Green Pennies

Lab Related Activity: *Chemicals of Innovation*

The Tech Museum of Innovation
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This activity is meant to extend your students' knowledge of the topics covered in our Chemicals of Innovation lab. Through this activity, students will experiment with different oxidizing compounds to turn pennies green…and back to copper.

Grades 5-8
Estimated Time: 20 minutes for experiment; 5-7 days observation

Student Outcomes:
1. Students will be able to determine through experimentation which compound will oxidize pennies the "best" (e.g. fastest, most oxidation, etc.)

Next Generation Science Standards
Physical Sciences Disciplinary Core Idea: PS1-B Chemical Reactions **Grade 5:** 5-PS1-4
Grades 6-8: MS-PS1-2
Common Core ELA Standards
Grade 5: *Speaking and Listening* 5.SL.1b-d
Grades 6-8: *Speaking and Listening* SL.1b-e

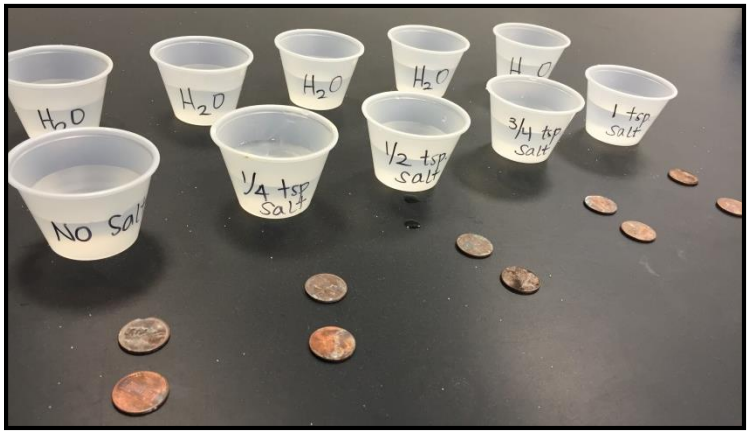
California State Science Standards
Physical Sciences/Chemistry
Grade 5: 5.1.a, b; **Grade 8:** 8.3.a, b
Investigation and Experimentation:
Grade 5: 5.6.a-d, g-h; **Grade 6:** 6.7.a-b, d-e;
Grade 7: 7.7.a, c, e; **Grade 8:** 8.9.a;

Vocabulary
Familiarity with these terms and concepts will enhance students' experience in the activity
- Oxidation reaction**:** a chemical reaction that results in a compound losing electrons and bonding with oxygen.
- Chemical reaction: a process in which one or more compounds (reactants) are transformed into a completely different set of compounds (products).
- Acid: a chemical solution that releases excess hydrogen (H^+) ions when water is added

Materials (one set per group of 4 students)
- 10 small Dixie cups (4 oz.)
- Water
- White vinegar
- Salt
- 10 pennies (pre-1982 will work best)
- Paper towels
- Drying Sheet (provided)
- Observation Sheet (provided)

Teaching points:
1. Remind students of the flame demonstration in the lab. Ask students what color copper burned (green). Ask if anyone remembers why copper is green and what statue is copper but green in color (Statue of Liberty)
2. Copper changes color when it is oxidized. Oxidized means that the copper atoms in the object react with oxygen atoms in the air. The oxygen atoms bond with the copper atoms and the copper atoms lose some of their electrons to the oxygen when they bond.

Procedure:
3. Begin by labeling 5 cups: vinegar + no salt; vinegar + ¼ tsp. salt; vinegar + ½ tsp. salt; vinegar + ¾ tsp. salt, and vinegar + 1 tsp. salt. The other cups will just have plain water in them for rinsing.
4. Add 1 tablespoon of vinegar into each cup. Add the listed amounts of salt to each cup and gently swirl to dissolve.



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5. Fill the other 5 cups with about 2 tablespoons of water.
6. Have students make hypotheses on what they think is going to happen to the pennies when they add them to the liquids.
7. Add two pennies to each labeled cup and let the pennies soak for 5 minutes.
8. While the pennies are soaking, have students make observations
    - If pennies had a dark brown or "dirty" appearance, they were already oxidized. The dark brown or "dirty" appearance is caused by something called copper oxide. By putting them in the solutions, the copper oxide dissolves due to the acid. Pennies should come out of the acid solutions looking bright and shiny like new.
9. After pennies have soaked for 5 minutes, take one penny out of each cup and put it on the Drying Sheet (attached) in the corresponding square (un-rinsed).
10. Take the remaining pennies out of the labeled cups (one at a time) and rinse them in one of the cups with plain water in them. Each penny should have its own water cup.
11. After rinsing with water, place each rinsed penny on the Drying Sheet in the corresponding square.
12. Let students make hypotheses on what will happen to the pennies. What will be the difference between the rinsed pennies and the non-rinsed pennies? Will certain amounts of salt make a difference on the pennies? Which will turn green fastest? Which will have the most oxidation? Which will have the least oxidation?
13. Let pennies sit for at least 5 days. Give students about 5 minutes each day to make observations and record on their Observation Sheet.

Teaching Points:

14. At the end of the 5 days observation time, ask students about the differences between the rinsed and un-rinsed pennies.
    - Why was there a difference?
    - Why did certain solutions produce more or less oxidation?
    - Which solution oxidized the penny the fastest? Slowest?
    - Why did we add salt to the vinegar? What difference did the salt make? What did the penny with no salt, just vinegar look like compared to the ones that did have salt?
        - The salt is actually the most important variable. The chlorine in the salt (NaCl) is what reacts with the copper and oxygen to produce the green-blue patina.
15. Copper can change to two colors when oxidized: green-blue or dark brown
    - When copper turns dark-brown or dirty looking, that means the copper was oxidized by just oxygen.
    - When copper turns green-blue, that means the copper was oxidized by oxygen and chlorine (often found in salt). This oxidation reaction creates a different compound called malachite, which is green-blue in color.

Taking it Further

- Keep the acid solutions that the pennies were soaking in to create copper coated nails. After the pennies have soaked in the acid solution, copper ions (Cu^{2+}) are floating freely in the acid from the copper oxide that was dissolved. When steel nails are added to the solution, the metal starts to dissolve a little and releases iron ions (Fe^{2+}). With the loss of the iron ions, the nail is left negatively charged (opposite charges attract). Since the nail is now negatively charged, the copper ions (positively charged) are attracted to the nail and bond with the extra electrons on the nail. This creates a copper coating on the outside of the nail.
- After the experiment, have students clean their oxidized pennies. To remove the malachite, students will need to use an acid solution with salt. Have students try several combinations: coke + salt; lemon juice +salt; vinegar + salt; and orange juice + salt. The experiment can be run the same way as before with one set of pennies being rinsed and one set remaining un-rinsed. Have students decide which solution was best at cleaning the pennies and find out what happens if they don't rinse the solution again. Will the acidic solution make a difference in the oxidation process?

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Drying Sheet

	Vinegar + no salt	Vinegar + ¼ tsp. salt	Vinegar + ½ tsp. salt	Vinegar + ¾ tsp. salt	Vinegar + 1 tsp. salt
Rinsed with water					
Not Rinsed					

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Observation Sheet

		Day 1	Day 2	Day 3	Day 4	Day 5
Vinegar + no salt	Rinsed					
	Un-rinsed					
Vinegar + ¼ tsp. Salt	Rinsed					
	Un-rinsed					

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Vinegar + ½ tsp. Salt	Rinsed					
	Un-rinsed					
Vinegar + ¾ tsp. Salt	Rinsed					
	Un-rinsed					
Vinegar + 1 tsp. salt	Rinsed					
	Un-rinsed					