Chemistry Celebration Weekend
May 3, 2003
University of Wisconsin Madison

Science is Fun: Electrical Energy
presented by the Wisconsin Initiative for Science Literacy

BUILD A BATTERY

We are going to assemble a battery to generate electric energy. A battery uses a chemical reaction to supply the energy. The chemicals are arranged so that they can't react directly. They must exchange electrons through a wire. As the electrons travel through the wire, we get them to do some work for us. We'll get them to light up an LED (light-emitting diode) and to run a motor.

At your station you will find the following equipment and supplies:

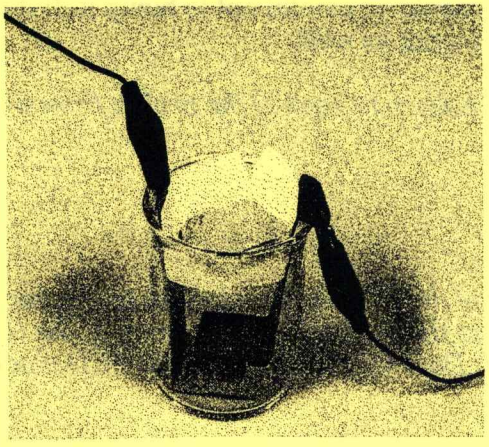
a 100-mL beaker
an L-shaped strip of copper
a strip of zinc
a bottle of copper sulfate solution (blue)
a bottle of zinc sulfate solution (colorless)
three wires with clips on each end
a plastic dropper

You will also need some tape and a voltmeter.

Rest the L-shaped piece of copper upright in the 100-mL beaker. Use a 2-inch piece of tape to hold it in place against the side of the beaker.

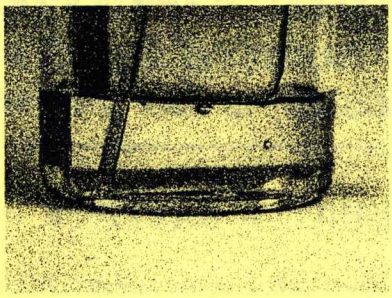
Hang the piece of zinc from the rim of the beaker on the opposite side from the copper. Use another piece of tape to hold it in position.

The tape will keep the copper from touching the zinc. If the zinc touches the copper, the battery won't work.



Attach a clip from one wire to the copper. Attach a clip ***from a different wire*** *to the zinc.*

Pour enough of the colorless zinc sulfate solution into the beaker to just touch the bottom of the piece of zinc.

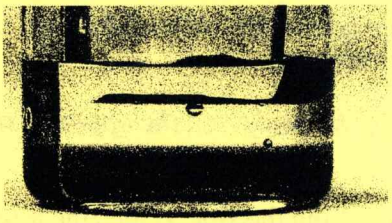


The copper sulfate solution will be added in a way to prevent it mixing with the zinc sulfate solution. The colorless zinc sulfate solution is less dense than the blue copper sulfate solution, so it will float on top of the copper sulfate solution, if the copper sulfate solution is added carefully.

Fill the plastic dropper with the blue copper sulfate solution. Insert the tip of the dropper through the colorless zinc sulfate solution down to the bottom of the beaker.

GENTLY squeeze the bulb of the dropper to SLOWLY inject the copper sulfate solution. This must be done slowly so the copper sulfate solution does not mix with the zinc sulfate solution. Instead, the zinc sulfate solution will float on top of the copper sulfate solution. Also, don't allow the dropper bulb to expand while the tip is in the liquid in the battery.

Continue to slowly add copper sulfate solution until the top of the blue solution is half way between the copper and the zinc metal strips.



Once the cell is completed, you should be careful not to bump it. If it is disturbed, the two solutions may mix and the battery will not work as well.

Clip one of the wires from your battery to each of the probes from a voltmeter. What is the voltage produced by your battery?

Attach the clips to the terminals of the LCD digital clock to see if your battery can operate the clock. Attach the clip from the copper to the positive (red) terminal of the clock and the clip from the zinc to the negative (black) terminal. Does your battery run the LCD clock?

Attach the clips to the terminals of the analog clock to see if your battery can operate the clock. Attach the clip from the copper to the positive (+) terminal of the clock and the clip from the zinc to the negative (–) terminal. Does your battery cause the hands of the analog clock to move?

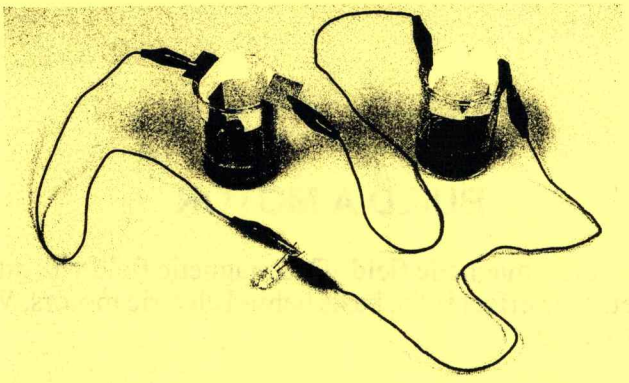
See if your battery will run a small electric motor by attaching one wire from your battery to each of the terminals on the motor. Does your battery run the motor?

See if your battery will light the red LED. Attach the wire from the copper to the longer wire of the LED and the wire from the zinc to the shorter wire of the LED. Does the LED glow?

BATTERIES IN SERIES

Often the voltage produced by one battery is not enough to operate a device. The voltage from your battery is not enough to light the LED.

However, if two or more batteries are combined in series, their voltages will add together. You will combine your battery with the battery your neighbor made to light the LED.



Gently and slowly move your battery close enough to your neighbor's to connect the two with one of the clip wires. Clip the wire from the zinc in one battery to the copper in the other battery.

Use the voltmeter to measure the voltage from the unconnected copper in one battery to the zinc in the other battery. What is the voltage?

How does this voltage compare to the voltage produced by each battery separately?

The two batteries are now connected in series. See if the batteries in series will light the red LED.

Connect the copper from one battery to the long wire of the red LED and the zinc of the other battery to the short wire of the LED. Does the LED glow?

Try to light the other color LEDs. Do they all light with two cells in series?

If two batteries in series don't light all colors of LED, what might to do to light the ones that don't light with two batteries in series? Try it to see if it works.

Connect the batteries in series to a motor. Does the motor run? Does it run differently than with one battery?

BUILD A MOTOR

An electric current will generate a magnetic field. This magnetic field will attempt to line up with the field of a permanent magnet. This effect is the basis behind electric motors. We will now build a very simple motor to see how it works.

You will need:

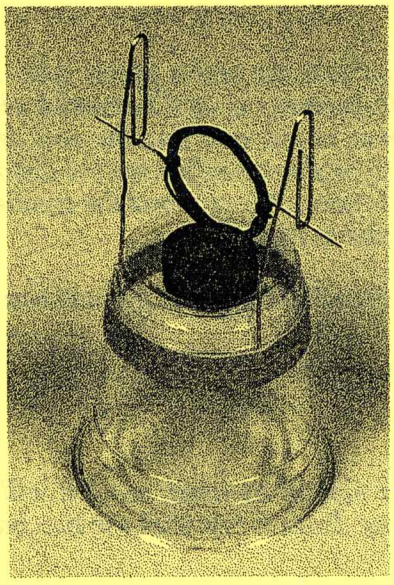
- 1 meter of insulated wire
- a plastic cup
- two disk magnets
- two large rubber bands
- two large paper clips
- 2 wires with clips on each end

You'll also use a D-cell battery, wire strippers, and a waterproof marking pen.

Take the 3-foot piece of insulated wire. Starting about 3 inches from the end of the wire, wrap it seven times around the D-cell battery to form a coil. Wrap the ends of the wire a couple of times around the coil to hold it together.

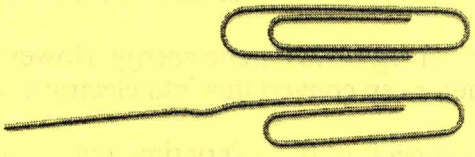
Use the wire strippers to remove the insulation from the two ends of the coil.

Turn the cup upside down and place a magnet on top in the center. Attach another magnet inside the cup, directly beneath the original magnet. This will create a stronger magnetic field as well as hold the top magnet in place.



Put two large rubber bands around the cup.

Straighten the larger loops of two paper clips.



Insert the straightened paper clips into the rubber bands, so they stand upright over the bottom of the cup.

Rest the ends of the coil in the cradles formed by the paper clips. Adjust the height of the paper clips so that when the coil spins, it just clears the magnets. Adjust the coil and the clips until the coil stays balanced and centered while spinning freely on the clips. Good balance is important in getting the motor to operate well.

Once you have determined how long the projecting ends of the coil must be to rest in the paper-clip cradles, you may trim off any excess wire.

Attach one of the clip leads to each paper clip just above the rubber bands. You may need to readjust the clips to make sure the coil still spins freely.

Hold the other ends of the clip leads against the two poles of the D-cell battery. If the coil is well balanced on the clips, it will rotate to a near horizontal position. The magnetic field created by the electric current in the coil aligns itself with the magnets.

However, the coil may not continue to turn, because the current continues to flow through the coil its magnetic fields stays aligned with the magnets. To get the coil to continue rotating, the current should be turned off when the coil is aligned with the magnets. This can be done by painting one of the ends of the coil.

Remove the coil from the paper clips. Hold the coil vertically. Use the permanent marker to paint the TOP HALF of one of the two end wires. Allow the paint to dry for a few seconds and then hang the coil on the paper clips again.

Connect the D-cell battery again, and give the coil a gentle spin. If it doesn't keep spinning on its own, check to make sure that the coil assembly is well balanced when spinning, that the projecting end has been painted with black pen as noted, and that the coil and the magnet are close to each other but do not hit each other. You might also try adjusting the distance separating the cradles: This may affect the quality of the contact between the coil and the cradles. With a little adjustment, your motor will spin rapidly when connected to the battery.

Once your motor is running with the D-cell battery, see if it will run with the battery you made. Does it run?

If your motor does not run with your battery by itself, see if it will run with your battery and your neighbor's battery connected in series. Does it run with the two batteries in series?

A MOTOR IS A GENERATOR TOO

An electric motor converts electric energy into kinetic energy. However, if kinetic energy is used to turn the shaft of the motor, the motor can convert this into electric energy.

The motor you built can also be a generator. It's a very tiny motor, so it can't make enough electric energy to be useful, but it can be measured with a voltmeter.

Connect the clips from your motor to the leads of the voltmeter. Set the voltmeter to measure AC voltage.

Give the coil a spin. See how the voltmeter reads a tiny voltage. What voltage do you get from your motor?

Because we painted one of the wires, the electrical energy is turned off and on as the coil spins. That's why we need to set the meter to read AC (alternating current) voltage.

How does the voltage change with the speed of the coil?
