Build a Lemon Battery

At-Home

A lemon on its own is not a battery. But add electrodes, make a path for electrons to move, and you have all the basic elements of a battery. Build your own lemon battery and feel energized when you juice up a small LED with electricity!

Question to investigate

How can you use lemons to light a small LED?

Chemistry concepts

- A battery is a device that converts chemical energy into electricity.
- Electrodes are parts of a battery that either donate or accept electrons as they react.
- The electrode that donates electrons is the anode and the electrode that accepts electrons is the cathode.

Activity logistics

- **Ages**: As written, this activity is well-suited for ages 8 and up.
- **Time**: 15-30 minutes

Be safe

- Juice from the lemon is acidic and may sting your eyes and skin. Wear safety glasses or splash goggles to prevent eye contact. Rinse hands with running water if you get any lemon juice on your skin.
- The knife is sharp and can cut or pierce your skin. Handle all sharp objects, including the knife, alligator clips, LED, and nail with care.
- Put the knife away immediately after using it.
- Do not taste or eat the lemon. Discard the lemon after performing this activity.
- Do not do this activity with young children who tend to put objects in their mouths.
- Tie back long hair, roll up sleeves, and secure loose clothing.
- Wash your hands before and after the activity.
- Be sure to clean up and dispose of materials properly when you are finished with after an activity.

What you'll need

- 7 lemons
- Sharp kitchen knife
- Permanent marker
- 2 thick books
- 8 alligator clips
- 7 zinc nails, such as galvanized roofing nails
- 7 copper pennies, before 1982 work best because they are all copper
- LED bulb, either 3 mm, 5mm or 10mm in diameter

Procedure

Prepare the battery

1. Roll the lemon against the counter or tabletop with the palm of your hand. Press down slightly as you roll to break some of the tiny juice-filled pouches inside the lemon. Do this for all 7 lemons
2. Use a permanent marker to make a line about the diameter of a penny on each lemon. Place the lemon between two books to hold it steady. Make sure the line you drew is face-up.
3. Using the tip of a sharp knife cut along the line. Do this for all 7 lemons. Put the knife away.
4. Tuck the penny half-way into the slit on each lemon.
   The penny is the **cathode**.
5. Press one nail into each of 7 lemons. The nail is the **anode**.

Connect the battery to the bulb

6. Connect one end of an alligator clip to the zinc nail (anode). Connect the other end of the alligator clip to the penny copper penny (cathode) of a different lemon.
7. Use the rest of the alligator clips to connect the lemons nail from one lemon to the penny of another lemon.
8. Before connecting the last lemon to the first, include the LED in the circuit. The LED has two leads. Using the loose ends of the alligator clips, connect the longer lead to a cathode (penny). Connect the shorter lead to an anode (nail).

What did you observe?

- Does the LED light?
- Does it make a difference how the LED is connected to your lemon battery?
- Can you see small bubbles at the cathode (penny) when the LED is on?
  Whether you see bubbles or not, hydrogen gas is released when the circuit is closed.

What else can you try?

- Are there other fruits (or tubers) that, when pierced with zinc and copper electrodes, can light a small LED?

How does it work?

Lemon juice reacts easily with the zinc from the nail and the copper from the penny. As the zinc from the nail reacts, Zn^{++} ions dissolve in the lemon juice making twice their number of electrons ready-to-move. The copper penny is ready to accept these electrons. The easiest way for the electrons to get from the anode (nail) to the cathode (copper penny), is through the wire and LED.

The LED (light emitting diode) controls the flow of electricity. This is why it will only work when the short lead is connected to the anode and the long lead is connected to the cathode.

When the electrons make the trip through the circuit to the penny, they combine with H^+ ions from the surrounding lemon juice. The H^+ ions and electrons form H_2, also known as hydrogen gas. Look closely to see if you can see tiny bubbles where the penny and lemon touch when the LED is on.

Because the breaking and making of chemical bonds inside the lemon cause electrons to move, the lemon, nail, and penny together are a battery!

Where does this happen in real life?

We rely on batteries to power our phones, laptop computers, toys, and some scooters. Some batteries are rechargeable and can be used over again, while others run out. Some are big, like the batteries that store energy generated from windmills and others are small, like the ones used to power hearing aids. Batteries are made of different things, too. You can get a hint about what they are made of from their names, such as alkaline batteries or lithium-ion batteries. These names describe the different chemistries used inside the battery to store and release energy.

The specific chemical reactions in each battery type are different, but they all share something in common: The chemical reactions involve gaining and losing electrons at electrodes. The easiest way for electrons to get from one electrode to the other, is not the short distance inside the battery. It is actually out the anode, through your favorite electronic device and into the cathode. This is how batteries power our electronic devices!