The Sustainability of Silver Nanoparticles

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ABSTRACT

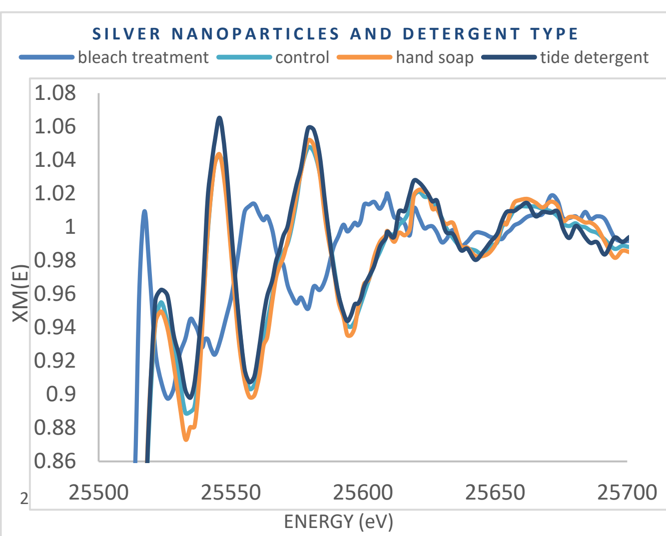
Silver nanoparticles are becoming an increasingly important topic of study in material science. Valued especially for their antibacterial properties, silver nanoparticles are appearing in everything from socks to hospital gowns. At the current moment, a rising problem with silver nanoparticles is their sustainability when woven into fabrics. After exposure to various detergents and the strains of daily wear, the nanoparticles may either be detached altogether or changed in their chemical structure (Impellitteri et al., 2009). Therefore, with this study, we seek to examine the effects different detergents and regular usage may have on the nanoparticles. If exposure to a detergent or regular usage effects the properties of silver nanoparticles, then the chemical structure of silver nanoparticles will be altered. We will utilize XAFS at Argonne to determine the interactions within silver nanoparticles. The results from this experiment may provide a guide for using silver nanoparticles in clothing with greater efficiency, allowing for a cleaner today and healthier tomorrow.

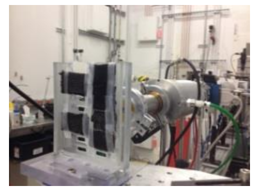
PROCEDURE

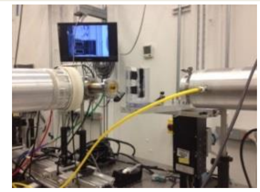
1. Obtain seven samples of socks implemented with silver nanoparticles.
2. Choose one sock sample to use as a positive control and standard.
3. Use XAFS technique with the Advanced Photon Source to determine the amount and distribution of nanoparticles in the control sock.
4. Record data in the spreadsheet.
5. Soak one sock sample each in bleach, Tide laundry detergent and Soft-soap hand soap for 12 hours.
6. Wear one sample each for five hours of rigorous wear, intermediate wear and normal wear.
7. Prepare and mount sock samples for XAFS analysis the day using the beam at Argonne.
8. Run X-ray fine structure with each sock sample.
9. Test and analyze the concentration and structure of Ag nanoparticles in the socks at Argonne National Laboratory.
10. Record data and store graphs.

RESULTS

Wear and usage of socks seemed to have a negligible effect on the silver nanoparticles. However, the type of detergent used seemed to alter the chemical structure of the silver. Bleach had the most deleterious effect on nanoparticle structure. *Tide* detergent also seemed to slightly alter the structure of the silver nanoparticles, whereas *Soft-soap* appeared to have no effect.

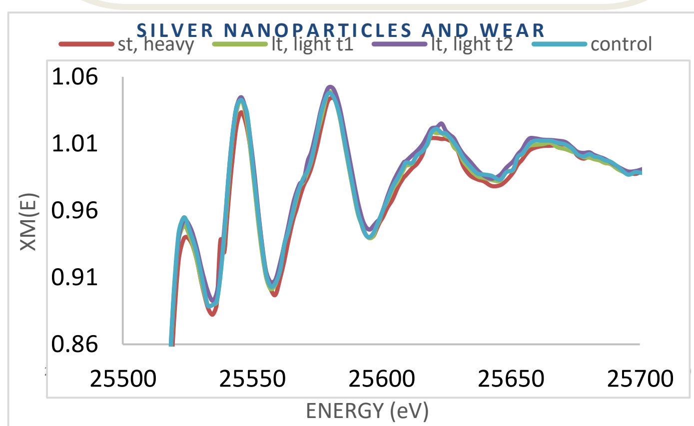






CONCLUSION

By examining the values from the x-ray absorption spectroscopies, we can deduce the effects those various mediums had on the nanoparticles. The wear test proved to be somewhat inconclusive. The data did not seem to vary much, although two of the samples showed higher absorption values than the others, possibly suggesting a certain small impact to the silver nanoparticles from mechanical stress, though we were unable to deduce its exact nature. The washing tests, however, indicated change. The hand-soap and tide results were very similar to those of the control, suggesting minimal impact on the nanoparticles. The bleach, however, exhibited a significant change in pattern and value. Previous studies have shown that silver nanoparticles may bond with chlorine, forming the much less antibacterial silver chloride. As a main component of bleach is chlorine, it is very possible that the silver nanoparticles had speciated into silver chloride. Possible sources of error may have included slight variances in procedure due to human error, chance un-uniform distribution of nanoparticles throughout the socks, and chance pieces of statistical noise. Our results implicate a possible flaw in the design of silver nanoparticles imbibed in socks: the nanoparticles may become silver chloride. From a longer perspective, because bleach was able to change the nature of the nanoparticles in the socks, other yet unknown factors may significantly alter the nature of silver nanoparticles in clothing as well. Without proper care and manufacture, our usage of silver nanoparticles may be rendered volatile and unpredictable. Silver nanoparticles serve as a protective, antimicrobial agent used in fabrics, which show promise to be implemented in hospitals and laboratories. However, without the proper care and manufacture, these nanoparticles could possibly end up in the environment and harm organisms.



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