



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI  
SHORT ABSTRACT OF THESIS

Name of the Student : ARINDOM BIKASH NEOG

Roll Number : 176122027

Programme of Study : Ph.D.

Thesis Title: Application of Responsive Lamellar Membranes of Layered Materials for Microdroplet Handling, Sensing, and Energy Harvesting

Name of Thesis Supervisor(s) : Prof. Kalyan Raidongia

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**SHORT ABSTRACT**

This thesis explores the development and application of advanced bilayer membranes and nanomaterials for precise liquid manipulation, contaminant detection, remote handling of reactive substances, and sustainable energy harvesting. A hydrophobic r-GO/agar bilayer membrane, controlled by electrical potential and infrared light, was designed to handle microliter-scale droplets with ultrafast reaction capabilities and potential for efficient chemical analyses. The same r-GO/agar membrane demonstrated shape-morphing properties sensitive to chemical impurities in liquid media, enabling real-time detection of contaminants such as water in acetone or alcohol in toluene. To address the remote handling of toxic and reactive chemicals, CNT-VO (carbon nanotube-vanadium pentoxide) and o-CNT-VO bilayer actuators were developed with light- and voltage-responsive behaviour, enabling rapid and precise manipulation of hazardous substances, alongside sensory capabilities mimicking human touch. Lastly, a novel permselective nanofluidic membrane coated with functionalized vanadium pentoxide nanosheets was fabricated for concentration gradient-driven energy harvesting. By integrating vanadium pentoxide and polyaniline electrodes, the power output was enhanced by 300%, demonstrating a significant advancement in sustainable energy generation. These studies significantly contribute to the fields of liquid manipulation, environmental monitoring, remote chemical handling, and energy harvesting.