Nanomaterials – Participant Guide

Building resources—nanomaterials, tiny manufactured particles in many products

Some uses of nanomaterials

Medicine: treatment and drug design

Cosmetics: sunscreens, makeup

Fillers: in plastics, construction paints and cements (e.g., glass fibers, talc, kaolin, bentonite)

Electromagnetic radiation shielding and heat protective clothing/insulation: nanotubes, graphite

Electronics

Anti-microbial/anti-fouling paints and treatments

Sources: Lines MG. 2008.Nanomaterials for practical and functional uses.J Alloys and Compounds. 449:242-245
Find commercial products at: http://www.wilsoncenter.org/article/new-nanotechnology-consumer-products-inventory
Cosmetics information: www.cosmeticsinfo.org/HBI/21/ ; www.ewg.org/skindeep

"A new use soon to be on the market: a coating to make cell phones waterproof, since 19% of users have dropped them in the toilet." *Times of India*. 2 December 2012.

Using resources during this exercise, you will

- Review relevant technical terms
- Identify an activity to continue learning about nano use
- Developed a plan to achieve the goal and chart progress and challenges

This training was developed as an introduction to these very small, manufactured materials that are emerging rapidly as a component of many consumer products. The

particles can also be workplace exposures to those making the materials, making products or working on products that contain nanomaterials.

In this exercise, resources will be used to find information, identify gaps and provide a framework for you to learn more.

This exercise is interactive and you are encouraged to provide feedback. We hope that you will share with us your experience in putting your plan in place to gather information or make a change, so that we can document the use of training. The feedback will be used to evaluate the training, not the participants.

What we know or do not know:

> *"We currently know very little about nanoscale materials' effect on human health and the environment. The same properties that make nanomaterials so potentially beneficial in drug delivery and product development are some of the same reasons we need to be cautious about their presence in the environment"* – Linda Birnbaum, Ph.D., director of NIEHS and the National Toxicology Program (NTP) https://factor.niehs.nih.gov/2009/december/spotlight-nanomaterials.cfm

The market to use nanomaterials is growing rapidly, worldwide:

Currently growing at 18.2% annually, should be a $ 90.5B market worldwide by 2021. From 2011 through 2014, expect annual growth of 19% in the industry.

https://www.globenewswire.com/news-release/2017/01/17/906164/0/en/Nanotechnology-Sees-Big-Growth-in-Products-and-Applications-Reports-BCC-Research.html

So what are these little things?

Nanomaterials are chemical substances or materials that are manufactured and used at a very small scale (down to 10,000 times smaller than the diameter of a human hair). Nanomaterials are developed to have very special characteristics (such as increased strength, chemical reactivity or conductivity) compared to the same material without nanoscale features.

Hundreds of products containing nanomaterials are already in use. Examples are batteries, coatings and anti-bacterial clothing. Financial analysts expect markets to grow to hundreds of billions of Euros by 2015. (1Euro is about $1.30)Nano innovation will be seen in many sectors including public health, employment and occupational safety and health, information society, industry, innovation, environment, energy, transport, security and space. http://ec.europa.eu/environment/chemicals/nanotech/

Activity 1 – Potential exposures to workers and consumers: finding information and identifying gaps

Just as children do not react to toxins as "little adults," nanomaterials are not assumed to have the same toxicity as the same material when the particle size is larger. In 2011, NIOSH recommended two different levels of exposure to titanium dioxide, based on particle size. For the respirable or fine material used in industry for a number of purposes including as a paint pigment, 2.4 mg/m3 was recommended; for ultrafine and engineered titanium dioxide, 0.3 mg/m3 was recommended. This is the first time NIOSH has made separate recommendations, based on particle size. Both are for TWA up to 10 hours per day, 40 hour work week and 45 year working lifetime. (http://www.cdc.gov/niosh/docs/2011-160/)

Review Resource 1, a listing of various nanomaterials and terms.

Work in small groups and choose a nanomaterial of interest; identify at least one use. Using resource listings provided by the facilitator and shown on Resource 2 use technology (computer, tablet, smartphone) to complete this page. Resource 3 shows approaches to reducing exposure that may be applicable to reducing hazards when known.

Material: _____

Use/application: _____

Complete the table below:

Group	Known Health Hazards	Possible health Hazards	Can exposure be .....?	
			Reduced	Eliminated
Residents				
Workers				
Consumers				

What are gaps in information, where more information would help you?

Activity 2 – What do you want to do?

Think about the information that you found in Activity 1. Do you need more information, or are you ready to act on information? I would like to…

Possible action/activity	Yes	No/don't know
Get more information for myself at work		
Get more information for myself as a consumer		
Get involved in consumer fact-finding		
Advocate to regulate/label		
Other:		

You may want to now change small groups—to work with others who have the same or similar goal.

The next part of this activity is to develop a plan to achieve the goal, including a timeline.

- What are the steps you need to work toward the goal?
- What barriers do you expect? How can these be overcome?
    - What is the measure of success at each step of your plan?
    - Who is responsible for each part of the plan?

Use the Worksheet provided (or use your own format) to organize your plan.

Personal plan example *(I own all steps and will complete in two weeks)*

Goal: Determine if nano materials are in the sunscreen my family uses

Actions: Read the label (as soon as I get home; could be done); if continuing:

- Search manufacturer website (today; if not found, contact manufacturer (delay; may need second request or phone call)
- Share experience with training center:
    - On label?
    - On website?
    - Manufacturer responded?

Report back to the larger group regarding the

- planned steps
- who owns each step
- strategies to overcome barriers
- timeline

We hope you will provide feedback to us as the plan progresses, so we can improve training and document successes from the training. Identifying barriers that are encountered is also important and this information will be used improve training. Our goal is to improve training.

Resource 1 – terms and definitions, illustrations of scale

- **Nano-object** – a unit with at least one dimension less than 100 nanometer (nm, 1 billionth of a meter; a human hair is 50,000 nm)
- **Nanomaterial** – a material containing nano-objects
- **Nanoparticles** – all three dimensions are on the nanometer scale
- **Engineered nanoparticles, engineered nanomaterials** – produced materials, not naturally-occurring

Types of nano-objects/nanoparticles

- **Buckyballs** – hollow spheres of graphite
- **Carbon nanotubes** – tubes of single molecules of graphite
    - **SWCNT**—single walled, one tube about 1 nm in diameter
    - **MWCNT** – more than one wall, a bit larger in diameter; think of multiple sheets of rolled paper
- **Fullerenes** – hollow nano-objects of carbon, includes Buckyballs and carbon nanotubes
- **Metals engineered as nanomaterials** – aluminum, manganese, zirconium, yttrium, gold
- **Metal oxide nanomaterials** – titanium, zinc and cerium
- **Semiconductors (quantum dots** – cadmium selinide, cadmium sulfide, zinc sulfide
- **Organic** – polymeric beads, Dendrimer

Particle size terms (ambient exposure – EPA definitions)

Size fractions

- Super coarse d > 10 um
- Coarse 2.5 um < d <= 10 um
- Fine 0.1 um < d <= 2.5 um
- Ultrafine d <= 0.1 um
- PM10 10 um particles collected at 50% efficiency
- PM2.5 2.5 um particles collected at 50% efficiency

Particle size terms (personal exposure--occupational hygiene definitions)

Inhalable: Enters the nose/mouth, average diameter, 100 um

Thoracic: Penetrates the head and enters airways, average diameter: 10 um

Respirable: Reaches terminal bronchioles, average diameter .4 um

Routes of entry

Inhalation: materials that enter your airways when you breathe. The particles can deposit in the nose (inhalable), upper airways (throat, trachea=thoracic) or deep in the lungs (alveoli=respirable) depending on diameter.

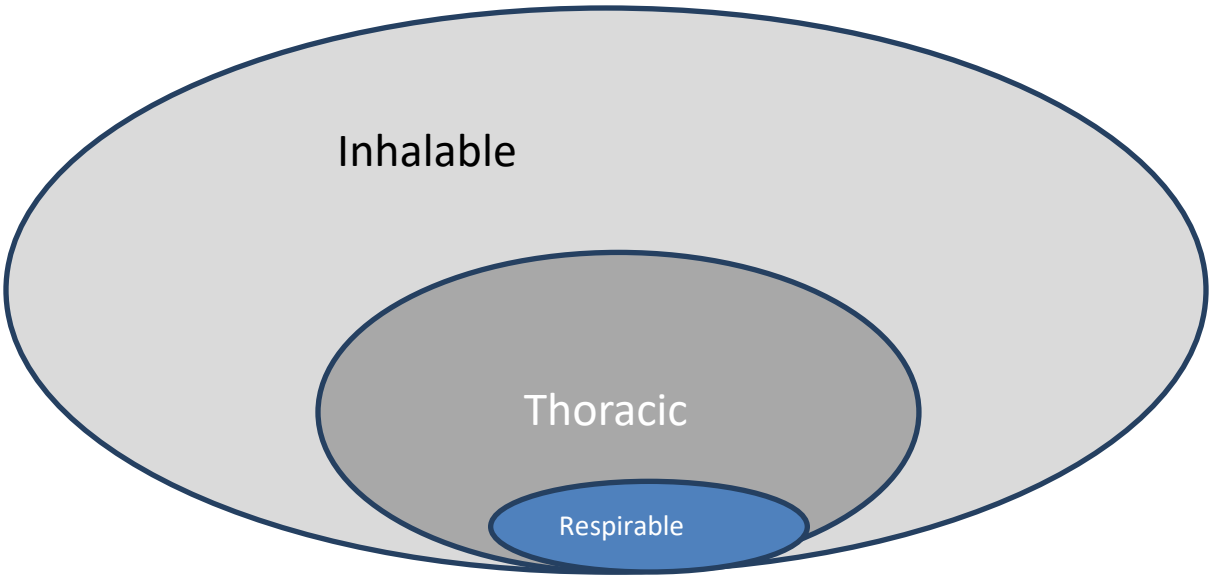
Ingestion: materials enter the stomach because they are on or in food products

Dermal: materials that go through intact skin, or enter through abrasions or cuts

Diameter/surface area – for one gram of material, as the diameter of particles decreases, the number of particles and overall surface area increases, as shown below.

Diameter (um)	Number (millions)	Surface area (sq M)
1000	0.002	0.006
100	2.0	0.06
10	2,000	0.60
1	2,000,000	6.0
0.1	2,000,000,000	60.0

Relationship of all particles in a parcel of air: Inhalable, Thoracic, Respirable



Resource 2 – Some sites for more information

- Nano in your state: Map at http://www.nanotechproject.org/inventories/map/
- Compendium of websites/reports/published papers:

  https://www.niehs.nih.gov/research/resources/nanotechnology/index.cfm
- Nanoscale in context: http://www.nano.gov/nanotech-101/what/nano-size

Videos

- Managing the small stuff – a visual nanotechnology primer (excellent intro)

  https://2020science.org/2009/02/02/managing-the-small-stuff-a-visual-nanotechnology-primer/
- How Nanotechnology Works (very basic)

  https://www.youtube.com/watch?v=cyLtGj8dAJs
- Nanotechnology Animation (applied to medicine)

  https://www.youtube.com/watch?v=1QwyMWM0Jjg

Legal aspects

"UPDATE: Nanotechnology and International Law Research Guide" found at:

http://www.nyulawglobal.org/globalex/Nanotechnology_International_Law1.html

Websites to follow for updates

- NIEHS: http://www.niehs.nih.gov/health/topics/agents/sya-nano/index.cfm
- HHS: http://sis.nlm.nih.gov/enviro/nanotechnology.html
- NIOSH: http://www.cdc.gov/niosh/topics/nanotech/
- OSHA: http://www.osha.gov/dsg/nanotechnology/nanotech_healtheffects.html
- EU: https://echa.europa.eu/regulations/nanomaterials

NIOSH reports

- Approaches to Safe Nanotechnology: managing the safety and health concerns associated with engineered nanomaterials. http://www.cdc.gov/niosh/docs/2010-112c/
- General Safe Work Practices for Working with Engineered Nanomaterials in Research Laboratories. http://www.cdc.gov/niosh/docs/2010-112c/

- Filling the Knowledge Gap for Safe Nanotechnology in the Workplace. http://www.cdc.gov/niosh/docs/2010-112c/
- Current Intelligence Bulletin 63: Occupational Exposure to Titanium Dioxide. http://www.cdc.gov/niosh/docs/2011-160/

NIEHS report

- Training Workers on the Risks of Nanotechnology. http://tools.niehs.nih.gov/wetp/public/hasl_get_blob.cfm?ID=9094

Research agendas

- NTP: https://ntp.niehs.nih.gov/results/index.html
- NIOSH: http://www.cdc.gov/niosh/topics/nanotech/critical.html

Note: All websites accessed May 9, 2019

Resource 3-- Hierarchy of Controls for hazard reduction

Control		Highest preference
	Eliminate	
	Substitute	
Prevent		
	Modify	
	Contain	
	Ventilate	
	Work Practice Change	
	Personal Protective Equipment	Lowest preference

This scheme illustrates that the best and surest approaches to hazard reduction is to eliminate the exposure or substitute a lesser hazard; the prevention strategies rely on modifying the process, contain (build a box), removing through ventilation, a change in work practice that must be done diligently (day after day) or use of personal protective equipment (that may not be 100% effective even when used and maintained diligently).

Worksheet: Build a plan

Goal: _____

Plan action item		Who 'owns'	Anticipated barriers and approach	Date to be complete d	Reason for Delay	Date done
Action 1						
Action 2						
Finalize work plan and set deadlines for each additional action	•					
	•					
	•					
	•					
	•					
	•					
	•					
Report final results to participants/commun ity						
Report results to Training Center						