

A Trainer's Approach to Increase Awareness of Engineered Nanomaterials in Construction

Gavin H. West, MPH, Director of Nanomaterials Research
CPWR – The Center for Construction Research and Training
gwest@cpwr.com | (301) 495-8522

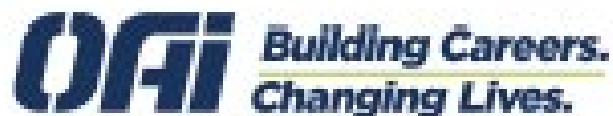


NATIONAL TRAINERS' EXCHANGE

EMERGING WORKPLACE HAZARDS: Creating Adaptable and Innovative Safety and Health Training

May 2–4, 2023 / Indianapolis, Indiana

Hosted by



In conjunction with



Overview of today's session:

1. Background on CPWR and our training on nano
2. Review course learning objectives and technical content
3. Opportunities to share and discuss throughout

CPWR has served as the NIOSH National Construction Center since 1990



[A-Z Index](#) [Lista de recursos en español](#)

[RESEARCH](#) [TRAINING](#) [SERVICE](#) [NEWS & EVENTS](#) [ABOUT CPWR](#)



**NATIONAL SAFETY
STAND-DOWN
TO PREVENT FALLS
IN CONSTRUCTION**

MAY 1-5, 2023



[Work Safely in Hot Weather](#)



[Partner with CPWR in our application to serve again as the National Construction Center](#)

Yes No

[New Checklist Improves Pre-task Planning](#)

Yes No

Yes No



[4/26 -- Protección Contra Caídas y los Planes de Rescate](#)

- Non-profit organization
- Created by North America's Building Trades Unions



www.cpwr.com

CPWR's research, training, and service programs are integrated

*Dissemination/ Promotion
of Results*

*Training Evaluation
Instructor Feedback*

SERVICE

Medical Screening
Program

RESEARCH

National Construction
Center Research
Programs

TRAINING

DOL/OSHA, NIEHS
Programs

Health Data

*Training Resources and Research Findings
Incorporated Into Training Programs*

I'm a researcher who recognizes the importance of what you do as trainers



We're all here to share and learn from each other

I'm thankful to work with a great team on the curriculum development and delivery



Bruce Lippy, PhD, CIH, CSP, FAIHA
CPWR Consultant



Sara Brooks, MPH
CPWR Industrial Hygienist

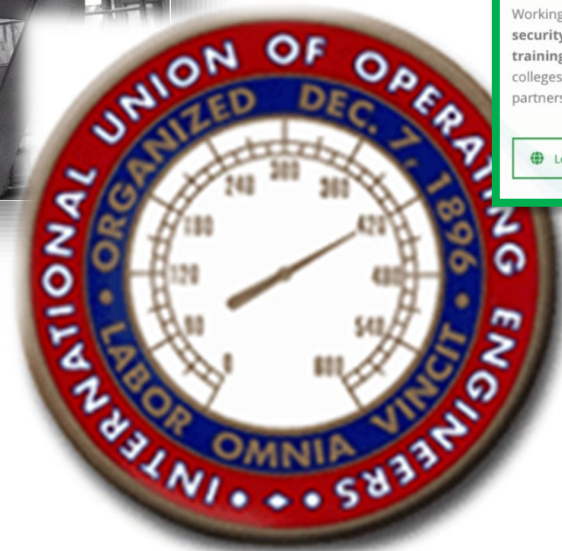


Bill Kojola, MS
AFL-CIO (retired)

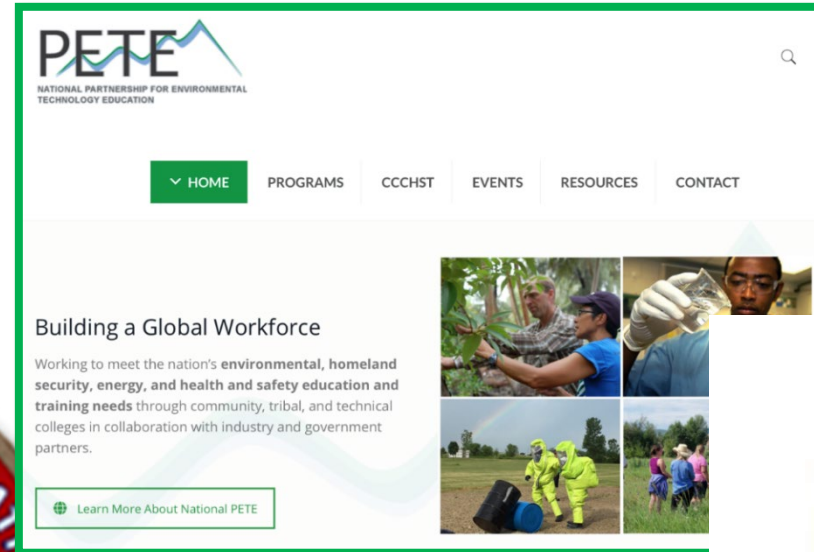
We use a train-the-trainer approach and tailor the content to different audiences



IUPAT / FTI



IUOE



National PETE
CCCHST



Insulators

We designed a group exercise for CCCHST based on an actual event



A truck transporting several bags each holding 750 kg (1650 lbs) of photocatalytic nano titanium dioxide (TiO_2) lost its cargo. Unprotected road maintenance workers did the clean up.

NIOSH classified nano-sized TiO_2 as a potential occupational carcinogen and recommended an exposure limit 8x lower compared to larger forms of TiO_2 .

Responding to an accidental spill of ENMs: Participants used documents, emergency response apps, and what they learned in the course to answer these questions

1. What actions would you take if you were the first responding unit on site?
2. Would you have highway maintenance crews doing the cleanup?
3. What cleanup methods would you use? What PPE?
4. Is there a fire risk?
5. What would you tell the school and businesses nearby to do?
6. What would you tell the local press?



**SDS group exercises
highlight deficiencies in
hazcom for nano**

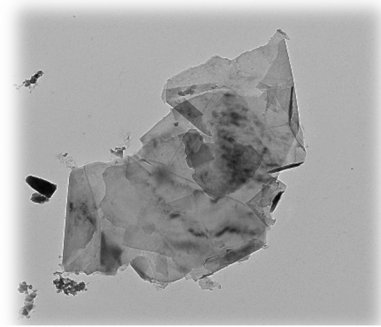
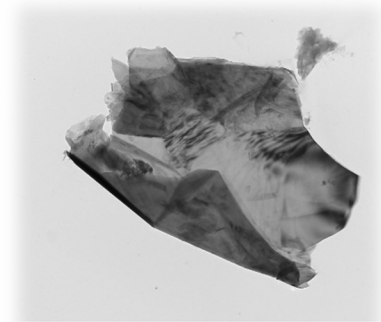
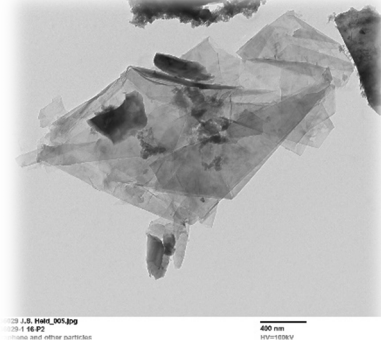


Participatory approaches have worked well for us along with assertion-evidence

Is anyone familiar with the assertion-evidence approach and willing to explain?



The training is updated to reflect current research including studies we conduct



Let's pause for discussion

What strategies and resources do you use to stay on top of new information and evolving best practices?

After this session you will be able to:



Explain nanotechnology using visual aids and familiar concepts



List 3 applications of engineered nanomaterials in construction



Discuss what is known about risks and controls



Use information about engineered nanomaterials in your courses

Explain nanotechnology using visual aids and familiar concepts

Objective 1



What is nanotechnology?

Science, engineering, and technology conducted at the size range of about **1 to 100 nanometers**

<https://www.nano.gov/nanotech-101/what/definition>



A yard is roughly a meter

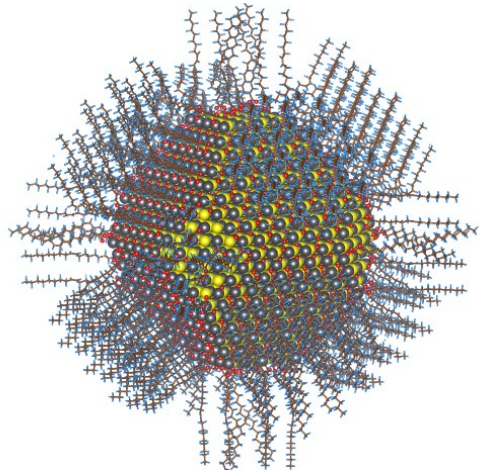



Think about cutting that into a **billion** sections

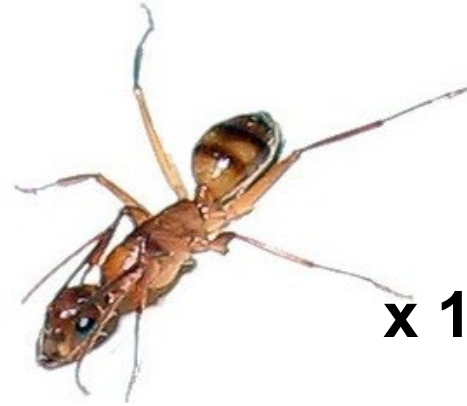


Getting a handle on size

This nanoparticle is one million times smaller than an ant




x 1,000,00

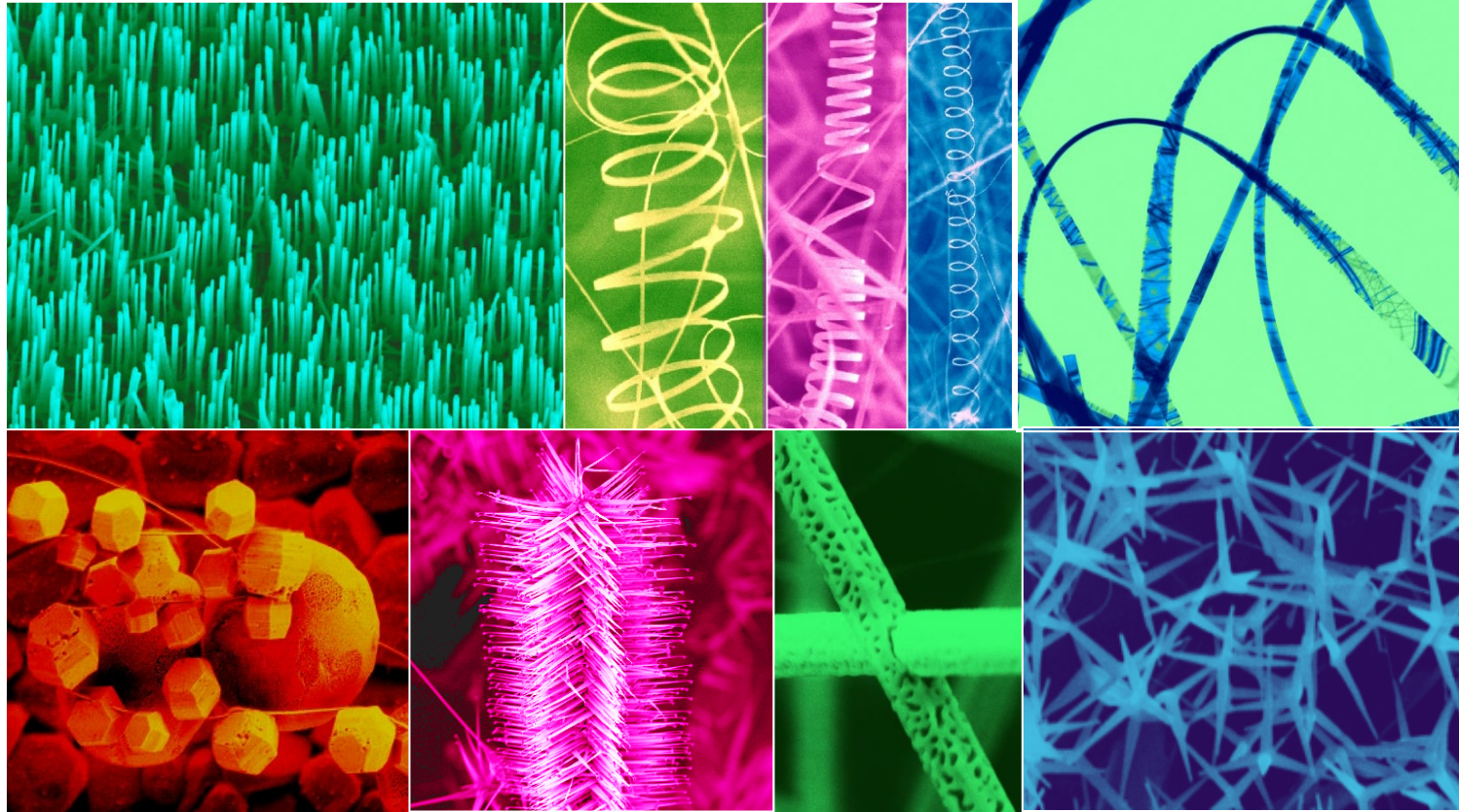


x 1,000,000



Indy 500 racetrack, 2.5 miles long.

What is an *engineered* nanomaterial (ENM)?

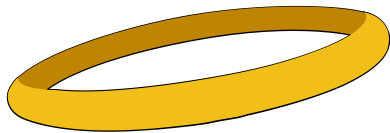
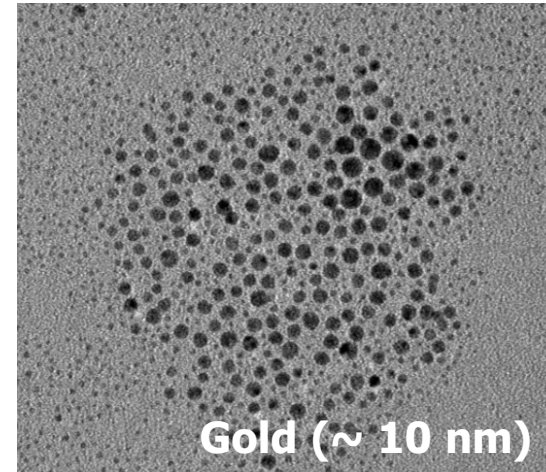
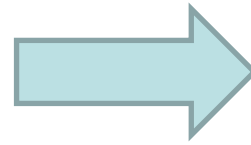


An object 1 to 100 nanometers in at least 1 dimension
created by human beings for some purpose

Welding generates fumes that contain nanoparticles. Are they engineered nanoparticles?



Can nanomaterials differ from larger forms of the same material?

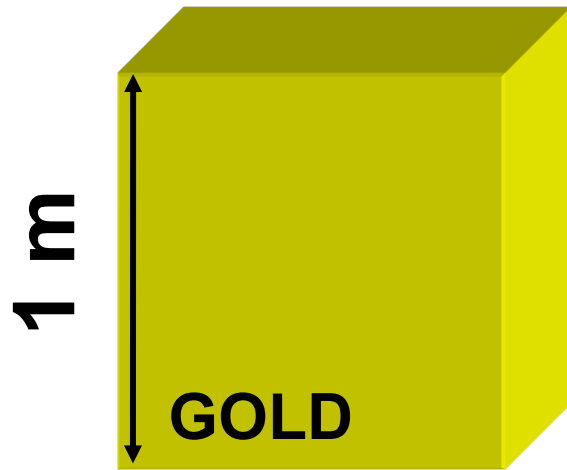


Bulk gold is yellow,
nonmagnetic,
inert

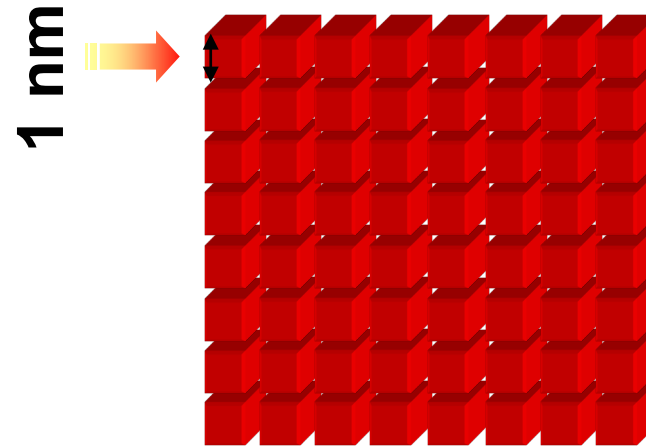


Nano gold is red,
magnetic,
explosive

Surface area is another major difference



Each side = 1 m (3.28 ft)
Weight roughly 43,000 lbs
Surface Area = 64.6 ft²



Each side = 1 nm
Mass stays same, 43,000 lbs
Surface Area roughly 2,500 miles² (State of Delaware)

Let's pause for discussion

- What strategies or techniques do you use to make technical information easier to understand?

**List three applications of
engineered nanomaterials in
construction**

Objective 2



One prediction ten years ago was that by 2025, over 50% of building materials will contain nanomaterials

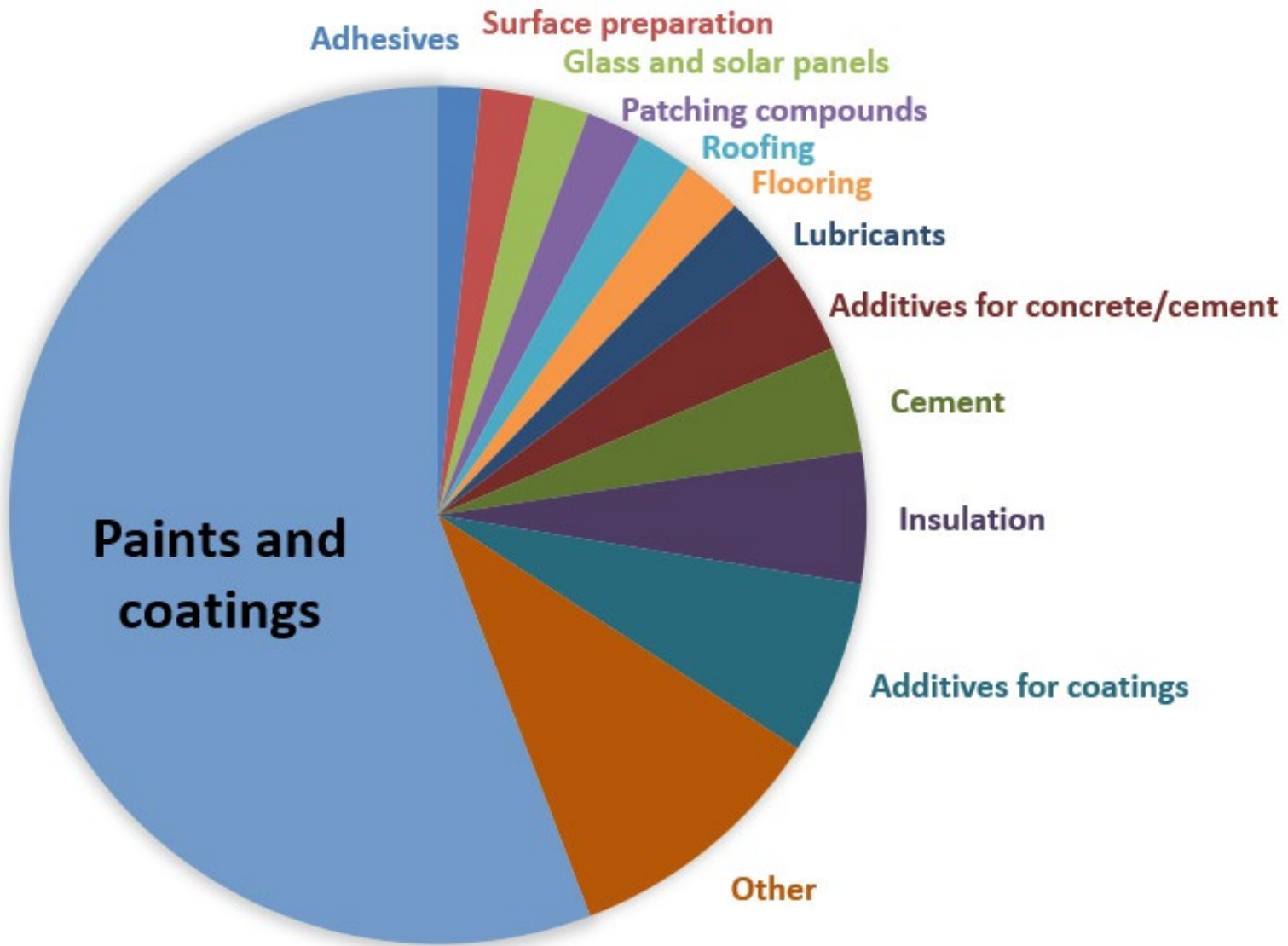


<https://aecom.com/blog/for-future-cities-think-small-as-in-nano-2/>

CPWR has documented “nano” claims for 873 construction products

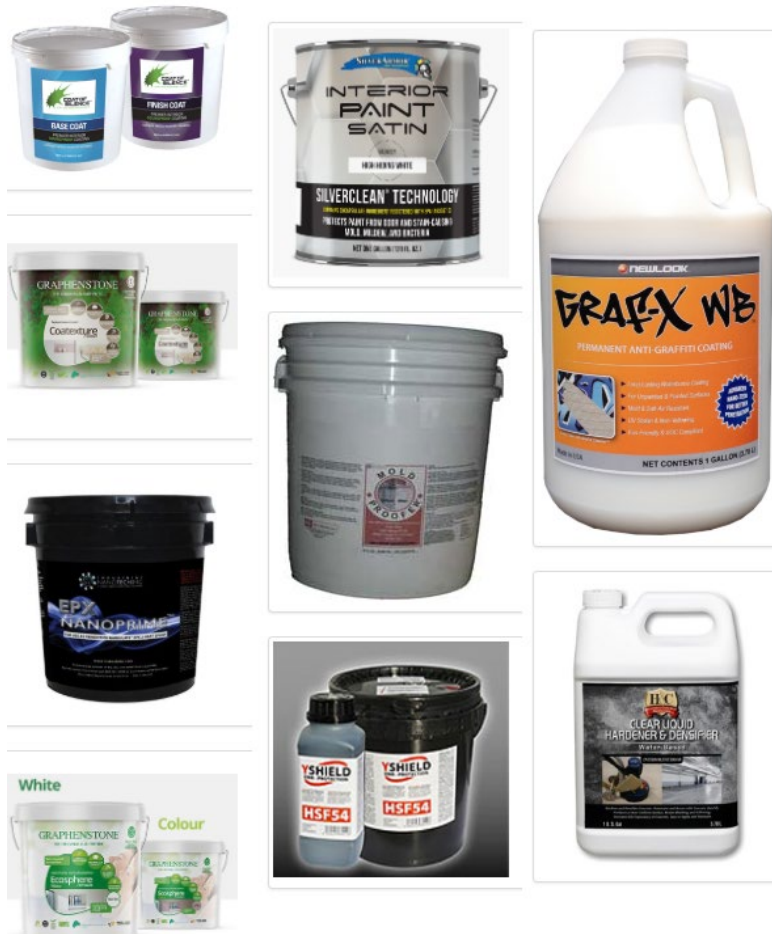


www.nano.elcosh.org



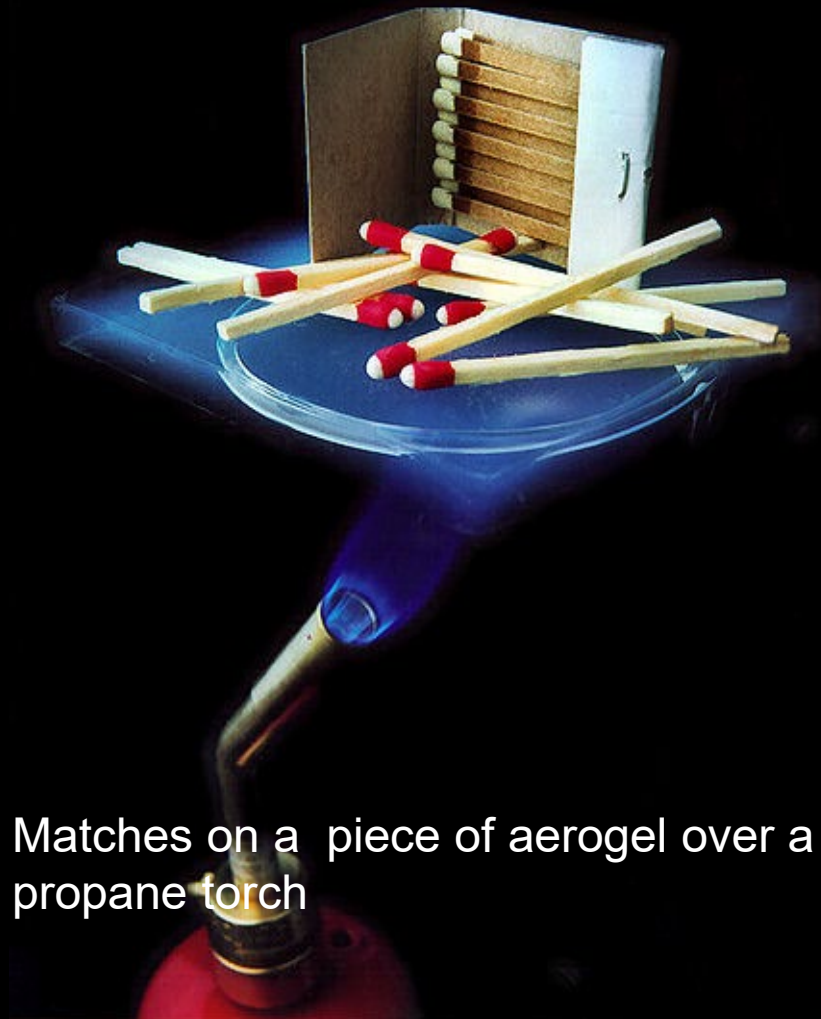
Paints and coatings dominate the inventory

The inventory helps to make the training trade-specific (e.g., painters)



- Anti-graffiti
- Anti-corrosive
- Anti-microbial
- Anti-pollution
- Densifying
- Self-cleaning
- Self-healing
- UV protective
- Water repellent
- Anti-corona virus

Case study: The insulators union worked with structured insulation material



Matches on a piece of aerogel over a propane torch



A 2.5 kg brick supported by a piece of aerogel with a mass of 2 grams

...but members experienced dustiness, skin rashes and bloody noses. They asked NIOSH to help.

Photo courtesy Aspen Aerogels



Evaluation of Aerogel Insulation Particulate at
a Union Training Facility

Karl D. Feldmann, MS, CIH
Kristin Musolin, DO, MS
Mark M. Methner, PhD, CIH

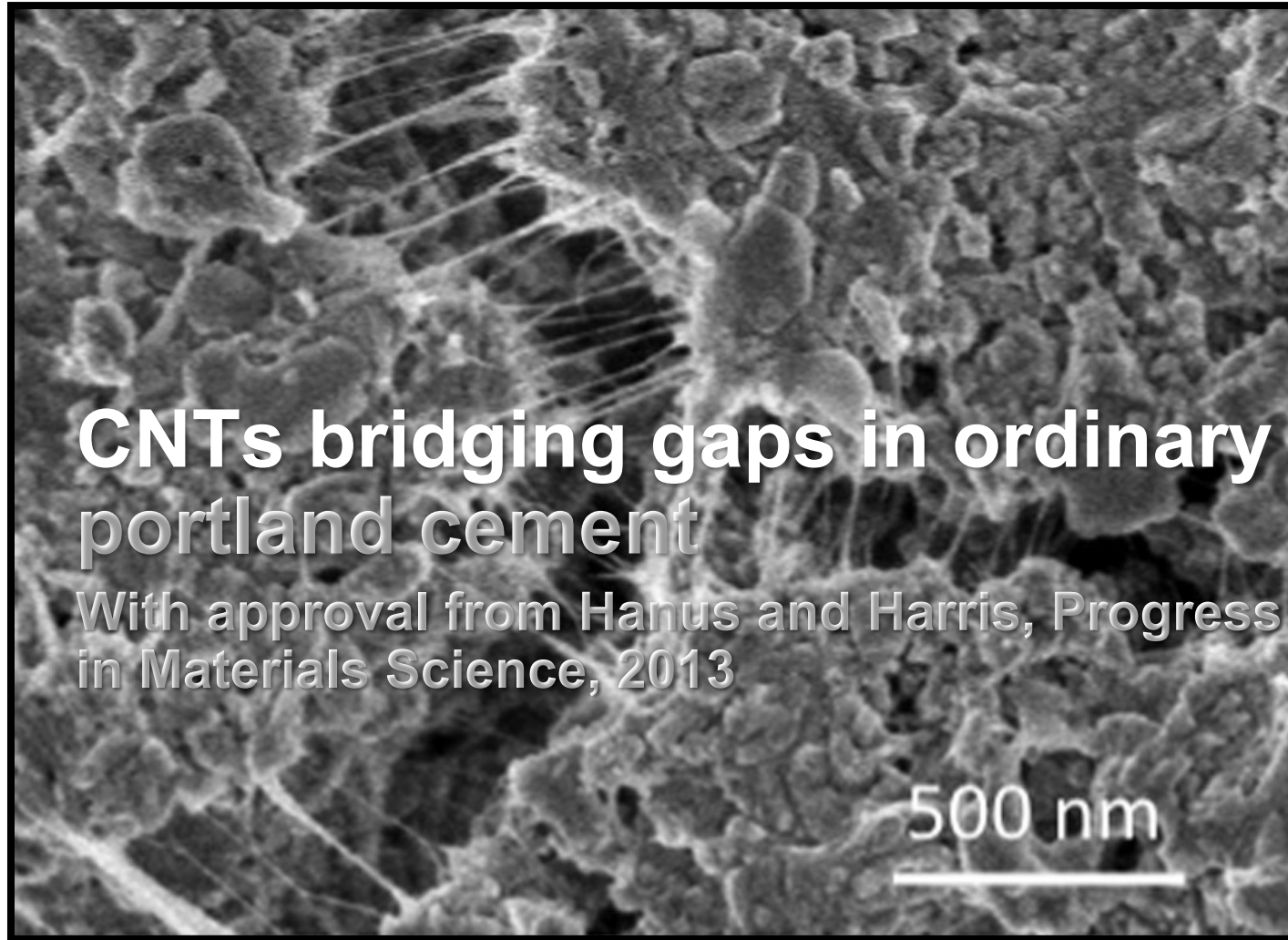
Health Hazard
Evaluation Program

Report No. 2014-0026-3230
March 2015

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health



Carbon nanotubes can reinforce cement at **100X the tensile (stretching) strength of steel at a fraction of the weight**



Carbon nanotubes are still being added to concrete roughly a decade after early testing began

In 2015, concrete road surface enriched with carbon nanotubes was tested on a portion of I-20 in GA and approved by GA DOT

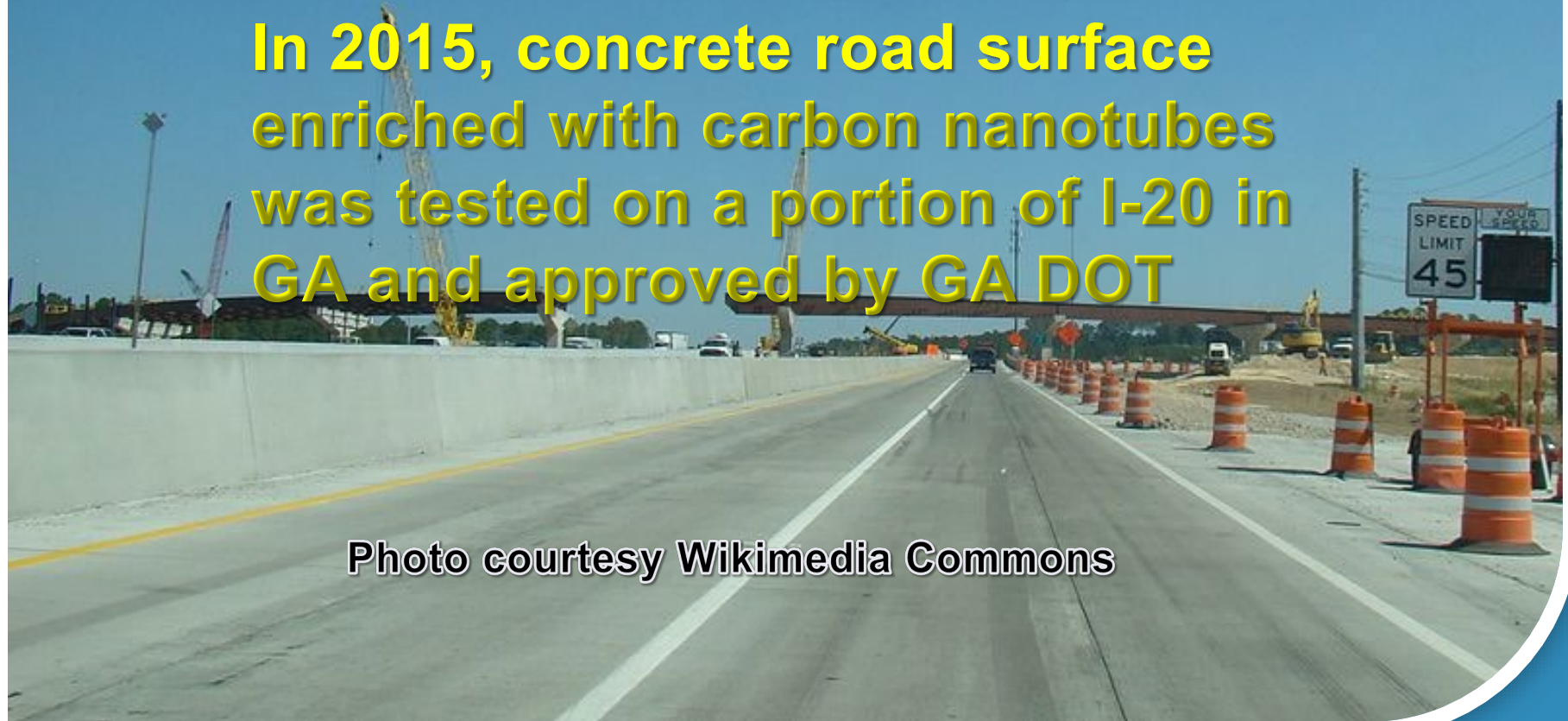


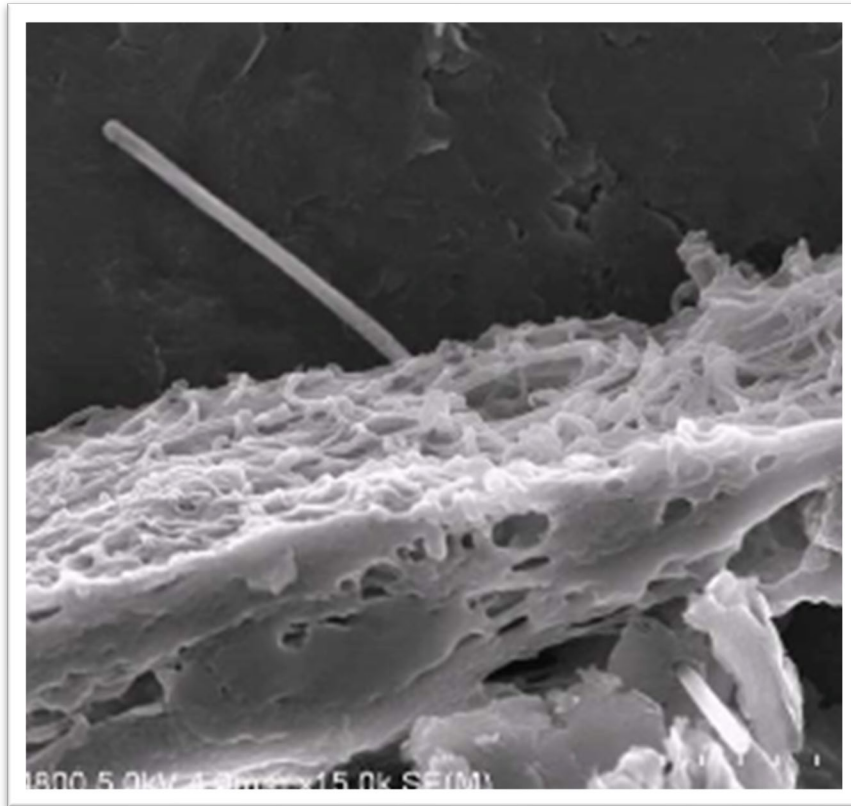
Photo courtesy Wikimedia Commons

Discuss what is known about engineered nanomaterial risks and exposure controls

Objective 3



Multi-walled carbon nanotubes have caused asbestos-like disease in lab animals (Suzui 2016; Takagi 2008; Poland 2008)



Multi-walled carbon nanotube penetrating the pleura of the lung. Courtesy of Robert Mercer, and Diane Schwegler- Berry, NIOSH

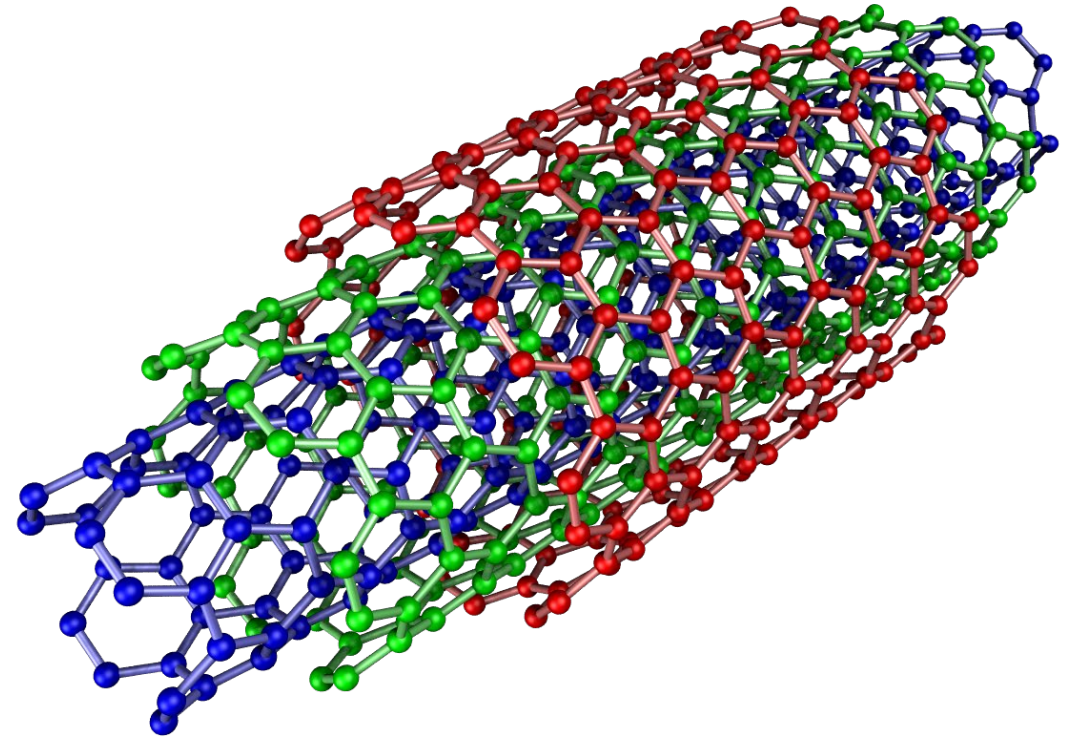


Diagram of multi-walled carbon nanotube
Courtesy of Eric Wieser and Wikimedia

Human health effects caused by ENM exposures remain largely unknown

But there is cause for concern based on:

- Air pollution research
- Laboratory tests in cells and animals

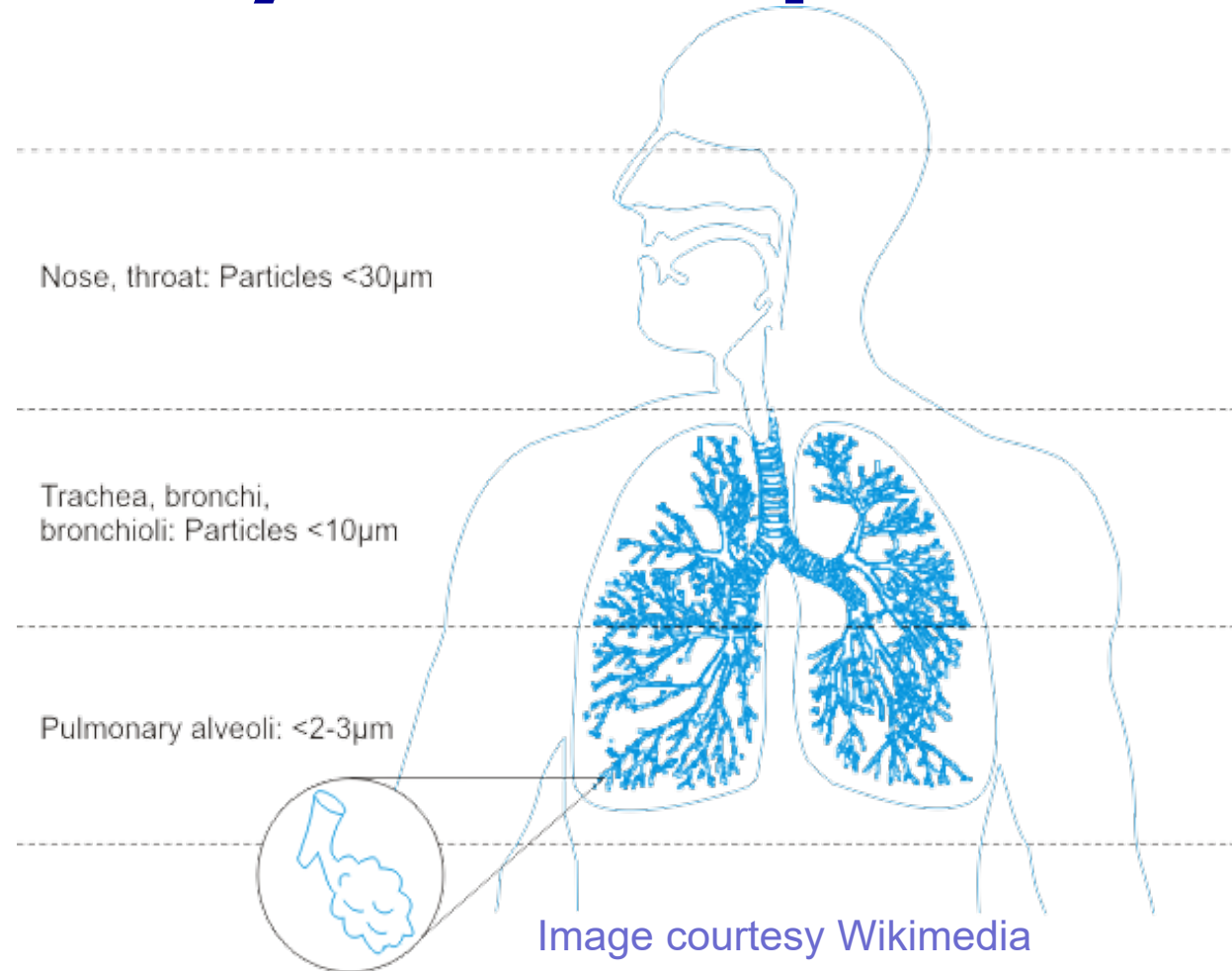


A 2019 review of worker health effects concluded that

“In this state of uncertainty, **precautionary controls for each engineered nanomaterial are warranted** while further study of potential health effects continues.”

Like other airborne hazards, **inhalation** is the main route of entry for nanoparticles

- Airborne NPs can be inhaled and deposited in the respiratory tract
- Inhaled NPs may enter the blood stream and move to other organs



Metal nanoparticles have been shown to penetrate **flexed, damaged or diseased skin**

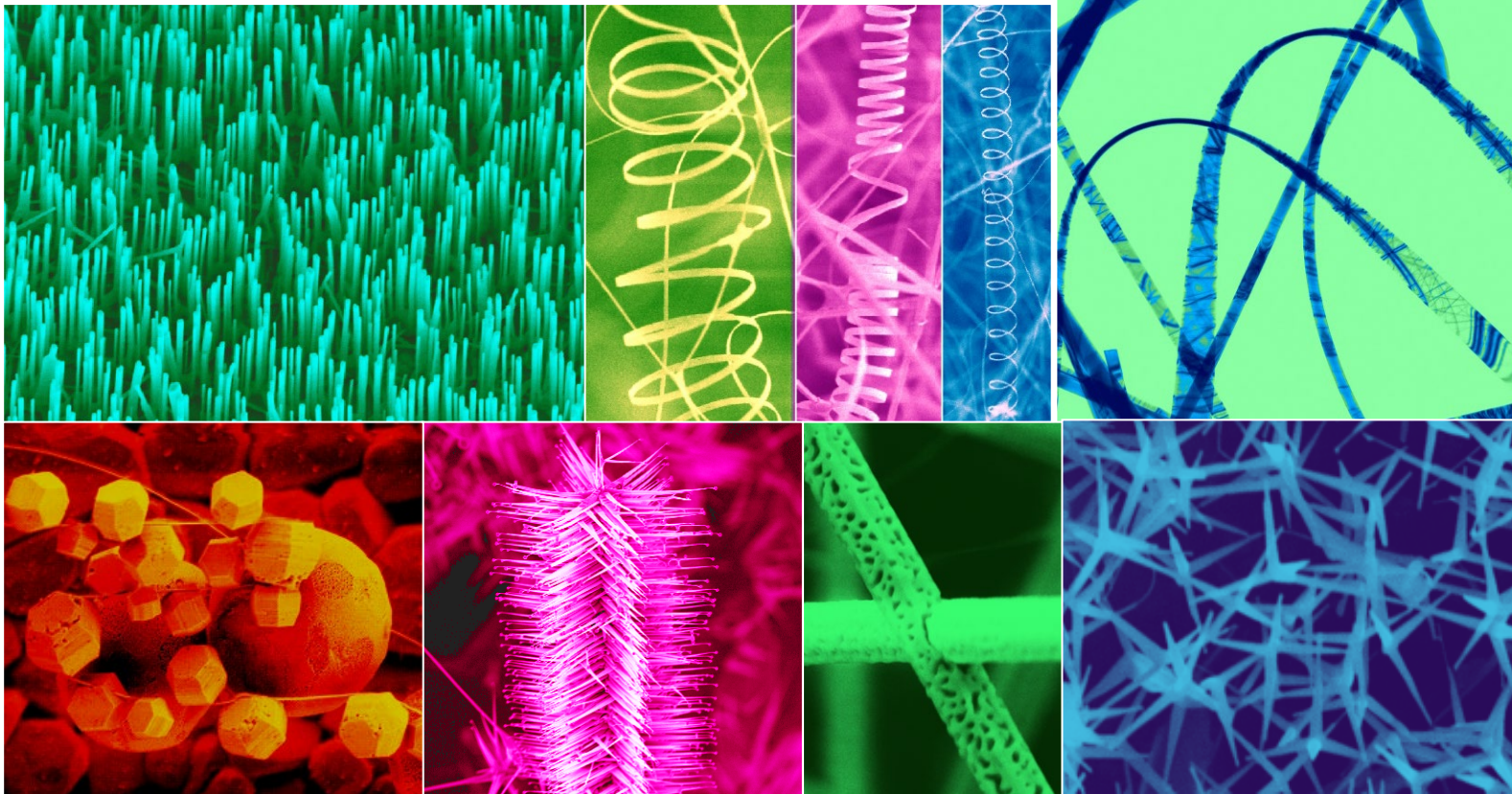


Photo courtesy International Union of Operating Engineers



Photo courtesy J. Vinton Schafer & Sons, Inc. and CCBC

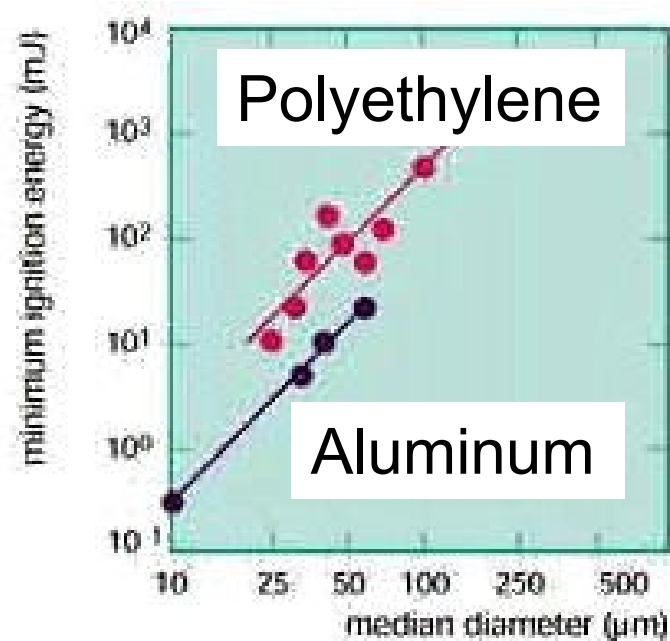
Remember this slide from earlier?



These are all nano zinc oxide

Image courtesy Dr. Zhong Wang, Georgia Tech

From a **safety** perspective, flammability and explosivity of nano-powders must be considered



Netherlands Organization for Applied Scientific Research

Slide courtesy John Howard

NIOSH has Recommended Exposure Limits (RELs) for 3 nanomaterials

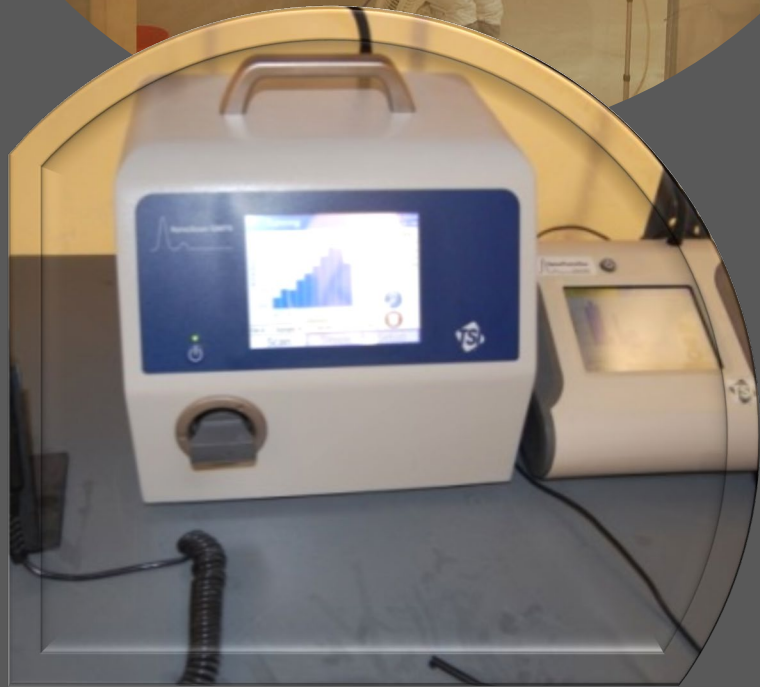
- Carbon Nanotubes and Nanofibers
- Titanium Dioxide
- Silver
- **NO OSHA PELs for any nanomaterials!**



However, official OSHA guidance recommends following all NIOSH RELs



CPWR conducted multiple exposure studies involving paints, coatings, and cementitious materials



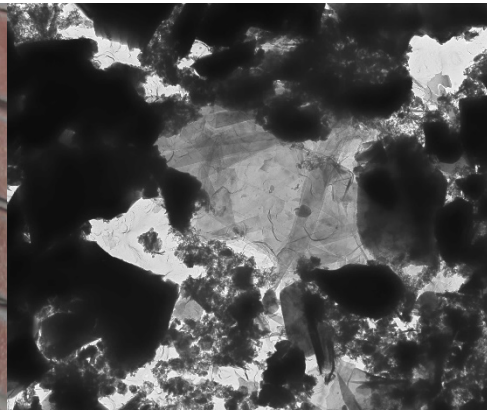
What have task-based exposure studies shown?



Spraying nano paints and coatings may **exceed** occupational exposure limits

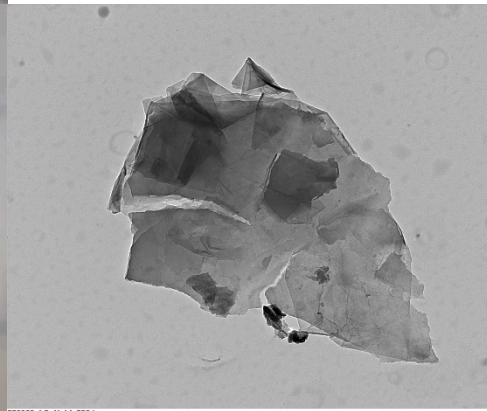
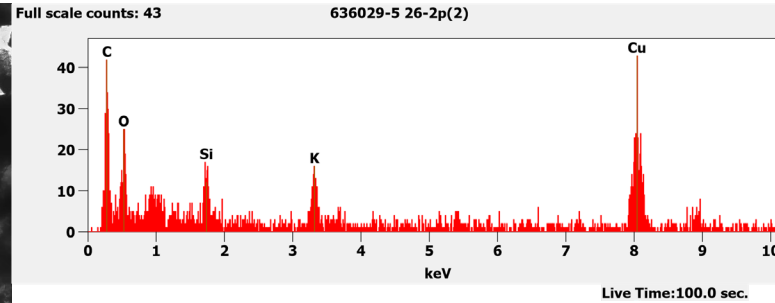


High energy tasks appear to increase the likelihood of ENMs being released in higher quantities from composites



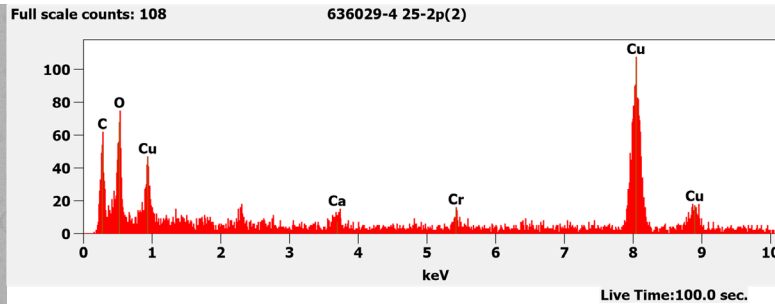
636029 J.S. Heisl_028.jpg
 636029-88 26-P2
 Graphene and particulate
 Cal: 0.003762 µm/px
 14:18 5/17/2022
 Microscopist: Andreas Saldivar
 Camera: NANOSPRT5, Exposure: 840 (ms) x 5 drift frames, Gain: 1, Bin: 1
 Gamma: 1.00, No Sharpening, Normal Contrast

1 µm
 HV=100kV
 Direct Mag: 2000 x
 AMA Analytical Services, Inc



636029 J.S. Heisl_023.jpg
 636029-4 26-P2
 Graphene
 Cal: 0.001430 µm/px
 13:29 6/17/2022
 Microscopist: Andreas Saldivar
 Camera: NANOSPRT5, Exposure: 840 (ms) x 5 drift frames, Gain: 1, Bin: 1
 Gamma: 1.00, No Sharpening, Normal Contrast

400 nm
 HV=100kV
 Direct Mag: 7200 x
 AMA Analytical Services, Inc



Our research shows that exposure controls used in construction are effective

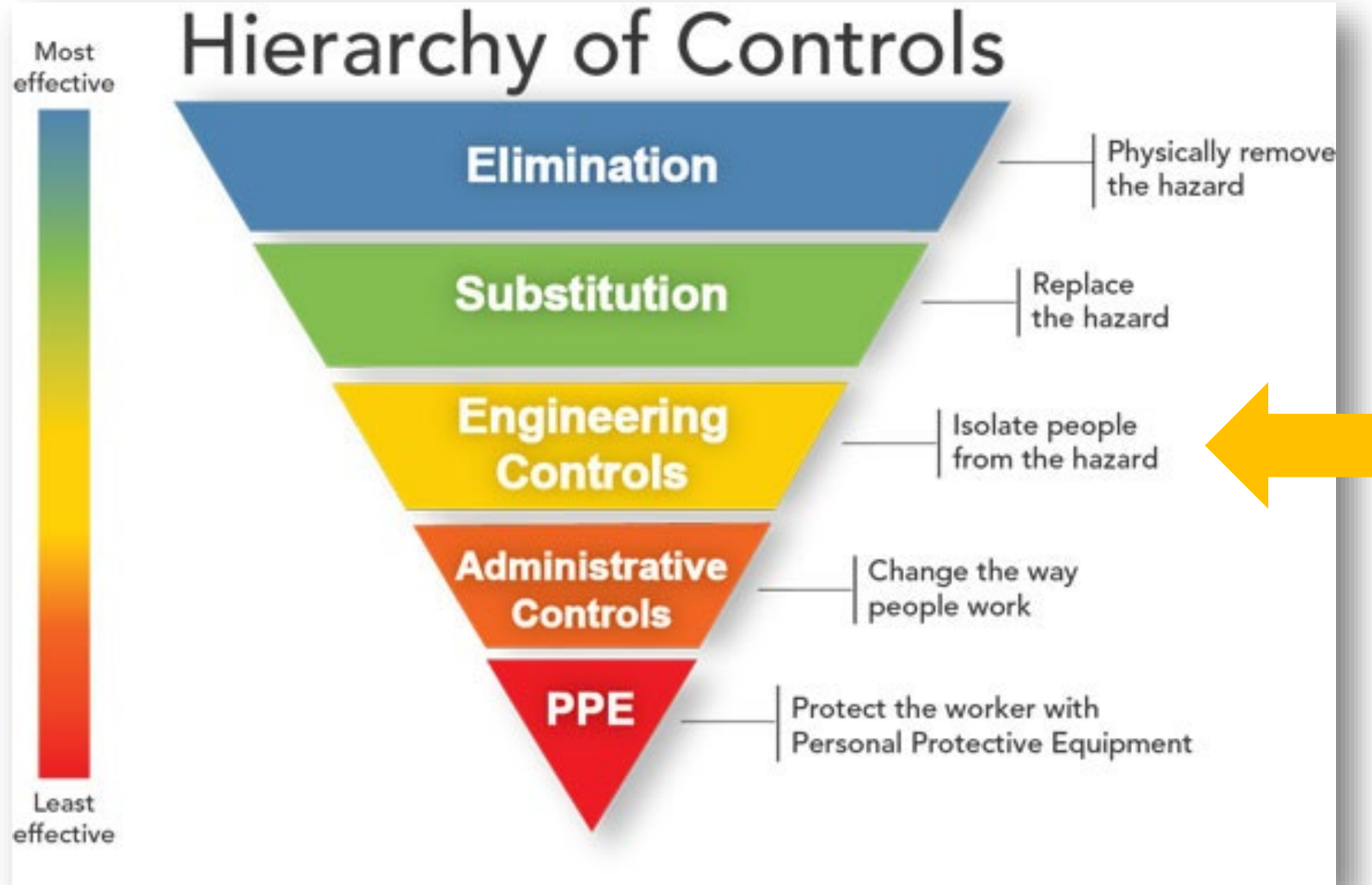


Photo courtesy
Earl Dotter

Wet methods will work too!



Image credit:
Kiewit Power Constructors



Work practices can make a difference because of “bystander exposures”



Spraying nano coating on glass
Photo courtesy Broekhuizen



Photo courtesy Zenjiro and Wikimedia

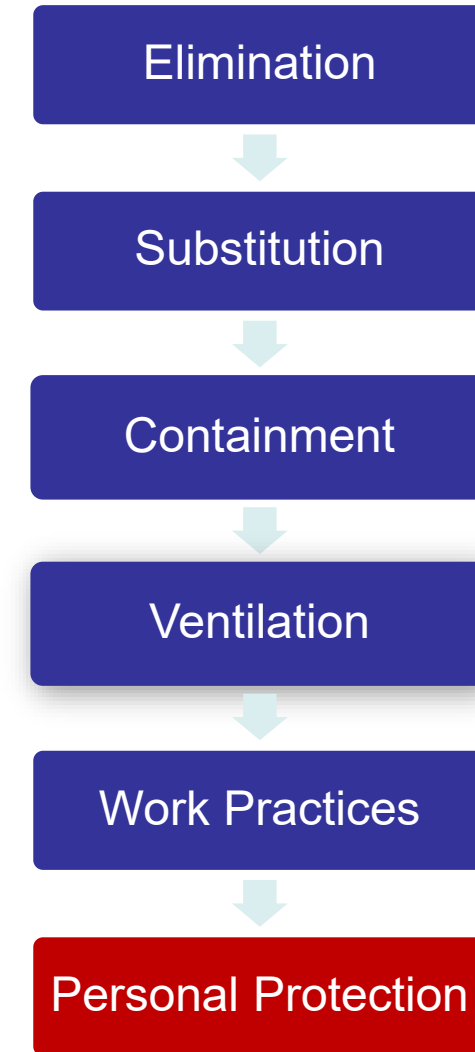
PPE

Will respirators work against nanoparticles?

- Full-face



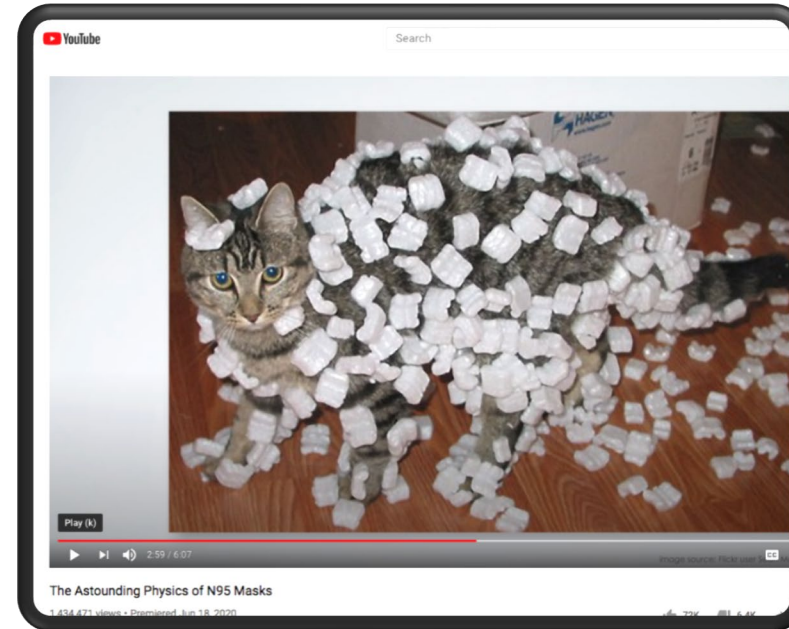
- Half-face



Yes! HEPA filters capture nanoparticles



3M half-face air-purifying respirator with P100 particulate filter and organic vapor (OV) cartridges



**Great video on how
filtration works!**

<https://www.youtube.com/watch?v=eAdanPfQdCA&feature=youtu.be&t=9>

**Use information about
engineered nanomaterials
in the courses you teach**

Objective 4



The news & info section of elcosh nano has a collection of articles by topic

The screenshot displays the elcosh nano website interface. At the top left is the elcosh NANO logo with the tagline "Construction Nanomaterial Inventory". The navigation bar includes "Product Categories", "News/Info" (highlighted with a red box), "About", and "elcosh Home".

The main content area is divided into several sections:

- Text Article:** A paragraph discussing the introduction of nano-enabled products in construction and the role of CPWR in creating a nanomaterial inventory.
- Search Bar:** A search input field with the placeholder text "Enter search terms..." and a magnifying glass icon.
- Product Categories:** A list of categories with item counts: Abrasive blasting media (1), Additives for asphalt (4), Additives for coatings (29), Additives for concrete/cement (21), Adhesives (12), and Boiler additives (1).
- NEWS AND RELATED INFORMATION:** A section with an orange header and a red box around it, containing three news items:
 - Highway contractor Amey trials graphene-enhanced asphalt:** An asphalt additive containing a graphene and plastic supermodifier is to be trialled on a road in north Kent in the UK...
 - NIOSH publishes Nanotechnology Research Center (NTRC) One-Pager:** The NTRC develops recommendations that support responsible development of nanotechnology. This snapshot shows recent ac...
 - Common Food Additive Causes Adverse Health Effects in Mice:** Titanium dioxide nanoparticles, a common food additive recently banned in France but allowed in the U.S. and many othe...
- Product Cards:** Two cards for "Adi-Con CSF" (Additives for concrete/cement) and "Silica Thickener" (Additives for coatings), both from Gemite®.

We continue adding to our collection of nano toolbox talks, which received over **10,000 downloads** in one year



Photo courtesy: Morgan Zavertnik and Hoar Construction

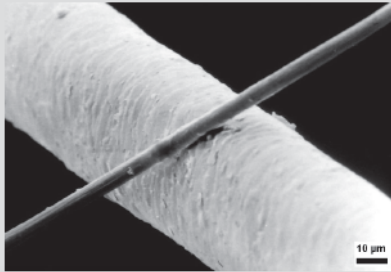


<https://www.cpwr.com/research/research-to-practice-r2p/r2p-library/toolbox-talks/>

What are Nanomaterials?

There are many kinds of nanomaterials, but they all share a remarkably small size (roughly 100,000 times thinner than a human hair). At this size, they can add new properties to many construction products.

Nanoparticles exist in nature and in man-made combustion sources, but this alert is about manufactured nanomaterials that are added to products. These products are called nano-enabled.

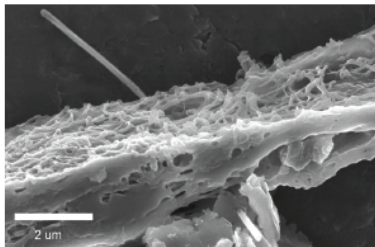


A carbon nanotube laying across a human hair

What are the risks?

Some nanomaterials may be safe, but others have been shown to be toxic in the lab. Of particular concern are respiratory exposures to long, thin fibers, such as carbon nanotubes (CNTs). Certain types of CNTs cause lung problems in rodents, similar to asbestos. Nanoparticles don't seem to penetrate healthy skin but may get through damaged skin. Nanomaterials can be released from nano-enabled products, but the risks are not well understood.

The key is to limit exposure.



Multi-walled carbon nanotube penetrating the lung

PROTECT YOURSELF

1 Learn about nanomaterials in your trade

CPWR maintains a website called **eLCOSH Nano** that features over 450 products that may be nano-enabled.



Construction products that may contain nanomaterials include:

- ▶ Coatings
- ▶ Lubricants
- ▶ Cements
- ▶ Adhesives
- ▶ Insulation
- ▶ Patching compounds

2 Control dust

NIOSH and CPWR have demonstrated that dust collection systems attached to tools will reduce the number of nanoparticles along with normal dust. Wet methods will work, too.



Worker with full protective gear conducting CPWR test inside a special chamber using a dust collection system

3 Wear a respirator

Testing shows that nanoparticles do **NOT** get through high efficiency respirator filters. Reduce dust first with a dust collection system or water. If dust levels are still high, use a respirator.



If you think you are in danger:

Contact your supervisor.
Contact your union.

Call OSHA
1-800-321-6742

Find out more about construction hazards.

To receive copies of this Hazard Alert and cards on other topics
call 301-578-8500



8484 Georgia Avenue
Suite 1000
Silver Spring, MD 20910
301-578-8500
www.cpwr.com

© 2015, CPWR – The Center for Construction Research and Training. All rights reserved. CPWR is the research, training, and service arm of North America's Building Trades Unions, and works to reduce or eliminate safety and health hazards construction workers face on the job. Production of this card was supported by Grant OH009762 from the National Institute for Occupational Safety and Health (NIOSH). The contents are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH.

COVER PHOTO: Air sampling during cutting of photocatalytic roofing tiles

HAZARD ALERT

NANOMATERIALS



It's available on CPWR's main website (also in Spanish)

<http://www.cpwr.com>

ADVERTENCIA DE PELIGRO
CPWR (CONSTRUCTION PRACTICE WORKERS' CENTER)
CENTRO DE TRABAJADORES DE LA CONSTRUCCIÓN

NANOMATERIALES



¿Qué son Nanomateriales?

Hay muchos tipos de nanomateriales, pero todos comparten un tamaño muy pequeño (aproximadamente 100.000 veces más delgados que un pelo humano). Con este tamaño, se pueden añadir nuevas propiedades a muchos productos de construcción.

Las nanopartículas existen en la naturaleza y en las fuentes de combustión hechas por el hombre, pero esta alerta es sobre nanomateriales manufacturados que se agregan a los productos. Estos productos se llaman nano-habilitados.



Un nanotubo de carbono pasa a través de un pelo humano

¿Cuáles son los riesgos?

Algunos nanomateriales pueden ser seguros, pero otros se han demostrado ser tóxicos en el laboratorio. De preocupación particular es la exposición respiratoria a fibras largas y finas, como los nanotubos de carbono (CNT). Ciertos tipos de nanotubos de carbono causan problemas pulmonares en los ratones, similares al asbesto. Las nanopartículas no parecen penetrar la piel sana, pero pueden pasar a través de la piel dañada. Los nanomateriales pueden ser liberados de productos nano-habilitados, pero los riesgos no se conocen bien. **La clave es limitar la exposición.**



Nanotubos de carbono de pared múltiple penetrando el pulmón

¡Protejase!

1 Aprenda sobre los nanomateriales en su comercio

CPWR mantiene un sitio web llamado **elCOSH Nano** que cuenta con más de 450 productos que pueden ser nano-habilitados. Los productos de construcción que pueden contener nanomateriales incluyen:

- ▶ Recubrimientos
- ▶ Lubricantes
- ▶ Cements
- ▶ Adhesivos
- ▶ Aislamiento
- ▶ Compuestos de Parche



www.nano.elcosh.org

2 Controle el Polvo

NIOSH y CPWR han demostrado que los sistemas de recolección de polvo conectados a herramientas reducirán el número de nanopartículas junto con el polvo normal. Métodos húmedos también son efectivos.

Foto: Trabajador con el equipo de protección completo realizando pruebas para CPWR dentro de una cámara especial utilizando un sistema de recolección de polvo



3 Use un respirador

Las pruebas han mostrado que los nanopartículas **NO** pasan por respiradores con filtros de alta eficiencia. Primero reduzca el polvo con un sistema de recolección de polvo o agua. Si los niveles de polvo siguen siendo altos, use un respirador.



¿Se regulan los nanomateriales?

OSHA no tiene una norma o Límite de Exposición Permisible para algún específico nanomaterial, pero hay muchas normas de OSHA existentes, como la norma de respiradores, que aun aplicarían. NIOSH ha establecido los Límites de Exposición Recomendados para nanotubos de carbono y dióxido de titanio de tamaño nanométrico que los empleadores deben seguir. La EPA tiene requisitos para el reportaje de nanopartículas bajo TSCA.

Aprenda más

- ▶ OSHA Norma de Protección Respiratoria (29 CFR 1926.103): <http://tinyurl.com/OSHA1926-103>

¡Infórmese más sobre los peligros en la construcción.

Para recibir copias de esta Advertencia de Peligro y las cartas sobre otros temas
Lláme al 301-578-8500

NIOSH's nanotechnology website has useful information on exposures and controls

<https://www.cdc.gov/niosh/topics/nanotech/default.html>

The National Institute for Occupational Safety and Health (NIOSH)

Promoting productive workplaces through safety and health research

NIOSH • Workplace Safety & Health Topics

NANOTECHNOLOGY

f t +

Overview

Nanotechnology is the manipulation of matter on a near-atomic scale to produce new structures, materials and devices. The technology promises scientific advancement in many sectors such as medicine, consumer products, energy, materials and manufacturing. Nanotechnology is generally defined as engineered structures, devices, and systems. Nanomaterials are defined as those things that have a length scale between 1 and 100 nanometers. At this size, materials begin to exhibit unique properties that affect physical, chemical, and biological behavior. Researching, developing, and utilizing these properties is at the heart of new technology.

Worker Risks

Workers within nanotechnology-related industries have the potential to be exposed to uniquely engineered materials with novel sizes, shapes, and physical and chemical properties. Occupational health risks associated with manufacturing and using nanomaterials are not yet clearly understood. Minimal information is currently available on dominant exposure routes, potential exposure levels, and material toxicity of nanomaterials.

Current Research

Studies have indicated that low solubility nanoparticles are more toxic than larger particles on a mass for mass basis. There are strong indications that particle surface area and surface chemistry are responsible for observed responses in cell cultures and animals. Studies suggests that some nanoparticles can move from the respiratory system to other organs. Research is continuing to understand how these unique properties may lead to specific health effects.

The NIOSH Effort

NIOSH leads the federal government health and safety initiative for nanotechnology. Research and activities are coordinated through the NIOSH Nanotechnology Research Center (NTRC) established in 2004.

News and Events

- Draft: Analysis of Carbon Nanotubes and Nanofibers on Mixed Cellulose Ester Filters by Transmission Electron Microscopy
- NIOSH Researchers Lead Development of New ISO Guidance Document
- NIOSH Director to discuss emerging technologies and worker health at Nov. 4 SUNY Poly nanotechnology event.
- NASA adapts NIOSH-funded nanoparticle sampling prototype for use on the International Space Station

More >

- Recommendations
- Guidance
- News

Group discussion

- Have you conducted training on emerging issues or topics that are not fully understood?
- If so, what challenges did you face and how did you try to overcome them?
- What strategies do you find effective in communicating risks to workers?
- Any other comments or questions?

Thank you!

Gavin H. West, MPH

Director, Nanomaterials Research

CPWR – The Center for Construction Research and Training

gwest@cpwr.com | (301) 495-8522

