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Electroplating with Zinc

Erinn Dady
Parkland College

Parkland Chemistry Honors Project
Erinn Dady
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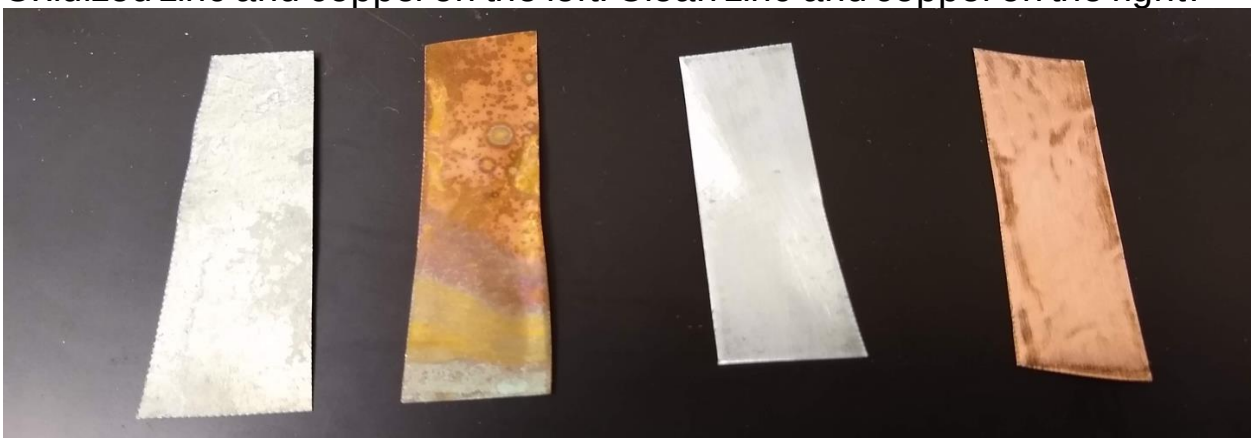
Professor Manuel Rodriguez

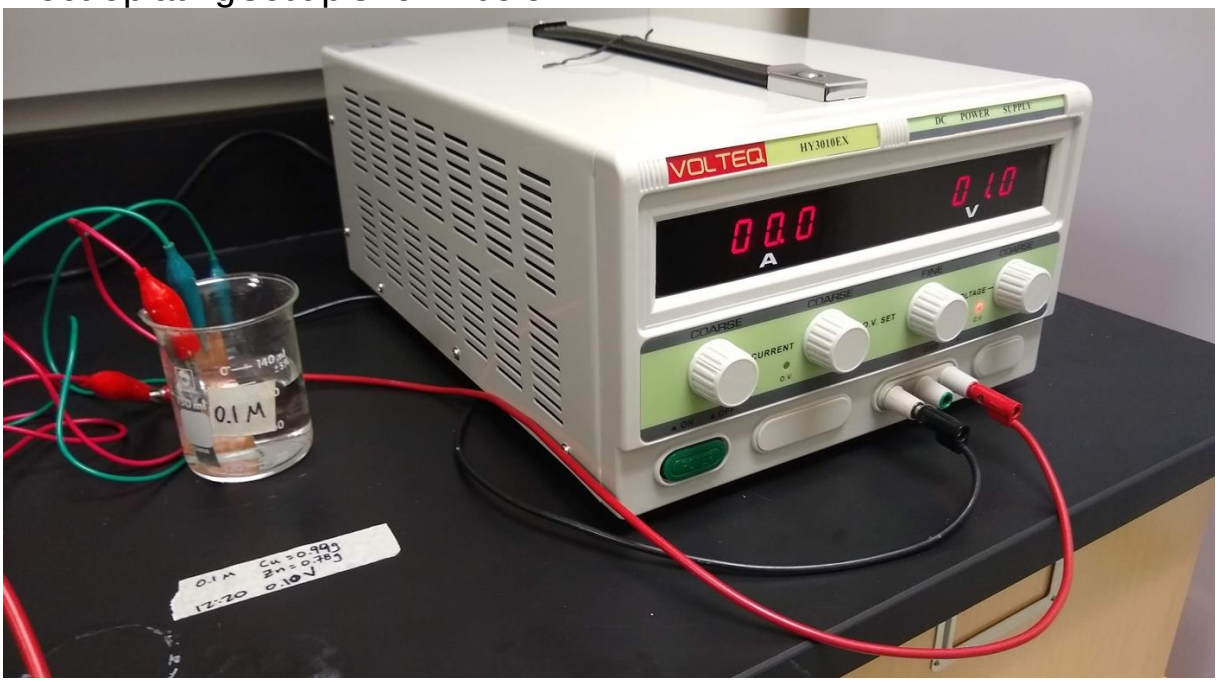
ELECTROPLATING COPPER WITH ZINC

Electroplating is a process that uses an electric current running through an electrolyte solution to form a thin coating (or "plate") of one type of metal over another. For my experiment, I attempted to electroplate pieces of copper with zinc by using Parkland's new Volteq HY machines. The sources of metal I used were thin sheets of copper and zinc, along with a solution of zinc sulfate ($ZnSO_4$). $ZnSO_4$ is an electrolyte, which is a chemical compound that dissociates into ions and is a good conductor of electricity. In order to efficiently electroplate, metals must be cleaned well of oxidation/patina and impurities. I used 220 grit sandpaper and vinegar to clean the strips of metal. Metal must be cleaned right before experiment as they oxidize just in the exposure to air.

Oxidized zinc and copper on the left. Clean zinc and copper on the right:



Electroplating set up shown below:



OBJECTIVE

- To determine the length of time needed to plate zinc over copper.
- To determine the necessary current to plate a minimum of 2.5 grams of zinc onto copper strip.
- Starting with a 1.0 Molar (1 M) solution of $ZnSO_4$, determine the lowest concentration that will work effectively.

PROCEDURE

- Ahead of time, mix up 1 M solution of $ZnSO_4$. Using the molar mass of $ZnSO_4$, (287.56 grams / mole), add this mass of powdered $ZnSO_4$ to an Erlenmeyer flask, and fill flask with distilled water up to the 1 Liter mark. This should be enough for about 10 trials.
- Make diluted concentrations of 0.1 M and 0.01 M.
- Follow the procedure below for each trial.

1. Clean one small strip of zinc. Weigh zinc on a top-loader balance and record mass. Attach positive (red) wire to zinc. The zinc is the anode.
2. Clean one small strip of copper. Weigh copper on a top-loader balance and record mass. Attach negative (black/green) wire to copper. The copper is the cathode. The cathode needs to gain electrodes, which will cause the positively charged Zinc cations to be drawn to it when the current is turned on.
3. Pour 100 mL of desired concentration of $ZnSO_4$ to a small beaker and record concentration. Place both metals with attached wires into the solution. Take care not to allow metals to touch, so the current has to run through the solution to complete the circuit.
4. Turn on and set up the Volteq HY machine Amperage and Voltage according to the instruction manual.
5. Connect the red wire attached to the zinc to the positive terminal of the power source. Connect the black/green wire attached to the copper strip to the negative terminal.
6. Record time plating begins and adjust current as necessary. Record end time and disconnect wires.

DATA TABLES:

1 M $ZnSO_4$		
4/19/19	Initial Mass	Final Mass
Zinc	0.79 g	0.54 g
Copper	0.77 g	1.28 g
Total Zinc added to Copper: 0.51 g		
Current: 1.8A / 09.9V - 2.6A / 09.7V		
Time Elapsed: 5 minutes		
Notes: Initial experiment ran fine but amperage and voltage fluctuated. Mass of zinc was too much.		

0.1 M $ZnSO_4$		
4/30/19	Initial Mass	Final Mass
Zinc	0.71 g	0.63 g
Copper	0.77 g	0.78 g
Total Zinc added to Copper: 0.01 g		
Current: 00.0 A / 0.10 V		
Time Elapsed: 25 minutes		
Notes: Turned current and amps all the way up but nothing would change. Ran time longer to compensate for low current.		

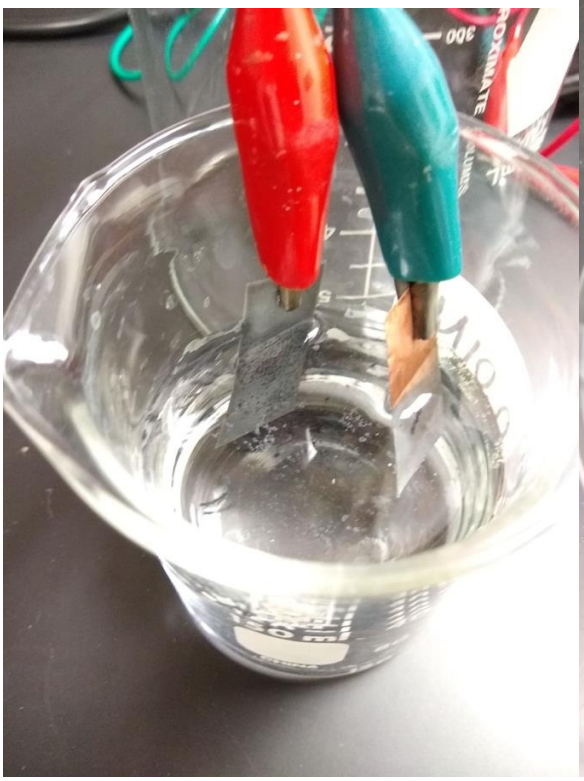
0.01 M $ZnSO_4$			
5/3/19	Initial Mass	Mass	Mass
Zinc	0.66 g	0.65 g	0.62 g
Copper	0.98 g	0.99 g	1.01 g
Total Zinc added to Copper: 0.01 g			0.03 g
Current: 00.1A/20V			00.1A/10.5
Time Elapsed:10 minutes			10 minutes
Total Time:10 minutes			20 minutes
Notes: Not very efficient. Zinc formed black crystallization, running towards and on top of the copper piece. When removed from solution, most of the black crystallization slid off the copper.			

0.1 M $ZnSO_4$			
5/3/19	Initial Mass	Mass	Mass
Zinc	0.84 g	0.75 g	0.63 g
Copper	0.94 g	1.03 g	1.14 g
Total Zinc added to Copper: 0.09 g			0.20 g
Current: 00.1A/00.1V – 00.5A/10.4V			00.8A/10.5V
Time Elapsed: 10 minutes			10 minutes
Total Time: 10 minutes			20 minutes
Notes: Zinc formed silver crystallization, towards and on top of the copper piece. Crackled a bit before disconnecting. When removed from solution, most of the silver crystallization slid off the copper.			

1 M $ZnSO_4$			
5/3/19	Initial Mass	Mass	Mass
Zinc	0.92 g	0.90 g	0.83 g
Copper	1.12 g	1.14 g	1.24 g
Total Zinc added to Copper: 0.02 g			0.12 g
Current: 00.2A/00.1V			1.1A/0.10V
Time Elapsed: 5 minutes			10 minutes
Total Time: 5 minutes			15 minutes
Notes: Quickest and most efficient plate. Most silver colored plating.			

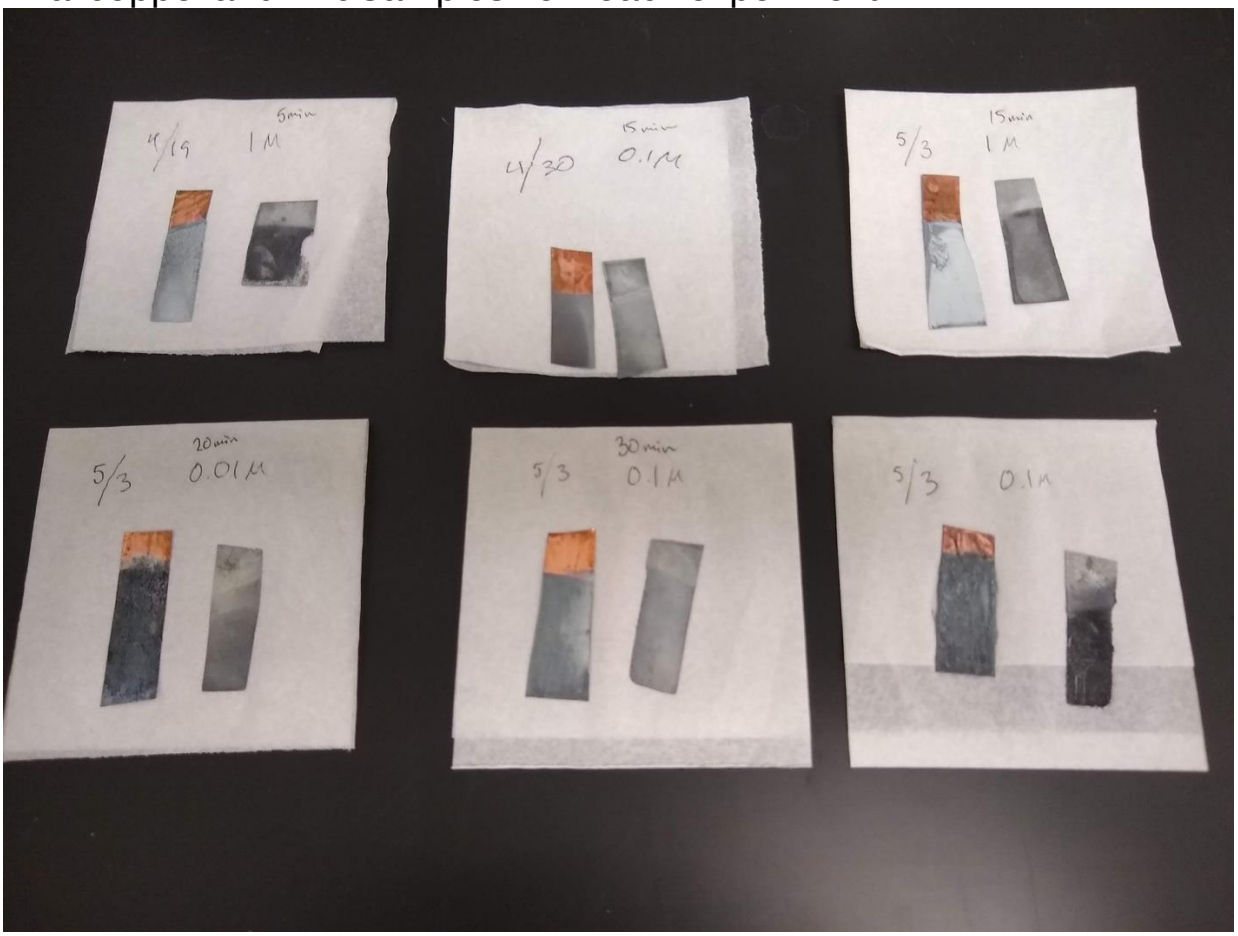
0.1 M $ZnSO_4$				
5/3/19	Initial Mass	Mass	Mass	Mass
Zinc	0.78 g	0.67 g	0.65 g	0.63 g
Copper	0.99 g	1.02 g	1.03 g	1.04 g
Total Zinc added to Copper: 0.03 g			0.04 g	0.05 g
Current: 00.1A/0.10V - 00.1A/11.9V			00.2A/11.9V	00.6A/2.3V
Time Elapsed:10 minutes			10 minutes	10 minutes
Total Time:10 minutes			20 minutes	30 minutes
Notes: Zinc formed silvery crystallization pattern, towards and on top of the copper piece. After about 9 minutes, it started making crackling sounds. When removed from solution, most of the silver crystallization slid off the copper. Removed, weighed and cleaned the samples. Performed experiment 2 additional times with same strips.				

Typical electroplating in progress:



Crystallization of zinc:

Final copper and zinc samples from each experiment:



CONCLUSION

The voltage and amperage were very difficult to maintain and control. Sometimes it slowly crept up with the only variable being time elapsed. Other times it was impossible to adjust. The manual is not very helpful for troubleshooting, so more experimentation is needed to clarify a procedure for adjustments.

Regardless of the current, electroplating was a success. The lowest effective solution was 0.1 M, the middle concentration. It was successfully able to plate the copper with zinc, and it had an attractive, shiny appearance at the conclusion of the experiments.