Nickel Nanoparticles Catalyst Enhanced Performance of Microbial Fuel Cell

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Abstract
Small amount of nickel nanoparticles (NPs) was used as cathode catalyst in microbial fuel cell (MFC) using recycled waste as carbon source in the anode chamber. With normalized concentration of Ni catalyst of 0.5 mg/cm2 on the cathode surface, power production of the MFC from 0.005 mW/m2 to 0.07 mW/m2 was observed. The maximum power density of the MFC was further enhanced to 0.32 mW/m2 in this study by increasing external load.

1. Introduction
High inner resistance is a significant issue that reduces the performance of microbial fuel cell (MFC). Polarization resistance of cathode is one major factor composed the inner resistance of the MFC. Different catalysts have been applied to the surface of the cathode electrode to reduce its polarization resistance. Pt is the most commonly used catalyst. As its cost is high, lots of cost-effective catalysts were developed. Cobalt oxide, lead dioxide, activated carbon nanofibers, carbon black, nickel nanoparticles (NPs), iron phthalocyanine, and copper-phthalocyanine have all been reported as cathode catalyst (Ghasemi et al. 2011; Zhao et al. 2005; Jeffery et al. 2007). In this study, Ni NPs was used as cathode catalyst. Ni is one kind of transition metal, and use of transition metal as catalyst in fuel cells has been reported.

2. Objective
The overall objective was to investigate the effect of nickel nanoparticles on the cathode of microbial fuel cell.

3. Materials and Methods
A two chamber MFC (0.5 L each) was built in this study. Carbon fiber brushes were used as anode and cathode with nominal surface area of 91 cm^2. Cation exchange membrane was used to separate the two chambers. Used vegetable oil was used as carbon source for bacteria growth in the anode chamber. During the operation of MFC, a 1 kΩ external resistor was used to connect the anode and the cathode. The anode solution was slowly stirred and oxygen was injected into the cathode chamber. Ni NPs was produced by the foam method, and mixed with Nafion solution (Fuel Cell Earth) before its deposition on the surface of the fiber brush with nominal concentration of 0.5 mg/cm^2. During 6 days operation, closed circuit voltage (CCV) was recorded at 10 min interval with data loggers (Agilent 34450A). The current through the electrical circuit was calculated by the measured CCV divides the external resistance. The power density was obtained by multiplying the CCV with the current, and dividing the area of the anode electrode. After achieving stable open circuit voltage, external voltage was measured by changing the external resistance in scale of 0~2.0 MΩ. The inner resistance of the MFC was calculated by the density peak method (Prashanth et al. 2010).

4. Results and Discussion
Power density was compared for MFC with or without Ni NPs on the cathode surface during 6 days operation with 1 kΩ external resistance (Fig.1). A maximum power density of 0.07 mW/m^2 was achieved during the third day with Ni NPs on the cathode surface. However a maximum of 0.005 mW/m^2 power density was produced from the control of carbon cathode. This showed the catalyst capacity of Ni NPs to enhance the power production of the MFC. The maximum power density of the cathode with Ni NPs was 0.32 mW/m^2 by changing the external resistance to 9.5 kΩ (Fig.2). As the maximum power density was obtained when the external resistance of the MFC equals to its inner resistance, the inner resistance of

this MFC was 9.5 kΩ. Fig.2 also showed that maximum of 0.17 V CCV was obtained for the MFC when applying 9.5 kΩ external resistance.

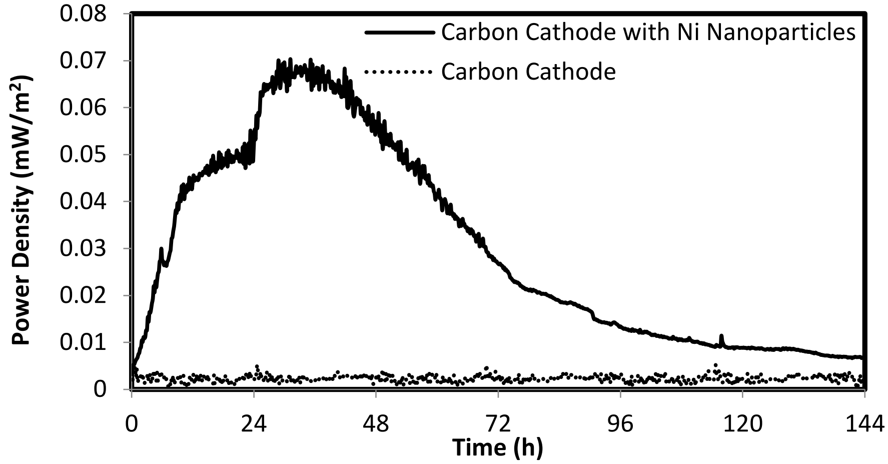

Fig.1 Power Density Change with Time of Microbial Fuel Cell with or without Ni Nanoparticles on Cathode Surface

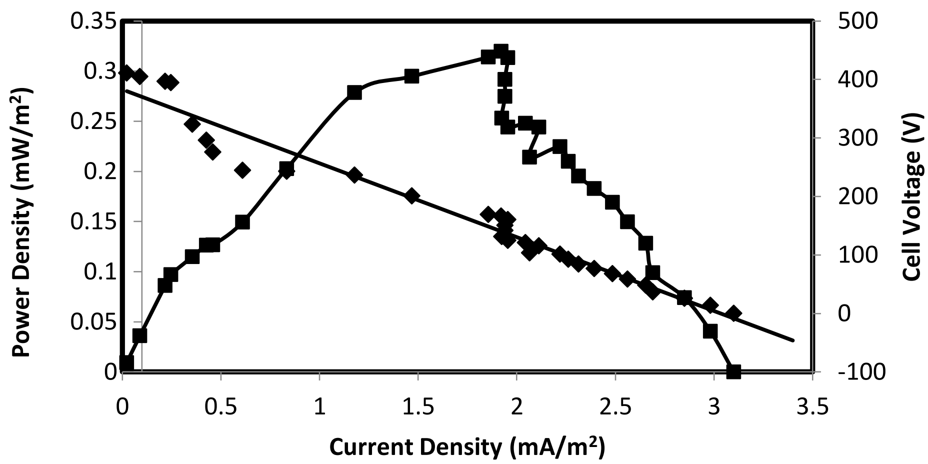

Fig.2 Power Density and Polarization Plot of Microbial Fuel Cell with Ni nanoparticles on Cathode Surface

5. Conclusions

Ni NPs on the cathode surface enhanced the power density of the MFC to 0.07 mW/m^2 with 1 kΩ external resistance. By changing the external resistance to 9.5 kΩ, the power density was further enhanced to 0.32 mW/m^2 in this study.

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7. References

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