Nanotechnology

Current NIOSH Activity and Looking to the Future

2018 Pharmaceutical Forum

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Current State

- Nanotechnology still a NIOSH priority
- Fourteen years: 2004-2018
- Have we made any progress ?
- Beyond “Nano to Advanced”
- Federal priorities

Nanotechnology in 2018-2020

Growth areas as noted by the sectors

- **2D materials**: Graphene, boron nitride, silicene: Energy storage, flexible electronics, supercapacitors, conductive inks
- **Quantum Dots**: manufacturing scalability solved: Flat panel displays 'booming'
- **Carbon Nanotubes**: CNT arrays, batteries, composites, sensors, filters
- **Nano coatings**: Architectural, construction, anti-corrosion,
- **Advanced Materials**: foundation material or activity enhancer/additive
- **Nano Cellulose**: still a promising renewable

Nanotechnology at NIOSH 2018-2020

- Continue to evaluate the toxicology of nanomaterials
  - Deeper evaluation of initial materials: CNT, Titania
  - Evaluate new or emerging nanomaterials
  - Develop a mechanistic approach; look for AOP
- Refine exposure measurement and assessment methods
- Broaden risk assessment to a categorical approach
- Continue Epi, Exposure and Health study of CNT cohort
- Demonstrate effectiveness of engineering controls
- Guidance
- (New) Employer survey

Nano-Bio-Medical Activity at NIOSH?

- Nothing specific to Pharma
- A lot of aligned work that applies
- Emission and exposure studies
- Containment and control evaluations

Nanomaterials Investigated at NIOSH

MWCNT – Mitsui 7

DWCNT – double walled CNT

MWCNT – amine and carboxyl functionalized

MWCNT – Doped (Nitrogen, Aluminum)

MWCNT – Heat Treated

Vapor-grown Carbon nanofibers (CNF)

CNT and CNF – 10 US Facilities in Epidemiology Study

SWCNT – single-walled CNT

Carbon Nanodots

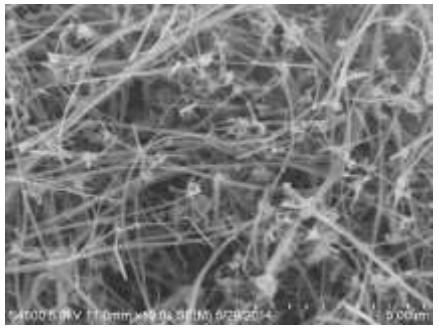
Graphite Nanoplatelets or Nanoplates

Graphene

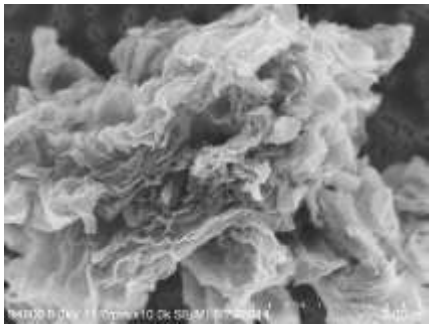
Graphene Oxide

Nanocellulose Nanomaterials

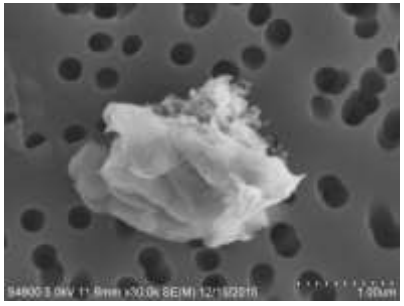
Natural and Organomodified Montmorillonite Nanoclay



MWCNT- Mitsui 7 – Courtesy of Bob Mercer



Layered Reduced Graphene Oxide



Stacked Plates of Nanoclay – courtesy of Todd Stueckle

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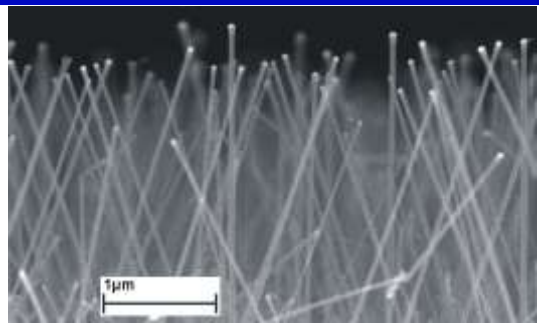
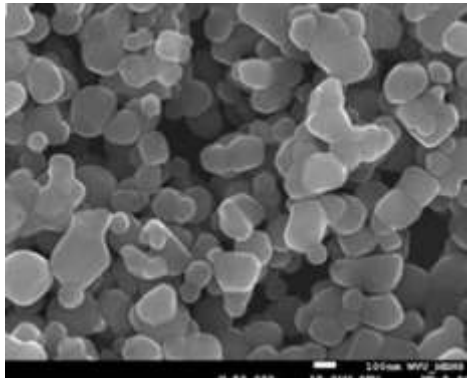
Nanomaterials Investigated at NIOSH

Boron Nitride Nanotubes
Boron Nitride Nanopowder
Silicon nanowires
Elemental nano-silver
Cerium Dioxide
Lanthium Oxide
Cobalt Oxides
Nickel Oxide
Iron Oxides – SiO2 coated and uncoated
Zinc Oxide Spheres and Nanowires
Elemental Zn
Titanium Dioxide Nanorods, nanowires, nanobelts
SiO_2 – amorphous and crystalline
Tungstate (particles and rods) CaWO4, SrWO4, BaWO4
Tungsten carbide-cobalt
Tungstate (particles and rods)
- CaWO4
- SrWO4
- BaWO4

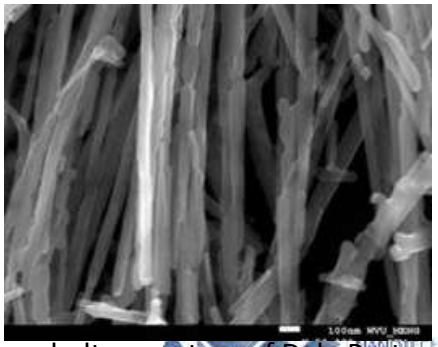
Copper Oxide
Quantum Dots – ZnS/CdSe



Si nanowires: Roberts et al., 2012



TiO2 nanospheres: courtesy of Dale Porter



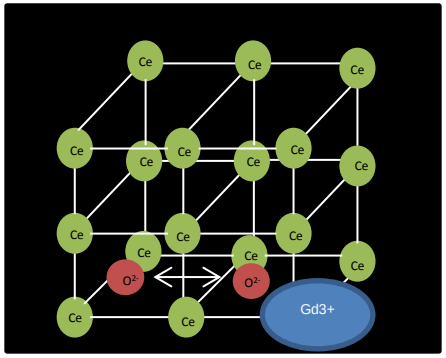
TiO2 nanobelts: courtesy of Dale Porter

Nanomaterials Investigated at NIOSH

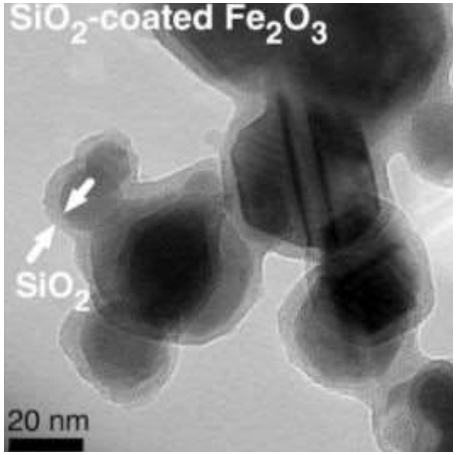
Functionally Modified Nanoparticles – Prevention through Design:

- Carboxylated and Humics Acid Titanium Nanobelts
- Nitrogen-doped MWCNT
- Carboxylated MWCNT
- Amine Functionalized MWCNT
- Heat-Treated MWCNT
- Amorphous silica coated Iron Oxide and Cerium Oxide
- Gadolidium-doped and SiO2 coated cerium oxide

http://goo.gl/vWa6HO



Courtesy of Stephen Leonard



Gass et al., 2013

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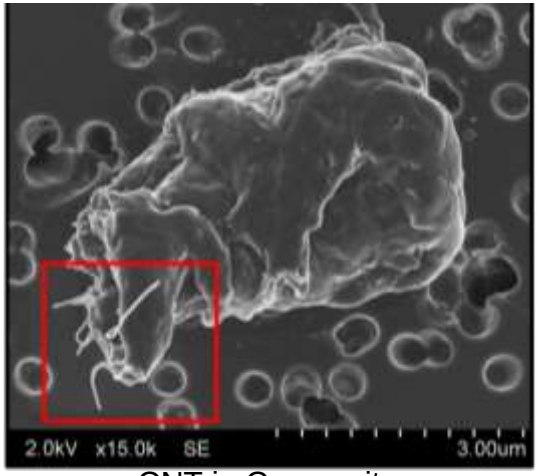
NIOSH Nanotoxicology Program Directions

- Generating Occupationally Relevant Aerosols for In Vivo Studies
- CNT – A Model Toxicity Assessment
- Into the Future with a life cycle approach

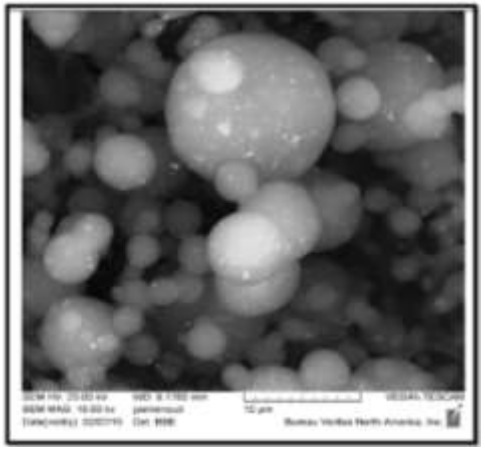
‘NanoProducts’ Investigated at NIOSH

Exposure with Nanoparticle Components – NanoRelease/Life Cycle:

Crushed Preparation MWCNT
CNT Polymer Composites – Construction operations – Sanding/Sawing
Printer-Emitted Particles – Toners and Inks (CPSC and Harvard University)
Three Dimensional Printing Emissions (CPSC and West Virginia university)
Copper-Treated Wood – Dust from Construction Operations (CPSC)
Suncreen Spray – ZnO nanoparticles (FDA)
Disinfectant Sprays – ZnO or Silver Nanoparticles
Wood Sealant/Stain Aerosol – Spraying Operations – ZnO Nanoparticles (CPWR)
Stain-Treated Wood Dust – Construction Operations – ZnO Nanoparticles (CPWR)
Welding Fume Exposure – mixture on metal nanoparticles



CNT in Composite
– Courtesy of A. Erdely


ZnO particles on paint droplets
– Courtesy of CPWR, B. Lippy

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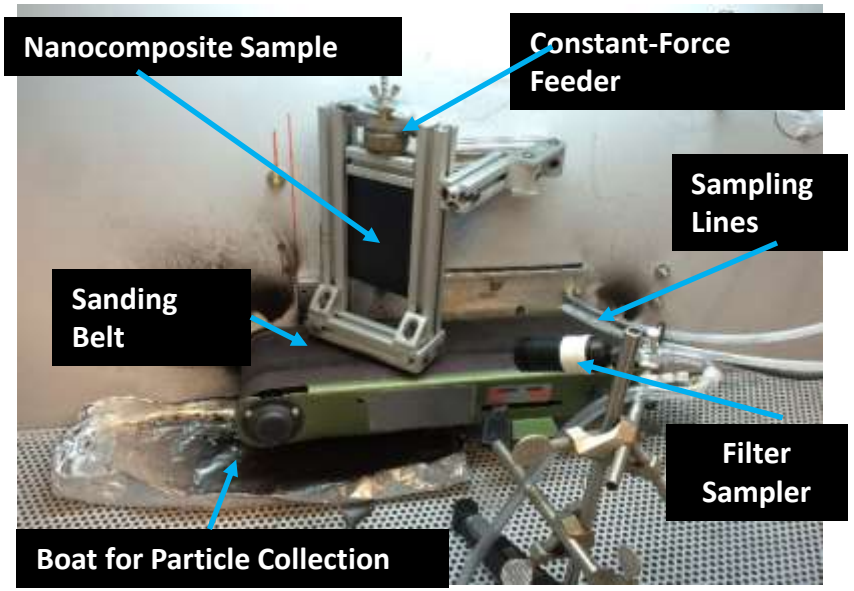
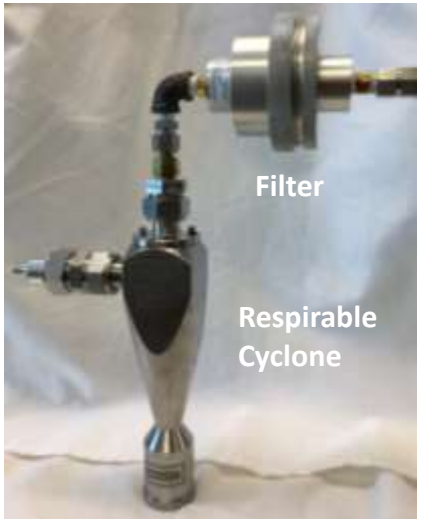
Processing and Characterizing Aerosols from Nano-Enabled Materials

Internal View





Courtesy of A. Erdely, L. Cena and A. Afshari

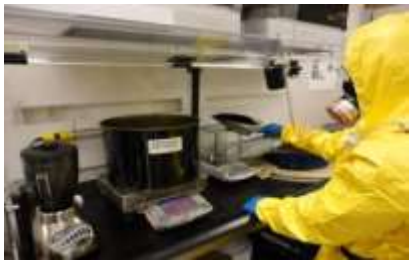
Future Directions

Occupational Material Lifecycle

Dry Powder
Wet Chemistry

Resource Extraction → **Production of Primary ENM** → **Material Processing**

Mixing
Coating
Compositing
Sonicating/Dispersing



Distribution

Product Use and Consumption

Cutting, Sanding, Grinding, Heating, Sonicating/Dispersing

Degradation/Leaching Affected by Environment and Weathering

Disposal

Recycle → **Other**

Images courtesy of Matthew Dahm, Doug Evans, Mary Schubauer-Berigan, NIOSH

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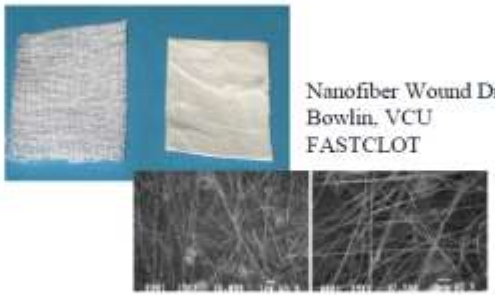
Food, Health Care and Medical

RipeSense.co.nz

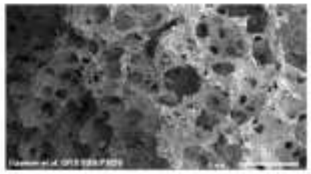
timestrip.com



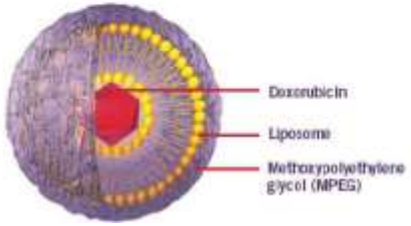
Nanofiber Wound Dressings
Bowlin, VCU
FASTCLOT

3M's FilTek® restorative dental

Acute lymphoblastic leukemia (ALL)
Sigma-Tau Pharmaceuticals



Stryker's Vitoss Bone Graft Substitute



Nanosphere

NIOSH

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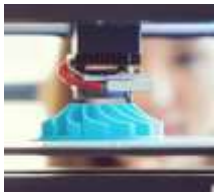
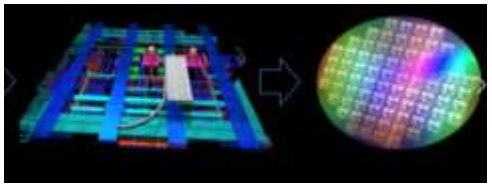
Some processes, some products, but all have a Nano element

Additive Manufacturing



3D Printing

Functional Fabrics



Photonics

Flexible Sensors

“Advanced Manufacturing”

Robotics

Light Weighting

Advanced Composites

Clean Energy

Engineered Biology

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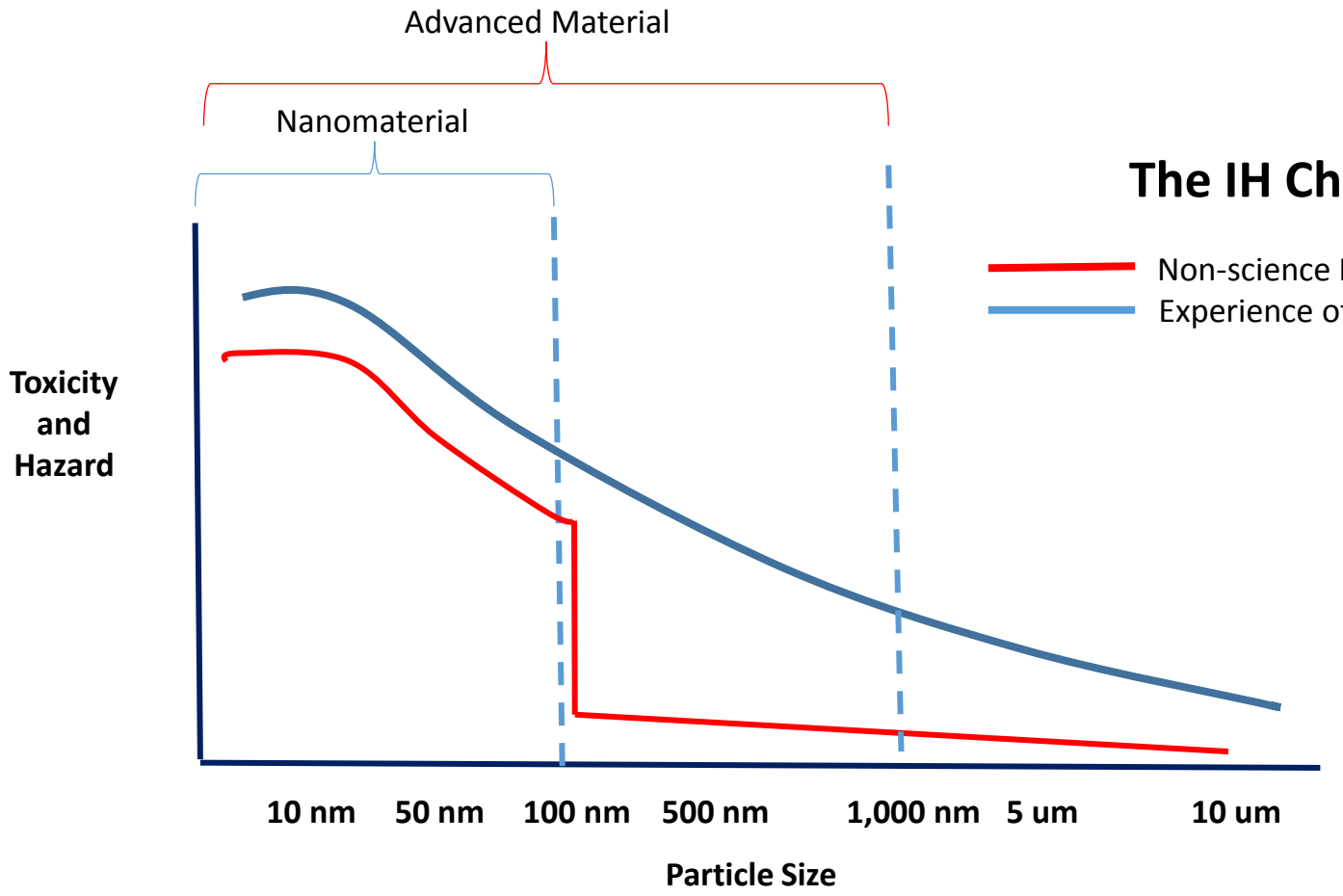
Why the Interest in 'Advanced Material"?

Advanced Materials refers to all new materials and modifications to existing materials specifically engineered to have novel or enhanced properties for superior performance over conventional materials, critical for the application under consideration.

Nano (Advanced) Material

~~Advanced~~ Nano Materials refers to all new materials and modifications to existing materials that are specifically engineered in the 1 to 100 nm scale to have novel or enhanced properties that result in superior performance relative to ~~conventional materials~~ their bulk counterparts that allow for novel applications, ~~that are critical for the application under consideration~~.

CLGeraci-11/17



Responsible Practice Needed

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NIOSH Site Studies

Exposure characterizations for a wide variety of Nano materials

- Active program since 2006.
- Completed >100 site visits.
- Summary results published.
- Basis for guidance.






Field Measurements

- Filter-cassette based
  - Elements and Electron Microscopy (EM)
  - PBZ, Source/ Area, Background
  - Full shift and task specific
  - With and without cyclones
  - Various filter media
- Data logging with DRI's
  - Source/Area and Background

Direct Reading Instruments (DRIs)

- TSI CPC 3007 (TSI Inc., Shoreview, MN)
  - Condensation Particle Counter
  - Measures particles between 10 nm and ~ 1 µm

- TSI OPS 3330 (TSI Inc., Shoreview, MN)
  - Optical Particle Counter with collection filter
  - 16 user defined bins
  - Measures particles between 300 nm -10 µm

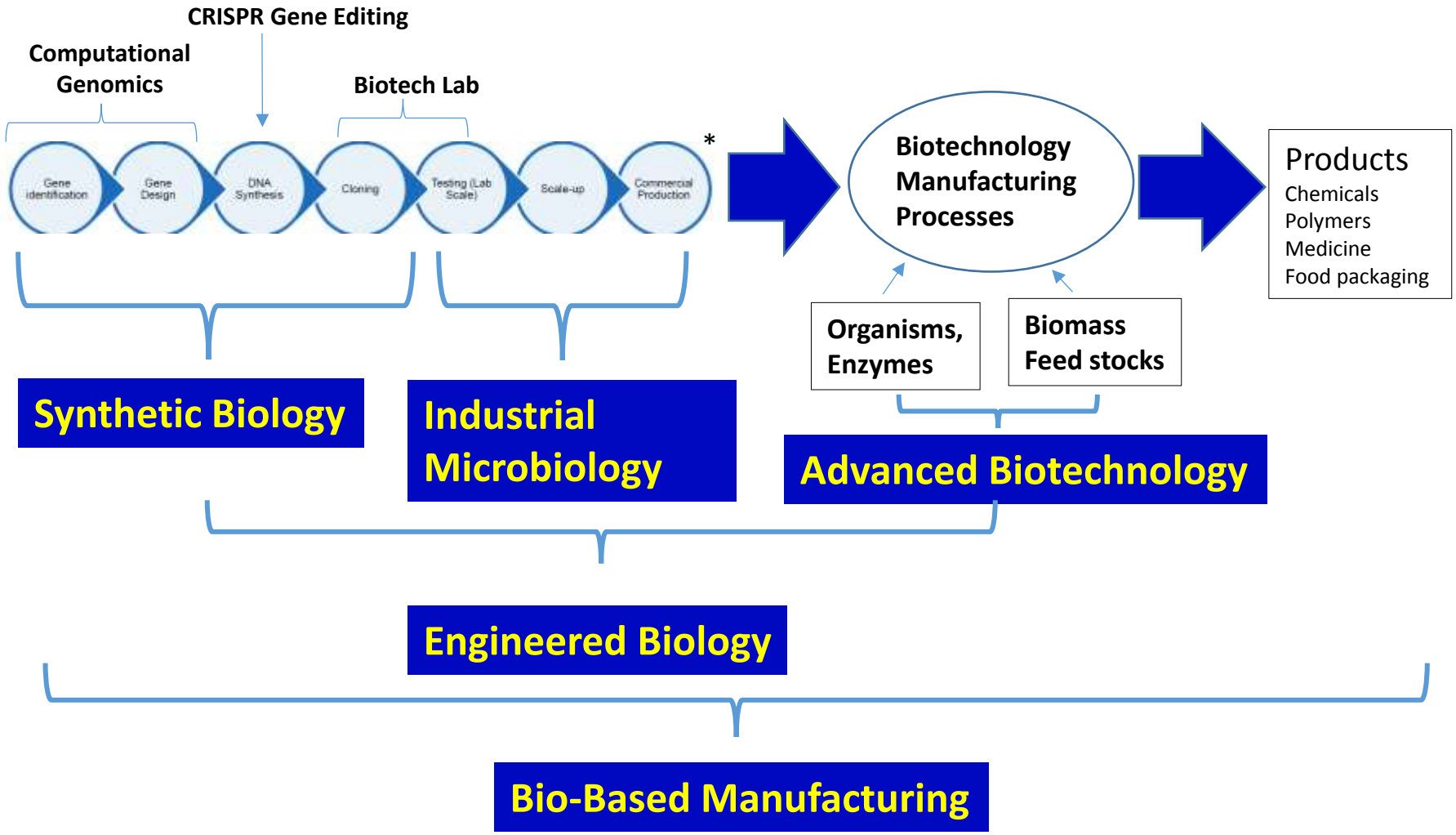
- TSI DustTrak DRX (TSI Inc., Shoreview, MN)
  - Optical Particle Counter with collection filter
  - 4 pre-determined size bins (1, 2.5, 4.0, and 10 µm)

Bio-Based Manufacturing

A new area of interest?

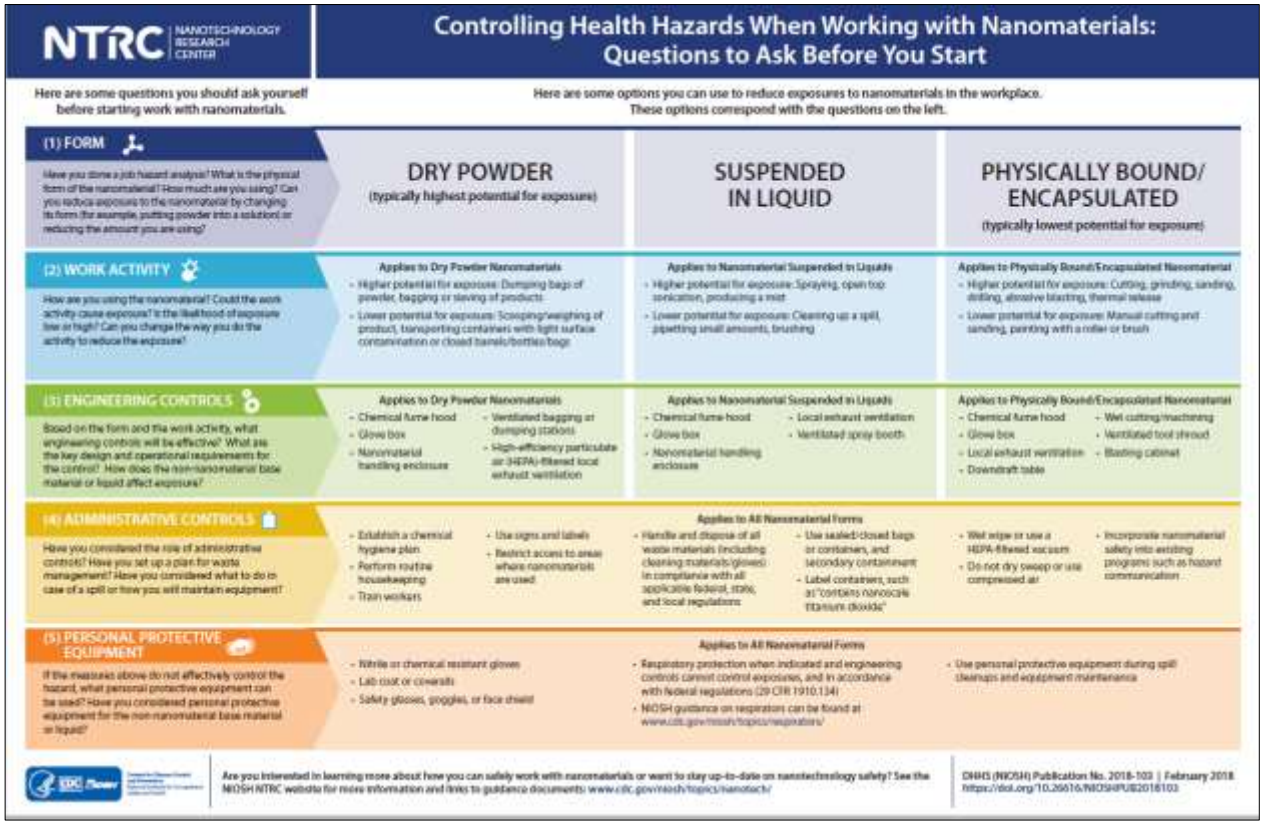
- Maybe for NIOSH
- Maybe not for Pharma

Elements of Biology – Based Manufacturing



* Adopted from Lux

Recent Guidance



Practical approaches to evaluating hazards and controlling exposures.
https://www.cdc.gov/niosh/topics/nanotech/pubs.html

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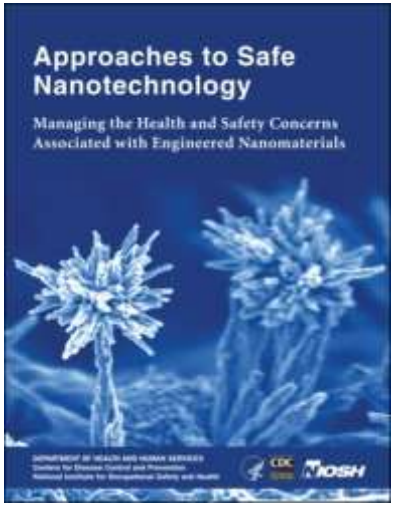
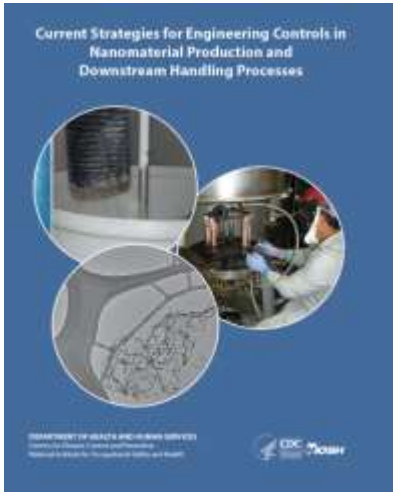
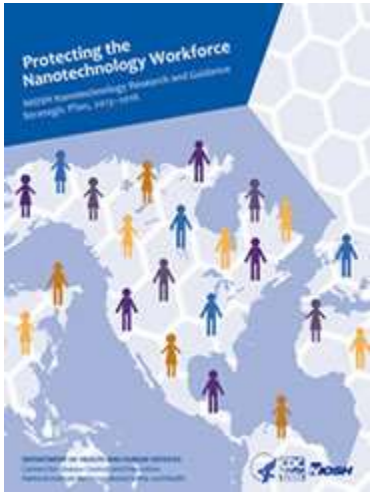
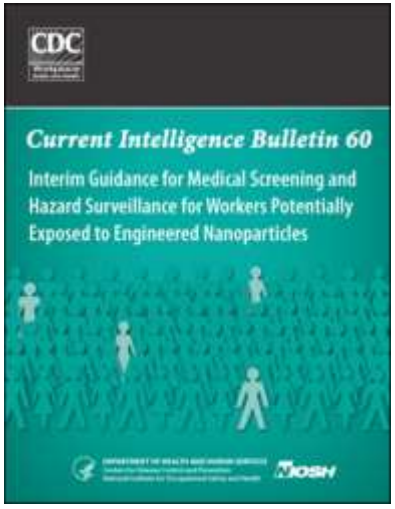
Key Communication Products

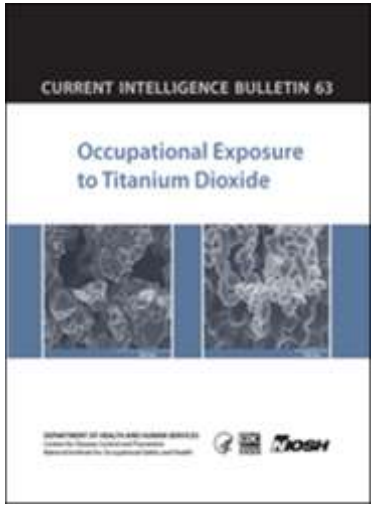
www.cdc.gov/niosh/topics/nanotech

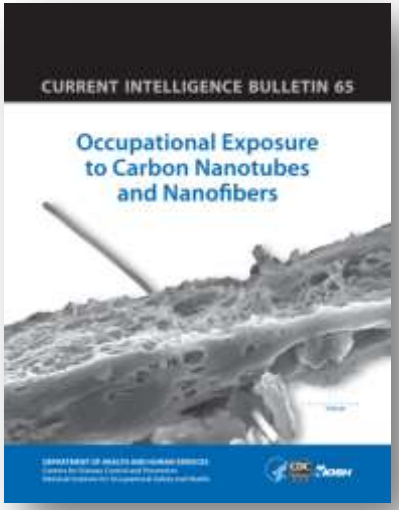






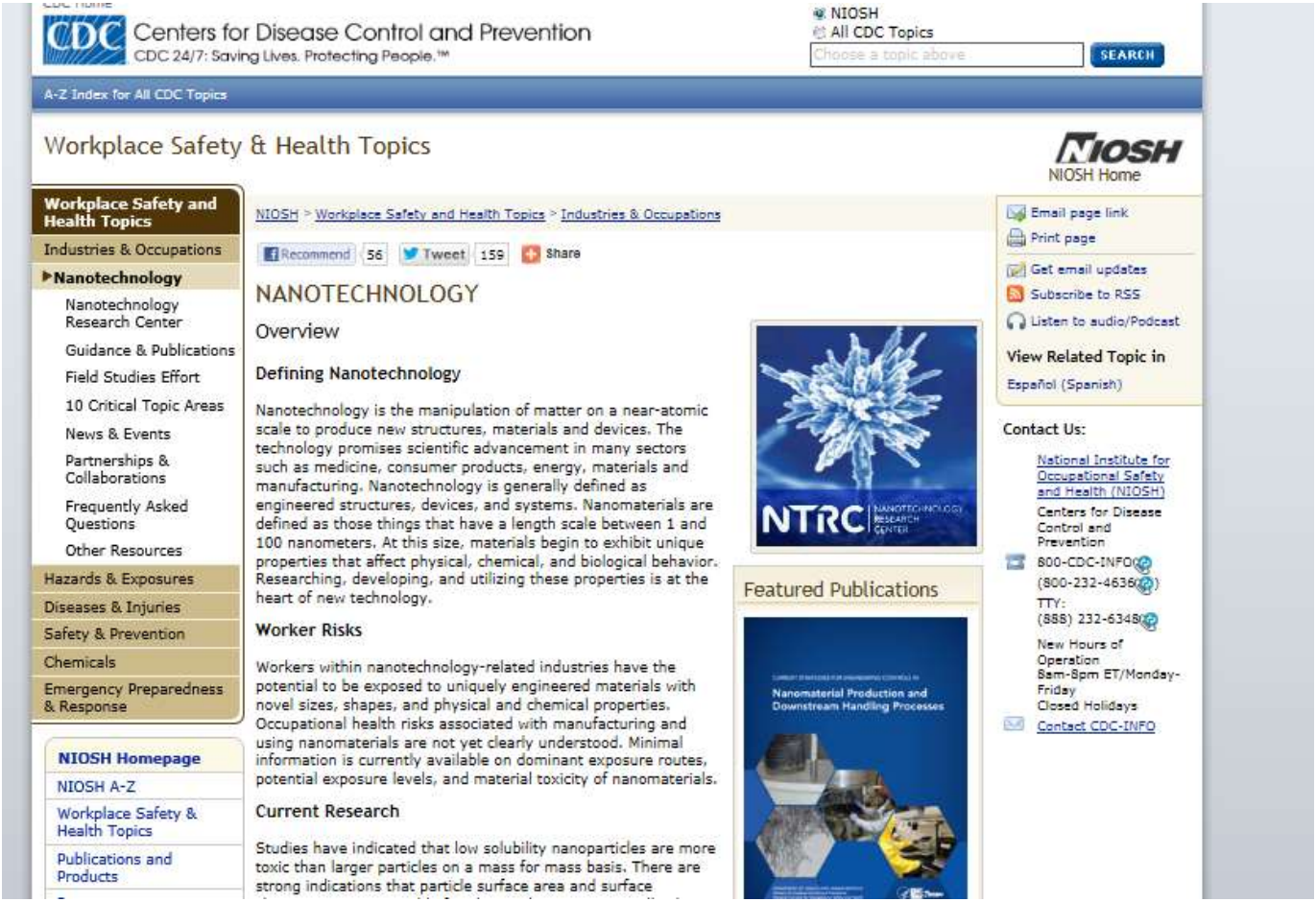






NIOSH Nanotechnology Topic Page

http://www.cdc.gov/niosh/topics/nanotech/



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