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Shine Bright Like a...Penny!

A shiny new chemistry activity

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A chemistry activity that makes good cents Credit: George Retseck

**Key concepts**  
Chemistry  
Chemical reactions  
Acidity  
Oxidation

**Introduction**  
**In this activity we’re going to explore why pennies don’t stay bright and shiny, and test different methods to bring their shine back!**

**Background**  
All pennies start out the same color—**bright copper**. But somewhere along the way, those pennies **lose their luster.** **What happens?**

The answer is pretty simple: Although copper is a shiny metal, it is also reactive. The negatively charged oxygen atoms in our air are attracted to the positively charged copper atoms in the penny. When oxygen binds with copper, they form a new molecule known as copper oxide. Copper oxide is brownish or sometimes black in color (depending on other things in the penny's environment). This is why most pennies you see look dirty or tarnished—it’s not actually dirt but copper oxide that makes them look so dull.

Luckily, there are a number of ways to clean pennies and make them look bright and shiny again—using chemistry! We’re going to test a few different methods for cleaning pennies and determine which gets our pennies the cleanest.

**Materials**

* Set of measuring spoons
* 10 very tarnished pennies (The more tarnished the better—and the activity works best with pennies that are about equally tarnished.)
* Two tablespoons of baking soda
* Four teaspoons of salt
* Two tablespoons of white vinegar
* Two tablespoons of freshly squeezed lemon juice
* Two tablespoons of ketchup
* Two tablespoons of Tabasco sauce (or other hot sauce)
* 11 plastic cups (Small Tupperware containers or bowls will work as well.)
* Paper
* Water
* Pen or pencil
* Dishwashing gloves
* Permanent marker
* Clear tape
* A timer or clock
* Paper towels
* Access to a sink
* Camera (optional)

**Preparation**

* Make a paste from your baking soda and water: Pour one quarter cup of baking soda into one of your plastic cups. Slowly add water, one tablespoon at time, until you’ve created a paste.
* Use your permanent marker to label your plastic cups as described below. If using bowls or Tupperware, write your label on clear plastic tape and gently attach it.

Cup labels—on each of the remaining cups place a label as follows:  
**Ketchup 1  
Ketchup 5  
Tabasco 1  
Tabasco 5  
Vinegar 1  
Vinegar 5  
Lemon 1  
Lemon 5  
Control 1  
Control 5**

* Put one tablespoon of ketchup into each “Ketchup” cup. Put one tablespoon of Tabasco into each “Tabasco” cup. Put one tablespoon of vinegar and one teaspoon of salt into each “Vinegar” cup. Put one tablespoon of lemon juice and one teaspoon of salt into each “Lemon” cup. Leave the “Control” cups empty.
* Use your paper and pencil to create a table with three columns and six rows that lists your five test substances (ketchup, Tabasco sauce, vinegar, lemon juice and control) in a column on the left. Label this column “Cleaning Method.” The next column, label “1 Minute.” And label the third column “5 Minutes.” Make each cell (square) of the table large enough to place your penny in it after your testing is complete. *Do you have a hypothesis about which substance will best clean a tarnished penny? Why?*

**Procedure**

* Place a penny on each square of your table, heads side up. **With your camera, take a picture of the pennies**. This will allow you to make a better judgment of how well each method cleaned, by looking at the pennies before and after their treatment. *What do you notice about each penny? Can you clearly see the date on the penny or is it too dirty?*
* Start with the cups labeled “1.” Line these cups up in a row. Take the penny from the “Ketchup, 1 Minute” square of your table, and place it in the “Ketchup 1” cup. Gently swirl the cup so the penny is completely covered with ketchup.
* Start a one-minute timer.
* Put on your dishwashing gloves.
* When one minute has passed, rinse the cup with water until its inside and the penny is clean. (Be careful not to lose your penny.) Keep the penny in the cup.
* Repeat this procedure with each of the other pennies in the “1 Minute” column, in turn placing each into their corresponding cup. In each case, make sure the penny is completely covered by the contents of the cup.
* For the “Control, 1 Minute” penny do not add anything to the cup. This is your control. Complete the full procedure.
* Once all of the “1 Minute” pennies have been rinsed, use your fingers to gently scrub the pennies one at a time with your baking soda paste. Keep your gloves on for this part, being careful to keep each penny with its labeled cup. Scrub each penny for 10 seconds, then rinse it again with water and place it back into its cup.
* Set these cups aside for now.
* Repeat these steps with the pennies in your “5 Minutes” column. Start by placing the “Ketchup, 5 Minutes” penny into the cup labeled “Ketchup 5.” Again, make sure the penny is completely covered by ketchup.
* Start a timer for five minutes.
* Continue to place each penny in the “5 Minutes” column in its corresponding cup.
* Once all the pennies are in their correct cups, use the remaining time to observe the pennies and the contents of the cups. *Do you notice any changes in the appearance of the pennies? What is changing? Do you notice any changes in the contents of the cups? Is anything bubbling or changing color?*
* Once five minutes have passed, rinse the cups with water until their insides and the pennies are clean. (Be careful not to lose your pennies). Keep the pennies in the cups.
* Once all of the pennies have been rinsed, use your fingers to gently scrub the pennies one at a time with your baking soda paste. (Again, keep your gloves on for this part.) Scrub each penny for 10 seconds, then rinse it again with water and place it back into its cup.
* Go back to the table you drew. Use your paper towels to gently dry off each penny then place it in the corresponding square of your table.
* Compare the “1 Minute” and “5 Minutes” pennies in each row. *How does time affect the cleanliness of the pennies? Was one or five minutes more effective in cleaning the pennies overall? Can you think of why time would be important? Were there any cleaning methods where the time didn't matter, so the "1 Minute" and "5 Minutes" pennies are equally clean? Why do you think this might be?*
* Compare all of the cleaned pennies with the control ones. *Which penny looks the cleanest compared with the control? Which is still the most tarnished?*
* If you took a picture at the beginning, go back and compare each penny's cleanliness before and after being cleaned. *Which penny is the cleanest compared with its before picture? Which is the least clean?*
* **Extra:**Test even longer periods of time with each of the cleaning methods. What is the optimal time to leave the pennies in the cleaning solution?
* **Extra:** Test whether these cleaning solutions work on other types of coins. What do your results tell you about the special properties of copper pennies?
* **Extra:** Can you think of other safe household acids you could test? What about soda? Orange juice?

**Observations and results**  
In this activity you tested four different cleaning methods to determine which was the most effective at cleaning pennies. You should have observed that each cleaning method made the pennies cleaner but some methods may have been more successful than others. Which method works best is determined by the amount of acid and the presence of salt. Different brands of ketchup and hot sauce will have different amounts of salt and acid in their ingredients, so your results might be different than someone else doing this activity at their house. In each case, however, the cleaning method that should have worked best for you is the one that has the highest concentration of acid.



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As they are exposed to the environment, pennies become coated with a layer of copper oxide, making them look tarnished (with a dull, brown, dirty appearance). Copper oxide dissolves in a mixture of weak acid and table salt. Vinegar and lemon juice are both acids. Check the ingredient list for your ketchup and Tabasco sauce—some of the labels might list vinegar or citric acid whereas others might say tomato puree. Tomatoes contain some naturally occurring citric acid, another acid that is generally slightly weaker than vinegar or the amount of citric acid in lemon juice. Therefore, each cleaning method you tested contained acid and salt but the ketchup and Tabasco sauce may have had a slightly weaker acid. In this case, you might have noticed the ketchup and Tabasco pennies were not quite as well cleaned as the pennies that were in the vinegar and lemon juice.

You also might have also noticed the longer the pennies stayed in the cleaning solution, the cleaner-looking they became! The chemical reaction that dissolves the copper oxide on your pennies is an ongoing process. Leaving your pennies in the cleaning solution longer gives the reaction more time to continue, and gives you shinier pennies!

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