2.1 INTRODUCTION OF SCHIFF BASES AND THEIR COMPLEXES:

Schiff bases and their transition metal complexes continue to be of interest even after over a hundred years of study. Schiff bases have a chelating structure and are in demand because they are straightforward to prepare and are moderate electron donors with easily tunable electronic and steric effects thus being versatile.

Schiff bases are compounds, having a formula RR'C=NR" where R is an aryl group, R' is a hydrogen atom and R" is either an alkyl or aryl group. There are several reaction pathways to synthesize Schiff bases. The most common is condensation reaction of amine and aldehyde or ketone under refluxing conditions. The first step in this reaction is an attack of nucleophilic nitrogen atom of amine or carbonyl carbon, resulting in a normally unstable carbinolamine intermediate. The reaction can reverse to the starting materials, or when the hydroxyl group is eliminated and a >C=N bond is formed, an imines can be formed.

\[
\text{RCHO/RR'CO} + \text{R"NH}_2 \quad \rightarrow \quad \text{RCH=NR"/RR'C=NR"} + \text{H}_2\text{O}
\]

The Schiff base class is very versatile as compound, can have a variety of different substituents. The presence of O, N and S donor groups at suitable position make Schiff bases an excellent ligand. This is because the complexation of Schiff base ligand with metal ion results commonly formation of a five or six membered cyclic structure. Cyclic structure in Schiff base complexes are commonly called chelate ring, it gives stability to the coordination compounds.
Schiff bases are widely in use for synthetic purposes both for organic and inorganic chemists. Because of structural curiosities and applicational possibilities in various fields of chemistry; these complexes have stimulated the research work in the areas of spectroscopy, stereochemistry, coordination polymers, magneto chemistry, reaction mechanism, material and biomedical sciences, photochemistry, nanotechnology etc.

Hugo Schiff [1] (1834-1915), synthesized, 2-hydroxy benzylidene-aniline and its series of derivatives in 1864, after whom they were named; subsequently compounds of this kind were extensively synthesized and studied. The method of synthesis has widely been reviewed by Dayagi and Degani [2]. A comprehensive systematic study on Schiff bases was initiated in 1940 by Pfeiffer, and coworkers [3]. They studied problems of synthesis, esterification, transamination, ligand replacement, metal exchange and stereochemistry of the complexes in particular reference to salen derivatives of copper (II). Their chelating characteristics were described in a monograph by Dwyer and Mellor [4]. In 1963, Layer reviewed the preparation and properties of Schiff bases [5]. For the first time in 1946, Domagk et al. observed the antitumor activity in some thiosemicarbazide derived Schiff bases [6].

Applications of Schiff bases in inorganic analysis have been described by Jungies et al. [7]. The applications of the Schiff bases and their derivatives are enormous. Some traditional and industrial uses are as pigments and dyes for cotton, wool, synthetic fibers and plastics, photographic emulsions, heat resistant polymers, high temperature stabilizers for lubricating oil inhibitors
against acid corrosion of metals and alloys, anti-knocking agents and burning rate modifiers, polyolefine [8-10].

Researches in poly-metallic Schiff base complexes, macrocylic complexes, polymeric Schiff base complexes and Schiff base chelates with metals in low valence state are on progress. Mehrotra et al. [11] studied Schiff base complexes of some IV$^{th}$ group elements. In past decade, the Schiff base complexes of main group elements [12-13] were studied with emphasis because of their applications in biology and industry. The emerging medicinal and biological applications of Schiff bases and their metal chelates are fungicides, insecticides, algaecides, plant growth regulators, enzymatic decarboxylation, catalysis, enzymatic aldolization, antiviral, antibiotic, anesthetic, antituberculosis, antitumor and oxygen carriers in biological system [14-17]. Chelates of platinum group metals and some of the 3d-transition metals with the Schiff bases derived from 5-methyl dithiocarbamate, purine, 6-mercapto purine and thioguanine have been reported with such activities [18, 19].

2.2 RELEVANT LITERATURE SURVEY:

Yamada and Yamanowchi have studied some metal complexes of Schiff bases obtained from substituted salicylaldehyde and 2-amino pyridine derivaties [20].

Bhattacharya and coworkers have studied the mixed ligand complexes of Cu(II), Ni(II), Zn(II) and Cd(II) [21]. Dey and coworkers have been synthesized and characterized the Cu(II) complexes of 3-aldehydosalicylic acid and its Schiff bases with aniline, methyl amine and ethanol amine [22].
Das and Livingtone have been studied metal chelate of furfural and thionyl-5-methyl dithiocarbazole Schiff bases [23]. Oxovanadium(IV) complexes of NS and ONS donor ligands derived from S-methylthio-carbazate have been reported by Sahni and Kapoor [24]. Pujar and Biradar have studied NMR and magnetic susceptibility of nitro-ammine cobalt (III) complexes [25].

Synthesis, characterization and reactivity of Cu(I) and Cu(II) complexes of N,N'-Bis (3-(2-thenylidenimino) propyl) piperazine and N,N'-Bis (3-(2-thenylidenamino)propyl) piperazine and their crystal structure have been reported by Casella and Ibers [26]. Jani et al. have studied some new mixed Schiff base complexes of Cu(II) and Ni(II) containing fused ring system [27].

Kaushik and Sharma have studied the solid state of complexes of titanium(IV) with bidentate Schiff bases derived from salicylaldehyde and 4-anisidine, 4-phenetidine, 4-chloroaniline [28]. Metal complexes of 2,4 (or 7)-dimethylbenzimidazole with different metal ions like Co(II), Ni(II),Cu(II) and Zn(II) have been studied by Lingaiah and Murthy [29]. Jadam and Luciano have been prepared the Cu(II)-2-aminobenzophenone complexes and characterized them by magnetic, spectral and X-ray techniques [30].

Co(II) chelate of some bi- and tridentate Schiff bases from toluidine and chloroaniline have been studied by Shah [31]. Syamal and Niazi have been reported Some new Cu(II) coordination compounds of Schiff bases derived from hydroacetophenone and hydrobenzophenone [32]. Magnetic and spectral studies of some binuclear copper(II) complexes have been done by Singh et al. [33]. Mostafa et al. have synthesized and characterized the metal
complexes derived from isobutyric acid hydrazide with some bivalent metal ions [34].

Sarkar et al. have characterized the 4-aminoantipyrine bidentate Schiff base complexes of lanthanides and uranyl ions [35]. A report on the complexes of Co(II), Ni(II) and Cu(II) with substituted 2-furoyl thiosemicarbazide was published by Hiremath and coworkers [36].

Cu(II) complexes of 6-furfuralamino purine have been studied by Carbras and Zoroddu [37]. Complexes of Co(II), Ni(II), Cu(II), Zn(II) and Cd(II) with some bi and tridentate p-dimethyl aminobenzylidene, amino-5-mercapto-3-trifluoro-methyl-5-triazole (DMMTT) have been reported by Dubey and Kaushik [38]. Cobalt, nickel, copper, zinc, cadmium and mercury(II) complexes with a tridentate ONO donor Schiff base have been studied by Das and coworkers [39]. The transition metal chelates involving 2-(2'-hydroxy-benzaldehyde)-amino benzylimidazole have been studied by Shrivastava [40].

Complexes of Mn(II), Co(II), Ni(II) and Cu(II) of a macrocyclic Schiff base ligand derived from N-N'-bis (2-aminophenyl)-O-phenyldiamine and acetal acetone were studied by Ahmad and coworkers [41]. Synthesis and characterization of Ni(II), Cu(II) and Zn(II) complexes with a tetrade ntate thioiminato Schiff base ligand have been done by Mishra et al. [42].

Syamal and Singh have been studied the complexes of Cu(II), Ni(II), Fe(II), Zn(II), Cd(II) and Zr(IV) with Schiff base derived from salicylaldehyde and 1-amino-2-napthol-4-sulfonic acid [43]. Characterization and antifungal properties of transition metal complexes of Schiff bases derived from 5-
methyl-β-N-(2-amino-phenyl) methylenedithio-O-carbazate and pyridine-2-aldehyde have been reported by Rahman and Ali [44].

Romer and coworkers have studied transition metal complexes of 6-amino 2-thiouracil; crystal structure of bis(6-amino-2-thiouracilato) aquazinc(II) dehydrate [45]. Singh and coworkers have synthesized, characterized and studied fungitoxic nature of Mn(II), Fe(II), Co(II), Ni(II), Cu(II) and Zn(II) complexes of N-phenyl-1,3,4-oxadiazole-2-sulphonamide and 5-phenyl-1,3,4-oxadiazole-2-imino sulphonamide [46]. Antibacterial silver have been studies by Clement and Jarrett [47]. Synthesis, physico-chemical and biological studies on oxovanadium (IV) derivatives of mercaptotriazole have been reported by Yadav et al. [48]. Non-isothermal decomposition and kinetic parameters of Schiff base metal chelates derived from salicylidene-anthranilic acid were studied by Mishra [49]. Alshihri and Ayed isolated and characterized the Cu(II), Zn(II) and Cu(II) complexes with Schiff base derived from salicylidene-2-amino-benzothiazole [50]. Nath and Yadav have studied synthesis, spectral and thermal characterization of Fe(III), Co(II), Ni(II), Cu(II) and Zn(II) complexes involving Schiff bases of 2-aminobenzylalchohol [51]. Islam et al. have studied the transition metal complexes with thiourea derivatives [52]. Syntheses, spectral, thermal, electrical and antimicrobial studies of some complexes derived from 7-(α-phenyl-α-m/p- nitroaniline-methyl)-8-quinoline have been reported by Patel and Patel [53]. Kour and Sangal have studied structural and biological studies of thia Diazole metal complexes [54]. Copper, Cobalt and Zinc(II) complexes with monofunctional Schiff base and monodentate neutral ligands have been reported by Chakrabarty and Patel [55].
CHAPTER-2

Metal complexes of bi-branchial Schiff base macrocycles and their potential application to the modeling of metallobiosites have been studied by Collinson and Fenton [56]. Mishra and Shrivastava have studied the complexes of Co(II), Ni(II) and Cu(II) with 2-furfurylidene-p-nitroaniline and 2-furfurylidene-m-nitroaniline Schiff base [57]. Complexes of Co(II), Ni(II) and Zn(II) with N-aroyl-N-thiobenzohydrazide have been synthesized and characterized by IR, electronic and H-NMR by Prasad et al. [58]. Jackson and coworkers have reported genetic activity profiles of anticancer drugs [59].

Oxovanadium(IV) and dichlorovanadium(IV) complexes of biologically active 4-aminoantipyrine derivatives have been prepared and characterized by Dissouky et al. [60]. Synthesis, characterization and in-vitro antitumor activities of binary and heterobimetallic complexes of VO(IV), Mn(II), Fe(II,III), Co(II,III), Ni(II), Cu(II) and Zn(II) with p-hydroxydithiobenzoate have been reported by Singh and coworkers [61]. Use of vanadium in modern organic synthesis was done by Hirao [62].

Yan and coworkers have reported spectral and characterization study on action mode of some anticancer agents of Schiff base and its metal complexes [63]. Coordination chemistry of bis (ferrocenylcarbaldimine) Schiff bases have been made by Halcrow et al. [64]. Synthesis and spectroscopic studies of Co(II), Ni(II), Cu(II) and Zn(II) complexes of pyridine-2-carboxaldehyde thiobenzoylhydrazone have been done by Singh and Agrawal [65]. A new biomimetic model for the active site of oxovanadium(IV)-Transferrines-[VO\textsuperscript{IV}(tf)] have been studied by Neves et al. [66]. Takeuchi and coworkers have reported selective inhibition of human r-thrombin by cobalt(III) Schiff base complexes [67]. Ji and coworkers have reported synthesis, crystal structure and properties of copper(II)
complexes of Schiff base derivatives containing imidazole and \( \beta \)-alanine groups [68]. Chohan have synthesized and characterized the biologically active transition metal chelates of Ni(II), Cu(II) and Zn(II) with 2-aminothiazole derived Schiff bases [69]. Synthesis, characterization and antimicrobial studies of Ni(II), Co(II), Cu(II), Zn(II) and Cd(II) complexes with 5-isopropylidene-1-methyl-2,4-dithio-biuret hydrochloride have been reported by Naik et al. [70]. Pessoa and coworkers have prepared and characterized some new oxovanadium(IV) Schiff base complexes derived from amino acids and aromatic \( \alpha \)-hydroxy aldehydes [71]. Utility of vanadium compounds as insulin mimics have been proved by Thompson and coworkers [72]. Waters and coworkers have reported Schiff base complexes of copper(II) [73]. Rehder have been reported the coordination chemistry of vanadium as related to its biological functions [74]. Dicopper(I) and disilver(I) complexes of a thiophene-derived Schiff base macrocycle have been studied by Ryan et al. [75]. Synthesis, structural investigation of biologically active complexes of lanthanide with chloromazine have been studied by Keshawan and Radhika [76]. Kriza and Spinu have synthesized Co(II), Ni(II) and Cu(II) complexes of bidentate Schiff bases [77]. Stanica and coworkers have done synthesis and characterization of some new complexes dimer combinations of Co(II) and Cu(II) with benzylidene-2-aminoethylpyridine [78]. Pleniceanu et al. have studied coordination of cobalt(II), nickel(II) and copper(II) with Schiff base derived from 2-thiophencarboxyaldehyde and 2-monopropanolamine [79]. Kojima et al. have synthesized and worked out crystal structure of oxovanadium(IV) complexes with \( N,N' \)-ethylene-bis-(aminoacids) [80]. Veeraraj and other have studied the Cu(II) complexes with 3-cinnamalidene acetylacetone [81]. Choudhary et al.
have studied the complexes of Ni(II), Cu(II), Zn(II) and Hg(II) with salicylaldehyde and 4,4-dimethyl-3-thiosemicarbazide [82]. Synthesis, characterization and biological properties of anions on bivalent transition metal Co(II) and Ni(II) complexes with acylhydrazone - derived ONO donor Schiff bases have been studied by Chohan and coworkers [83]. Crans has studied chemistry and insulin like properties of vanadium(IV) and vanadium(V) compounds [84]. Khare and Mishra have studied the synthesis, thermal, magnetic, ESR and antibacterial studies of Co(II), Ni(II) and Cu(II) complexes with Schiff base derived from furfuraldehyde, ethylmethylketone, salicylaldehyde and 2-amino pyridine [85]. Chen and coworkers have studied kinetics of acid catalysed dissociation of N,N'-dialkyl-1,10–phenanthroline-2,9-dimethanamine copper(II) complexes [86]. Synthesis of new vanadyl complexes of hydroxyazine-type heterocycles and their insulin-mimetic activities have been done by Katoh et al. [87]. Ternary complex formation between VO(IV) picolinic acid or VO(IV)–6-methylpicolinic acid and small blood serum have been studied by Garribba et al. [88]. Symmetric 1,1’-dimethylferrocene-derived amino acids: their synthesis, characterization, ligational and biological properties with Cu(II), Co(II) and Ni(II) ions have been studied by Chouhan [89]. Matias et al. have published oxovanadium(IV) complexes with aromatic aldehydes [90]. New inorganic/organic coordination polymers generated from bidentate schiff-base ligands have been studied by Dong and coworkers [91]. Patsalides and Robards have reported configurational isomerism in oxovanadium(IV) complexes [92]. Synthesis and characterization of Cr(II), Mn(II), Fe(II), Co(II), Ni(II) and Cu(II) complexes of 4-pyridyl thioacetic acid and 2-pyrimidyl thioacetic acid have been studied by Kamruddin and Roy [93]. Chohan and Farooq have studied
synthesis, characterization, ligational and biological properties of some acylhydrazine derived furanyl and thienyl Schiff bases with Co(II), Cu(II), Ni(II) and Zn(II) metal ions [94]. Synthesis, characterization and antibacterial properties of transition metal ion complexes of Schiff bases have been studied by Chohan et al. [95]. Gyuresik and coworkers have reported oxovanadium(IV) complexes of N-D-gluconylamino acids [96]. Synthesis and antibacterial activity of some metal complexes of betalactamic antibiotics have been studied by Anacona [97]. Hiremath and coworkers have studied Co(II), Ni(II), Cu(II), Zn(II) and Cd(II) complexes with 3-acetylamin-2-benzoyl benzofuran [98]. Synthesis and crystal structure of Co(II) complexes containing pyridine-2-selenolato and its oxidation product have been reported by Kita and coworkers [99]. Crans et al. have published effect of vanadium(IV) compounds in the treatment of diabetes (in-vivo and in-vitro studies) with vanadyl sulphate and bis (maltolato) oxovanadium(IV) [100]. Balogh and coworkers have done dendrimer-silver complexes and nanocomposites as antimicrobial agents [101]. Synthesis, characterization and electrochemical studies of mixed ligand copper(II) complexes with tridentate bis(2-ethylbenzimidazolyl) disulphide have been studied by Das and Mathur [102]. Spectroscopic studies of metal complexes with redox-active hydrogenated Schiff bases have been studied by Kasumov [103]. Thompson and Orvig have been reported coordination chemistry of vanadium in metallopharmaceutical candidate compounds [104]. Venkappaya and coworkers have studied spectral properties, thermal profiles, antibacterial, antifungal and antitumor studies of some metal chelates of 5-morpholinomethyl-2-thiouracil [105]. Dominguez-vera and coworkers have published a tris-imidazole-carboxaldehyde Copper(II) complex
with un-usual carbonyl coordination [106]. Vanadium(IV/V) complexes containing [VO]^{2+}, [VO_2]^+ and [VO (O_2)]^{2+} core with ligands derived from 2-acetylpypyridine and 5-benzyl or 5-methyldithiocarbazate have been prepared by Maurya and coworkers [107]. Saydam have synthesized and characterized the new thiazole and its complexes with Co(II), Cu(II) and Ni(II) ions [108]. Synthesis, physico-chemical characterization and antibacterial studies of complexes of Co(II), Ni(II) and Cu(II) with salicylidene-2-aminophenol, furfurylidene-N-phenyl thiourea and salicylidene-N-phenylthiourea have been done by Mishra et al. [109]. Use of vanadium in cancer treatment has been studied by Evangelou [110]. Wagner and coworkers have studied characterization of silver anthranilate, a promising antibacterial agent [111]. A theoretical analysis of [M(tmtaa)] and [M(acacen)] fragments employed in the organometallic chemistry of early transition metals have been studied by Belanzoni et al.[112]. Smith II has been reported paramagnetic spectroscopy of vanadyl complexes and its applications to biological systems [113]. Visnjevac et al. have done synthesis and crystal structures of 7-bromo-1, 3-dihydro-1-methyl-3-methyl-5-(2'-pyridyl)-2H-1,4-benzo-diazepin-2-one and its Cu(II) complexes [114]. Synthesis, crystal structure, stacking effect and antibacterial studies of novel quaternary copper(II) complexes with quinolone have been done by Wang et al. [115]. Alves and coworkers have reported diimine Cu(II), complexes as building blocks for microporous catalytic materials [116]. Synthesis, spectral and magnetic studies of mononuclear and binuclear Mn(II), Co(II), Ni(II) and Cu(II) complexes with semicarbazone ligands derived from sulfonamide have been done by Saleh et al. [117]. Orvig and coworkers have investigated vanadyl maltol complexes [bis (maltolato) oxovanadium(IV) (BMOV)] and its ethyl maltol analogue for
the treatment of diabetes mellitus [118]. Kwiatkowski and coworkers have synthesized and characterized dioxovanadium(V) Schiff base complexes derived from o-hydroxy aldehydes/ketones; these complexes catalyse the oxidation of thioanisole to the corresponding sulfoxides by cumene hydroperoxide [119]. Kojima et al. have reported structures and reactivity (in solid state) of tetradeutate Schiff base oxovanadium(IV) complexes [120]. Ando et al. have published composition and geometry of oxovanadium(IV) and (V) amino ethanol Schiff base complexes [121]. They also studied the stability of their peroxo complexes in solution. Vanadium(IV) complexes with NNS-donor systems have been reported by Koo et al. [122]. Model studies related to vanadium biochemistry have been reported by Baran [123]. Dimeric silver(I) complex: bis(dipropyldithiophosphato), bis(1,10-phenanthroline), disilver(I); Ag$_2$(phen)$_2$[S$_2$p(opr)$_2$]$_2$ have been reported by Jian et al. [124]. Ziegler and coworkers have been reported metalloporphyrin probes for antimalarial drug action [125]. Chemical and biological consideration in the treatment of metal intoxications involving chelating agents have been done by Ole [126]. Roberto et al. have synthesized metal complexes as chemotherapeutic agents against tropical diseases: they also have evaluated trypanosomiasis, malaria and leishmaniasis activity [127]. Mishra and Goutam have synthesized and characterized Co(II), Ni(II) and Cu(II) complexes with Schiff base derived from 4-chlorobenzaldehyde and furfural, which exhibit good antimicrobial activity [128]. Mishra and coworkers have synthesized, characterized and studies molecular simulations as well as phenol binding properties of Cu(II) and Zn(II) Schiff base complexes involving p-phenylenediamine and benzidine [129]. Synthesis, structural properties and catecholase activity of copper(II)
complexes with reduced Schiff base N-(2-hydroxybenzyl)-amino acids have been done by Vittal and coworkers [130]. Metal complexes of 1,10-phenanthroline-5,6-dione altering the susceptibility of the yeast *Candida albicans* to amphotericinb and miconazole, have been reported by Eshwika *et al.* [131]. Shukla and coworkers have done synthesis, structural properties and insulin-enhancing potential of bis(quercetinato)oxovanadium(IV) conjugate [132]. Chandra *et al.* have been reported synthesis, EPR, electronic and magnetic studies on cobalt(ii) complexes of semicarbazone and thiosemicarbazone [133]. Synthesis, structural analysis and reactivity of oxovanadium(IV) Schiff base complexes have been reported by Mishra and Pandey [134]. Synthesis, spectral and thermal investigation of some oxovanadium(IV) complexes of hydrazones and isonicotinic acid hydrazide have been done by Agrawal and coworkers [135]. Synthesis and characterization of new 5-hydroxy salicylidene-p-amino acetophenone oxime and its complexes with Co(II), Ni(II), Cu(II) and Zn(II) have been done by Kaya and Canpolat [136]. Kiss *et al.* have reported oxovanadium(IV) complexes of salicyl-L-aspartic acid and salicylglycyl-L-aspartic acid [137]. New silver(I) complexes of Schiff base with hydrogen-bonding interactions: effects of anions on the framework formations of complexes have been reported by Zhao *et al.* [138]. Olar and coworkers have studied thermal behavior, spectroscopic and biological characterization of Co(II), Zn(II), Pd(II) and Pt(II) complexes with N,N-dimethylbiguanide [139]. Synthesis and characterization of cobalt(II), nickel(II), copper(II), palladium(II) and dioxouranium(VI) complexes of the antipyrine Schiff base of 3-formylsalicylic acid have been studied by Nag and coworkers [140]. New dihydro-bis (salicylidene) 2,2’-aminobenzothiazolyl borate complexes; kinetic and
voltammetric studies of dimethyl tin copper complex with guanine, adenine and calf thymus DNA, have been done by Arjmand et al. [141]. Saydam and Yilmar have done synthesis, characterization and thermal behavior of 4-chloromethyl-2-(2-hydroxybenzilidene-hydrazino) thiazole and its complexes with Cr(II), Co(II), Ni(II) and Cu(II) [142]. Synthesis pathway to carbohydrate-derived salicylidene hydrazides as ligands for oxovanadium complexes have been done by Becher et al. [143]. Taylor and coworkers have studied the effect of donor groups and geometry on the redox potential of copper Schiff base complexes [144]. Synthesis and spectroscopic investigation of binuclear Cu(II), Co(II), Ni(II), Mn(II), Zn(II) and Cd(II) complexes derived from N,N’-Bis (2-carboxyphenyl)-2,6-pyridinedicarboxamide have been done by Gudasi and coworkers [145]. Maurya and Kumar have studied oxovanadium(IV) based coordination polymers and their catalytic potential for the oxidation of styrene, cyclohexene and trans-stilbene [146]. Synthesis, characterization, reactivity and antiamoebic activity of dioxo-and oxovanadium(V) complexes of thiohydrazone ONS donor ligands have been done by Maurya et al. [147]. Zhang et al. have reported synthesis and characterization of metal complexes of Cu(II), Ni(II), Zn(II), Co(II), Mn(II) and Cd(II) with tetradeinate Schiff bases [148]. Synthesis and characterization of some complexes of Schiff base condensation ligands have been done by Farag et al. [149]. Structural, electrochemical and magnetic properties (new end a end single dicyanamide bridged Cu(II), complexes with Schiff base ligands) have been studied by Karmakar and coworkers [150]. Xu et al. a new Co(II) complex with N,O-donor schiff base have been synthesis, structure and characterization [151]. Dinuclear cobalt and manganese squarate complexes with bidentate N-donor ligand:
syntheses, crystal structures, spectroscopic, thermal and voltammetric studies have been done by Ucar [152]. Metalloantimalarialas: synthesis, X-ray crystal structure of potent antimalarial copper(II) complex of arylazo-4-hydroxy-1,2-naphthoquinone have been reported by Gokhale et al. [153]. Tuna and coworkers have studied complexes of Co(II), Ni(II), Cu(II), with 3-hydroxysalicylidene-P-aminoacetophenoneoxime [154]. A DFT investigation on molecular structures of semicarbazone complexes with Co(II), Ni(II) and Zn(II) and reaction energies of their complexation have been studied by Ruangpornvisuti et al. [155]. Synthesis, structures and fluorescence of nickel, zinc and cadmium complexes with the N, N, O-tridentate Schiff base N-2-pyridylmethylidene-2-hydroxy-phenylamine have been done by Majumder et al.[156]. Kianfar and Mohebbi have studied synthesis and electrochemistry of vanadium(IV) Schiff Base complexes [157]. Hosny has studied spectroscopic characterization of some metal complexes derived from 4-acetylpyridine nicotinoylhydrazone [158]. Oliveira and coworkers have done metallation of ligands with biological activity: synthesis and X-ray characterization of the new sulfathiazolato complexes of gold(I) and silver(I): [(sulfathiazolato)AuPPh3] and [Ag(sulfathiazolato)]2 (sulfathazole-N1-2-thiazolyl-sulfanilamide) [159]. Badwaik and Aswar have done synthesis, characterization and biological studies of some Schiff base complexes [160]. DNA cleavage, structural elucidation and antimicrobial studies of three novel mixed ligand Schiff base complexes of copper(III) have been studied by Raman et al. [161]. Iqbal and coworkers have reported synthesis, characterization and biological studies of 2-[phenylmethylamino] benzoic acid and its complexes with Co(II), Ni(II), Cu(II) and Zn(II) [162]. Raman and Joseph have reported synthesis, characterization, DNA binding and cleavage
studies of some novel biosensitive transition metal(II) complexes [163]. The role of sulfur in platinum anticancer chemotherapy has been studied by Wang and Guo [164]. Potentiometric performances of 2-aminothiophenol based dipodal ionophore as a silver sensing material have been reported by Mittal et al. [165]. Synthesis and characterization of a metal complex containing naringin and Cu, and its antioxidant, antimicrobial, anti-inflammatory and tumor cell cytotoxicity have been reported by Pereira et al. [166]. Burguete and coworkers have done synthesis and anti-inflammatory/antioxidant activities of some new ring substituted 3-phenyl-1-(1,4-di-n-oxide quinoxalin-2-yl)-2-propen-1-one derivatives and of their 4,5-dihydro-(1h)-pyrazole analogues [167]. Preparation and characterization of a ligand containing 1,3,4-thiadizole groups have been done by Omar et al. [168]. Kumar and Kumar have studied synthesis and antimicrobial activity of metal complexes from 2-(1’/2’-hydroxynaphthyl) benzoxazoles [169]. Oxovanadium(IV) and copper(II) complexes of 1,2-diaminocyclohexane based ligand encapsulated in zeolite-Y for the catalytic oxidation of styrene, cyclohexene and cyclohexane have been studied by Maurya et al. [170]. Cocco et al. have done synthesis, characterisation and insulin-mimetic activity of oxovanadium(IV) complexes with amidrazone derivatives [171]. Maurya and Sikarwar have studied oxidation of phenol and hydroquinone catalysed by copper(II) and oxovanadium(IV) complexes of N,N-bis(salicyledene) diethylenetriamine (H2saldien)covalently bonded to chloromethylated polystyrene [172]. A new di-l-oxo bis[oxovanadium(V)] complex containing Schiff base ligand derived from 1,2-diaminopropane and 2’-hydroxy-4’-methoxyacetophenone: Synthesis, structure and catalytic properties have been studied by Rayati and coworkers [173]. Suresh et al. have studied asymmetric sulfoxidation of
prochiral sulfides using aminoalcohol derived chiral C3-symmetric trinuclear vanadium Schiff base complexes [174]. Role of endogenous androgen against insulin resistance and atherosclerosis in men with type-2 diabetes have been reported by Fukui et al. [175]. Singh and coworkers have been done synthesis and characterization of cobalt(ii), nickel(ii), copper(ii) and zinc(ii) complexes with schiff base derived from 4-amino-3-mercapto-6-methyl-5-oxo-1,2,4-triazine [176]. Characterization of the reaction products derived from alanine and 2-acetylpyridine with Cu(II) and Cd(II) have been studied by Hosny [177]. Spinu and coworkers have reported biologically active new Fe(II), Co(II), Ni(II), Cu(II), Zn(II) and Cd(II) complexes of N-(2-thienylmethylene) methanamine [178]. Mishra and coworkers have done synthesis, structural and biological studies of some Schiff bases and their metal complexes [179]. Zhizhin and coworkers have been done an imido-transfer reaction of aldehydes with N-sulfinylamines using vanadium and molybdenum oxochlorides as catalysts [180]. Synthesis, spectroscopic and anticancerous properties of mixed ligand palladium(II) and silver(I) complexes with 4,6-diamino-5-hydroxy-2-mercaptopyrimidine and 2,2’-bipyridyl have been reported by Mostafa et al. [181]. Medvetz and coworkers have done anticancer activity of Ag(I) N-heterocyclic carbene complexes derived from 4,5-dichloro-1h-imidazole [182]. Kiss and coworker have done biospeciation of antidiabetic VO(IV) complexes [183]. Singh and coworker have done anti-inflammatory activity of hydroxytriazenes and their vanadium complexes [184]. Tiwari et al. have done time and dose-dependent antimicrobial potential of Ag nanoparticles synthesized by top-down approach [185]. Synthesis, characterization and biological activity of some transition metal complexes with Schiff bases derived from 2-formylindole, salicyldehyde, and n-
amino rhodanine have been reported by Elzahany et al. [186]. Ajibade and Kolawoloe have been reported Synthesis, characterization and antiprotozoal studies of some metal complexes of antimalarial drugs [187]. Basak et al. have studied square planar complexes of Cu(II) and Ni(II) with N₂O donor set of two Schiff base ligands: synthesis and structural aspects [188]. Ebrahimi-Kahrizsang and Abbasi have been studied evaluation of reliability of Coats-Redfern method for kinetic analysis of non-isothermal TGA [189]. Synthesis, characterization and crystal structure of new silver(I) and palladium(II) complexes containing 1,2,4-triazole moieties have been done by Ghassemzadeh et al.[190].

Synthesis, spectral and antimicrobial behavior of first row transition metal complexes derived from Lansoprazole drug have been reported by Revanasidda et al. [191]. Karki and coworkers have done synthesis, anticancer and cytostatic activity of some 6h-indolo [2,3-b]quinoxalines [192]. Kalia and coworkers have reported antimicrobial and toxicological studies of some metal complexes of 4- methylpiperazine-1-carboxthioate and phenanthroline mixed ligands [193]. Synthesis, characterization and antimicrobial activity of cobalt metal complex against multi drug resistant bacterial and fungal pathogens have been reported by Saha et al. [194]. Synthesis, characterization, biological and thermal studies of Cu(II) complexes of salen and tetrahydrosalen ligands have been reported by Khanmohammadi et al. [195]. Physicochemical characterization, thermal, and electrical conductivity studies of some transition metal complexes of bis-chelating Schiff base have been reported by Makode et al. [196]. Biological activity studies of metal complexes of novel tridentate Schiff base ligand. Spectroscopic and thermal characterizations have been studied by Mohamed et al. [197]. Arayne and coworkers have been reported synthesis, characterization,
antibacterial and anti-inflammatory activities of enoxacinmetal complexes [198]. Yu et al. have done synthesis, characterization, crystal structure and antibacterial activities of transition metal(II) complexes of the schiff base 2-[(4-methylphenylimino)methyl]-6-methoxyphenol [199]. Antimalarial mixed ligand metal complexes have been reported by Adedij [200]. Synthesis and antibacterial activity of M(II) Schiff base complex have been reported by Johari et al. [201]. Nejati and coworkers have been done the synthesis, characterization, thermal and optical properties of copper, nickel, and vanadyl complexes derived from azo dyes [202]. Synthesis, characterization and preliminary insulin-enhancing studies of symmetrical tetradentate Schiff base complexes of oxovanadium(IV) have been reported by Nejo et al.[203]. Hypoglycemic activity of Grifola frondosa rich in vanadium have been studied by Lv et al. [204]. Rafique and coworker have done transition metal complexes as potential therapeutic agents [205]. Silver–palladium cathode selective one-electron scission of alkyl halides have been reported by Poizot and Simonet [206]. Role of oxidative stress in the antitumoral action of a new vanadyl(IV) complex with the flavonoid chrys in two osteoblast cell lines & their radical scavenger activity have been reported by Naso et al. [207]. Metallo–allixinate complexes with anti-diabetic and anti-metabolic syndrome activities have been reported by Sakurai et al. [208]. Sakurai has studied overview and frontier for the development of metallopharmaceuticals [209]. Rosu et al. have been done synthesis, characterization and antibacterial activity of some new complexes of Cu(II), Ni(II), VO(II), Mn(II) with Schiff base derived from 4-amino-2,3-dimethyl-1-phenyl-3-pyrazolin-5-one [210]. Ming and coworkers have studied anti-diabetic effects of vanadium(III, IV, V)–chlorodipicolinate complexes in streptozotocin-induced diabetic rats [211].
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Structural properties, cytotoxicity, and anti-inflammatory activity of silver(I) complexes with tris(p-tolyl)phosphine and 5-chloro-2-mercaptobenzothiazole have been reported by Kyros et al. [212]. Kumar and coworkers have done synthesis of oxygen bridged complexes of Cu(II) and Ni(II)-salicylaldoxime with alkali metal salts of some organic acids and studied their antimicrobial activities [213]. Anti-inflammatory and antimicrobial studies of biosensitive knoevenagel condensate β-ketoanilide schiff base and its Co(II), Ni(II), Cu(II) and Zn(II) complexes have been reported by Raman et al. [214]. A study of anti-inflammatory and analgesic activity of new 2,3-disubstituted 1,2-dihydroquinazolin-4(3h)-one derivative and its transition metal complexes have been reported by Hunoor et al. [215]. Synthesis, crystal structure, spectral and magnetic studies and catecholase activity of copper(II) complexes with di- and tri-podal ligands have been reported by Bhardwaj [216]. El-kosasy et al. have done determination of dl-methionine in soyabean natural extract and pharmaceutical preparation by new HPLC method and detection of its antioxidant activity [217]. Thermal behaviour of malonic acid, sodium malonate and its compounds with some bivalent transition metal ions have been reported by Caires et al. [218]. Mechanisms of antibacterial activity of silver and praseodymium-loaded white carbon black have been reported by Bin et al. [219]. Sadeghi and coworkers have done synthesis and characterization of silver nanoparticles for antibacterial activity [220]. Preparation and antibacterial activity of silver nanoparticles impregnated in bacterial cellulose have been reported by Maria et al. [221]. Synthesis, characterization and antibacterial activity of some 3d metal complexes of sulphadimidine as antibacterial agents have studied by Tella and Obaleye [222]. Sharma and coworkers have studied transition metal complexes and their
antibacterial activities [223]. Kosman has studied multicopper oxidases: a workshop on copper coordination chemistry, electron transfer, and metallophysiology [224]. Synthesis and antitumor screening of new 1,7-diphenyl-3-(1,3-disubstituted-1h-pyrazole-4-carbonyl)-[1,2,4]triazolo[4,3-a]pyrimidin-5(1h)-ones have been done by Shawali et al. [225]. Kim and coworkers have studied synthesis and microbiological evaluation of honokiol derivatives as new antimicrobial agents [226]. Synthesis and antimicrobial screening of the metal complexes with Cyanex-302 have been reported by Pal and Alam [227]. Asadi and coworkers have been done thermodynamics of cobalt(III) Schiff base complexes in various solvents [228]. Prashanthi and Raj have been done Synthesis and Characterization of Transition Metal Complexes with N,O; N,N and S,N-donor Schiff Base Ligands [229]. Oxovanadium(IV) complexes with cephradine: synthesis, semi-empirical study, spectroscopy, potentiometric study and antimicrobial activity have been done by Shahzadi et al. [230]. Emara has studied Structural, spectral and biological studies of binuclear tetradentate metal complexes of N\textsubscript{3}O Schiff base ligand synthesized from 4,6-diacetylresorcinol and diethylenetriamine [231]. Idemudia and Ajibade have been done antibacterial activity of metal complexes of antifolate drug pyrimethamine [232]. Structurally diverse metal coordination compounds, bearing imidodiphosphinate and diphosphinoamine ligands, as potential inhibitors of the platelet activating factor have been done by Tsoupras and coworkers [233]. Srivastava et al. Synthesis of oxygen bridged complexes of Cu(II) or Ni(II)-salicylaldoxime with alkali metal salts of some organic acids and studies on their antimicrobial activities [234]. Bruijnincx and Sadler have been studied new trends for metal complexes with anticancer activity [235]. Elsayed and coworkers have been reported
antineoplastic activity of new transitionmetal complexes of 6-methylpyridine-2-carbaldehyde-n(4)-ethylthiosemicarbazone : X-ray crystal structures of [VO$_2$(mpetsc)] and [Pt(mpetsc)Cl] [236]. Tumor cellular proteasome inhibition and growth suppression by 8-hydroxyquinoline and clioquinol requires their capabilities to bind copper and transport copper into cells have been studied by Yan et al. [237]. Chang and coworkers have been reported cobalt complexes as antiviral and antibacterial agents [238]. Synthesis, crystal structures, and biological activities of silver(I) and cobalt(II) complexes with an azole derivative ligand have been reported by An et al. [239]. Synthesis, characterization and antimicrobial activity of some nitrilotriacetic acid−V(III), −Sn(II), −Sm(II) and −Sm(III) complexes have been reported by Gaballa and coworkers [240]. Marinescu and coworkers have reported new d10 heterometallic coordination polymers based on compartmental Schiff-base ligands: Synthesis, structure and luminescence [241]. Bernhardt et al. have been done cobalt hexaamine mediated electrocatalytic voltammetry of dimethyl sulfoxide reductase: driving force effects on catalysis [242]. Molecular and statistical modeling of reduction peak potential and lipophilicity of platinum(IV) complexes have been studied by Platts and coworkers [243]. Via and coworkers have been reported platinum(II) chloride indenyl complexes: electrochemical and biological evaluation [244]. Gao et al. have been done vanadyl bisacetylacetonate protects b cells from palmitate-induced cell death through the unfolded protein response pathway [245]. Chei et al. have been studied new chelating ligands for Co(III)-based peptide-cleaving catalysts selective for pathogenic proteins of amyloidoses [246]. Schulz have been done synthesis and characterization of a N-salicylaldimine ligand and its vanadium(V) complex [247]. Maurya et al. have been done oxovanadium(IV)
complexes of medicinal relevance: synthesis, characterization, and 3D-molecular modeling and analysis of some oxovanadium(IV) complexes in O,N-donor coordination matrix of sulfa drug Schiff bases derived from a 2-pyrazolin-5-one derivative [248]. Synthesis, spectroscopy, electrochemistry and thermal study of vanadyl unsymmetrical Schiff base complexes have been done by Kianfar et al. [249]. Synthesis and thermal studies of bisphenol-a based bismaleimide have been reported by Vijayakumar and coworkers [250].

2.3 WORK DESCRIBED IN THESIS:

Present studies are focused on synthesis, structure and bio-medicinal investigation of some ligands (Schiff bases and bioactive ligands) and their metal complexes with some biologically important transition metals viz; Oxovanadium(II), Cobalt(II) and Copper(II). Considering the relevance and significance of the work, author has synthesized and characterized twenty complexes of Oxovanadium(II), Cobalt(II) and Copper(II) with ligands.

Among the various nitrogen, sulphur and oxygen donor atoms, the following five Schiff bases have been synthesized viz. N-(4-acetyl phenyl)-3-acetimidene pyridine (AAP), 1-acetonapthelidene-4-amino acetophenone (NPE), 1-(4-amino phenyl) ethanaledine-4-thiobiuret (AET), 1-(nephthyl) ethanaledine-4-thiobiuret (NET) and 4-chlorosalicylidine aniline (CMP). All the Schiff bases have been characterized by elemental analysis and FT-IR. These Schiff bases were reacted with metal salts to get Schiff base metal complexes.

The synthesized complexes have been analyzed and characterized on the basis of elemental analysis, magnetic measurements, molar conductance, infra-red, electronic absorption, FAB-mass, Thermal, ESR and XRD. These metal
chelates have been tested for their reactivity and substitution behavior against aquo, amine, chloro, hydroxo, thiocyanato, oxalato and DMG ligands.

Seven complexes have been studied by thermal analysis including TG, DTA, DSC and DTG. Non-isothermal solid state degradation based kinetic parameters ($E^*$, $Z$, $\Delta S^*$, $\Delta H^*$ and $\Delta G^*$) of the relevant complexes have also been calculated by Coats-Redfern (C-R). Two complexes have been studied by ESR and four complexes have been studied by XRD. Three Co(II) metal complexes have been studied by molecular modeling. Some ligands and their Co(II) and Cu(II) metal complexes have been screened for their possible antimicrobial (bacterial and fungal) and VO(II) complexes have been tested for anti-diabetic activity; all VO(II) complexes selected for anti-inflammatory activity. The results of the above investigation have been presented in the thesis entitled "SYNTHESIS, STRUCTURE AND BIOMEDICINAL INVESTIGATIONS ON SOME METAL-CHELATES".
REFERENCES:


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