Biofilm Batteries

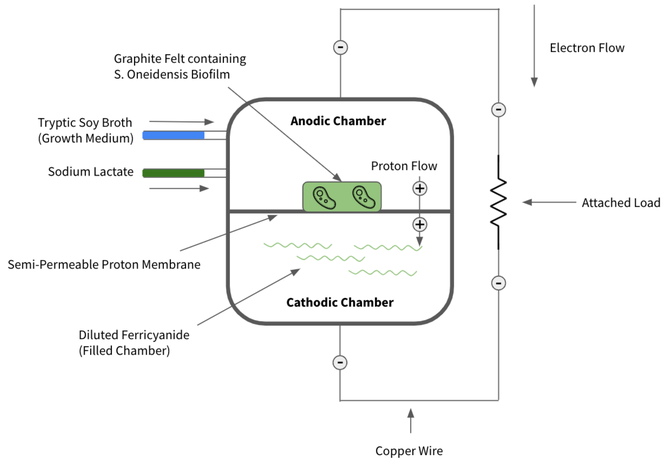
The Efficacy of Biofilm Microbial Fuel Cells in Microgravity over Time

Roshan Bellary, Emily Lan, Bryant Wong, Praneeth Tummala, Richard Hockett, Neha Narayanam, Aayan Maheshwari, Jack Eatherton

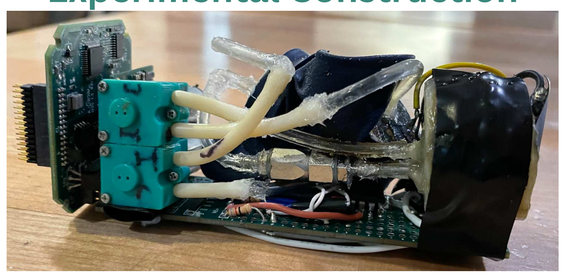
Background

- Bacteria produce extracellular polymeric substances and carbohydrate-binding proteins to form a biological extracellular matrix known as a **biofilm**
- Extracellular matrix is crucial for cell-to-cell interaction for **electrochemically-active bacteria**
- Previous research has reported increased biomass and thickness of **biofilms in microgravity**, forming a column and canopy structure rather than a flat structure
- Electrochemically-active biofilms are comprised of bacteria that can exchange electrons with an electrode via “electron shuttles”

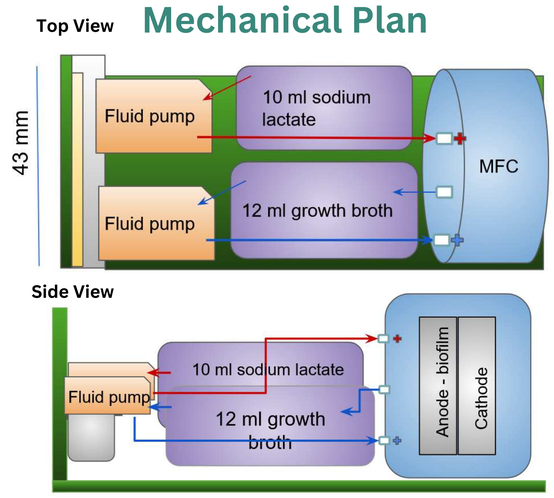
Microbial Fuel Cell (MFC)



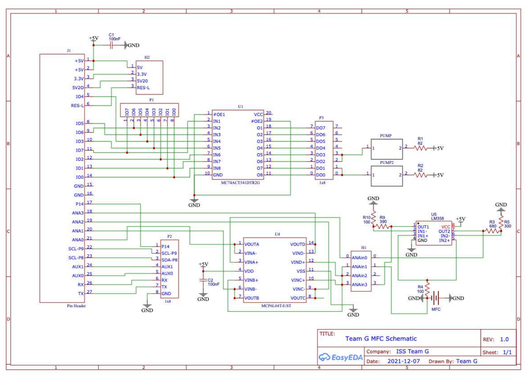
Experimental Construction



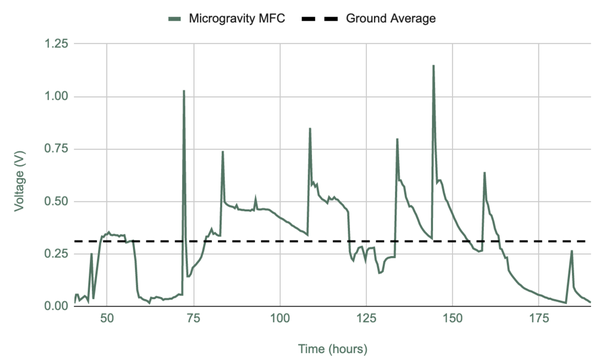
Mechanical Plan



Electrical Schematic



Data



Data Analysis

- Voltage spikes correlate with sodium lactate pumping intervals
- Two major voltage peaks experienced an **11.56% increase**
- **Intermediate spikes** indicate that unused sodium lactate may have circulated through the system along with the growth medium
- The voltage output of the MFC reflects multiple peaks with a slight increase over time, reaching a maximum of **1.15 volts**
- Voltage production diminished after **6 days** from MFC activation
- For reference: average voltage achieved over 6 days was **0.298 volts**

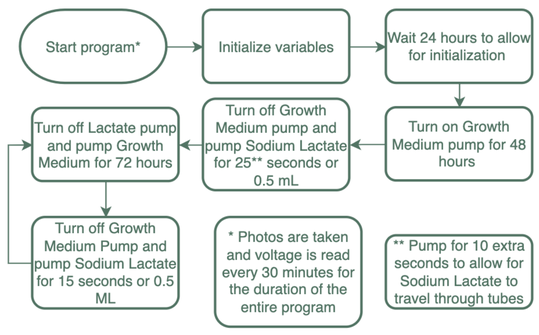
Purpose

In light of the expanded growth of biofilms in microgravity, we constructed a biofilm microbial fuel cell utilizing S. Oneidensis MR-1 which was sent to the ISS to **identify a viable renewable energy source for long term space travel.**

Hypothesis

As the S. Oneidensis biofilm **grows prolifically** due to the consumption of tryptic soy broth in microgravity, the anaerobic respiration of the microbial fuel cell will occur more prolifically thus **increasing the voltage** difference recorded across the cell

Software Flowchart



Conclusion and Application

Results conform with our hypothesis showing an increase in voltage while the biofilm grows; yet, the biofilm seems to have died after roughly 6 days reflecting a lack of sufficient growth medium for the 30 day flight plan. MFCs have become a prominent source of renewable energy especially in space. The potential in MFCs lies within the ability to utilize bacteria which would otherwise be treated as waste, such as organic matter or wastewater. This experiment established that an MFC is a promising avenue for the development of renewable energy both in microgravity and on Earth.