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

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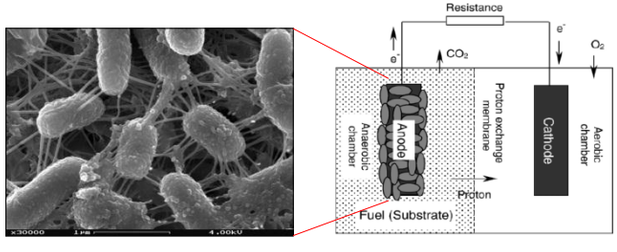
Abstract

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 $mW \cdot m^{-2}$ (25.3 $mW \cdot m^{-3}$) was obtained using a carbon cloth anode and cellobiose as the substrate. Sustained current densities ranging from 5.63 and 39.9 $mA \cdot m^{-2}$ regularly persisted for 4-17 hour durations. Additional changes can potentially improve observed values, including new substrates, inclusion of separators and new anode materials.

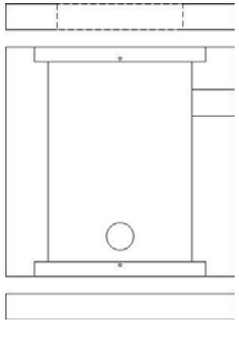


$$C_6H_{12}O_6 \rightarrow 6CO_2 + 12e^- + 12H^+ \quad (1)$$

$$3O_2 + 12H^+ + 12e^- \rightarrow 6H_2O \quad (2)$$

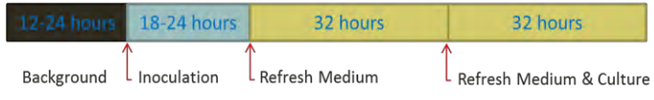
Materials and Methods

- 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

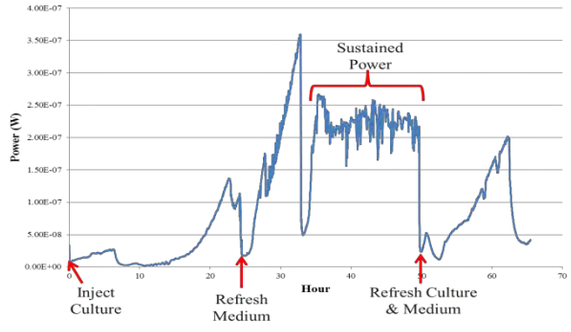


Results

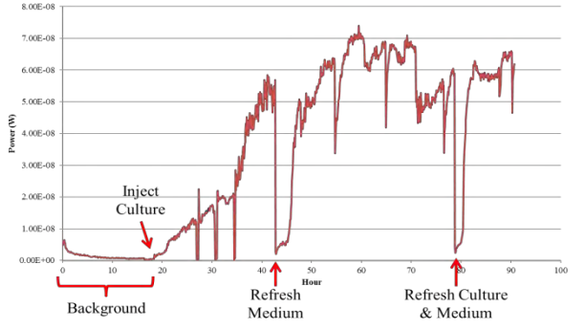
- Continuous, sustained current and power densities
- Higher performing runs had shorter sustained periods
- Cellobiose –similar substrate, highest output
- Brush anodes: large surface area, lower outputs-greater surface utilization required
- Values comparable to studies with thermophilic and single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

	Trial Number		
Value	3	5	7
Anode Type	Carbon Cloth	Carbon Cloth	Carbon Brush
Anode Surface Area (Projected, m^2)	1.13E-03	1.13E-03	8.83E-02
Substrate	Glucose	Cellobiose	Glucose
Max net current Density (mAm^{-2})	27.3	33.7	0.12
Max Power Density (mWm^{-2})	0.46	0.67	0.077
Max Sustained power density (mWm^{-2}) and duration (hrs)	0.28	0.24	0.068
	8.0	6.5	4.7

Cloth anode, Glucose Substrate



Cloth anode, Cellobiose Substrate



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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