DEVELOPMENT OF LOW COST MICROBIAL CARBON-CAPTURE CELL FOR SIMULTANEOUS WASTEWATER TREATMENT, ELECTRICITY GENERATION AND ALGAE PRODUCTION

ABSTRACT

In today's decade, clean energy, wastewater treatment and carbon sequestration are the major global issues that demands an attention. A microbial carbon-capture cell (MCC), which converts chemical energy present in wastewater to electrical energy with bacterial catalysis and utilizes oxygen produced by microalgae as terminal electron acceptor, provides a sustainable solution for these global issues. However, an optimum growth condition need to be provided for both bacteria in the anodic chamber and microalgae in the cathodic chamber. With this focus, optimization of key parameters, which determines the performance of MCC such as nitrate concentration in catholyte, light/dark cycle and the lipid extracted algae (LEA) concentration in the anodic chamber, has been attempted. A maximum power density and algae productivity of 7.05 W/m^3 and 0.83 g/L.d, respectively, were predicted at an optimal LEA concentration, nitrate concentration and light duration of 5.53 g/L, 46.9 mg/L and 10.39 h, respectively, and the same was validated by running a lab-scale MCC. The Box-Behnken design aided in optimizing the influential factors with an aim to render feasibility in scaling up of MCC in an economic way.

Recently, proton exchange membranes (PEMs) have gained extensive attention because of its unattractive cost contribution in scaled-up MCC. Novel low-cost efficient PEMs for short and long term application in MCC with bare coconut shell (CS) and activated carbon (AC) derived from CS blended with clay, respectively, were developed and both exhibited a 2 fold increase in power production than commercially available Nafion membrane. Also, suppression of activity of non-electrogenic bacterial species to enhance the electrogenic bacterial activity was attained by treating the anodic inoculum with neem leaves and garlic peels extract; wherein a 60-65% reduction in the methane yield along with a 2 times increase in power density was achieved.

Along with the efficiency of the electrodes, the bacterial-anode interaction in case of anode and reduction kinetics in cathode, the cost associated with the same is of a major concern in scaling up. This was addressed by developing a novel anode out of sludge immobilized beads with AC filled in stainless steel mesh. In addition to the advantage of delivering a two times more power than the MFC operated with commercially available carbon felt as electrode and 92% removal of organic matter, the major highlight of the finding was a seventeen fold decrease in cost associated with electrode. Similarly a two-fold increase in power generation by enhancing the cathodic reduction kinetics was achieved by using catalyst developed from nickel adsorbed algae biochar. Along with scaling up MCC (65 L) using these developed materials and optimized conditions, applications of MCC in sediment bioremediation, urine treatment and desalination was successfully experimented.

Keywords: Algal biochar; Bacterial-anode interaction; Lipid extracted algae; Methane suppression; Microbial fuel cell; Proton exchange membrane