Copper (I) Oxide Solar Cells

Overview:

Copper and its cation forms can have very colorful properties, ranging from black, “copper,” red, green, to blue. The metal can be quickly oxidized on a hot plate to form a semi-conductor—a solid with conductive properties between that of an insulator and most metals, often triggered by temperature or light variations. Two forms of copper will be generated in this lab:

Cupric oxide with a Copper(II) oxidation state is black

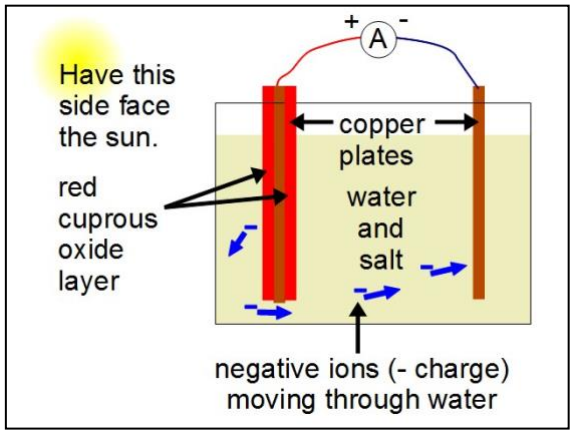
$$2\ Cu + O_2 \rightarrow 2\ CuO$$

Cuprous oxide is with the Copper(I) oxidation state is red.

$$4\ Cu + O_2 \rightarrow 2\ Cu_2O$$

Cuprous oxide is the semiconductor we will use in the solar cells. Without light, some electrons can flow through a salt water bridge and act as a battery. With light, the electrons in cuprous oxide can jump from the valence band to the conduction band, creating electron flow that can do electrical work. This is similar to how N-type layer electrons in silicon solar cells can jump to the P-layer and perform electrical work.

In this solar cell, the red cuprous oxide sheet electrons will jump into the salt water solution and electrons will flow to the unoxidized copper plate. With a multimeter connected to both copper sheets, the circuit is complete and electrical work can be done. Although electron flow will still occur without light like a battery, added light will increase this flow significantly in the solar cell. The effect is summarized in the image on the right.



Source: https://rimstar.org/renewnrg/sp_diy_homemade_solar_cell.htm .

Materials per student group:

- 2 Copper sheets
- Dish soap
- Sandpaper or steel wool
- Gloves
- 1 Hot plate or electric burner
- 1 250 mL glass beaker or clear plastic cup
- 75 grams (or ¼ cup) of table salt
- 250 mL water

Procedure:

Part I:

1. Clean off and degrease one copper sheet with soap and water. If there is any corrosion on your copper sheet, use sandpaper or steel wool to remove any visible impurities.
2. Place the clean and dry copper sheet directly on your hot plate or electric burner. Let your teacher know immediately if you see or smell any smoke. The copper should turn to an iridescent red color, to gray, and then start to form a black layer on the surface.

3. Once the black layer starts to form, keep the copper sheet on the heat source for an additional 20 minutes.

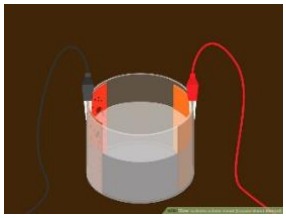
   If you are continuing onto Part II in a single period, you can begin the Part II steps 1-4 while the oxidized copper is cooling in step 4 of Part I.

   If you will be continuing Part II on another day, let the copper sheet cool overnight undisturbed in step 4 of Part I. Make sure to label your burner and copper sheet clearly and safely.

4. Turn off the heat source and allow the copper sheet to cool slowly on the burner for at least 15 minutes. Some black cupric oxide may flake off during cooling.

Part II:

1. Clean off and degrease the unoxidized copper sheet with soap and water. If there is any corrosion on your copper sheet, use sandpaper or steel wool to remove any visible impurities.
2. Add 75 grams of table salt to 250 mL of water in a 250 mL glass beaker or clear plastic cup. Stir to mix the solution
3. Use alligator clips to attach the unoxidized copper sheet to the rim of the beaker or plastic cup. See the image to the right from WikiHow.



4. Connect the unoxidized copper sheet to the positive (red) terminal of your multimeter so that the clip remains dry and the copper sheet is mostly submerged in the salt water.
5. Prepare your cooled oxidized copper sheet by rinsing the cupric oxide layer under running water. Most of the black oxide will come off by rubbing your fingers over the layer underwater.
6. Connect the oxidized copper sheet to the salt water container as shown in the above image. Connect the lead to the negative terminal of the multimeter.
7. Measure the voltage and current of the cell under multiple conditions as directed by your teacher:
   - Under ambient indoor classroom lighting
   - Under enhanced indoor lights such as clamp on lamps or halogen workshop lights
   - Outdoors in full sun
   - Outdoors in the shade

Measuring amperage:

1. Plug the positive (red) end of the multimeter lead into the positive terminal or socket labeled “mA”
2. Plug the negative (black) end of the multimeter lead into the negative terminal or socket labeled “COM”
3. Set the multimeter dial to measure microamps (μA)

Measuring voltage:

1. Plug the positive (red) end of the multimeter lead into the positive terminal or socket labeled “V”
2. Plug the negative (black) end of the multimeter lead into the negative terminal or socket labeled “COM”
3. Set the multimeter dial to measure volts DC (VDC or 10V)

Name(s):_____

Date: _____

Period:_____

Copper (I) Oxide Solar Cell Data Sheet

Condition	Voltage	Amperage
Indoor Ambient Light		
Indoor Enhanced Light Wattage:		
Indoor Enhanced Light Wattage:		
Outdoors (shade)		
Outdoors (partial sun)		
Outdoors (full sun)		