INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	TANUSHREE DAS
Roll Number	:	206122035
Programme of Study	:	Ph.D.
Thesis Title:		Shaping Ultrasmall Peptide-Based Supramolecular Hydrogel into Robust, Reusable, and Multifunctional Core-Shell Beads
Name of Thesis Supervisor(s)	:	Prof. Debapratim Das
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SHORT ABSTRACT

The thesis "**Shaping Ultrasmall Peptide-Based Supramolecular Hydrogel into Robust, Reusable, and Multifunctional Core–Shell Beads**" explores the design, fabrication, and functional applications of peptide-based core–shell hydrogel beads, focusing on how small molecular systems can be engineered into robust, multifunctional platforms.

Chapter 1 provides an introduction to hydrogels, explaining their classification, crosslinking mechanisms, and structural properties that enable diverse applications. It also describes the preparation methods for hydrogel beads and reviews their roles in drug delivery, catalysis, sensing, and water purification.

Chapter 2 presents the fabrication of core–shell hydrogel beads and hollow capsules using the low molecular weight peptide PyKC through a simple extrusion technique without external cross-linkers. It demonstrates how the chemically tunable surfaces of these beads allow versatile functionalization and the preparation of hollow capsules via selective removal of the hydrogel core.

Chapter 3 describes the functional surface engineering of the core–shell beads to enable host–guest interactions, covalent biocatalyst immobilization, and the in situ, reducing-agent-free synthesis of gold nanoparticles within the polymeric shell. It highlights the catalytic applications of the AuNP-embedded beads, demonstrating efficient reduction of nitroaromatic compounds and azo dyes with excellent reusability and stability.

Chapter 4 discusses the development of gold nanostar-coated hydrogel beads as photo-oxidase mimics that exhibit light-induced, peroxide-free catalytic oxidation. It details their application in the sensitive and selective colorimetric detection of uric acid and successful integration into a smartphone-based point-of-care testing system.

Chapter 5 presents the design of sulfonate-functionalized hydrogel beads embedded with gold nanoparticles that display non-plasmonic, light- and chemical oxidant-free oxidase-like activity for broad-spectrum water decontamination. It demonstrates the system's effectiveness in degrading phenolic pollutants, azo dyes, and catecholamines, as well as its antibacterial activity, mechanical robustness, and reusability.