Maximum Electricity Production Time from Tofu Whey using Microbial Fuel Cell

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Abstract

This study was aimed at evaluating the performance of double chamber microbial fuel cell from tofu whey. The value of open circuit voltage (OCV) and surrounding temperature were taken at four different time which were 6 am, 12 pm, 6 pm, and 12 am. A double chamber microbial fuel cells (MFC) with different was developed to produce electricity from tofu whey and studied for 7 days. Anode and cathode were made by uncoated graphite rod. After 7 days, the electricity production characteristics at four different time were obtained. The results show that the average maximum OCV was reached at 6 pm during the MFC operation. This study also indicated that higher surrounding temperature provide higher electricity production. The optimum surrounding temperature of this study was 31˚C.

Keywords: microbial fuel cell, tofu whey, surrounding temperature

Abstrak

*Penelitian ini bertujuan untuk mengevaluasi kinerja sel bahan bakar mikroba ruang ganda dari air fermentasi tahu. Nilai tegangan rangkaian terbuka (OCV) dan suhu lingkungan diambil pada empat waktu yang berbeda yaitu pukul 06.00, 12.00, 18.00, dan 12.00. Sebuah sel bahan bakar m*ikroba double chamber (*MFC*) *dengan berbeda dikembangkan untuk menghasilkan listrik dari air fermentasi tahu dan dipelajari selama 7 hari. Anoda dan katoda dibuat dengan batang grafit yang tidak dilapisi. Setelah 7 hari, diperoleh karakteristik produksi listrik pada empat waktu yang berbeda. Hasil penelitian menunjukkan bahwa rata-rata OCV maksimum dicapai pada pukul 6 sore selama operasi MFC. Studi ini juga menunjukkan bahwa suhu lingkungan yang lebih tinggi memberikan produksi listrik yang lebih tinggi. Suhu lingkungan optimum penelitian ini adalah 31˚C.*

Kata kunci: *bahan bakar sel mikroba, air fermentasi tahu, suhu lingkungan*

1. Introduction

Considering the environmental issues due to energy production, there is a search for alternate source of renewable energy. One such form of energy source is residue of food production. It can be driven by Microbial fuel cell (MFC) technology [4-7], which converts the energy present in the food production residue to electricity through bio-catalytic activity of micro-organism.

Tofu whey is a residue of tofu production which is one of the largest food productions in Indonesia. That waste is formed in liquid. It is addressed by a complex structure and a high pollutant [2] and formed from the hydrolysis or acidogenic stage of the anaerobic process of microorganisms that are rich of volatile fatty acids [9]. Moreover, leachate can be obtained from food waste that contains many organic elements [1] such as NH_4^+-N, heavy metals, organic and inorganic chlorine, salt, etc. Heavy pollutants from leachate can also contaminate water sources [8]. It adversely affects the health of the ecosystem.

A MFC is a bio electrochemical system that can convert chemical energy to electrical energy contained in an organic substrate directly [3] and it can be used as a solution to treat tofu whey to be cleaner waste. In the common principle of MFC, microbes play an important role as the oxidizing agent from the substrate in the anode side. Microbes oxidize the substrate which produces proton and electron. Here, the electron is produced from microorganisms in the anode side which is then passed into the cathode through an external circuit. After that, electrical energy is resulted and finally water is produced as the waste product. Since the waste product is harmless, MFC is an environmentally friendly method to produce power and a viable alternative for leachate/whey treatment.

Few experiments to know the potential of tofu whey to produce an electricity have been done. The addition of electrolyte to the anode chamber in the MFC with tofu whey substrate increases the electricity production [10]. Furthermore, double chamber configuration for the tofu whey MFC relatively easier to manufacture than using the single chamber configuration [9]. The oxygen which is supplied to the cathode chamber also provides higher electricity production [9]. So far, study of electricity production time and temperature using MFC has not been studied yet, especially the electricity production from tofu whey using MFC.

The objective of this study was to evaluate the maximum electricity production time from tofu whey using Microbial fuel cell.

2. Materials and Methods

The tofu whey was collected fresh from the home industry tofu production in Yogyakarta, Indonesia. An acrylic double chamber MFC was used in this study. The anode and cathode chamber were designed with capacity of 130 ml and 70 ml working volume respectively. They were separated by a proton exchange membrane (PEM) of Nafion 212. The anode and cathode were constructed from graphite rod (effective area = 13 cm^2). The electrodes were uncoated with any catalyst, thus cost of this MFC configuration was much cheaper than the MFC with the coated electrode. The electrodes were submerged into the anode and cathode chambers. The electrodes were connected by a copper wire. The configuration of the aerated MFC is shown in Fig.1. At anode chamber, electrons and protons are generated through the catalytic activity of micro-organism, the generated electrons pass through the external circuit to the cathode chamber and protons pass through the membrane to the cathode chamber, at cathode reduction takes place.

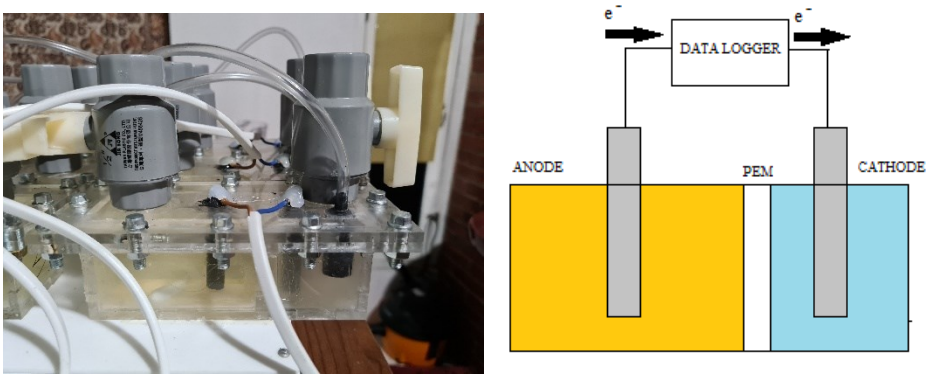

Figure 1. Schematic of double chamber microbial fuel cell.

The anode chamber was fed with 130 ml tofu whey (as a substrate) and maintained to be in anaerobic condition. A 1 M solution of sodium acetate solution was used as an electrolyte in the 70 ml of cathode chamber and maintained to be in aerobic condition. Those microbial fuel cells were operated within 168 hours (7 days). The result of open circuit voltage (OCV) was recorded every 1 hour. A data logger (Omega OM-SQ2020) was used to record OCV and surrounding temperature. At 6 am, 12 pm, 6 pm, and 12 am the electricity productions were evaluated.

3. Results and discussion

The electricity from tofu whey was resulted during the experimental period. A MFC was operated continuously for 168 hours (7 days) at open circuit conditions. Fig.2 shows OCV of MFC with different time (6 am, 12 pm, 6 pm, and 12 am) during the experiment. Close observation of the figure indicates that the maximum OCVs (under no-load condition) from four different times are obtained at the different day of operation. The average maximum OCV was reached at 6 pm, it was 129 mV and achieved maximum OCV 139 mV in day 5 of operation. The average maximum OCV were 120, 120, 129, and 124 mV at 6 am, 12 pm, 6 pm, and 12 am respectively for recorded time. The graph curve for the all-time has identical pattern. At 2nd day, the OCVs slightly decreased from 113, 112, 117, and 109 mV respectively at 1st day to 104, 108, 114, and 105 mV for 6 am, 12 pm, 6 pm, and 12 am respectively. After that, they all gradually inclined until reached the maximum OCV at 4th until 6th day. The maximum OCV was achieved at 4th day that was taken at 12 am, it was 140 mV. After reached the maximum OVC, they started to decline until the last day at day 7. At the end of the study, the OCV were between 128 and 130 mV for all recorded time.

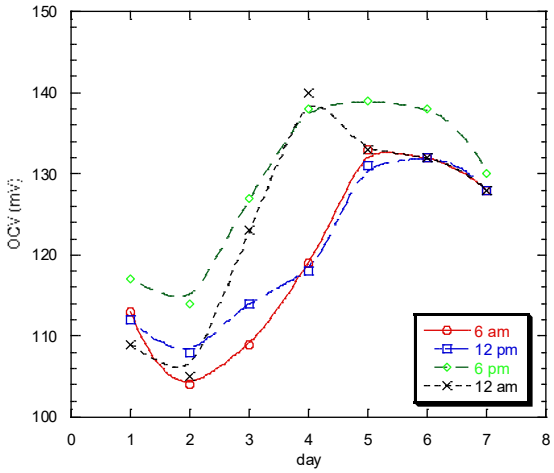

Figure 2. Open circuit voltage of MFCs during operation.

The increase of the OCV indicate that the bacteria start to feed the substrate. Due to the anaerobe condition, the bacteria produce the electron and after that the electron captured by anode. During day 2 until day 4-6, the electron production from bacteria increased. Until reached the maximum OCV, the electron production started to decrease to the end of operation. It was shown by the decrease of OCV. This phenomenon also points out the decrease of nutrient concentration in the feed and the bacteria start to collapse (die) due to the exhaustion of nutrients.

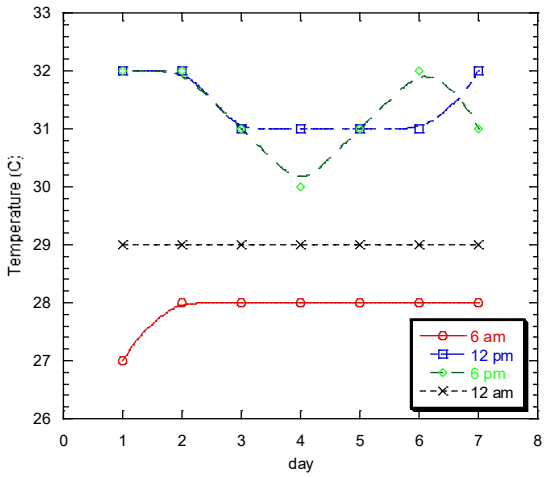

Figure 3. Surrounding temperature

Figure 3 shows the surrounding temperature during the period of recording the OCV. As we can see from Fig.3, the surrounding temperature at 6 pm of the experimental period was relatively high than the other time. The average surrounding temperature at 6 pm during the period was 31˚C. From the Fig.2 and 3, it was shown that the optimum surrounding temperature for electricity production from tofu whey using MFC was 31˚C.

4. Conclusion

An experimental study to investigate the electricity generation from tofu whey using Microbial fuel cell was obtained under four-time recorded time which were 6 am, 12 pm, 6 pm, and 12 am. As a result, the average maximum OCV was achieved at 6 pm. This study also indicated that higher temperature provided higher electricity production.

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