

Make-and-Take Paper Battery

You can make a battery out of foil, paper, and saltwater! Copper tape and aluminum foil serve as the electrodes and the paper holds the salty electrolyte. This small battery is portable and about as effective as a voltaic pile made with washers. However, it takes a while to get started and only lasts several hours.

Question to Investigate

- Can your foil battery light each of the different colors of LED bulbs?

Science Content

- A battery is made of 2 electrodes and an electrolyte.
- The electrodes are made of two different metals.
 - The copper cathode has a positive charge.
 - The aluminum anode has a negative charge.
- The longer leg of the LED must be on the copper cathode and the shorter end must be on the aluminum anode so that the bulb will light
- Batteries have properties that make them useful.
- Chemists and other scientists are working to make better batteries.

Materials

- 4 rolls of copper tape, 1- inch wide and 50 feet long
- 2 rolls of aluminum foil, 25 sq feet
- 1 pad of construction paper, cut into 12 one-inch strips
- 1-inch hole punch
- Scissors, 1 per station
- Digital voltmeter
- Small light emitting diode (LED), 5 mm bulb, any color (2.0V - 2.8V)
- Tap water
- 4 two-liter bottles
- saltwater
- Short clear plastic cups
- Plastic tweezers
- 300 snack-sized zip-closing plastic bags



Safety Requirements

- LED bulbs have sharp ends. Use caution when handling them.

Preparation

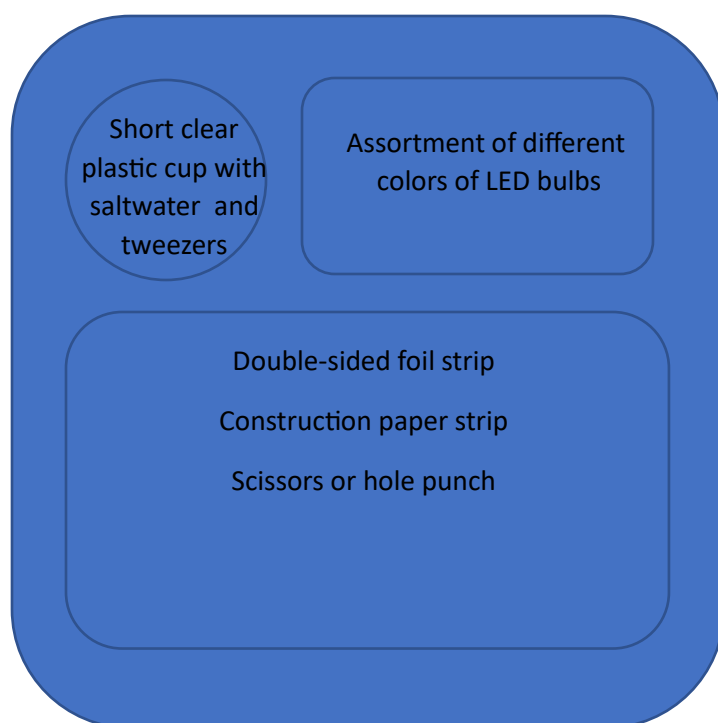
Prior to the activity

1. Cut the construction paper into 12-inch-long strips that are the same width as the copper tape.
2. Stick 12-inch pieces of copper tape across the aluminum foil until both rolls are used up.
3. Label 2 two-liter bottles *saltwater* and 2 other two-liter bottles *used saltwater*.



Prepare on site

1. Make a saltwater solution by adding 200 mL (approximately 300 grams) of salt to 1L of water in the bottle for saltwater.
2. Close the lid, hold it securely, and shake the bottle until the salt dissolves.
3. Arrange four trays along the front of the table close to participants.
4. Place items on each tray as indicated.
5. Prepare several sets of paper batteries following the instructions in the chart. Participants will use these when exploring with you and will set up their own to take home.



Onsite activity		
Step	Details	Ask participants
Introduce the supplies used in this activity	<ul style="list-style-type: none"> • Make a battery out of foil, paper, and saltwater, that can light a small LED bulb. You will be able to take this home! • Copper tape is used inside of electric guitars and to make paper circuits in science lab notebooks. It has a coating on it so that the tape stays bright and shiny longer. • LED bulbs are used inside of electronics to let you know whether a component is on. 	<ul style="list-style-type: none"> • How do people use aluminum foil?
Light different LEDs using a pre-made paper battery	<ul style="list-style-type: none"> • Instruct participants to slide the LED bulb over all the layers of the foil-paper battery so that the longer leg is on the copper side and the shorter leg is on the aluminum side. • Trace the path of the flow of electrons from the aluminum anode through the short leg of the LED into the bulb, through the long leg of the LED and to the cathode. 	<ul style="list-style-type: none"> • Does it matter which way you turn the LED bulb? • Do all the colors of bulbs light up? • Can you get the bulb to light using fewer layers?
Have participants cut the foil and paper	<p>Direct participants to:</p> <ul style="list-style-type: none"> • Layer the paper and foil strips together. • Use scissors to cut the strips into 12 one-inch squares. 	
Guide participants as they assemble their own paper battery to take home	<p>Direct participants to:</p> <ul style="list-style-type: none"> • Place a piece of foil either copper- or zinc- side up— participant's choice. • Use tweezers to pick up a piece of construction paper and dip it in the saltwater. Give it a little shake under the water to help wet it. Then layer this paper on top of the foil. 	<ul style="list-style-type: none"> • Would you like to put the double-sided foil either copper-or-zinc-side up?

	<ul style="list-style-type: none"> • Add another piece of double-sided foil either copper-or zinc-side up, making sure that it is the exact same way as the first. • Continue assembling all the pieces using the same pattern. 	
Pack the battery up and select three LED bulbs to take home	<ul style="list-style-type: none"> • This battery will be in prime working condition in about an hour. The battery will work for only a few hours. • Chemists and other scientists are working to make better batteries. 	<ul style="list-style-type: none"> • Which 3 LED bulbs would you like to take home? • What are the good things about this battery? • What would you like this battery to do that it can't?

Chemistry Details

Batteries, including the one made in this activity, have the same key parts—two electrodes and an electrolyte. In this activity, the copper and aluminum foil are the electrodes, and the electrolyte is saltwater held in place by a piece of construction paper.

The aluminum foil is the anode and the copper tape is the cathode. The LED must be positioned in the proper orientation in order for the bulb to light.

In a battery that is in a closed circuit with a device such as the small LED bulb, electrons move from the anode through the short leg of the LED into the bulb, through the long leg of the LED to the cathode. After a few hours, this battery no longer works. This happens for a couple of reasons, 1. The electrolyte dries up and crystalizes. 2. The chemical reactions that made the battery work, changed the foils.

It is possible, although not exactly practical, to make batteries out of foils, paper, and saltwater. Fortunately for us, scientists have figured out how to make batteries that are small, efficient, and light enough to carry. Better yet, scientists continue to work to make batteries that are even more convenient, are safer for people, animals, and the environment, and work better than those that you use every day.