Importance and Application of Co-ordination Compound in Various areas

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Abstract : Profound changes occur in the properties of a metal ion on complex formation. These changes are generally reflected in solubility, colour, stability, magnetic properties etc. These changes in properties find manifold applications. A major application of co-ordination compounds in their use as a catelysts, which serve to alter the rate of chemical reactions. There are many applications of co-ordination compound in modern day society including qualitative/quantitave chemical analysis within analytical chemistry, metallurgy, biological system, therapeutic chelating agents, photography, detergents etc.

Keywords : Theropeutic chelating agent, Metallurgy, Analytical chemistry.

I. INTRODUCTION

A Co-ordination complex consists of a central atom or ion which is usually metallic and is called co-ordination centre and a surrounding array of bound molecules or ions that are in turn known as ligands or complexing agent. Many metal containing compounds especially those of transition metals are co-ordination complexes. A co-ordination complexes whose centre is a metal atom is called a metal complex of d-block element. Many of the properties of transition metal complexes are dictated by their electronic structure. The electronic structure can be described by a relatively ionic model that ascribed formal charges to metals and ligands. Hans Bethe in 1929 gives a quantum mechanically based attempt at understanding complexes. The electronic configuration of the complexes gives them some important properties such as colour of transition metal complex and magnetic property etc.

II. APPLICATION

(i) Catalysis - Many enzymes which serve as the catalysts in living system are co-ordination compound. Many enzymes (biological protein catalyst) in our body require a metal ion bound in a co-ordination complex for their activity. These metal protein complexes are called metalloenzyme.

Some examples of co-ordination complex metalloenzyme are

Zinc complex enzyme like carbonic anhydrase, important to buffering reaction in blood.

Copper - Complex enzyme important to iron storage and producing pigments in hair, skin and eyes.

Cobalt- complex vitamin- B_{12} enzyme, co-factor, essential to metabolism of carbohydrate, proteins and fats.

(ii) Photography - Formation of $[Ag(S_2O_3)_2]^{3-}$ complex ion has an important role in photography. After the exposed film is developed, sodium thiosulphate solution is u sed to dissolve the unreduced silver halide.

$$AgBr + 2S_2O_3^{2-} \rightarrow [AG(S_2O_3)_2]^{3-} + Br^-$$

(iii) Metallurgy - (a) The noble metals like silver and gold are extracted from their ores through the formation of cyamide complexes, dicyanoargentite (I) $[Ag(CN)_2]^-$ + Na_2S and dicyanoaurate (I).

$$Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2]^- + Na_2S$$

(b) Metal can be purified by the formation and subsequent decomposition of their co-ordination compound.

e.g. Nickel can be purified by its reaction with carbon monoxide to form the volatile carbonyl complex, which is decomposed thermally to yield pure nickel.

$2NA\ [Ag(CN)_2] + zn \rightarrow Na_2[Zn(CN)_4] + 2Ag$

(iv) Artificial Silk - Schweitzer's reagent i.e. tetramimine copper(II) hydroxide $[Cu(NH_3)_4]\ (OH)_2$ is used as solvent for cellulose during the manufacturing of artificial silk.

(v) Biological Application - A number of metal complexes are biological importance in particular.

(a) haemoglobin in the red blood cells contain an iron porphyrin complex

(b) chlorophyll in green plants contain magnesium porphyrin complex.

(c) Vitamin B_{12} is a cobalt complex. Body contains a number of compounds like adrenaline, citric acid and cortisone which formed unwanted complexes with metal like lead, copper, etc and prevent normal metabolism. Lead poisoning and copper poisoning are treated by injecting EDTA. So, that metal EDTA complex is excreted in the urine

(vi) Analytical chemistry

(a) Multidentate Ligand EDTA tethylene diamine tetra acetic acid) forms highly stable complexes with metal ion like ca^{2+} and Mg^{2+}. The fact is used to estimate the hardness of water by simple titration method using EDTA solution.

(b) A confirmatory test for the detection of copper(II) involves the formation of deep blue coloured complex $[Cu(NH_3)_4]^{2+}$ on addition of ammonia solution to a solution of copper (II) salt.

$$Cu_{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4]^{2+}$$

Tetra amine copper(II) ion (Dark Blue)

(c) The separation of group I precipitate of AgCl Hg2Cl2 and PbCl2 involves in the addition of aqueous ammonia solution to the precipitate, when only silver chloride dissolve due to formation of the complex ion [Ag(NH3)2]+

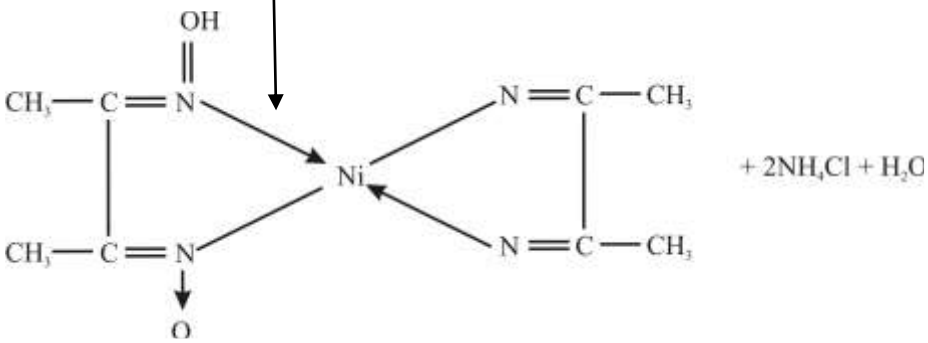
$$AgCl + 2NH_3 \rightarrow [Ag(NH_3)_2]^+ + Cl^-$$

Hg_2Cl_2 and $PbCl_2$ do not form complex ion with NH_3 and hence do not dissolve.

(d) A confirmatory test for nickel consists in adding a solution of dimethyl glyoxime, when a scarlet red coloured precipitate is formed due to formation of chelate complex.

$$2\ \begin{matrix} CH_3 - C = N - OH \\ | \\ CH_3 - C = N - OH \end{matrix} + 2NH_4OH + NiCl_2$$

(Dimethyl glyoxime



Nickel dimethyl glyoxime complex.

(e) Use in gravimetric determination

Inner complexes are often insoluble in aqueous medium but soluble in organic solvents. The formation of such chelates of ten need suitable PH range and many metal ions can be quantitatively precipitated and metal ion determined gravimetrically. Some applications include estimation of aluminium

as yellow coloured tris (8-hydroxy quinolonate) aluminium (III) and copper (II) as light green coured bis (quinolonate) aluminimum (III) and copper(II). Some complexes are unstabe at the drying temperature (120-150^{0}C) and such complexes are ignited to metal oxide.

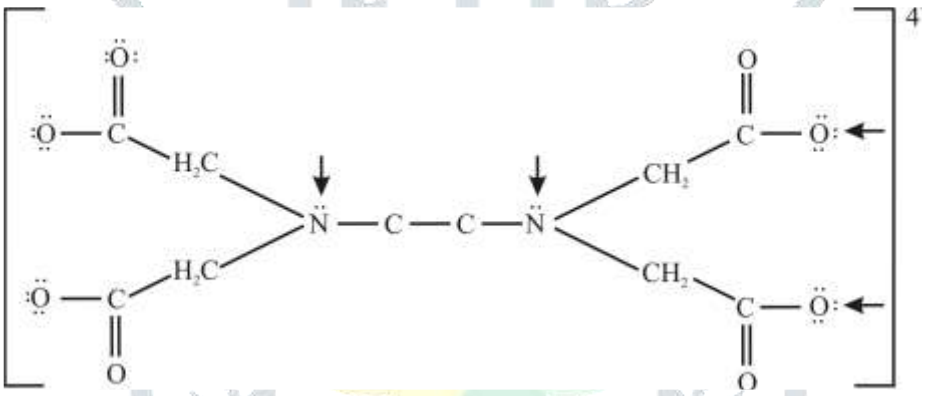
vii) Therapeutic chelating Agent -

One of the most important human medical application of co-ordination compound is as chelating agents. Chelating agents are co-ordination compound that are either bidentate or polydentate. These agents bind to metal cation of multiple site like a clow. This creates a very stable complex for further extraction or excretion.

A chelating agents used in medicine to capture heavy metals (like lead) that poison our bodies is ethylenediammine tetra acetic acid (EDTA) or its ion form ethylene diammine tetra acetate.

EDTA chelates free lead ions removing them from the blood and tissue and allowing excretion from the body.

The EDTA complex ion has six binding sites that can form co-ordinate covalent bonds with metal ion. EDTA bends around to occupy multiple bonding site on the metal making for a strong and stable complex.



Structure of Ethylene diammine tetra acetate ion.

EDTA is also used tin the clean up of radio active metal spill, again due to stability of the metal ligand complex and ease of extraction from whatever was contaminated.

III. Conclusion

Co-ordination chemistry enjoys a prominent place in inorganic chemistry. The recent surge in the popularity of co-ordination compound is their perceived application in many areas such as catalysis analytical chemistry and medicine Co-ordination complexes show diversity in structures depending on the metal ion; its co-ordination number and the denticity of the ligand used.

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