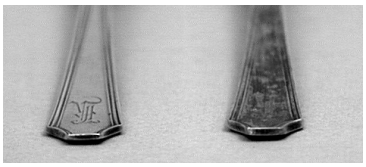
Silver to Black—and Back



by the *Journal*'s Editorial Staff

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Background

Silver and silver-plated objects react with sulfur and sulfur compounds to produce silver sulfide (Ag_2S), or tarnish. Contact with materials that contain sulfur compounds, such as hard-boiled eggs, mayonnaise, mustard, and rubber bands can cause tarnish (*1*). In air, a silver object can tarnish owing to the reaction of silver with hydrogen sulfide (H_2S). This is a gas found in the air as a result of some industrial processes and the decomposition of dead plants and animals (*1*). The reaction of silver with hydrogen sulfide to form tarnish is as follows:

$$2Ag(s) + H_2S(g) \rightarrow Ag_2S(s) + H_2(g)$$

The tarnish on silver can be removed with commercial silver polishes. This method usually removes the tarnish through abrasion. As a result, each time tarnish is removed, some of the silver is lost. However, tarnish can also be removed chemically through the reaction of aluminum with the tarnish. The aluminum is a more active metal than silver, so it reacts with the tarnish to chemically convert the tarnish back to silver. The reaction is as follows:

$$3Ag_2S(s) + 2Al(s) \rightarrow 6Ag(s) + Al_2S_3(s)$$

This Activity allows students to remove tarnish from silver using the reaction of tarnish with aluminum.

Integrating the Activity into Your Curriculum

This Activity can be used with topics that range from beginning to advanced levels. These include chemical changes, metals, electrochemistry, and redox reactions. The Activity could introduce a discussion of silver and its reactions. *JCE* describes a demonstration sequence of reactions in the silver series (*2*). The final reaction in the sequence removes tarnish from silver. The Activity also relates the use of chemistry to everyday objects. It can lead to parental involvement and a discussion of household chemistry; the instructor can encourage students to share the tarnish removal method with those at home. The topic of silver and tarnish removal can also be used in other curriculum areas, such as home economics, photography, and art conservation and restoration. The light-sensitive materials in film are silver compounds. This Activity could be used with *JCE* Classroom Activity #18, "Photochemistry and Pinhole Photography" (*3*). PBS has produced an episode of Scientific American Frontiers called "The Art of Science: Returned to Glory" that discusses the restoration of art (*4*) that could complement this Activity.

About the Activity

This Activity uses a method of tarnish removal from silver that is less labor intensive and less expensive than the use of commercial silver polish. An electrochemical reaction is used to convert tarnish back to silver. If only untarnished silver items are available, students can attempt to tarnish them with sulfur compounds, as described on the Student Side.

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The Activity can be used with beginning to advanced chemistry students. Instructors may wish to supplement the questions on the Student Side with simpler or more advanced questions of their own. The Activity can be performed in a lab or as an at-home experiment. It is an excellent candidate for use at home, since few materials are needed and all materials used are commonly found in the home, except that some students may not have easy access to silver objects. If the Activity is done in a lab, students could bring in their own silver objects.

Answers to Questions

1. The reaction for tarnish formation due to contact with hydrogen sulfide is $2Ag(s) + H_2S(g) \rightarrow Ag_2S(s) + H_2(g)$.
2. The reaction for the tarnish removal method in the Activity is $3Ag_2S(s) + 2Al(s) \rightarrow 6Ag(s) + Al_2S_3(s)$.
3. All these items contain sulfur compounds.
4. A rotten egg odor can be detected. This smell is commonly associated with sulfur compounds.
5. Possible benefits are that the Activity's method tends to involve less work, it can be less expensive, it doesn't involve the loss of any silver through abrasion, and it is easier to remove tarnish from small crevices.
6. Rust is an oxide ($Fe_2O_3 \cdot xH_2O$) and forms on the surface of objects that contain iron when the object is exposed to air and water. Rust is usually powdery and can easily be flaked off of the object. It usually causes severe, irreversible damage to the affected object.

Additional Activities and Demonstrations

1. Sarquis, M.; Sarquis J. *Fun with Chemistry*, Vol. 2; Institute for Chemical Education: Madison, WI, 1993; pp 333–337.
2. Schwenck, J. R. *J. Chem. Educ.* 1959, *36*, 45.
3. Rigos, A. A.; Salemme, K. *J. Chem. Educ.* 1999, *76*, 736A.
4. Scientific American Frontiers 1997–1998 Teaching Guides. The Art of Science: Returned to Glory; *http://www.pbs.org/saf/4_class/44_guides/guide_804/4484_glory.html* (accessed Jan 2000)

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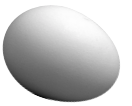
A chemical reaction with the silver of flatware, jewelry, or other silver objects can change their beautiful lustrous sheen to a dull, blackened surface. This dark coating is called tarnish. Compounds in the air and in foods can contact silver metal and react to form tarnish. One such compound is hydrogen sulfide, a gas found in air. Removing tarnish usually involves a lot of elbow grease, since commercial silver cleaners commonly remove tarnish through abrasion. This Activity uses a less labor intensive method of removal. You will chemically remove the sulfur from tarnish, leaving silver behind.

Try This

You will need: tarnished silver or silver-plated spoon or other silver item, baking soda, aluminum foil, water, 250-mL glass beaker or small glass bowl, heat source such as hot-plate or microwave, 1/4-tsp measuring spoon, graduated cylinder or measuring cup, hot-pad, stirring rod. (If you only have an untarnished silver item, you will need one or more of the following: hard-boiled egg, mayonnaise, mustard, rubber bands, or powdered sulfur.)

__1. Examine a tarnished silver or silver-plated spoon or other silver item. Record your observations.

__2. If you only have an untarnished silver spoon or other item, take one of the following: hard-boiled egg, mayonnaise, mustard, rubber bands, or powdered sulfur. If a hard-boiled egg is used, peel the egg and push the handle of the silver spoon into the egg yolk and leave overnight. If mayonnaise or mustard is used, coat the handle of the spoon with mayonnaise or mustard and leave overnight. If rubber bands are used, wrap the rubber bands tightly around the handle of the spoon and leave overnight. If powdered sulfur is used, sprinkle the powder onto the handle and leave overnight. Afterward, wipe off any materials used or remove the rubber bands. Repeat as needed.



__3. Measure 200 mL (3/4 cup) of water into a 250-mL glass beaker or small glass bowl. Heat the water to boiling on a hot-plate or in a microwave. When it boils, remove it from the heat source and slowly add 1.2 grams (1/4 tsp) of baking soda. (The mixture will foam as you add the baking soda, so you may want to add it over a sink.) Stir.

__4. Wrap the lower half of the tarnished spoon handle with a piece of aluminum foil. Some of the tarnish on the handle should remain uncovered by the foil. Place the spoon, handle side down, into the beaker or bowl. The handle should be submerged up to a point beyond the foil wrapping. Wait 10–15 minutes.

__5. Remove the spoon from the beaker or bowl. Carefully remove the foil from the handle. Do you notice any odor coming from the foil and the water pooled inside the foil? Does the water pooled inside the foil have a particular color? Record your observations.

__6. Compare the portion of the handle covered by the foil with the portion not covered by the foil.

Optional (Consult your instructor before trying any additional experiments.)

__1. Design a procedure to determine if the side of the aluminum foil (shiny or dull side) that touches the tarnished metal makes a difference in the results.

__2. Design a procedure to determine the effect of using a different solution (other than baking soda with aluminum foil). For example, try table salt, ammonia, or vinegar.

__3. Design a procedure to determine if the aluminum foil must come in direct contact with the silver item or if the foil can simply sit in the baking soda–water mixture.

__4. Design a procedure to determine if other metals are affected in the same way as silver.

Questions

__1. Write the reaction for the formation of tarnish due to contact with hydrogen sulfide.

__2. Write the reaction for the tarnish removal method described above.

__3. Why do the yolks of hard-boiled eggs, mayonnaise, mustard, and rubber bands have the same tarnishing effect as hydrogen sulfide?

__4. Describe the odor that comes from the foil and the water pooled inside the foil after the tarnish is removed using aluminum foil, water, and baking soda. What type of chemical compound is this odor associated with?

__5. What are the benefits of this Activity's method of tarnish removal over the use of commercial silver cleaners?

__6. How is tarnish different from rust?

Information from the World Wide Web *(accessed Jan 2000)*

Silver. *http://www.fwkc.com/encyclopedia/low/articles/s/s023001726f.html*
Silver. *http://www.minerals.net/mineral/elements/silver/silver.htm*
The Care of Silver. *http://gopher.bishop.hawaii.org/bishop/conservation/silver.html*