Preface

Controlled drug delivery systems are designed to release medications precisely at the target site, in the optimal dose, and over a sustained period. Recently, polymer-based systems have gained considerable attention due to their remarkable versatility, seamlessly integrating both hydrophobic and hydrophilic components that interact effectively with a variety of biological environments. These systems can be crafted from both synthetic and naturally derived polymers, such as polysaccharides. Naturally occurring biopolymers, in particular, stand out for their non-toxic, biodegradable nature, and cost efficiency. By advancing the development of these sophisticated polymeric delivery systems, researchers are working to improve therapeutic outcomes, reduce side effects, and lower the overall costs of healthcare, making treatments more effective and accessible.

In our study, we developed controlled drug delivery systems using LDHs and functionalized LDHs. Their unique layered structure enables the intercalation of therapeutic agents, facilitating sustained drug release while maintaining drug concentrations within the therapeutic window. LDHs provide several advantages, including enhanced stability, biocompatibility, and the capacity to encapsulate a diverse range of drugs, allowing for tailored release profiles that meet specific therapeutic needs. Their non-toxic nature and compatibility with biological systems make LDHs particularly suitable for pharmaceutical applications. By optimizing LDH design, researchers can create systems that respond to specific physiological conditions, ensuring prolonged and controlled drug release. LDHs possess stable physicochemical properties, high surface area, and significant anion exchange capacity, making them effective inorganic nanocarriers. Furthermore, functionalized LDHs can act as grafted receptors, facilitating targeted delivery across cellular membranes. This innovative approach aims to minimize side effects, enhance patient adherence, and ultimately lead to more cost-effective treatment options. Overall, our findings underscore the potential of LDHs in advancing drug delivery technologies and improving therapeutic outcomes.

The thesis has been bind up using the following outlines: Introduction and literature review, results and discussion, and conclusion. The description of the different chapter has been given below

Chapter I: Introduction and Significance of Controlled Drug Delivery

This chapter emphasizes the critical role of controlled drug delivery systems in modern therapeutics. It addresses the limitations of conventional methods, such as rapid drug release and fluctuations in plasma concentrations, which can reduce therapeutic effectiveness and increase side effects. The chapter explores various organic and inorganic controlled drug delivery systems, detailing their mechanisms, advantages, and the diverse hydrophobic and hydrophilic components involved. Additionally, it provides an overview of LDHs and functionalized LDHs, highlighting their unique structural properties that position them as effective drug delivery vehicles capable of sustained and targeted release.

Chapter II: Synthesis and Characterization of LDH and Functionalized LDH Nanocomposites

This chapter examines the synthesis of LDHs and their functionalized variants. Various techniques, including hydrothermal methods and co-precipitation, are discussed in detail. The chapter also outlines different characterization techniques such as XRD, SEM, and FTIR etc. which help assess the physicochemical properties of the synthesized LDHs and their effectiveness as drug delivery systems.

Chapter III: Development of Li-Al LDH Nanoparticles and Doxorubicin Intercalation

Focusing on lithium-aluminium (Li-Al) LDH nanoparticles, this chapter presents their synthesis and potential drug delivery applications. It describes the details of intercalation of Doxorubicin, creating a pH-responsive therapeutic cargo, and emphasizes how this approach can enhance therapeutic efficacy in tumor treatment while minimizing systemic side effects.

Chapter IV: Synthesis of Polyurethane-Grafted LDH for Controlled Drug Delivery

This chapter explores the synthesis of polyurethane-grafted LDHs as a strategy for improved drug delivery. It describes the rationale for grafting and examines various synthesis techniques, highlighting how this approach enhances drug encapsulation efficiency and release profiles.

Chapter V: *In vitro* and *In vivo* Studies of Organic-Inorganic Hybrid for Drug Delivery in Melanoma Treatment

Presenting comprehensive *in vitro* and *in vivo* studies, this chapter evaluates a thermodynamically stable organic-inorganic hybrid for melanoma treatment. The findings demonstrate the hybrid's efficacy in reducing tumor size and improving therapeutic outcomes.

Chapter VI: Conclusion and Future Directions

The final chapter synthesizes key findings and discusses their implications for drug delivery. It outlines potential future research directions, emphasizing the need for new materials and enhanced drug-loading techniques, aiming to inspire innovation in patient-friendly drug delivery solutions.