Engineered Nanomaterials and Public Health

- The Nano Scale
- ENM in the US and CCC
- Product Lifecycle
- Biological Effects/Toxicity
- Regulatory landscape
- Data Gaps and Uncertainties
- Summary and Opportunities

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The Nano Scale

Nano Materials (Ultrafine PM: < 100 nm)

<table>
<thead>
<tr>
<th>Naturally occurring</th>
<th>Incidental</th>
<th>Engineered</th>
</tr>
</thead>
<tbody>
<tr>
<td>ocean spray</td>
<td>combustion</td>
<td>designed</td>
</tr>
<tr>
<td>friction</td>
<td>laser printers</td>
<td>properties/</td>
</tr>
<tr>
<td>erosion</td>
<td>welding</td>
<td>functions</td>
</tr>
</tbody>
</table>

Nano fibers: Pollen, Human Hair

www.elmarco.com

nano range
ENM: Unique Properties...due to Quantum Effects

- Nano properties ≠ macro properties
- Surface area / gram
  (VERY large!)
- Size, size distribution
- Shape
  (tubes, rods, wires, spheres, sheets, ...)
- Composition
  (organic, metal, hybrid)
- Surface modification
  (charge, hydrophilic, lipophilic, magnetic, ...)
- Agglomeration
- Protein corona

... leading to amazing applications of ENMs, including public health applications! We all want the benefits of this technology..... but not the unintended consequences.

http://www.jianghutio2.com
Engineered Nano Materials in the US (estimates!)

Nano materials produced in US
(metric tons/yr, 2010, low and high estimates)

- Copper
- Silver
- Carbon Nano Tubes
- Cerium oxide
- Nano clays
- Aluminium oxide
- Zinc oxide
- Iron
- Silicon dioxide
- Titanium dioxide

US: 50% of world-wide production US
Total production is in US:
134,000 – 158,000 tons/yr

Major uses
> 1600 consumer products
> 487 construction products

- Coatings, paints, pigments (textiles)
- Personal care products
- Electronics, optics
- Energy, environment
- Catalysts
- Automotive
- Medical

Sources:
http://www.nanotechproject.org/
http://www.nano.elcosh.org
Exposures to humans & releases into the environment: UNKNOWN!

- Raw materials
- Development, production of ENM
- Transportation, storage; manufacturing of nano-enabled products
- Worker’s exposure
- Consumer exposure
- End-of-life, recycling, Incineration, landfill, waste water, env. fate
- Consumer use, releases from aging products, by-products
Accidental Release

Nano TiO2 spill, France, 2011
Each bag 1500 lb of nano TiO2

Source: Nowack et al, Env. Sciences Europe, 2014, 26:2
ENM: Observed Biological Effects

- **Local**
  Absorption through membranes, accumulation in lung

- **Systemic**
  Translocation, blood-brain barrier, placenta, reproductive effects

- **Acute**
  Reactive Oxygen Species, inflammation, mutations

- **Chronic**
  Animal studies: fibrosis (CNT); asbestos-like effects, possibly carcinogenic to humans (IARC – 2B); lung tumors (TiO₂); in vitro: transformation of lung cells
ENM: Difficulties in Assessing Toxicity

- Nano toxicity ≠ macro toxicity
- Few standard methods
- Dose metrics (NOT mg/kg bodyweight): reactivity, surface area, particle number, …?
- Appropriate toxic endpoints?
- Impurities, endotoxins in commercial ENM
- Poor reproducibility of published research
- Lack of published negative data
- ID worker cohorts?
- ID Sensitive Subpopulations?

Krug et al., 2014: Are we on the right track?
Regulatory Landscape

No legal framework specific to nano-scale materials

- Feds **regulate by product**: chemicals, consumer products, pesticides, foods, drugs, medical devices, cosmetics, hazardous waste, etc.
- **Definitions** do not differentiate between nano- and “regular” chemicals.
- Example of federal law: **Toxic Substances Control Act**
  Update on Reporting Rules (5/12/2017)?
- Local level? Worker’s RtK? Community RtK?

**NIOSH Guidance:**
- REL nano TiO$_2$: 300 µg/m$^3$ (potential occ. carcinogen)
- REL CNT/CNF: 1 µg/m$^3$ (effects similar to asbestos)
  (REL: Recommended Exposure Limit)

**DoE:** Registry for nano workers (DoE O 456.1)
ENM: Data gaps and uncertainties!

- Unknown releases into the environment during Lifecycle
- Little discussion of ENM in public health field/funding?
- No location of ENM facilities
- Little knowledge of worker cohorts
- Poor reproducibility of published data
- Lack of published negative data
- Little information on Environmental Fate and Transport
- Unknown exposures to general public
- Few useful Safety Data Sheets
- Commercial ENM may contain impurities, endotoxins
- Lack of risk communication
- Few standard methods
Summary and Opportunities

- Great potential for beneficial uses!
- Large gaps in data, knowledge, infrastructure, especially toxicology, environmental fate
- Increasing number of products
- Unknown exposures to consumers and workers
- Unknown releases into the environment

Unknown consequences for Public Health

Opportunities for local activities:
- Identify local facilities and exposed populations
- Prepare locally (emergency response, Workers RtK, Community RtK)
- Communicate with public

Thank you!

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ENM Resources

- Nano EHS: Communities of Research: [www.us-eu.org](http://www.us-eu.org)
- National Nanotechnology Initiative: [www.nano.gov](http://www.nano.gov)
- NIOSH: [http://www.cdc.gov/niosh/topics/nanotech/](http://www.cdc.gov/niosh/topics/nanotech/)
- NIOSH: Good NanoGuide: [https://nanohub.org/groups/gng](https://nanohub.org/groups/gng)
- USEPA: [http://www.epa.gov/chemical-research/research-evaluating-nanomaterials-chemical-safety](http://www.epa.gov/chemical-research/research-evaluating-nanomaterials-chemical-safety)
- Woodrow Wilson Center: [www.nanotechproject.org/](http://www.nanotechproject.org/)
- Nanomaterial Registry: [https://www.nanomaterialregistry.org/](https://www.nanomaterialregistry.org/)