CLEANING METALS:
MAKE YOUR OWN SILVER CLEANER

Part I. Silver Lightning

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Purpose

To investigate the claim made by the "miracle product" Silver Lightning that it "is by far the *fastest, easiest, and most effective* way to clean all of your sterling silver, silver plate, gold, gold plate, stainless steel and copper" with no scrubbing. To examine the chemistry of tarnish and use oxidation-reduction to show how a slab of aluminum and rudimentary electrochemistry can be combined to remove the tarnish without having to purchase the named product.

Introduction

The tarnish that collects on objects made of silver is silver sulfide, a black solid. Tarnish forms from trace amounts of hydrogen sulfide present in the atmosphere. The reaction for the formation of tarnish on silver is:

$$4\,Ag_{(s)} + 2\,H_2S_{(g)} + O_{2(g)} \rightarrow 2\,Ag_2S_{(s)} + 2\,H_2O_{(l)}$$

There is money to be made by selling a piece of metal wrapped in a scientific principle. Silver Lightning is one such product that was sold widely on television and in stores for $19.95 (most recently, $10.00) and enabled you to clean silver (remove the tarnish) merely by dipping it in water. How can this be when the kit only contains a 5x7" aluminum block? The instructions direct you to "Simply place the amazing Silver Lightning Tray into any container or sink with hot water. Add some baking soda to activate the tarnish removing reaction and put in your tarnished objects. Now watch as Silver Lightning with it's incredible electrolytic reaction instantly draws the tarnish away from your silver in just seconds!" Furthermore it is "guaranteed to last forever!"

In practice, place the tarnished silver into the container making sure it comes in contact with the metal plate. A few minutes later, a rotten egg odor is present in the air and the silver item is removed - tarnish free!
In this experiment, we will try this same procedure but substitute aluminum foil for the block and see if we can save our money.

Materials Needed

untarnished silver metal item (Note: Some tarnished silver items may be available for this experiment.)
real mayonnaise, egg yolk, or powdered sulfur
600 mL beaker (or container large enough to hold the silver item)
baking soda, sodium bicarbonate, $NaHCO_3$
stirring rod
100 mL graduated cylinder
hot plate
aluminum foil
crucible tongs
2-250mL beakers
25mL vinegar

SAFETY PRECAUTIONS

Goggles should be worn while conducting this experiment.

Baking soda, sodium hydrogen carbonate, $NaHCO_3$, can be an irritant to the eyes.

Vinegar, a 5% acetic acid solution, $HC_2H_3O_2$, is an irritant to nasal passages, heat the vinegar solution under a fume hood. The vinegar can be irritating to eyes and tissues.

Procedure

Prepare your tarnished sample the day before you start the experiment. Expose the silver item to sulfur compounds by dipping it into some mayonnaise, an egg yolk (raw or hard-boiled), or some powdered sulfur. Set the item aside for 24 hours. **Note:** Some tarnished silver items may be available for this experiment.

Wash the silver item with water and carefully examine the tarnished area. Does the tarnish appear to be on the surface, or is it an integral part of the silver metal?

Fill a 600 mL beaker to about three-quarters of its volume with water. Place it on a hot plate and heat until almost boiling. Add 15 g (one tablespoon) baking soda and stir to dissolve.

Push a piece of aluminum foil to the bottom of the beaker, then place the silver item into the beaker so it is in direct contact with the foil. Continue heating for several minutes (not quite to boiling), and observe the results. What changes do you see?

Do you smell a rotten egg odor? (The rotten egg odor is hydrogen sulfide *gas* being released as the tarnish is dissolved. This is the reverse of the chemical reaction shown in the introduction.)

After a few minutes use the tongs to remove the silver item and rinse it in running water.

How does the silver item compare with its condition at the start of the experiment?

The overall redox reaction for this experiment is:

$$2\ Al_{(s)} + 3\ Ag_2S_{(s)} + 6\ H_2O_{(l)} \rightarrow 6\ Ag_{(s)} + 2\ Al(OH)_{3\ (s)} + 3\ H_2S_{\ (g)}$$

Dissolve 5 g of baking soda in 100 mL water in a 250m1 beaker. In a second 250m1 beaker, add 75mL water and 25m1 of vinegar. Put a piece of aluminum foil in each of the beakers, and set them aside for a day or two. Later, observe the foil and any other material in each beaker.

What differences do you see?

Questions

1. In the cell formed by the silver item to be cleaned, the aluminum, and the baking soda solution, which element is oxidized? Write the half-cell reaction for the oxidation of this element.

   Which element is reduced? Write the half-cell reaction for the reduction of this element.

2. Which element is the cathode?

   Which element is the anode?

3. Based on your observations from adding a piece of aluminum foil to a beaker containing water and baking soda, what can you conclude about one purpose of the baking soda used in the experiment?

4. Based on your observations from adding a piece of aluminum foil to a beaker containing water and vinegar soda, do you think that the vinegar could be used in place of the baking soda used in the experiment?

5. Based on your knowledge of redox reactions and what event has to occur for them to take place, what could you conclude is the other purpose of the baking soda solution?

Part II. A Silver Cleaning Paste

Introduction

Tarnished silver? Want to clean that silver without scratching it or wearing down the surface?

The tarnish on silver is a result of various materials and atmospheric gases that react with the silver to produce a discoloration, usually violet to black, on the surface. The main culprit is sulfur, which can be in the atmosphere in the form of hydrogen sulfide gas, sulfur oxides, or other compounds arising from natural waters, soil and vegetation (including fruits and vegetables we eat), in foods such as eggs, mayonnaise and mustard, in materials such as dishmats, placemats (rubberized and plastic), silverware holders, or other objects that contain rubber (rubber is cured or vulcanized with sulfur), or sulfurous materials in our perspiration and skin oils.

Constant use of silver utensils and silver accessories usually minimizes buildup of tarnish due to constant handling and cleaning. In storage, if not protected from materials listed previously, tarnish will build up.

Silver cleaners generally contain materials to dissolve oils and other residues along with a very mild abrasive to help remove the tarnish. If the abrasive is too coarse, it may scratch the silver surface as well as wear down the surface with extended use. One such abrasive is silica, very finely powdered sand. If the silica is not ground to a superfine powder, it will damage the silver. Another abrasive is finely powdered calcium carbonate or chalk (not finely ground limestone, as it is too hard).

Materials Needed

A piece of tarnished silver
Beaker, 100 mL
Stirring rod
Turpentine
Ethyl alcohol, 95%
Ammonia, NH_3, 3 M solution (Made by diluting 20 mL concentrated ammonia to 100 mL with distilled or deionized water)
Calcium carbonate, $CaCO_3$
Small sponge or towel
Soft cloth or paper towels
Small jar or container for the silver polish

Safety Precautions

Wear safety goggles or glasses.

Turpentine and ethyl alcohol are flammable. Keep away from flames or sparks.

Skin contact with alcohol and turpentine can remove natural oils drying the skin. Avoid or minimize skin contact.

Ammonia fumes are irritating and toxic. Work under a fume hood or in a well ventilated area. If any ammonia solution gets on the skin, rinse well with water.

Disposal

Dispose of all waste materials in the proper container.

Procedure

Measure 12 mL turpentine into a 100 mL beaker.

Add 6 mL ethyl alcohol.

Add 1.5 mL of 3 M ammonia

Weigh 45 g of calcium carbonate.

Add the calcium carbonate in small amounts to the liquid in the beaker. Stir well after each addition. Keep adding the calcium carbonate until a smooth paste is obtained. (Note: You may not need all 45 g of calcium carbonate.)

Test the resulting paste. Using a damp (not wet) sponge, rub a small amount of the paste onto a piece of tarnished silver. Rub to loosen any tarnish. Allow the paste to dry. Remove the dried paste with a soft cloth. If desired, the silver can be rinsed with soapy water and dried before use or storage.

Questions

1. How well does the metal cleaning paste clean the tarnished metal?

2. Compare the cleaning paste to the Silver Lightning method of cleaning metals.