Nanotechnology helps scientists keep silver shiny

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There are thousands of silver artifacts in museum collections around the world, and keeping them shiny is a constant challenge. So scientists are using new technology to give conservators a helping hand. A team of researchers led by Ray Phaneuf, a professor of materials science and engineering at the University of Maryland, College Park, has partnered with The Walters Art Museum in Baltimore to investigate less labor-intensive ways to protect silver artifacts from tarnishing. The new techniques, which might keep silver surfaces shiny for longer than traditional methods, could help ensure that historically important artifacts are preserved for future generations to learn from and enjoy. The researchers will present their work at the AVS 59th International Symposium and Exhibition, held Oct. 28 – Nov. 2, in Tampa, Fla.

Silver tarnishes when hydrogen sulfide in the air reacts with the silver, forming an unsightly black layer of silver sulfide on the surface of the artifact. If the tarnish appears on Grandma's silver flatware set, a little polisher and some elbow grease will easily remove it. But polishing, which works by dissolving or grinding away the silver-sulfide layer, can also remove some of the underlying silver, an undesirable outcome for priceless works of art.

Currently museum conservators can apply a thin layer of nitrocellulose lacquer to protect the silver. The coating is often hand-painted by a trained specialist and must be removed and reapplied an average of every thirty years. Phaneuf notes that it is difficult to apply a layer of even thickness over an entire piece, and the process of applying, removing, and reapplying the film is time-consuming.

"We did a quick back-of-the envelope calculation and found that for a big museum like the Metropolitan Museum of Art in New York, treating their entire silver collection with nitrocellulose films would likely be a never-ending task," says Phaneuf.

A quicker conservation method is to display silver pieces in an enclosed chamber with filtered air, but the chambers often leak, are expensive to install and maintain, and putting an artifact behind glass may prevent visitors from seeing the object up-close and from multiple angles.

Phaneuf and his colleagues are investigating a technique that could overcome some of the shortcomings of current preservation methods. Called atomic layer deposition (ALD), the process gives scientists atomic-level control over the thickness of a transparent oxide film that they grow on the surface of silver objects. By running a series of surface-limited chemical reactions, researchers can build the protective film one atom-thick layer at a time. The films Phaneuf and his team have tested are under 100 nanometers thick, less than 1/1000th the thickness of a human hair.

Phaneuf and his colleagues are currently experimenting by applying ALD films to highly uniform silver test wafers. The uniformity of the wafers allows the researchers to control variables, such as the composition of the silver, in order to create a model of the tarnishing kinetics as sulfur diffuses through the ALD film.

"This is when we get to put on our physicists' hats," Phaneuf says of simplifying the test cases and building a predictive model. The test case results showed two components to the concentration profile, indicating a faster rate of sulfur diffusion through tiny pinholes in the protective oxide film. The researchers are now experimenting with multilayer films that plug these pinholes.

Before the researchers use ALD on prized museum pieces, they will need to demonstrate that the coating can be removed without damaging the artifact, and that the thin film will have a minimal effect on the aesthetic look of the silver. In terms of appearance, ALD films may have another advantage over conventional nitrocellulose lacquer, which can yellow with age. Phaneuf and his colleagues are performing tests to measure how the thickness of the ALD films affects the way silver reflects light.

"Untreated silver beautifully reflects white light," Phaneuf explains. "You don't want the protective film to create interference effects that make it look blue or yellow." The expert eyes of art conservators will also help the researchers judge their success in this respect.

Phaneuf says that collaborating museums may soon allow the team to test their methods on forgeries of silver artifacts, and by year's end the team should be working with genuine pieces. "There is no shortage of complex objects this method might be applied to," Phaneuf notes. "There is a lot of interest now in the conservation community in how nanotechnology and other high technologies can be used to preserve art."

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