A COMPARATIVE STUDY OF ELECTRICITY GENERATION FROM INDUSTRIAL WASTEWATER THROUGH MICROBIAL FUEL CELL

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ABSTRACT

The present study presents a comparison of the electricity generation from industrial wastewater via Microbial Fuel Cell (MFC). Four experimental setups with four types of MFC were developed for this study. For MFC 1, 75% of wastewater from Factory A added to a fixed concentration of cow manure to obtain a solution of 600ml in the anodic chamber while adding distilled water into the cathodic chamber. Contrastingly, for MFC 2, 75% of wastewater from Factory A was added to a fixed concentration of cow manure to obtain a solution of 600ml in the anodic chamber, whereas distilled water mixed with 15g of potassium ferricyanide was added to the cathodic chamber. For MFC 3, a similar setup was made as in MFC 1 though it utilizes wastewater from Factory B. MFC 4 in return replicated the setup of MFC 2, yet the wastewater was collected from Factory B. Two (2) tests were conducted where Test 1 was to compare the voltage readings from MFC 1 and MFC 3, while Test 2 was for MFC 2 and MFC 4. It was observed that the voltage produced by the wastewater from Factory A was higher than that of voltage produced from Factory B by 41% in test 1 and 82.4% in test 2. Interestingly, the addition of potassium ferricyanide further increased the voltage by 63.17% when comparing between MFCs 4 and 3, while 111% for MFCs 2 and 1, respectively. Hence, it can be deduced that the addition of an external electron acceptor such as the potassium ferricyanide greatly increases the voltage produced. For future studies, other types of external electron acceptors could be tested in identifying its potential in improving the capability of the MFC.

Keywords: *microbial fuel cell, natural mixes, isoelectronic microbes, ecological concern*

INTRODUCTION

Energy crisis could be a massive issue that exists in today's era, and consequently, the share of renewable energy sources in total world energy production has increased in the last decade [1]-[3]. One amongst the foremost promising solutions that have surfaced relating to harnessing energy from renewable resources square measure the utilization of Microbial Fuel cells (MFC) [4]-[6]. The MFCs provide an excellent advantage that harmful gases, such as CO2 and carbon monoxide gas, are not emitted throughout its operation [7]. The feasibility of this method has greatly improved due to the grass-root in-dept data of the ways in which the microorganisms decompose the substrate [8]. Consequently, factors such as the substrate concentration or the microorganism are often tested to convey promising results [9]. There are plenty of factors influencing the electricity generation from the microbial cell, specifically concentration of either the substrate or microorganism, types of MFC, oxygen supply, temperature, external mediators, variety of exchange membrane [10].

MFC is a promising elective method for accomplishing sustainable power sources [11]. Natural mixes can be disintegrated utilizing different types of isoelectronic microbes, which have the capacity of delivering power in the MFC. MFCs are an extraordinary point of intrigue on account of the assortment of substrates accessible for use alongside the wide range of parameters that can be controlled; for instance, the air supply, pH to accomplish the ideal outcomes. There are MFCs with single and isolated chambers. In a solitary chamber MFC, both the anode and cathode are available in a similar chamber, and in the isolated chamber there is a layer isolating the anodic chamber from the cathodic chamber. The MFC, even though with incredible ecological focal points, has weaknesses. For example, low vitality creation as the way toward using the substrate utilizing miniaturized scale climax is a reasonable procedure that should be continually observed because of its parameters. Alongside the vitality emergency, the ecological concern is organized too. MFC is a conceivable way for both the issues. MFC creates power, yet the yield is genuinely less and tedious [12]. In the moderate power age, MFC is still a promising arrangement in light of the fact that smaller-scale energy unit can use the biomass and modern waste to deliver power. Accordingly, the natural issues and vitality concerns can be tended to by using the waste being created. Agrarian wastes could impose a massive danger to the earth. Both Modern and Horticultural waste substrates were explored. The difficulties and key components influencing the age of power utilizing MFC have likewise been reported.

The MFCs often operated in two completely different setups: batch mode and continuous mode [13]. Inside the batch mode, the substrate is pushed once within the MFC at the initiation of the cycle. However, in the continuous mode, the substrate is replenished or pushed into the cell in short durations to make sure the concentration of the substrate remains contestant throughout the operation.

The operation of MFCs within the continuous mode provides rise to hydrodynamic troubles that influence the complete overall performance of the cell [14]. Consequently, the succeeding hydraulic retention time (HRT) and shear stress square measure are very important parameters that have to be optimized for MFC operation to make sure most output from the cell is obtained [15]. It reported that higher concentration affects the general performance of MFC for each energy density and COD elimination [16]. The analysis advises that a higher concentration lowers the electricity output, likewise as COD elimination potency [17] and coulombic performance [18]. In this line, the higher the concentration, the lower is the HRT. It offers the microorganism less time to oxidize the substrate and consequently alter the COD removal potency of the MFC.

Moreover, another vital parameter in the MFC is hydrodynamic electricity. It impacts the microorganism adhesion and biofilm formation at the anode [19],[20]. The formations of denser biofilms are often attributed to robust microorganism presence on the electrode (anode). Therefore, the objective of this study is to identify the trend in electricity generation for cases with and without external electron acceptor. It presents the power produced from industrial wastewater through MFC. The external electron acceptor of choice was Potassium Ferricyanide. The findings are believed to be useful for more understanding of MFC's power generation capabilities. Therefore, more abundant in-depth analysis could be put forward.

MATERIALS AND METHODS

The operating model of a microbial fuel cell consists of an anodic and cathodic chamber of five hundred millilitre unit capacity. Figure 1 shows the schematic diagram of the MFC established. The electrode used was a carbon rod. The copper wire used to hold the carbon rod and its accustomed pass the electrons created from anode to cathode by acting as the linker between them.

An exploitation PVC pipe made the salt bridge of 8 cm length and a diameter of 2.5 cm. Within the PVC pipe, a chemical compound like 5% agar was used in conjunction with 0.1 M KCl that forms the salt bridge and helps to transfer the proton to the anode. The multimeter was connected to the anode and cathode to measure the voltage and currently created throughout the method. Figure 1 is an example of glucose in the presence of acetate inflicting the generation of the electron.

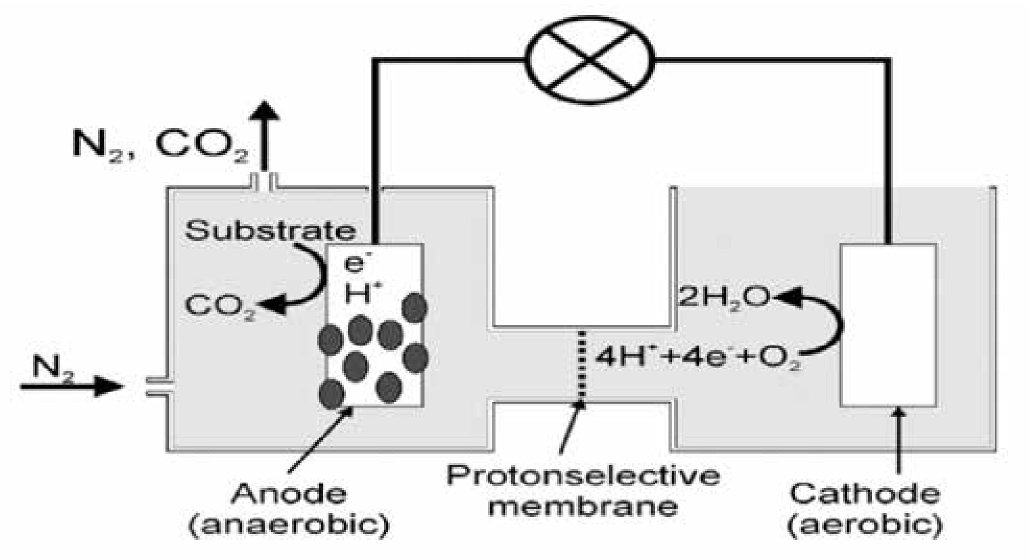

Figure 1 An operating model of the microbial fuel cell

For this study, cow manure was accustomed to offer microorganism within the chamber. This can be as a result of harnessing energy from biomass which has gained quite the eye within recent years. The goal was to spot whether the cow manure was a potential candidate in treating wastewater because it does not, at the same time, solely produce electricity from wastewater; however, conjointly uses the cow manure that is widely available in several parts of the globe.

The following experimental setup was conducted. In MFC 1, 75% of wastewater from Factory A added to a fixed concentration of cow manure to obtain a solution of 600 ml in the anodic chamber while adding distilled water to the cathodic chamber. In MFC 2, 75% of wastewater from Factory A added to a fixed concentration of cow manure to obtain a solution of 600 ml in the anodic chamber while distilled water mixed with 15 g of Potassium Ferricyanide into the cathodic chamber. MFC 3 belongs to 75% of wastewater from Factory B added to a fixed concentration of cow manure to obtain a solution of 600ml in the anodic chamber while adding distilled water to the cathodic chamber. On the other hand, in MFC 4, 75% of wastewater from Factory B was added to a fixed concentration of cow manure to obtain a solution of 600ml in the anodic chamber while distilled water mixed with about 15 g of Potassium Ferricyanide into the cathodic chamber.

In this study, two tests were conducted. Test 1 was to compare voltages produced from MFC 1 with that of MFC 3. Test 2 was intended to compare voltage produced between MFC 2 and MFC 4. The experiment was endured virtually half days till the KCL solution within the salt bridge deteriorated, and therefore the solution from the anodic chamber began to jaunt the cathodic department affecting the results.

RESULTS AND DISCUSSION

Figure 2 compares voltage values at different time intervals for both the wastewater of Factory A and Factory B at 75%. It can be observed that at 75% concentration, the wastewater from Factory A produced a higher voltage when compared with that produced from the wastewater of Factory B. The voltage values at hour 1 for Factory A and Factory B were 0.0989 V and 0.0412, respectively. At hour 120, the voltage values at 75% concentration for Factory A and Factory B were 0.208 V ad 0.194 V, respectively. This hence justifies that the voltage produced by the wastewater from Factory A was greater than that of voltage produced from Factory B wastewater at 75% concentration. The average electric generated in Factory A is 0.138 V, while 0.098 V was read for Factory B.

Figure 3 shows the comparison of values of voltage at different time intervals for both the wastewater of Factory A and Factory B at 75% with the addition of Potassium Ferricyanide in the cathodic chamber. It can be observed that 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 75% with potassium ferricyanide for Factory A and Factory B were 0.0915 V and 0.0369 V, respectively.

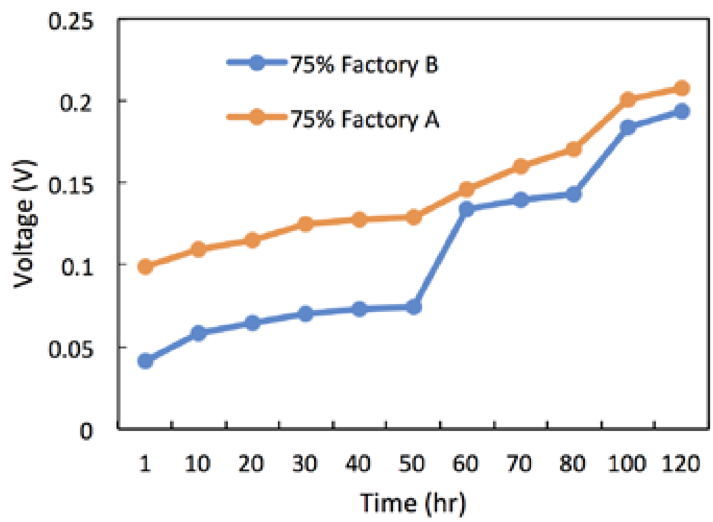

Figure 2 Voltage comparison between Factory A and Factory B at wastewater concentration of 75% with distilled water

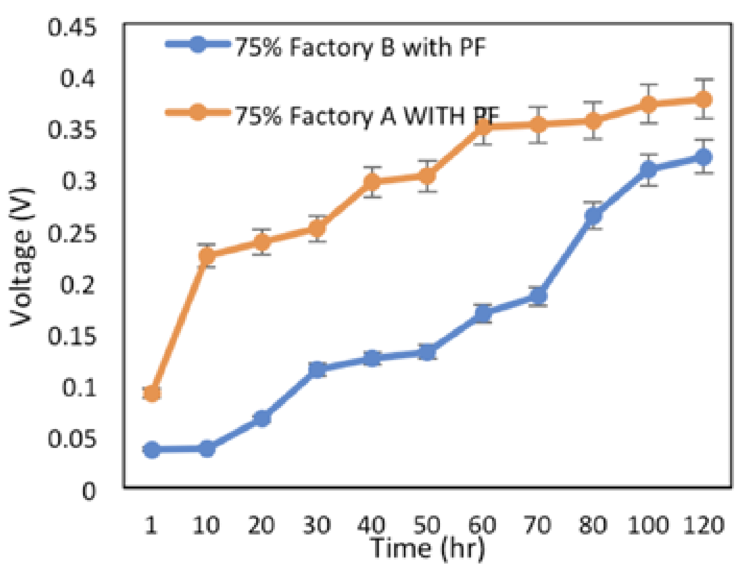

Figure 3 Voltage comparison of Factory A versus Factory B wastewater concentration of 75% with Potassium Ferricyanide

At hour 120, the voltage values at 75% concentration with potassium ferricyanide for Factory A and Factory B were 0.377 V and 0.321 V, respectively. The average reading for Factory A was 0.29 V, while for Factory B, it was 0.16 V.

Overall, the voltage produced by wastewater from Factory A was higher than B by 41% in Test 1 and 82.4% in Test 2. Interestingly, the addition of potassium ferricyanide further increases the voltage by 63.17% in comparing the readings between MFC 4 and 3, while 111% for MFC 2 and 1, respectively. Hence, it can also be deduced that the addition of an external electron acceptor such as the potassium ferricyanide significantly increases the voltage being recorded [21].

CONCLUSION

In this study, the investigation of the power generated from industrial wastewater via MFC found that the addition of an external electron acceptor (for the study was potassium ferricyanide) greatly increases the voltage. The results have shown that the MFC built by utilizing the wastewater from factory A produces enhanced electricity from Factory B by 41% in Test 1 and 82.4% in Test 2. Furthermore, the addition of potassium ferricyanide further increases the voltage by 63.17% in comparing the readings between MFC 4 and 3 (both using wastewater from Factory B), while 111% for MFC 2 and 1 (both using wastewater from Factory A) respectively. The microbial fuel cell could be a bright prospect; it could be scaled up to produce energy for powering small appliances such as a crystal rectifier, or alternative small sensors. Moreover, it is a bright future prospect as it does not unleash any harmful gases like CO into the environment. CO into the environment. Small scale MFCs may not provide abundant power in the separate mode as the voltage produced varies because of the limiting factors. However, in multiple MFC's setups along joined the unit to produce energy to any small connected appliance could power up small daily use appliances with green energy.

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