Microbial Fuel Cells with Ceramic and Earthen Plate Membranes for Ricemill Wastewater

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Microbial fuel cells (MFC) function as reactors, which can catalyse the conversion of organic matter found in wastewater into electricity using microorganisms. This catalytic activity is used to oxidise organic substrates in an anaerobic anode chamber to generate electrons and protons. Electrons are transferred from the anode to the cathode through an external circuit at the same time the protons are transferred towards the cathode through the membrane, which separates anodic and cathodic chambers. In the cathode chamber, electrons combine with protons and oxygen to form water. Nafion is the most commonly used membrane in MFCs. However, Nafion is quite expensive, which raises the production cost of MFCs. Therefore, some alternative membranes were used such as Salt Bridge, Ultrex, porcelain septum made from kaolin and earthen pot.

In this study, the efficiency of treatment of a rice mill wastewater in MFC was evaluated in terms of electricity harvesting and chemical oxygen demand (COD) removal using ceramic plate (MFC-1) and earthen plate (MFC-2) membranes. MFC-1 was made up of polymethylmethacrylate (Perspex sheet) with the anode chamber having a working volume of 500 ml and the cathode chamber having a working volume of 420ml. Both anode and cathode chambers were separated by a ceramic plate with the thickness of 4mm (having dimensions of 9 cm × 10 cm). The electrode arrangements consisted of a carbon rod with an affective area of 191cm^2 as the cathode and a stainless steel mesh with a surface area of 262.5 cm^2 as the anode. Distilled water was used as the cathodic electrolyte. Distilled water was aerated by an air pump but towards the end of the experiment, the air pump was removed and potassium permanganate was added as the cathodic electron acceptor. MFC-2 was identical to the MFC-1 except for the ceramic plate. In MFC-2, an earthen plate (thickness, 7 mm) was used. Electrodes were connected using copper wire through an external resistance of 100 Ω. MFCs were operated under batch mode. Reaction cycle time was 15 days for MFC-1 and 13 days for MFC-2.

Maximum chemical oxygen demand (COD) removal efficiencies of 57.5% and 48.75% were obtained in MFC-1 and MFC-2, respectively. A power density of 287.02 W/m^2 and volumetric power of 15 mW/m^3 was generated by MFC-1 with 100 Ω external resistance at the influent COD concentration of 890 mg/L. MFC-2 generated a maximum power density and volumetric power of 146 W/m^2 and 7.7 mW/m^3 respectively with 100 Ω external resistance, when the influent COD was 960 mg/L.

This study therefore, shows that MFCs were able to economically treat the rice mill wastewater with simultaneous generation of bio-electricity.