Cosmo Cassette: A Microfluidic Microgravity Microbial System for Synthetic Biology Unit Tests and Satellite Missions

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Introduction

Problem

- Need low-mass, controllable, repeatable platform for space based Microbial Fuel Cell (MFC) experiments on small satellite and International Space Station.
- Need standard hardware and assay for unit testing forward MFC.

Proposed Solution

- A microfluidic MFC device for small satellite and space station applications.
- Bioelectrosynthesis technology for In-Situ Resource Utilization (ISRU) and the production of food, fuel and biomaterials in space.
- Double the sample size, cost efficiency, and speed of iteration.
- A demonstration of this platform via a unit test for synthetic biology.

Science of MTR Pathway

The MTR pathway is a metabolic pathway from the microbe *Shewanella oneidensis* which reduces the iron ions for the production of electricity [2][3]. Electrogenesis will be useful in space where the traditional methods of electricity generation must be modified to accommodate limited feedstock. In this case, a metal reduction pathway, native to *S. oneidensis*, will be transformed into *E. coli* and yeast through synthetic biology techniques.

Technology Combination

![Image of Cosmo Cassette: A Microfluidic Microgravity Microbial System for Synthetic Biology Unit Tests and Satellite Missions](https://ntrs.nasa.gov/search.jsp?R=20140005236)

3D Printing

![AutoCAD Diagram of MFC. Parts List: tubing, valves, anode chassis, cathode chassis, PEM membrane, and electrode pins, and carbon felt electrodes.](https://ntrs.nasa.gov/search.jsp?R=20140005236)

Figure 3: AutoCAD Diagram of MFC. Parts List: tubing, valves, anode chassis, cathode chassis, PEM membrane, and electrode pins, and carbon felt electrodes.

Voltage and Current Outputs

![Voltage vs Time, Middle: Current vs Voltage, Right: Power vs Time.](https://ntrs.nasa.gov/search.jsp?R=20140005236)

Figure 5: Left: Current and Voltage vs Time. Middle: Current vs Voltage; Right: Power vs Time. blue, black, and green are identical experimental wells, red is control.

![Table 1: Voltage, Current, and Power Outputs of printed MFC. Experimental wells contained approx. 0.4 mL of [16 mL 50mM PBS, 4 grams glucose and 6mL *S. oneidensis* in LB media]. Control contained 0.4 mL of [16 mL 50mM PBS, 4 grams glucose and 6mL LB media].](https://ntrs.nasa.gov/search.jsp?R=20140005236)

<table>
<thead>
<tr>
<th>Well Contents</th>
<th>Color</th>
<th>Mean Current [µA]</th>
<th>Std Current [µA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 S.Onei + LB</td>
<td>Blue</td>
<td>0.274</td>
<td>0.033</td>
</tr>
<tr>
<td>2 S.Onei + LB</td>
<td>Black</td>
<td>0.481</td>
<td>0.039</td>
</tr>
<tr>
<td>3 S.Onei + LB</td>
<td>Green</td>
<td>0.040</td>
<td>0.031</td>
</tr>
<tr>
<td>4 LB</td>
<td>Red</td>
<td>0.036</td>
<td>0.026</td>
</tr>
</tbody>
</table>

![Figure 2: Top: Illustrates membrane activity of MTR pathway. Left: Growth Curves of *S. oneidensis*. Right: OD Correlated to Cell Count.](https://ntrs.nasa.gov/search.jsp?R=20140005236)

![Figure 6: Scanning Electron Microscopy of anode well 1. Note *Shewanella oneidensis* adherence to carbon felt electrode. Mechanism for attachment: bionanowires.](https://ntrs.nasa.gov/search.jsp?R=20140005236)

Electrode SEM

![Photo of 3D Printed Reactor. Valves, tubing, and electrode pin design not shown. Wires connect to carbon felt electrodes within wells.](https://ntrs.nasa.gov/search.jsp?R=20140005236)

Figure 4: Photo of 3D Printed Reactor. Valves, tubing, and electrode pin design not shown. Wires connect to carbon felt electrodes within wells.

Electrode SEM


References

