Developing a Novel Membrane to Increase the Performance of Single Chamber Microbial Fuel Cells

Ben Foley, SBI internship 2010
Yanzhen Fan, Hong Liu, Biological and Ecological Engineering

Background

Microbial fuel cells (MFCs) use bacteria as catalysts to generate power from organic compounds. MFC technology provides a completely new approach for renewable energy generation from wastewater treatment. *Figure 1* shows how an MFC works. Electrochemically active bacteria on the anode oxidize organic compounds under anaerobic conditions and generate electrons and protons. The electrons flow through a wire and the protons are transported to the cathode where they combine with oxygen and generate water. Single chamber membrane-free MFCs demonstrated a higher performance than other type of MFCs.

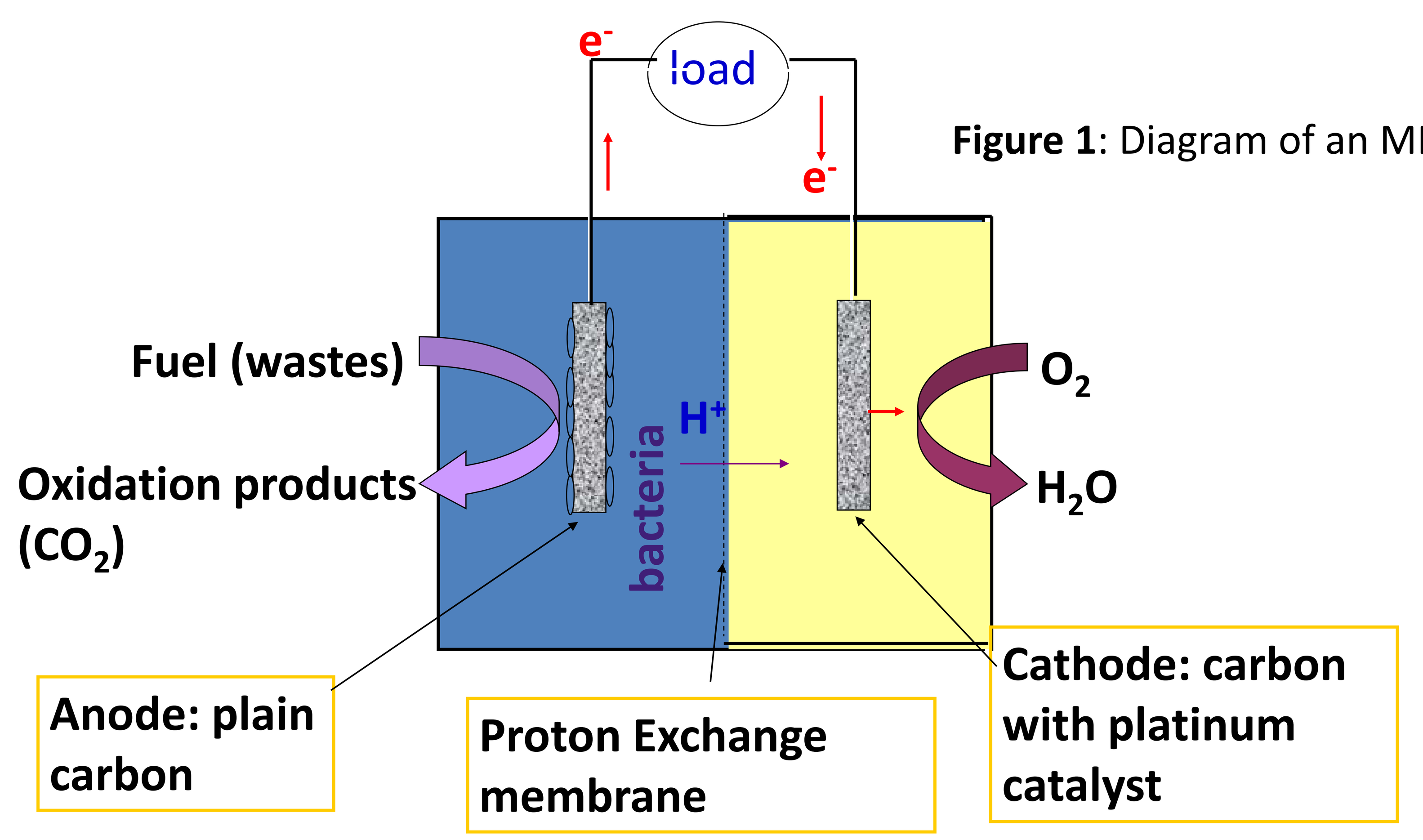

Figure 1: Diagram of an MFC

Anode: $C_xH_yO_z + H_2O \rightarrow CO_2 + e^- + H^+$

Cathode: $O_2 + 4\,H^+ + 4\,e^- = 2\,H_2O$

Problems

- Oxygen can permeate across the cathode to the anode in membrane-free MFCs, which may inhibit the electrochemical activity of anaerobic bacteria on the anode.
- Biofilms developed on the cathode reduce long term performance of membrane-free MFCs.
- Membranes can reduce oxygen diffusion but also increase the resistance.
- Membranes currently used are expensive.

Objective

To develop a membrane that is cheap and effective for ion diffusion and oxygen blocking with long term stability.

Experiments

- The polymer membrane was made by using compound A with compound B or C. Then agent D was added to improve the mechanical properties of the polymer.
- Different combinations of B,C, and D were examined.
- The membranes (casted onto the cathode or J-cloth) were evaluated in terms of their electrochemical performance, oxygen diffusion, and anion conductivity.
- Comparisons were made with a commercially made membrane.

Results

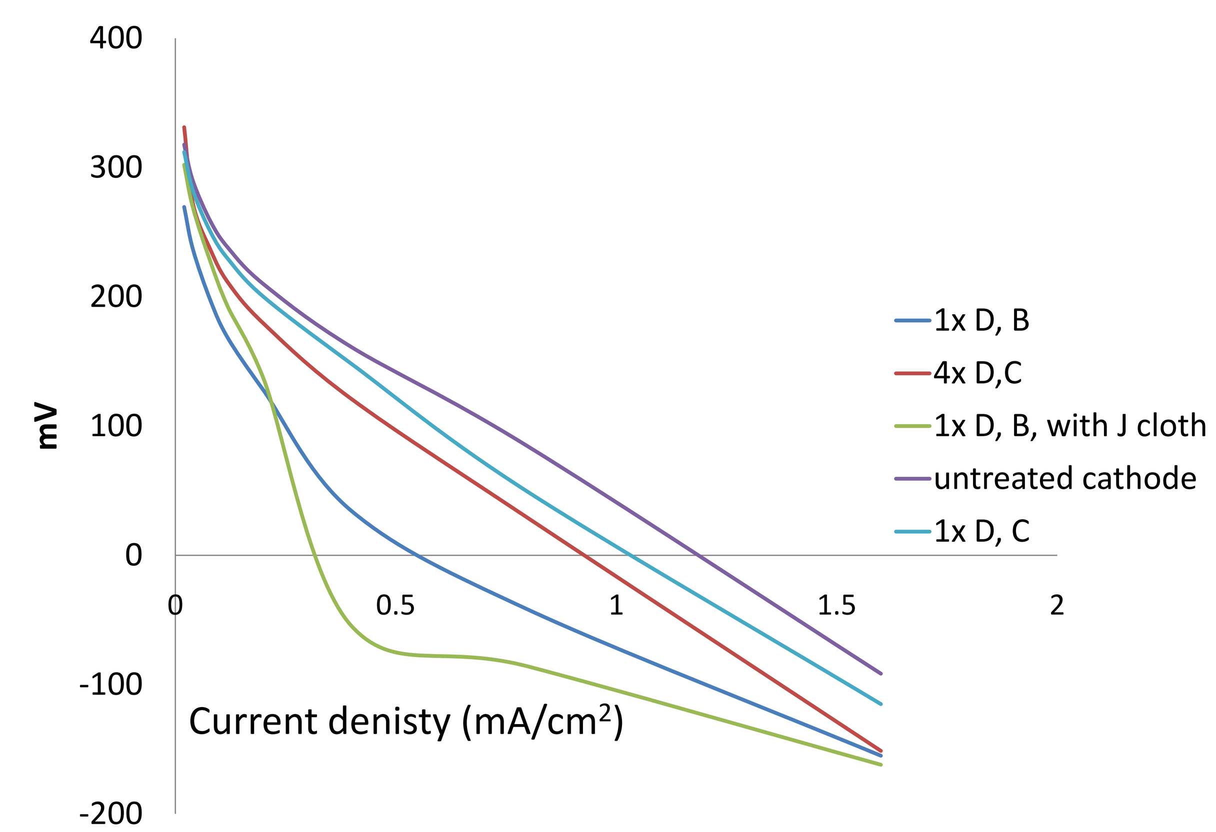

Figure 2: This test gives a very good indication of how well the cathode will perform in an actual MFC. Altering the cathode always reduced performance , but the polymer made of A, C and D reduced performance the least.

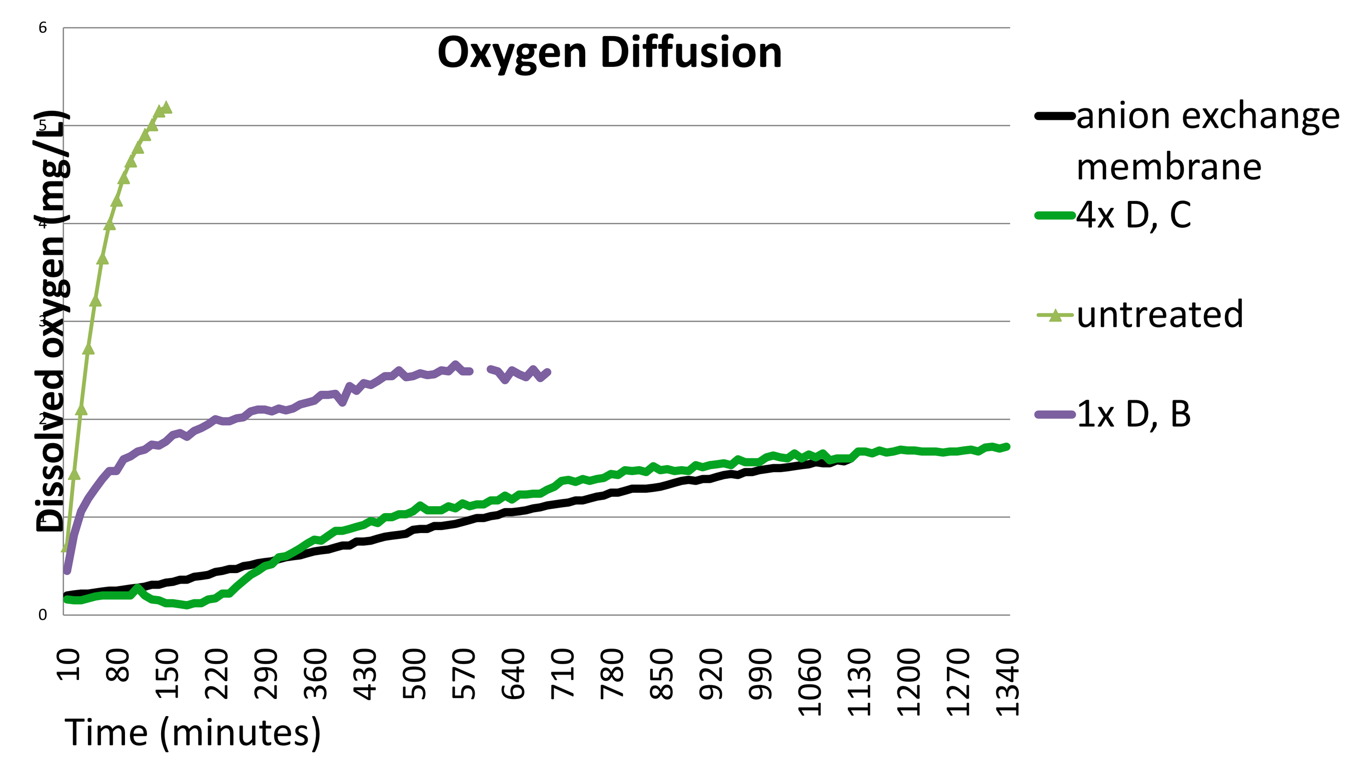

Figure 3: These tests were conducted using a single chamber cell with membrane casted cathode facing air directly. Dissolved oxygen was continually measured in the chamber. This result demonstrates that the polymer membrane developed significantly reduces oxygen diffusion across the cathode.

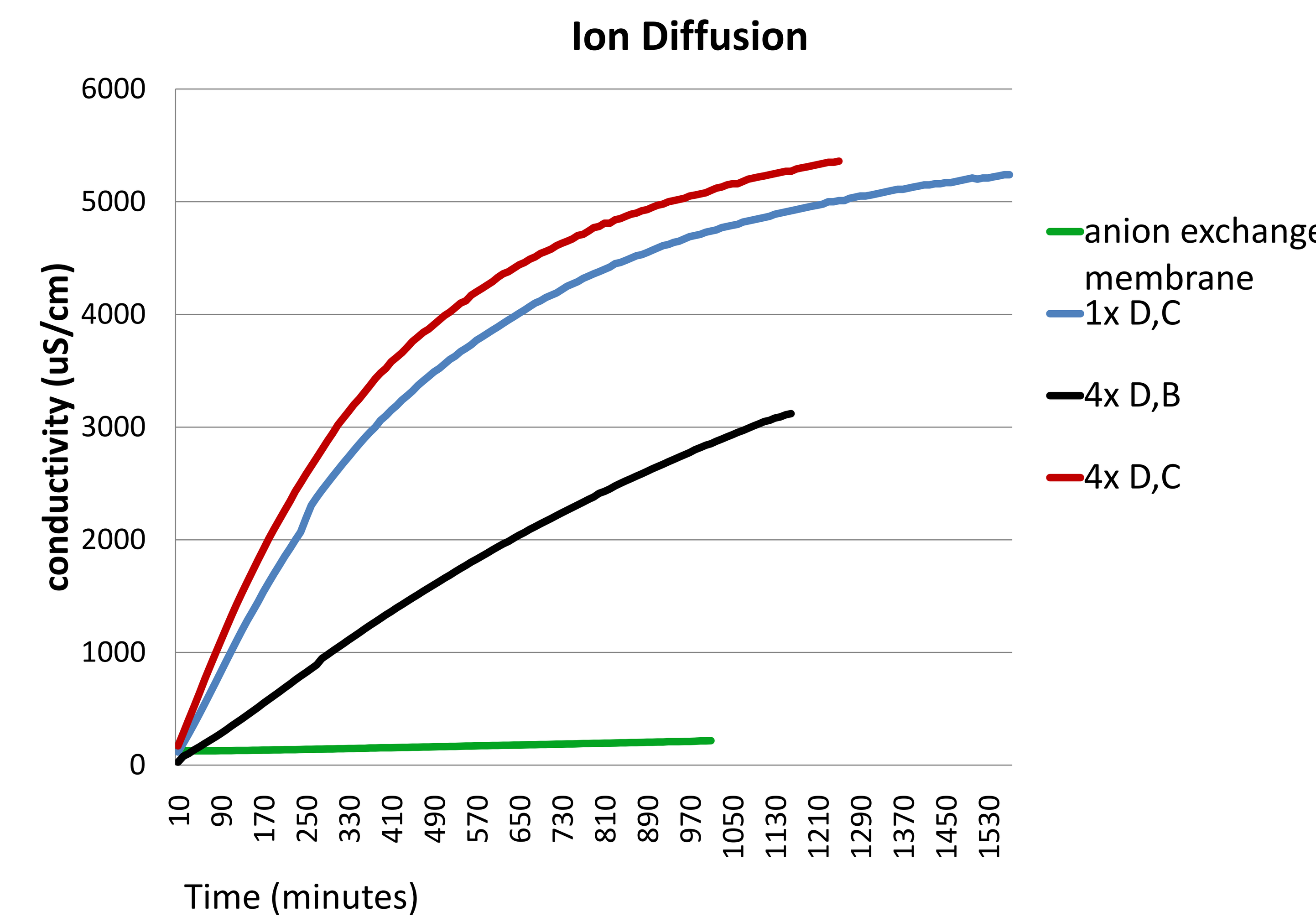

Figure 3: These tests were conducted in a diffusion cell consisting of two chambers separated by a membrane. The chambers were filled with solutions with different ion concentrations. The concentration of ions was measured with a conductivity probe. The polymer made of A, C, and D was superior.

Future Work

The polymer has not been tested in a real MFC, but the results from the above tests are promising. An MFC is currently being prepared to test the polymer treated cathodes.