

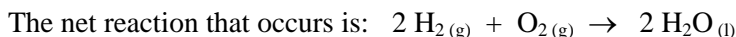
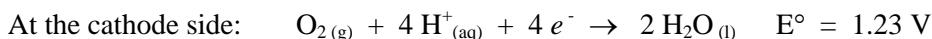
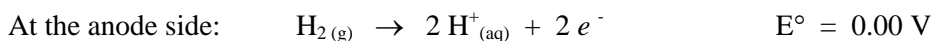
CONSTRUCTION OF A MICROSCALE FUEL CELL

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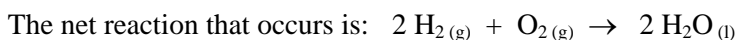
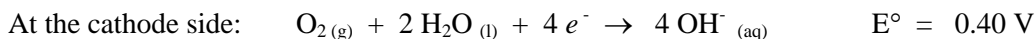
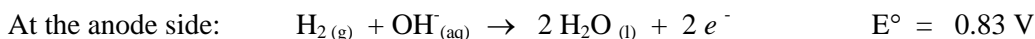
Fuel cells are being publicized as the energy source of tomorrow. They can be made with materials that are environmentally safe, they can last for long time periods, and they do not pollute the environment. One type of fuel cell uses hydrogen as a fuel. With our current technology, it is not practical to construct hydrogen filling stations, similar to gasoline stations, nor to properly store hydrogen in an automobile or other fuel cell powered device. The most practical way to obtain hydrogen is from water, which is cheap and plentiful. The hydrogen is produced from the electrolysis of water, and, since it is produced in small quantities, it does not require any special storage containers. Although energy is required to electrolyze water (a battery is used in this experiment), solar energy can be used, or, in an automobile, a generator or alternator, which works while the engine is running, can supply the necessary energy.

The main components of a fuel cell are an **anode**, the negative post of the fuel cell, a **cathode**, the positive post, an **electrolyte** or solution, usually basic, which can be used to generate the gases to power the fuel cell, and a **catalyst**, which may be part of the electrodes, to split the gaseous hydrogen into H^+ ions.

The reactions that occur in a fuel cell are:



In a fuel cell with an alkaline material present, such as the one you will be constructing in this experiment, the reactions are:



In both of the fuel cells, above, they generate about 1.2 volts.

Materials Needed

Carbon electrodes. Drafting pencil leads, 1.4 mm, or larger diameter, from a stationery or art/drafting supply store.

2 Electrode tubes. 1 mL, plastic, slip tip syringe. (These syringes do not include any sharps and no special disposal methods are required.) The syringe barrels are graduated and will allow for measurement of relative volumes of gas. Note: the clear plastic barrel from a Bic (or similar) ball point pen, cut in half, will also work, but these are not graduated.

Knife or small, fine tooth saw.

Hot glue gun with glue sticks

Reaction plate, 24 well OR substitute a 10 mL beaker

Beaker 50 or 100 mL
Beral pipet, fine tube
Epsom salt, magnesium sulfate heptahydrate, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
Water, distilled or deionized
9-volt battery
9-volt battery clip with small alligator clips attached to the wire leads (See Figure 1)
Multimeter
Light bulb or LED, 1.3 to 1.5 V, 100 mA or less.
Small motor
Watch with second hand or stopwatch

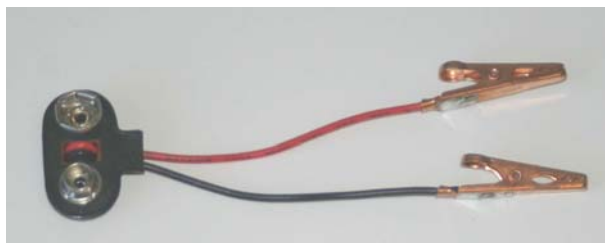


Figure 1. A 9-volt battery clip small alligator clips attached to the wire leads

Safety Precautions

Wear safety goggles at all times in the laboratory.

Epsom salts, magnesium sulfate heptahydrate, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, do not pose any safety hazards. Clean up any spilled material immediately.

Take extreme care in cutting the ends off the 1 mL syringe. Keep your fingers away from the cutting tool. Protect the surface of the table or laboratory bench by placing a sheet of heavy cardboard, or a piece of wood, under the syringe.

The tip of the glue gun, and the glue are hot. Take proper precautions to prevent burns.

Disposal

Clean up your work area and dispose of any waste materials in the proper trash receptacles.

Dispose of any excess Epsom salts, or Epsom salts solution, according to local regulations.

Procedure

Obtain two 1 mL slip-tip syringes. Remove and discard the plunger.

Protect the surface of the table or laboratory bench by placing a sheet of heavy cardboard, or a piece of wood, under the syringe.

Using a knife or small saw, cut the tip and flange off of each syringe. (See Figure 2)

Obtain one long or two 1.4 mm pencil leads. (If you have a long pencil lead, carefully break it into two equal length pieces.)

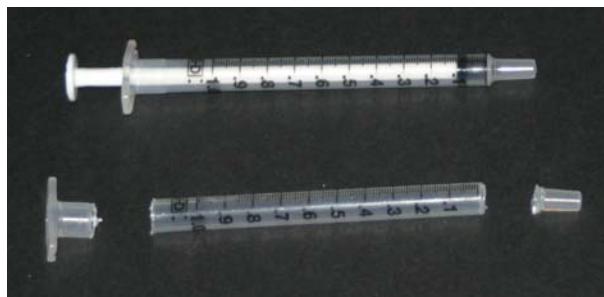


Figure 2. A 1-mL slip-tip syringe (top) and the syringe with the tip and flange removed (bottom).

Place a pencil lead into one tube from the syringe. Place it in the end closest to the 0.1 mL graduation. Using a hot glue gun, squeeze a small amount of hot glue around the pencil lead at the end of the syringe tube. Make sure the pencil lead electrode is centered, then, immerse the end of the tube, vertically, into some cold (room temperature) water in a small beaker. This will set the glue and allow you to see if you have any leaks in your sealed end. (See Figure 3) Repeat this procedure with the second piece of lead and syringe tube.

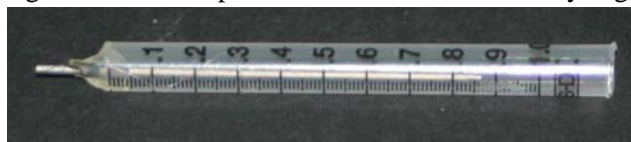


Figure 3. The electrode tube with the pencil lead glued into place

Make a saturated solution of Epsom salts in water. Fill one well of the 24-well plate to approximately $\frac{1}{3}$ to $\frac{1}{2}$ full with solid Epsom salts. Add distilled or deionized water to fill the well. Stir the mixture with the end of the thin stem pipet to dissolve the solid.

Fill the pipet with the Epsom salts solution, leaving the well in the well plate about $\frac{1}{4}$ full. Hold one of the electrode tubes, open end up and carefully, fill the tube with the Epsom salts solution. It may be necessary to tap the tube gently to dislodge any air bubbles. Then invert the tube, carefully, and place it open end down into the well containing the remainder of the Epsom salts solution. Repeat this procedure with the second electrode tube.

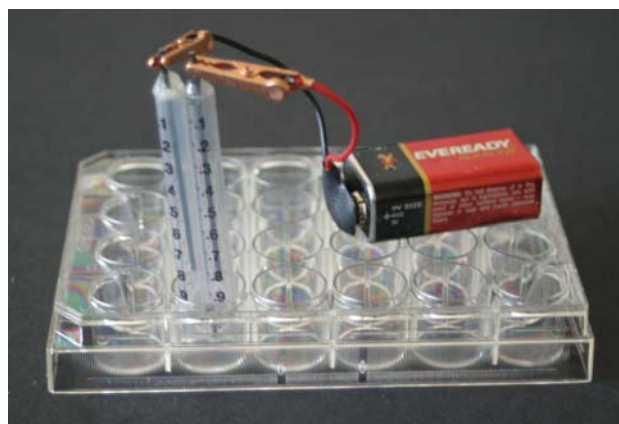


Figure 4. The assembled fuel cell in a 24-well micro reaction plate.

Attach a 9-volt battery to the battery clip. Note the time and attach the small alligator clips to the electrodes. (See Figure 4)

Do you observe any changes in the electrode tubes?

Allow the reaction to proceed until there has been enough gas generated in one of the tubes, so that it comes about $\frac{3}{4}$ of the way down the pencil lead electrode. Note the time and disconnect the alligator clips from the electrodes. NOTE: If the gas volume becomes large enough that the electrode is no longer in contact with the solution, you will not have a complete circuit and will be unable to use the fuel cell.

Record the volume of gas in each electrode tube.

Set a multimeter to the 2-Volt scale and attach the leads to the two electrodes. What is the voltage of the fuel cell?

Do you observe any changes in the electrode tubes.

There may be small light bulbs available in the laboratory. Attach a light bulb to the fuel cell. How long does the bulb remain lit?

Do you observe any changes in the electrode tubes.

There may be small motors available in the laboratory. Attach a motor bulb to the fuel cell. How long does the motor run?

Reference and Acknowledgement

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Slater, Alan, *A Simple, Safe Fuel Cell*, **CHEM 13 NEWS**, October 1999, page 34.