Application of a Cobalt Porphyrin as Catalyst in Microbial Fuel Cells

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Introduction

Microbial fuel cells

In microbial fuel cells (MFCs), microorganisms are used as catalysts to oxidize substrates to generate electricity via electrochemical reactions. A generalized MFC system comprised of a two-chambers (anode and cathode) system is shown in Figure 1.

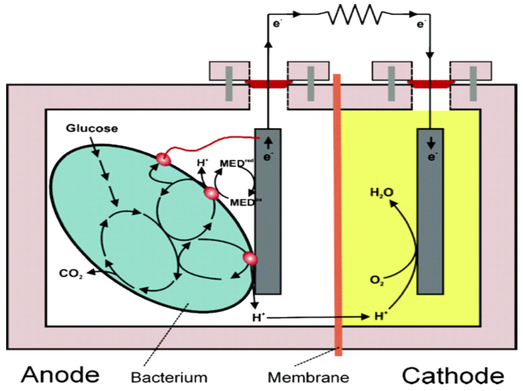

Figure 1. Operating principle of a double chamber MFC.

Catalyst

Catalysts facilitate the reaction by reducing the activation energy and are essentially necessary to perform the reduction reactions at the cathode in MFCs. The most robust cathode is currently platinum (Pt), which is very efficient at reducing oxygen.

Porphyrin

Porphyrins are a group of aromatic compounds consisting of macrocycles (a ring architecture of 12 or more atoms) and substituents, and are capable to effectively conduct oxygen reduction reaction.

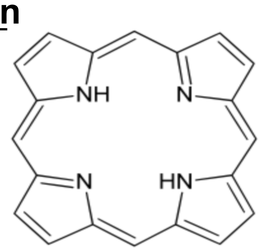

Figure 2. Structure of the simple porphyrin.

Research Objectives

1. Various porphyrin loading densities were investigated in order to determine the optimal catalyst loading as determined by power production in MFCs.
2. Electrochemical performance of porphyrin CoT3M4HPP catalyst was evaluated by comparing with Pt catalyst.

Results

Microbial fuel cell tests

Table 1: A summary of electrochemical performance of the 2 kinds of cathodes

	10% Pt/ Carbon black	80% Co-Porphyrin/ Carbon black
Catalyst loading amount (mg/cm^2)	0.5	4
Open circuit voltage (V)	0.634	0.643
Vmax Power Density (mW/m^2)	12.17	28.13
Internal Resistance (Ω)	1650	1442

Electrochemical Characterizations

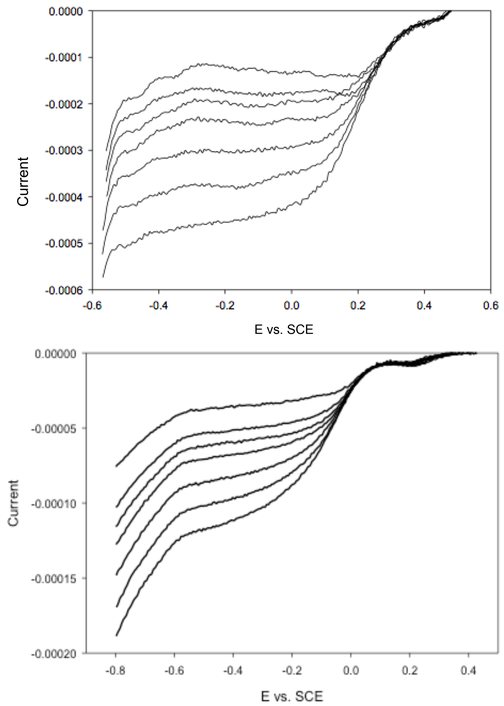

Figure 3. a) 10% Pt/C (Left) and b) porphyrin/C (Right) catalysts RDE results with rotating rates from 100 to 3600 rpm in a pH=7 buffer.

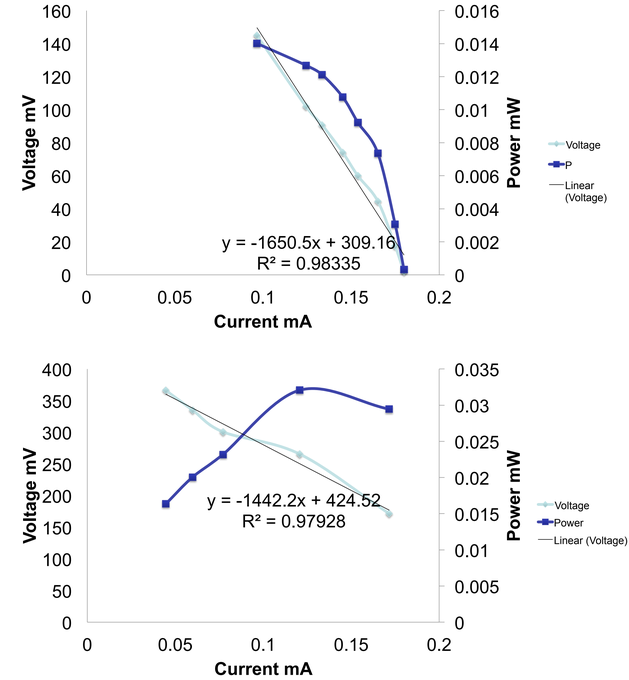

Figure 4. a) Polarization slope method and b) power density peak method was applied to estimate the internal resistance and maximum power density of MFCs.

Conclusion

- 80% porphyrin/C cathode had the best electrochemical performance among various porphyrin loading densities.
- The MFC with 80% porphyrin/C cathode generated larger maximum power density than one with 10% Pt/C cathode.
- However, Pt/C showed better performance than porphyrin/C in RDE tests

The cobalt porphyrin catalyst showed considerable catalytic activity as a catalyst in MFCs and is much cheaper than Pt catalyst. Further studies are needed to determine the reasons that result in the better performance of the porphyrin than the Pt catalyst.

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