Potato Power: Teacher's Guide

Introduction

In this activity, you will learn how to build a battery from potatoes. Along the way, you will answer the following questions:

1. **How does a battery work?**
2. **What is current?**
3. **What is voltage?**
4. **What happens when you put two batteries in series?**
5. **What happens when you put two batteries in parallel?**

You will then use what you have learned to design a potato battery to light two LEDs (Light Emitting Diodes). I will tell you now, the two LEDs need 1.6 volts and 2 milliamps. What does that mean?! You will find out...

Background

The battery was invented around 1800 by Alessandro Volta in Italy. It has become an indispensable part of modern life. Wherever you look, you'll find devices that use batteries.

Why are batteries so useful? Because they convert chemical energy into electrical energy. You can use this electrical energy to light a flashlight, to start a car, or to listen to your favorite music.

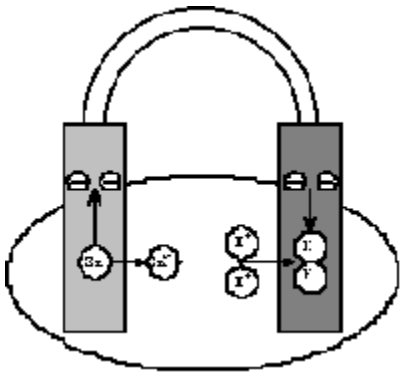
You can make a simple battery by placing a zinc strip and a copper strip in an acid. At the zinc strip, the acid dissolves the zinc freeing electrons. At the copper strip, the acid uses those electrons to form hydrogen gas. Because the zinc strip

frees electrons and the copper strip uses electrons, if you put a wire between the two strips, then electrons will flow from the zinc to the copper. This is electrical energy.

Pre-Activity

Done before the class as an introduction to batteries and the chemical reactions going on.

Need two 500 mL beakers, vinegar, 2 copper strips, 2 zinc strips, and low current LED. Hook up the beakers and strips as 2 batteries in series and attach the LED. Half fill the beakers with water. Show that the LED is dimly lit. Add vinegar, representing free protons, to the beakers and show that the LED is now brightly lit.



Materials

- **metal strips: copper, aluminum, zinc (galvanized steel)**
- **potatoes (at least 4)**
- **multimeter (volts, milliamps)**
- **wire clips**
- **steel wool (to clean the metal strips)**

Simple Potato Battery

1. **Select two different metal strips and one potato.**
2. **Carefully place the metal strips into the potato.**

Congratulations! You have just made a battery! Simple, yes? Now you will learn about your battery.

At this point, you may be wondering, What is the acid in the potato? What is causing a chemical reaction? The explanation is:

1. the potato has a mild phosphoric acid content H_3PO_4
2. reduction at Cu (copper) electrode:
$2H^+ + 2e^- \rightarrow H_2$ gas
3. oxidation at Zn (zinc) electrode:
$Zn \rightarrow Zn^{++} + 2e^-$

The H_3PO_4 acid puts the hydrogen ions in solution.

So basically, the phosphoric acid in the potato acts like the acetic acid (vinegar) that we used in the pre-activity.

Voltage

1. **Set the meter to "DC Volts" and make sure the probes are plugged into the correct jacks. Also make sure that the scale is correct. All multimeters are different, but there should be a low scale, something like 2V, or 6V.**
2. **Attach wires from the meter's probes to the metal strips.**
3. **What does the meter read? (enter on the worksheet)**

Remember that in a battery, one metal strip is becoming positive and the other negative. Voltage is a measure of this charge difference. It is measured in units called "volts", named after the inventor of the battery.

Voltage is a lot like a hill. A hill is due to a height difference. Voltage is due to a charge difference. Say you roll a ball down a hill. The higher the hill, the faster the ball will go. A ball rolling down a high hill has more energy than a ball rolling down a low hill. In the same way, an electron going across a large voltage has more energy than an electron going across a small voltage.

Current

1. **Set the meter to "DC milliamps" and make sure the probes are plugged into the correct jacks. (Use the smallest setting on the multimeter.)**
2. **Attach wires from the meter's probes to the metal strips.**

3. **What does the meter read? (enter on the worksheet) (You may notice that the current decreases. As the current decreases, you are draining the battery. So take your measurement, then disconnect the wires.)**

Remember that in a battery, electrons are leaving one metal strip and flowing to the other strip. Current is a measure of how many electrons are flowing in time. It is measured in units called "amps", but because our currents are so small, we use milliamps (1/1000 of an amp).

Electron current is a lot like a stream. A stream is the flow of water. Electron current is the flow of electrons.

Different Metals

Now that you know how to make a potato battery, and know what voltage and current are, you will try to make a better battery.

Some metals make better batteries than others. You will try to find the combination of metals that gives the most voltage and current.

What combination of metals made the most voltage and current together? (circle it on the worksheet)

From now on, use this best combination of metals in making batteries.

Potatoes in Series

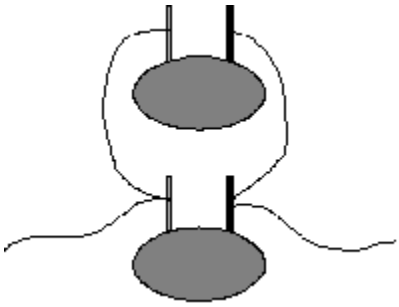
1. **Make another potato battery.**
2. **Wire up the two potatoes in series, as shown below.**

3. **Think about voltage as the height of a hill. What do you predict the total voltage will be? (What would the total height be if you put two hills in series?) (enter on worksheet)**
4. **Measure the voltage of the two potatoes in series. (enter on worksheet)**
5. **How does this voltage compare to the voltage produced by just one potato?**
6. **Think about current as a stream. What do you predict the total current will be? (What would the total current be if you put two streams in series?) (enter on worksheet)**

7. **Measure the current of the two potatoes in series. (enter on worksheet)**
8. **How does this current compare to the current produced by just one potato?**

Potatoes in Parallel

1. **Wire up the two potatoes in parallel, as shown below.**



2. **Think about voltage as the height of a hill. What do you predict the total voltage will be? (What would the total height be if you put two hills in parallel?) (enter on worksheet)**
3. **Measure the voltage of the two potatoes in parallel. (enter on worksheet)**
4. **How does this voltage compare to the voltage produced by just one potato?**
5. **Think about current as a stream. What do you predict the total current will be? (What would the total current be if you put two streams in parallel?) (enter on worksheet)**
6. **Measure the current of the two potatoes in parallel. (enter on worksheet)**
7. **How does this current compare to the current produced by just one potato?**

Light the LEDs

Now you are qualified to be a battery engineer! Your job is to design a more complicated potato battery to light two LEDs.

Two LEDs need 1.6 volts and 1 milliamp to light brightly. The more current, the brighter the light. By putting potatoes in series and parallel, design a battery to do this:

Now test your battery with the LEDs. LEDs are special lights that have a positive side (red wire) and negative side (black wire). Make sure you attach the positive side of your battery to the red wire and the negative side to the black wire.

Notes

- **The best combination of metals should be copper and zinc.**
- **The LEDs used here are special low current LEDs, rated for 1.8 V and 1 mA, but they will fire at about 1.6 V and .2 mA.**
- **One LED should fire with 2 potatoes in series (this barely produces the needed 1.6 V), but you may need 3.**
- **The 2 LED eyes are wired in parallel. Four potatoes should brightly light the eyes: two pairs in series, those pairs in parallel.**
- **The zinc used here is really galvanized steel, meaning zinc coated steel. Zinc is dissolved from the strips in the battery, so the metal strips have a finite lifetime.**
- **Do not eat the potatoes afterwards!**