anti-bacterial silver

GOAL:

Visitors will understand that the increased surface to volume ratio of nano-scale particles can enhance chemical reactivity.

MATERIALS:

- 2 Petri dishes with images of bacterial growth experiment
- 2 beakers of hydrogen peroxide (H_2O_2) working solution
- Silver casting pellets
- Silver powder
- 16 oz. squirt bottle of water
- Waste bucket
- The Sharper Image FresherLonger™ food storage container with Velcro loop "bacteria" inside
- Intact foam "silver" disk
- Divided foam "silver" disk
- 2 flipbooks of strawberry storage experiment
- Paper towels

PROCEDURE:

Set-up:

1. Prepare 40 ml H_2O_2 working solution in each beaker by adding 20 ml tap water to 20 ml H_2O_2 stock solution. Lay out all other supplies.

Doing the demonstration:

1. Use the Petri dish images to introduce visitors to the concept that silver has antibacterial properties. Explain that the images are pictures of an experiment where bacteria were grown on plates with a center disk soaked in either a silver solution (silver nitrate) or water. The pale yellow area on the plates is *E. coli* growth. Ask visitors if they see a difference between the two images. The dark ring around the silver-soaked disk is a zone of inhibition where the silver prevented bacterial growth.

2. While silver's antibacterial properties have been known for a long time, recent research has shown that nanoparticles of silver are more effective because given

the same volume of small and large particles, smaller particles have greater surface area for chemical reaction. Drop a few silver casting pellets into one beaker of H_2O_2 working solution. Small oxygen bubbles will begin to form slowly as the silver surface catalyzes the breakdown of H_2O_2 into water and oxygen.

3. Add a few grains of silver powder (very little is needed to demonstrate the effect) to the second beaker of H_2O_2 working solution. Ask visitors to compare the two beakers to identify which one is producing oxygen bubbles at a faster rate. The silver powder grains have a higher surface to volume ratio than the silver sheet coating the penny, so a small amount creates a “fizzier” effect. Remove the silver-coated penny, rinse it off with water into the waste bucket, and dry with a paper towel for reuse. You can continue to add a few grains of silver powder to the second beaker each time you do the demo and empty the beaker at the end of the day.

4. Explain that one application of nano-silver is in food storage containers, where nano-silver is embedded in plastic to slow bacterial growth and keep food fresh longer. To demonstrate the principle, bring out the food storage container and attach the intact foam “silver” disk to the inside. Close the container and have a visitor shake it for 10 seconds. Open the container, remove the disk, and count how many “bacteria” (usually about 10-15) stuck to the disk as you detach them.

5. Next, attach the six pieces of the divided foam “silver” disk to the inside of the container. Close the lid and again have a visitor shake the box for 10 seconds. Open the container, remove each piece of the disk, and count how many total “bacteria” (usually around 30) stuck as you detach them. Ask visitors whether the large disk or smaller pieces were more effective – more “bacteria” stuck to the smaller pieces because there was more Velcro surface for the same size disk.

6. Tell visitors that the food storage container is a real product containing nano-silver, but that they can decide for themselves whether the product is effective based on the results of an experiment comparing strawberries stored in either a regular container or a nano-silver container. Have visitors flip through the flipbooks and try to guess which container is which before looking at the answer on the last page.

Clean-up:

1. Rinse silver casting pellets with water and dry for reuse; return to vial. Pour H_2O_2 working solutions down the drain and rinse beakers with water. Empty waste bucket down the drain.

2. Collect Velcro bacteria in Ziploc bag. Gather all supplies and return to storage.

EXPLANATION:

The anti-bacterial properties of silver have long been recognized. In ancient times, people stored food and drink in silver containers to prevent spoiling; more recently, newborn infants received silver drops in their eyes to fight infection. Silver interacts with bacteria via multiple targets, although the mechanisms are only partially understood: it reacts with sulfur groups in cell proteins, it induces structural changes to increase cell permeability, and once inside the cell, it binds to DNA. This broad range of results makes silver an effective anti-bacterial agent, since organisms are less likely to develop resistance when multiple simultaneous mutations are required. In addition, the bactericidal effects of both metallic silver and charged silver ions can occur at low concentrations of silver that are generally nontoxic to human cells. (Ingestion of too much silver can result in argyria, a permanent blue-gray discoloration of the skin and deep tissues.)

Recent research has focused on silver nanoparticles, which have enhanced reactivity due to a higher surface to volume ratio. The interaction of nano-silver with bacteria is size-dependent; nanoparticles less than 10 nm in size are more likely to attach to and penetrate the *E. coli* cell membrane. In addition, nanoparticles exhibit a multi-faceted surface structure (e.g. icosahedral or decahedral) that is different from and more active than larger bulk metal.

Nano-silver is being applied to many commercial products, including socks, washing machines, and band-aids, as well as food storage containers. In 2006, the U.S. Environmental Protection Agency declared that products containing silver nanoparticles and claiming anti-bacterial action would be regulated as pesticides. Subsequently, some companies, including The Sharper Image with its FresherLonger™ food containers, stopped advertising nano-silver content to avoid regulation. Compare early press releases (e.g. http://www.nsti.org/press/PRshow.html?id=867) that publicize the benefits of silver nanoparticles to current Sharper Image product literature that mentions only “specially treated” polypropylene. Regulation of nanoparticles in consumer products continues to be a controversial aspect of commercial nanotechnology. Critics of widespread nano-silver use suggest regulation is needed until potential health and environmental risks have been fully investigated, while proponents claim that existing research demonstrates that the threat is minimal.

WHAT COULD GO WRONG?

The silver coating on the pennies will wear off over time. Bubbles will appear more quickly on the penny as the coating wears off, but the silver powder should always produce a significantly faster reaction. Switch to a different penny when the coating has worn off to the point that it is no longer a convincing silver color.

Visitors can be very energetic in shaking the food storage container. Have them take two steps back before shaking to avoid hitting other visitors or knocking over the beakers of H_2O_2 working solution. However, very young visitors may not be able to shake the container vigorously enough to produce a dramatic difference in the number of “bacteria” that get stuck; you may want to give them some assistance.

GENERAL MAINTENANCE:

The H_2O_2 stock solution is commercially available at any drugstore.