Introduction

Metal ions play a vital role in a vast number of widely differing biological processes. The role played by metal ions in bio-molecules has been considered as fascinating phenomenon by coordination chemist. This is because metal chelation involved in many biological processes [1-4].

For many years transition metal complexes have gained considerable interest due to their efficient DNA binding and cleavage properties under physiological conditions for varied applications of such complexes in nucleic acid chemistry [5-24]. Interaction of metal complexes with nucleic acids and investigation of cleavage mechanism have gained much more attention due to their great importance in design of new chemotherapeutic agents, biotechnological manipulation of genetic material, development of tools or probes for the study of nucleic acid structures, or development of new drug [25-28].

Nucleic acids provide exciting and difficult challenges for chemists and biochemists. They are inherently important, yet highly complex to study. Many aspects of nucleic acid biochemistry are widely appreciated throughout the scientific community.

The recognition that DNA serves as a target for natural and artificial molecules in the inhibition of cellular disorders and in therapy of certain diseases is of paramount importance in bioinorganic chemistry [29-31]. There was a sudden eruption in the design and synthesis of artificial compounds that can bind or/and

cleave DNA. Organic reagents for DNA modification often rely upon transition metal ions [32].

The utility of these compounds (nucleases) is enormous and ranges from the creation of synthetic restriction enzymes for use by molecular biologists to the development of chemotherapeutic agents that may be effective against a variety of neoplastic diseases. Nucleases have become the molecular scalpels of the biochemists and the indispensable tools for analyzing DNA structure.

In the past few years, multinucleartiy has been one of the successful strategies to increase the efficiency and selectivity of the metallo nucleases due to the potential cooperative effects between the metal centers [33-38]. The DNA binding and cleavage properties of lanthanide complexes under physiological conditions [39,40] have attracted much attention and curiosity of bio-inorganic chemists.

Metal-DNA binding ensures a new area of research with therapeutic application. The mode of binding of metal complexes with DNA may be divided into three categories. They are: a) Co-ordination, b) Intercalation and c) Hydrogen bonding. *Cis* platin a potential anti cancer drugs binds DNA in N-7 position guanine [41].

It will be of interest to elucidate the factors that affect the binding of metal complexes with DNA. Important factors are (i) shape of the complex, (ii) size of complex, (iii) presence of other ligands and (iv) presence of hydrogen bonding.

One of the most of significant factors contributing to the binding of complexes on DNA helix is shape of molecule. Metal DNA interactions may be studied with physical and spectral techniques such as (1) Temperature denature studies (2)Viscometary (3) Electron Microscope, (4) X-ray crystallography, (5) NMR spectroscopy, (6) spectrophotometry and (7) spectrofluorimetry.

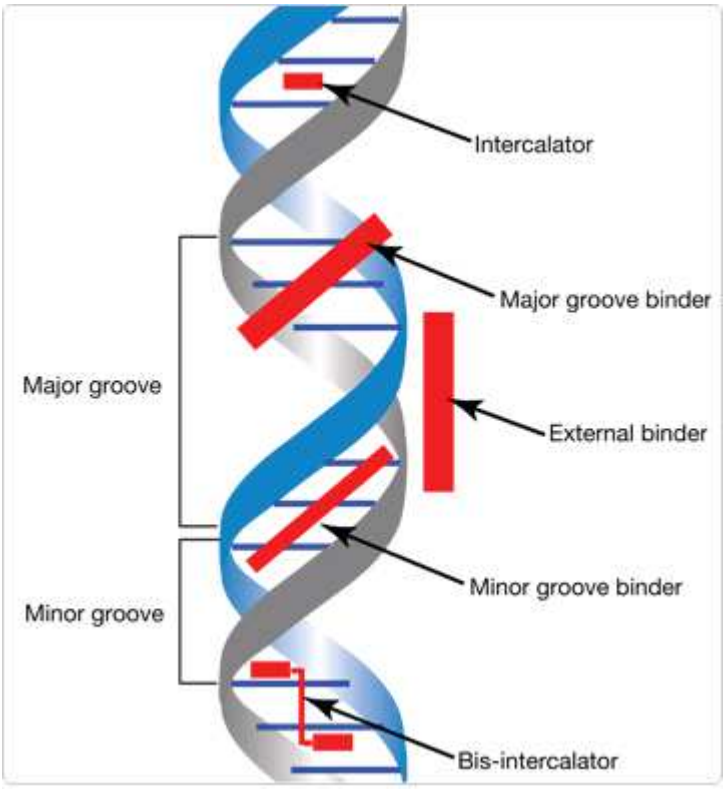
Metal DNA interaction has been studied in our laboratory by using spectrophotometry. Binding constants have been calculated using data obtained in spectrophotometric analysis.

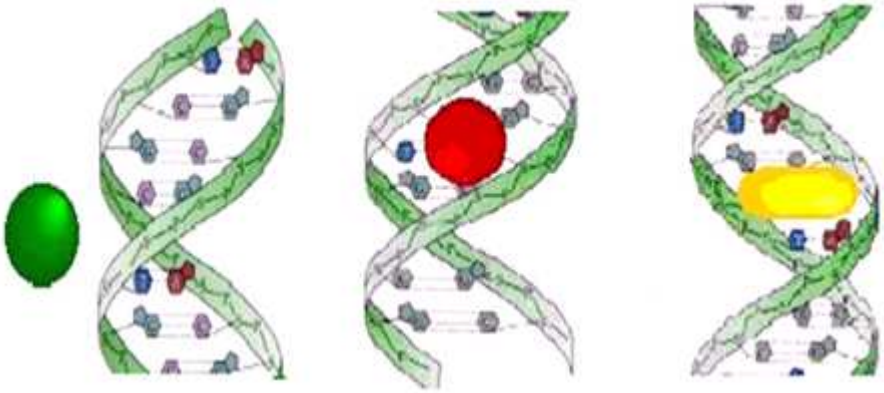
(i) Binding Modes

The complex is bound to DNA through three non covalent modes. They are external static electronic binding (Electrostatic attraction), groove binding and intercalation. The binding modes are shown in Fig.1.1

(a)Electrostatic Attraction

The luminescence of a complex may be enhanced upon binding with DNA. This is due to coulombic attraction between positively charged complex and negatively charged DNA. When the luminescence of complex in the presence of DNA depends on pH (ion concentration), it is referred as electrostatic interaction. For example the interaction between $Ru(bpy)_3]^{2+}$ (bpy = bipyridine) and DNA. It is of electrostatic attraction [42].





External Binding **Groove binding** **Intercalation**

Fig. 1.1: Different types of binding modes of DNA with metal complexes.

(b) Adsorption of the complex in DNA grooves

The molecule approaches within V*an der Waals* contact and resides in the DNA groove. Hydrophobic and/or hydrogen-bonding are usually important components of this binding process, and provide stabilisation. The antibiotic netropsin is a model groove-binder. Geometric and steric factors also play a role as shown with $[Ru(TMP)_3]^{2+}$ (TMP = 3,4,7,8-tetramethyl phenanthroline) where the methyl groups prevent intercalation [43].

(c) Intercalation of a planar ligand of the complex in the DNA base pairs stack

This association involves the insertion of a planar fused aromatic ring system between the DNA base pairs, leading to significant π-electron overlap. This mode of binding is stabilized by stacking interactions and is thus less sensitive to ionic strength relative to the two other binding modes. This mode of binding is usually favoured by the presence of an extended fused aromatic ligand as 4, 7 – diphenylphenanthroline (DIP) [44] or Dipyridophenazine (DPPZ) [45]. Indeed with less extended aromatic systems, the intercalation is usually prevented through clashing of the ancillary ligands with the phosphodiester backbone, so that only partial intercalation can occur as it is the case for $[Ru(phen)_3]^{2+}$ [46].

A major current research interest in bioinorganic chemistry is concerned with binding and cleavage of DNA by metal complexes. It is due to the utility of these complexes in the design and development of synthetic restriction enzymes, new drugs, DNA foot printing agents etc., [47-49]. Lewis acidic metal centers are chemically well suited to influence fundamental cellular processes [50-52] because of

their affinity for basic nitrogen and oxygen donor ligands, as well as their capacity to support larger aromatic architectures capable of π interactions with the nucleic acid building blocks. Their ability to directly hydrolyze phosphodiester linkages as well as promote redox chemistry or generate reactive oxygen-derived species further accentuates their natural aptitude for participation in cellular functions involving nucleic acids. Because binding and cleavage of nucleic acids lies at the heart of cellular transcription and translation, these substrates are obvious targets for therapeutic intervention and the development of diagnostic probes of nucleic acid structure.

The numerous biological experiments performed so far suggest that DNA is the primary intracellular target of an anticancer complex. Because these interactions can cause DNA damage in cancer cells, blocking the division of cancer cells and resulting in cell death [53].

Cleavage of DNA by metal complexes generally follows three major pathways, viz., oxidative cleavage by abstraction of a sugar hydrogen atom, hydrolytic cleavage involving a phosphate group, and damage of DNA by oxidation of bases, primarily at the guanine site.

Basic elements of DNA structure

DNA may be viewed [54] as a double-helical, assembly of the polynucleotides held together by hydrogen bonding and hydrophobic forces. Each polynucleotide includes a backbone of 2'-deoxy ribose and phosphate moieties condensed together to form an alternating polymer (Fig. 1.2). The phosphodiester links involve the 5' and 3'

oxygen of sugar and as a result, the polymer normally has terminal 5'- and 3'-phosphate ends. In addition, each sugar residue in the chain has a purine (adenine or guanine) or a pyrimidine (thymine or cytosine) bases covalently linked to its 1'-carbon.

Naturally occurring DNA molecules (A and B forms) [55] are generally right hand helices. The B-form of DNA is a classic Watson-Crick structure. It has 11 base pairs per turn and the base pairs are perpendicular to the helix axes. B-Form DNA can be viewed as a twisted ladder with base pairs as the rungs and sugar-phosphate chains as the sides. The A-form of DNA entails a different sugar conformation and represents a coiled form of a double helix. In this structure the major groove is narrower and deeper, and the bases are no longer perpendicular to the helix axis.

The third structure, Z-form DNA is left-handed, the sugar phosphate backbone follows zig-zag path. It has a single groove in the helix in contrast to the major and minor grooves found in the classic form of B-DNA

The width of each base pair is similar contributing to the smooth cylindrical shape of the double helix. The base pairs are rotated by 36° with respect to each adjacent pair so that there are ten pairs per helical turn [56], each represented by 3.4 A˚. This gives rise to two well defined channels known as minor groove and major groove. The major groove is approximately 24 A˚ in width and much deeper than minor groove which is only 10 A˚ in width

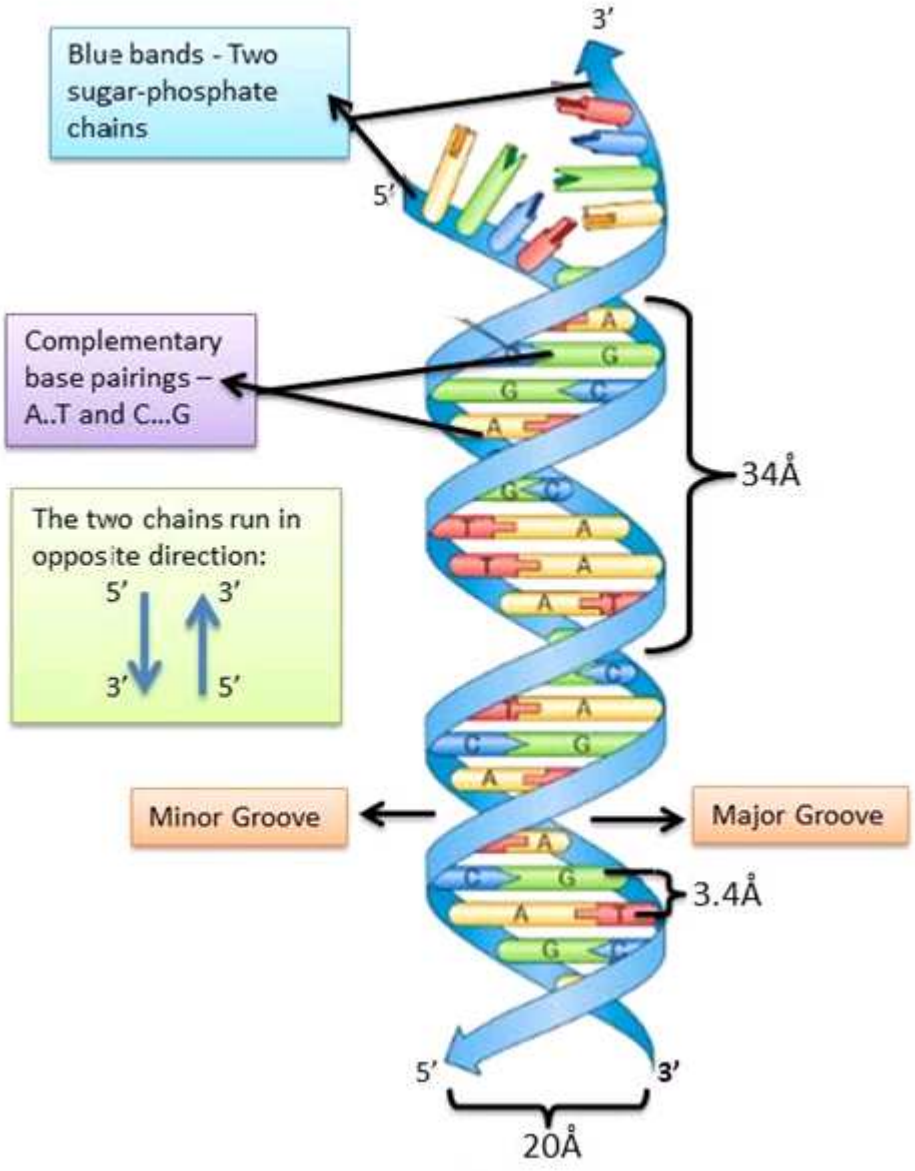


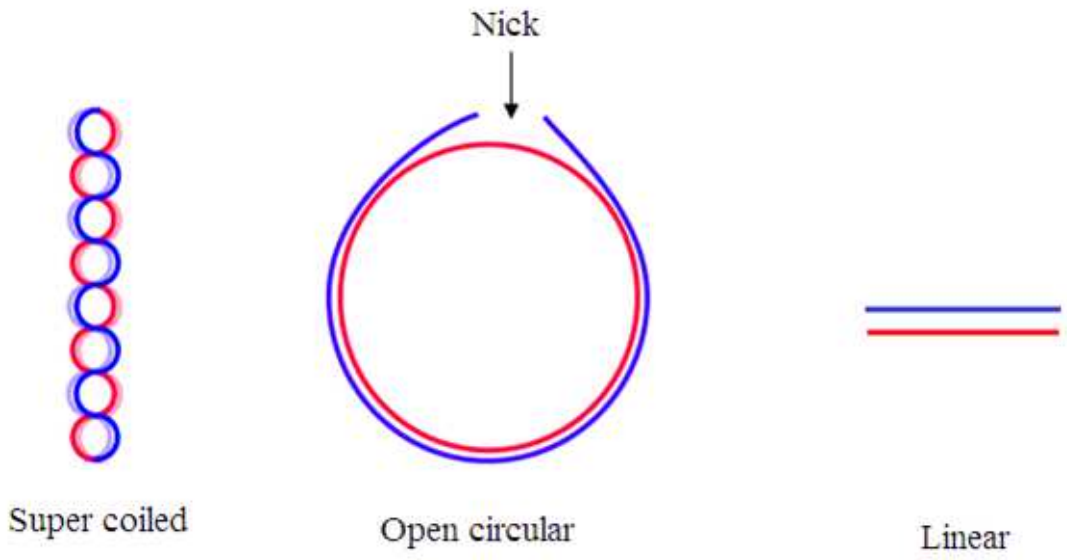
Fig. 1.2: Double helical structure of DNA in the common B form

Gel electrophoresis : Forms of DNA

The pBR 322, a double stranded circular plasmid DNA exist in three forms, i.e. super coiled, relaxed circle (open circle) and linear. Pure DNA generally consists of only super coiled and open circular (nicked) forms.

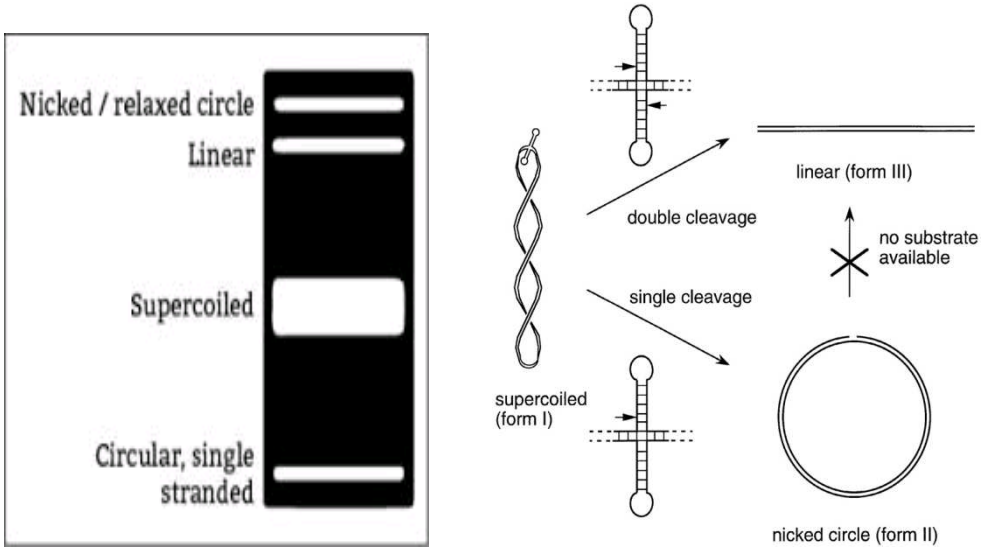
The double helix represents DNA as a linear molecule. But DNA *in vivo* generally has a closed structure and it lacks freedom. The genomes of some small viruses actually consist of circular DNA, in which both strands of the double helix run continuously around the circle.

Super coils are introduced into DNA when a duplex is twisted in space around its own axis. The usual anology is to consider a rubber band twisted about itself to generate a tightly coiled structure in which the rubber band (the double helix) crosses over itself in space.



Super coiling can occur only in closed structures, because an open molecule can release the torsion simply by untwisting. A closed molecule must have no breaks on either strand of DNA, a break even in one strand of a circular molecule allows untwisting. A molecule that lacks super coiling whether closed or open is said to be relaxed (nicked). Physical stressing (or) some chemical treatment can cause to cut the relaxed circle (nicked) and give linear DNA.

The cleavage reactions on plasmid DNA can be monitored by agarose gel electrophoresis. When circular plasmid DNA is subjected to electrophoresis, relatively fast migration will be observed for the intact supercoil form (From I). If scission occurs on one strand (nicking), the supercoiled will opens to generate a slower-moving open circular form (From II). If both strands are cleaved, a linear form (From III) that migrates between Form I and Form II will be generated [57]



Schematic representation of unselective cleavage on a DNA plasmid. On the left, a schematic lane from an electrophoresis gel is depicted. Bands are annotated next to this lane.

A REVIEW ON LANTHANIDE COMPLEXES OF ACETOYL AND AROYL HYDRAZONES BEARING PYRIDINE MOIETY

1. **Introduction**
2. **Synthesis of hydrazones**
3. **Denticity of pyridine hydrazones**
4. **Tautomeric forms of pyridine hydrazones**
5. **Chelating behaviour of pyridine hydrazones**
6. **Scope of the Review**
7. **Literature on lanthanide complexes of hydrazones**
8. **General features and Recent Applications**
9. **DNA studies**
10. **Conclusions**

1. Introduction

Hydrazones are a versatile class of compounds which present a wide range of biological applications as antimicrobial [58], antitubercular [59], anticonvulsant[60], anti- inflammatory[61], cytotoxic[62] and vasodilator [63] agents. Further, quinoxaline-*N*-acylhydrazones showed trypanocidal activity [64]. In addition, methyl pyrazinylketone isonicotinoyl hydrazones have been synthesized in an attempt to develop novel chelators with high affinity for iron for the treatment of iron overload disease.[65] Hydrazones are also proved to be useful as sensitive analytical

reagents for the determination of trace amounts of metal ions [66,67]. Metal complexes with hydrazones have potential applications as catalysts[68], luminescent probes[69], and molecular sensors[70]. Moreover, metal complexes with hydrazones present antimicrobial[71-73], DNA-binding and cytotoxic activities[74]. It has also been shown that metal complexes with hydrazones can be potent inhibitors of cell growth and DNA syntheses[75].

Hydrazones are important class of compounds for drug design , as possible ligands for the synthesis of metal complexes, in organic catalysis and also for the synthesis of heterocyclic compounds[76-85] Hydrazones and their metal complexes have been found to be potential application in industry and biology. The ease of preparation, increased hydrolytic stability relative to imines, and tendency toward crystallinity are all desirable characteristics of hydrazones. Due to these positive traits, hydrazones have been under study for a long time, but much of their basic chemistry remains unexplored.

Acyl and aroylhydrazone-type ligands have a large number of potential donor atoms; hence they display versatility in metal coordination. The mode of coordination depends on the nature of the central metal atom, the type of ligand as well as on the presence of other species capable of competing for coordination sites. Aroylhydrazones, as well as their metal complexes, have interesting and important biological properties such as anti-bacterial, anti-fungal, anti-oxidant, and anti-cancer properties.

Compared to simple hydrazone Schiff bases, acetoylhydrazones and aroylhydrazones have an additional donor site in >C=O functional group. This introduces a wide range of properties in them. Hydrazones of variedly substituted

formyl, acetyl, malonyl, oxalyl, succinyl, benzoyl, picolyl and quinolyl hydrazones with flexidentate and ambiprotic properties are reviewed in the year 1985 by Dutta and Hossain [86]. The related reviews on the applications of hydrazones and their metal complexes are well contributed by Rollas et al[87] Bakuleva et al[88] Shakdofa et al[89] and Ivan et al[90].

: Metal complexes have played an important role in the fields of Biology and Medicine. A great deal of work has been carried out on the synthesis and characterization of transition metal compounds, mainly due to their applications in various fields. However, the ability of the metal ion to participate in bonding depends on preference for the donor atoms of the coordinated ligand, flexibility and conformational adaptability of the ligand used, as well as the competition from other Lewis acids.

The architectural beauty of coordination compounds arises due to the interesting ligand systems containing different donor (N, O, S) sites in heterocyclic rings. Among the ligand systems, hydrazones occupy special place in coordination chemistry. This is because these complex systems are extensively used in analytical [91,92], inorganic, bioinorganic, medicinal and in industrial applications [93-97].

2. Synthesis of hydrazones

Hydrazones are obtained by the **condensation** of hydrazide with aldehydes and ketones. Substituted hydrazones can be obtained by introducing substituents either in hydrazide or carbonyl compounds or in both. A general formula for a substituted acetoyl/ aroylhydrazone is shown in **Fig 2.1.**

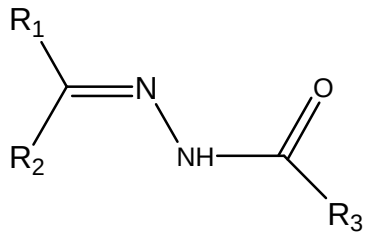


Fig 2.1: A general formula of hydrazone

3. Denticity of pyridine hydrazones

Azomethine nitrogen and amide oxygen are available donor sites in hydrazone compound. Further the number of coordination sites can be increased by suitable substitution on the hydrazone frame work. If a hetero ring is attached to the hydrazone frame work, the hetero atom can also coordinate to the metal center thus increasing the denticity as shown in **Fig 2.2**

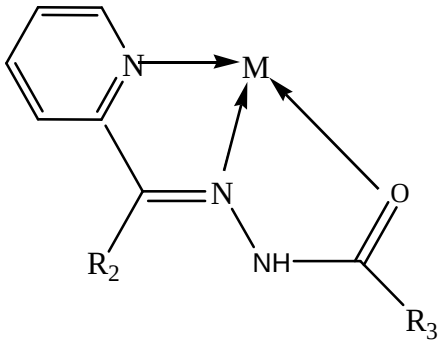
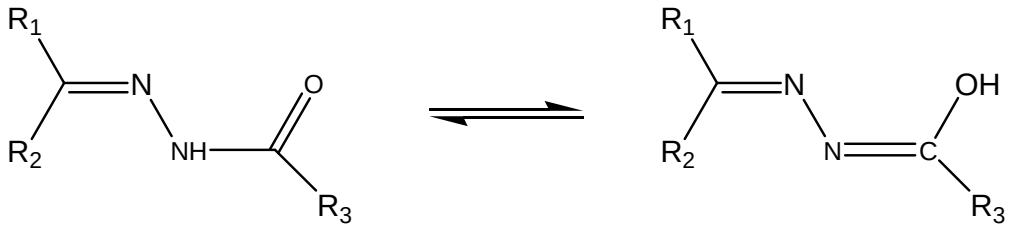


Fig 2.2: Denticity of acetuyl/ aroylhydrazone bearing pyridine moiety

4. Tautomeric forms of pyridine hydrazones

In hydrazones it is well known that a proton transfer can occur between the hydrazine nitrogen and keto group of hydrazide part. Therefore, tautomeric equilliun exists between amido form and iminol form through intramolecular proton transfer. This proton transfer causes a change in the π- electron configuration and thus increases conjugation. Thus these hydrazones can be present either as neutral amido

form or as deprotonated from. In soid solid state, hydrazones predominantly exist as amido form(I), whereas in solution iminol form(II) dominates **(Fig 2.3)**. This is well established from IR spectral studies and X- ray crystal structures.

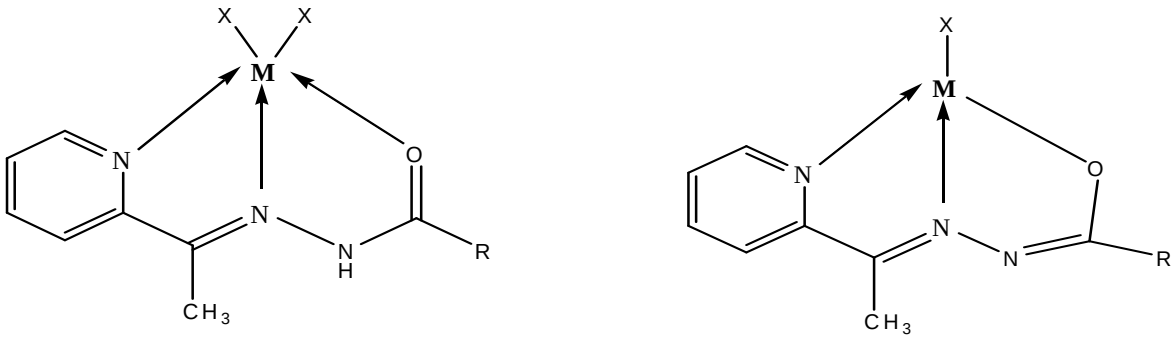


(I) (II)

Fig 2.3: Tatomeric forms of hydrazone

5. Chelating behaviour of pyridine hydrazones

The chelating behaviour **(Fig 2.4)** depends on their amido-iminol tautomerism. The number and type of the substituents attached to the hydrazone frame work influences the coordination mode. The expected donor sites in simple hydrazones are azomethine nitrogen and amide oxygen. In addition to this, if the carbonyl part contains a ring with hetero atom, the hetero atom (like oxygen, nitrogen or sulphur) can coordinate to metal centre thus behaving as a tridentate ligand. Due to tautomerism in hydrazones the amide oxygen and be in neutral keto from (structure I) or enolic form structure (II). **The actual ionization state is dependent on upon the condition (pH of the medium) and the metal salts employed**. In basic solution, amide oxygen get deprotonated and coordinate to the metal ion in enolic form. In acidic medium deprotonation does not occur and the ligand binds metal via keto group of hydrazide part.



Structure I Structure II

Fig 2.4: Chelating behaviour of hydrazones

The coordination chemistry of lanthanide is fascinating because they have a tendency to form complexes with coordination number greater than **six,** and even up to **twelve.**

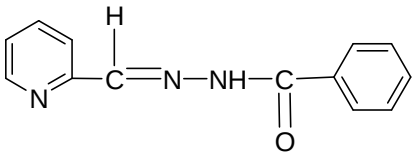
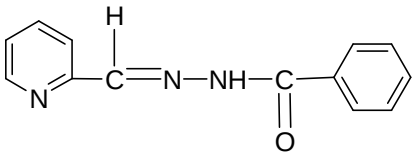
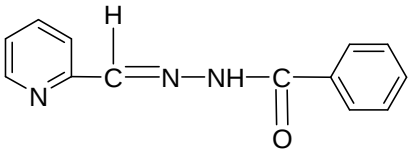
6. Scope of the Review

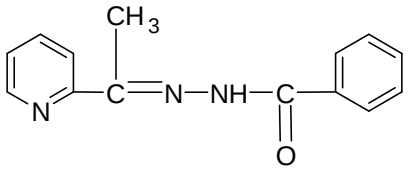
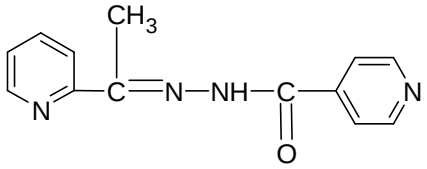
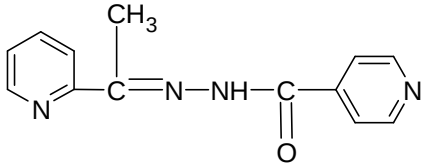
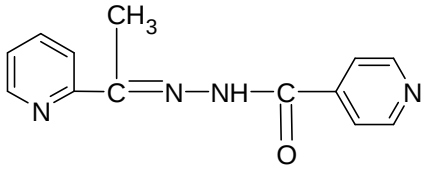
The present work deals with investigations on lanthanide complexes of acetoyl and benzoyl hydrazones bearing pyridine group. Hence, only mononuclear lanthanide (III)complexes of viz. acetoylhydrazones and aroylhydrazones bearing pyridine moiety will be cited in this review . Hydrazones ligands containing two or three hydrazone moieties viz. bis(hydrazones) or tris (hydrazones) will not be mentioned here.

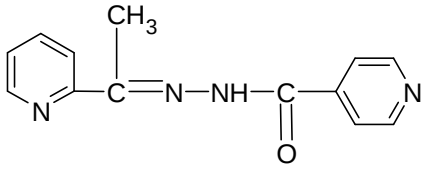
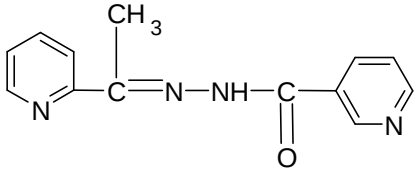
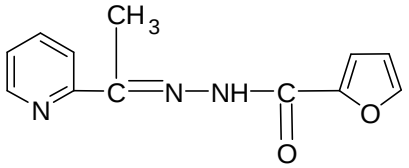
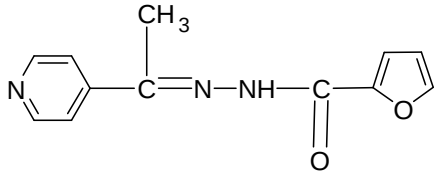
7. **Literature on lanthanide complexes of hydrazones bearing pyridine moiety**

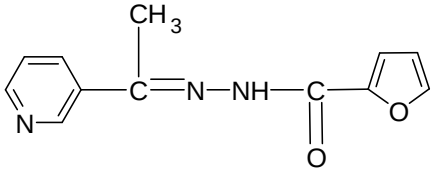
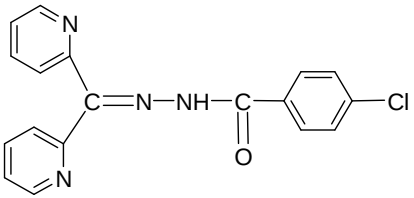
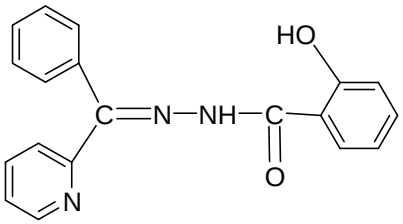
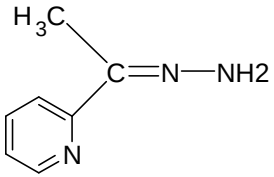
Coordination number, geometry, general formula and applications of lanthanide complexes of hydrazones bearing pyridine moiety [98-111] are summarized in **Table 2.1.**

Table 2..1 A summary of lanthanide complexes of hydrazones bearing pyridine moiety

S. No	Name of the compound	Structure of the ligand	C.N and Geometry of the complex	Genaral formula of the complex	Studies	Ref
1	2-Forylpyridine benzoyl hydrazone		12 and Distorte icosahedron (X-ray)	[Ce $(PBH)_2(NO_3)_3$]. $C_3H_6O.2H_2O$	…	98
2	2-forylpyridine benzoyl hydrazone		10 and Distorted bi capped square antiprism (X-ray)	$[Ln(PBH)_2(NO_3)(NCS)(H_2O)]NO_3{\cdot}n$H2O Ln = La, Ce, Pr	…	99
3	2-forylpyridine benzoyl hydrazone		10 and Distorted bi capped square antiprism (X-ray)	[Ln(PBH)2(NO3)2] NO3·*x*H2O for x = 6 Ln = Y, Nd, Gd and for x = 5 Ln = Eu, Tb, Dy, Ho, Er, Yb,	…	100

S. No	Name of the compound	Structure of the ligand	C.N and Geometry of the complex	Genaral formula of the complex	Studies	Ref
4	2-acetylpyridine benzoyl hydrazone		12	$Ln(L)_2(NO_3)_3 . nH_2O$ Ln = La, n = 5.5 = Ce, Pr n = 5 = Nd, Eu n = 4	Luminescen-ce	101
5	2-acetylpyridine isonicotinoyl hydrazone		12 bicapped pentagonal-antiprism (X-ray)	$[Ce(NO_3)_3(C_{13}H_{12}N_4O)_2]$	…	102
6	2-acetylpyridine isonicotinoyl hydrazone		9 9	$M(2\text{-}ApINH)_2Cl_3]$ $[M'(2\text{-}ApINH\text{-}H)_3]$ and $[Eu(2\text{-}ApINHH)_2(OH)]$	…	103
7	2-acetylpyridine isonicotinoyl hydrazone		8 7	$[M(2\text{-}ApINH)_2Cl_2]Cl$ M = Y, Gd, Tb, DY $[M(2\text{-}ApINH\text{-}H)_2OH]$ M = Y, Gd, Tb, DY	…	104

S. No	Name of the compound	Structure of the ligand	C.N and Geometry of the complex	Genaral formula of the complex	Studies	Ref
8	2-acetylpyridine isonicotinoyl hydrazone		10 Distorted bi capped square antiprism (X-ray)	$[Ln(L)_2(NO_3)(CH_3OH)_2]. CH_3CH_2OH$ Ln = Pr, Nd	DNA binding, Anti oxidant	105
9	2-acetylpyridine nicotinoyl hydrazone		8	$[Ln(Hapnh)Cl_2]Cl\cdot nH_2O$ Ln = Pr, Nd, Sm, Dy	…	106
			9	$[Ln(apnh)_3]$ Ln = Pr, Nd, Sm, Dy		
10	2-acetylpyridine-2-furoyl hydrazone		7	$[M(Hapfh)_2Cl]Cl_2$ and $[M(apfh)_2OH]$ M=La, Pr, Nd, Eu, Dy		107
11	4-acetylpyridine-2-furoylhydrazone		8	$[Ln(apfh)_2Cl_2]Cl$ Ln = La, Pr, Nd. Sm. Eu. Gd. Tb. Dy	…	108

S. No	Name of the compound	Structure of the ligand	C.N and Geometry of the complex	Genaral formula of the complex	Studies	Ref
12	3-acetylpyridine-2-furoylhydrazone		8	$[Nd(apfh')_2Cl2]CI$	…	108
13	di-2-pyridyl ketone-*p*-Cl-benzoylhydrazone		8	$[Ln(DpkClBH)_2(NO_3)_2]$ $NO_3 \cdot nH_2O$ Ln=Y, Gd, Tb, Ho, Er,	Thermal behaviour	109
14	2-benzoylpyridine Salicylohydrazone		9 Distorted tri capped trigonal prism (X-ray)	$[Sm(BPSH)_3]$	…	110
15	2-acetylpyridine hydrazone		9 (X-ray)	$[Ln_2(CH_3COO)_4(NO_3)_2$ $(aphz)_2]$ Ln = Eu, Tb, Dy	Magnetic properies	111

Lanthanide (III) chloride complexes with Schiff's base obtained by the condensation of 2-benzimidazolyl mercaptoaceto hydrazide and **2-acetyl pyridine** have been prepared and characterized on the basis of elemental analysis, molar conductance, magnetic, electronic, infrared and 1H NMR spectral studies. IR and ^{1}H NMR spectra indicates coordination through azomethine nitrogen, pyridine ring nitrogen and the carbonyl oxygen of the hydrazone moiety. A coordination number eight is suggested for these complexes. The ligand and complexes were screened for their antimicrobial activity [112].

A new ligand, 3-carbaldehyde chromone-(benzoyl) hydrazone (L), was prepared by condensation of 3-carbaldehyde chromone with benzoyl hydrazine. Its four rare earth complexes have been prepared and characterized on the basis of elemental analyses, molar conductivities, mass spectra, ^{1}H NMR spectra, UV-vis spectra, fluorescence studies and IR spectra. The Sm(III) complex exhibits red fluorescence under UV light and the fluorescent properties of Sm(III) complex in solid state and different solutions were investigated. In addition, the DNA binding properties of the ligand and its complexes have been investigated by electronic absorption spectroscopy, fluorescence spectra, ethidium bromide displacement experiments, iodide quenching experiments, salt effect and viscosity measurements. Experimental results suggest that all the compounds can bind to DNA via an intercalation binding mode [113]. Furthermore, the antioxidant activities of the ligand and its complexes were determined by superoxide and hydroxyl radical scavenging methods in vitro. The rare earth complexes were found to possess potent antioxidant activities that are better than those of the ligand alone

7. General features and Recent Applications

. Salient features and recent applications of lanthanide complexes are summarized here .

I. The chemistry of lanthanide complexes of hydrazones has been intensively investigated in the recent year owing to their coordinative capability, their pharmacological activity and their use in analytical chemistry as metal extracting agents. Bonding between lanthanides and coordinating ligands depends on the electronegativity of the donor atom in the ligand, the bonding of ligand to lanthanide is essentially electrostatic with a little if any interactions between the 4f orbitals and the ligand orbitals. The study of complexes of hydrazones is interesting from the structural point of view. It is their ability to exist in keto or enol form depending on the experimental conditions, IR spectroscopy is extensively used to study metal complexes of hydrazones.

II. The lanthanide(III) ions have a general electronic configuration of [Xe] $4f^n$, $5s^2$, p6 , d^0. It has been suggested that the involvement of deep seated 4f orbitals during complexation with ligand orbital systems is almost negligible and the ***nephelausetic effect*** (i.e., the slight red shift in the absorption bands) is a second order phenomenon.

III. In view of their large sizes, the mode of bonding between lanthanide ions and the ligands may be considered mainly electrostatic in nature. In a given series,

increasing covalency is expected with decrease in the sizes of the central metal ions.

IV. Recent X-ray studies have radically altered the views regarding the coordination number of complexed lanthanide ions . Coordination number six with a preferred 'octahedral geometry' has been assumed for a long time on the basis of computing only the main donor atoms of the chelated ligands and ignoring the potentiality of subsidiary coordination with adduct molecules like water and intermolecular coordination e.g., $Pr_2[(CH)_3CCOCHCOC(CH_3)_3]$. Coordination numbers as high as 12 have been now established for lanthanide ions , e.g., in K_3M_2- $(NO_3)_9$ (where M = Pr, Nd and Sm). This tendency to saturate the metal coordination sphere is largely determined by geometry of the ligand.

V. Lanthanide ions behave as hard acids and are expected to form stronger bonds with ligands having 0 or N as donor atoms. In view of the lack of any directional bonding between lanthanide ions and the ligands, a kind of flexibility in accommodating the latter around the metal ions results in non-rigid (distorted) patterns for the structures of their complexes.

VI. Water of hydration plays a significant role in the formation and stabilities of coordination compounds of lanthanides. The tenaciously held water molecule (tendency increases with decrease in size) which cannot be removed without decomposition, also inhibits further coordination by other potential donors to the metal ions. The strong coordination tendency of oxy- or hydroxy- ion is probably the main driving force in such decomposition.

VII. In view of the above special characteristics of lanthanide ions, the synthetic chemistry of complex formation is rather complicated, particularly in aqueous solutions.

VIII. The unusual spectroscopic properties of the Ln(III) cations results from shielding of the 4*f* orbitals by the filled $5s^2$ and $5p^6$ sub-shells. For example, each of the elements have very characteristic and very narrow 'line-like' emission bands, mostly in the visible and near infrared range. As an example, the typical 'green' emission of Tb(III) is compared with fluorescein.

IX. The importance lanthanide complexes, as excellent diagnostic and prognostic probes in clinical diagnostics, and as anticancer drugs, are remarkably increasing. Lanthanide complex based X-ray contrast imaging and lanthanide chelate based contrast enhancing agents for magnetic resonance imaging (MRI) are being excessively used in radiological analysis in our body systems. The most important property of the chelating agents, in lanthanide chelate complex, is its ability to alter the behaviour of lanthanide ion with which it binds in biological systems, and the chelation markedly modifies the bio-distribution and excretion profile of the lanthanide ion

X. The metal-based anticancer complexes have attracted many bioinorganic chemists' interest since the success of platinum complexes as anticancer agents[114-116]. Among various metal complexes, La (III) complexes have been intensively investigated due to their more physiological activities and lower toxicities after coordination with ligand. People have paid great interest

to synthesis, DNA interaction, and anticancer activity of La (III) complexes in recent years[117-121] in order to develop novel metal-based anticancer drugs,

XI. Because of special photophysical and biological properties, lanthanide complexes can be used as biological probes in the areas of clinical chemistry and molecular biology[122]. Due to their special electronic configuration, lanthanide complexes have inspired many efforts on the design and synthesis as potential anticancer and antibacterial agents[123].

8. DNA studies

Investigation on the interactions of small molecules with DNA have attracted much attention over the past years, owing to increasing research in new efficient drugs and in many intracellular processes[124-126] . This study is of current general interest and importance, especially for the designing of new DNA-targeted drugs and the screening of these in vitro. The interaction of small molecules with the DNA is of three types: (i) electrostatic interaction with the anionic phosphate of DNA backbone, (ii) intercalation into the stacked base pairs of DNA, and (iii) groove binding [127-129]. Many chemotherapeutic agents inhibit the synthesis of the DNA by intercalation, groove-face binding or external electrostatic binding, or a covalent interaction [130].

9. Conclusions

The review revals that the hydrazones are peerless ligands and are extremely needed because of their structural, analytical and biological properties such as antitumor, antimalarial, anti bacterial, antiviral, anti inflammatory and anticonveelsant.

The metal complexes of show interesting structural and biological activities. The hydrazones show more activity in the form metal complexes. In metal complexes, the coordination reduces the polarity of the metal ion mainly because of sharing is positive charge with the donor atom within the chelate ring system. This process inturn increases liphophilic nature of the central metal atom, which favours its permeation more efficiently through lipid layer of the microorganism, thus destroying them more aggressively. The destruction of microorganism may be due its interaction with nuclicacids. Investigations on DNA binding and cleavage activities of hydrazone metal complexes are very limited.

A close survey of literature revealed that the acetoyl and benzoyl hydrazones derived from carbonyl compounds containing pyridine group show promising structural and biological properties.

The survey of literature also revealed that spectral and biological studies on rare earths metal complexes of a series of hydrazones with varying functional groups are very limited [105].

Objectives of the present work

The following are important objectives of present work

- To synthesize and characterize novel pyridine based hydrazone ligands having N, O and N donor atoms.

- To synthesize mononuclear 10- and 12- coordinate lanthanide complexes.

- To characterize the complexes based physico- chemical and spectral Techniques.

- To grow single crystals and determine the structure by using single crystal X-ray crystallography.

- To investigate DNA binding interaction of metal complexes with calf thymus DNA.

- To investigate DNA cleavage activity of lanthanide metal complexes by using gel electrophoresis technique.

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