Microbial Fuel Cells for Bioelectricity Generation from Persimmon Fruit Waste and organic Wastes Mixing With Soils

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1. Introduction

Resource recovery from waste material as electricity is an impoetant topic. It has resulted in great concern to finding alternate sources of electricity that are green and safe. A plentiful and renewable carbon source that has been considered for microbial fuel cell (MFC) applications (mainly for electricity generation) is biomass (Moqsud et al., 2013). The MFC has emerged as an efficient and eco- friendly solution for organic waste management. However, the use of persimmon waste as biomass to generate electricity in MFC has not previously attracted the attention of researchers. Persimmon fruit production is very abundant in Japan and they generated a huge amount of waste which should be utilized, reuse and recycled as a valuable resource. Therefore, the objective of this study was to explore and to evaluate bioelectricity generation in MFCs by using persimmon waste as a low cost feasible potential substrate for efficient and economical conversion to bioenergy generation.

2. Materials and methods

In this study, a rectangular container of MFC with some blend of persimm wastes and some supporting materials are developed as a cell. Figure 1 illustrates laboratory test device set up for the MFC's schematic diagram. The laborat investigation was conducted in a constant room temperature of 25°C and measured a data-logger.

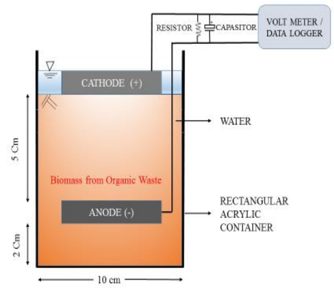

Figure 1. MFC's schematic Diagram

3. Results and Discussion

Figure 2 illustrates the variation of voltage with duration of time by usi persimmon waste (PW) mixed with some type of soil (S), leafmold (LM), a ricebran (RB). It can be seen that the voltage of each MFC increased gradually w elapsed time and the peak value were reached in between 2 dan 9 days. In the case persimmon waste mixed with soil (PWS) and persimmon waste mixed with leafmold (PWLM), the voltage (*V*) increased sharply during the initial time (4 days); after that, it increased gradually and peaked after 8 days.

During the initial stage, the bacteria got ample food and their activities increased very rapidly. Mixed MFC of PWLM and PWS seems to generate a higher value of stable voltage when compared to effect of the microbes MFC else individually. The reason for enhanced stability would be the use of mediators of one microbe by the other to transfer electrons to the electrode (Rakesh et al., 2014). For that reason, the voltage increased sharply. The voltage decreased gradually with time as the supply of food was used up by the bacteria. Peak voltage was around 127.2 mV using persimmon waste mixed with soil.

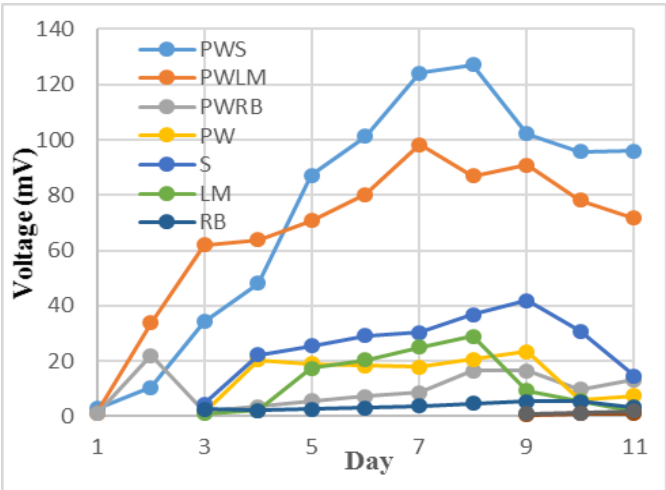

Figure 2. The variation of voltage with duration of time

The peak voltage was considerably higher (about 300%) than values stated in other mixture and single samples. This performance's stage is caused by the bacteria got ample food and their activities increased very rapidly; After the anaerobic condition prevailed, voltage increased sharply. The possible reason why the persimmon waste mixed with soil sample showed a higher value of voltage than the other is that in soil there were more mineral and nutrients which supplied the cell with a large amount of energy. Another, this ample amount of glucose inside the sample made the bacteria active and hence generated a higher voltage. This amount is the maximum amount of voltage generated in a one-chamber MFC using organic waste/organic matter to date. In this figure also shows that over 8 days, the voltage gradually decreased. Over this period, bacteria reproduced and died out. It was expected that initially when there was enough food the bacterial colony would grow, and that after some period of time, as the food source depleted, and the remaining bacteria would die out leaving little or no bacteria to produce electricity (Jessica Li, 2013). However, the voltage generation for another samples were almost constant in all the stages. A small amount of voltage was generated due to the potential difference between the anode and cathode and also probably the phenomenon of organic matter decomposition in the soil. On all samples seen the voltage is still rising at a certain time. This is possible because the microbes are encouraged to metabolically more active than ever and

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the free electrons generated too much. This indicates that the MFC was able to recover his own electrical charge and this ability is a potential that can be developed. (Siti.L.A , 2012).

Figure 3 shows the polarization curve of the MFC using the persimmon waste. A polarization curve is used to characterize current as a function of voltage. The polarization curve shows how well the MFC maintains voltage as a function of the current production. The power curve is calculated from the polarization curve and describes the power output of the cell as a function of the current. Usually it has a parabolic shape with a single point of maximum (called Maximum Power Point or MPP), which occurs when the external resistance of the circuit equals internal resistance of the cell.

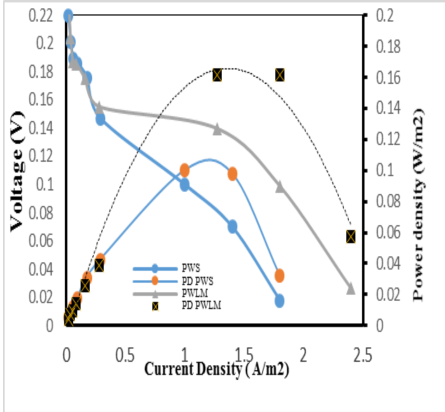

Figure 3. Polarization curve of MFC

Current was measured using Ohm's law and by changing the circuit`s external resistance (load) we obtain a new voltage, and hence a new current at that resistance. It was observed that the performance index, that is, maximum power density (mW/m^2, normalized to the anode projection area), reached around 0.0098 W/m^2 and 0.162 W/m^2 using persimmon waste mixed with soil (PWS) and persimmon waste mixed with leafmold (PWLM), respectively.

The power densities showed an incremental trend with decreasing external resistance and reaches to peak value. After that, the power densities began to fall with increasing current density, which indicated typical fuel cell behavior.

Figure 4 shows the relationship between voltage and current in the MFCs for 8th day of elapsed time. It is found that the relationship was almost linear. The intercept and inclination of the line represents electromotive force and internal resistance for the MFCs, respectively. It represents that MFC with a good performance indicates high electromotive force and low internal resistance. The electromotive force of MFC was approximately 0.22 V. The internal resistance of MFC was relatively low.

On the other hand, the performance of MFC persimmon wastes with oil is lower than mixed with leafmold. As described above, it is considered that soil does not work well in dry conditions. Maximum electric power is calculated from the linear relationship between voltage and current. The maximum power per anode area is 0.162 W/m^2 for the MFC with persimmon waste mixed with leafmold.

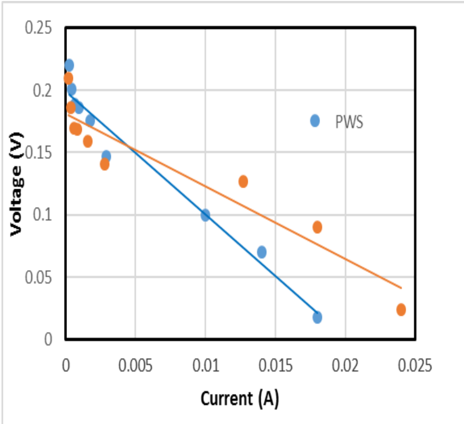

Figure 4. Relationship between voltage and current in the MFCs (Day 8)

4. Conclusions

This investigation established the feasibility of producing electricity directly from persimmon waste using MFCs. It was observed that MFCs using both persimmon waste and organic waste mixed with soil have proved to be a good way to get green electricity generation in order to maintain healthy and pollution free environments, particularly in developing countries where solid waste management is a great concern. A small amount of electricity is also necessary for electricity-scarce populations (25% of the world's population are deprived of electricity). Though the amount of electricity is smaller in MFCs when using persimmon waste mixed with soil (0.0098 W/m^2) compared with persimmon waste mixed with leafmold (0.162 W/m^2), it is still very much needed for the future green energy era, as it is an abundant source in many developing countries. Increasing the portion of biomass in the energy matrix will help to diminish the negative environmental impact of atmospheric CO_2 accumulation and to meet the targets predicted in the Kyoto protocol.

So, by using persimmon waste we can address some important problems currently faced by the world: first, the health and pollution of geo-environment problems due to unmanaged organic waste, as this organic waste would be used as raw material to generate electricity (people will reuse it carefully); second, we need not use our valuable food products (corn and soybean) to obtain transportation fuel, while at the same time millions of people, including children, cannot get food regularly; third, the urgent need to reuse bamboo is very much an important concern for the sustainable geo-environment in Japan, as well as other countries in the world—if we consider a 200 kW rated bioelectricity generator by MFC, then an average of huge amounts of persimmon waste will be required to conceptually extrapolate our findings; finally, it is clear that bioelectricity can be produced by persimmon waste, which could provide some sort of 'light of hope' to the people who still live in the dark at night.

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