Building a Two-Chamber Microbial Fuel Cell  
[Notes by Karl Shellenberger]

These instructions are aimed at helping someone to build a microbial fuel cell (MFC) using relatively inexpensive and readily available materials. The method is based on the microbial fuel cells built by Abbie Groff (then a student at Conestoga Valley High School in Lancaster, PA). The research she performed with her MFCs helped her win the Grand Champion Award at the 2005 Lancaster County Science Fair. The information given here is intended to be a rough guide to constructing a MFC, not an exact step-by-step procedure.

Materials

Unless otherwise noted, all materials should be available at local stores.

1. Two heavy duty plastic bottles with sealable lids
2. Short section of plastic pipe (polyethylene or PVC) for salt bridge
3. Means to connect pipe to bottles (plastic flanges, end caps with holes drilled)
4. Agar¹
5. Salt (NaCl, KCl, KNO₃, etc)
6. Carbon cloth²
7. Bacteria³
8. Food for the bacteria and a buffer⁴
9. Fish tank air pump with plastic tubing
10. Sealing materials (epoxy)
11. Resistors
12. Copper wire (plastic coated)
13. Wires with alligator clips
14. Multimeter for electrical measurements

Construction Procedure

1. Collect materials
2. Connect end caps of flanges to bottles
   * Epoxy end caps or flanges to sides of plastic bottles.
   * After epoxy has hardened, drill or cut holes through plastic bottles to allow for contact between liquid and the salt bridge.
3. Assemble Salt Bridge
   * Dissolve agar into boiling water (at concentration of 100 g/L).
   * Add salt (1 M KCl, for example) to the agar/water mixture while the mixture is still hot.
   * Seal one end of plastic pipe.
   * Pour agar/salt mixture into plastic pipe while it is still warm and before it begins to thicken.
   * Allow the agar/salt mixture to cool and solidify.
4. Assemble electrodes
   * Connect copper wire to piece of carbon cloth.
   * Use epoxy to fasten the wire to the carbon cloth and to help protect from corrosion.
   * Test electrodes with multimeter - there should be a small amount of resistance between a point on the carbon cloth and the end of the wire opposite the cloth.
* For anode, pass wire through a hole in the bottle lid and seal with epoxy. Cathode chamber does not necessarily need a lid.

5. Assemble MFC
   * Connect salt bridge between the two plastic bottles and use epoxy to seal.

One of Abbie Groff's MFCs (originally downloaded from www.geocities.com/abigail_groff).

Running your MFC

1. Add inoculum (wastewater, anaerobic benthic sediments) to anode chamber. You can also use diluted wastewater or sediments (1-5%) in water. Make sure there no chlorine in the water (aerate tap water or use river or lake water). You can add a little salt; if you have a conductivity meter, keep it below 20 mS/cm. Check the pH is not below 6.5 before and after adding any organic fuels (i.e. glucose or acetate).
2. Add conductive solution (saltwater) to cathode chamber
3. Insert anode (connected to lid) into anode bottle. Add cathode to cathode bottle. Begin bubbling air in cathode bottle with fish pump.
4. Connect external circuit through a resistor (say 10 to 100 ohm), and start measuring voltage drop across the resistor. The power is the voltage times the current.

Important Hints for Operating your MFC

1. Oxygen must be kept out of the anode chamber, although it can initially have some dissolved oxygen. Just don’t leave it exposed to air.
2. For long-term operation, electrodes should be constructed in a way that limits corrosion of copper wire due to contact with liquids. Cover with epoxy.
3. Power can be significantly increased by using a cathode catalyst (typically platinum) on the cathode (but of course platinum is expensive).

Material Notes
1. Agar should be available in most high school science labs. If not, it can be purchased from several sources online.
2. Carbon Cloth can be purchased online from www.etek-inc.com. The carbon cloth necessary for the electrodes is standard carbon cloth without wet proofing.
3. Bacteria for a MFC can be obtained from several sources. A sample of wastewater from a local wastewater treatment plant would contain the proper microorganisms. Some locations at the plant may be better than others for obtaining the proper organisms. Anaerobic benthic sediments in a wetland or lake would also be likely to contain the proper organisms.
Most likely, wastewater or anaerobic sediments will initially contain enough organic matter to serve as food for the bacteria, but this will quickly run out. A food source (substrate) such as glucose or acetate (vinegar) can then be used to maintain the MFC. Consider adding per liter: 1 g sodium acetate; and a phosphate buffer (for example 50 mM, made of 4.57 g Na₂HPO₄ and 2.45 g NaH₂PO₄·H₂O)