INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

The thesis, titled *"**Microrheology of Biomaterials in Healthcare Applications**,"* focuses on the fundamentals and applications of the viscoelastic behavior of two key biomaterials: mucin and synovial fluid. The first technical chapter explores the assembly of porcine gastric mucin modulated by bovine serum albumin through microrheological studies employing Diffusing Wave Spectroscopy. This analysis demonstrated that non-mucin proteins, such as albumin, interact with mucin via electrostatic forces, facilitating mucin-mucin assembly. The findings are significant for understanding the formation of functional mucus layers in both healthy and pathological conditions, including Crohn's disease and cystic fibrosis. The second chapter delves into microrheological experiments and density functional theory (DFT) simulations to explore mechanisms for delivering protein-based drugs through mucus. Bovine serum albumin was used as a model drug, and its transport through mucus was studied using an ionic liquid-based mesoscale drug delivery system. Microrheological changes in the system were analyzed to understand molecular interactions during the assemblage of bovine serum albumin, mucin, and the ionic liquid. These findings were corroborated through morphological analysis using atomic force microscopy (AFM). Additionally, a biomimetic in-vitro microfluidic prototype simulated the human intestine, demonstrating the stability and penetration of the model drug through mucus in the presence of the ionic liquid. The third chapter explores the microrheology of synovial fluid, focusing on the impact of lactic acid, a byproduct of hypoxia-induced anaerobic respiration, on its viscoelastic properties. The study revealed that beyond a critical concentration of lactic acid, colloidal nanoscaffolds in the synovial fluid collapse and precipitate, significantly impairing its viscoelasticity. This reduction compromises the fluid's load-bearing and resistance capacity, shedding light on synovial fluid behavior in arthritic conditions and aiding the design of artificial viscosupplements in arthritic conditions. The final chapter explores the development of a novel viscosupplement for arthritic joints by blending mucin with hyaluronic acid. High levels of lactic acid in arthritic joints compromise the effectiveness of traditional hyaluronic acid injections. Rheological analysis at both micro and bulk scales demonstrated that the mucin-hyaluronic acid blend maintains its viscoelastic properties even in the presence of elevated lactic acid concentrations. Thus, the addition of mucin in hyaluronic acid helps to mitigate the effects of lactic acid, preserving the viscoelasticity of synovial fluid. Furthermore, microrheological studies near the cartilage surface showed that the mucin-hyaluronic acid composite forms a less viscous layer compared to hyaluronic acid alone. This layer supports boundary lubrication under high-load conditions, promoting smoother joint movement and reducing cartilage wear.