ABSTRACT

Microbial fuel cell (MFC) is promising technology which exploits the ability of electrogenic bacteria to convert organic matter present in the wastewater directly into electricity. In the present research, the effect of different non-catalyzed electrode materials on the performance of scalable clayware MFC was investigated along with electrode kinetics. Stainless steel (SS) mesh out performed over carbon cloth and SS coil as anode material, while carbon felt was found kinetically more efficient cathode material compared to flexible graphite and graphite plate. Air cathode MFC made with separator cathode assembly, by coating exterior surface of clayware pot with conductive carbon ink, demonstrated better performance in terms of electricity generation and organic matter removal over dual chambered MFC. An attempt has been made to develop low cost scalable air cathode MFC using clayware cylinder (26 L). Sustainable current of 47.3 mA (Power, 17.85 mW) and lower internal resistance (5.2 Ω) observed for this MFC are among the best values reported in literature for MFC with larger anodic chamber volume.

Ceramic separators (CS) were developed from the natural clay blended with cation exchangers such as Montmorillonite and Kaolinite. The separators were characterized in terms of conductivity, oxygen, acetate and proton diffusion, and ion transport ability. MFC M-20 (CS blended with 20% Montmorillonite) exhibited maximum power density of 7.5 W/m^3 which was 48% higher than MFC without exchanger (Control) and 30%, 9%, 27% higher than MFC M-10 (10% Montmorillonite), MFC M-15 (15% Montmorillonite), and MFC K-20 (20% Kaolinite), respectively. Coulombic efficiency of MFC M-20 (30%) and MFC K-20 (23%) was higher compared to control (18%). As compared to oxygen, hypochlorite proved to be better cathodic electron acceptor, supporting rapid sludge digestion within 8 days of retention time in anodic chamber and improved power production in MFC. Optimal anodic chamber volume is proposed based on the substrate required to produce maximum current for maximizing electrogenesis. Charge transfer kinetics dominates the minimum anode surface area required to satisfy electrode area requirements for biofilm formation, polarization behavior, and mass transfer limitations. Commercialization of MFC is shown to be feasible only through the use of catalyzed cathode and smaller anodic chamber volume.

Keywords: Clayware separator; Cation exchanger; Microbial fuel cell; Optimal anode chamber volume; Power generation; Scaling up; Sludge digestion; Wastewater treatment.