ONAMI Safer Nanomaterials and Nanomanufacturing Initiative (SNNI) statement on EHS research needs for engineered nanoscale materials.

Current estimates suggest that nanotechnology will exceed the impact of the industrial revolution and become a 1 trillion dollar industry by 2015. There is a growing general consensus within the scientific community that to ensure the success of the new technologies we need to understand the possible biological and environmental effects of nanomaterials in order to avoid the consequences of any harmful effects. The NNI report "Environmental, Health, and Safety Research Needs for Engineered Nanomaterials" presents a comprehensive list of environmental, health, and safety research needs for engineered nanomaterials.
We believe that it is essential to pursue a proactive approach to the design of safer, greener nanomaterials in parallel with the research activities described in the Report. In order to address EHS needs and delineate putative problems that may arise in creation of nanomaterials, environmental and biological testing should be conducted in concert with development of advanced functional nanomaterials and greener synthetic methods for nanomaterial production. We need precise toxicological methods to assess nanomaterials safety and molecular-level design schemes that create high-performance, yet inherently safer nanomaterials. These methods need to be scalable to volume production levels while optimizing for performance and safety and minimizing cost. These objectives can be achieved by utilizing proactive design strategies that hazard assessment into design schemes that merge green chemistry and nanoscience.

Below, we outline our views on strategies and research needs for nanotechnology. Further discussion of our approach to a greener nanotechnology can be found in a Nanotechnology Now article that can be found here: http://www.nanotech-now.com/columns/?article=022

Safer Nanomaterials and Nanomanufacturing Strategies and Research Needs
In order to ensure human and environmental safety while meeting performance and cost objectives, nano EHS research must not be limited to assessment of potential risks, but also focus on methods for optimized design of nanomaterials. Questions to be answered, actions to be taken and capacities to be built include:

Design for safety – Chemical principles and first level risk assessment

1. Examine the properties of molecular and microscale analogs. Can anything be learned from an understanding of the hazards of materials that bracket the dimensions of nanomaterials?
2. Pay attention to elemental composition and carefully examine any claims regarding the availability of those elements. What are the odds that these

materials will become disperse in the environment in a form that can cause harm? What are the odds of human exposure?

Precautions in the face of uncertainty

1. If no data are available, and especially if elemental composition or analogies to smaller or larger materials suggests hazards might exist, caution should be exercised and testing should be carried out before distribution.
2. Consumer products need appropriate testing. What is this testing? Who is responsible for carrying out the testing? Who will judge the quality of these approaches?

Design for safety – Fact finding

1. A battery of tests need to be done to ascertain the likely impacts of engineered nanomaterials on human health and the environment. What are those important tests? How will concentration be determined (molarity, surface area, number of particles)?
2. Testing needs to be done on the appropriate materials. While it is tempting to study commercially available nanomaterials, synthetic libraries will be needed to explore the many structural parameters and correlate structure with biological impact. Testing on both types of materials should be carried out, but must be done carefully, ensuring that the materials used are structurally well-characterized (e.g. core composition, size, shape) and pure. The effects of impurities can mask the effects of the nanomaterial. A lack of definition in the material structure prevents establishment of the predictive relationship that testing should inform.
3. Mechanisms need to be put in place to share data. These data are key to formulating products and necessary to design new nanomaterials with defined properties. What is the best dissemination mechanism? A database? Who will manage the database? How to avoid IP issues related to these data? How should the data be managed to facilitate their use in QSAR (Quantitative Structure-Activity Relationship) studies?

Design for safety – synthetic strategies, purity

1. In parallel with the development of the SARs, new synthetic nanoparticle fabrication processes and functionalization methods need to be developed. Functionalized nanoparticles are new, complex materials requiring significant production method development. New methods are needed to expand the available compositions for cores and shells, for controlling functionality, and for influencing core shape and size. It is essential that these capabilities be developed in parallel to the SAR work to avoid delays in material development – we need capacity to respond when desired modifications become clear.
2. Nanomaterial purity is essential to assessment of biological impacts (as well as most physical properties). Greater attention to material purity is necessary to make rapid progress in developing SARs. It is critical to develop appropriate methods of assaying nanomaterial purity and developing new, efficient purification strategies (for example, nanofiltration). The lack of convenient

methods of purification and assessment are both significant barriers to producing high purity nanomaterials at this time.

Design for safety – need for adequate materials characterization

1. There needs to be a suite of characterization tools and some consensus on which methods are the most appropriate for each material class.
2. In situ methods needed to monitor syntheses in order to gain better control over batch-to-batch variation. This is essential, because usually manipulating synthetic parameters is easier than trying to invoke size separations later.