Estimating the Effect of Saliva on Silver Nanoparticle Concentration on Cloth Samples

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Abstract

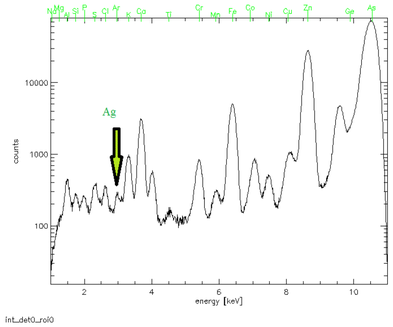
The goal of this experiment is to determine if the presence of saliva will reduce the silver nanoparticle concentration on a surface. As discussed below, the toxicity of silver nanoparticles is currently being researched by a number of groups. In this experiment, we attempted to determine whether the concentration of silver nanoparticles diminishes on surfaces when immersed in an environment designed to mimic a human mouth.

Our results suggest that there is a correlation between the silver concentration on a sample and the saturation time. We can see this in both the elemental maps produced using the hard x-ray nanoprobe and the integrated spectra of our samples, which show a reduction in silver concentration with the amount of time that the cloth spent in the saliva solution.

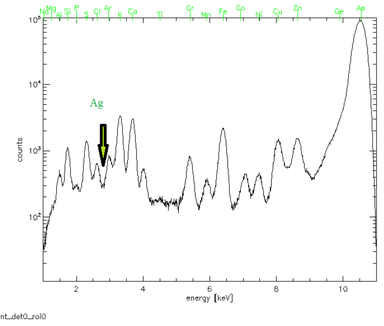
More work needs to be done in this area to quantitatively determine the rate of silver removal from the sample, as well as the absorption of silver nanoparticles into the human body and the possible effects of silver nanoparticles on human health.

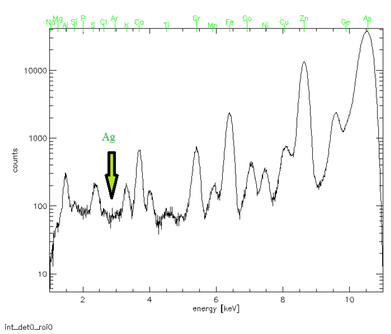
Results

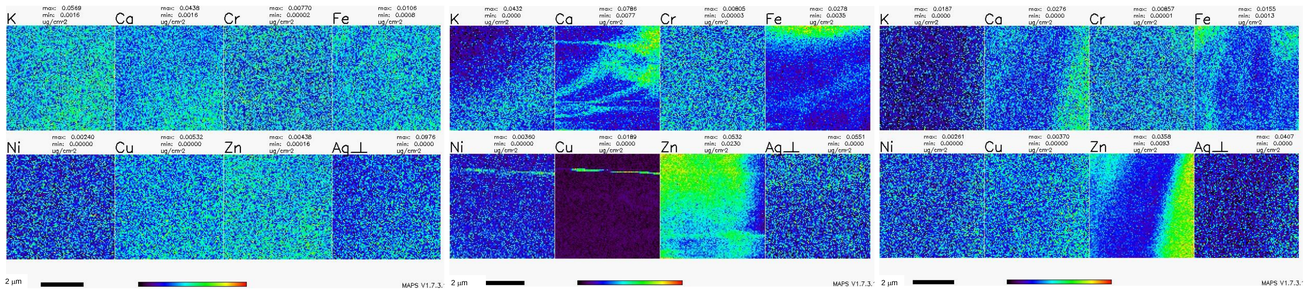
Sample 1: 0 days in saliva solution



Sample 2 – 1 day in saliva solution







Conclusion

Our experiment concluded that the silver deposited on the cloth appeared to be located on the fibers of the sample in evenly distributed quantities before immersion in the saliva solution. Additionally, our results suggest a correlation between the length of time the cloth was saturated in the artificial saliva solution and the amount of silver present.

The quantitative results were derived by taking counts of each element and calibrating them against a standard sample. We found a significant difference in the level of silver found on the sample saturated for zero days (insert quantity), as opposed to that of the one-day (insert quantity) and seven-day (insert quantity) samples.

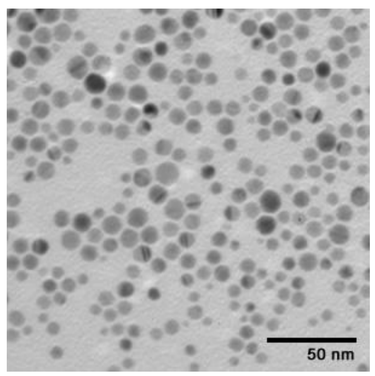
Although the data would indicate there is a correlation between the silver and the saturation time, it would be inaccurate to assume that these findings would be the same on a larger scale. The samples were small cross sections, so the findings could very well be poor representations of the full sample. Additionally, the cloth itself was not ideal, as it was potentially unstable when the fibers reacted with the x-ray beam, which could also alter the statistical data.

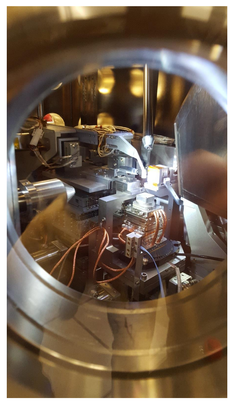
Experiment

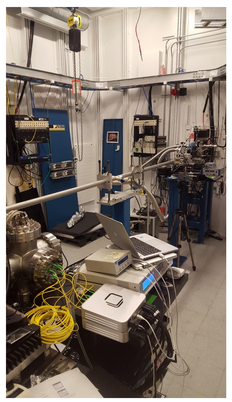
In this experiment, we soaked a cloth in a silver nanoparticle solution. The silver nanoparticles were suspended in a 2 mM sodium citrate solution and had an average diameter of 10 nm (± 2 nm).

Three cloth samples were produced for this experiment. All the samples were soaked in the silver nanoparticle bath for 1 hour and then allowed to dry at 60 ºC for 45 minutes. Two samples were then immersed in an artificial saliva solution at 37 ºC: one for a period of 24 hours, the other for a period of 168 hours (1 week). The samples were then allowed to air dry.

Below shows a TEM micrograph of a sample of the silver nanoparticles used in our experiment.







Samples were analyzed using the Center for Nanoscale Materials Hard X-ray Nanoprobe instrument, which operates on Sector ID-26 at the Advanced Photon Source. The hard x-ray nanoprobe has many unique capabilities, including having a high x-ray flux as well as a 30 nm spatial resolution that allows for trace element analysis at small length scales.

X-ray fluorescence measurements were used to create the spatial maps. X-ray fluorescence allows for the creation of element specific maps at the nanoscale to determine not only the presence of an element, but physically where it is located in the sample.

Discussion

The integrated spectra above show that the total amount of silver present is decreasing with the sample's exposure to the saliva environment.

The amount of material present can be estimated by comparing the amount of signal generated at a given energy with a known sample used as a reference. This allows us to get an estimate of the concentration of a give element in the images above. Out samples show that initially, before exposure to any saliva, the sample had a maximum silver concentration of 0.0976 $\mu g/cm^2$ (corresponding to the green-yellow areas on the images). After one day of exposure to the saliva solution, the maximum concentration of silver dropped to 0.0551 $\mu g/cm^2$, and after seven days, this concentration further dropped to 0.0407 $\mu g/cm^2$.

We can infer that the silver was found on the fibers by noting that in the 1 day and 7 day sample, the silver concentration tended to be higher in areas were zinc is present in large quantities. We believe that the presence of zinc is due to the pigment of the cloth itself, and therefore correlation between high zinc and silver concentrations indicate deposition of silver on the fibers of the sample. The lack of spatial detail in the zero day sample is likely due to some sample instability noted during the experimental run.

References & Citations

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Silver nanoparticle samples and TEM micrograph of silver nanoparticles provided by nanoComposix.

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