CHAPTER I

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INTRODUCTION

1.1 Thiosemicarbazides and Thiosemicarbazones as sulphur ligand have dominated the area of coordination chemistry since long. These ligands form two types of complexes with the metal ion namely MLnX̅, or MLn where n is the valency of metal ion and X̅ = monovalent anion. This indicates that the metal ion may form simple four coordinate square planar or tetrahedral or six coordinate octahedral stereochemistry. These complexes form ideal systems for studying physicochemical properties of the complexes. Such investigations have been carried in large number of cases using a variety of techniques.

Thiosemicarbazones are known to show a wide range of biological applications. Thiosemicarbazones and their complexes have extensively been studied during recent years owing to their pharmaceutical properties. These compounds present a wide variety of biological activity such as antitumour [13], bacteriocidal and fungicidal [14], antiviral [15] etc. These had been used for the metals analysis [12] and application in telecommunications, optical computing, optical storage and optical information processing [16]. Hence to study the transition metal complexes of semicarbazones and thiosemicarbazones are of highly desirable.
1.2 PRESENT WORK

The present work relates to the synthesis and characterization of transition metal complexes with a number of semicarbazones namely acetylacetone semicarbazone (Ia), benzissemicarbazone (Ib), 4-methyl cyclohexanone thiometoscl (Ic) and thiosemicarbazones namely acetylacetone thiosemicarbazone (Iia), benzissemicarbazone thiosemicarbazone (Iib), 4-methyl cyclohexanone thiosemicarbazone (Iic).

Transition metals used for the synthesis of complexes are Mn⁺⁺ (3d⁵), Co⁺⁺ (3d⁷), Ni⁺⁺ (3d⁸) and Cu⁺⁺ (3d¹⁰).
1.3 **Object and scope of the work**

The main interest to synthesise and characterize the transition metal complexes of semicarbazones and thiosemicarbazones are due to their pharmacological activities. These complexes show more activities as compared to free semicarbazone and thiosemicarbazone.

Thiosemicarbazones have gained special attention due to their activity against malaria, tuberculosis, cancer. The fungicidal activity of these complexes is due to their ability to form chelates with the essential metals in which the fungus needs in metabolism. Owing to the wide range of medicinal properties of semicarbazone and thiosemicarbazone, their metal complexes are emerging as a new class of experimental studies.

Thiosemicarbazones have significant biological activity and new examples continue to be tested for their antitumour and anti-HIV activity. Complexes of metals and thiosemicarbazone ligands exhibit a broad spectrum of biological properties which includes antimalarial, antiviral and antineoplastic activities. The studies on ferrocenothiosemicarbazone...
have received great attention because of their great use in antitumour activity.

It is believed that the activity of thiosemicarbazones is due to their ability to strongly chelate the metal ions present in biological systems in trace amounts. There is also much interest in the development of artificial nuclease.

Artificial metallo-nuclease require ligands which effectively deliver the metal ion in the surroundings. West et al. had done a lot of work on the complexation behaviour and biological activity of nitrogen-sulphur donor ligands viz. thiosemicarbazone and thiosemicarbazones.

Thiosemicarbazone and thiosemicarbazone complexes exhibit biological activity and have been used as medicines. It is believed that the ligands show variety in structure and bonding in its transition metal complexes and also show significant antitumour activity. Various metal complexes have been synthesized with alkylthiosemicarbazone-based ligands such as salicylaldehyde S-alkylthiosemicarbazone. Interesting biological properties such as antitumour, anti-bacterial and antifungal of these ligands are due to its coordination the metal in the monomeric or dimeric form.

The copper(II) complexes show significant activity against animal and human tumour systems. Studies on such complexes suggest that thiosemicarbazone drugs can interfere with growth of the copper ions which are constituents of the virus. Because of such activity, considerable interest has developed in the coordination chemistry of copper(II) with Schiff base ligands as models of the physical and chemical behavior of biological copper systems. West et al. have carried out a lot of studies on the
structure and biological activity of copper II complexes with
semicarbazones

The actions of the cytotoxic activity of the copper complexes as well as
some compounds characterized recently. Semicarbazones have been
widely used as spectroscopic agents for the analysis of metal ions. A
number of investigations on the structure and chemical properties of
semicarbazone has demonstrated its similarity to thiosemicarbazone. Metal
complexes of thiosemicarbazone and semicarbazones have been studied
extensively but considerably less information is available on
semicarbazone and semicarbazone complexes. Copper II complexes of
semicarbazone and thiosemicarbazone have been reviewed with emphasis on EPR
spectra. However, few reports dealing with EPR spectra studies of
complexes of semicarbazone and thiosemicarbazone have appeared for the
detection and determination of metal ions. Studies of thiosemicarbazones
relate to iminodiacetic acid, which is well-known for its antitumor activity
and as a potent chelating agent for the treatment of tumors, caused by
virus-diseases.

The study of transition metal complexes of semicarbazone and
thiosemicarbazone is not highly acceptable. With the present study we
synthesize following metals:

1. Semicarbazones of acetyl salicylic acid and 4-methyl thiosemicarbazone
2. Semicarbazones of salicylic acid
3. Semicarbazones of 4-methyl benzaldehyde and 4-methyl benzene and 4-
methycyclam and using thiosemicarbazone
Their transition metal complexes of Mn(II), Co(II), Ni(II) and Cu(II) have also been synthesized.

These complexes are characterized by various physico-chemical techniques namely elemental analysis, molar conductance, magnetic moment measurements, electronic, infrared and EPR spectral studies. The complexes of the type M(ligand);X, and M(ligand)X₂ show the different type of stereochemical form. Change in anions causes the various stereochemical structures.

A salient feature of the present work is the opportunity to compare the coordination behaviour of NO and N-S donor ligands. The special donor properties of sulfur as compared to oxygen may be regarded to the fact that the lower electronegativity of sulfur lessens the ionic character, changes the relative stabilities of the different kinds of bonds and lessens the hydrogen bonding in its compound. Sulfur binds more strongly to class (b) metals than (b) character being strongest for transition metal in low oxidation states. These metals contain non bonding electrons and have capability of forming weak bonds by donating pair of electrons to the ligands.

1.4. **MODE OF COORDINATION**

**Bonding in semicarbazone complexes**

Nardell et al. had carried out the X-ray crystallography studies on [Cu(CS)₂Cl₂] and [Zn(CS)₂C₂] complexes where CS = semicarbazide which indicate that semicarbazide or semicarbazones may coordinate to the metal ion as a bidentate. They explained that the compounds in each metal atom is surrounded by a transplanar arrangement of two O and two N atoms situated at the corner of square. Six co-ordination is completed by two chloride atoms.
occupying the axial positions. Hence the geometry of this may be described as distorted octahedral. The semicarbazone molecule is planar and there are no particular differences in the bond distances between metal coordinated semicarbazide and semicarbazide hydrochloride. It is expected that semicarbazones and substituted semicarbazides use only one oxygen atom of the carbonyl group and the nitrogen atom of the hydrazinic residue this indicate bidentate behaviour of the ligands.

In the present study the semicarbazone of 4-methylcelohexanone behave as a bidentate ligand with all metal ions as it is confirmed by the IR spectrum as δ (NH₂) of the hydrazinic nitrogen of semicarbazide (1622 cm⁻¹) is absent in the spectrum of mchsc as it is expected. The amide II band in mchsc is at lower wave number as compared to that of semicarbazide as a result of removal of the electron density forms the surrounding of the hydrazinic nitrogen. The characteristic absorption band of the carbonyl group is observed at 1684 cm⁻¹ in mchsc. On complex formation this band shifted towards lower wave number by (Ca 40 cm⁻¹). The band corresponding to amide II appears at 1584 cm⁻¹ in the mchsc also shifted towards lower wave number by (Ca 35 cm⁻¹) on complexation.

This observation suggests that coordination takes place through the ν (C=O) oxygen. The strong band at 1584 cm⁻¹ in mchsc contains apparently large contribution from ν (C=N). Coordination through "O" increases the double bond character of the CN bond. This bond changes position towards higher wave number which shows that coordination takes place through "N" of ν (C=N) group.
n complexes of semicarbazones, it is difficult to differentiate the band corresponding to NH₂ and NH group. The band corresponding to NH₂ group at 3396 cm⁻¹ is shifted towards lower frequency by 20 cm⁻¹ in semicarbazone of acetylacetone (asc); and benzil (bzsc). Similarly, band near 3205 cm⁻¹ corresponds to NH group is also shifted towards lower frequency.

In both the semicarbazones, ligand of acetyl acetone and benzil, a band is observed at 1782 cm⁻¹ and 1731 cm⁻¹ which corresponds to \( \nu(C=O) \) group. On complexation this is shifted towards lower side this indicate that this group is involved in coordination.

**Bonding in thiosemicarbazone complexes:**

It has been observed in studies that the thiosemicarbazide molecule itself exists in trans configuration and while complexing in such configuration, it acts like a monodentate ligand bonding only through the sulphur atom. Gerbeleu et al. also suggested that bonding may happen through the hydrazinic nitrogen and the amide nitrogen the centre of sulphur is substituted in most of the complexes study the thiosemicarbazone coordinate to the metal ion in the cis configuration as a bidentate ligand bonding both through the thione terminal sulphur atom and the hydrazinic nitrogen atom in a bidentate manner.

When another coordinating functionality is present nearer to the SN donating centres, the ligands are found to act as tridentate species yielding a polymeric compound in some cases.

By the experiments of Gerbeleu and co-workers, it was observed that alkylation of the thiosemicarbazide sulphur of thiosemicarbazone derivatives give can not only complexation through the terminal amino group but also
enough acidic character for it to function as a mono acidic ligand. When the salts of metals, e.g., Cu(II), Ni(II), VO(IV) are present, these ligands are condensing at the terminal amino nitrogen atom through another aldehyde or ketone to yield bidentate ligands. Gerbeletu and Zhovmir (21) claimed to have isolated thiosemicarbazone complexes without sulfur coordination.

In the present work all the thiosemicarbazones of acetyl acetone and benzil behave as a tetradentate ligand with all metal ions. It is confirmed by comparing the spectra of the ligands and complexes in thiosemicarbazide. The bands at 3370 and 3375 cm\(^{-1}\) are assigned to NH\(_2\) group (21) is shifted towards lower frequency by Ca 20 cm\(^{-1}\). Similarly, band near 3235 cm\(^{-1}\) corresponds to NH group is also shifted towards lower frequency.

In both the thiosemicarbazone ligand of acetyl acetone and benzil a band is observed at 788 cm\(^{-1}\) which corresponds to (C=S) group. On complexation this is shifted towards lower side this indicates that this group is involved in coordination.

The IR spectrum of the complexes more clearly confirms the mode of coordination. The IR band observed at 1595 cm\(^{-1}\) corresponds to (C=N) is shifted towards lower side in the spectra of most of the complexes. Further, the (C=S) band of (montis) at 788 cm\(^{-1}\) exhibits a negative shift in most of the complexes. Thus the comparative study of this ligand and its complexes confirm that this ligand behave as bidentate.
determinations and conductivity measurements and found to be monomeric and non-electrolyte. Tetrahedral geometry for the manganese(II) complex was proposed.

Mn(II) complex [Mn[capMnCl₄] with 2-anthranilic acid, 2-Methylanthracene-carboxylate] have been synthesized by Granfo et al.¹⁷ and suggested the tentative structure of complexes by using various spectral studies. Mn(II) complexes with p-chlorophenylazo semicarbazone and p-nitrophenylazo semicarbazone have been prepared by Singh et al.¹⁸. The complexes were characterized by various physico-chemical studies.

Singh et al.¹⁹ have also reported prepared manganese(II) complexes of N-sulfonyl-N-phenylcarboxylate. These complexes were characterized by elemental analyses, magnetic susceptibility measurements and UV-Vis R, ESR, NMR, F and C; mass and molar absorptivity studies. The biological activity have also been screened against several bacteria and fungi. The complex [Mn(SBm)I₂O₂] has also been reported by Singh et et al.²⁰ from a potential terdentiate ligand N-sulfonyl-N-thioanilinoisocyanate (SBI). The complexes have been characterized by elemental analysis, magnetic susceptibility measurements UV-Vis R, NMR studies.

Singh et al.²¹ have synthesized 1-semicarbazide-2-benzoyl-3-thiosuccinimide (SBm) and its Cu, Mn, Co, Ni, Cu and Zn²⁺
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