Electricity Generation using Sulfolobus solfataricus in a High-Temperature Microbial Fuel Cell

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Electricity Generation using *Sulfolobus solfataricus* in a High-Temperature Microbial Fuel Cell

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**Abstract**

Microbial fuel cells (MFCs) are an emerging biomass-to-energy technology, which break down organic materials in liquids while generating electricity. This project includes the construction and operation of a membrane-less single chamber microbial fuel cell (ML-SCMFC), using the hyperthermophilic archaeon *Sulfolobus solfataricus* at 80°C. Use of extremophiles as the fuel cell culture has many potential applications, such as generating electricity in harsh and isolated environments, including deserts and alien space environments. A maximum power density of 0.67 mW·m⁻² (25.3 mW·m⁻³) was obtained using a carbon cloth anode and cellobiose as the substrate. Sustained current densities ranging from 5.63 and 39.9 mA·m⁻² regularly persisted for 4-17 hour durations. Additional changes can potentially improve observed values, including new substrates, inclusion of separators and new anode materials.

\[
\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 6\text{CO}_2 + 12\text{e}^- + 12\text{H}^+ \quad (1)
\]

\[
3\text{O}_2 + 12\text{H}^+ + 12\text{e}^- \rightarrow 6\text{H}_2\text{O} \quad (2)
\]

**Materials and Methods**

- Single Chamber membrane-less MFC (28mL volume)
- Carbon Cloth and Brush anodes (untreated)
- Air Cathode with 0.5 mgcm⁻¹ Pt loading
- Sealed with silicone

**Operation**

- Run in incubator for several days at 80°C
- Continuous fed medium into chamber 2.75 ml hr⁻¹
- Allotted times for substrate injection

**Results**

- Continuous, sustained current and power densities
- Higher performing runs had shorter sustained periods
- Cellobiose – similar substrate, highest output
- Brush anodes: large surface area, lower output—greater surface utilization required
- Values comparable to studies with thermophilic and single strain systems.

<table>
<thead>
<tr>
<th>Trial Number</th>
<th>Value</th>
<th>Anode Type</th>
<th>Anode Surface Area (Projected, m²)</th>
<th>Substrate</th>
<th>Max net current Density (mA·m⁻²)</th>
<th>Max Power Density (mW·m⁻²)</th>
<th>Max Sustained power density (mW·m⁻²) and duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
<td>Carbon Cloth</td>
<td>1.13E-03</td>
<td>Glucose</td>
<td>27.3</td>
<td>0.46</td>
<td>0.28 and 0.24 and 8.0 and 6.5 and 4.7</td>
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<tr>
<td>5</td>
<td></td>
<td>Carbon Cloth</td>
<td>1.13E-03</td>
<td>Cellobiose</td>
<td>33.7</td>
<td>0.67</td>
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<tr>
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<td>Carbon Brush</td>
<td>8.83E-02</td>
<td>Glucose</td>
<td>0.12</td>
<td>0.077</td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion**

MFCs are a developing technology that uses microbes to generate electricity from biomass. In this work, continuous electricity generation using *S. solfataricus* was demonstrated using different substrates and anode types in a single chamber membrane-less MFC. Power and current densities were comparable to or greater than systems at lower temperatures. Continued characterization of hyperthermophiles for MFC use could make them a favorable choice for renewable electricity generation—particularly in extreme settings. Future studies will explore anode pretreatment for bacterial adhesion and use of electron shuttles to aid electron transport.

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