Enhanced Performance of Microbial Fuel Cell under Different Cathode Operation Modes

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Abstract: Electricity generation during biosurfactant production from used vegetable oil in a two chamber Microbial Fuel Cell (MFC) was investigated under two different cathode environments. The output voltage across the optimum load was monitored to evaluate the performance under both aerated and open air cathode operations. The relatively stable average output voltage and the maximum power density in the aerated cathode operation was obtained as 45 mV and 0.45 mW/m^2 respectively and the corresponding values obtained in much shorter time during the open air cathode operation were 80 mV and 0.77 mW/m^2. Surface tension of the anode substrate was 29 mN/m after 4 days of operation and remained relatively unchanged during the operation.

1. Introduction

Electricity generation using renewable and environmental friendly energy sources is gaining interest in recent years. After some families of microorganisms are found to be able to degrade (oxidize) the organic matter and produce electrons and also exogenously transfer electrons, MFCs are drawing increasing attention as an effective means of electrical energy production from complex organic wastes (Logan 2008). The major constrain associated with the generation of electricity using MFC is the low and instability of the power output. There are only few studies focused on producing electricity using MFC while using it for some other productive purposes. Treatment of wastewater using MFC while generating electricity is the focus of most of those studies. In this study, electricity is generated using MFC while producing biosurfactant. UH-biosurfactant has been successfully produced from used vegetable oil (Hariharan 1996).

2. Objectives

The overall objective of this study was to investigate the performance of the MFC under two different cathode environments.

3. MFC Arrangement and Operation modes

Two chamber MFC arrangement used in this study is shown in Figure 1. Graphite and aluminum was used as the anode and cathode electrodes respectively and square shaped plastic bottles were used as the chambers with working volume of 1000 mL each. Used vegetable oil was used as the anode substrate and salt buffer was used in the cathode chamber. At the start, MFC was operated in the open circuit mode, when the open circuit voltage attains a steady value the internal resistance of the arrangement was estimated using power density peak method and polarization slope method (Logan 2008).

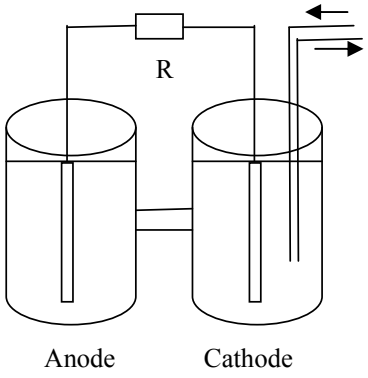

Figure 1. MFC Arrangement

A resistor equal to the internal resistance value was connected as the external load for the closed circuit operation because the power output of the MFC achieves its maximum value when the external resistance is equal to the internal resistance. During the closed circuit operation, initially, MFC is operated with aerated cathode arrangement. After closed circuit operation for two weeks, the anode substrate was changed with a new batch of the same substrate and the aeration tube was removed and cathode chamber was open to air, this mode of operation termed as the open air cathode operation of the MFC.

During the experiment, output voltage and current were measured using a multimeter. pH and oxygen reduction potential (ORP) of the solutions were measured by pH-ORP meter. Surface tension of the anode substrate was measured using the Du-Nouy tensiometer.

4. Results and Discussions

From the power density peak method the internal resistance of the MFC was estimated as 15 kΩ. Salt bridge could be the main reason for the very high internal resistance obtained in this study. The output voltage during the closed circuit operation showed similar trends under both aerated and open air cathode operations but the relatively stable average output voltage under aerated and open air cathode operations were 45 mV and 80 mV respectively. This difference may be due to the increase in oxidation rate in cathode compartment in the open air cathode operation. Surface tension of the anode substrate was 29 mN/m after 4 days of operation and remained relatively unchanged. This indicates the production of biosurfactant during the MFC operation. Maximum power density obtained during the aerated and open air cathode operations were 0.45 mW/m^2 and 0.77 mW/m^2. Very high internal resistance could be the main reason for the relatively low power density achieved in this study. During the steady state operation, the average values of pH and ORP of the anode substrate were obtained as 7.5 and -49.4 mV respectively.

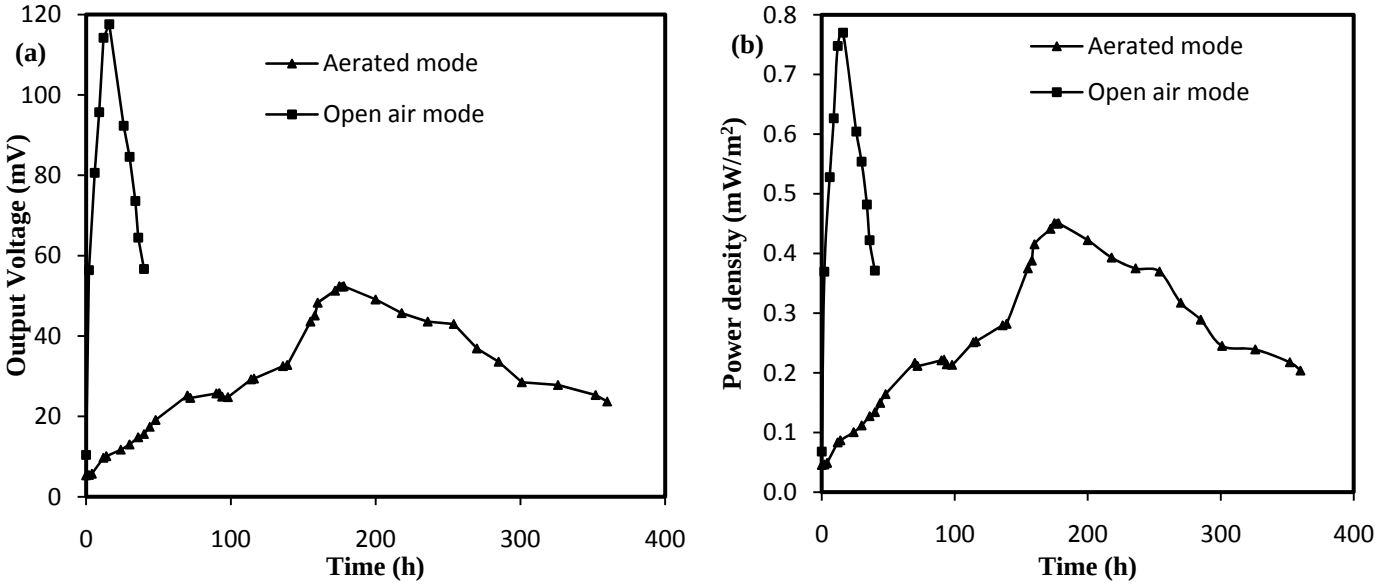

Figure 2. Comparison of (a) the output voltage and (b) the power density during aerated mode and open air mode cathode operations of MFC

5. Conclusion

Among the two modes of cathode operations investigated open air mode had shown better results and it was more attractive because the input energy for the MFC operation was reduced as the cathode compartment need not to be aerated externally.

6. Acknowledgement

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7. References

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