Adventures in handling and characterizing nanomaterials: challenges and opportunities


1 Environmental Molecular Sciences Laboratory, Pacific Northwest National Laboratory
Richland, WA 99252 USA
*don.baer@pnnl.gov

1. Introduction
This talk addresses issues associated with the characterization and handling of nanomaterials. The growing recognition of these challenges is indicated by publication titles that include phrases such as: “Common pitfalls in nanotechnology…”[1] “The characterization bottleneck….”[2] and “…What are we missing?”[3] A consequence of inadequate characterization and lack of detailed information about materials synthesis and handling is that the true value of the data often uncertain. This presentation will use examples from our work on silver and ceria nanoparticles as well as work from the literature to identify characterization challenges, demonstrate the value of common surface analysis methods, and provide examples of other methods such as nuclear magnetic resonance (NMR), sum frequency generation (SFG) and ion scattering for which recent developments enable collection of information that not otherwise available.

2. Challenging Characteristics of Nanomaterials
Along with other groups we have found that characteristics intrinsic to the nature of nanoparticles often make their analysis unexpectedly difficult [4; 5]:
- Nanoparticles are like chameleons, they can change as their environment changes.
- In many environments nanoparticles are not stable and change as a function of time. The rates may be rapid or relatively slow.
- Nanoparticles are not created equal – minor differences in synthesis or handling can produce significant differences in behavior.
- Nanoparticles are easily damaged by handling or during analysis.
- Nanoparticles have high surface area and the surfaces of these particles are often different than planned or expected.

3. Unexpected Contamination
Surface sensitive analysis methods such as X-ray photoelectron spectroscopy (XPS), low energy- and medium energy- ion scattering (LEIS and MEIS) are particularly useful to detect surface contamination and coating integrity during sample preparation.

4. Preparing Nanoparticles for Biological Studies
Due to their increasing use, many studies are examining toxicological impact of many types of nanoparticles. Because silver particles may dissolve, to understand the sources of any toxicological impacts it is particularly relevant to understand the particle dissolution in the media for which particles are stored and delivered. We have examined aggregation and dissolution of silver particles in DI water, DI water with fetal bovine serum (FBS) and the biological media RPMI with and without FBS. We find that FBS when added to either DI water or RPMI significantly inhibits aggregations and enhances particle dissolution. In addition, dissolution studies on two 20 nm silver nanoparticles with differing microstructures have significantly different rates of dissolution. Therefore, particle and ion exposure in biological systems depends on both the nature of the media and the detailed structure of the particles.

5. Other Methods
Understanding the nature of molecular sorption on nanoparticle surfaces in solution is important and difficult. Ceria nanoparticles may exist with Ce in +4 and +3 oxidation states with apparent differences in the biological. Using sum frequency generation (SFG) it has been possible to observe the ratio of bidentate bridging and chelating species on the particles surfaces in acetic acid solutions [6]. Nuclear magnetic resonance (NMR) has been useful to look at how ethanol attaches to titania surfaces [6].

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7. References