Bioconversion on Wastewater of Soybeans using Microbial Fuel Cell

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Abstract. Microbial fuel cell (MFC) is a technology developed to obtain new sources of renewable energy to produce electricity. It can be an alternative for wastewater treatment and bioenergy producers of renewable electricity. This method requires bacteria to convert substrate in wastewater into electrical energy. The mechanism of MFC were oxidation of substrate by bacteria to produce electrons and protons at the anode. The proton in anode chamber passes through a membrane exchange to the cathode chamber, however the electrons couldn't through. It caused accumulation of electron in anode chamber and then both of electrode had a potential difference, so electron in anode chamber passed through membrane exchange to cathode chamber. In this study used dual-chambers reactors with each compartment having 8 cm × 10 cm × 10 cm of dimensions and 5 mm of thickness. This study was subjected to evaluate the performance of MFC in soybean washing wastewater treatment with bacteria of EM4 to analyze the potentials production of electricity energy. The focus of this study was to evaluate the effect of time to electricity. MFC system was observed for 40 hours, measurement of voltages and electric currents performed every 4 hours. The results showed that there was potential of electricity production from soybean wastewater treatment by MFC. The maximum electricity reached in soybean wastewater media were voltage 441 mV (at 24 h), the electric currents 170 µA and the power density 51, 35 mW/m2 (at 24 h after acclimatization). Increasing of time effect to decreasing of electricity produced.

Keywords: bioenergy, electricity, microbial fuel cell, membrane, wastewater soybean

1. Introduction

One of the renewable alternative energy to produce electricity is Fuel Cell (FC), which produces energy by using High Value Metal Catalyst. FC have advantages over other energy because FC was not produce exhaust emissions such as SOx, NOx, CO2, and CO, and has high efficiency [1]. One such of FC used active microbes as biocatalysts in anaerobic anode chambers to produce biolytic known as Microbial Fuel Cell (MFC) [2]. MFC utilize microbial as a biocatalyst and capture the electricity from an organic and inorganic substances through the activity of microbial [3]. In MFC there are two anode and cathode chambers, the anode chamber set in anaerobic condition but in the cathode chamber, oxygen allowed to circulate and contains an electrolyte solution as an electron acceptor. In MFCs, microorganisms employ a solid electrode in an anode as the terminal electron acceptor of their electroactive anaerobic [4]. Through the metabolic activity of anaerobic microorganisms convert organic matter to be electricity [5,6]. Oxidation-reduction reactions occur in the microbial electrochemical systems through two steps. The first, microbial in the anode interaction is initiated to oxidize the organic substrate into smaller organic molecules, protons, electron and carbon dioxide [3]. The second, electron transfering from the anode to the cathode through the external electrical circuit, and the protons into anode transferred to chatode by membrane. In the chatode proton and electron react to form water and bioelectric current detected because there are electron flow through the external circuit. Electrolyte electron acceptors in cathode act as electron catchers. One such of electron acceptor electrolyte is potassium ferricyanide ($K_3Fe(CN)_6$). The reaction is as follows:

$$4\ Fe(CN)_6^{3-} + 4e^- \rightarrow 4\ Fe(CN)_6^{4-} \quad (1)$$

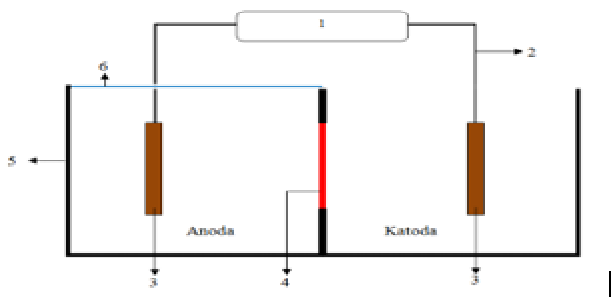
$$4\ Fe(CN)_6^{4-} + 4H^+ + O_2 \rightarrow 4\ Fe(CN)_6^{3-} + 2H_2O \quad (2)$$

The long-term performance of ferricyanide in the MFC system is strongly influenced by the efficiency of its diffusion through PEM to the cathode chamber [11].

2. Methods

2.1. Material and Equipment Preparation

The equipment of MFC using dual chambers were made up of glass sheet material with working volume 800 ml for each chamber, with dimension 8 cm × 10 cm × 10 cm and 5 mm of thickness. Anode and chatode chamber were separated by proton exchange membrane (type Nafion 117) and connected by electrode. Carbon coated on carbon cloth acts as anode electrode, while platinum/C coated on carbon cloth acts as cathode electrode. The compartment configuration of microbial fuel cell, with wastewater soybeans substrate is shown in Fig. 1. Before being applied to MFC, PEM was sterilized used aquadest at 100°C for 1 hour then heated in 3% hydrogen peroxide for 1 hour then rinsed by water, next heated in 1M sulfuric acid for 1 hour. This process to clean the pores of PEM from contaminants. The microbial fuel cell equipment was sterilized by cleaned and rinsed with 70% ethanol to remove the bacterial.



1. Measuring instrument, 2. Power Cable, 3. Electrode, 4. Proto Exchange Membrane (PEM), 5. Anode Chamber, 6. Cathode Chamber

Figure 1. Schematic Microbial Fuel Cell Dual Chamber

2.2. Bioelectricity Conversion

After all the equipment ready fill up the anode chamber with soybean wastewater as substrate and EM_4 as bacteria source. The anode chamber maintained at pH 4.1 and sealed to keep anaerobic condition. 450 ml kalium permanganate was filled on chatode chamber which was worked on anaerobic condition. The anode and chatode electrode was connected by stainless steel wire (type 316) .

3. Results and discussion

Effect Optical Density to Voltage

Figure 2. shows that from the bioconversion process of organic matter of waste water soybeans in processing for the production of tempe using the MFC method could produce electricity. The electricity was produced of reforming nutrients in organic matter of wastewater soybeans by bacteria contained in EM4 which produced protons and electrons. These protons exchange to the cathode/anode and then reacts with $KMnO_4$ to produced H_2O. Based on Figure 2, it appears that for increasing of OD effect to increasing voltage of electricity, it caused the increasing of OD in substrate similar the amount of bacteria that change the substrate from the processing of soybean liquid waste.

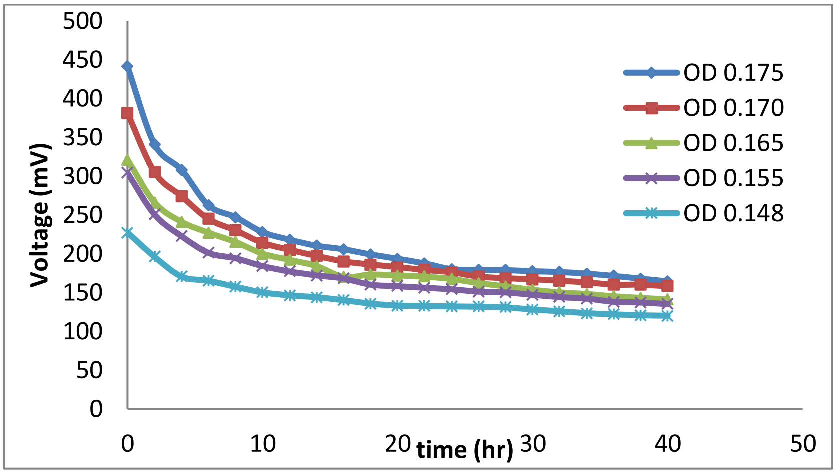


Figure 2. Time dependence to the Electrical Voltage

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Effect Optical Density to Electrical Current

Figure 3 shows that increasing time makes the electrical current decrease. Similar to the voltage of electrical produced in figure 2, the decreasing of electrical current was related to the number of free electrons produced by these bacteria.

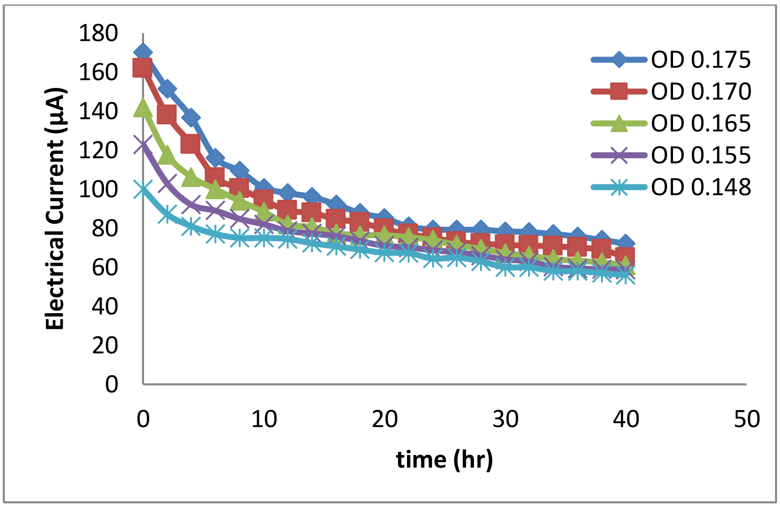

Figure 3. Time dependence to the Electrical Current

Figure 3 also shows that OD effect to the voltage and the electrical current produced by MFC system. The OD in substrate 0.175, the early of electrical current 162 µ A. and decrease to be 65 µ A after 40 hours. When the OD 0.148 In the early process, the electrical current 100 µ A, and after 40 hours, electrical current to be 56 µ A.

Power Density

The electrical current and voltage data from this study were treated with equation 3.1to get a power density value that can represent productionelectricity produced by the MFC system. The power density produced in this system is presented in the following picture

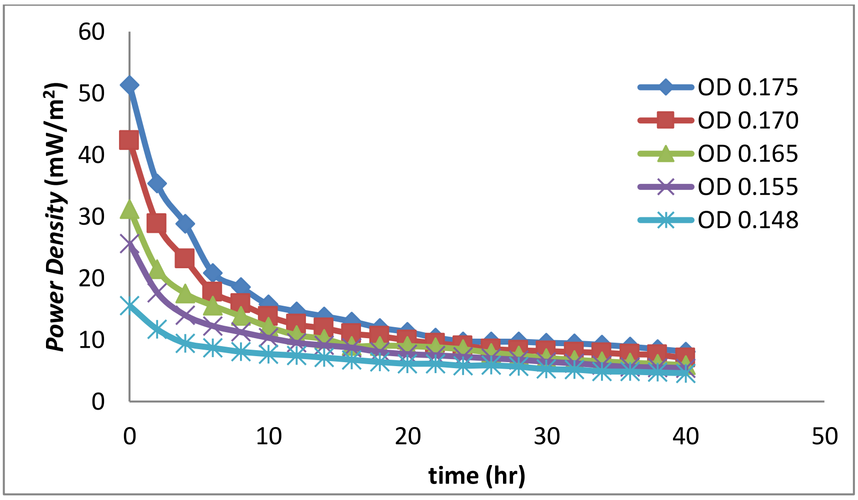

Figure 4. Time dependence to the Power Density

4. Conclussion

1. The bioconversion process of organic compound of waste water soybeans in processing for the production of tempe using the MFC method could produced electricity
2. The bioconversion process of organic compound of waste water soybeans in processing for the production of tempe using the MFC method could produced electricity
3. The increasing OD effect to the increasing voltage and current of electricity.
4. In the early process, the OD of substrate 0.175 produced the electricity voltage 441 mV and electrical current 162 μ A. After 40 hours, voltage to be 164.2 mV and electrical current 65 μ A. For OD substrate 0.148, in early process produced the voltage 227.2 mV and the electrical current 100 μ A, after 40 hours, the voltage to be 120 mV electrical current to be 56 μ A.

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