CHAPTER-I

Introduction

Literature Survey

Aim and Significance of the Present study
"THE EVER INCREASING APPLICATIONS OF METAL COMPLEXES IN VARIOUS FIELDS OF SCIENCE IS THE DRIVING FORCE FOR THE RESEARCH AND DEVELOPMENT IN COORDINATION CHEMISTRY"

Coordination chemistry was founded by Swiss scientist A. Werner (1866-1919), who won the Nobel Prize in 1913. Great contribution was further made by Russian chemist L.A. Chugaev (1873-1922). Coordination (complex) entities consist of a cationic, anionic or neutral complex. Those substances, whose molecules contain a central atom (cations), coordinated with ligands (anions, neutral molecules or radicals) can be considered as coordination or complex entities [1] and the area of inorganic chemistry, studying joint behavior of cations and their ligands was termed as coordination chemistry [2].

The main direction of metal-complex chemistry in 21st century is emphasized as "From Biology to Nanotechnology" [3]. β-Diketones and their analogues, diketonate complexes [4], azomethinic and heterocyclic ligands remain "eternal". Creation of new hard-soft ligand systems is attractive [5-8]. Creation of hybrid biologically perspective ligating systems is also interesting [9-13]. The principal goal is to work not only for theoretical, but also for practically useful coordination chemistry (competitive coordination), taking into account an operated creation of polyfunctional materials (for instance, selective electrodes). Modern achievements in coordination chemistry are detailed [14]. The list of noble prizes on Coordination chemistry is significant and shows the manifestation of Coordination chemistry into various fields of science.
Nobel Prizes on Coordination Chemistry.

<table>
<thead>
<tr>
<th>Year</th>
<th>Name</th>
<th>Worked on</th>
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<tbody>
<tr>
<td>1912</td>
<td>Victor Grignard</td>
<td>Grignard's reagents.</td>
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<tr>
<td>1913</td>
<td>Alfred Werner</td>
<td>The area on the nature of bonds of atoms in molecules in inorganic chemistry.</td>
</tr>
<tr>
<td>1915</td>
<td>Rihard Vilshtetter</td>
<td>The area of pigments in plant world especially chlorophyll.</td>
</tr>
<tr>
<td>1963</td>
<td>Karl Ziegler Giulio Natta</td>
<td>Discovery of isotactic polypropylene.</td>
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<tr>
<td>1964</td>
<td>Doroti Meri Kroufut Hodzkin</td>
<td>Determination of structures of biologically active substances by X-Rays.</td>
</tr>
<tr>
<td>1987</td>
<td>Donald James Cram, Jean-Marie Lehn and Charles J. Pedersen</td>
<td>Elaboration and applications of molecules having structurally-specified interactions of high selectivity.</td>
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</table>

Coordination chemistry is dominated by the utilization of Schiff bases as ligands [15] due to its chelating ability and complexing ability towards transition metal ions. Schiff base compounds containing imine group (-RC= N-) are usually formed by the condensation of a primary amine/diamine with an
active carbonyl compound. The Schiff base ligands and their complexes have significant importance in chemistry, and every year a number of reports are published on the preparation of these compounds and their application in chemical reactions [16]. The Schiff base compounds and their complexes are widely applied in enantioselective cyclopropanation of styrenes [17], asymmetric addition of cyanide to aldehydes [18], asymmetric aziridination of olefins [19], enantioselective epoxidation [19, 20], regio-selective ring opening of epoxides [21] and as a membrane in ion selective electrode [22–26]. The metal complexes of Schiff bases also finds applications in versatile catalytic reactions for organic synthesis [27-30], degradation of organic substances [31], in radiopharmaceuticals [32], their ability to reversibly bind oxygen [33] and photochromic properties [34]. Schiff base metal complexes have also found greater applications in biological field. Schiff bases have been reported to exhibit a variety of biological actions by virtue of the azomethine linkage, which is responsible for various antibacterial, antifungal, herbicidal, clinical and analytical activities [35–38]. Recently, there has been tremendous interest in studies related to the interaction of transition metal ions with nucleic acid because of their relevance in the development of new reagents for biotechnology and medicine [39]. There has also been substantial interest in the rational design of novel transition metal complexes, which bind and cleave duplex DNA with high sequence and structure selectivity [40–42].

**Coumarin**

Coumarin (2H-chromen-2-one, 2H-1-benzopyran-2-one) is structurally the least complex member of a large class of compounds known as benzopyrones and also coumarins are among the best known oxygen heterocyclics with a δ-lactone ring which comprise a very large class of compounds found throughout the plant kingdom [43-45].

The biological activities of coumarin derivatives are multiple and include antithrombotic [46], antimicrobial [47], antiallergic [48], anti-inflammatory [49], antitumor [50] and anticoagulants [51]. Derivatives of
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coumarin are known to possess significant antifungal as well as antibacterial properties. Many of the coumarins present in plants, and also their synthetic analogues, have been reported to be good antifungal and antibacterial agents [52-59]. Preliminary structure–activity relationship studies have showed that, the presence of hydroxyl or carboxylic groups on the coumarin nucleus is necessary for antimicrobial activities [60]. The presence of coumarin nucleus in the antibiotics, such as novobiocin, clorobiocin and coumermycin A₁ were identified over forty years ago. But, the use of these antibiotics has been limited due to their poor water solubility, low activity against Gram-negative bacteria and the rapid emergence of resistance [61, 47]. However, renewed interest in these antibiotics has arisen following the discovery that they are potent catalytic inhibitors of DNA gyrase. Additionally, these antibiotics have been shown to be active against Gram-positive bacteria, especially against methicillin-resistant Staphylococcus aureus (MRSA) [47]. Further derivatisation of novobiocin, clorobiocin, and coumermycin A₁ has allowed for the production of novel coumarin antibiotics displaying excellent inhibition of DNA supercoiling by DNA gyrase B and good antibacterial activity against vancomycin, teicoplanin and novobiocin resistant Enterococci species [47]. In view of such a fascinating structural and biological features of coumarins, in the present study hydroxy substituted formyl coumarins have been utilized for the synthesis of various Schiff bases.

Isatin

Isatin (1H-indole-2,3-dione) was first discovered in 1842 as a product from the oxidation of indigo [62]. The synthetic versatility of isatin has led to the extensive use of this compound in organic synthesis. Various reviews have been published time to time regarding the chemistry of this compound and on the utility of isatin as a precursor for the synthesis of other heterocyclic compounds [63-65]. Oxindoles usually have a broad range of pharmacological actions such as anxiogenic and sedative agents [66, 67], as antagonists of guanylate cyclase-coupled atrial natriuretic peptide receptor [68, 69] and as
potent inhibitors of monoamine oxidase B [70-72]. Schiff bases derived from \textit{N}-methyl/\textit{N}-acetyl isatin derivatives and aryl amines were prepared and screened for anticonvulsant activity. The compounds with bromo substituent in the isatin ring and chloro substituent in the phenyl ring exhibited a broad-spectrum activity and seem to be good prototypes for the development of new drugs against epilepsy [73]. Some hydrazones, Schiff and Mannich bases of isatin have also exhibited significant anticonvulsant activity, and based on these results some structural features responsible for interaction with the receptor site were established within a suggested pharmacophore [74]. As pharmacological activities started to be demonstrated for isatin and its derivatives, their metal complexes also gained biological relevance and their antibacterial, antiproliferative or mutagenic properties were also investigated. The Cu(II), Co(II), Ni(II) and Zn(II) complexes of isatin-derivatives incorporating thiazole, thiadiazole, benzothiazole and \textit{p}-toluene sulfonylhydrazide moieties were prepared [75]. These compounds showed good results as antibacterial and antifungal agents against different strains and most of them had their activity enhanced on complexation. 1-methylisatin-3-thiosemicarbazone copper(II), cobalt(II) and nickel(II) complexes were isolated and structures were determined by X-ray crystallography and also studied for their biological activities [76].

**Triazole**

Substituted-1,2,4-triazoles are among the large number of heterocyclic compounds that have received the most attention during the last two decades as potential antimicrobial agents. They are associated with diverse biological activities such as fungicidal, antimicrobial, antiviral activities etc. [77-81]. The 1,2,4-triazole nucleus has been incorporated into a wide variety of therapeutically interesting drugs, including \textit{H}_1/\textit{H}_2 histamine receptor blockers, cholinesterase-active agents, CNS stimulants, antianxiety agents and sedatives [82]. Mercapto derivatives of substituted 4-amino-1,2,4-triazoles are particularly interesting as complexing agents due to the presence of four
potential donor atoms (three nitrogen and one sulphur), consequently many metal derivatives of ligands of this type have been prepared [83-87].

Schiff bases of o-phenylenediamine and its complexes have a variety of applications including biological [88], clinical [89] and analytical [90]. Earlier work has showed that, some drugs exhibited increased activity when administered as metal chelates rather than as organic compounds [88, 89] and that the coordinating possibility of o-phenylenediamine has been improved by condensing with a variety of carbonyl compounds. Also the primary amines are known as better condensing agents.

Survey of the Previous Work

Recently Emara and Adly have reported the synthesis of new series of copper(II), nickel(II), cobalt(II), zinc(II), iron(III), chromium(III), vanadyl(IV) and uranyl(VI) complexes with two bifunctional tridentate Schiff bases derived from 4,6-diacylresorcinol and o-aminophenol/o-phenylenediamine [91]. The ligands contain two symmetrical sets of either OON or NNO tridentate chelating sites. The ligands and their metal complexes have been characterized by elemental analysis, $^1$H-NMR, FT-IR, mass, electronic, ESR spectra, thermal gravimetric analysis and magnetic susceptibility. The metal complexes exhibit different geometrical arrangements such as square planar, tetrahedral, square pyramid and octahedral arrangement.

Raman et al., have reported the synthesis of neutral tetradentate $N_2O_2$ Schiff base formed by the condensation of o-phenylenediamine with acetoacetanilide in alcoholic medium [92]. The Schiff base has been checked for its complexation ability towards Cu(II), Ni(II), Mn(II), Zn(II) and VO(II) metal ions. All the synthesized metal complexes were characterized on the basis of their microanalytical data, molar conductance, magnetic susceptibility, IR, UV–Vis $^1$H NMR and ESR spectra and the data suggested that, all the complexes were square-planar except the Mn(II) and VO(II) chelates, which are of octahedral and square pyramidal geometry respectively.
Trendafilova et al., have studied the coordination ability of 3,3'-benzylidenedi-4-hydroxycoumarin with lanthanum(III) ion [93]. The La(III) complex was characterized by elemental analyses, mass spectra, $^1$H, $^{13}$C NMR, and IR spectroscopy.

The anti-fungal activity and mode of action of a range of silver(I)-coumarin complexes was studied by B. Thati et al [94]. Amongst all the silver(I)-coumarin complexes, some of the complexes viz. 7-hydroxy coumarin-3-carboxylatosilver(I), 6-hydroxycoumarin-3-carboxylatosilver(I) and 4-oxy-3-nitrocoumarinbis(1,10-phenanthroline)silver(I) exhibited MIC$_{80}$ values between 69.1 and 4.6 μM against the pathogenic yeast *Candida albicans*. Further, Thati et al., have reported that, a number of metal complexes disrupted cytochrome synthesis in the cell and induced the appearance of morphological features consistent with cell death by apoptosis. Silver(I)-coumarin complexes demonstrated good anti-fungal activity and manifest a mode of action distinct to that of the conventional azole and polyene drugs thus raising the possibility of their use when resistance to conventional drug has emerged or in combination with such drugs.

Bagihalli et al., have reported the synthesis and characterization of Co(II), Ni(II) and Cu(II) complexes of Schiff bases derived from 3-substituted-4-amino-5-mercapto-1,2,4-triazole and 8-formyl-7-hydroxy-4-methylcoumarin [95]. The elemental analyses, spectroscopic (IR, UV-vis., Fluorescence, ESR) studies, magnetic measurements and thermal studies suggested that, all the metal complexes were polymeric in nature. The Schiff bases and their metal complexes were found to possess high antimicrobial activities.

S. U. Rehman et al., have synthesized the Schiff bases derived from 3-formyl-4-chlorocoumarin and heteroaromatic amines/hydradizes [96]. The Co(II), Ni(II), Cu(II) and Zn(II) complexes of these Schiff bases have been synthesized, spectroscopically characterized and screened for their *in-vitro* antibacterial activity against *E. coli, K. pneumoniae, P. mirabilis, P. aeruginosa, S. typhi, S. dysenteriae, B. cereus, C. diphtheriae, S. aureus* and *S.
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B. S. Creaven et al., have reported the Cu(II) complexes of bidentate coumarin Schiff bases [97]. The Schiff bases have been synthesized via condensation of 7-amino-4-methylcoumarin with substituted salicylaldehydes and are characterized by IR, $^1$H & $^{13}$C NMR, UV-vis., and elemental analyses. Subsequently, these ligands were reacted with copper(II) acetate to form Cu(II) complexes. These Cu(II) complexes were characterized by IR, UV-vis., molar conductance, magnetic properties and crystal analysis data. The Schiff bases and their Cu(II) complexes were studied for their anti-candida activities.

Literature also records the synthesis of metal complexes with coumarin derivatives. B.S. Creaven et al., have reported the synthesis, characterization and antimicrobial activity studies of Cu(II) and Mn(II) complexes with coumarin-6,7-dioxyacetic acid and 4-methycoumarin-6,7-dioxyacetic acid [98]. Metal complexes have been characterized by X-ray crystal structures along with other spectroscopic techniques. The complexes were screened for their antimicrobial activity against a number of microbial species, including methicillin-resistant Staphylococcus aureus, Escherichia coli and Candida albicans. I. Kostova et. al., have studied the lanthanide complexes of 4-methyl-7-hydroxycoumarin and their pharmacological activity [99]. Complexes of cerium(III), lanthanum(III) and neodymium(III) with 4-methyl-7-hydroxycoumarin were synthesized by the mixing of equimolar amounts of the respective metal nitrates and 4-methyl-7-hydroxy coumarin sodium salt in water. The complexes were characterized and identified by elemental analyses, conductivities, IR, $^1$H and $^{13}$C NMR spectroscopies and mass spectral data. The newly synthesized compounds were assayed for acute intraperitoneal and per oral toxicity, influence on blood clotting time and for spasmolytic activity.

B. Murukan et al., have conducted a study on synthesis, spectral, electrochemical and antibacterial activities of Cu(II) complexes with isatin derived bishydrazone and different co-ligands [100]. The bishydrazones were
prepared via condensation of isatin monohydrazone and salicylaldehyde. The authors have characterized the ligand and their metal complexes on the basis of elemental analyses, molar conductance, magnetic susceptibility data, NMR, UV-visible, IR and EPR spectral studies wherever possible and applicable. The spectral studies revealed that, the bishydrazone is monobasic tridentate; coordinating through the deprotonated phenolate oxygen, azomethine nitrogen and carbonyl group of the isatin moiety respectively.

G. Cerchiaro and A.M. da C. Ferreira have reported a review article on the oxindoles and copper complexes with oxindole-derivatives as potential pharmacological agents [101]. The review article illustrates the structural and biological importance of isatin. Various Schiff bases of isatin and their metal complexes have been reported in the article. The importance of Cu(II) complexes alongwith other transition metal complexes of versatile isatin Schiff bases have been demonstrated. The review records the potential antitumoral activity studies of Cu(II) complexes in comparison to other complexes, based on the proposal of a synergistic effect on adding the metal coordinating and redox properties.

An interesting isatin-Schiff base copper(II) complex was prepared and characterized by different techniques, both in the solid state and in solution, and its reactivity toward carbohydrate oxidation was verified [102]. The Schiff base has been derived from 1,3-diaminopropane and isatin. In aqueous solution, this complex undergoes a peculiar keto-enolic equilibrium. This Cu(II) complex was shown to catalyze the oxidation of hexoses (glucose, fructose and galactose) in alkaline medium.

G.A. Bain et al., have reported the coordination behaviour of Cu(II) complexes of N(4)-substituted thiosemicarbazones of isatin [103]. The Schiff bases have been characterized by crystal studies. The Cu(II) complexes have been characterized by IR, solid state UV-vis., solid state EPR studies.

Some Schiff bases derived from isatin were prepared by reaction with amino acids or substituted hydrazines and were subsequently metallated with
nickel(II), iron(III) or cobalt(II) ions to form respective metal complexes [104]. Zinc(II) and mercury(II) complexes of isatin-3-thiosemicarbazone were isolated and spectroscopically characterized [105]. Copper(II), chromium(III), manganese(II), cobalt(II), nickel(II), zinc(II), cadmium(II) and lead(II) chelates with tetradeutate Schiff base in the enolic form derived from isatin and \( o \)-phenylenediamine were reported. In this case, the complexes were obtained as neutral species with divalent ions [106]. Copper(II), nickel(II) and cobalt(II) complexes with pyridyl- and quinolylhydrazones of isatin and \( N \)-methylisatin have also been prepared. In case of the copper complex, spectroscopic results suggested a planar geometry [107, 108].

J.G. Hasnoot et al., have reported Cu, Ni, Co and Fe metal complexes with 3,5-bis(pyridin-2-yl)-4-amino-1,2,4-triazole ligand system [109]. The complexes exhibit very similar spectroscopical and electrical properties. The four compounds appear to be isostructural according to their IR spectra and X-ray powder diffraction data. And the crystal structure of Cu complex has been solved.

N.K. Singh et al., have reported the 3d metal complexes with sulfur donor ligands [110]. The metal complexes were characterized by spectroscopic and analytical methods. The ligand and its metal complexes were studied for their \textit{in-vitro} and \textit{in-vivo} antitumour studies.

M.H.S.A. Hamid et al., have reported the Cu(II) complexes with tridentate ligand system of NNS donor sequence [111]. The Schiff base is coordinated to the copper(II) ion in its iminotiolate form via the thiolate sulfur atom, the azomethine nitrogen atom and one of the pyrazine nitrogen atoms. The ligand and Cu(II) complexes have been solved by X-ray crystal structure alongwith spectroscopic studies.

Very recently G.B. Bagihalli et al., have studied the synthesis and biological importance of Co(II), Ni(II) and Cu(II) metal complexes of triazole Schiff bases [112]. The Schiff bases have been derived from 3-substituted-4-amino-5-hydrazino-1,2,4-triazole and 8-formyl-7-hydroxy-4-methylcoumarin.
The metal complexes were characterized by elemental analyses, spectral (IR, Uv-vis., ESR, FAB-Mass and CV), magnetic and thermal data. The authors have studied all the ligands and their Co(II), Ni(II) and Cu(II) complexes for their antibacterial (E. coli, S. aureus, S. pyogenes and P. aeruginosa) and antifungal (A. niger, A. flavus and cladosporium) activities by MIC method and also the brine shrimp bioassay was carried out to investigate their in-vitro cytotoxic properties.

P.G. Avaji and S.A. Patil have reported the Co(II), Ni(II) and Cu(II) metal complexes with hydrazino-1,2,4-triazole Schiff bases [113]. The complexes have been synthesized by template condensation of 2,6-diformyl-4-methylphenol and 3-substituted-4-amino-5-hydrazino-1,2,4-triazole with CoCl$_2$$\cdot$6H$_2$O, NiCl$_2$$\cdot$6H$_2$O and CuCl$_2$$\cdot$2H$_2$O in ethanol. These metal complexes were characterized by elemental analyses, magnetic susceptibility, molar conductance, spectral (IR, Uv-vis., ESR, $^1$H NMR and FAB-Mass), thermal, fluorescence and solid-state DC electrical conductivity studies. The solid state DC electrical conductivity showed that the complexes were semiconducting. All the Schiff bases and their Co(II), Ni(II) and Cu(II) complexes were evaluated for their antimicrobial properties.

P.G. Avaji have reported the synthesis, spectroscopic and thermal characterization of Co(II), Ni(II) and Cu(II) complexes of triazole Schiff bases [114]. The Schiff bases have been derived from 3-substituted-4-amino-5-mercapto-1,2,4-triazole and indole-3-aldehyde in ethanol which acts as bidentate ligands. The authors have proposed octahedral geometry for Co(II) and Ni(II) complexes and square-planar geometry for Cu(II) complexes in the light of elemental analyses, magnetic, spectroscopic (IR, UV-vis., NMR, ESR, FAB-Mass) and thermal studies. Further, authors have studied electrochemical (CV), solid state d.c. electrical conductivities and biological applications of these metal complexes.
Aim and Significance of the Present Research Work

Reactivity of metal complexes is an important area of coordination chemistry [115-118], including reactions on coordinatively-unsaturated donor centers [119-122] or metal complex-formers [119, 123, 124] as well as reactions of self-assembling leading to various supramolecular structures [125-127]. Reactions of coordinated inorganic and organic ligands are of the high interest.

The rational design of coordination architectures based on multitopic organic ligands and metal centres represents one of the most rapidly developing fields in current coordination chemistry owing to their potential as functional materials [128-130]. It is well known from the literature that, much work has been done on the synthesis, characterization and electrochemical studies of first row transition metal complexes of Schiff bases. Metal complexes with Schiff base ligands have played an important role since the early days of Coordination Chemistry. Indeed, a great deal of work has been carried out on the synthesis and characterization of transition metal compounds with Schiff bases as ligands, mainly due to their applications in the field of organic chemistry and in catalytic processes. Also, the past decade has seen an upsurge of interest in metal ion therapeutics for both diagnosis and treatment of diseases.

It is in this context that, the author undertook a comprehensive research work on the synthesis of some transition and inner transition metal complexes of various bidentate, tridentate and tetradaentate Schiff bases. Thus the aim of present research work is to synthesize some Schiff bases derived from coumarin, triazole, isatin etc. and to stitch these Schiff bases with various transition and inner transition metal ions to form metal complexes.

The literature records the utilization of various substituted coumarins as ligands for the synthesis of metal complexes [93, 94, 99, 131, 132] and fewer attempts have been made to synthesize metal complexes of Schiff bases derived from coumarins. Hence, in the present study various new Schiff bases derived from coumarins have been synthesized and studied for their
coordinating ability towards metal ions. Various amines and diamines have been utilized for the synthesis of Schiff bases owing to their chelating tendency. Due to versatile structural properties of substituted triazoles and isatin, some Schiff bases of these derivatives have been synthesized and studied for their coordinating abilities towards metal ions. Also metal complexes of bishydrazone of isatin have been synthesized.

The Schiff bases and their metal complexes were characterized by extensive spectroscopic and analytical methods. The structural properties of Schiff bases have been studied by FT-IR, UV-vis., FAB-Mass, NMR (\(^1\)H and \(^{13}\)C), 2D NMR (HOMOCOSY and HETCOR) and elemental analyses. Owing to the fluorescence properties of precursors, some of the Schiff bases have been evaluated for their fluorescence properties.

X-ray crystallographic studies are the most definite source of information regarding the structure of a complex. But, due to the difficulty in obtaining the crystals of metal complexes suitable for X-ray crystallographic study, has rendered this method less suitable for these complexes. In such cases a variety of other techniques can be used with good effect and have been done in this investigation. The structural diversities of metal complexes have been undoubtedly proposed in the light of FT-IR, UV-vis., FAB-Mass, NMR and ESR spectral data wherever possible or applicable, elemental analyses, conductance measurements, magnetic measurements and thermogravimetric analyses studies. Electrochemical behaviour of some metal complexes has been studied by the Cyclic voltametry. From the study, electron transfer mechanisms were proposed. Thermal decomposition studies of some metal complexes resulted some valuable information regarding the thermal stabilities of the metal complexes. The fluorescence properties of some metal complexes have been also investigated.

With respect to the significant applications of Schiff bases and their metal complexes in medicinal field, appropriately termed as "Medicinal Inorganic Chemistry", Schiff bases and their metal complexes have been evaluated for their antibacterial and antifungal activities. Also some of the
metal complexes have been tested for their DNA cleavage properties on isolated genomic DNA of various human pathogens.

The main purpose of this research work has been to synthesize some new Schiff bases to utilize as ligands and to study the ligands and their metal complexes from a structural point of view. These ligands with a variety of bonding interactions, tautomeric phenomena, potential variety of bonding modes and hydrogen bonding interactions, were expected to provide stimulating results. This expectation became fruitful. Metal chelates of Schiff bases hold exciting possibilities for the future concerning to their vide applications viz. in designing new catalytic systems, in formulating new synthetic route, in developing new analytical reagents and in metal based antimicrobial agents etc. Hopefully, the results of this investigation would attract increased interest in this field.

Schiff Bases Synthesized in the Present Investigation

The following series of new Schiff bases have been synthesized in the present research investigation.

- Synthesis of Schiff bases derived from 8-formyl-7-hydroxy-4-methylcoumarin and o-chloroaniline/o-toluidine (Figure-I).
- Synthesis of Schiff bases derived from 5-formyl-6-hydroxycoumarin/8-formyl-7-hydroxy-4-methylcoumarin and o-aminophenol (Figure-II).
- Synthesis of Schiff bases derived from 3-substituted-4-amino-5-mercapto-1,2,4-triazole and isatin (Figure-III).
- Synthesis of Schiff base derived from 8-formyl-7-hydroxy-4-methylcoumarin and o-phenylenediamine (Figure-IV).
- Synthesis of Schiff base derived from 8-formyl-7-hydroxy-4-methylcoumarin and ethylenediamine (Figure-V).
- Synthesis of Schiff base derived from fluvastatin and isatin monohydrazone (Figure-VI).
- Synthesis of Schiff bases derived from 3-substituted-4-amino-5-mercapto-1,2,4-triazole and fluvastatin (Figure-VII).
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