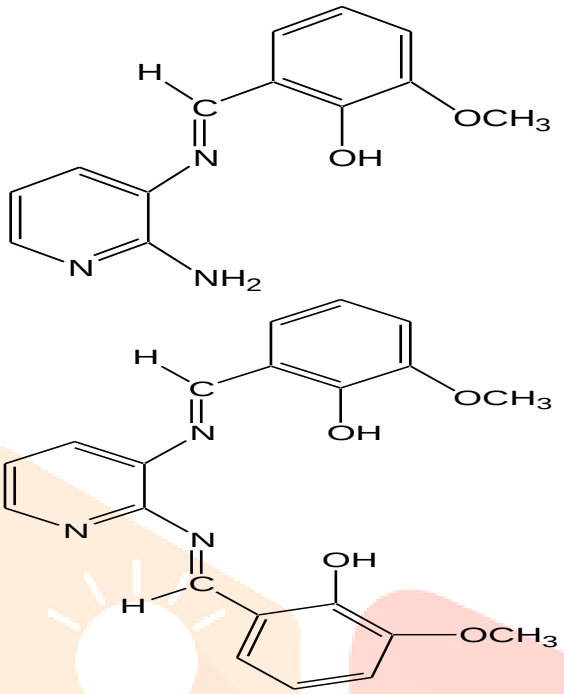
Hearn and Cynamon[63] have reported the synthesis and ant tubercular activity of Schiff base of the following type (**20**).



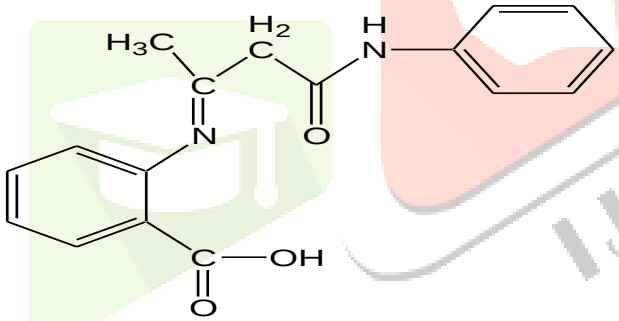
Nair and coworkers[64] have studied the synthesis and antibacterial activity of some Schiff base complexes. The Schiff bases showed greater activity than their metal complexes.



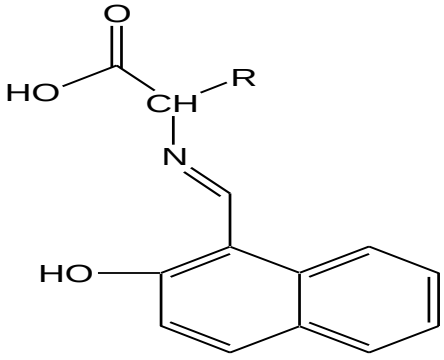
Two new Schiff bases (**35 and 36**) and eight transition metal complexes derived from 2, 3-diminopyridine (DAPY) and ortho-vanillin have been synthesized[65] and characterized by elemental analysis, magnetic susceptibility measurements, IR and NMR spectra. The Schiff bases and most of the metal complexes display antibacterial activity.



An investigation dealing with the impact of Schiff base derived from anthranilic acid and acetoacetanilide and its copper complex on in star larvae of Spodopetra litura was done by Raman *et* [66]



Synthesis, crystal structures and antimicrobial activities of two thiocyanato-bridged binuclear copper (II) complexes derived from 2, 4-dibromo-6-[(2diethylaminoethlimino) methyl] phenol and 4-nitro-2-[(2-thylaminoethylimino) methyl] phenol was proposed by Zhe Hong[67]. These complexes have been characterized by physico-chemical and spectroscopic methods. These are found to be antimicrobial. The in-vitro antibacterial and antifungal activities of five different amino acid Schiff bases derived from the reaction of 2-hydroxy-1-napthaldehyde with glycine, L-alanine, L-phenylalanine, L-histidine, Ltryptophaneandthemanganese(III) complexes of these bases were investigated by Iffet Sakiyan *et al* [68].The in-vitro activities against some Gram positive and Gram negative bacteria and fungi were determined.



Nowadays, there is a great interest in new compounds with active antioxidant components, whether they are synthesized or obtained from the nature.[69]

Antioxidant activities are related to the compound capability of protecting biological systems from the potentially harmful effect of processes involving reactive oxygen species that can cause excessive oxidation. Reports on such activity investigations of Schiff bases and structurally similar compounds could be found in literature.[70-71] The DPPH (2, 2'-diphenyl-1-picrylhydrazyl) assay is one of the most important methods used for evaluation of antioxidant activity. It is technically simple and rapid and that might explain its widespread use in antioxidant screening. Antioxidant activity can be determined spectrophotometrically or by high-performance liquid chromatography (HPLC), but also using some faster and inexpensive methods, such as thin layer chromatography (TLC).[72] DPPH may be neutralized either by direct reduction via electron transfer or by radical quenching via hydrogen atom transfer.[73] It is difficult to interpret reactivity patterns and mechanisms without specific information about the composition and structures of the investigated antioxidants.In the last decade, it was shown that quantum-chemical calculations can be a valuable tool in predicting and explaining antioxidative activity of various compounds. A good correlation between some quantum-chemical descriptors (i.e., various electronic descriptors, bond dissociation enthalpy and spin density) and antioxidant activity for a series of molecules were reported.[74]

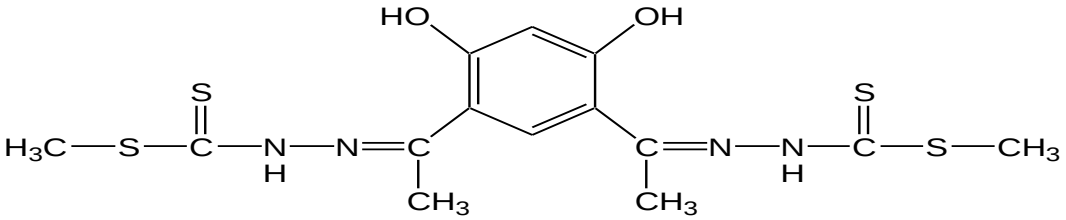
Our group has been investigating tetra dentate Schiff bases and their complexes from different aspects for a long time. Their retention was investigated on different thin layers and relationships between the structure, retention and activity/property as well as the antioxidant capacity and electrochemical behaviour were discussed.[75-79] Experimental results motivated us to investigate the influence of the structure on the antioxidant activity of these compounds and to perform calculations by hybrid density functional theory (DFT) methods. Several works were published to describe and explain the antioxidant activity using molecular descriptors.[80-82]

Coordination of the Schiff bases and the presence of the copper (II) ion have significant effect on the increase of antioxidant activity. All copper (II) complexes possess a square-planar geometry around the metal. Angle between best planes of two chelate rings in complex 1 is only 8.99°, indicating square-planar geometry.

Day by day Schiff bases are more frequently applied for the betterment of human welfare. The applications of Schiff bases and their metal complexes have aroused considerable attention, mainly because of preparative accessibility and structural variability. [83-84] Schiff bases play an important role in both synthetic and structural researches. Binuclear complexes with Schiff bases of various aldehydes with aromatic amines are known .[85-87] The oxygen bridged homo and hetero binuclear and trinuclear complexes have attracted much attention due to their interesting spectral and magnetic properties and their use in biochemical processes and homogeneous catalysis.[88-90] In recent years environmentally being synthetic methods have received considerable attention and some methods are reported.[91-92] Catalysed synthesis of Schiff bases using microwaves have been reported.[93-94]

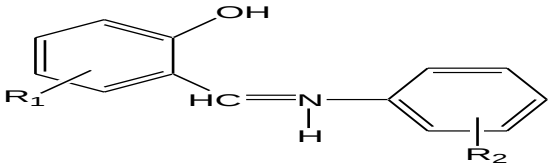
The Schiff bases have been subject of great interest for a number of years because of their various chemical and structural characteristics and also their proved applications as biologically active molecules.[95] their complexes are known to be biologically important and act as models to understand the structure of bio molecules and metalloproteinase. They have also a variety of applications, including biological, clinical, analytical, and also industrial purposes.[96] Superoxide dismutase (SOD) is an enzyme that catalyses the dismutation of the superoxide radical very efficiently through a redox reaction of its copper center. The mechanism believed to be operating in the metallo proteins involves one-electron reduction of a metal ion by superoxide followed by re oxidation of the reduced metal ion by a second superoxide anion.[97] Metal complexes that can undergo such redoxcycling can function as superoxide scavengers; copper is the active metal center in the best studied SOD and many copper complexes have been synthesized and tested for SOD-like activity.[98-99] Metal complex mediated cleavage of DNA is a subject of continued interest[100], particularly, toward development of new metallopharma-ceuticals. The importance's of copper complexes for promoting such studies in development of copper-based drugs are well-established .[101] Copper complexes with imines have deserved much attention, probably because of their ability to intercalate between the bases of DNA [102] and to participate in catalytic cycles with usual reducing and oxidizing agents in biological medium.[103]

Makode et al.[104] have synthesized complexes of Mn(II), Fe(II), Co(II), Ni(II), Cu(II), Cd(II), with Schiff's bases derived from resdiaceaophenone and S-methyl di thiocarbazate.

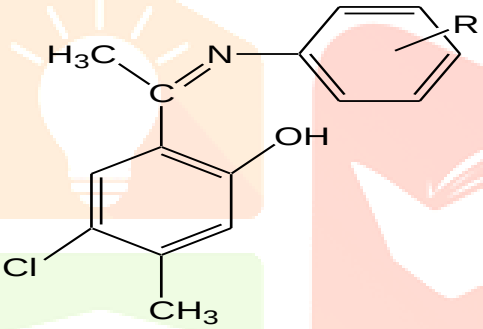


BIS (S- Methyldithiocarbazate) resdiaceaophenone

A large number of metal complexes with Schiff base ligands formed from salicylaldehyde or substituted salicylaldehydes with various aromatic amines are known [105-108]. Solution stability constants of the complexes of a number of Schiff bases with various divalent metal ions have been studied by dodwad et al [109.]



The oxygen bridged mono-bidentate and tridentate complexes have attracted much attention due to their interesting spectral and magnetic properties and their use in biochemical processes and homogeneous catalysis.[110-114] M.M. Shaika and co-workers[115] have prepared bidentate complexes directly by the reaction of Schiff bases derived from 5-chloro-4-methyl-2-hydroxy acetophenone aniline and substituted anilines with thorium and uranyl nitrates. The complexes obtained are of the type [Th (L_2) (NO_3)2] respectively, where L is a Schiff base molecule as shown below.



Where R=H, o, m, p-chloro or o.m.p-methy

REFERENCE-

1. Spichiger-Keller U., "Chemical Sesors and Biosensors for Medical and Biological Applications", Wiley-VCH, 1998, Weinheim.
2. Lawrence J. F. and Frei R. W., "Chemical Derivatization in Chromatography", Elsevier, 1976, Amsterdam.
3. Patai, Ed. S., "The Chemistry of the Carbon-Nitrogen Double Bond", J. Wiley & Sons, 1970, London.
4. Jungreis E. and Thabet S S., "Analytical Applications of Schiff bases", Marcell Dekker, 1969, New York.
5. Metzler C M, Cahill A and Metzler D E, J. Am. Chem. Soc., 1980, 102, 6075.
6. Dudek G. O. and Dudek E. P., Chem. Commun., 1965. 464.
7. Pfeiffer P., Breith E., Llibbe E. and Tsumaki T., Justus Liebigs Ann. Chem.,1933, 503, 84.
8. Hunter L. and Marriott J.A., J. Chem. Soc, 2000 (1937).
9. Sacconi L., Ciampolini M., Maggio F., and Cavasini F.P., J. Am. Chem. Soc.,1962, 84, 3246.
10. Holm R.H. and Swaminathan K., Inorg. Chem., 1962, 1, 599.
11. Perry G.C. and, Thornton D.A., J. Inorg.Nue.Chem, 1972, 34, 3357.
12. Alt G.H. (Monsanto Co.), US. 1980, 4.226.615. Chem. Abstr., 94, (1981) 26155
13. Hamada Y., Takeuchi I., Ita Y., Matsui S. and Ita T., Yakugaku Zasslzi, 101, 633 (1981); Chem. Abstr.,1981, 95, 181559.
14. Ismail M., 'Indian J. Pharm. Sei., 1986, 45, 121, Chem. Abstr., 1987, 107,175589.
15. Palet P.R., Thaker B.T., and Zele S., Indian, J. Chem., A38 (1999)563.
16. Abbaspour A., Esmaeilbeig A.R., Jarrahpour A.A., Khajeh B., and Kia R., Talanta, 2002,58 397.

17. Mahajan R.K., Kaur I., Kumar M., Sens. Actuators, 2003, B-91, 26.
18. Ganjali M.R., Golmohammadi M., Yousefi M., Norouzi P., Salavati-Niasari M. and Javanbakht M., Anal. Sci, 2003, 19,223.
19. Jain A.K., Gupta V.K., Ganeshpure P.A. and Raisoni J.R., Anal. Chim. Acta, 2005, 553, 177.
20. Jeong T., Lee H.K., Jeong D.C., S. Jeon, Talanta, 2005, 65, 543.
21. Gupta V.K., Singh A.K. Mehtab, S. and Gupta B., Anal. Chem. Acta, 2006,566, 5.
22. Hernandes M.M., Mckee M.L., Keizer T.S., Yeaswood B.C. and Atwood D.A., J. Chem. Soc., Dalton Trans, 2002,410.
23. Olie G. H., and Olive S., Springer, Berlin (1984).
24. Vinodkumar R., Vaidya S.D., Siva Kumar B.V., Bhise U.N., Bhirud S.B. and Mashelkar U.C. 'Synthesis, anti-bacterial, anti-asthmatic and anti-diabetic activities of novel N-substituted 2-(4-styrylphenyl)-1H-benzimidazole and N- substituted-3[4-(1H-benzimidazole-2-yl)-phenyl]-acrylic acid tertbutylester. ARKIVOC. Xiv: 2008, 37-49.
25. Sutha S., Shobana S., Dharmaraja J. and Selvaraj S., 'Mixed ligand complexation of some transition metal ions in solution and solid state: Spectral characterization, antimicrobial, antioxidant, DNA cleavage activities and molecular modeling, Spectrochim Acta a Mol Biomol.Spectrosc.2013, 107C: 117-132.
26. Reddy V.B., Singla R.K., Bhat V. and Shenoy G., 'Synthesis and Antimicrobial Studies of Some Novel Benzimidazole Derivatives, Asian J. Research Chem.,2009, 2: 162-167.
27. Micco I., Nencini A., Quinn J., Bothmann H., Ghiron C., Padova A. and Papini S., 'Parallel synthesis of a series of potentially brain penetrant amino alkyl benzoimidazoles. Bioorg. Med. Chem., 2008, 16: 2313-2328.
28. Shadia A.G., Abd El-All A.S., Abdallah M.M. and El-Diwani H.I., 'Synthesis of potent antitumor and antiviral benzofuran derivatives. Bioorg. Med.Chem. Lett., 2009, 19: 2420-2428.
29. Shadia A.G., Abd El-All A.S., Hegab K.H., Magd-El-Din A.A., Youssef N.S. and El-Diwani H.I., 'Novel antiviral benzofuran-transition metal complexes, Eur. J. Med. Chem.,2010, 45: 3035-3046.
30. Saydin A., Beis K.D. and Can D. 'Analgesic and antispasmodic activities of 2-(2-nitro-phenyl)-1Hbenzimidazole 5-carboxylic acid: evidence for the importance of the 2-(o-substituted phenyl) groups, Pharmazie.2003, 58: 405-408.
31. Rubbiani R., Kitanovic I., Hamed A., Can S., Kitanovic A., Onambele L., Stefanooulou M., Goldmacher Y., Sheldrick W., Wolber G., Pork A., Welof S. and Ott I., 'Benzimidazol-2-ylidene gold (I) complexes are thioredoxin reductase inhibitors with multiple antitumor properties. J. Med. Chem., 2010, 53: 8608-8618.
32. Kumar D., Jacob M.R., Reynolds M.B. and Kerwin S.M., 'Synthesis and evaluation of anticancer benzoxazoles and benzimidazoles related to UK-1, Bioorg. Med. Chem., 2002, 10: 3997-4004.
33. Suthakaran R., Nagarajan G., Balasubramaniam V., Suganthi K., Kannan M. and Velrajan G., 'synthesis and anti-tumor activity of 4-aryl/alkyl -2-D aldosugar, disubstituted Bis-benzimidazoles. Indian J. Heter. Chem., 2005, 15: 173-176
34. Ishida T., Suzuki T., Hirashima S., MIzutani K., Adachi T. and Hashimoto H. 'Benzimidazole inhibitors of hepatitis C virus NS5B polymerase: identification of 2-[(4-diarylmethoxy) phenyl]-benzimidazole. Bioorg Med. Chem. Lett., 2006, 16: 1859-1863.
35. Neef D.K., Lee-Dutra A., Blevitt J.M., Axe F.U., Hack M.D., Buma J.C., Rynberg R., Brunmark A., Karlsson L. and Breitenbucher G., '2-Aryl benzimidazoles featuring alkyl-linked pendant alcohols and amines as inhibitors of checkpoint kinase Chk2. Bioorg. Med. Chem. Lett., 2007, 17: 6467-6471.
36. Arienti K.L., Brunmark A., Axe F.U., Mcclure K., Lee A., Blevitt J., Neef D., Hung L., Crawford S., Pandit C.R., Karlsson L. and Breitenbucher J.G. 'Checkpoint kinase inhibitors: SAR and radio protective properties of a series of 2- aryl benzimidazoles. J. Med. Chem., 2005, 48: 1873-1885.
37. Joseph E.P., Bonnefous C., Symons K.T., Nguyen P.M., Sablad M., Rozenkrants N., Zhang Y., Wang L., Yazdani N., Shiau A. K., Noble S. A., Rix P., Rao T.S., Hassig C.A. and Smith N.D., 'Discovery of dual inducible/neuronal nitric oxide synthase (iNOS/nNOS) inhibitor development candidate 4-((2-cyclobutyl-1H-imidazo[4,5-b]pyrazin-1-yl)methyl)-7,8-difluoroquinolin-2(1H)-one (KD7332)part 2: identification of a novel, potent and selective series of benzimidazole-quinolinone iNOS/ nNOS dimerization inhibitors that are orally active in painmodels,J. Med. Chem.,2010, 53: 7739-55.

38. Ingle R.G. and Magar D.D., 'Heterocyclic chemistry of benzimidazoles and potential activities of derivatives, IJDRT, 2011, 1: 26-32.
39. Scates A.C. and Doraiswamy P.M., 'Reboxetine: a neither selective nor epinephrine reuptake inhibitor for the treatment of depression, Ann Pharmacotherapy, 2000, 34: 1302-1312.
40. David Baldwin., Buis C. and Mayers A., 'Selective serotonin reuptake inhibitors in the treatment of generalized anxiety disorder, Expert Rev. Neurother, 2002, 2: 717-724.
41. Sharma M.C., Kohli D.V., Sharma S. and Sharma A.D., 'Synthesis and antihypertensive activity of some new benzimidazole derivatives of 4'-(6- methoxy-2-substituted-benzimidazole-1-ylmethyl) - biphenyl-2-carboxylic acid in the presences of BF_3 •OEt_2, Der Pharmacia Sinica, 2010, 1: 104-115.
42. Bharat S., Bhatta D., Panda P.K., Mishra P. and Pradhan D., 'Synthesis and Antiulcer Activity Studies of 2-(1'-Iminothioimido Subs titu ted)-1'- Substituted Phenyl benzoic acids, Indian J. Pharm. Sci.,2008, 70: 381-383
43. Rajasekaran S., Gopalkrishna R. and Chatterjee A., 'Synthesis, Anti-Inflammatory and Anti- activity of some substituted Benzimidazole Derivatives, IJDDR, 2012, 4: 303-309.
44. Naik B.K. and Desai K.R., 'Synthesis of some heterocyclic Schiff base and azetidinone compounds and their antibacterial activity, Asian J. Chem., 2004, 16: 1749-1752.
45. Warad D.U., Satish C.D., Kulkarni V.H. and Bajgur C.S., 'Synthesis, structure and reactivity of zircordum(IV), vanadium(IV), cobalt(II), nickel(II) and. copper(II) complexes derived from carbohydrazide Schiff base ligands, Indian J. Chem., 2000,39A: 415-420.
46. Desai S., Desai P.B. and Desai K.R., 'Synthesis of new heterocyclic thiazolidinone and azetidinonecompounds and their anticancer activity, Heterocycl Commun., 1999, 5: 385-387.
47. Paryzek W.R., Kaczmarek S.M., Patroniak V., Pospieszna-Markiewicz L., 'New Supramolecular dinuclear rare earth Schiff base Podands, Inorganic Chemistry Communications, 2003,6: 26-29.
48. Przybylski P., Schroeder G., Pankiewicz R., Brzezinski B., Bartl F., 'Complexes of Schiff base of gossypol with n-butylamine and some monovalent or bivalent cations studied by ESI-MS, NMR, FTIR as well as PM5 semiemprical methods, Journal of Molecular Structure,2003, 658: 193-205.
49. Przybylski P., Kolodziej B., Leniec G., Kaczmarek M.T., Grech E., Typek J., Brzezinski B., 'ESI-MS Spectroscopic and semiemprical characterization of macrobicyclic complex with Er(III) cation, Journal of Molecular Structure,2007, 878: 95-103.
50. Przybylski P., Pyta K., Wicher B., Gdaniec M., Brzezinski B., 'Structure of a new Schiff base of gossypol with 1-(3-aminopropyl)2-pyrrolidinone studied by X-ray, FTIR, NMR, ESI-MS, and PM5 method, Journal of Molecular Structure,2008, 889: 332-343.
51. Zeng Q.L., Chen W.Z., Zhao Y.F., 'Electrospray ionisation mass spectral fragmentation study of amino acid derived ox vanadium Schiff base complexes and oxovanadium Schiff base complexes, International Journal of Mass Spectrometry, 2007, 262: 161-167.
52. Jirasco R., Holcapek M., Kolarova L., Nádvornik M., Popkov A., 'Characterization of Ni(II) complexes of Schiff bases of amino acids and (S)-N-(2-benzoylphenyl)-1-benzylpyrrolidine-2-carboxamide using ion trap QqTOF electrospray ionization tandem mass spectrometry, Journal of *Mass Spectrometry*,2008, 43: 1274-1284.
53. Przybylski P., Pyta K., Brezinski B., Bartl F., 'Complexes of heterocyclic aza derivatives of phytoalexin from cotton plant-gossypol with alkali metal cations and perchlorate anion studied by ESI mass spectrometric method in the positive and negative modes, Journal of Mass Spectrometry, 2009,44: 838-846.
54. Kantilal S.P., Rinehart K.L., Bailar J.C. 'Mass spectral studies of Schiff bases and their metal complexes, Organic Mass Spectrometry.1970, 4: 441-451.
55. Morris M.L., Koob R.D., 'Mass Spectral Analysis of Schiff Bases Derived from l,l,l-Trifluoro-2,4-pent anedione and 1,2-Diaminoethane, 1,3-Diaminopropane,1,4-Diaminobutane and 1,2-Diaminobenzene and their Copper (II) and Nickel(II) Complexes, Organic Mass Spectrometry,1983,18: 305-314.
56. Tarnburini S., Vigato P.A., Traldi P., 'Electron Impact Mass Spectrometry of SomeMacrocyclic and Acyclic Aldimines, Organic Mass Spectrometry.1986, 21: 183-192.
57. Ma Y.C., Munson B., 'Thermal Effects on the Mass Spectra of Benzophenone OximesObtained by Gas Chromatography Electron Ionization, Organic Mass Spectrometry.1991, 26: 821-825.
58. Vijfhuizen P.C., Terlouw J.K., 'The ElectronImpact Induced Fragmentation of AromaticAldoximes, Organic Mass Spectrometry.1977, 12: 245-253.

59. Ugras H.I., Basaran I., Kilic T. and Cakir U., J. Heterocyclic Chem.,2006, 43**,** 1679.
60. Morad F.M., Ajaily M.M.EL. And Gweirif S.B., Journal of Science and ItsApplications. 2007, 1, 72.
61. Baluja S., Solanki A. and Kachhadia N., Journal of the Iranian Chemical Society. 2006, 3, 312.
62. Raman N., Muthuraj V., Ravichandran S. and Kulandaisamy A., Indian Acad. Sci (Chem.Sci*).*,2003, 115, 161.
63. Hearn M.J. and Cynamon M.H., Journal of Antimicrobial Chemotherapy, 2004, 53, 185.
64. Nair R., Shah A., Baluja S. and Chanda S., J. Serb. Chem.Soc.*2006* 71(7**)**, 733.
65. Henri L.W., Tagenine J. and Gupta B., Indian Journal of Chemistry. 2001, 40A, 999.
66. Raman N., Joseph J., Muthukumar S., Sujatha S. and Sahayaraj K., Journal of Biopesticides.,2008,46B, 884.
67. Hong Z., Transition Metal Chemistry, *2008,* 33, 797.
68. Sakiyan.L., Logoglu E., Arslan S., Sari N. and Sakiyan N., Biometals.,2004, 17, 115.
69. Hussain H. H., Babic G., Durst T., Wright J., Flueraru M., Chichirau A., Chepelev L. L., J. Org. Chem. 2003, *68*, 7023.
70. Alkan M., Yuksek H., Gursoy-Kol, O., Calapoglu M., Molecules 2008, *13*, 107.
71. Yrjonen T., Peiwu L., Summanen J., Hopia A., Vuorela H., J. Am. Oil Chem. Soc. 2003, *80*, 9.
72. Lapornik B., Golc Wondra A., Prosek M., J. Planar Chromatogr. 2004, *17*, 207.
73. Jimenez A., Selga A., Torres J. L., Julia L., Org. Lett. 2004, *6*, 4583.
74. Mladenovic M., Mihailovic M., Bogojevic D., Matic S., Niciforovic N., Mihailovic V., Vukovic, N., Sukdolak S., Solujic S., Int. J. Mol. Sci. 2011, *12*, 2822.
75. Baosic R., Tesic Z., J. Serb. Chem. Soc. 1995, *60*, 903.
76. Baosic R., Radojevic A., Radulovic M., Miletic S., Natic M., Tesic Z. Biomed. Chromatogr. 2008, *22*, 379.
77. Baosic R., Milojkovic-Opsenica D., Tesic Z., J. Planar Chromatogr. 2003, *16*, 412.
78. Baosic R., Radojevic A., Tripkovic T., Aburas N., Tesic Z., Chromatographia,2010, *72*, 545.
79. Aburas N., Lolic A., Stevanovic N., Tripkovic T., Nikolic-Mandic S., Baosic R., J. Iran. Chem. Soc. 2012, *9*, 859.
80. Rastija V., Medic-Saric M., *Eur. J. Med. Chem.* 2009, *44*, 400.
81. Cheng Z., Ren J., Li Y., Chang W., Chen Z., *J. Pharm. Sci.* 2003, *92*, 475.
82. Farkas O., Jakus J., Héberger K., *Molecules*, 2004, *9*, 1079.
83. Gour S., Assian J. Chem, 2003,15,1,250.
84. Prakash Anant and Adhikari Devjani, Int. J. Chem., Tech. Res, 2011,3,4,1891.
85. Akilan P. et al, Polyhedron, 2003, 22, 3483.
86. Omar Hamad Shihab Al-Obaidi, Bio-Inorg Chem App Ln., (2012), 2012: 601879.
87. Chondhekar T.K. and Khanolkar D.D., Ind. J. Chem. 1986, 25A (1986) 868.
88. Macho.V et al, J. Mol. Catal, A; Chem, 2004, 69, 209
89. Dodwad S.S. et al, J. Ind. Chem Soc; 1983, 60, 546.
90. Jorraupur A.A. et cl Molecules, 2004, 9, 815
91. Bhattacharya P.K., Ind. J. Chem, 1982, 12, 505.
92. Khanolkar V.D. and Khanolkar D.D., Ind, J. Cham. 1979, 18A, 315.
93. Sousa C. Freire C., Moleules, 2003, 8, 894.
94. Srivastva K.P. et al J. Chem Pharma, Res. 2010, 2(6), 68.
95. Yamada, S., Coordination Chemistry Reviews, 1999, 192, 537.
96. Jeewoth, T., Bhowon, M. G., & Wah, H. L. K., Transition Metal Chemistry, 1999,24, 445.
97. Saczewski, F., Dziemidowicz-Borys, E., Bednavski, P. J., Grunert, R., Gdaniec, M., & Tabin, P. (2006).Journal of Inorganic Biochemistry, 100, 1389.
98. Anacona, J. R., Rodriguez, C., & Rodriguez-Barbarin, M. C. (2004). Monatshefte fur Chemie, 135, 785.
99. Anacona, J. R., Nusetti, O., Gutierrez, C., & Loroño, D., Journal of Coordination Chemistry, 2002,55,1433.
100. Guinovart, C., Navia, M. M., & Tanner, M., Current Molecular Medicine, 2006, 6, 137.
101. Rice-Evans, C. Current Medicinal Chemistry, 2001, 8, 797.

102. Swearingen, J. K., & West, D. X., Transition Metal Chemistry, 2001 26, 252.
103. Sorenson, J. R. J., Journal of Medicinal Chemistry, 1996, 19, 135.
104. Makode J.T. and Answer A.S. J.Indian Chem.Soc. 2003, 80, 44-46.
105. Shalla A.M., Mostafa M.M. and Bekheit M.M., Indian J.Chem.Soc.1976, 17A, 516.
106. Biradar N.S. and Angadi S.D., Monatsh, 1977,108,525.
107. Biradar N.S. and Angadi S.D., J.Inorg. Nuclear Chem., 1977, 38, 1405.
108. Pujar M.A. and Bharamagoudar T.D., J.Indian Chem. Soc., 1977 57,462.
109. Dodwad S.S., Datar M.G. and Patil I.R., Indian J.Chem.1983 22A, 83.
110. Prabhu P.S. and Dodwad S.S., J.Indian Chem. Soc., 1983, 60 1, 546-549.
111. Kato M., Muto Y., Jonassen H.B., Imai K., atsuki K.K.andlkegamy S.,Bull. Chem.Soc. Japan, 1969, 42, 2555.
112. Harris C.M. and Sinn E., J.Inorg. Nucl. Chem., 1968, 30, 2723.
113. Raman N., Joseph J., Sakthivel A. and Jeyamurugan R., J. Chil. Chem. Soc., 2009, **54**, 4.
114. Raman N., Ramaraj J. and Jeyasekaran Joseph, J. Iran. Chem. Res., 2010, **3**, 83.
115. Angelusiu M. V., Barbuceanu S. F., Draghici C. and Almajan G. L., Eur. J. Med. Chem.,2010, **45**, 2055.