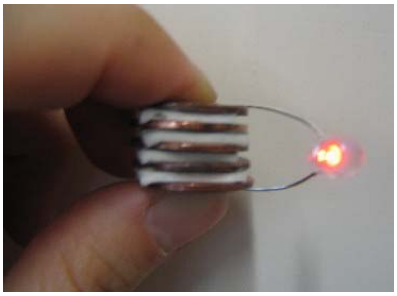
Penny Battery

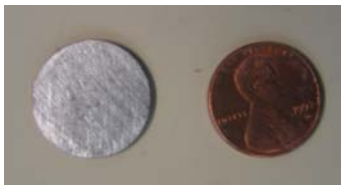


Light an LED with five cents

Use two different metals and some sour, salty water to create a cheap battery.

Materials
5 or more post-1982 pennies
100 grit sandpaper
matboard or thick cardboard
scissors
water
salt
vinegar
red LED; high-intensity ones are easier to see (Radio Shack #276-309 and 276-307 or MUCH cheaper online at Jameco #1555489)
(optional) electrical tape, voltmeter

To do and notice



1. Use sandpaper to sand the copper off of one side of four of the pennies. Leave the fifth penny intact. Sand until you see zinc (shiny silver color) covering the entire face of the coin. This takes some effort. Try placing the sandpaper on a hard surface and moving the penny. The "tails" side may be easier to sand than the "heads" since the Lincoln Memorial does not protrude as far as Lincoln's head. The sanded coins should now have a bronze-colored copper side and a silver-colored zinc side.

2. Make a saturated salt solution by adding salt into water until it doesn't dissolve anymore. Add a splash of vinegar to this solution.

3. Cut the matboard into four ½" squares. Soak the pieces in the saltwater solution.

4. Lay out the pennies with the zinc side facing up and place a damp piece of matboard on each one.

5. Stack the penny-matboard pieces on top of each other to make a tall pile. The pile should have alternating layers of penny-matboard-penny-matboard, etc., with the zinc sides all facing up. Make sure that the pennies aren't directly touching each other and, likewise, that the pieces of matboard aren't touching each other.

6. Place the intact penny on the top layer of matboard.

7. Connect the LED by touching the longer lead to the intact penny and the shorter lead to the bottom of the stack. Make sure that the leads don't touch any other layer. Did the LED turn on? If not, try adding an additional sanded-penny/soaked-matboard layer to the bottom.

Things to troubleshoot: make sure that the individual layers are separate (ie. no coins touching, no matboards touching); check for drips – a stream of saltwater can cause a short in the battery; check that the LED is in the correct orientation.

8. (Optional) Check the voltage of the battery with a voltmeter. To keep your LED lit, wrap the entire assembly together with electrical tape. The LED will grow fainter as the matboards dry out, but should stay lit over 24 hours! To recharge, just re-soak the matboards and reassemble.

What's going on?

Batteries are devices that convert chemical energy into electrical energy. When two different metals are connected by an electrolyte, a chemical reaction occurs at each metal surface, called **electrodes**, that either produces or uses electrons. When these electrodes are connected by a wire, electrons will move from one surface to the other, creating an electric current. Pennies that were made after 1982 have zinc cores that are plated with copper. By sanding off one face of a penny, you create a zinc electrode that can pair with the copper electrode on the face of the next penny. The matboard soaked in salty vinegar water serves as the electrolyte between the two terminals. Each zinc-matboard-copper stack represents one individual cell. By stacking additional matboards and sanded pennies, you've created a **battery**, which is a series of electrochemical cells. This is also called a voltaic pile, which is named after Alessandro Volta, who created the first battery in 1800 by alternating zinc and copper electrodes with sulfuric acid between them. In Volta's battery and your penny battery, an oxidation reaction occurs at the zinc electrode that produces electrons and a reduction reaction occurs at the copper electrode that consumes them.

If you have a voltmeter, you can see that each cell can generate over 0.6 V. A stack of 3 cells should actually be enough to generate the voltage to needed to light a red LED, which usually require around 1.7 V. LEDs that emit other colors require a higher voltage; so try stacking additional cells to light a green or blue LED.

Legal Disclaimer: Before 1982, pennies were made of 95% copper, but the rising costs of copper led the United States Mint to change the composition of the penny. The metal content in a pre-1982 penny is actually worth more than its one-cent face value. Consequently, in December 2006, the United States Mint implemented regulations that prohibit the melting or treatment of all one-cent coins. The Exploratorium does not take responsibility for any damaged coinage, and certainly don't try to sell your battery for more than 5¢!

References

Chemical Demonstrations: A Handbook for Teachers of Chemistry Vol. 4 by Bassam Z. Shakhashiri (1992)

US Mint: http://www.usmint.gov