ABSTRACT

Distillery wastewater is the residual unwanted liquid generated during alcohol production, which is characterised by very high COD, high solids and acidic pH, usually generated at around 8-15 L per litre of alcohol produced. The conventional treatment methods employed for distillery wastewater treatment like evaporation, solar drying, aerobic processes, etc., either need high temperature or are energy intensive in nature. Hence, alternate treatment methods, which can not only degrade organic matter present in wastewater but also result in a net energy gain can offer an attractive solution to the high pollution potential of distillery wastewater. Microbial fuel cell (MFC) is an emerging wastewater treatment technology, which utilizes organic matter present in wastewater as substrate to generate electricity in a single step process. The two components, which significantly influence the electrical output and the cost of MFC are the proton exchange membrane (PEM) and the cathode catalyst employed. Hence, low-cost PEM and cathode catalyst should be synthesized to reduce the overall fabrication cost of MFC, which will increase the feasibility of utilizing it in real field. PVA-Nafion borosilicate membrane was synthesized at 11-folds lower cost than Nafion 117 and when used in MFC, it demonstrated a power density of 6.8 W m^{-3}, which was comparable to MFC with Nafion 117 (MFC-N). MFC with PVA-GO-Clay membrane exhibited a power density of 297.3 mW m^{-2}, which was around 88 % of power achieved by MFC-N at nearly 15-folds lower cost of fabrication. Carbon supported nickel phthalocyanine doped with manganese oxide (NiPc-MnO_x/C) was synthesized and used as ORR catalyst in a MFC. MFC with NiPc-MnO_x/C demonstrated a power density of 8.02 W m^{-3}, which was around 80 % of the power density achieved by MFC with platinized cathode. However, the normalized power output (1.02 W $\$^{-1}$) was 2-folds higher than MFC with platinized cathode. A combined UASB-MFC system when used for distillery wastewater treatment, achieved a maximum COD removal above 90 % and recovered energy in the form of methane (0.35-0.40 m^3 CH_4 kg^{-1} COD removed) and electricity (4.35 W m^{-3}). Life cycle analysis was carried out to compare the environmental impacts of UASB, MFC and UASB-MFC. Considering the effluent quality, environmental impacts and economics of distillery wastewater treatment, combined UASB-MFC system was found to be the most suitable solution for high strength distillery wastewater.

Keyword: Distillery wastewater; Microbial fuel cell; Proton exchange membrane; Oxygen reduction reaction; Life cycle analysis.