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Power Generation from Industrial Wastewater using Microbial Fuel Cell

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Abstract

The paper presents the trend in power production from industrial wastewater using microbial fuel cell. Four experimental setups with four types of MFC were developed for this study. For MFC 1, 25% of wastewater from Factory A were added to a fix concentration of cow manure to obtain a solution of 300ml in the anodic chamber while distilled water was added to cathodic department respectively. Similarly, for MFC 2, the wastewater was collected from Factory B. For MFC 3, 25% of wastewater from Factory A and B was added to a fix concentration of cow manure to obtain a solution of 300ml in the anodic chamber while distilled water mixed with about 15g of Potassium Ferricyanide was added to cathodic chamber. For MFC 4, the wastewater was collected from Factory B. Two tests were conducted where Test 1 was to compare the voltage readings from MFC 1 and MFC 2, whilst, Test 2 was for MFC 3 and MFC 4. The results for the Factory A wastewater proved to be more efficient than that of wastewater from Factory B. In addition, the addition of potassium ferricyanide provided more effective generation of voltage production. It can be concluded that these wastes can be scaled up to provide energy for powering up small appliances such as a LED, or other small sensors.

Keywords

Microbial fuel cell, Renewable energy, Factory wastes

Introduction

One of the most promising solutions that have surfaced regarding harnessing energy from renewable resources are the use of Micro Fuel cells or MFC's (Choi et al., 2013, Ma'arof et al., 2018). MFC has a great advantage that harmful gases such as carbon dioxide and carbon monoxide are not emitted during its operation (Najjar et al., 2011). The feasibility for this process as of now has greatly improved much because of the grass root in depth knowledge of the ways the microorganisms decompose the substrate, due to this knowledge factors such as the concentration of either the substrate or the micro-organism can be tested to give much promising results (Kim

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and Lee, 2010). There a lot of factors affecting the electricity generation in a Microbial fuel cell namely, concentration of either the substrate or micro-organism, type of MFC being used, oxygen supply, temperature, external mediators, type of exchange membrane (Liu and Li, 2007).

The MFCs can be operated in two different setups, the first is known as the batch mode and the second one is known as the continuous mode (Rahimnejad et al., 2011). Within the batch mode, the substrate is pushed once in the MFC at the initiation of the cycle, however, inside the continuous mode, the substrate is replenished or pushed into the cell after short durations to ensure the concentration of substrate remains contestant throughout the operation. The operation of MFCs inside the continuous mode gives rise to hydrodynamic troubles (Oliveira et al., 2016) that influence the entire overall performance of the cell. Consequently, the float fee and the subsequent hydraulic retention time (HRT) (Walter et al., 2016) and the shear stress are vital parameters that must be optimized for MFC operation to ensure maximum output from the cell is obtained. It has been observed that higher the concentration is, it affects the overall performance of MFCs for both energy density and COD elimination (Zhang et al., 2011). The research advises that higher concentration lower the electricity output as well as COD elimination efficiency (Hua et al., 2003) and coulombic performance (Li et al., 2009). In exercise, the higher the concentration the lower the HRT. It offers the bacteria less time to oxidize the substrate, consequently affecting the COD removal efficiency of the MFC. Furthermore, another important parameter in MFCs is the hydrodynamic electricity (Pant et al., 2010). It impacts the bacterial adhesion and biofilm formation at the anode (Liu et al., 2010). The formation of denser biofilms can be attributed to strong bacterial presence on the electrode (anode). The objective of this study was, therefore, to identify the trend in power production when concentration of substrate is increased and an external electron acceptor (Potassium Ferricyanide) is added. The findings will be beneficial for greater understanding on MFC with respect to its power generation capabilities.

Methodology

The working model of microbial fuel cell consists of anodic and cathodic chamber of 500 mL capacity. Figure 1 shows the schematic representation of MFC set up. The electrode used is a carbon rod. Copper wire is used to hang the carbon rod and it is used to pass the electrons produced from anode to cathode by acting as linker between them. The salt bridge is constructed by using PVC pipe of length 8 cm and diameter of 2.5 cm. Inside the PVC pipe, polymer such as 5% agar is used along with 0.1 M KCl which forms the salt bridge and helps to transfer the proton to anode. The multimeter is connected to the anode and cathode to measure the voltage and current produced during the process.

For this study, cow manure was used to provide bacteria in the chamber, this is because harnessing energy from biomass has gained quite the attention in the recent years. The goal was to identify whether the cow manure was a possible candidate in treating wastewater as it simultaneously not only produces electricity from wastewater but also uses the cow manure which is widely available in many parts of the world. In MFC 1, 25% of Wastewater from Factory A was added to a fix concentration of cow manure to obtain a solution of 300ml in the anodic chamber while distilled water was added to cathodic department. In MFC 2, 25% of Wastewater from brewery was added to a fix concentration of cow manure to obtain a solution of 300ml in the anodic chamber while distilled water was added to cathodic department. MFC 3: 25% of Wastewater from Factory A was added to a fix concentration of cow manure to obtain a solution of 300ml in the anodic chamber while distilled water mixed with about 15g of Potassium Ferricyanide was added to cathodic department. In MFC 4, 25% of Wastewater from brewery was added to a fix concentration of cow manure to obtain a solution of 300ml in the anodic chamber while distilled water mixed with about 15g of Potassium Ferricyanide was added to cathodic department. Two tests of MFC 1 vs. MFC 2 voltage comparison test and MFC 3 vs. MFC 4 voltage comparison test were then conducted. The experiment was run for almost 6 days until the KCL solution in the salt bridge deteriorated and the solution from the anodic chamber started to travel to the cathodic department affecting the results.

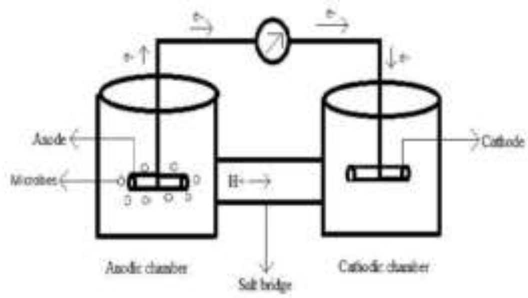

Figure 1. A working model of the MFC

Results and Discussion

Figure 2 shows voltage comparison at different time intervals for both the wastewater of Factory A and Factory B at 25%. It can be observed that at 25% concentration, the wastewater from Home peanut produced a higher voltage to that of the wastewater from Factory B Brewery. At hour 1 the voltage values at 25% for Factory A and Factory B were 0.022V and 0.0024 respectively. At hour 120 the voltage values at 25% concentration for Home peanut and Factory B were 0.1606V ad 0.0754V respectively. This hence justifies that the voltage produced by the wastewater from Factory A was greater than that of voltage produced from Factory B by 0.071% in the total of 120hours duration.

Figure 3 reflects the comparison of values of voltage at different time intervals for both the wastewater of Factory A and Factory B at 25% with the addition of Potassium Ferricyanide in cathodic department. It can be observed from the graph that at 25% concentration, the wastewater from Factory A produced a higher voltage to that of the wastewater from Factory B with the addition of the external electron acceptor. At hour 1 the voltage values at 25% with potassium ferricyanide for Factory A and Factory B were 0.0359V and 0.0053 respectively. At hour 120 the voltage values at 25% concentration with potassium ferricyanide for Factory A and Factory B were 0.302V ad 0.1389V respectively. This hence justifies that the voltage produced by the wastewater from Factory A was greater than that of voltage produced from Factory B by only 0.134% in the total of 120hours duration.

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In addition, it can also be deduced that the addition of an external electron acceptor such as the potassium ferricyanide greatly increases the voltage being recorded. As recorded in these experiments, the addition of potassium ferricyanide increases the voltage generation by 0.1179% for Factory A and 0.05292% for Factory B. The results for the Factory A wastewater proved to be more efficient than that of wastewater from Factory B, with potassium ferricyanide provide more effective in the case for Factory A wastewater as the maximum recorded value for voltage was 0.377V.

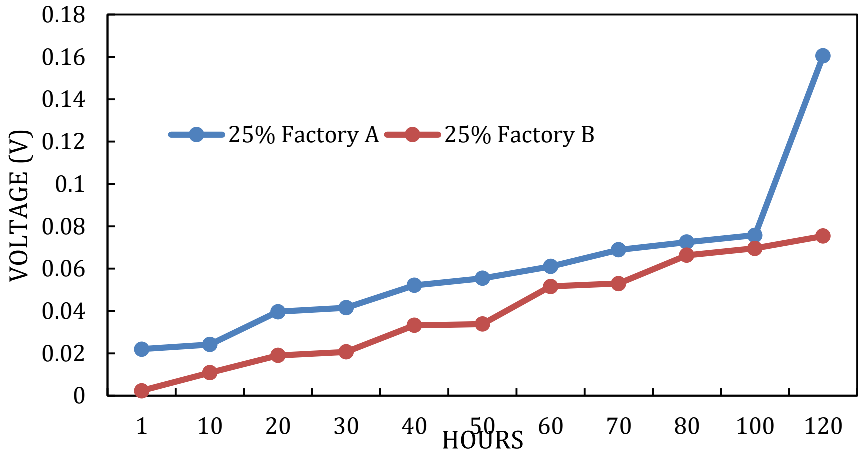

Figure 2. Comparison of Factory A vs Factory B wastewater concentration of 25% with Distilled water

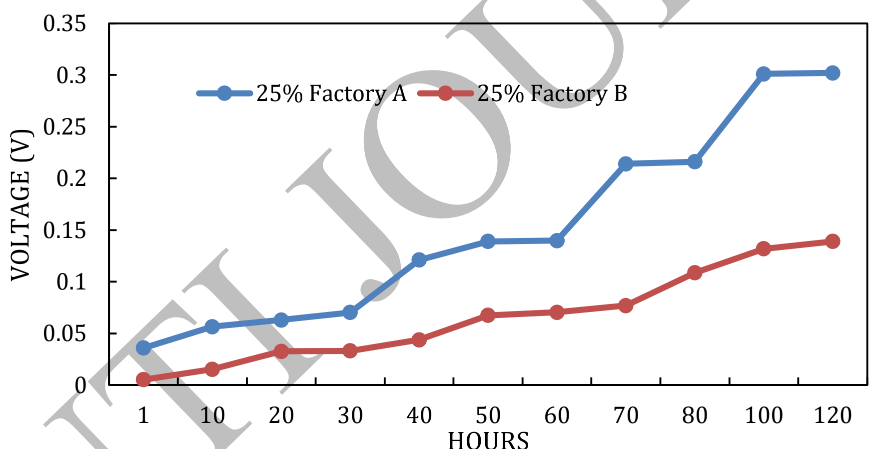

Figure 3. Comparison of Factory A vs Factory B wastewater concentration of 25% with potassium ferricyanide

In conclusion, MFC is a solution to the problems which persist in today's era such as environmental and energy concerns. It is the solution to manufacturing modern energy from metabolism of microorganisms. In this research, the focus has been on using cow manure to treat various industrial wastewater. From the results above it can be concluded that that the addition of an external electron acceptor such as the Potassium ferricyanide greatly increases the voltage being recorded. The results for the Factory A wastewater proved to be more efficient than that of wastewater from Factory B, with potassium ferricyanide provide more effectives in the case for Factory A wastewater as the maximum recorded value for voltage was 0.377V. The microbial fuel

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cell is a bright future prospect, it can be scaled up to provide energy for powering up small appliances such as a LED, or other small sensors. It is a bright future prospect because it does not release any harmful gases such as carbon monoxide into the surroundings as the by product. Small scale MFC's do not provide much power individually as the voltage produced varies due to the limiting factors, what can be done however is to connect multiple MFC's together as one unit to provide energy to any small connected appliance. This way MFC can be setup to power small daily to use appliances with green energy.

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