



How to Make a Battery with Metal, Air, and Saltwater

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Experimental Procedure

Setting Up and Testing Your Zinc-Air Battery

1. Prepare the saltwater electrolyte for your zinc-air battery.
 - a. Place the bowl on your scale and put the balance back to zero (tare the scale).
 - b. Weigh 25 grams (g) of table salt (NaCl) into the bowl.
 - c. Fill your measuring cup with 500 milliliters (mL) of tap water.
 - d. Add the water into the bowl with your weighed salt.
 - e. Stir the solution with a clean spoon until all salt is dissolved.
2. Label three plastic cups or Mason jars #1–3 using a permanent marker. You will do three trials in parallel to make sure that you get accurate and reproducible results.
3. Get your electrodes ready. The shiny reddish electrode with a "Co" imprint is the copper (Cu) electrode and will be your cathode. The silver-looking electrode with a "Zinc" imprint is your zinc (Zn) anode. Take a picture of your electrodes before you begin your experiment for your [project display board](http://www.sciencebuddies.org/science-fair-projects/science-fair/science-fair-project-display-boards) (<http://www.sciencebuddies.org/science-fair-projects/science-fair/science-fair-project-display-boards>). You will compare the electrode condition and appearance at the beginning and at the end of your experiment. Create a data table, such as Table 1, in your lab notebook, and record your observations about the electrodes, such as their color, surface roughness, gloss, etcetera.

Trial #	Electrode Condition at the Beginning		Electrode Condition at the End	
	Anode (Zn)	Cathode (Cu)	Anode (Zn)	Cathode (Cu)
1				
2				
3				

Table 1. Data table for recording your observations about the zinc and copper electrodes (such as color, surface roughness, gloss, etcetera) at the beginning and at the end of your experiment.

4. Fill each of your labeled cups or jars with 150 mL of your prepared saltwater electrolyte.
5. In each of your cups or jars, insert one zinc and one copper electrode. Place them on opposite sides of the cup so they face each other. Be careful not to knock over the cups. The electrodes should remain in the saltwater electrolyte throughout the entire experiment. You have to make sure that they *never* touch each other to prevent an accidental short circuit.
6. Now you are ready to test if your batteries are working. Test each of your batteries successively.
 - a. Take one red and one green alligator clip cable from the Veggie Power Kit and connect one end of the green alligator cable to the zinc anode. Use the clip to attach the electrode to the cup wall, as shown in Figure 3. *Note:* Figure 3 shows a black alligator clip. Your kit may come with a green alligator clip instead of black. The colors of the cables are just used for convenience and color-coding circuits, but there is no practical difference between wires/cables with different colors.

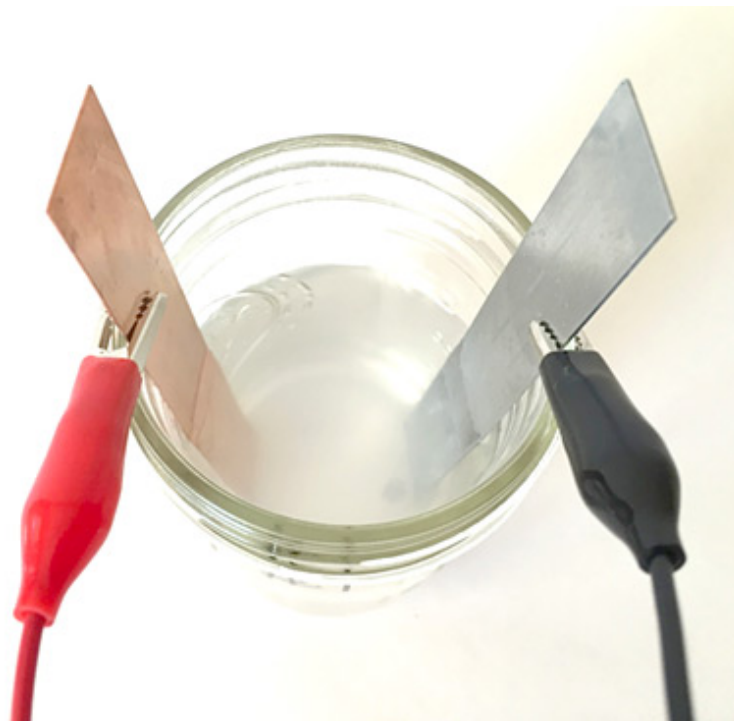


Figure 3. Use the clips of the alligator cables to attach the electrodes to the cup or jar wall to hold them in place.

- b. Take the red alligator clip cable and connect one end of the cable to the copper cathode. Again, attach the electrode to the cup wall with the clip to hold it in place.
- c. Get the piezoelectric buzzer (round-shaped black object) from the kit. Connect the second end of the red alligator clip cable to buzzer's positive (red) wire, and the green alligator clip to the buzzer's negative (black) wire, as shown in Figure 4.



Figure 4. Alligator clips connected to the buzzer. **Note:** the buzzer shown in this picture has short metal pins, with one marked by a "+" sign for positive. Your buzzer may have longer red (positive) and black (negative) wires attached.

- d. If your battery is working you should hear the buzzer making some loud noise. If you do not hear a sound, check

- your battery setup and all your cable connections, or refer to the [Frequently Asked Questions](#) (#help). Make sure you did not connect the buzzer backwards by getting red and black wires mixed up.
- e. Remove the buzzer from the alligator clip cables before you continue with the next step.

Measuring Voltage and Current Output

1. Prepare a data table, like Table 2, in your lab notebook. You will use this table to record the **open-circuit voltage** (the voltage across both electrodes when no current is flowing) and the **short-circuit current** (the current when the battery's electrodes are shorted together) for each of your zinc-air batteries under different experimental conditions.

Treatment	Trial #	Open-circuit Voltage (V)	Short-circuit Current (mA)	
			Beginning of Measurement	(Highest Value) 3 Minutes Later
None	1			
	2			
	3			
	Average			
Continuous stirring with straw	1			
	2			
	3			
	Average			
Continuous blowing bubbles with straw	1			
	2			
	3			
	Average			
+ 5 mL of 3% H ₂ O ₂	1			
	2			
	3			
	Average			
+ 5 mL of 3% H ₂ O ₂ plus continuous stirring	1			
	2			
	3			
	Average			

Table 2. Data table for recording open-circuit voltages and short-circuit currents of all your zinc-air batteries for each individual

experimental condition.

2. Measure the open-circuit voltage and short-circuit current of each of your zinc-air batteries. Start with the first one and then continue with the other two trials. These values give you the highest voltage and the highest current that your battery can supply (but note that it cannot provide both at the same time). Refer to the Science Buddies resource [How to Use a Multimeter](http://www.sciencebuddies.org/science-fair-projects/references/how-to-use-a-multimeter) (<http://www.sciencebuddies.org/science-fair-projects/references/how-to-use-a-multimeter>) if you need help using a multimeter.
 - a. Connect the alligator clip cables that are still connected to your electrodes to the multimeter leads, as shown in Figure 5.
 - i. First, plug the red multimeter probe into the multimeter port labeled $V\Omega mA$, and the black multimeter probe into the multimeter port labeled COM.
 - ii. Now clip the end of the red alligator clip cable (still connected to your copper electrode) onto the metal part of the red multimeter probe.
 - iii. Finally, clip the end of the green alligator clip cable (still connected to your zinc electrode) onto the metal part of the black multimeter probe.



Figure 5. Setup for measuring the open-circuit voltage and short-circuit current of your zinc-air batteries. *Note:* The multimeter screen has been blurred in the image. We do not want to give away the data!

- b. Set the multimeter dial to measure in the 20 V range (the "20" in the upper left of the dial). Record the open-circuit voltage in your data table (Table 2).
- c. Change the multimeter dial to measure in the 200 mA range (the "200m" on the right side of the dial). *Quickly* record the short-circuit current in your data table. The current will start to drop rapidly as the battery begins to drain and the oxygen dissolved in the electrolyte gets depleted.
- d. Then set your timer to 3 minutes and record the short-circuit current again in your data table, even if it has not

- fully stabilized yet. These will be your results for the "no treatment" batteries.
- e. Refer to the [Help](#) (#help) section if you get stuck or have trouble taking a reading.
3. Once you finished measuring the open-circuit-voltage and short-circuit-current of all three batteries, you are ready to start with your first mechanical treatment. Start with the first battery and repeat the procedure with the other two afterwards.
 - a. Keep the multimeter dial set to measuring direct current in the 200 mA range (the green "200m" on the right side of the dial). The readings should still be very low and fairly stable from your previous measurements. If the current is still rapidly decreasing, wait 3 more minutes until the reading has stabilized and does not change much anymore.
 - b. Take the straw and stir the solution (electrolyte) in the cup without knocking the cup over. It is okay to touch the electrodes with the straw, but do not bump them too hard.
 - c. Right after you started stirring, watch the short-circuit-current readings on your multimeter display. They probably will fluctuate a lot. In your data table, write down the highest current reading that you see during stirring.
 - d. Keep stirring and set your timer to 3 minutes. You will notice that the current readings will still fluctuate. After 3 minutes of treatment, while still stirring, record the highest reading of the short-circuit current in your data table.
 - e. Set the multimeter dial back to measure in the 20 V range (the "20" in the upper left of the dial). Repeat the stirring procedure and observe the voltage readings on the multimeter. Write down the voltage that you get when you stir the solution in your data table.
 - f. Set your multimeter dial back to measuring direct current in the 200 mA range (the "200m" on the right side of the dial) as you did before, and wait 5 minutes before you continue with the next step until the current reading is stable or does not change much anymore.
 4. Next, you will continue with your second mechanical treatment. Repeat step 3, but this time, instead of stirring the electrolyte with the straw, use the straw to blow bubbles into the solution. Hold the straw close to the copper electrode, as this is where the dissolved oxygen gets reduced. *Note:* You do not have to blow bubbles continuously, and can breathe normally in between.
 5. Now you will do the chemical treatment. Again, start with the first battery and then repeat the same treatment with the second and third one.
 - a. Keep the multimeter set to measuring direct current in the 200 mA range (the "200m" on the right side of the dial). The current reading should be stable again after completing step 4. If not, wait a little longer until the current does not change that much anymore.
 - b. Add 1 tsp. of 3% hydrogen peroxide to the electrolyte and quickly stir the solution with the spoon to disperse the H_2O_2 equally. Then stop stirring.
 - c. Immediately after adding the hydrogen peroxide and you have stopped stirring, record the current in your data table.
 - d. Just as with the mechanical treatment, wait 3 minutes for the current to get more stable and then write down the short-circuit-current in your data table (even if the current is still decreasing a little bit).
 - e. Set your multimeter back to measure DC voltage in the 20 V range (the white "20" in the upper left of the dial) and note down the voltage that you get with hydrogen peroxide added to your electrolyte.
 6. The last treatment is the combination of chemical and mechanical treatment. With the hydrogen peroxide still added to your battery, repeat step 3 and stir the electrolyte with a straw for 3 minutes while you are monitoring the short-circuit current.
 7. Once you have completed your data table (Table 2), you can start disassembling your zinc-air batteries.
 - a. Disconnect the alligator clip cables from the multimeter leads, as well as the two electrodes.
 - b. Take the zinc anode and the copper cathode out of the electrolyte solution and put them down on a paper towel. Look at their appearance and write down your observations in Table 1. Do they look different compared to the beginning?
 - c. Rinse the electrodes with tap water and dry them with a paper towel. How do the electrodes look now?
 - d. *Optional:* To see a more obvious electrode change, let the saltwater battery run for longer in short-circuit mode, meaning that you keep your electrodes in the saltwater electrolyte with the alligator clip cables attached. Disconnect the multimeter leads, then connect the free ends of the red and black alligator clips directly to each other. After one or two more days, take the electrodes out and assess their condition again.

Analyzing Your Data

1. Both your data tables should be complete. Making graphs helps you to visualize your data.
2. Make a bar graph in which you specify the treatment (none, stirring, blowing bubbles, hydrogen peroxide, hydrogen peroxide plus stirring) on the x-axis and plot the average short-circuit current that you measured after 3 minutes on the y-axis.
3. How does the current change with each treatment? Why do you think the current changed? What treatment resulted in the highest current output? If you need help with these questions, read the [Technical Note](#) (#technical-note) in the [Introduction](#) (#background) to review the electrode reactions in the zinc-air battery.
4. Look at your data in Table 2. How do the initial current readings differ from the values you measured after 3 minutes? If you want to visualize your data, you can make another bar graph similar to the one you made in step 2, but this time plot

- the current that you measured at the very beginning of your treatment on the y-axis. Can you explain your data?
5. Make another bar graph that shows the treatment type on the x-axis and the average open-circuit voltage for each treatment on the y-axis.
 6. How is the battery voltage influenced by the different treatments? Does the cell voltage change with any treatment? Remember that your treatments included mechanical and chemical treatments. Did the type of treatment matter? Note that the voltage or electrical potential difference of a battery is dependent on the redox reactions that happen at the electrodes. Looking at your results, do you think the presence of hydrogen peroxide changes the cell chemistry and electrode reactions? *Tip:* Revisit the [Technical Note](#) (#technical-note) in the [Introduction](#) (#background) for more information.
 7. Look at your observations in Table 1. Did the electrodes change at all over the course of the experiment? How do they look different? Can you explain your findings? *Note:* The time frame of your experiment might not be long enough to detect obvious electrode changes. Leave your battery setup in short-circuit measurement mode for 1–3 days to see how the electrodes of a zinc-air battery change over time. For this, leave the alligator clip cables connected to the electrodes, but instead of attaching the other ends of the cables to a buzzer or the multimeter, connect the free ends of the red and black alligator clips directly to each other.

Frequently Asked Questions (FAQ)

FAQ for this Project Idea available online at https://www.sciencebuddies.org/science-fair-projects/project-ideas/Chem_p107/chemistry/make-a-battery-with-metal-air-and-saltwater#help.