West Side Science Club – Event #8 – "Electroplating"

Original Presentation

Date: 9 March 2013
Time: 10 am to 12 pm
Site: West Side Science Club

Attendance: Mentors – Ben, Levi, Paul, Anna, Kevin, Emma, Dylan, Jackson, Harry S., Kim, Bridgett
Students – Sam, Adrian, Kristopher; Daisy, Katherine; Emily, Itzel, Diana, Allison.

Big Questions

- These questions are meant to frame the day's event and might be written on the chalkboard

  (1) How do you put metals onto things?

  (2) How can you make metallic materials?

Concepts

- Concepts to cover from the "Work of CCI Solar" Mind Map

  electrochemistry, voltage/potential, current, battery, energy, electrons, ions, metals, Periodic Table, materials, alloys, solution

Lesson Plan

Student Objectives

- To learn what electroplating is and how it is used to deposit layers of metals on objects
- To discover how electrons can jump onto metal ions to generate elemental metals
- To make a gold-colored souvenir penny

Schedule/Agenda

- Review: Event #7 – "Lemon Batteries" (10 min.)
- Warm-up Demo: Cutting a penny in half (5 min.)
- Activity: Electroplating copper with a battery (45 min.)
- Activity: Copper-to-silver-to-gold penny (45 min.)
- Wrap-up (10 min.)

Materials

Warm-up Demo

- Penny (post-1982) to cut in half to expose its core (Paul)
- Heavy-duty shears (??)
- Poster of the Periodic Table of the Elements (Ben)

Activity: Electroplating copper

- 6 clear plastic cups (Paul)
- 3 alkaline batteries, size C or D (Paul)
- 6 leads/wires with alligator clips (Ben)
- Copper acetate stock solution (Paul)
- Vinegar (Paul)
- Saran wrap (??)
- 4 L plastic bottle, for collection of waste (Paul)
- Water (on site)
- 3 steel wool pads (Paul)
- Electrical tape (Paul)
- 1 pairs of scissors (Paul)
- 3 nickels (Levi)

Activity: Copper-to-Silver-to-Gold

- Zinc granules (Paul)
- 3 M sodium hydroxide solution (Paul)
- 20 U.S. pennies, pre-1982 (Levi)
- 3 tweezers (Paul)
- 3 hot plates (Levi)
- 3 extension cords, heavy (Ben)
- 3 250-mL glass beakers (Paul)

Safety

- Students must wear their eye protection and disposable nitrile gloves for all activities
- The sodium hydroxide solution is caustic and should not be touched directly; use tweezers
- The sodium hydroxide solution should not be brought to a strong boil, because it might splatter
- Careful: Cool hot plates look the same as hot hot plates. Mentors: keep the kids and their stuff away from the plates when they are not in use. Also, remember it takes a long time for the plates to cool down.
- Do not dispose of any waste products down the drain or in the trash. Collect waste in the plastic waste jug for proper disposal at Caltech.

Review of Previous Event: Lemon Batteries

- Recall the demo: When a zinc nail was placed in a solution of copper ions, the nail turned brown/black within minutes. Electrons jumped from the zinc to the copper ions, depositing copper metal on the surface of the nail. You could wipe the solid copper away with a paper towel.

- Recall the activity: Making lemon batteries by sticking a zinc nail and a copper penny into a lemon and connecting them with a wire

Facilitation Questions

- Do you remember what happened last time when we put a zinc nail into a solution of copper? (The nail turned black. That was solid copper forming on the nail.)

- Do you remember what things were jumping from the zinc to the copper? (Electrons)

- What is it called when electrons move through wires? (Electricity. And that is a form of energy.)

- What happened when we connected the penny and the nail in the lemons? (We saw the generation of electricity, and measured it with the multimeter.)

Warm-Up Demo/Attention Grabber: Cutting a Penny in Half

Procedure

1. When ready, take a U.S. penny made after 1982 and cut it in half with heavy-duty shears. Alternately, use a saw before the event and bring the cut penny with you. (You must use a penny made after 1982. Those made prior to 1982 do not have zinc cores.)

Facilitation Questions and Advice to Mentors

- Do you remember what metal a penny is made out of? (Copper)

- Where is copper on the Periodic Table? (Find it under “Cu” at #29)

- Yes, pennies are made of copper, but what if I told you that pennies made today are not 100% copper. They are only copper on the outside, but zinc on the inside.

- Where is zinc on the Periodic Table? (Find it under “Zn” at #30, next to copper)

- Where did we use zinc last time? What color is it? (The nails in the lemon batteries. It is silver colored.)

- So, if we were to cut a penny in half, what color should it be inside? (Silver)

- Pennies used to be made completely of copper. Why do you think the mint changed to pennies made of zinc on the inside? (Zinc is less expensive than copper, but there are other good guesses, like strength).

Activity: Electroplating Copper onto a Nickel Coin

Procedure

1. Students will break down into groups of 3 or 4 per table. Distribute the following materials to each table of students:

    - 2 leads with alligator clips on their termini
    - 2 transparent plastic cups
    - A piece of steel wool
    - A nickel coin
    - A copper penny (pre-1982)
    - Electrical tape and scissors
    - A C or D cell battery, 1.5 V

2. Use the steel wool to scrub the outside of the nickel and penny, then wash them with soap and water. (The copper must plate onto a clean surface, otherwise it will not deposit evenly.)

3. Pour the blue solution of copper acetate into the cup such that it is 1 cm deep.

4. Pour the vinegar into the cup such that the entire solution is 3 cm deep.

5. Take an alligator clip from one wire and tape it to the (+) contact of the battery, and then tape an alligator clip from a different wire and tape it to the (−) contact of the battery.

6. Connect the penny to the (+) wire, then tape the wire to the side of the cup such that the penny is submerged halfway.

7. Connect the nickel to the (−) wire and tape the wire to the side of the cup such that the coin is submerged where you want to plate copper.

8. Wait 10−20 minutes and observe the plating take place.

9. Remove the nickel from the bath by only touching the alligator clip (not the nickel). Drop it into a cup of clean water to wash it.

10. Pour the copper bath into the waste container.

11. Wash and dry the alligator clips

Facilitation/Concept Questions

- What do you think would happen if you left the nickel in the bath for longer times? (The layer of copper would get thicker)

- What is the purpose of the battery? (It gives the electrons enough energy to hop onto the copper ions in the water to make the solid metal.)

- What could we use instead of the battery as an energy source? (The sun! A solar panel. Many other answers.)

- Why do we need a battery for electroplating when we didn't need a battery for the lemon to produce electricity? (We need something to provide electrons that have enough energy to hop onto the copper ions and make copper metal.)

Activity: The Copper-to-Silver-to-Gold Penny

Procedure

1. Students will break down into groups of 3 or 4 per table. Distribute the following materials to each table of students:

    - A hot plate
    - A 250-mL glass beaker
    - A piece of steel wool
    - A plastic cup filled with water
    - 1 or 2 copper pennies per student (pre-1982)
    - Zinc granules
    - 3 M sodium hydroxide

2. Use the steel wool to clean the outside of the pennies, then wash them with soap and water. (The zinc must plate onto a clean surface, otherwise it will not deposit evenly.)

3. Pour the zinc granules into the beaker such that ⅛ to ½ of the floor of the beaker is covered with them.

4. Pour 3 M sodium hydroxide into the beaker such that the depth of the liquid is 1 to 2 cm

5. Turn on the hot plate to “3” on the dial and wait for the sample to heat to near boiling

6. Using the tweezers, place a penny into the bath such that it is both submerged and also in contact with at least one zinc granule

7. Wait for 3 minutes. The coin should appear silver. Use the tweezers to pick up the coin and drop it into the cup of water (to cool it).

8. Repeat for as many pennies as desired

9. Using the tweezers, place one of the zinc-coated coins onto the hot plate.

10. Wait until the coin changes to a golden color (roughly 15 seconds), then remove it from the hot plate using tweezers. Drop it into the cup of water to cool it.

Facilitation Questions and Concepts

- The silver color is not due to silver; it is a layer of zinc. The golden color is not due to gold; it is a layer of brass. Brass is a mixture of zinc and copper that forms when they are heated together. (Elements cannot change identities easily, but they can form new materials when mixed in different amounts.)

- What about the brass penny? Will the inside be golden like the outside or a different color? Will it be the same color as the inside of the zinc coated, silvery penny? (Inside will be brown because its copper, the same interior as the zinc coated penny, because we only changed the outside)

- Do you think the inside of the penny changed when we plated zinc on top? (No…the changes were only at the surface, not the core. This is similar to how we could wipe the copper off of the nail last week.)

Check for Understanding

- Can you locate the metals we're using on the Periodic Table?

- What does electroplating produce? (Thin layers of metals on objects)

- Why do we need a power source like batteries sometimes for our reactions to happen? (Some reactions need a source of energy)

- Did we have an extra 'power source' for the second activity? Did you have to add extra energy for the reaction to take place? Think about the temperature! (Yes! We had to heat the reaction to make it happen. Heat is a form of energy.)

Wrap Up: Event #9 Preparation

- Options for the kids to vote on – conveniently, all options lead to the same activity

  1) Hydrogels
  2) Soft polymers
  3) A problem-solving challenge/competition

References

(1) Instructables: “Clean and Simple Electroplating”
http://www.instructables.com/id/Clean-and-Simple-Electroplating/?ALLSTEPS

(2) Katz, David A. “An Experiment in Alchemy: Copper to Silver to Gold”
http://www.chymist.com/copper%20silver%20gold.pdf

(3) ScienceLand Wiki
http://scienceland.wikispaces.com/Electricity