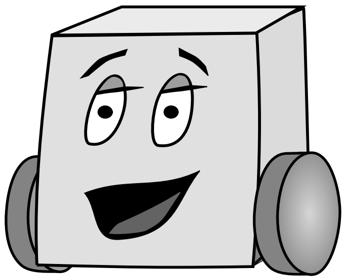


E11: Autonomous Vehicles

Fall 2010

Harris & Lape with Keeter & Ong

Fuel Cell Assembly and Characterization

The goal of the lab is to finish building and characterize your hydrogen-oxygen Proton Exchange Membrane Fuel Cell (PEMFC).

Introduction

In the last lab, all of the fuel cell components were machined, cut and drilled. In this lab, you will assemble those parts into a functioning fuel cell stack and characterize it as a power source. Characterizing the fuel cell will include finding the open loop voltage, voltage under load and current in the circuit. By hooking up a variable resistor in series with the fuel cell, you can vary the resistance and plot how the voltage and current changes to create various curves.

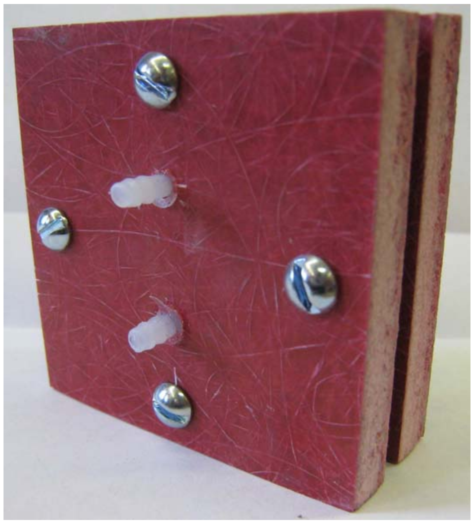
Make sure your electrolyzer is plugged in and splitting water. The hydrogen will be used to both check leaks during your assembly, as well as serve as the fuel source during characterization.

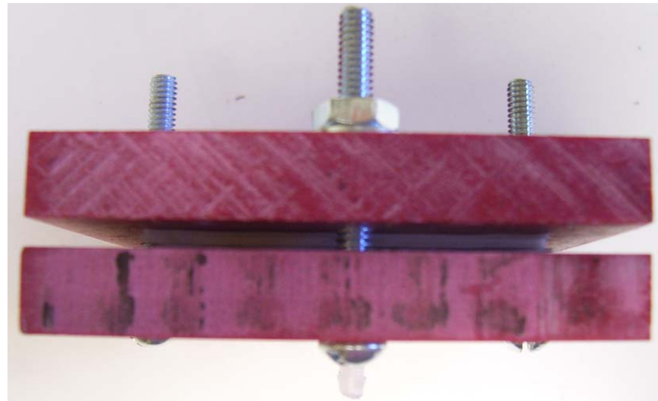
Fuel Cell Assembly

The first step in assembling the fuel cell is to eliminate each component as a leak source.

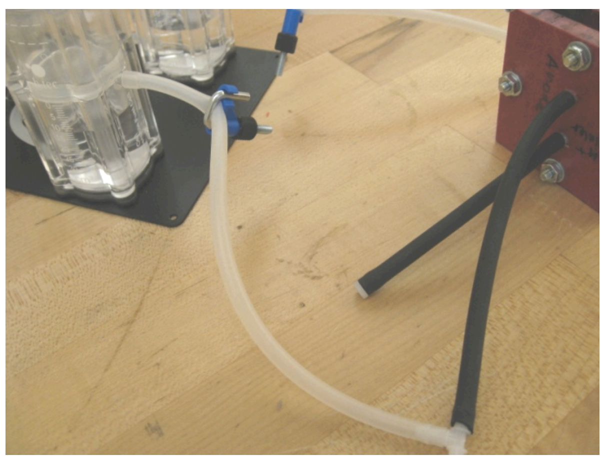
1) **Ensure that there is no gas leak with only the outer gasket and endplates.**

   Sandwich the outer gaskets between the endplates, and screw the endplates tight together.





Add the tubing stoppers on three of the four gas ports. Hook the remaining port up to the hydrogen side of the electrolyzer. Unplug the electrolyzer, so that the generated hydrogen is a fixed volume trapped in the tank.



If there is a leak (seen by a sharply declining hydrogen level in the electrolyzer), this means an inlet or outlet tube (port) is not fully sealed in the endplate. Either add more silicone adhesive or, if there are large gaps, remove the tube and reseal it.

2) **Ensure there is no gas leak with gasket, endplates, flowplates and inner gasket.**

Remove the plastic from both sides of the inner gasket. Make sure only one side touches the graphite endplate. The other side will have to adhere to the Nafion membrane in the next step. Therefore, you need to keep that surface clear and dirt-free.

3) **Get a protonated Nafion membrane from the lab instructor.**

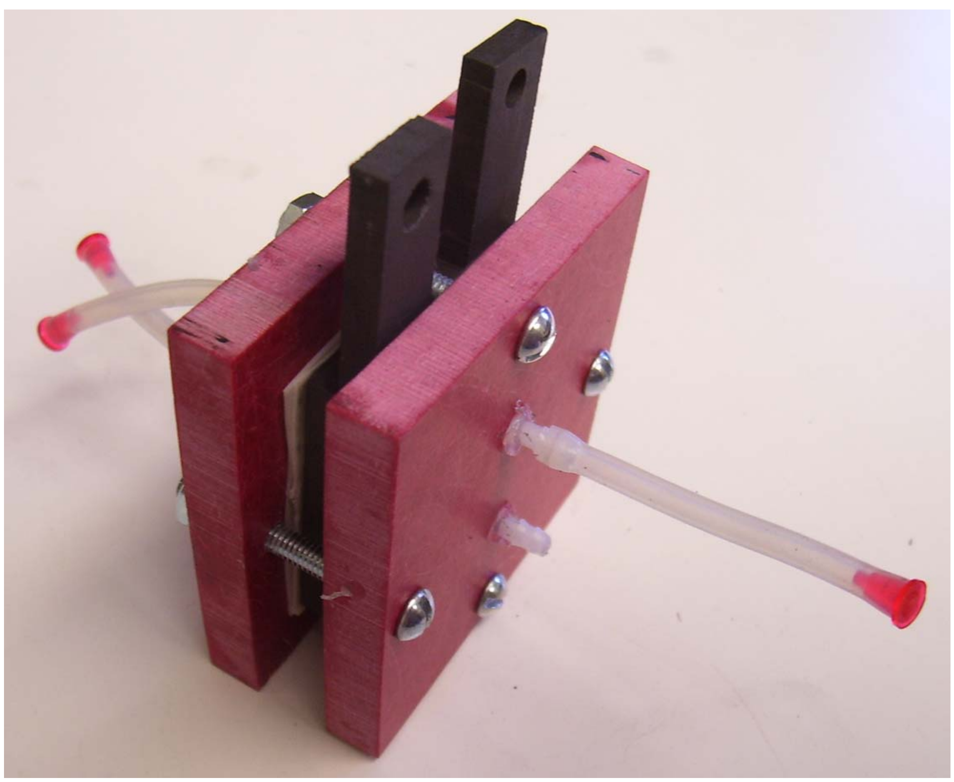
Your 5 Layer membrane will be composed of your two catalyst-covered carbon paper diffusion layers, and a Nafion membrane. The membrane serves as the electrolyte for your fuel cell.

Put on your gloves and go to your lab instructor with a Kimwipe to get a Nafion membrane. **Be careful to not drop the membrane** as it will hinder its functionality. Return to your workstation and carefully place your inner gasket on both sides of the membrane. Make sure the gasket lies flush against the membrane. The centering is not important, as long as the membrane is completely bordered by the gasket.

Now, place the GDL (platinum covered carbon paper) on either side of the membrane with the catalyst-coated side facing the membrane. They will not stick of their own accord, but when your fuel cell is bolted together the mechanical connection will be sufficient for the fuel cell to function. You now have a full 5 Layer membrane sandwich, also known as the Membrane Electrode Assembly (MEA)! This MEA is the main workhorse of the fuel cell.

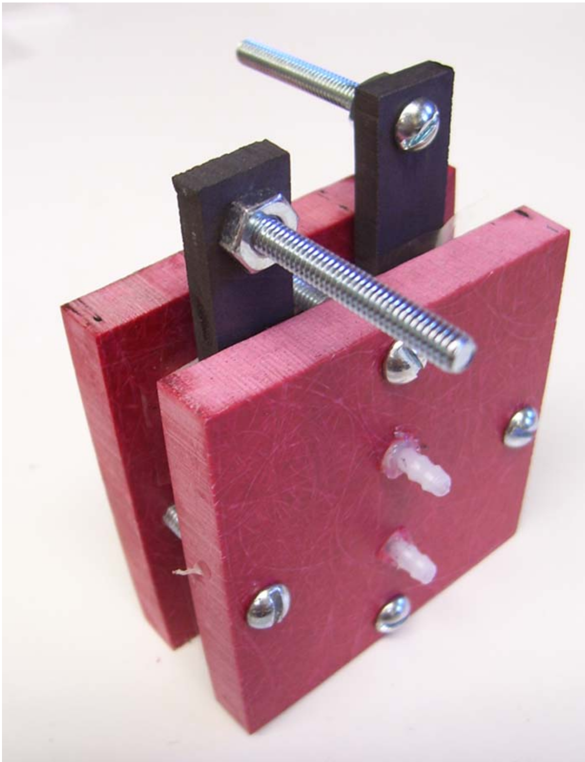
4) **Insert the 5L MEA and check for leaks.**

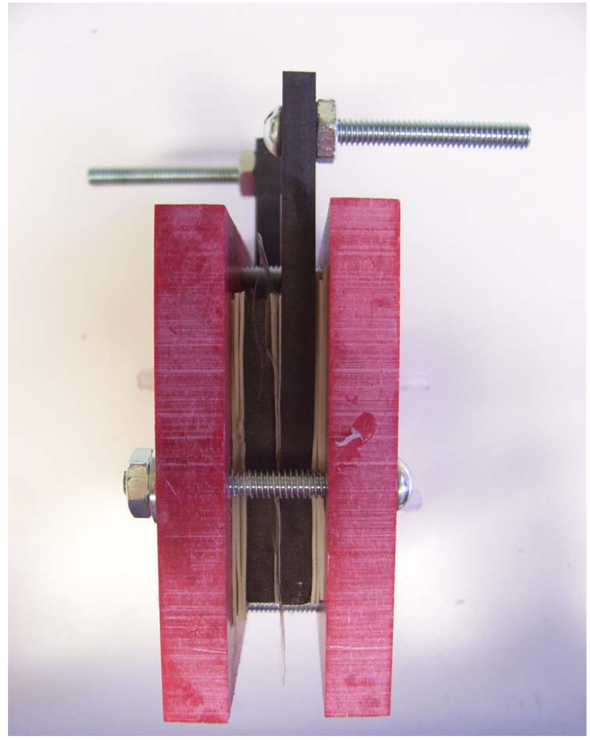
Now unscrew the bolts, if you have not already. Each endplate should have a three-layer stack of outer gasket. Carefully sandwich the 5 Layer PEM between the two graphite electrodes. Gently place this on one endplate, centering the flow field on the outer gasket. Complete the stack with the other endplate, and screw the fuel cell together. **Do not over tighten the bolts**, as this puts excess pressure on your flow plates and might cause them to crack or shatter. When checking for leaks, if you find one side leaks more than the other, make a mark on this side. Hopefully neither side leaks**,** but the side that leaks less will be hooked up to the hydrogen in the future.



5) **Add the bolts onto the flow plates (image below).**

The bolts allow you to easily connect your fuel cell to an electrical circuit. Check that there is a good electrical connection between the flowplate and the bolt terminal by checking there is zero resistance between the two points with a multimeter, like you did in the board assembly lab.

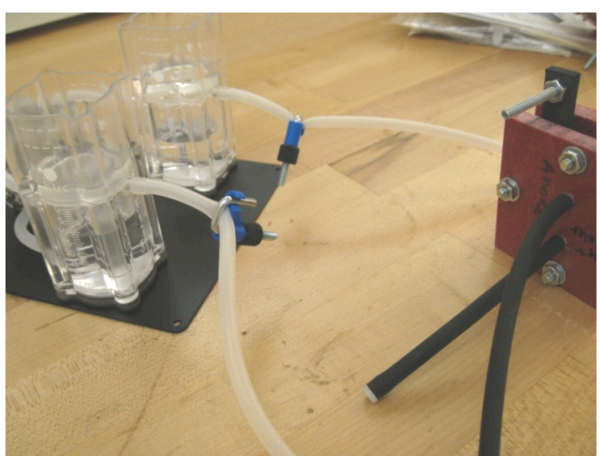




Fuel Cell Characterization Setup

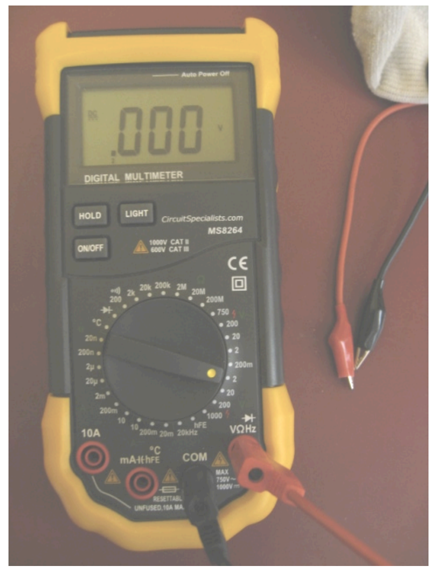
Now we will characterize the power output of your homemade fuel cell! Despite being low voltage, the fuel cells are excellent sources of current, even when made in a freshman lab. For this lab you'll need two multimeters (one to serve as an ammeter and one to serve as a voltmeter) and variable resistor.

First, we need to hook the fuel cell up to its own fuel supply properly. There are 5 electrolyzer stations; find a partner and share a lab station. You will be taking turns characterizing your fuel cell. We will let the fuel cell work in a hydrogen-air environment as air is in wonderfully high supply. Hook up the less-leaky side of your fuel cell to the hydrogen supply and leave the other side open.

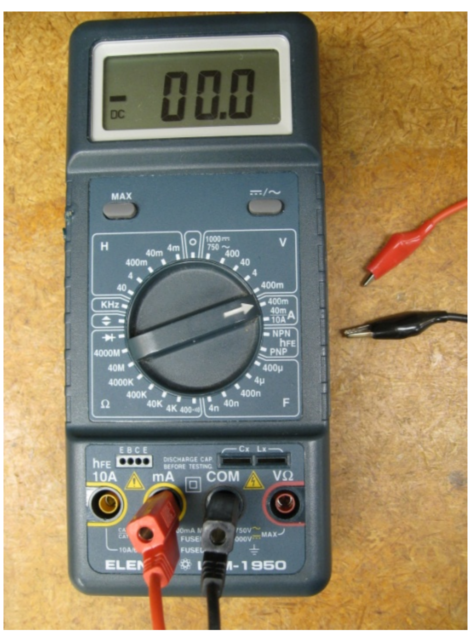


Note: Mark the side hooked up to the hydrogen as the anode using a Sharpie. This will now always be the side hooked up to the hydrogen for future setups.

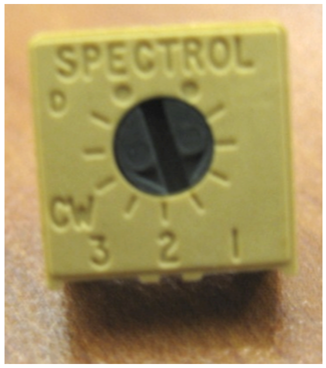
Second, set up the circuit to measure the fuel cell's output voltage. This means setting up the voltmeter in parallel with the fuel cell. You can use this to measure the open loop voltage of your fuel cell, when there is no load applied.

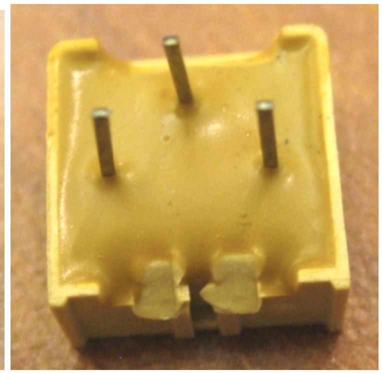


Third, set up the circuit to measure the fuel cell's output current. You will be doing this with a different multimeter, setting it to be used as an ammeter. Put the variable resistor and ammeter in series with the fuel cell. This way you can vary the load on the fuel cell and measure how the current and voltage vary.

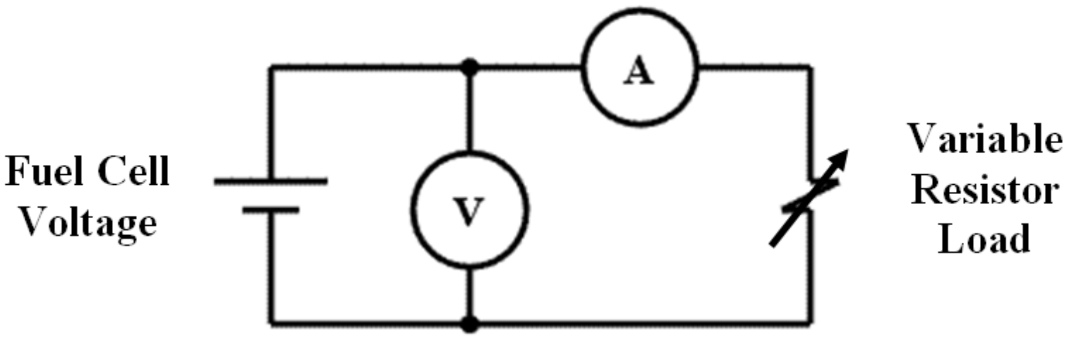


Note: You will want to connect the center pin and one of the side pins. The two side pins are fixed at 500Ω resistance. Varying the resistance changes how much resistance is "allocated" between each side and the middle pin.





In the end you should have a circuit like the picture below.



Fuel Cell Characterization

To actually characterize the fuel cell, make a chart with the columns resistance, voltage and current. Vary the resistance at fixed intervals and record what the resulting voltage and current are. You can vary the resistance by turning the small circular indentation with the small screwdriver in your kit.

You'll notice there are areas where finer variances in resistance result in larger jumps in voltage and current output, where other times large variances lead to little change.

After you are done, plot the V-I curve and show it to your lab proctor.

You can now use this data to plot a P-V curve as well, as $P = V \cdot I$.

This way you can see at what voltage there is a maximum power output.

Based on Ohm's Law:

$$V = I \cdot R$$

You can then calculate the resistance at which gives the optimal power output.

TADA! You've characterized your fuel cell ☺.