INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Microbial Fuel Cells (MFCs) are promising sustainable energy technology which integrate power generation with waste remediation. However, its practical application is mainly hindered by firstly, its low power density owing to poor bacterial adhesion and electron transfer efficiency between bacteria and anode. Secondly, the use of Nafion as proton exchange membrane in microbial fuel cells (MFCs) is expensive with operational issues like biofouling and fuel crossover. Therefore, the current work addresses three issues of MFCs namely, to improve its performance, reduce the cost of operation and expand its horizon to real field application. The uniqueness of the work is the validation of the experimental study with comprehensive computational model complementing the experimental studies with new information about the system assembled with the indigenous membrane components The properties of the Nafion-alternative membranes, developed from environmentally benign polymers, poly (vinyl alcohol) (PVA) crosslinked with glutaraldehyde (GA) and Chitosan (CS)have been systematically studied and its performance evaluated against the commercial membrane in real wastewater fed MFCs. The membranes developed demonstrate potential as separator in future MFCs based on its enhanced performance and low cost of installation. Another important aspect hindering the practical application of MFCs which is low power density owing to poor bacterial adhesion and electron transfer efficiency between bacteria and anode. This issue is addressed by development of flexible electrodes using conducting polymer polyaniline (PANI) with sustainable polymer polylactic acid (PLA). An elaborate analysis of the performance of the bio-based flexible anode against commercial anode in domestic wastewater fed MFCs asserts its excellent biocompatibility, outperforming the flat graphite anode in achieving maximum power density and COD removal efficiency. The knowledge gap in the area of energy harvesting using complex substrates like hospital wastewater has been addressed using the indigenous PVA membrane developed. Experimental study conducted by replacing the commercial membrane in the recirculation mode honeycomb pattern MFC displayed enhancement in power production. An attempt to delve deeper into the atomic level to investigate the proton transport mechanism across the developed PVA membrane using Classical Molecular Dynamics study is demonstrated. The proton transport mechanism forms a crucial step which is a difficult to observe experimentally. The findings of the study demonstrated presence of multi-hydrated protons observed from MD trajectories suggesting that the proton transfer in the PVA polymeric membrane system occurred via vehicular mechanism. Furthermore, an essential parameter for the MFCs operating in recirculation mode, is its operating flow rate. To this end, numerical modeling, is utilized with parallel experimental study to get deeper insight into its effect on the performance in real wastewater fed MFCs for its viability for future commercial applications. Thus, the present study is focussed on adding a new dimension to the design of sustainable anode material to enhance microbial binding and achieve high power output, besides, developing an in-depth understanding of proton transfer mechanism and flow dynamics and its effect on the performance of MFC and lastly, to indigenously develop low-cost membranes to demonstrate the enormous potential of scale-up of MFCs for wastewater treatment in the future