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Rhizospheric Oxygen Release of Hydroponically Grown Wetland Macrophytes as Passive Source for Cathodic Reduction in Microbial Fuel Cell

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Abstract : The cost of aeration is one of the limiting factors in the upscaling of microbial fuel cells (MFC) for field-scale applications. Wetland macrophytes have the ability to release oxygen into the water to maintain aerobic conditions in their root zone. In this experiment, the efficacy of rhizospheric oxygen release of wetland macrophytes as a source of oxygen in the cathodic chamber of MFC was conducted. The experiment was conducted in an MFC consisting of a three-liter anodic chamber made of ceramic cylinder and a 27 L cathodic chamber. Untreated carbon felts were used as electrodes (i.e., anode and cathode) and connected to an external load of 100 Ω using stainless steel wire. Wetland macrophytes (Canna indica) were grown in the cathodic chamber of the MFC in a hydroponic fashion using a styrofoam sheet (termed as macrophytes assisted-microbial fuel cell, M-MFC). The catholyte (i.e., water) in the M-MFC had negligible contact with atmospheric air due to the styrofoam sheet used for maintaining the hydroponic condition. There was no mixing of the catholyte in the M-MFC. Sucrose based synthetic wastewater having chemical oxygen demand (COD) of 3000 mg/L was fed into the anodic chamber of the MFC in fed-batch mode with a liquid retention time of four days. The C. indica thrived well throughout the duration of the experiment without much care. The average dissolved oxygen (DO) concentration and pH value in the M-MFC were 3.25 mg/L and 7.07, respectively, in the catholyte. Since the catholyte was not in contact with air, the DO in the catholyte might be considered as solely liberated from the rhizospheric oxygen release of C. indica. The maximum COD removal efficiency of M-MFC observed during the experiment was 76.9%. The inadequacy of terminal electron acceptor in the cathodic chamber in M-MFC might have hampered the electron transfer, which in turn, led to slower specific microbial activity, thereby resulting in lower COD removal efficiency than the traditional MFC with aerated catholyte. The average operating voltage (OV) and open-circuit voltage (OCV) of 294 mV and 594 mV, respectively, were observed in M-MFC. The maximum power density observed during polarization was 381 mW/m³, and the maximum sustainable power density observed during the experiment was 397 mW/m³ in M-MFC. The maximum normalized energy recovery and coulombic efficiency of 38.09 Wh/m³ and 1.27%, respectively, were observed. Therefore, it was evidenced that rhizospheric oxygen release of wetland macrophytes (C. indica) was capable of sustaining the cathodic reaction in MFC for field-scale applications.

Keywords : hydroponic, microbial fuel cell, rhizospheric oxygen release, wetland macrophytes
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