INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
PhD-17 SHORT ABSTRACT OF THESIS

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Programme of Study	:	Ph.D.
Thesis Title:Studies on Biopolymer Membrane-based Microbial Fuel Cells for Energy Generation and Wastewater Treatment		
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Thesis Submitted to the Academic Division	:	Chemical Engineering
Date of completion of Thesis Viva-Voce Exam	:	12-05-2026
Key words for description of Thesis Work	:	Microbial fuel cell ; wastewater treatment; Bioenergy; Biopolymer; membrane

SHORT ABSTRACT

Microbial Fuel Cells (MFCs) have emerged as a promising bioelectrochemical technology capable of simultaneously treating wastewater and generating renewable electricity. Despite their potential, large-scale and practical implementation of MFCs remains limited due to high material costs, membrane fouling, low power output, and reliance on expensive and environmentally persistent commercial membranes such as Nafion. Addressing these challenges, the present research focuses on the development and systematic evaluation of sustainable, bio-based membrane materials and miniaturized MFC configurations to improve energy recovery and wastewater treatment efficiency under real operating conditions.This thesis investigates the design and performance of micron-scale, wastewater-fed MFCs integrated with bio-inspired flow architectures and low-cost monitoring systems. A heart-shaped biomimetic microfluidic flow channel was developed to enhance fluid mixing, reduce mass transfer limitations, and promote stable biofilm formation on the anode surface. To enable continuous and reliable performance evaluation, a microcontroller-based smart data-logging system was designed, allowing real-time monitoring of voltage during

start-up and acclimation phases at a fraction of the cost of commercial data loggers.A major focus of this work is the development of PFAS-free, environmentally benign membrane alternatives for MFC applications. Several bio-based membranes, including crosslinked poly(vinyl alcohol) (PVA-GA), cellulose acetate–chitosan (CA-CS) composites, and graphene oxide (GO) modified cellulose ether membranes, were fabricated using green or water-based processing routes. These membranes were systematically characterized for their physicochemical, thermal, mechanical, electrochemical, and surface properties, and their performance was evaluated in real wastewater-fed MFC systems.