CHARACTERIZATION OF MICROBIAL FUEL CELL

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Abstract:

Currently, around 90% of the world's energy is obtained from non-renewable fossil fuels. Microbial fuel cells (MFC's) are a promising new technology that can produce electricity from renewable organic compounds, such as glucose, acetate, and municipal wastewater. MFC's rely on bacteria that extract electrons from organic compounds and use the MFC anode as an electron acceptor, either via direct contact or via biogenic electron shuttles. We studied several potential factors that may affect the MFC dual-chamber performance, including the cathode material and oxidant, the type of microbial growth in the anode compartment, and the type of proton exchange membrane (PEM). For each condition, we measured the MFC performance for a range of resistances from 10Ω– 1MΩ. We also measured the oxygen diffusion capacity of two types of PEM. We found that biofilms growing on the anode played a greater role in power generation than suspended bacteria, and that Pt-coated cathodes and ferric-cyanide in the cathode chamber greatly enhanced power generation. The Ultrex PEM allowed less O_2 to pass from the cathode to the anode chamber than the Nafion PEM, but Nafion allowed greater power production. Resistors greater than 10,000Ω produced unstable conditions. The optimal power production conditions for the MFC were with attached microbial growth in the anode chamber, Pt-coated cathodes, ferricyanide as an oxidant in the cathode chamber, a Nafion PEM, and a 1000-Ω load.

Introduction:

Around the world, energy is produced from non-sustainable and non-renewable sources. Fuel cell (FC) technologies are a very promising solution to limited energy resources. Microbial fuel cells (MFC's) are special type of FC that can convert hydrocarbons, such as acetate, glucose and wastewater, into electrical energy. Because it is a new device, research is needed to identify factors that may affect its performance, and to determine optimal operating conditions.

Objectives:

- Characterize dual chamber MFC by studying anode, cathode and PEM behavior.
- Determine the role of suspended and attached microbial growth in MFC power production.
- Establish optimal conditions for MFC electrical power production.

Theory:

Conventional FC's can produce electricity using H_2/O_2 as a feed and Pt as an electrode catalyst.

MFC's can produce electricity: Feed = organic compounds
Bacteria =catalyst
No intermediate steps
No P and T control required

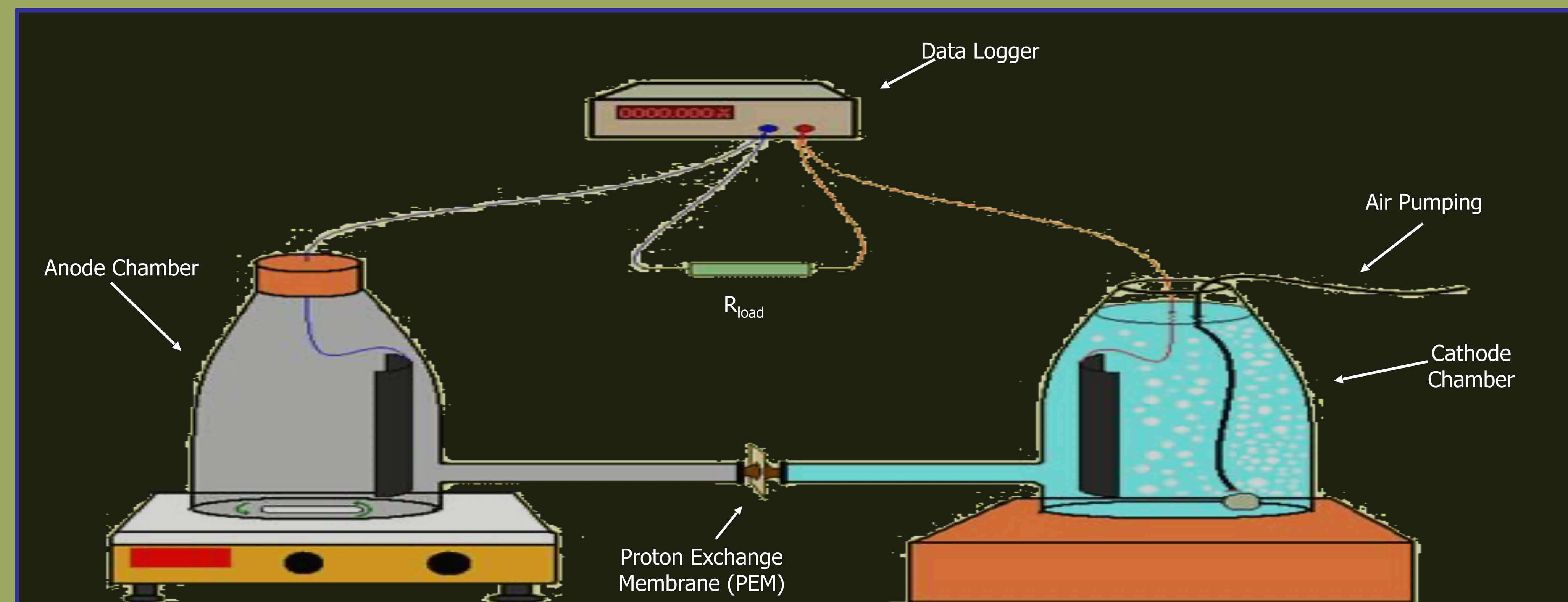
Waster water + nO_2 → mH_2O+ pCO_2 + …,
with qe^- transferred from wastewater to O_2

MFC's have three parts: Anode, cathode and PEM

Power production → Ohms Law: $V = IxR_{load}$

→ Watts Law: $P = VxI$

Methods:



- Anode chamber: 585 mL growth medium, 65 mL of 10g/L acetate solution, Electrode material: carbon cloth attached to copper wire
- Cathode chamber: 16 mM phosphate buffer solution
- Anode to cathode electron transport via copper wires, H^+ transport via Ultrex PEM.
- Cathode and Anode area: 6cm x10cm.

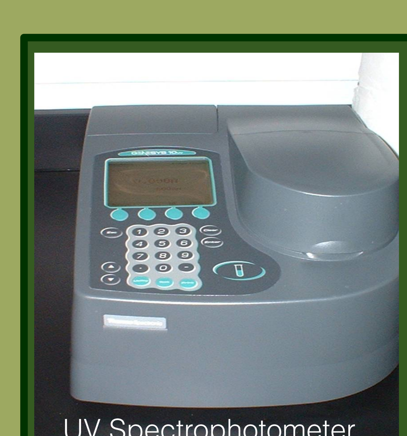
Experimental procedures

1. Measure open circuit voltage
2. Wait for a stable voltage measurement.
3. Initially, determine voltage for resistor loads between (10-1M) Ω.
4. Subsequently, use 100k, 10k , 1k, 100 and 10-Ω resistors.

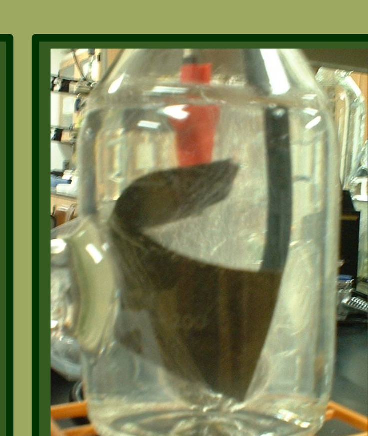
- The reference experiment was run for approximately two days.
- The MFC was supplied with 7.5mL of 1g/L acetate solution after every run
- The average time for reaching a stable voltage measurement was three hours.

Anode	PEM	Cathode	
•Importance of bacteria •Role of organic feed •Role of attached vs. suspended microbial growth	Nafion vs. Ultrex O_2 Difusión rate Nafion vs. Ultrex Power Production	Electrode	Importance
		Air pumping	
		Electrode	Size
			Surface Area Form
			Thickness
			Material
			Oxidant

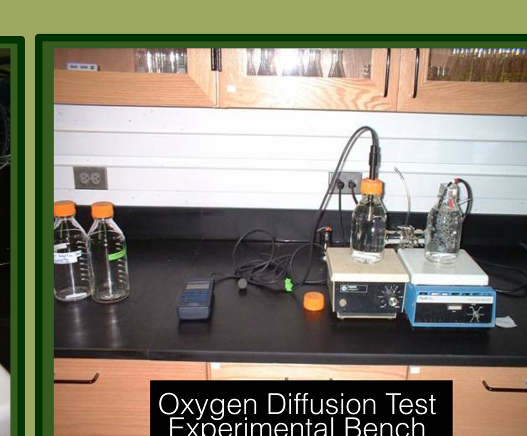
Experimental process pictures


UV Spectrophotometer

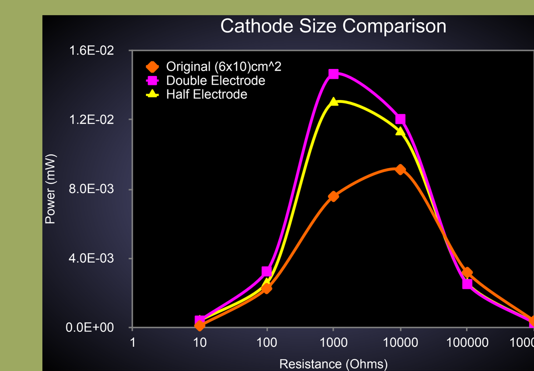

Original Cathode Electrode


Double Size Cathode Electrode

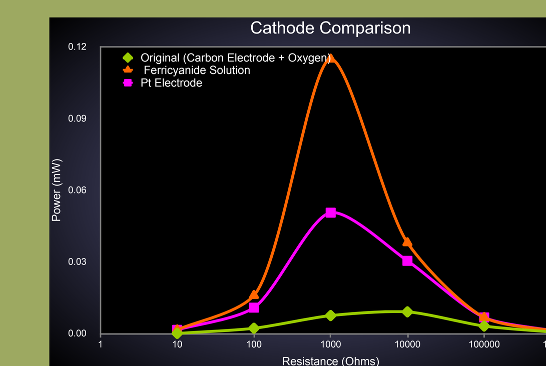

Ferric-cyanide Compound Cathode Electrode


Oxygen Diffusion Test Experimental Bench

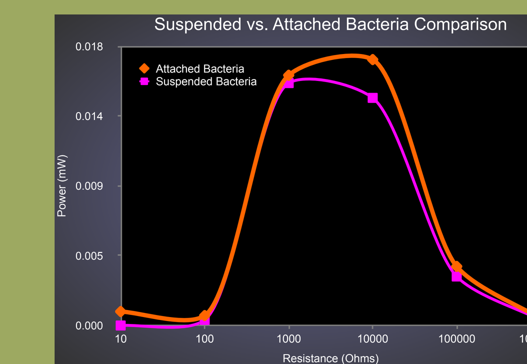
Results:



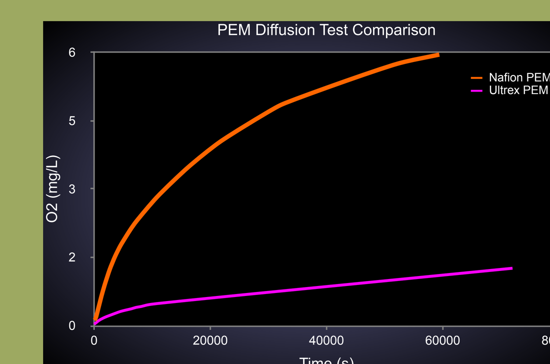
Cathode Size Comparison Test



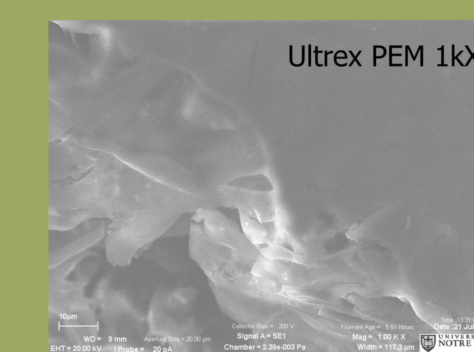
Cathode Electrode Characterization Higher Results Comparison

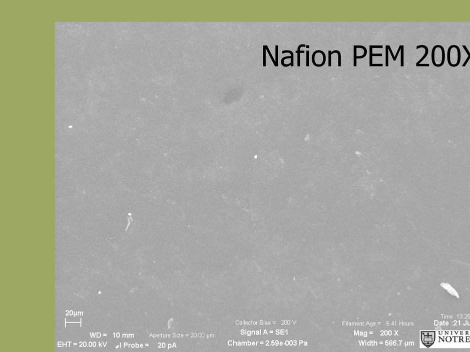


Anode Attach vs. Suspended Bacteria Comparison



Nafion vs. Ultrex PEM Oxygen Diffusion Comparison

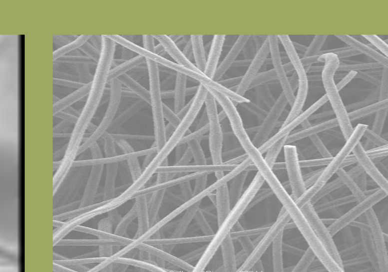




Anode Experiments	Bacteria and organic feed are both needed to obtain power Attached electrode bacteria > suspended bacteria for power production
PEM experiments	Nafion > Ultrex for power production Ultrex > Nafion for O_2 diffusion prevention
Cathode Experiments for power production	Cathode electrode and air pumping have an important effect on power Double surface size > others Rod surface electrode > planar surface Pt electrode > carbon cloth electrode Thin electrode > thick electrode Ferric-cyanide strong oxidant compounds > air pumping
Overall experiments for power production	Ferric-cyanide strong oxidant compound is 2.27 > Pt electrode material and 12.6 > air pumping Pt electrode 5.5 > air pumping


Rod Electrode 2.5kX


Original Planar Electrode 2.5kX


Thick Electrode 200X


Original Thin Electrode 200X

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