

### **Research Needs and Data Gaps**

#### U.S. EPA Office of Research and Development Chemical Safety for Sustainability Research Program

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#### **Problem Statement**

- Chemicals, including emerging (and nano) materials are a lynchpin of innovation in today's economy.
- Sustainable innovation requires designing, producing, and using chemicals in safer ways.
- Information and methods are needed to make better-informed, more-timely decisions about chemicals, many of which have not been thoroughly evaluated for potential risks to human health and the environment.
- Scientific understanding is required to anticipate potential for adverse impacts on human health or wildlife populations based on knowledge from data rich chemicals.





**Figure 4.** NNI Goal 2. Nano-enabled products in the United States and other regions are increasing their market revenue, with significantly increasing growth rates predicted for the coming years. Data from Lux Research.



#### **Commercial Nanomaterials**

Category	# product listings	Examples
Carbon nanotubes	714	SWCNT, MWCNT
Fullerenes	136	Pure or functionalized
Graphene	38	Film, on substrate
Nanoparticles of elements	549	Metals
Binary compounds	750	metal oxides, salts, carbonates
Complex compounds	205	Doped metal oxides
Quantum Dots	183	Cadmium selenide
Biomedical Quantum Dots	205	Peg modified Qdots, Antibody coated
Nanowires	26	Copper, gold, indium
Nanofibers	30	Carbon
Non-carbon nanowires	1	Titania

http://www.nanowerk.com/phpscripts/n\_dbsearch.php; accessed August 6, 2012



#### Challenges

- The rate that new engineered nanomaterials (ENM) are being developed makes it impossible to evaluate materials individually and traditional testing approaches may be inappropriate for ENM
- Understand how the physical/chemical properties of ENM influence their behavior in complex environments
- Identify intermediate properties of nanomaterials that can predict exposure and/or hazard
- Identify/develop methods to characterize ENM in complex media
  - Release from consumer products along the product life cycle
  - Fate, transport and transformation in environmental media
- Develop alternative testing approaches to evaluate adverse outcome pathways
  - Potential for adverse human health effects
  - Potential to impact sensitive environmental species



#### **The Great Chemical Unknown**

**The Great Chemical Unknown** 

[Scientific American October 28, 2010]

- Only a tiny fraction of the compounds around us have been tested for safety
- Chemicals used by U.S. consumers and industry: 50,000 (80,000)

- Tested: 300
- What is different about nanomaterials?

## **SEPA**

#### **Research Priorities**

- Core library of nanomaterials and analytical capability
- Informatics, database and decision support tools
- Fate, transport and transformation across life cycle
- Effects on human health and ecosystems





Environmental fate, transport, transformation and exposure through the life cycle

- Identify and measure key physical-chemical properties of ENMs
  - Identify points in the ENM life cycle critical for potential exposure
  - Release into near-field or far-field environments
  - Transport (from manufacture or product use scenarios)
  - Transformation in the environment or at the bio-interface
  - Exposure to human populations and/or indicator organisms
- Protocols for characterization, release & transformation of ENMs
  - in complex biological and environmental systems
- Link structure to outcome through systematic variations
  - size, shape, surface chemistry, etc.

# **Relevance of Pristine Materials** COa slow fast

#### Photochemical transformation of graphene oxide in sunlight

 Graphene oxide photo-transforms rapidly under sunlight exposure, resulting in chemically reduced and persistent photoproducts

Likely to exhibit transport and toxic properties unique from parent GO

# Sepa Other Considerations

- Victim of success ubiquity of materials
- Linking exposures and related effects to chemical mixtures in the environment

11

Nanomaterials harbinger of other emerging materials

# **A Framework**

## to Guide Selection of CHEMICAL ALTERNATIVES

NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMIES

#### Design and Evaluation of Safer New Chemicals: A Framework to Inform Government and Industry Decisions

A more universal approach to evaluation of substitutes is needed to enable:

- •wider use of appropriate evaluations
- •development and introduction of less hazardous, more sustainable
- substitutes in commerce
- •dialogue among different stakeholders
- •planning for the scientific information and tools that will be required

US National Academy of Science Oct. 10, 2014

