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SYNTHESIS, CHARACTERIZATION AND INVITRO-ANTIMICROBIAL ACTIVITIES OF Ni (II) AND Fe (II) COMPLEXES OF SOME HYDRAZONE LIGANDS

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ABSTRACT

hydrazone which are compounds that have N-N bond in addition to –C=N- bond of well-known Schiff's bases. They are formed by the reaction of carbonyl compounds (ketones or aldehydes) with hydrazides or its derivatives. They form coordination compounds with almost all transition elements, forming various geometries. The present work focuses on the synthesis and characterization of Ni (II) and Fe (II) complexes of some hydrazone ligands. For this purpose, three (3) different hydrazone ligands were synthesized, by reacting different types of hydrazide derivatives with carbonyl compounds (ketones or aldehydes). Each of these ligands were used to formed complexes with Ni (II) and Fe (II), using their hexahydrated metal salts. The complexes were characterized using; IR spectroscopy, UV-Visible spectroscopy, elemental analysis, conductivity measurement and magnetic susceptibility measurement.

Key words* — Hydrazone, Antimicrobial, complexes and Schiff base.

INTRODUCTION

Coordination compounds are composed of a metal atom or ion and one or more ligands (atoms, ions, or molecules) that donate electrons to the metal. This definition includes compounds with metal–carbon bonds, or organometallic compounds. coordination *compound* comes from the coordinate covalent bond, which historically was considered to form by donation of a pair of electrons from one atom to another. In coordination compounds the donors are usually the ligands, and the acceptors are the metals. Coordination compounds are examples of acid–base adducts frequently called complexes or, if charged, complex ion.

Although the formal study of coordination compounds really begins with Alfred Werner (1866–1919), coordination compounds have been used as pigments and dyes since antiquity. Examples include Prussian blue ($KFe[Fe(CN)_6]$), aureolin yellow, ($K_3[Co(NO_2)_6]\ 6H_2O$), and alizarin red dye (the calcium aluminum salt of 1,2-dihydroxy-9,10-anthraquinone). The tetraamminecopper (II) ion, actually $[Cu(NH_3)_4(H_2O)_2]^{2+}$ in solution, which has a striking royal blue color—was known in prehistoric times. The formulas of these compounds were deduced in the late nineteenth century, providing background for the development of bonding theories [7]

Nickel

Nickel is a chemical element, It has symbol N and atomic number 28. It is a silvery-white lustrous metal with slight golden tinge. Nickel is hard ductile transition element. Pure metal is chemically in reactive, but large piece are slow to react with air under standard conditions because a passive layer of nickel oxide forms on the surface that prevent further corrosion. Even so, pure native nickel is found in the earth crust only in tiny amounts, usually in ultramafic rocks and in the interiors of large nickel-iron meteorites that were not exposed to oxygen when outside Earth's atmosphere [4]

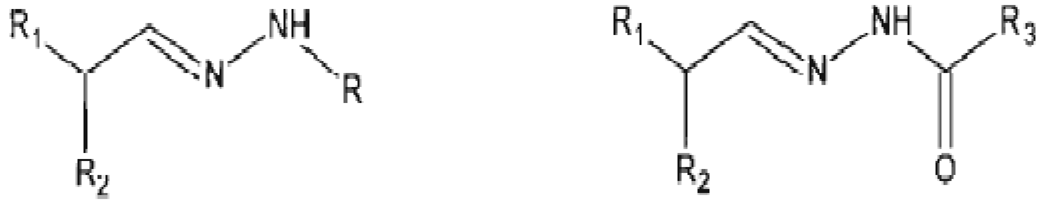
Among the numerous metals having antimicrobial properties 'nickel' is one of them. Mechanism of action is to inactivate the enzymes by different ways, ultimately killing the microorganisms. Its ions can penetrate in microbial cells and kill them mainly by inactivating their enzymes. Alternatively, 'nickel (II) complexes exhibit antimicrobial actions. Stability of the complex depends upon the ligand, metal ion and the chelate geometry. It is interesting to note here that the antimicrobial activity of Nickel complexes when compared with the ligands was high in case of complexes [1] A number of scientists have proved the importance of nickel in the emerging field of the pharmaceutical chemistry.

Iron (Fe)

Iron is a chemical element. It has symbol Fe (from the Latin ferrous 'Iron') and atomic number 26. It is a metal that belongs to the first transition series and group8 of the periodic table. It is by mass the most common element on the earth, forming much of the Earth's outer and inner core. It is fourth most common element in the earth crust, being mainly deposited by meteorites in its metallic state (en.m.wikipedia.org). Iron (ii) tetrahedral or pseudo tetrahedral complexes are always high spin (S= 2), octahedral or pseudo octahedral complexes may have either high spin (S= 2) or low spin (S = 0) ground states. Iron (II) complexes with S= 1 can be observed when deviation from octahedral symmetry is large. [2]

Hydrazones

Hydrazones which belong to a class of azomethines having the group—C=N—N— are interesting ligands in coordination chemistry. Introduction of a C=O group in the hydrazide part increases the electron delocalization and denticity of the hydrazones and the resulting compound is known as *an* ***aroylhydrazone*****.** [3].



Hydrazone **Aroylhydrazone**

Fig. 1 1-hydrazone and aroylhydrazone structure [5]

MATERIAL AND METHOD

C, H, and N analyses were performed by perkin-Elmer 2400 instrument. Ftir spectra (4000-600 cm^{-1}) as KBr discs of the samples were recorded on a jasco-460 plus spectrophotometer. Electronic spectra were obtained using a cecil ce7400, 7000 series, uv/vis spectrophotometer. Magnetic susceptibility was measured with a sherwood scientific msbmk1 sample magnetometer with $Hg\ [Co\ (SCN)_4]$ as calibrant.

Chemicals and solvents:

Chemicals used are of high purity and were used without further purification. Hydrazine hydride, diethyl ether, calcium chloride, methyl benzoate, methyl salicylate, benzaldehyde, triethyl mine and acetophenone were obtained from loba chemie laboratory reagents and fine chemicals. Methyl anthranilate, cobalt chloride (hexahydrate) and cupric chloride (hexahydrate) were obtained from ASES chemical works (laboratory chemical division), jodhpur (india). Methanol and ethanol were used as solvents and were obtained from sigma-aldrich.

Synthesis of ligands

acetophenone anthranoylhydrazone *ligand* ***($L_1^AH_1$)***

The ligand Acetophenone anthranoylhydrazone ($L_1^AH_1$) was prepared by modifying the procedure in [8]. Through reacting 2-aminobenzoylhydrazide (1.51 gm / 10 mmol) and acetophenone (1.19 gm / 10 mmol) in 25mL of absolute EtOH. Three drops of conc. HCl were added and the resulting solution was refluxed for 3 h. The compound precipitated upon cooling to room temperature, was collected by filtration and recrystallized from EtOH and dried over fused $CaCl_2$

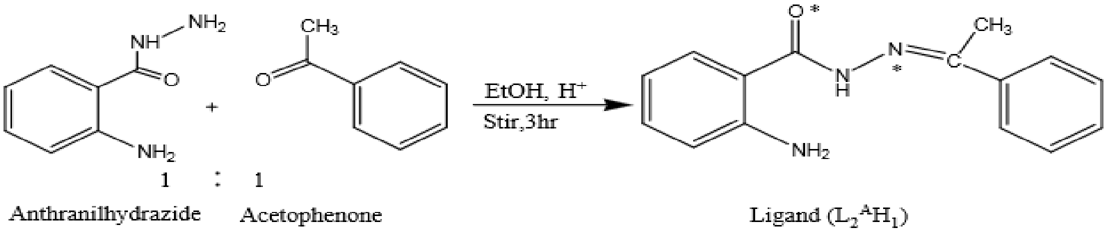


Fig.2 synthesis of ligand (L_1^AH)

Benzaldehyde Benzoylhydrazone Ligand (L_2^BH)

The ligand Benzaldehyde Benzoylhydrazone($L_2^BH_1$) was prepared by adopting the procedure in [6], with little modification, through the reaction of benzoylhydrazide (1.36 gm / 10 mmol) and benzaldehyde (1.19 gm / 10 mmol) in 25mL of absolute EtOH. Three drops of conc. HCl were added, and the resulting solution was refluxed for 3 h. The compound precipitated upon cooling to room temperature, was collected by filtration and recrystallized from EtOH and dried over fused CaCl2.

synthesis of the metal complexes:

Complex 1, [Ni^{2+} ($L_1^AH)_2$]:

The complex of Nickel was prepared by modifying the procedure in [8]. 0.506 gm / 2.00-mmol sample of ligand $L_2^AH_1$ was dissolved in 30 ml of methanol and (0.238gm/1.00-mmol) of $NiCl_2.6H_2O$ was added to the solution. Color of the solution slowly changed to wine red. After 3 hour of refluxing, the remaining product was filtered, washed with methanol and dried over Calcium chloride ($CaCl_2$), in which red colored crystals were produced

Complex 2, [Fe^{2+}($L_1^AH)_2$]

The complex of Iron was prepared by modifying the procedure in [8]. 0.506 gm / 2.00-mmol) sample of ligand $L_2^AH_1$ was dissolved in 30 ml of methanol and 0.238gm/1.00-mmol of $FeCl_2.6H_2O$ was added to the solution. Color of the solution slowly changed to light brown. After 3 hour of refluxing, the remaining product was filtered, washed with methanol, followed by ether and dried over $CaCl_2$, in which brown colored crystals were produced.

Complex 3, [Ni^{2+} ($L_2^BH)_2$]:

A (0.448gm /2.00-mmol) sample of ligand L_2^BH was dissolved in 30 ml of methanol and (0.238gm /1.00-mmol) of $NiCl_2.6H_2O$ was added to the solution, to this solution drop of Et3N was added. Color of the solution slowly changed to dark pink. After 3 hr of refluxing, the remaining product was filtered, washed with methanol and dried over $CaCl_2$, in which red colored crystals were produced. This modified procedure adopted [9]

Complex 4, [Fe^{2+} ($L_2^BH)_2$]:

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The complex of Iron was prepared by modifying the procedure in [9]. 0.448gm /2.00-mmol sample of ligand L_2^BH was dissolved in 30 ml of methanol and (0.238gm /1.00-mmol) of $FeCl_2.6H_2O$ was added to the solution, to this solution drop of Et3N was added. Color of the solution slowly changed to light green. After 3 hr of refluxing, the remaining product was filtered, washed with methanol, followed by ether and dried over $CaCl_2$, in which green colored crystals were produced.

RESULT AND DISCUSSION

The ligands and the complexes have been characterized on the basis of IR spectral data, UV-VIS spectral data, magnetic susceptibility, elemental analysis molar conductivity. I have successfully characterized all the complexes; the different results were presented below:

Table 1: I.R spectral data of the Ligands

Ligands	v(C=N)	v(C=0)	v(N-H)	v(N-N)
$L_2^AH_1$	1609	1669	3067	1110
$L_1^BH_1$	1603	1632	3075	1124

Table 2: I.R spectral data of Nickel (II) Complexes

Complexes	v(C=N)	v(C-O)	v(N-N)	v(Co-O)	v(Co-N)
Ni $[L_2^AH_1]_2$	1607	1348	1155	488	429
Ni $[L_1^BH_1]_2$	1590	1335	1140	426	456

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Table 3: I.R spectral data of Iron (II) Complexes

Complexes	ν(C=N)	ν(C-O)	ν(N-N)	ν(Cu-O)	ν(Cu-N)
Fe $[L_2{}^AH_1]_2$	1594	1233	1140	486	420
Fe $[L_1{}^BH_1]_2$	1591	1244	1155	480	419

Spectral characteristics

Infrared spectra

Infrared spectra of the hydrazones were recorded on a JASCOFT-IR-5300 spectrometer in the 4000-400 cm^{-1}range using KBr pellets. The significant bands observed in the IR spectra of the hydrazones along with their relative assignments are presented in the Table 2.1. FT-IR spectral data of the compounds are in accordance with their molecular structure. In the IR spectra of hydrazones, ν(C=N) bands are observed in the1597-1609 cm^{-1} range indicating the condensation of hydrazide and the aldehyde/ketone moiety and it is in agreement with the literature reports of hydrazones [40]. In the IR spectra of hydrazones the ν(C=O) stretching vibrations are observed at 1669, 1632 and 1683 cm^{-1} for $L_1{}^AH_1$, $L_2{}^BH_1$ and $L_3{}^SH_1$ respectively suggesting that the hydrazones exist in the amido form in the solid state as in [10]. This is further supported by medium bands in the 3067-3186 cm^{-1}range due to ν(N–H) vibration. The N−N stretching vibrations are found in the 1102-1127 cm^{-1}region.Coordination of iminolate oxygen is consistent with the presence of new bands in the 1335-1348 cm^{-1}region, assignable to ν(C–O) stretching vibration for these complexes. This is further confirmed by the appearance of new bands in the 488-559 cm^{-1}region assigned to ν(Co–O). The bands corresponding to the stretching vibration azomethine group of the free hydrazones which appeared in the 1603-1609 cm^{-1}region have been shifted to 1592-1603 cm^{-1}region in the spectra of the complexes indicating the coordination of the azomethine nitrogen to the central metal ion. This is further corroborated with the appearance of new bands in the 1519-1523 cm^{-1}region due to the newly formed C=N moiety. Bonding through the N of the azomethine group as in [1]

Table 1: Molar Conductivity & Magnetic susceptibility of Nickel II Complexes and Iron II complexes (Molar conductivity (in mho cm^2 mol^{-1}) taken in 10-3M DMF

Complexes	$\lambda m^{\sharp}$	μ_{eff} (BM)
Ni $[L_1{}^AH_1]_2$	15	4.60
Ni $[L_2{}^BH_1]_2$	10	4.42
Fe $[L_1{}^AH_1]_2$	8	1.80
Fe $[L_2{}^BH_1]_2$	5	1.90

Magnetic studies

The Ni (II) complexes and the Fe (II) complexes were found to be paramagnetic which excludes of square planar configuration. The measured magnetic moment value for Nickel (II) complexes were found to be in the range of 4.60-4.42 BM (theoretical value 3.84 BM) and for Iron (II) complexes in the range of 1.80-1.90BM (theoritical value 1.73BM) are evidence for tetrahedral geometry This higher experimental values may be due to orbital contribution.

Expected geometry of Ni (II) and Fe (II) complexes

Having all the characterization data of all the Six Nickel (II) and Iron (II) complexes we can predict from the preliminary finding, that the geometry of these complexes is tetrahedral geometry, as the final structure can be predicted after having the corresponding X-ray crystallography.

Table 5: Zone of inhibition of Fe Complex Benzaldehyde Benzoylhydrazone Ligand

Microorganism	75mg/ml	50mg/ml	25mg/ml	Control mg/ml
E. coli.	15mm	10mm	6mm	
Staph..	12mm	8mm	4mm	
ASP.	14mm	10mm	5mm	

Key: *E. coli= Escherichia coli, Staph = Staphylococcus Aureus,* ASP = *Aspergillus*

Table 6: Zone of inhibition of Benzaldehyde Benzoylhydrazone Ligand (L_2^BH)

Microorganism	75mg/ml	50mg/ml	25mg/ml	Control mg/ml
E. coli.	13mm	9mm	5mm	
Staph..	9mm	6mm	4mm	
ASP.	14mm	9mm	6mm	

Key: *E. coli= Escherichia coli, Staph = Staphylococcus Aureus,* ASP = *Aspergillus*

Antimicrobial Result

The results of hydrazone ligands and their Ni^{2+} and Fe^{2+} complexes indicate activity against all the isolates tested even at lower concentration. The result also shows that hydrazone has less antimicrobial activities (13mm, 9mm and 14mm at 75) than the Iron (II) complex (15mm, 10mm and 14mm at 75 concentration). The largest zones of inhibition of the hydrazone complex of Iron occurred with E. coli and Aspergillus 15 mm and 14mm respectively at 75 mg/ml (table 5). *Staphylococcus Aureus* shows the lowest zone of inhibition of 12mm, 8mm and 4mm as the concentration of the compound decrease from 75 mg/ml, 50 mg/ml and 25 mg/ml.

In general, all the compound reveals good zone of inhibition in different concentration to both in fungi and bacteria isolate, this shows that the hydrazone and its complexes have anti-fungi (Aspergillus *Spp.)* and anti-bacteria component in them addition to anti-inflammatory and analgesic properties reported [11]. Thus, the compound can also be used to treat Aspergillus *Spp.* Staphylococcus aureus and Escherichia coli.

CONCLUSION

Two bidentate O-N donor Schiff's base of hydrazone ligands were synthesized and successfully characterized by IR and UV spectrophotometer, C H N analyzer and magnetic susceptibility measurement. The basic and electronic properties of these ligands have been nicely explored in the syntheses of various Nickel and Iron hydrazone complexes. All the complexes are characterized by elemental analysis, IR, UV-Visible spectrophotometer, conductivity measurement and magnetic susceptibility measurement. The result shows that all the complexes are non-electrolytes and paramagnetic. From the preliminary findings, the complexes were also suggested to have tetragonal geometry. Both the ligands and the complexes show high antibacterial activities against grams positive and gram negative Escherichia coli (15mm, 10mm and 6mm), Staphylococcus Aureus (12mm, 8mm and 4mm) and Aspergillus (14mm, 10mm and 5mm). Similarly, the result shows that the complexes shows better antibacterial effect than the ligands.

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