



REVIEW

Schiff Bases Derived from 2-Hydroxynaphthalene-1-carbaldehyde and their Metal Complexes

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2-Hydroxynaphthalene-1-carbaldehyde is a key predecessor to an assortment coordinating agent and the Schiff bases derived from these ligands played a unique role in the development of important biomolecules which exhibit a widely range as a model system for biological macromolecules. Schiff bases formed from *o*-hydroxy aromatic ketones and aldehydes are stellar design for the study of keto-enol tautomerism in liquid and solid state. The metal-Schiff base complexes obtained from 2-hydroxynaphthalene-1-carbaldehyde had been revealed to show a broad area of biological effectiveness, catalytic reaction, sensors, selective electrodes and fluorescent.

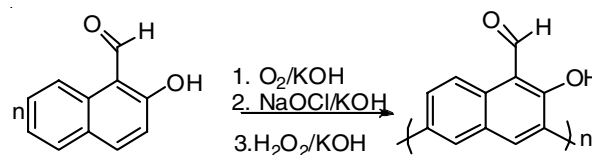
Keywords: Schiff Bases, 2-Hydroxynaphthalene-1-carbaldehyde, Metal complexes.

INTRODUCTION

2-Hydroxynaphthalene-1-carbaldehyde or 2-hydroxy-1-naphthaldehyde (HNA) [1] is a key predecessor to assortment coordinating agent. The literature survey revealed that 2-hydroxynaphthalene-1-carbaldehyde played an important role in the development of commercial useful compounds. 2-Hydroxy-1-naphthaldehyde is a prevalent highly functionalized aromatic ring that has often been utilized as a predecessor to satisfy other chemicals. There also exist a number of reports on the biological effects of 2-hydroxynaphthalene-1-carbaldehyde Schiff bases (azomethine or imine) [2-5]. 2-Hydroxy-1-naphthaldehyde is a trading material and frequently used as a stellar predecessor for the preparation of various fluorescent chemosensors [6]. The better way it to be synthesized is Reimer-Tiemann method by incorporating 2-naphthol [7]. The salicylic moiety of 2-hydroxy-1-naphthaldehyde is a famous synthesis peer for nucleophilic addition formation because of its carbonyl function gathering which is actuated by hydrogen proton of phenol ring through an intramolecular hydrogen binding creation [8-10]. 2-Hydroxy-1-naphthaldehyde dye compound is one of the most utilized fluorophores for the expansion of various fluorescent examine because of its contributors as well as withdrawer destinations. Due to vicinity of hydroxy group in position-2 (a hydrogen giver destination) and aldehyde group in location-1 (or derivatives concerning illustration different azomethine groups) (as acceptor destination), a few degree for intramolecular charger exchange transform inside the naphthalene ring

starting with location-2 as -OH group to the location-1 as aldehyde group donates to its feeble yellow fluorescence. By the chemical treatment of aldehyde gathering and naphthyl-OH gathering, one can use this fluorophore for sensing of cations, anions as well as both cations and anions in a single sensor [11].

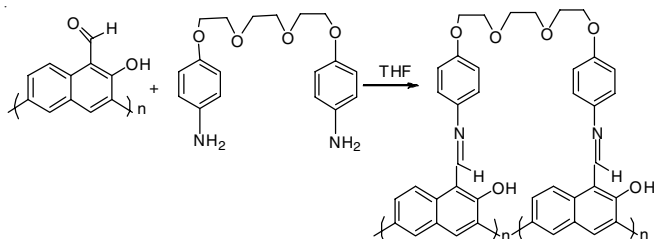
Kaya and Senol [12] reported the synthesis of oligo-2-hydroxynaphthalene-1-carbaldehyde (OHNA) (Schemes I and II) starting with the oxidative multi-condensation from the reaction of 2-hydroxynaphthalene-1-carbaldehyde with oxygen, sodium hypochlorite and hydrogen peroxide in the aqueous basic medium at 50-95 °C. The results and the oxidative polycondensation reaction of 2-hydroxynaphthalene-1-carbaldehyde with oxidants such as oxygen, sodium hypochlorite and hydrogen peroxide were established. For these reactions, H₂O₂ might have been all the more dynamic over air oxygen and sodium hypochlorite, also their ideal reaction states were investigated.



Scheme-I: Synthesis of HNA and OHNA

2-Hydroxynaphthalene-1-carbaldehyde Schiff bases:

Schiff bases or azomethine are aldehydes or ketone like components in which the carbonyl gathering is suppressed by -CH=N- imine or azomethine gathering. Azomethine groups are adapt-



Scheme-II: Synthesis of compound OHNA-1

able ligands prepared from the reaction of an amino compound with carbonyl groups [13,14]. The configuration of Schiff base, by and large, happens under corrosive or base catalysis or with warm. The normal Schiff bases are crystalline solids, which are feebly alkalis' but leastwise a lot of them are insoluble salts in concentration acids [15-17]. Now, Schiff bases are utilized as intermediates for the preparing of amino acids or as ligands for the planning of metal complexes having a progression of various structures. The Schiff bases obtained from 2-hydroxynaphthalene-1-carbaldehyde are well known multidentate ligands which have the potency to bind to deprotonated or impartial structures. Imine compounds may contain an assortment of substituent's with various electron donor or electron-pulling back gatherings and may have intriguing compound properties. 2-Hydroxy-1-naphthaldehyde Schiff base that has the contributor framework, ON, ONO, N2O2 have been generally announced as the center for blend exceptionally foreign made ligands which discover route in numerous fields. There are numerous sensible purposes behind examiners significant consideration paid to Schiff bases formed from 2-hydroxynaphthalene-1-carbaldehyde that are possibly utilized as a part of variation natural fields [18,19], as models framework for organic molecules other than the natural activity [20,21]. The high fondness for the chelating of Schiff bases towards the progress metal is used in setting up their solid complexes [22,23].

Novel set of azomethine ligands (Z)-2-[(2-hydroxy-1-naphthyl)methyleneamino]benzonitrile were reported by Zhou *et al.* [24] from the reaction of 2-aminobenzonitrile with 2-hydroxynaphthalene-1-carbaldehyde. Appropriate crystals for X-ray diffraction determination were obtained (Fig. 1) and demonstrates atom receives the phenol-imine tautomeric shape with a solid intra molecular O-H...N hydrogen linkage. The C-N and C-O bond lengths [1.296 and 1.324 Å] are practically identical to comparing esteems saw in a comparative phenol-imine tautomeric geometry shape [25], while diverse geometry is seen on account of zwitterionic particles [26,27]. Phenyl and naphthyl rings are obviously planar and the dihedral point is 8.98 (9)°.

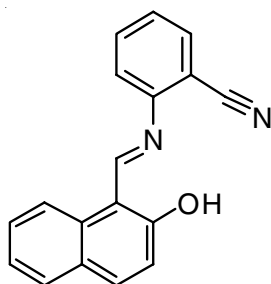
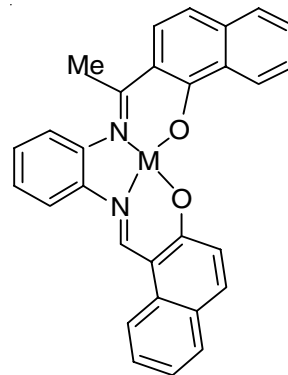


Fig. 1. 2-[(2-Hydroxy-1-naphthyl)methyleneamino]benzonitrile

Boghaei and Lashanizadegan [28] had illustrated the preparation and significant properties of Cu(II) and Ni(II) complexes of novel non-symmetrical N2O2 azomethine ligand (Fig. 2) obtained from the reaction of half-unit (HL), 2-hydroxynaphthalene-1-carbaldehyde in two route response (i) synthesis of Schiff base which is then responded with the coveted metal and (ii) format preparation without separation of Schiff base.

Fig. 2. Structure of complexes ML_2

Threonine Schiff base (Fig. 3) formed from 2-hydroxy-1-naphthaldehyde and threonine. The stoichiometry of this Schiff bases was determined using FTIR, 1H , ^{13}C NMR and UV spectroscopic strategies. X-ray beam diffraction technique was likewise used to get the single-precious crystal structure. The particle had phenol-azomethine tautomeric shape in the precious crystal structure. Some of the linkage distance and points found in the atomic structure were contorted because of π -electron delocalization and steric impact of naphthylidene and threonine gatherings [29].

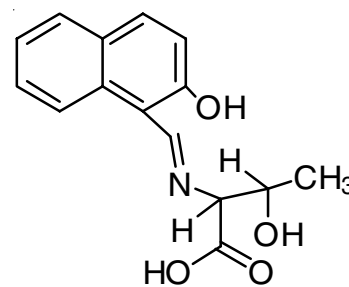
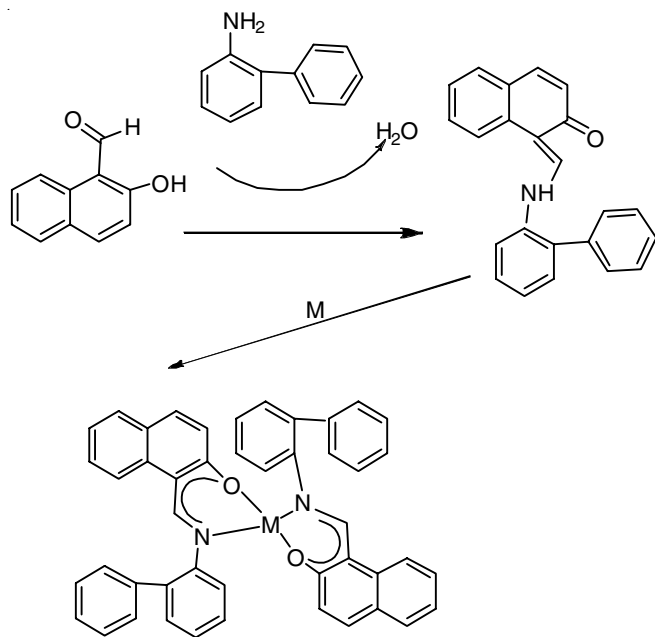


Fig. 4. Structure of threonine Schiff base

The azomethine compounds formed from 2-hydroxynaphthalene-1-carbaldehyde, in particular, 1-[(2-biphenylamino)methylene]naphthalen-2(1H)-one and its Co(II) and Cu(II) compounds (Scheme-III) were prepared and characterized by infrared spectroscopy, thermal investigation and by powder and single crystal X-beam diffraction. The shape of Cu(II) complex was irregular square planar while the shape of Co(II) complex was unpredictable tetrahedral [30].

2-Hydroxynaphthalene-1-carbaldehyde Schiff bases tautomerism: Imine compounds obtained from *o*-hydroxy aryl aldehydes and ketones are great designs for the investigation of keto-enol tautomerism both in liquid and in the crystal state [31,32]. Because of the presence of either O-H...N or O...H-N sort of intramolecular hydrogen binding and the concerned tautomerism between keto-azomethine and enol-



Scheme-III: Synthesis of ligand and complexes

azomethine [33,34]. Amid past decade such Schiff base ligands attracted consideration because of their physical attributed in the crystalline state [35,36]. These properties are conceivably impacted by the topochemistry of Schiff base particles, which thus is incredibly influenced by the *gem* structure. The nearness of specific tautomer in the precious crystal depends for the most part on the parent *o*-hydroxy aromatic aldehyde and the kind of N-substituent. The electro donor or acceptor capacity of N-substituent, their stereo-science, position, and hydrogen bond donor and acceptor properties, can balance some tautomer in the crystal. In this manner, the examination of precious crystal pressing and intermolecular connections in the crystal structure of different Schiff base ligands can promptly generate the combination of new materials.

Blagus *et al.* [37] described their research on the tautomerism of Schiff bases obtained from aromatic hydroxyl aldehydes. They identified the presence of enol-azomethine tautomer had been set up in most precious crystal structures of N-substituted salicylal-dimines. In naphthal-dimines, the keto-amino tautomer showed up to some degree common over enol-amino tautomer [38]. The adjustment of keto-amino tautomer in naphthyl-dimine is typically associated with quinoid impact since the framework of this tautomer is like that of *o*-naphthoquinine [39] (Fig. 4).

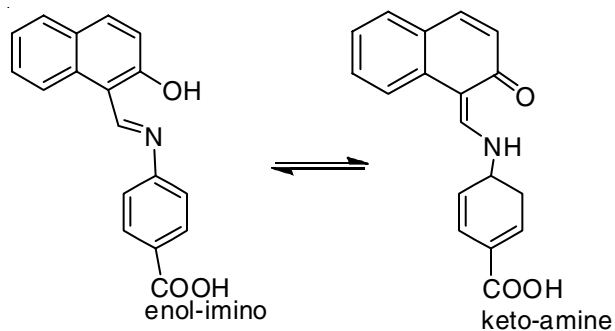


Fig. 4. Structure of keto-amino tautomer in naphthyl-dimine

Dziembowska *et al.* [40] synthesized derivatives of 2-hydroxy-1-naphthaldehyde with aliphatic and heterocyclic amines (Fig. 5). The proton promotion harmony in Schiff bases obtained from 2-hydroxy-1-naphthaldehyde had been contemplated. They found that the expansion of π -electron delocalization by substituting the aryl ring by naphthalene moiety and presentation of more aliphatic or heterocyclic gatherings at azomethine N-atom balance out the tautomeric NH form [41].

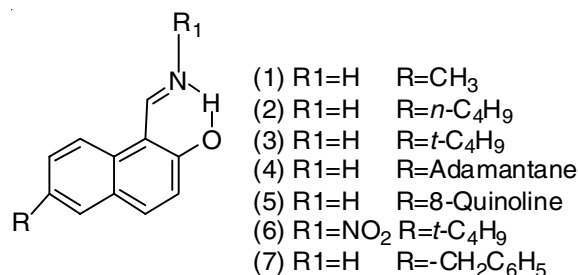


Fig. 5. Schiff bases derived from aliphatic and heterocyclic amines

Yildiz *et al.* [42] synthesized new 2-hydroxynaphthal-dimine Schiff bases to investigate the intra-molecular hydrogen bonding and tautomeric in liquid and crystal states, and compared with the Schiff bases derived from salicylal-dimine in same states, using infrared and X-ray crystallography techniques [42] (Fig. 6).

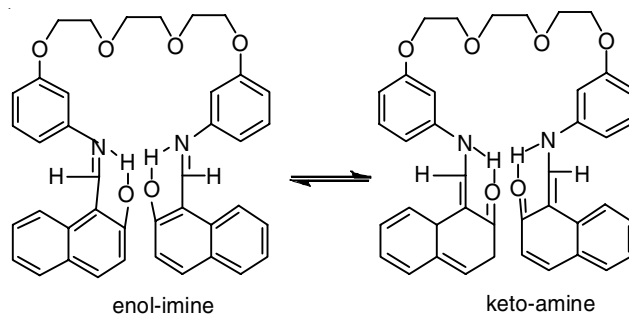


Fig. 6. Tautomerism in Schiff bases derived from salicylal-dimine

Kilic *et al.* [43] also found that in the liquid phase, the presence of phenol-azomethine and keto-azomethine tautomerism rely upon the development of intra-molecular hydrogen bonding [19]. It is asserted that keto-amino tautomerism was commanded in naphthyl-diamine, while phenol-imine in salicylal-dimine Schiff constructs depends on the polarity of the solution [33]. However, in solid state, it was indicated that keto-azomethine tautomerism founded in naphthyl-diamine, while phenol-azomethine in salicylal-dimine Schiff bases [44].

Intra-molecular hydrogen binding and tautomerism in the synthesized N-(2-pyridyl)-2-oxo-1-naphthylidenemethylamine was reported by Nazir *et al.* [45] using infrared spectroscopy and X-ray beam diffraction studies [46]. The impact of aromatic ring moiety with naphthalene has been examined. In this work, they found that phenol-azomethine and keto-amino balance moved overwhelmingly to keto-amino side [45] (Fig. 7).

Several novel ligands containing imine linkage were synthesized from the reaction of 2-hydroxynaphthalene-1-carbaldehyde with different amines having additional ligating center and the resultant products 2-(β -naphthalideneamino)-2-methyl-1-propanol

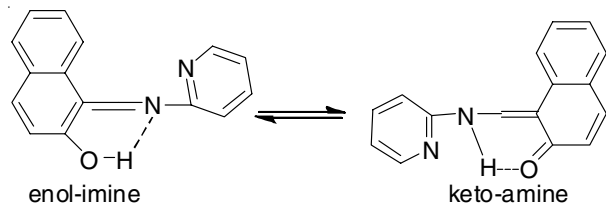


Fig. 7. Synthesized of N-(2-pyridyl)-2-oxo-1-naphthylidenemethylamine

(H2L1), 2-(β-naphthalideneamino)-2-hydroxymethyl-1-propanol (H3L2), 2-(β-naphthalideneamino)-2-hydroxymethyl-1,3-propanediol (H4L3), 2-(β-naphthalideneamino)pyridine (HL4) were characterized by spectroscopic instruments [47] (Fig. 8).

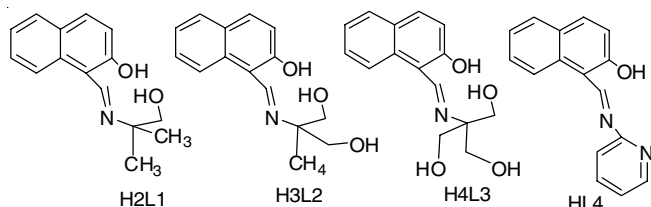


Fig. 8. Chemical structures of ligands containing imine linkage

The naphthyl moiety in each of these Schiff base ligands was stabilized in a quinoid form in the solid state. Interesting lattice structure was observed due to intermolecular interactions. A novel imine ligand containing macrocyclic moiety was planned and built by reaction of a different diamine with 2-hydroxynaphthalene-1-carbaldehyde and the obtaining compounds were examined by analytical and spectroscopic methods [48]. In infrared spectrum of imine ligand, $\text{C}=\text{N}$ -extending vibration band seen at 1620 and 1602 cm^{-1} as a sharp band. The existence of two diverse hydrogen binding inside imine ligand can be possible (Fig. 9).

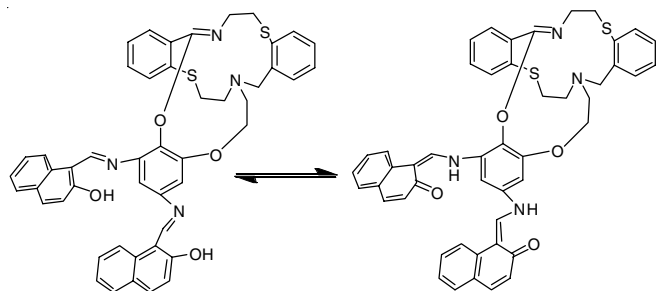


Fig. 9. Tautomerism forms of macrobicyclic Schiff base ligand

There are many models of ligands containing naphthalidimine compounds in which one aspect of naphthalidimine is as enol-azomethine while the other site is as keto-amine [49].

Marijana-Gavranic *et al.* [46] examined intra-molecular $\text{N}\cdots\text{H}-\text{O}$ hydrogen bonding, quinoid impact and partial π -electron delocalization in the crystal structure of planar N-(α-naphthyl) and N-(β-naphthyl)-2-oxy-1-naphthaldehyde (Fig. 10). They also observed that the existence of intra-molecular hydrogen bond was confirmed by the spectroscopic analysis but unequivocally established by diffraction experiment in both cases.

Tautomerism in 2-hydroxy-1-naphthaldehyde ligands containing imine linkage in liquid and the solid state studied by Salman *et al.* [50] using ^{13}C NMR. It had been demonstrated that ligands exist basically as the keto-amine frame in the crystal state [50] (Fig. 11).

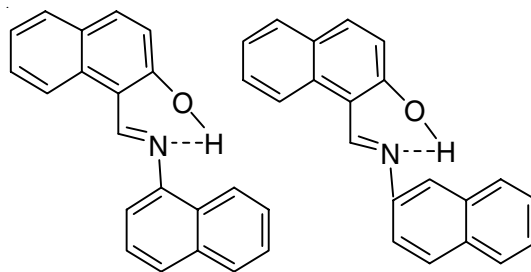


Fig. 10. Structures of N-(α-naphthyl) and N-(α-naphthyl)-2-oxy-1-naphthaldehyde

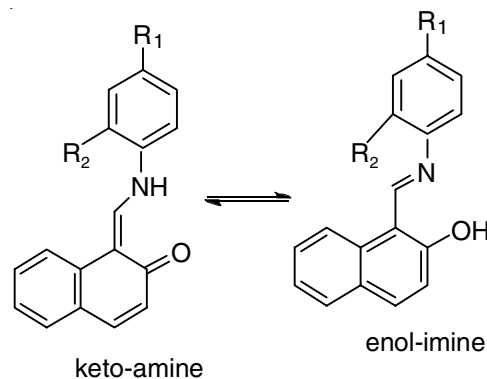
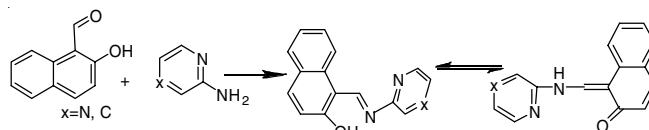


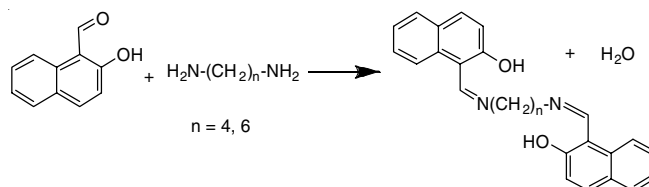
Fig. 11. Tautomerism in HNA Schiff bases

New Schiff bases 2-(2-hydroxynaphthalidene)aminopyridine and 2-(2-hydroxynaphthalidene)aminopyrazine were prepared from the condensation of 2-hydroxynaphthalene-1-carbaldehyde with 2-aminopyridine and 2-aminopyrazine (**Scheme-IV**). The UV-spectroscopic data of the synthesized compounds showed tautomeric equilibrium enol-azomethine and keto-amine form in both non-polar and polar solvents [51].



Scheme-IV: Synthesis of HNA with aminopyrazine and aminopyridine

N,N'-Butylene-N,N'-hexylene bis(2-oxy-1-naphthalidimine) ligands were prepared by condensation of 2-hydroxynaphthalene-1-carbaldehyde with 1,4-diaminobutane and 1,6-diaminohexane, respectively (**Scheme-V**). The synthesized Schiff bases were investigated in crystal state using crystallographic method. The well-known crystallographic bond length pattern as well as quinoid effects were detected in the fused ring system in both cases and $\text{O}\cdots\text{H}-\text{N}$ type of intra-molecular hydrogen bonding was established in both Schiff base compounds [52].



Scheme-V: Synthesis of N,N'-butylene-N,N'-hexylene bis(2-oxy-1-naphthalidimine)

Teoch *et al.* [53] prepared new Schiff bases N-(2-hydroxynaphthalene-1-carbaldehyde)-1-amino-2-phenylene azomethine and N,N-bis(2-hydroxynaphthalene-1-carbaldehyde)-1,2-phenylenediazomethine from the condensation of 2-hydroxynaphthalene-1-carbaldehyde with 1,2-phenylenediamine (Fig. 12). The prepared ligands were characterized using spectroscopic methods and found that the obtained imine compounds show cursory intra-molecular -C=N- bond linkage and intermolecular -C=N- bond linkage [53].

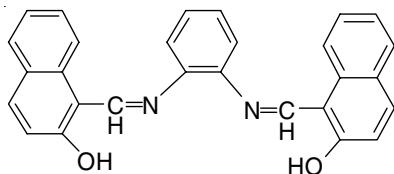


Fig. 12. Structures of N-(2-hydroxy-1-naphthaldehyde)-1-amino-2-phenyleneimine

Akkurt *et al.* [54] reported the structure of 4-[(2-hydroxynaphth-1-yl methylidene)amino]-3,5-diethoxy carbonyl-4-methyl thiophene (Fig. 13) as a piece of examination concerning the improvement of anil compounds. In naphthalen-2-ol gathering and thiophene ring are each relatively planar, and the particular ring planes are situated with a dihedral point of 5.75 (7)° between them. Intramolecular O...H-O, N...H-O and S...H-C hydrogen bonds affect this modulation and the structure is additionally settled by intermolecular C-H...O hydrogen binding connections.

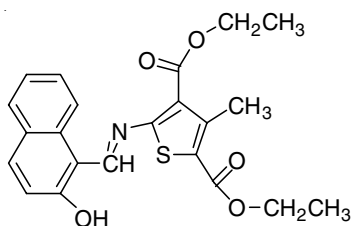


Fig. 13. Structure of 4-[(2-hydroxynaphth-1-yl methylidene)amino]-3,5-diethoxycarbonyl-4-methylthiophene

Complexes of 2-hydroxynaphthalene-1-carbaldehyde azomethine ligand

In recent years, there has been significant attention in the chemistry of transition elements with azomethine ligands [55-58]. Additionally, azomethine ligand complexes have turned out to be progressively vital as biochemical, systematic and antimicrobial reagents [59]. The chemoselectivity of different senses obtained from 2-hydroxynaphthalene-1-carbaldehyde towards various metal ions is because of the existence of -C=N- bond and hydroxyl group to O-location. In various receptors, -C=N- rotations and hydrogen binding contributor ability of -OH group play important function for the metal bonding. The -OH group afford from powerful ICT over metal bonding and also accountable for the coordination with the different metal ions by forming various bulk of sinus with the approaching moieties (formed from aldehyde group in location-1) relating to the various bulk of metal ions for their eclectic bonding [60]. The derivatization of aldehyde group in 2-naphthol backbone with various amines by means imine linkage formation makes different receptors

which tie Al^{3+} electively on simile with the other meddling metal ions. Jia *et al.* [61] prepared a novel azomethine, ligands as 1-[(1*H*-1,2,4-triazole-3-ylimino)-methyl]-naphthalene-2-ol by choosing 2-hydroxynaphthalene-1-carbaldehyde as a fluorophore and bonding moiety and 3-amino-1*H*-1,2,4-triazole as a synergic ligand to give a more particular chelating site for Al^{3+} with as far as possible 0.69 μM in DMF.

Preparation and identification of chelating complexes obtained from coordinating Ln(III) with 4-[N-(2'-hydroxy-1'-naphthalidene)amino]antipyrine thiosemicarbazone had been studied (Fig. 14). All the complexes had the general structure $LnX_3 \cdot n$. IR-spectra uncovered that HNAAPS acts as a neutral tridentate (N,N,S) ligand. The coordination number of these compounds was either six or nine relying upon the anionic ligand [62].

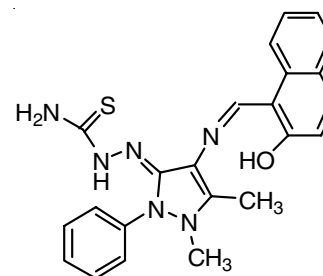


Fig. 14. Structure of 4[N-(2'-hydroxy-1'-naphthalidene)amino]antipyrine-thiosemicarbazone

Chakrabarty *et al.* [63] investigated the synthesis and characterization of some nickel complexes as mono and homo dimetallic derived from bis(2-hydroxynaphthalene-1-carbaldehyde)succinoyldihydrazone (Fig. 15). They observed that the complexes with mono nickel have octahedral geometry while complexes with bi-nickels have deformed octahedral geometry in which one of the nickel lobes is available in N2O2 coordination circle and another nickel focus is bind to it through oxygen of phenolate.

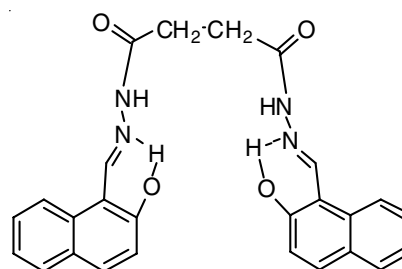


Fig. 15. Structure of bis(2-hydroxy-1-naphthaldehyde)succinoyldihydrazone

Novel complexes of cobalt, nickel, copper, cadmium and zinc individually with novel imine ligand [benzyl(2-hydroxy-1-naphthalidene)hydrazine]carbodithioate (Fig. 16) obtained from the reaction of 2-hydroxy-1-naphthaldehyde and benzyl hydrazine carbodithioate (**Scheme-VI**) was investigated. The structures of the azomethine ligand and their metal complexes had been resolved, the ligand behaves as a tridentate and coordinated with metal through nitrogen of imine, oxygen atom of hydroxyl, and sulfur atom of thione and the proportion of ligand to metal (M: L) is (1:2). All of the complexes have

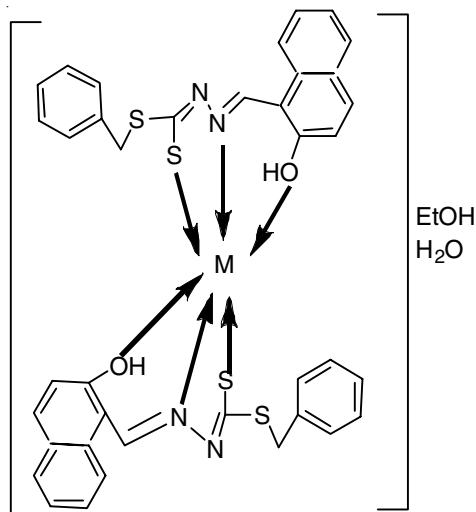
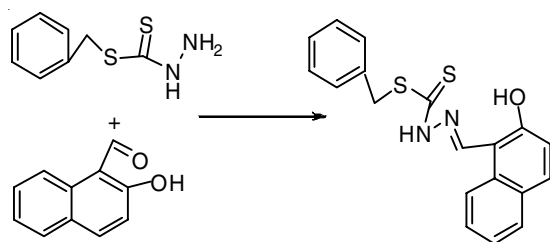


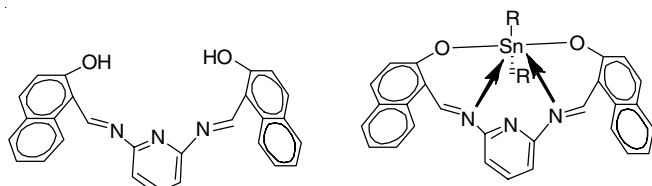
Fig. 16. Structure for synthesized complexes



Scheme-VI: Synthesis of [benzyl(2-hydroxy-1-naphthalidene)hydrazine]-carbodithioate

octahedral geometry unless copper complex has distorted octahedral geometry [64].

Chelating compounds obtained by the reaction of metals with multidentate Schiff base *N,N'*-bis(2-hydroxynaphthalene-1-carbaldehyde)-2,6-diaminopyridine (Fig.17) had been synthesized. Stoichiometries of the produced compounds had been determined by elemental analysis and molecular weights. The coordination numbers and geometry of the metal complexes around Sn(IV) were determined for each situation [65].

Fig. 17. Structure of *N,N'*-bis(2-hydroxy-1-naphthaldehyde)-2,6-diaminopyridine and metal complexes

Metal complexes formed from 2-hydroxynaphthalene-1-carbaldehyde and amino acid

Novel set of complexes of azomethine amino acid formed from the condensation of 2-hydroxynaphthalene-1-carbaldehyde with various amino acids and Mn(III) (Fig. 18) was investigated. The structures of synthesized imine complexes were determined by using different spectroscopic analysis method. The biological effectiveness of complexes tended to reduce with the expanding bulk of amino acid remains [66].

Sakjan [67] synthesized novel set of Mn(III) complexes and amino acid imine ligand from the reaction of 2-hydroxynaphthalene-1-carbaldehyde and various α -amino acids. The

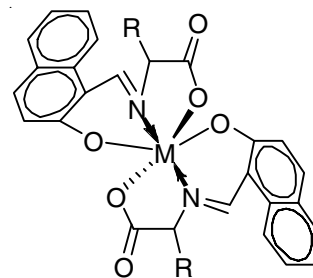
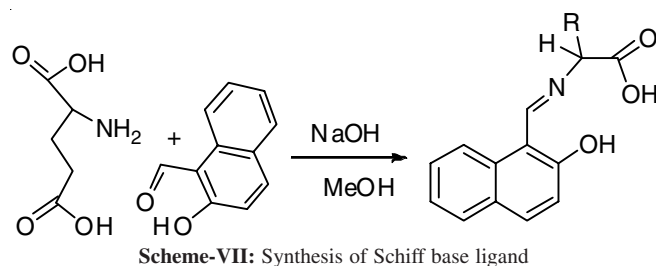


Fig. 18. Structure of metal complexes

structure identification of the synthesized metal complexes and ligands were carried out using a different method of analysis. The outcomes of analysis proposed a different ratio of chelating between ligands and metals with different coordination numbers (Scheme-VII).



Scheme-VII: Synthesis of Schiff base ligand

Triplex complexes formed by the reaction of copper and uranium dioxide with two types of imine ligand, first complexes prepared by the reaction of 2-hydroxynaphthalene-1-carbaldehyde with various amino acids as primary ligand and the second type of complexes formed by using heterocyclic bases ligand (Fig. 19). The spectroscopic results revealed that Schiff bases were composed of the focal metal as a divalent triplex [68] (Fig. 20).

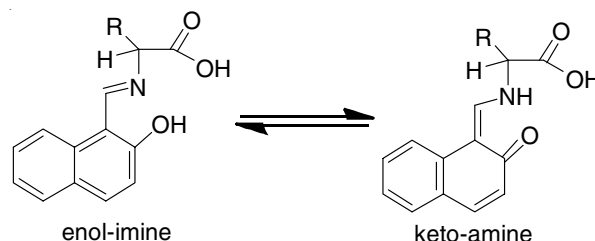


Fig. 19. Structure of Schiff base as enol-imine and keto-amine form

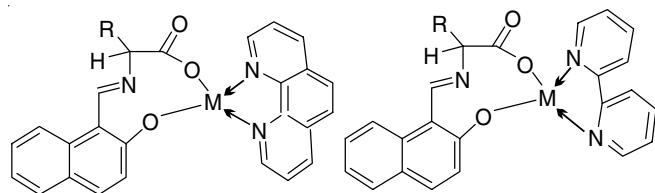


Fig. 20. Structure of synthesized complexes

A novel set of manganese complexes synthesized by reaction of 2-hydroxynaphthalene-1-carbaldehyde with different amino acids (Fig. 21). The complexes formed were bonded to the metal with ONO chelating site from phenolate, azomethine and carboxyl gathering of the ligands [69] (Fig. 22).

Novel series of amino acid imine ligands of *N*-(2-hydroxynaphthalene-1-carbaldehyde)phenyl glycine had been synthesized (Scheme-VIII) alongside with X-ray crystallographic

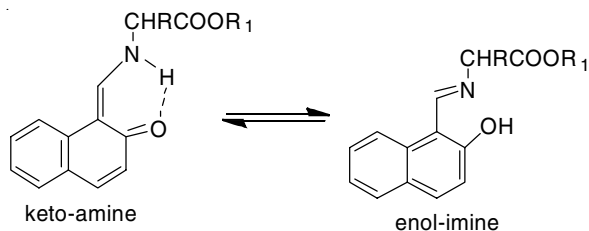
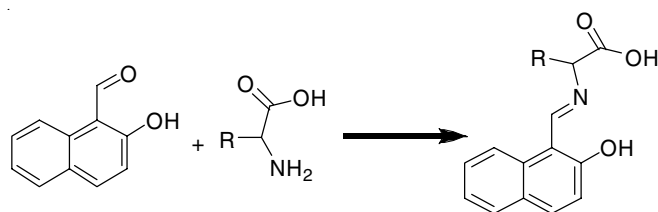


Fig. 21. Tautomeric forms of Schiff bases derived from amino acids



Scheme-IX: Synthesis of amino acids Schiff base containing azomethine linkage

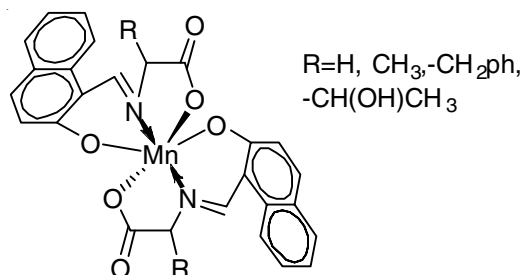
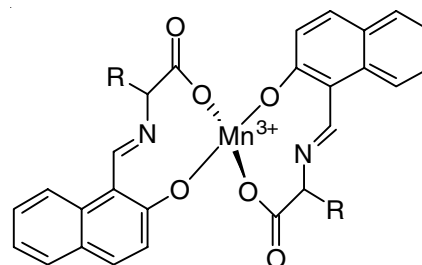
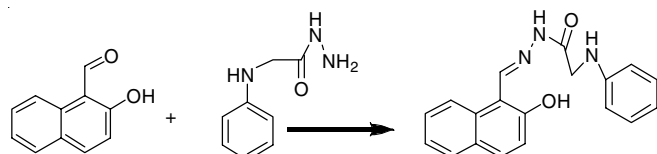


Fig. 22. Structure of manganese complex

Fig. 24. Suggested structure of Mn^{3+} complexes of lysine and tyrosine

Scheme-VIII: Synthesis of new amino acid Schiff base, N-(2-hydroxy-1-naphthalidene)phenylglycine

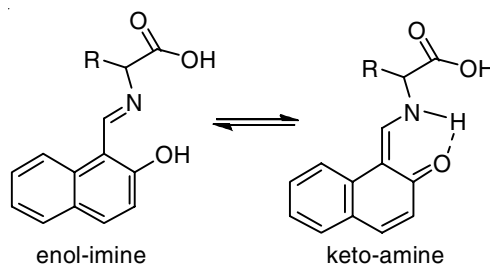


Fig. 25. Amino acids Schiff bases tautomerism

analysis. Several transitional metal ions viz., Cu(II), Ni(II), Co(II), Mn(II) and Zn(II) complexes with the azomethine Schiff base ligand were prepared and their structure identification carried out on the basis of different spectroscopy methods. The infrared absorption data of the metal complexes displays the same idea about the ligating of ligand to metal and detected that the ligand coordinated through carbonyl oxygen, azomethine nitrogen and hydroxyl oxygen atoms [70] (Fig. 23).

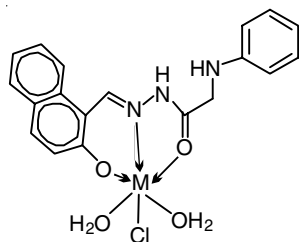
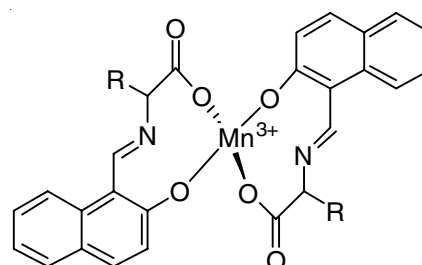


Fig. 23. Structure of prepared metal complexes

Sakiyan *et al.* [71] synthesized series of amino acids ligand containing azomethine linkage (Scheme-IX) and their Mn complexes (Fig. 24) in order to study the biological activity against bacteria. They used several antibiotics as standard to compare the effect of synthesized complexes against bacteria. They found that some of these complexes have acceptable activity compared with the standard antibiotics.

Furthermore, in continuation of their research by Sakiyan *et al.* [72] in the field of amino acids azomethine ligands, synthesized from the condensation of 2-hydroxynaphthalene-1-carbaldehyde with different amino acids (Fig. 25). Moreover, Mn(III) complexes of some ligands were prepared (Fig. 26) and their geometry shape were studied using several spectroscopic methods

Fig. 26. Structure of Mn^{3+} complexes with amino acids Schiff base

of analysis in addition to the crystallographic structure identification.

2-Hydroxynaphthalene-1-carbaldehyde ligands and their metal-complexes in electro-systematic sciences

New series of N2O2 chelating ligands based on 2-hydroxynaphthalene-1-carbaldehyde and their nickel(II) complexes had been synthesized by condensation of different diamines with 2-hydroxynaphthalene-1-carbaldehyde and Ni(II) (Fig. 27). The structure of the complexes identified using X-ray crystallographic method. The complexes showed a new sort of pressing diverse to other Ni(II) Schiff base complexes, due to the interactions between the monomers happened through covering of naphthyl group [73].

In order to study the electrochemical behaviour of the compound containing imine linkage in their structure, Sundaravel *et al.* [74] prepared 3-(2,6-diisopropylphenyliminomethyl)-naphthalen-2-ol by reaction of 2-hydroxynaphthalene-1-carbaldehyde with 2,6-di-isopropyl aniline (Fig. 28a). The copper(II) complexes of the ligands had been characterized and the

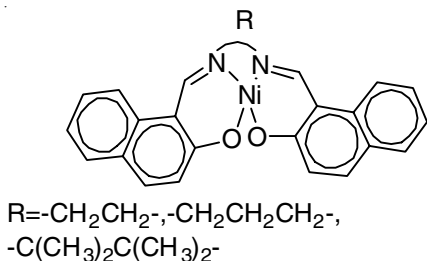


Fig. 27. Structure of pseudomacroyclic Schiff base ligands

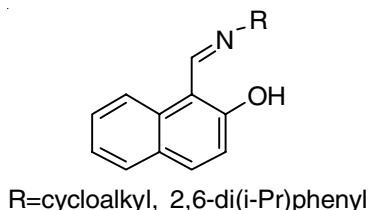


Fig. 28a. Bidentate Schiff base ligands

structures by using crystallographic (X-ray diffraction) methods. The geometry of the complexes as square planar has been predicted (Fig. 28b). The enormous 2,6-diisopropyl gathering on N-aromatic cycle in azomethine complexes resort to press just a little geometric deformation on square planar shape.

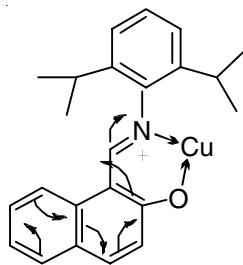


Fig. 28b. Electron delocalization in aromatic rings in Schiff base complexes

Novel azomethine ligands synthesized from the condensation of 2-hydroxynaphthalene-1-carbaldehyde with 2,6-pyridinediamine (Fig. 29) and PCV based layers utilizing diverse plasticizers had been synthesized and studied as elective substance for lead(II) by Gupta *et al.* [75]. It is demonstrated that the sensor properties was better in numerous regards when contrasted with the current sensors [75].

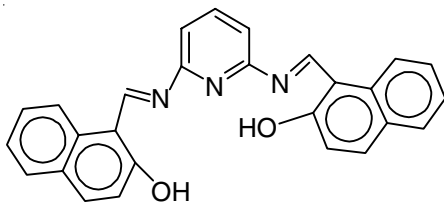
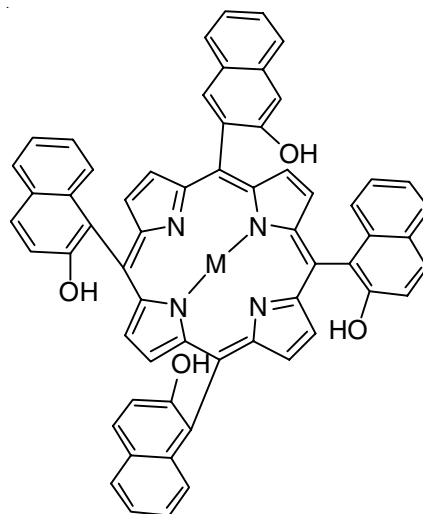


Fig. 29. Structure of N,N'-bis(2-hydroxy-1-naphthalene)-2,6-pyridinediamine Schiff base

Moreover, work has been improved the situation seeking of novel specific electrodes to distinguish the presence of some heavy metals. PVC film electrodes for lead ion in view of *meso-tetrakis*(2-hydroxynaphthyl)porphyrin and *meso-tetrakis*(2-methoxynaphthyl) porphyrin atropisomers as layer bearers were synthesized (Fig. 30). Among their atropisomers, a layer anode had a fast potential reaction, potential steadiness and long-

Fig. 30. Structure of *meso-tetrakis*(2-hydroxy-1-naphthyl)porphyrin

haul strength. This layer terminal can be utilized for the detecting of lead(II) ions and also other anions [76].

Ardakani *et al.* [77] synthesized a new bidentate Schiff base ligand *bis*[(2-hydroxynaphthalene-1-carbaldehydedehyde)-1,4-diamino]benzene were synthesized by reaction of 2-hydroxynaphthalene-1-carbaldehydedehyde with 1,4-diaminobenzene. The molybdenum complexes of these ligands (Fig. 31) with nanoparticles of titanium oxide as another new electrocatalysis was qualified [77].

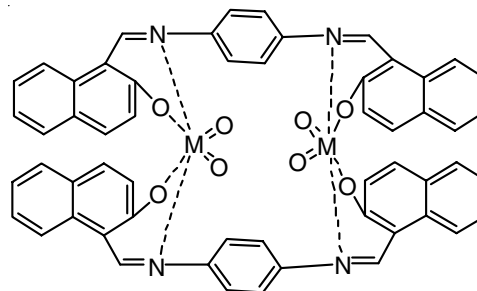
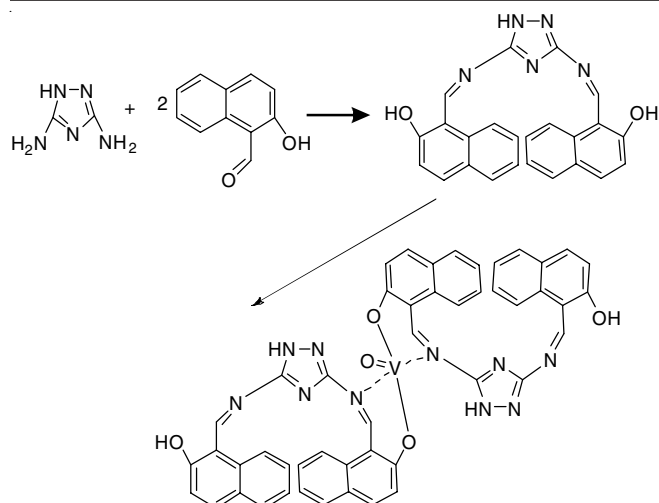


Fig. 31. Suggested structure of molybdenum complex

Some novel iron(II) complexes derived from N-(2-hydroxynaphthalene carbaldehyde with various amino acids were prepared and characterized. From the magnetic properties data, an octahedral geometry around the metal particle was proposed [78].

Biological activity of 2-hydroxynaphthalene-1-carbaldehyde imine and their complexes

Chohan *et al.* [79] studied the effect of some azomethine ligands and their metal complexes on the biological activity. A novel set of oxovanadium(IV) complexes had been prepared with a novel type of triazole formed from the reaction of 3,5-diamino-1,2,4-triazole with 2-hydroxynaphthalene-1-carbaldehyde (**Scheme-X**). The ligand and their VO(IV) complexes were investigated for *in vitro* antimicrobial activity for both Gram-negative and Gram-positive bacterial strains, in the same time the prepared ligands and their complexes screened also *in vitro* for antifungal activity against several fungal. The ligand showed low to acceptable action against at least one bacterial and parasitic strain. In general cases, more activity was exhibited upon chelating with VO(IV) [79].



Scheme-X: Synthesis of triazole ligands and their complexes

More research had been conducted about the biological action of some imine ligands and their complexes. Murukan and Mohanan [80] reported the synthesis of Mn(III), Fe(III) and Co(III) complexes with hydrazone, derived by reaction of isatin-monohydrazone with 2-hydroxynaphthalene-1-carbaldehyde (Fig. 32). The imine ligand and their complexes had been investigated for their biological action and it has been noticed that the complexes show more powerful biological activity than the free ligand.

The new set azomethine ligand of 2-[(2-hydroxynaphthalen-1-yl)methylene]-N-(4-phenylthiazol-2-yl)hydrazine carboxamide (L) formed by the reaction of N-(4-phenylthiazol-2-yl)hydrazine carboxamide with 2-hydroxynaphthalene carbaldehyde and its designed copper(II), cobalt(II), nickel(II), zinc(II) and cadmium (II) complexes had been prepared (**Scheme-XI**). The recently prepared compounds were examined for their biological action. The *in vitro* cytotoxicity behaviour against *Artemia salina* carried out. The ligand displayed more *in vitro* antioxidant potential than its metal complexes [81].

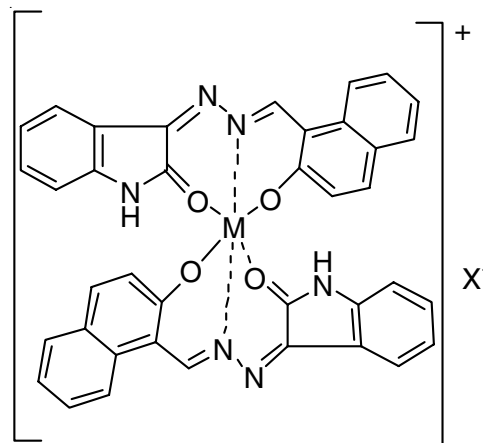


Fig. 32. Structure of the metal complexes

In recent years, more interest is shown with the synthesis of novel biologically active compounds. Novel azomethine ligands and their metal complexes formed from 2,3-diaminopyridine and 2-hydroxynaphthalene-1-carbaldehyde had been prepared by Jeewoth *et al.* [82] (Fig. 33). The new ligands and their metal complexes were screened for their antimicrobial activity and the results showed significant biological activity of the prepared complexes [82].

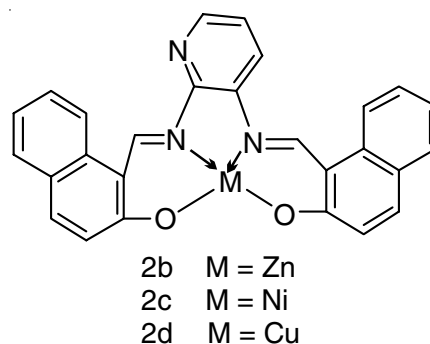
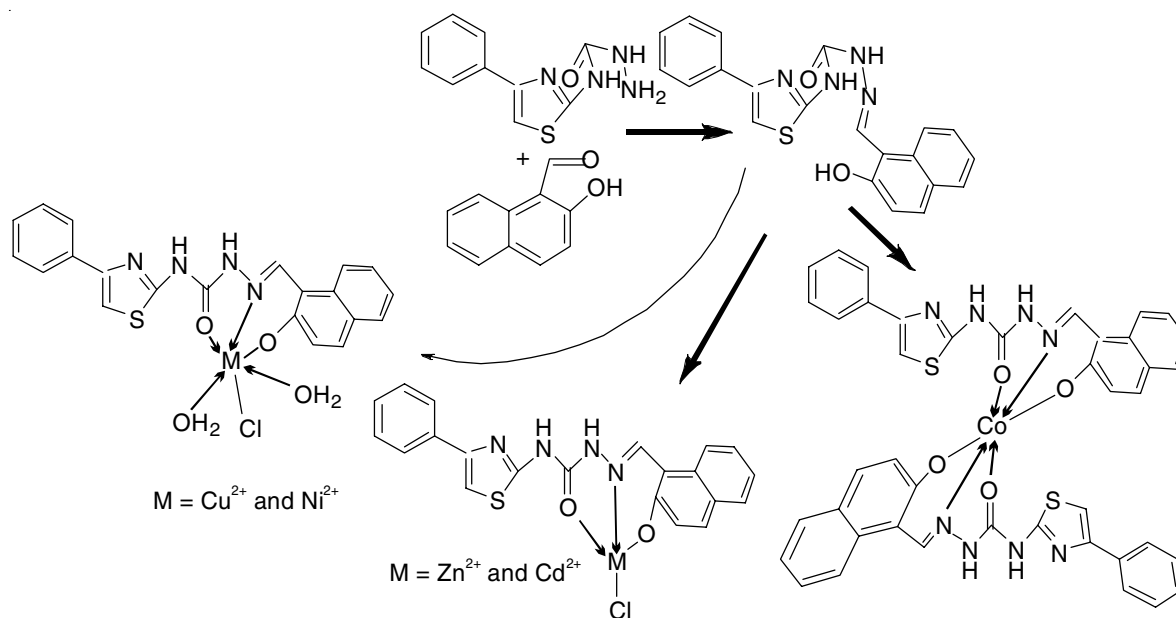
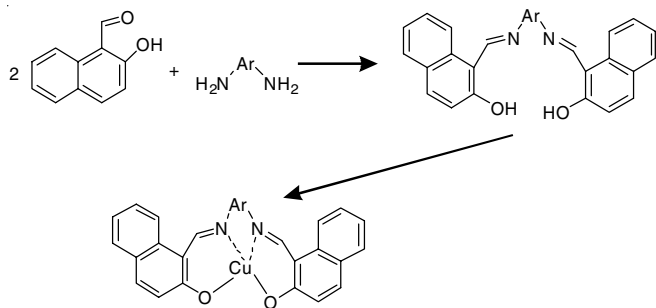


Fig. 33. Proposed structure of metal Schiff base complexes



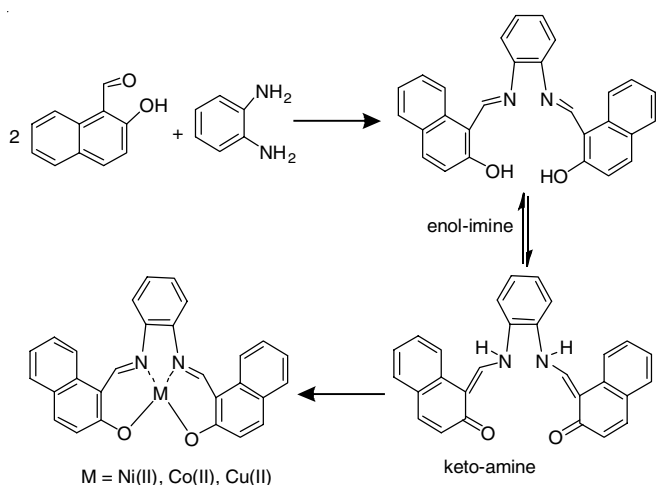
Scheme-XI: Synthesis of Schiff base ligand and the structures of proposed metal complexes

Some new imine complexes of copper(II) had been synthesized by Naeimi *et al.* [83] from the condensation of 2-hydroxynaphthalene-1-carbaldehyde with various amines under template condition (**Scheme-XII**). The complexes were examined for their antimicrobial action. The outcomes results demonstrated that despite the fact that azomethine ligand did not display a critical antimicrobial effectiveness, compared with their complexes which indicated higher biological effectiveness under the same conditions [83].



Scheme-XII: Synthesis of Schiff base ligands and their metal complexes

Novel complexes of copper(II), nickel(II) and cobalt(II) with tetracoordinate O,N,N,O azomethine ligands designed from 2-hydroxynaphthalene-1-carbaldehyde and various aromatic diamines (**Scheme-XIII**) had been prepared by Maher *et al.* [84]. The results of biological activity of these compounds should consider to the utilization of compounds as nutritious supplements with biological exercises pertinent to avoidance of bacterial and contagious ailments. They can be additionally assessed for restorative as well as ecological applications [84].



Scheme-XIII: Synthesis of Schiff base and their suggested metal complexes

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