ABSTRACT

Polydentate ligands have been widely studied due to their ability to form stable and efficient metal complexes. In recent years, there has been growing interest in the use of these metal complexes as catalysts for various chemical reactions, including oxidase activity. Oxidases are enzymes that play a crucial role in biological processes such as cellular respiration and metabolism. The development of synthetic metal complexes with oxidase-like activity has the potential to provide alternative catalysts for these important processes.
In this abstract, we discuss the design and synthesis of polydentate ligand based metal complexes for oxidase activity. We focus on the use of N, O-chelating ligands that have been shown to form stable and efficient metal complexes. The metal complexes are characterized using various spectroscopic techniques, and their oxidase activity is evaluated using a variety of assays. We also explore the mechanistic aspects of the oxidase activity of these metal complexes and compare their activity to that of natural oxidase enzymes.

Overall, the results demonstrate the potential of polydentate ligand based metal complexes as efficient catalysts for oxidase activity. These complexes may provide a viable alternative to natural oxidase enzymes, and their development could lead to the development of new therapeutic agents and industrial catalysts.

Polydentate ligands are molecules that possess multiple donor atoms capable of bonding with a central metal ion. Metal complexes of polydentate ligands have gained significant interest in recent years for their potential applications in various fields, including catalysis, drug design, and biotechnology. In particular, metal complexes of polydentate ligands have been shown to exhibit exceptional oxidase activity, making them an attractive candidate for various oxidation-based reactions.
Oxidation is an essential process in biological systems, and the use of metal complexes of polydentate ligands in catalyzing oxidation reactions is a promising area of research. The oxidase activity of these metal complexes can be attributed to the presence of redox-active metal centers, which can donate or accept electrons during the oxidation process. The polydentate ligands stabilize the metal ion and enhance its reactivity, resulting in increased catalytic activity.

The catalytic activity of polydentate ligand-based metal complexes for oxidase activity is dependent on several factors, including the types of metal ion, the coordination environment, and the ligand structure. The choice of metal ion plays a significant role in determining the catalytic activity of the complex. Transition metals such as copper, iron, and manganese have been extensively studied for their oxidase activity. These metals possess a variable oxidation state, allowing them to undergo redox reactions during the oxidation process.

The coordination environment of the metal ion is another critical factor in determining the oxidase activity of the metal complex. The coordination environment influences the electron transfer properties of the metal ion, which in turn affects the catalytic activity of the complex. Ligands that provide a favorable coordination environment, such as chelating ligands, can enhance the catalytic activity of the complex.

The structure of the polydentate ligand also plays a crucial role in determining the catalytic activity of the metal complex. The ligand structure can influence the binding affinity of the ligand for the metal ion, as well as the redox properties of the metal ion. Ligands with multiple donor atoms, such as bidentate and tridentate ligands, have been shown to exhibit excellent catalytic activity due to their ability to stabilize the metal ion.

Polydentate ligand-based metal complexes have been shown to exhibit oxidase activity in various reactions, including the oxidation of alcohols, amines, and sulfides. These complexes can also catalyze the oxidation of organic compounds under mild conditions, making them attractive for industrial applications. The use of polydentate ligand-based metal complexes in the oxidation of biomolecules, such as DNA and proteins, is an exciting area of research that holds promise for various biotechnological applications.

In conclusion, polydentate ligand-based metal complexes have shown exceptional oxidase activity, making them a promising candidate for various oxidation-based reactions. The catalytic activity of these complexes is dependent on several factors, including the choice of metal ion, the coordination environment, and the ligand structure. The use of these complexes in industrial applications and biotechnology holds significant promise and is an exciting area of research for the future.

CHAPTER I

Chapter I is an introductory one that describes polydentate ligand based metal complexes as efficient catalysts for oxidase activity and their applications in various fields as well as single crystals, their classification and methods of growth. Object and application of the present research work has also been outlined in this chapter. A brief description of the advantages of different type of technique of crystal growth was described.

CHAPTER II

Chapter II involves the experimental section briefly describing the chemicals and materials used in completing this research. This chapter also describes the novelty behind choice of organic linkers/ligands used in the works embodied in this thesis. This chapter also contains details of the physico-chemical and spectroscopic techniques, viz., single crystal, FTIR spectroscopy, NMR, and EPR, etc., used for the physicochemical characterization of the synthesized complexes. This chapter also describes the theoretical characterization (DFT, etc) of the hybrid complexes.

CHAPTER III

2-(3-(Dimethylamino)propyl)isoindoline-1,3-dione (**DAPID)** has been synthesized and utilized to produce 3-(1,3-dioxoisoindolin-2-yl)-N,N-dimethyl propan-1-aminium perchlorate **(DIDAP)**. Both **DAPID** and **DIDAP** were characterized using different spectroscopic techniques. Structure of the **DIDAP** has been determined using single crystal X-ray diffraction technique. **DIDAP** found to self assemble in a helical motif in its supramolecular structure with the aid of different hydrogen bonding, *Cg···Cg* and short interatomic contacts in the solid state. The compound **DIDAP** exhibited anticancer activity against the human hepatomas cell line (Hep G2) and the activity was further complemented by performing docking study. In addition, the computational studies have also been performed to examine the chemical reactivity of the compound. *Shape index* and *Curvedness* surfaces indicated π-stacking with different features in opposed sides of the molecule. Fingerprint plot showed C···C contacts with similar contributions to the crystal packing in comparison with those associated to hydrogen bonds. Enrichment ratios for H···H, O···H and C···C contacts revealed a high propensity to form in the crystal.

CHAPTER IV

N^1, N^4- Bis(3-(dimethylamino)propyl)succinamide (**DAPS**) has been synthesized and utilized to produce 3,3'-[succinylbis(diazaneyl)]bis(N,N,N-trimethylpropan-1-ammonium) perchlorate (**SAPAP**). Both **DAPS** and **SAPAP** were characterized using different spectroscopic techniques. Structure of the **SAPAP** has been determined using single crystal X-ray diffraction technique. The compound **SAPAP** had excellent anticancer activity against the human colon carcinoma cell line (HT-29), proposing them as a suitable candidate for future anticancer therapies. Docking, Molecular dynamics simulation, pharmacokinetic predictions and ELISA were also employed to evaluate the inhibitory action of the synthesized compound against the said cancer cell line HT-29.

CHAPTER V

Keeping in mind the importance of oxidase activity it includes a versatile bioinspired metallocatalyst $[Cu_2L_2(OAc)_4]$ (L = *2-(3-(dimethylamino)propyl)isoindoline-1,3-dione*), which has been synthesized and characterized as reported. To the best of our knowledge, a very few articles of paddlewheel type complexes have reported behave as catechol oxidase activity and phenoxazinone synthase activity. The EPR, CV, and ESI Mass analyses collectively support that the complex exhibits such activity via oxygen dependant enzymatic radical pathway. Furthermore, these activities are observed under fully aerobic conditions in which 3,5-di-tert-butylcatechol (3,5-DTBC) and 2-amino phenol (2-AP) are used as model substrates. Michaelis-Menten analysis derived from the pseudo first-order reaction kinetics established that this complex shows prominent catalytic activity towards 3,5- DTBC and 2-AP (K_{cat} 12.0726×10^3 h^{-1} and 6.6654×10^3 h^{-1}). Molecular electrostatic potential (MEP) diagrams and density functional theory (DFT) reveals the charge density region within the complex while growth inhibition (GI50) and molecular docking study exposes substantial dose dependent anti-leukemic activity against Hep-G2 cell line.

Moreover, promising anti-bacterial property was also detected on multi-drug resistant *E. coli* and *B. cereus* bacteria.

CHAPTER VI

In this chapter a promising bioinspired metallocatalyst $[Cu(L1)_2(L2)]$ (L1 = P-hydroxybenzoic acid, L2= N^1,N^1-dimethylpropane-1,3-diamine) has been produced and characterized in accordance with reports.. In the octahedron arrangement around the copper ion, the elongation along one axial direction and one equatorial direction results in a distorted geometry. Molecular assembly shows both inter and intra molecular H-bonding along with C-H---π interactions evident from the Hirshfeld surface analysis. The fingerprint plot discloses the relative contribution of percentage of intermolecular contacts (H···H, C···H and O···H) in the complex. To the best of our knowledge, no one has reported catechol oxidase activity and phenoxazinone synthase activity of Cu(II) complexes with P-hydroxy benzoic acid and propyl amine ligands so far. The EPR, CV, and UV analyses collectively support that the complex exhibits such activity via oxygen dependant enzymatic radical pathway. Furthermore, these activities are observed under fully aerobic conditions in which 3,5-di-tert-butylcatechol (3,5-DTBC) and 2-amino phenol (2-AP) are used as model substrates. Michaelis-Menten analysis derived from the pseudo first-order reaction kinetics established that this complex shows extremely high catalytic activity towards 3,5- DTBC and 2-AP (K_{cat} 1.729×10^5 h^{-1} and 0.260×10^5 h^{-1}). The suggested mechanism has been supported by UV spectra data in which formation of hydrogen peroxide by observing the appearance of spectral band at λmax 353 nm indicates the active participation of molecular oxygen in the catalytic process.

CHAPTER VII

Future research in the field of polydentate ligand-based metal complexes with a focus on enhancing oxidase activity holds significant promise. These studies may lead to the development of novel ligands, versatile multifunctional complexes, and applications spanning biotechnology, medicine, energy conversion, and industrial processes, offering innovative solutions with broad-reaching implications for various fields.