

# AIHce2015

SALT LAKE CITY, UTAH + MAY 30 - JUNE 4

## **The Emergence of Nanomaterials in Construction**

Bruce Lippy, Ph.D., CIH, CSP, FAIHA  
Director of Safety Research

CPWR – The Center for Construction  
Research and Training, Silver Spring, MD



# Here's where we are headed:

1. Introduction to CPWR, our nano team and collaborators
2. Emerging uses of Nano in construction
3. Inventories (mostly ours)
4. Uniqueness of construction work
5. Worker exposures to nano in construction
6. Hazard Communication



# Introduction to CPWR, our nano team and collaborators

## Topic 1



# Everyone heard of CPWR?

- NIOSH-funded National Center for Construction Safety and Health for 20 years
- Construction Solutions
- AIHA Social Responsibility award winner 2015



**Work Safely with Silica**  
A ONE-STOP SOURCE OF INFORMATION ON  
HOW TO PREVENT A SILICA HAZARD AND PROTECT WORKERS

About • Know the Hazard • Regulations & Requirements • What's New • Create-A-Plan

Search  **GO**

### Know the Hazard

Workers may be exposed to dangerous levels of silica dust when cutting, drilling, grinding, or otherwise disturbing materials that contain silica. These materials and tasks are common on construction jobs. Breathing that dust can lead to serious, often fatal illnesses. This section contains information that workers – and contractors – need to know to [recognize the hazard](#), understand the risk factors, and work safely with silica.

### Control the Dust

There are ways **contractors** can reduce the dust and reduce the hazard. This easy to use planning tool takes you step-by-step through conducting a **job hazard analysis for silica**, selecting appropriate controls, and creating a job-specific plan to eliminate or reduce silica hazards. You can save as a pdf, print and/or email your plan.

**CREATE-A-PLAN**

#### Training & Other Resources

Find silica-related handouts, fact sheets, videos, toolbox talks and other resources for workers and contractors.

#### What's Working

Contractors, workers, manufacturers, and researchers are on the lookout for the best ways to control silica dust. Learn what is happening in the field and share what you are doing.

#### Ask a Question

Get answers to commonly asked questions about silica and ask one of your own.





Electronic Library of Construction Occupational Safety & Health

[Versión en Español](#) | [Other Languages](#)

Search:

Developed and maintained by CPWR - The Center for Construction Research and Training.

## Hazards



## Trades



## Jobsites



### Media

- [Presentations / Powerpoints](#)
- [Images](#)
- [Videos](#)

[All](#)

### Documents

- [Toolbox Talks](#)
- [Training Materials](#)
- [Handouts](#)
- [Research Reports](#)

[All](#)



### What's New

[Best Practice Engineering Control Guidelines to Control Worker Exposure to Respirable Crystalline Si...](#)

[Field Guide for Controlling Silica Dust Exposure on Asphalt Paving Machines](#)



Join us

**In October 2014 we launched a web-based construction nanomaterial inventory**



# CPWR's Nanotechnology Research Team

- Gavin West, MPH CPWR statistician
- Dan Marsick, Ph.D., CIH, CSP (consultant)
- Mike Cooper, MPH, CSP, CIH (consultant)
- Leonard Burrelli, MS, Environmental Profiles
- Alan Segrave, Bureau Veritas
- Rouzbeh Shahsavari, Ph.D., Rice U. (consultant)

# We are collaborating with Wendy Jones and Alistair Gibb of Loughborough University, UK

## Nanomaterials in construction and demolition:

How can we assess the risk if we don't know where they are?

Wendy Jones,  
Loughborough University



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# Improvements nano-enabled products will bring to construction

## Topic 2



# We spend 2.4% of our GDP on transportation infrastructure

- Spending still 60% below what is needed
- 550 million tons of hot-mix asphalt annually
- Stronger asphalt is critical (NSF)
- Potholes and poor roads are large contributors to the 30,000 vehicular deaths each year

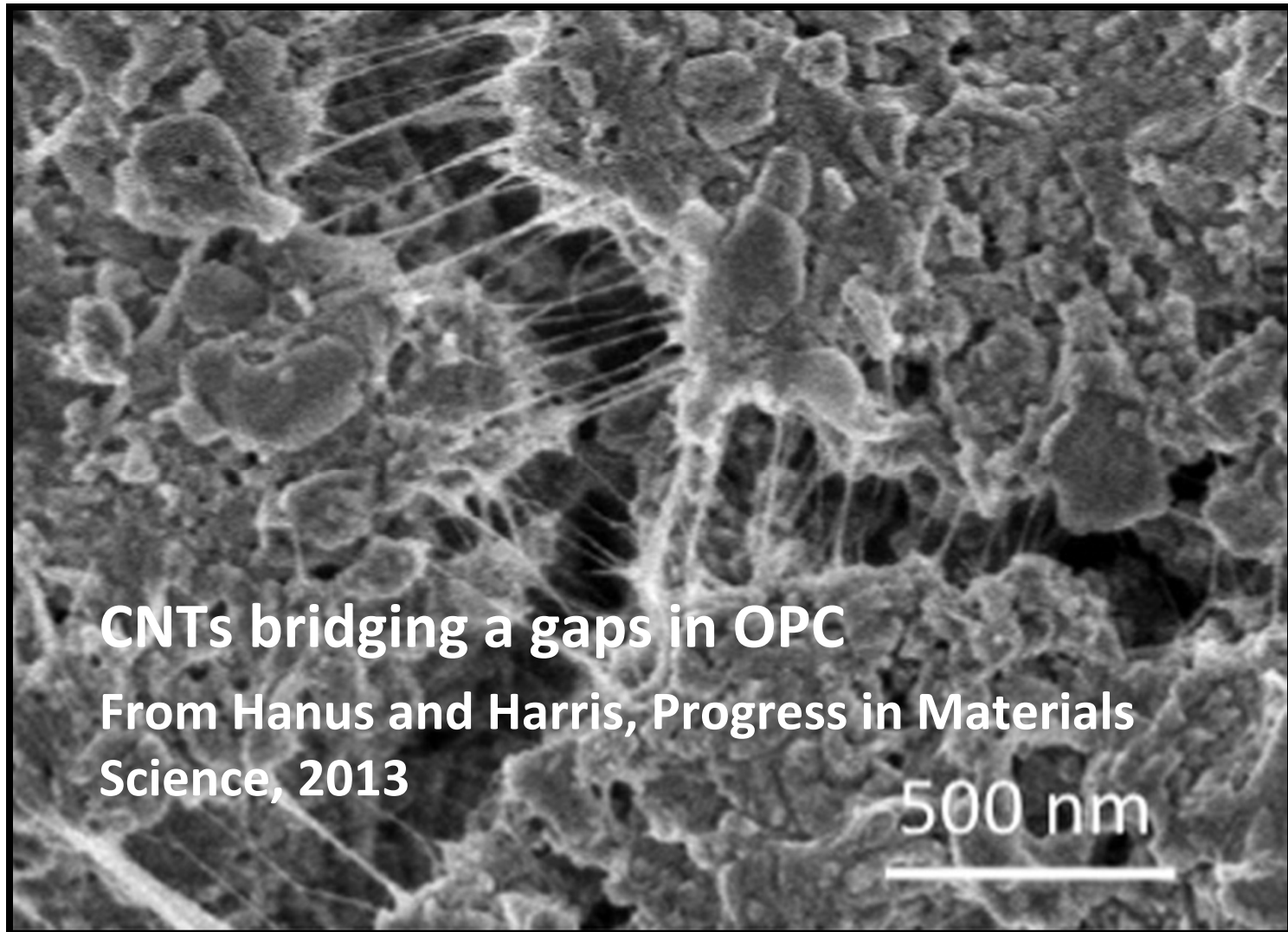


NYC, Photo courtesy  
NY Daily News

# Changes to concrete can have a huge impact

- **Manufacture of concrete releases 7% of CO<sub>2</sub> emissions globally.**
- **Structures have life-span of 50-100 yrs. How about 500?**
- **Increasing concrete compressive strength could reduce amount of rebar by 50%.**

# Carbon nanotubes reinforce cement at the nano scale



# Water repellent surfaces for masonry are impressive


## 3001 Concentrate


3001 is a new surface protection product to reduce water absorption, efflorescence, moss and algae buildup on mineral substrates. 3001 is a concentrate, that will be diluted prior the application with 9 parts of tap water. Therefore, each litre of 3001 concentrate will give you 10 litre of ready to use, penetrating sealer. Traditional solvent based products have high water repellent values, but fail to meet modern environmental standards. 3001 is the most sustainable penetrating sealer on the market.


The product has deep penetrating properties, without the use of any hazardous hydrocarbon solvents, or substances. 3001 is nearly odour free and still matches and even outperforms conventional sealer solutions. The extreme reduction of the water absorption results in fast drying surfaces where moss and algae will not find the appropriate growing ground. Slippery surfaces and unsightly discolourations can be avoided and the risk of falls can be significant reduced.


Supplying such a usual voluminous building product as a concentrate is truly ground breaking, and has significant financial benefits.

<b>High penetration</b> 3001 shows very high penetration.	<b>Moss and Algae reduction</b> Fast drying surface, less microbial growth and less slippery surfaces.	<b>Durable</b> Last up to 10 years on horizontal surfaces and up to 15 years on vertical surfaces	<b>Reduced Costs</b> up to 90 % cheaper to transport 90 % reduced packaging material
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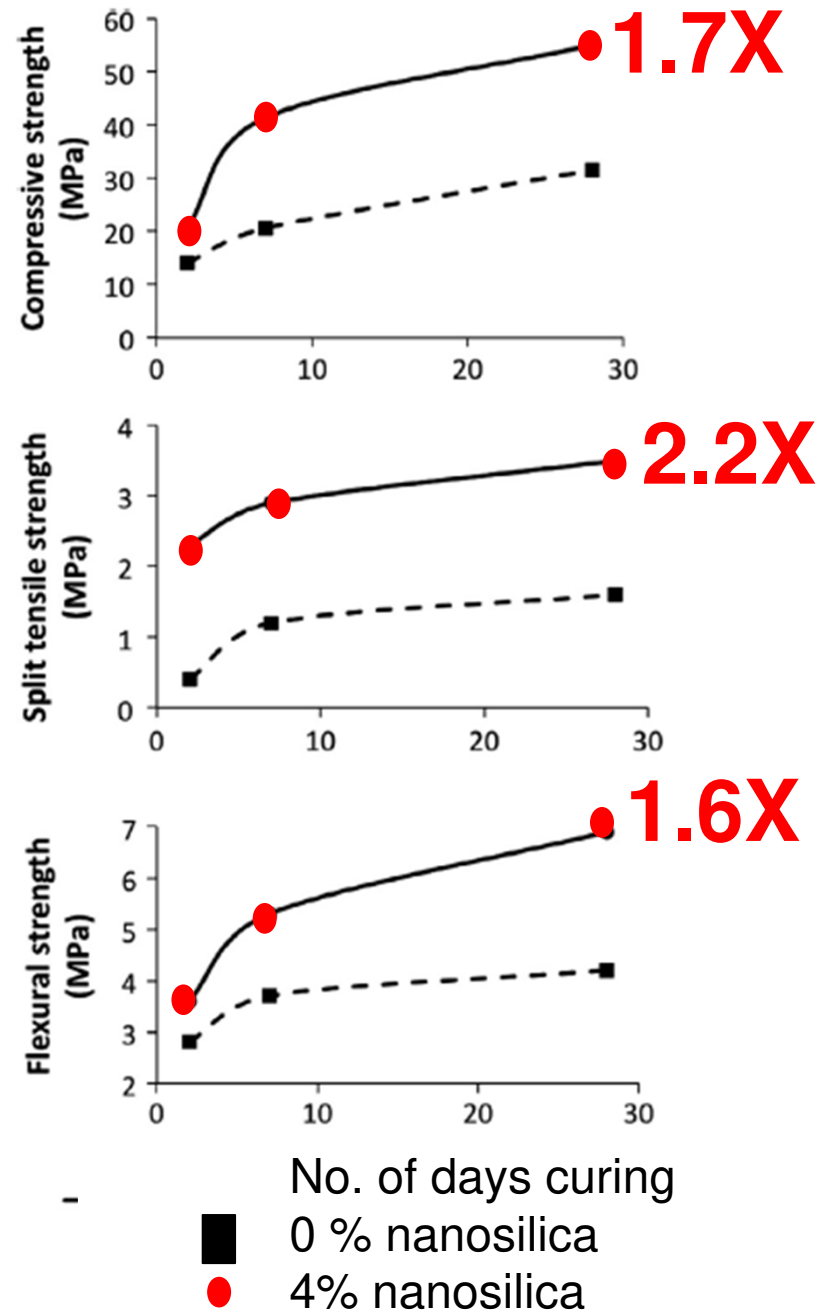
What is the nano part?

# Nano-scale UV absorbers in coatings protect wood while remaining transparent



**Nanovations Lignol wood coatings on red cedar**

# Nanosilica strengthens cement composites



Narazir and Riahl in  
Hanus and Harris, 2013

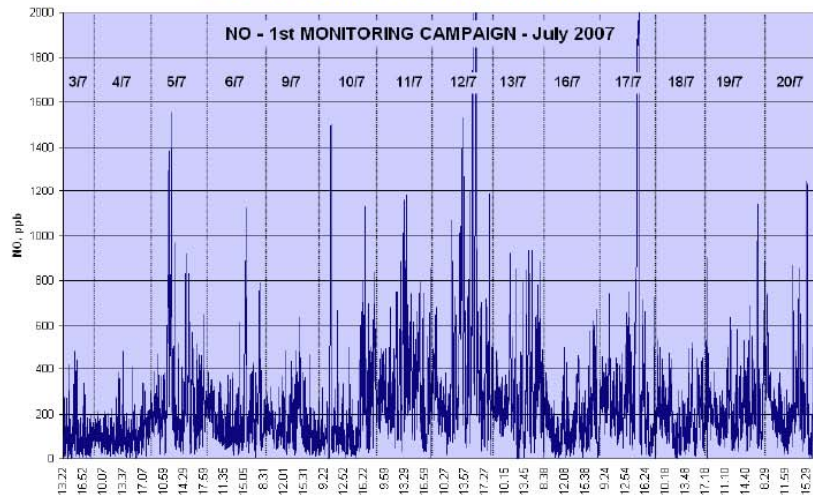
# Photocatalytic cement containing $\text{TiO}_2$ is being used in Europe



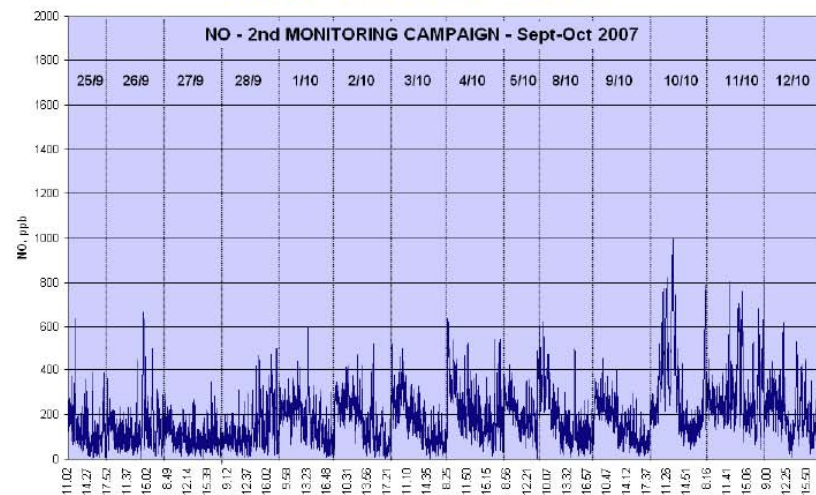
Gian Luca Guerrini, "Photocatalytic performances in a city tunnel in Rome. NOx monitoring results"  
*Construction and Building Materials* 27 (2012) 165–175

# There was a reduction in nitric oxide of 20 - 60% in the tunnel

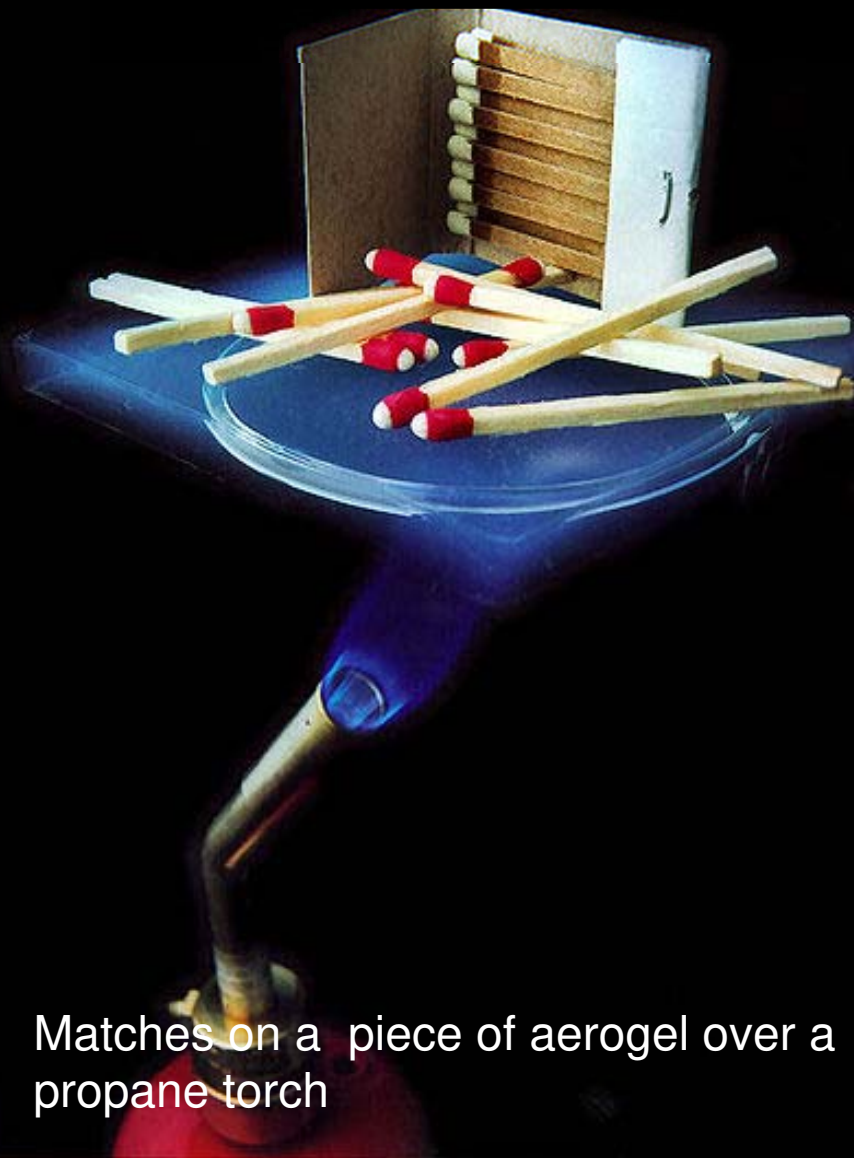
before the renovation



after the renovation



# Aerogels are incredible insulators



Matches on a piece of aerogel over a propane torch



A 5 pound brick supported by a piece of aerogel with a mass of 2 grams

# Translucent aerogel is used for thermal insulation and lighting



**Baetens , Jelle & Gustavsen**

**Energy and Buildings Volume 43, Issue 4**

# Aerogels are great at insulating and reducing noise

Average attenuations of -60 dB for a thickness of 70mm.



“Aerogel insulation sheets suffer from dust production.”

R. Baetens, Nanotechnology in eco-efficient construction, 2013

# **NIOSH conducted an HHE of Aerogel insulation for the insulators union**

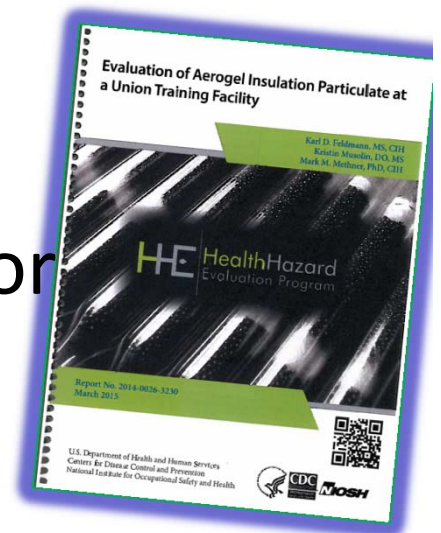


Mark Methner, NIOSH

**Feldmann, Musolin and Methner, March 2015**

# The March 2015 HHE reported:

- Exposures for amorphous silica approached OELs
- Exposures for crystalline silica, aluminum, titanium and iron were **below** OELs
- **Most** of the particulate released during aerogel handling was respirable
- Many participants reported upper respiratory tract irritation or very dry or chapped skin



# Smart windows can dramatically lower energy bills



*Anna Llordés, Lawrence Berkeley National Lab*

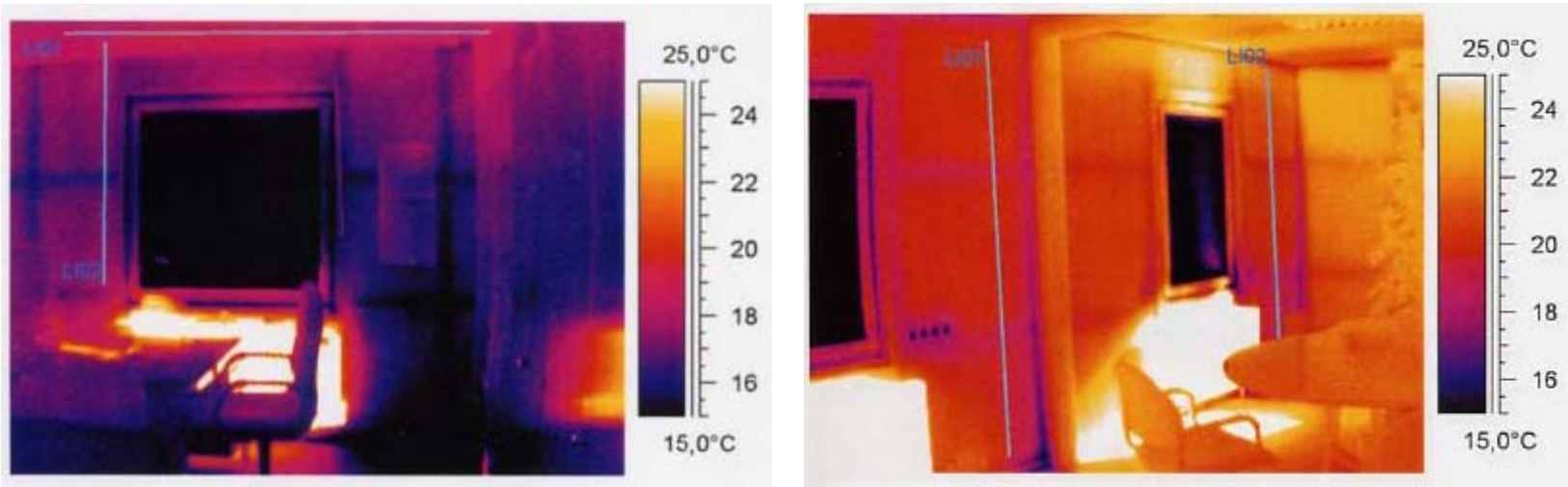
An example of the self-darkening glass next to a normal pane of glass in sunlight.

# Self-cleaning windows can reduce worker exposures

March 16, 2015  
CPWR's offices



# Paint with glass spheres distributes heat more evenly



**Non-flammable, zero-VOC, Bioni Comfort can  
be applied over normal paint**

# Paint containing silver and titanium dioxide acts as a biocide



The first clinical interior coating system



Nature Interior Paint  
New multi-functional interior paint based on green nanotechnology



BIONI Perform - Exterior  
New multi-functional energy saving paint for exteriors based on green nanotechnology



BIONI Roof  
New multi-functional energy saving roof coating based on green nanotechnology



BIONI Grip  
Special Primer for interior and exterior use, free of solvents

# “Nanotechnology protects horses from lung diseases”



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# CNTs added to cement could heat airport runways



Denver Airport, Dec 2006

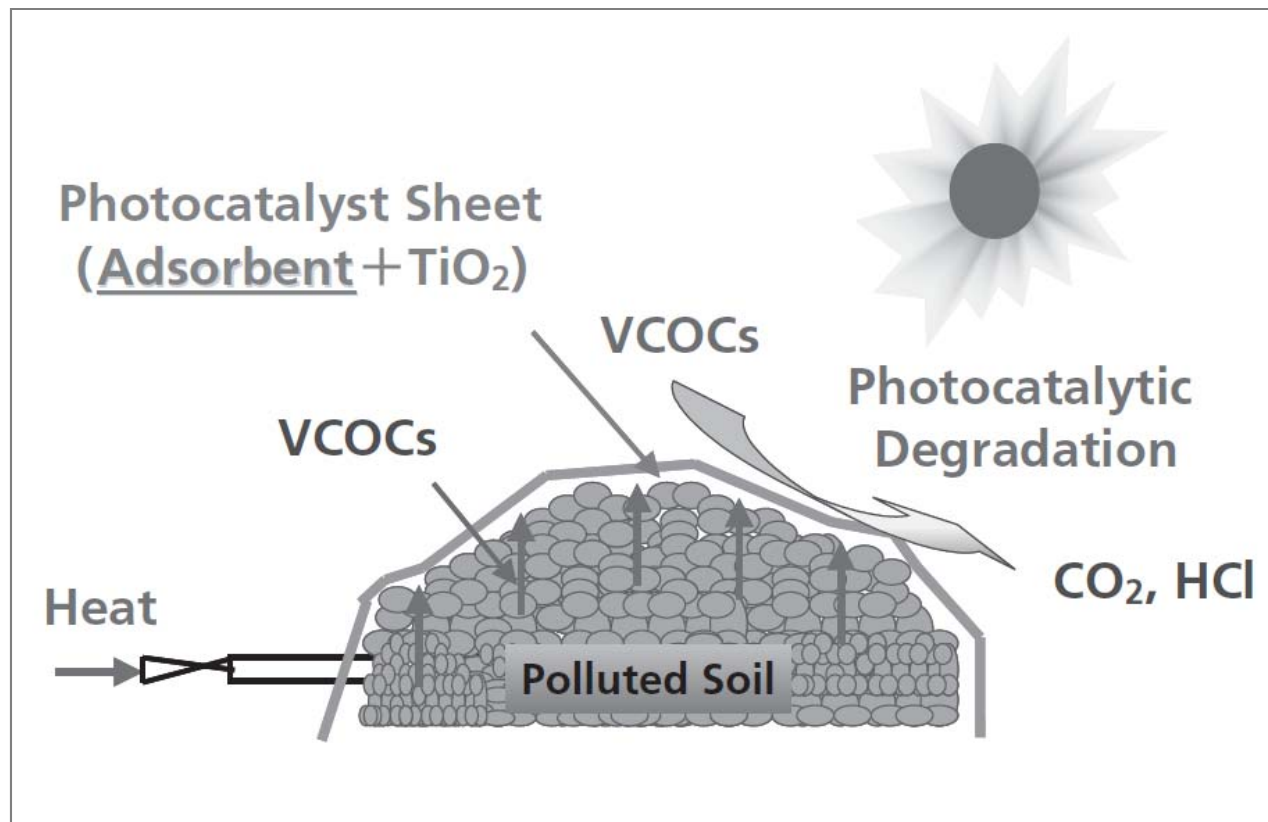
Photo courtesy Wikimedia and Ashley Niblock

# TiO<sub>2</sub> hydrophilicity can be applied to many products affecting consumers and workers



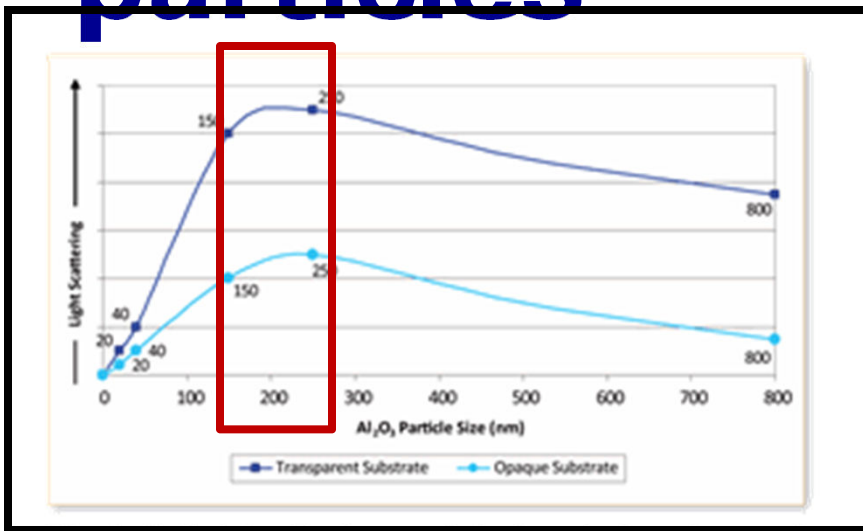
Hashimoto et al. JJAP 2005

# TiO<sub>2</sub> photocatalytic effects can be used in environmental cleanup

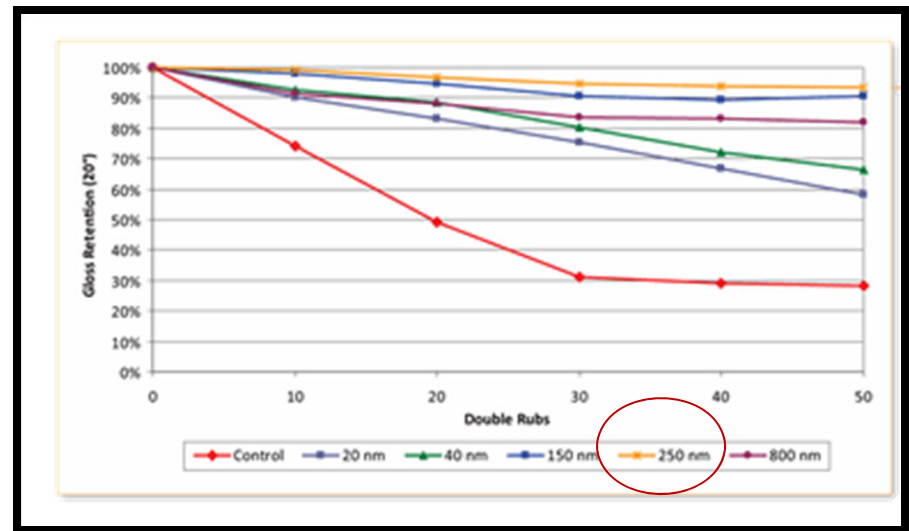


Hashimoto et al. JJAP 2005

# Not all properties are more robust in nano-sized particles



**200 nm** alumina particles in organic matrix provide the maximum scattering of light



**250 nm** alumina particles provide greatest gloss protection in sealants

# Inventories

## Topic 3



# Does anyone know how many nano-enabled products are in commerce?



Yes






No

# The Wilson Center's Project for Emerging Nanotechnology has nearly 2,000 consumer products

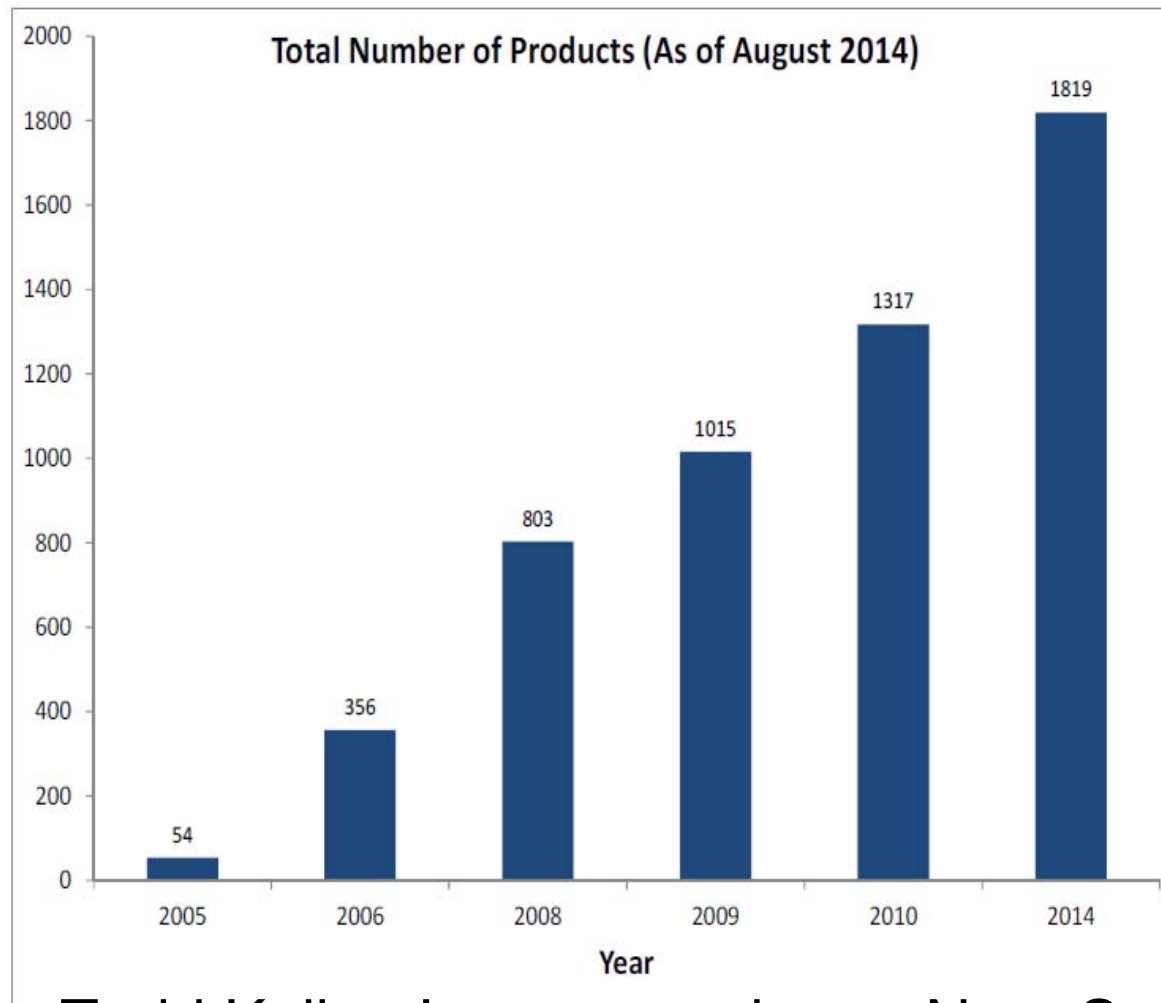
The screenshot shows the website's navigation bar with links for Home, News, Events, Topics, Publications, Inventories, Pressroom, and About Us. The main header features the Project on Emerging Nanotechnologies logo and a 'get findNano' button. The 'Inventories' section is highlighted, listing three categories: Consumer Products, Environment, Health and Safety Research, and US NanoMetro Map.

HOME > INVENTORIES >

## Inventories

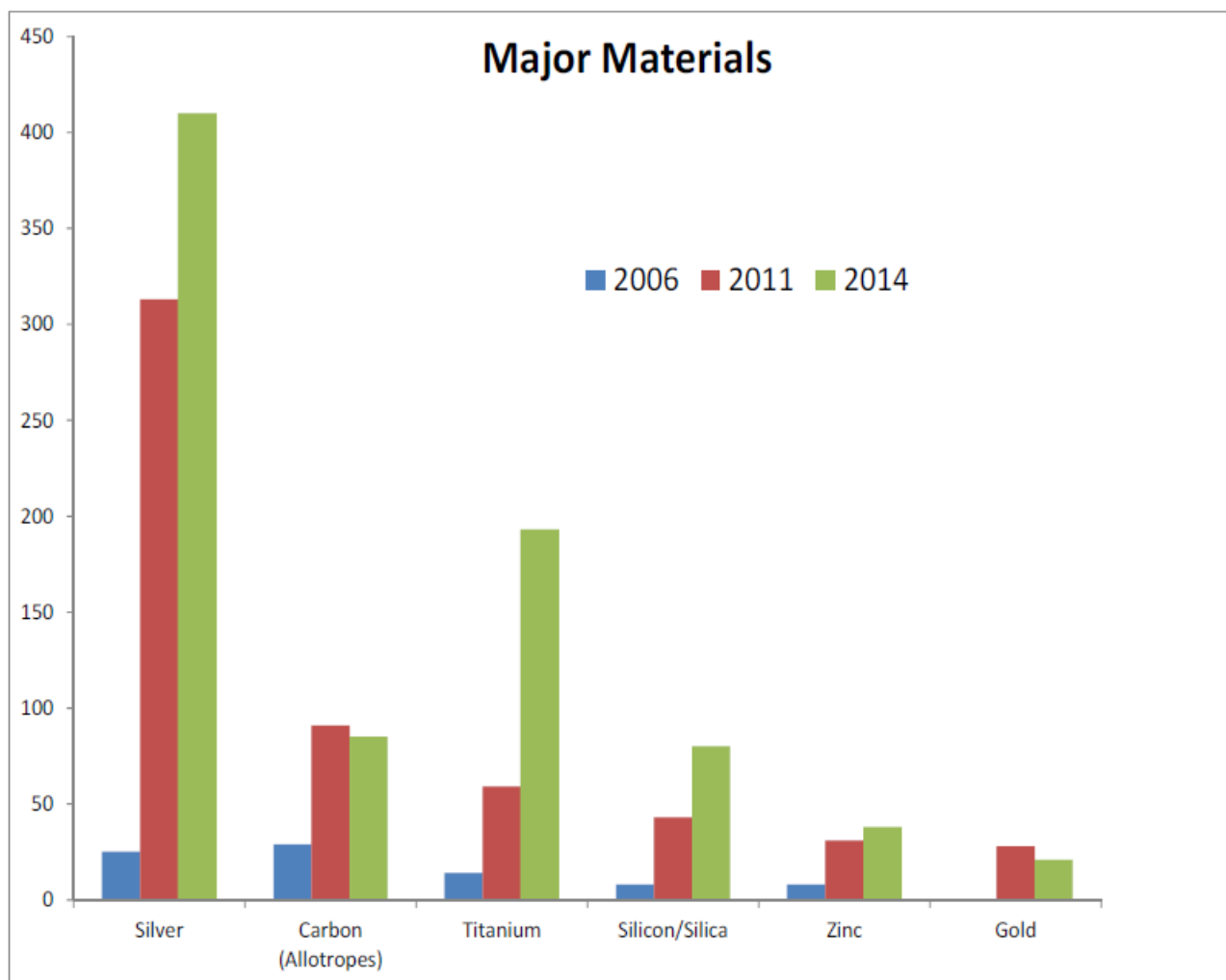
- **Consumer Products**  
While not comprehensive, this inventory gives the public the best available look at the 1,600+ manufacturer-identified nanotechnology-based consumer products introduced to the market.
- **Environment, Health and Safety Research**  
An inventory of current research involving nanotechnology health and environmental implications
- **US NanoMetro Map**  
This information is on view as part of a new interactive map displaying the growing "Nano Metro" landscape.

# The PEN consumer product inventory has grown significantly since 2005



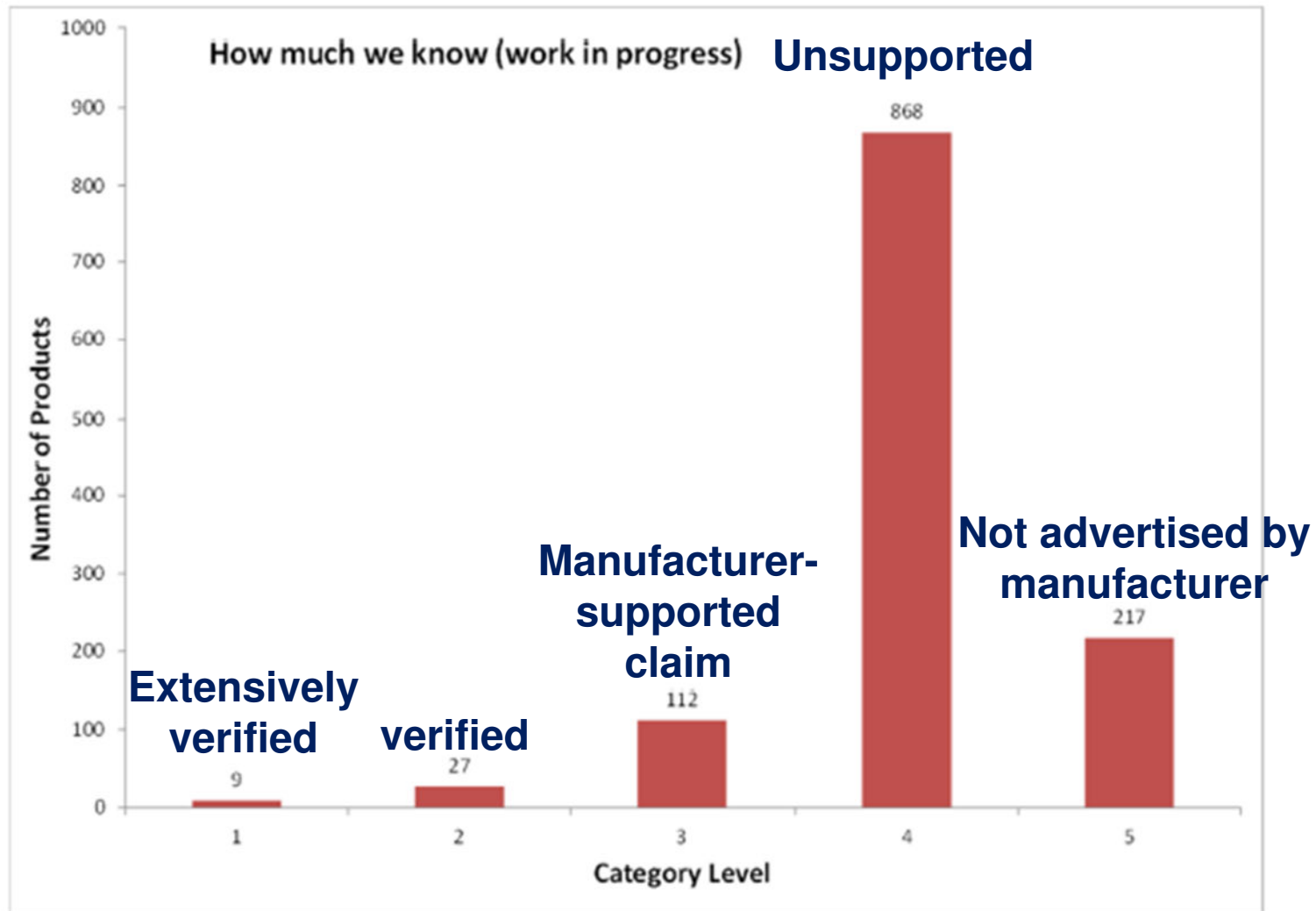
From Todd Kuiken's presentation at NanoSafe2014

# Silver has been the most common nanomaterial in the PEN database



From Todd Kuiken's presentation at NanoSafe2014

# PEN assigns confidence to entries




From Todd Kuiken's presentation at NanoSafe2014

# Alibaba.com is the 500 pound e-gorilla in the room

- Sept 2014 IPO value of \$231 billion US
- World's largest online business-to-business trading platform for small businesses (WSJ)
- Importers and exporters >240 countries
- **Many** construction products with 'nano' claims we've not attempted to tackle

# N=871 'Nanotechnology' Flooring Tiles



Q Search

Related Searches: [nanotechnology products](#) [nanotechnology liquid](#) [nanotechnology spray](#) [nanotechnology coatings](#) [nanotechnology fabric](#)

### Suppliers by Area

East Asia (871)

### Suppliers by Country/Region

China (Mainland) (871)

### Categories

Construction & Real Estate  
Tiles (871)

### Material

Porcelain Tiles

### Authentication & Service

Trade Assurance ?


Gold Supplier

Onsite Check

Assessed Supplier


**Top Products 2015**

Win a **FREE** inspection



Products > nanotechnology 871 Product(s)

Minimum Order: 
 Online
View as: ☰ ☐



**600\*600 tiles prices, nanotechnology products, coral pool tile made in foshan**

**US \$8.5-9.6 / Square Meter ( FOB Price)**

**200 Square Meters (Min. Order)**

Size: 300 x 300mm,300 x 600... Usage: Interior Tiles  
Color Family: Blacks,Browns /... Material: Porcelain Tiles  
Function: Acid-Resistant,Anti... Tile Type: Floor Tiles,Wall Tiles

[View more products >](#)


☆ Favorites + Compare

**3VR** Foshan Toscana Ceramics Compan...  
China (Mainland) | [Contact Details >](#)

**US \$65,000** Trade Assurance Amount

← **64.2%** Response Rate

[Contact Supplier](#) Leave Messages



**Full polished glaze porcelain nanotechnology product**

**300 Square Meters (Min. Order)**

Size: 300 x 600mm,600 x 600... Usage: Interior Tiles  
Color Family: Yellows / Golds Material: Porcelain Tiles  
Function: Acid-Resistant Tile Type: Floor Tiles,Wall Tiles


[View more products >](#)

☆ Favorites + Compare

**7VR** Foshan Victory Tile Co., Ltd.  
China (Mainland) | [Contact Details >](#)

← **69.4%** Response Rate

[Contact Supplier](#) Leave Messages



**60x60 cm nanotechnology products for indoor or outdoor full body material**

**US \$8.0-10.0 / Square Meter ( FOB Price)**

**500 Square Meters (Min. Order)**

Size: 600 x 600mm,600X600... Usage: Interior Tiles  
Color Family: Whites Material: Porcelain Tiles,porc...  
Function: Acid-Resistant,Anti... Tile Type: Accents,Borders,FL...

[View more products >](#)

☆ Favorites + Compare

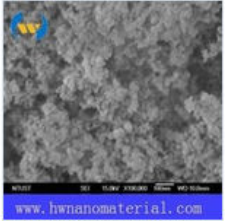
**2VR** Foshan ABM Production Building M...  
China (Mainland) | [Contact Details >](#)

**US \$47,000** Trade Assurance Amount

← **74.7%** Response Rate


[Contact Supplier](#) Leave Messages

### Premium Related Products



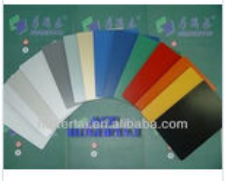
**High quality 99.99% nanotechnology silver**

[www.hwmaterial.com](#)



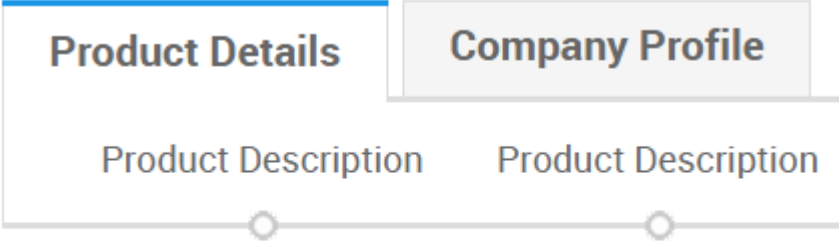
**Competitive price nanotechnology**

PE Coated With 10 Years Guarantee



**alucobond aluminium composite panel**

# Example: “Polished with NANO”



**JBN CERAMICS**  
 We believe our high quality and sincere service will be your final choice and are looking forward to establishing long-term cooperating relationship with you!

Description	porcelain floor tiles
Surface	polished
Available Size	600x600, 800x800, 1000x1000
Available Color	white, pink, yellow
Material	Porcelain
Water absorption	<0.5%
Thickness	9.5-9.8mm, 11mm, 13mm
Unit Price	USD 4.00-8.00/SQM
MOQ	one container, trial order acceptable
Payment terms	T/T, L/C, Western Union
Delivery time	Within 15-25 days

## Quick Details

- Type: Tiles
- Model Number: JP5028
- Usage: Interior Tiles, Floor and Wall
- Technique: Soluble Salts Tiles
- Feature: Polished with NANO
- Style: Natural
- Special Features: Soluble Salt

# Carbon nanotube thermal coating for boat paint and building construction

“It does no harm to human body before and after construction.”

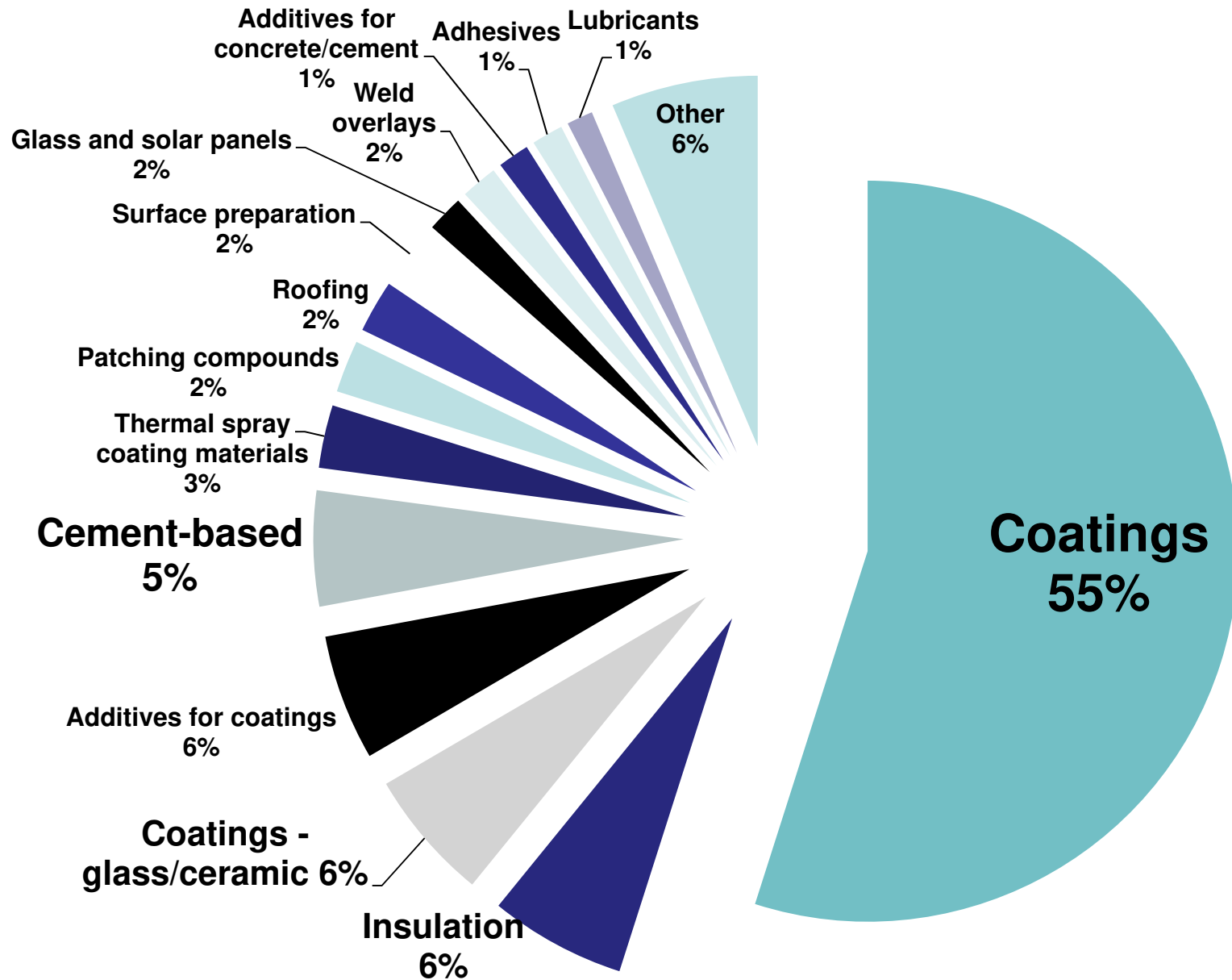


# CPWR maintains an inventory of construction-related nanomaterials

## What is our criteria?

- Manufacturer's reference to nano
- Use of term "nano" in product or company names
- Product description suggests presence of nano
- Product cited elsewhere as using nano





**Coatings dominate the database**

**208 out of 458  
nanoproducts(45  
%) have a  
specified  
composition**

	<b>Products (N)</b>	<b>%</b>
<b>Specified composition</b>	<b>208</b>	<b>45.5</b>
<b>aluminum oxide</b>	8	1.8
<b>austenite</b>	1	0.2
<b>boehmite</b>	1	0.2
<b>calcium hydroxide</b>	1	0.2
<b>carbon</b>	4	0.9
<b>carbon nanotubes</b>	12	2.6
<b>cerium oxide</b>	4	0.9
<b>diamond</b>	1	0.2
<b>lithium</b>	8	1.8
<b>magnesium</b>	1	0.2
<b>multiple</b>	10	2.2
<b>nanoscale pores</b>	17	3.7
<b>polycarbon</b>	51	11.1
<b>polycarbonate</b>	1	0.2
<b>polysiloxane</b>	3	0.7
<b>silane</b>	2	0.4
<b>silica</b>	21	4.6
<b>silica fume</b>	2	0.4
<b>silicone</b>	3	0.7
<b>siloxane</b>	6	1.3
<b>silver</b>	9	2.0
<b>titanium dioxide</b>	22	4.8
<b>titanium nitride</b>	2	0.4
<b>tungsten carbide</b>	4	0.9
<b>tungsten disulfide</b>	3	0.7
<b>nanofullerenes</b>		

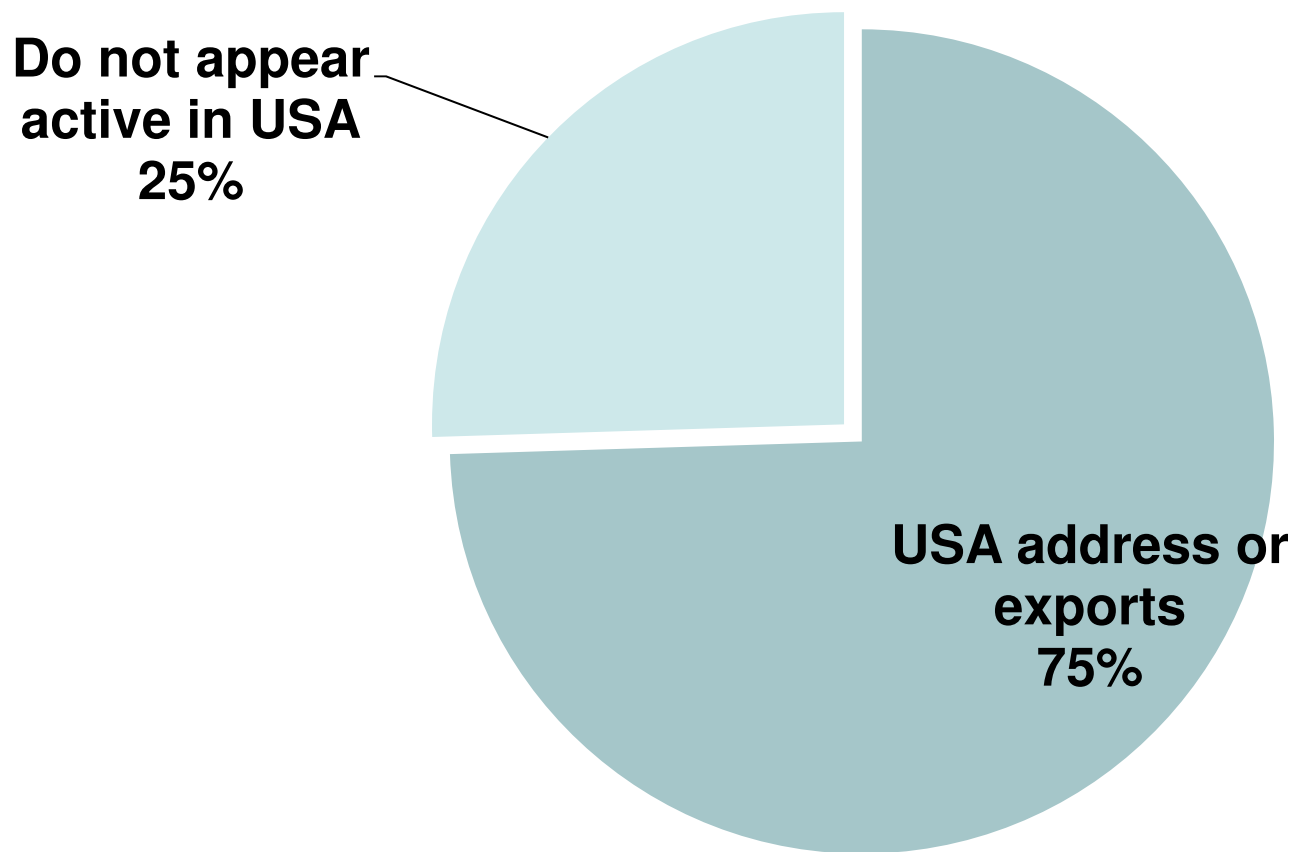
# 72 (15.7%) have a partially specified composition

Partially specified composition	72	15.7 %
acrylic	3	0.7
acrylic-urethane	1	0.2
ceramic	5	1.1
crystal	2	0.4
fluorochemical	1	0.2
<b>nanostructured</b>	<b>27</b>	<b>5.9</b>
oxide	11	2.4
polymer	22	4.8

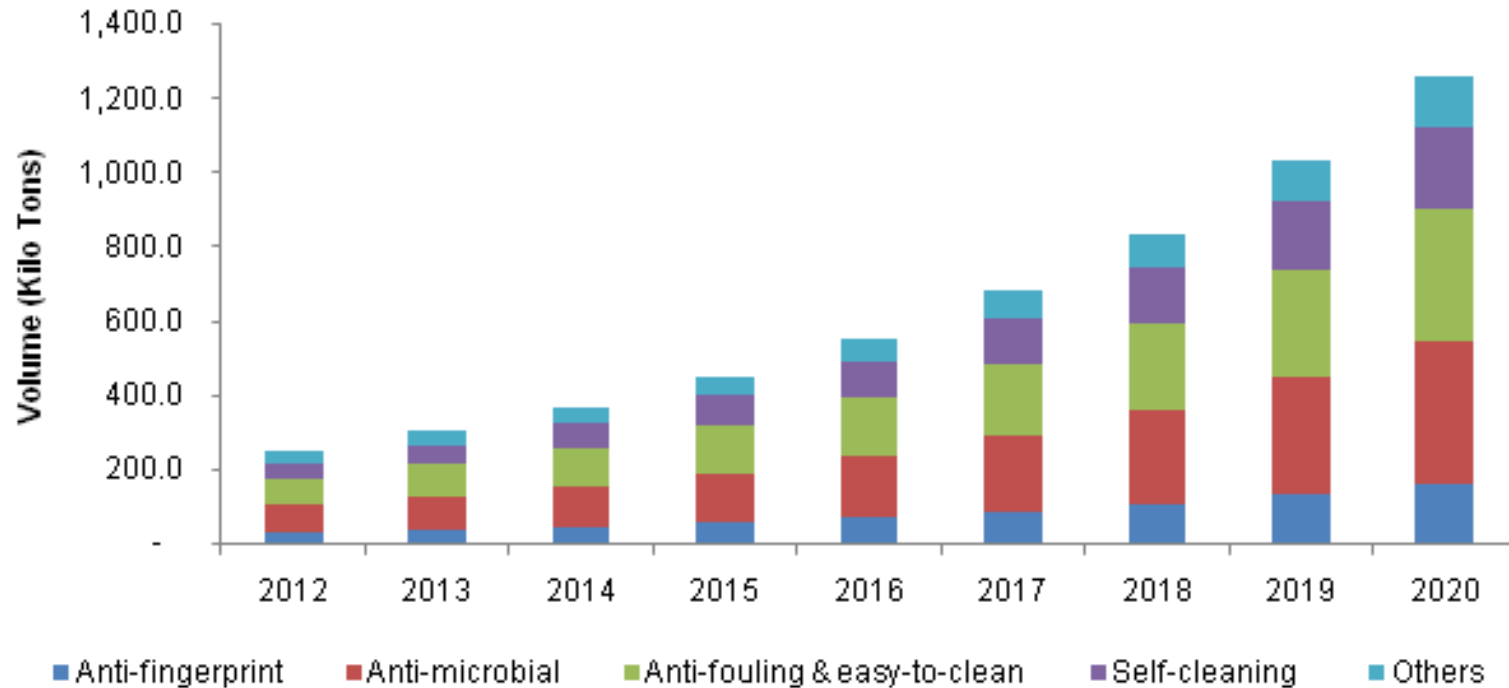
# 178 (38.9%) did **not** specify the composition

<b>Unspecified composition</b>	<b>178</b>	<b>38.9</b>
<b>nanofibers</b>	<b>1</b>	<b>0.2</b>
<b>nanomaterials</b>	<b>15</b>	<b>3.3</b>
<b>nanoparticles</b>	<b>76</b>	<b>16.6</b>
<b>nanotechnology</b>	<b>70</b>	<b>15.3</b>
<b>nanotubes</b>	<b>1</b>	<b>0.2</b>
<b>photocatalytic materials</b>	<b>5</b>	<b>1.1</b>
<b>reference to 'nano'</b>	<b>10</b>	<b>2.2</b>

# Three-quarters of the products in our inventory are probably available in the U.S.



# Nanocoatings revenues are estimated to be \$8.17 billion by 2020

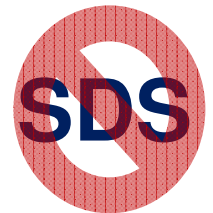


Graphic courtesy Grand View Research, Inc.

# Nanoprotech Electric



**“NANOPROTECH Electric displaces moisture, lubricates mechanisms, securely proofs electrical components even in damp environment, and improves performance of the equipment.”**



# Nanoprotech Anticor Industry



**“Anticorrosion protection should be used on all stages of production and operation of metal parts and mechanisms. Average loss due to corrosion accounts for about 12% of annual volume of metal production.”**



# Solvent-based coatings are available for most surfaces



# NanoTech Coatings SDS for metal coating

## Composition

Ingredient	Concentration	C.A.S. Number	ACGIH TLV
Trade Secret A-1	10-12	Proprietary	1000 ppm
Trade Secret A-2	6-8	Proprietary	--
Ethyl Alcohol	6-8	64-17-5	1000 ppm
Butyl Acetate	54-56	540-88-5	200 ppm
Trade Secret B	16-18	Proprietary	--



## Exposure Limits

Ingredient	ACGIH (TLV)	OSHA (PEL)
Trade Secret A-2	10 ppm	100 ppm
Ethyl Alcohol	1000 ppm	1000 ppm
Butyl Acetate	200 ppm	1000 ppm

“Shake the contents thoroughly to re-suspend the **nanoparticles** that have settled to the bottom.”

# Tesla Nanocoatings prevent corrosion and contain CNTs



Teslan® 1101 Zinc CNT Primer



Teslan® 1500 Aluminum CNT Low-VOC Primer



Teslan® 1700 Magnesium CNT Primer



Teslan® 3000 Epoxy Low-VOC Topcoat



Teslan® 3100 Epoxy CNT Low-VOC Topcoat



Teslan® 4000 Low-VOC Polyurethane Topcoat

# Many nano-enabled lubricants are on the market



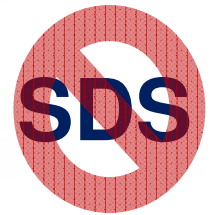
**NanoLub® Gear  
lubricant**



**NanoLub® Metal  
Forming Fluid**



**NanoLub®  
Heavy Duty  
Diesel Engine  
Oil Additive**

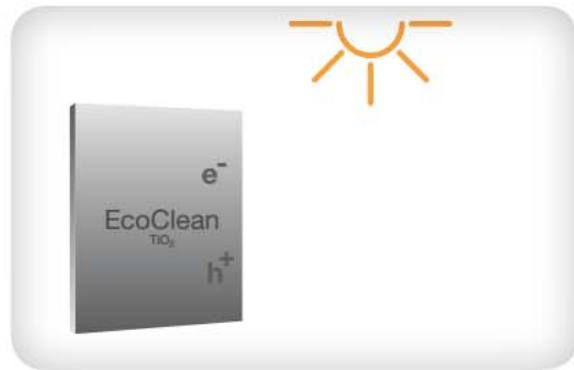


<http://www.apnano.com/products/nanolub-de-m4600-heavy-duty-diesel-engine-oil-additive/>

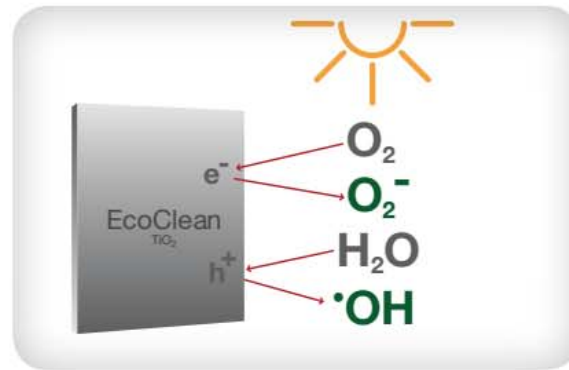
# CurTran LiteWire is carbon nanotube technology in wires and cables, directly replacing copper



# Reynobond, a coil-coated architectural panel that cleans itself and the air around it



1 Electrons in the  $\text{TiO}_2$  become energized by UV light.



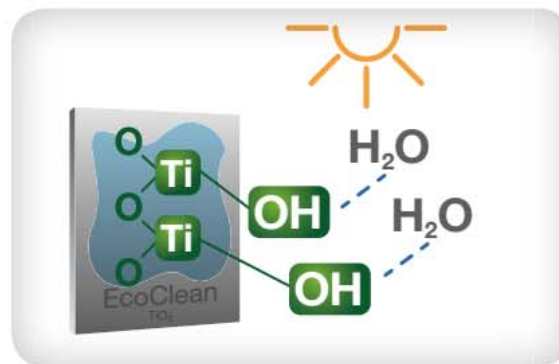
2 These electrons transfer energy to oxygen and water in the air.



3 Free radicals are formed by the transferred energy ( $\text{O}_2^-$ ,  $\bullet\text{OH}$ ).



4 The free radicals attack and destroy organic matter via oxidation.

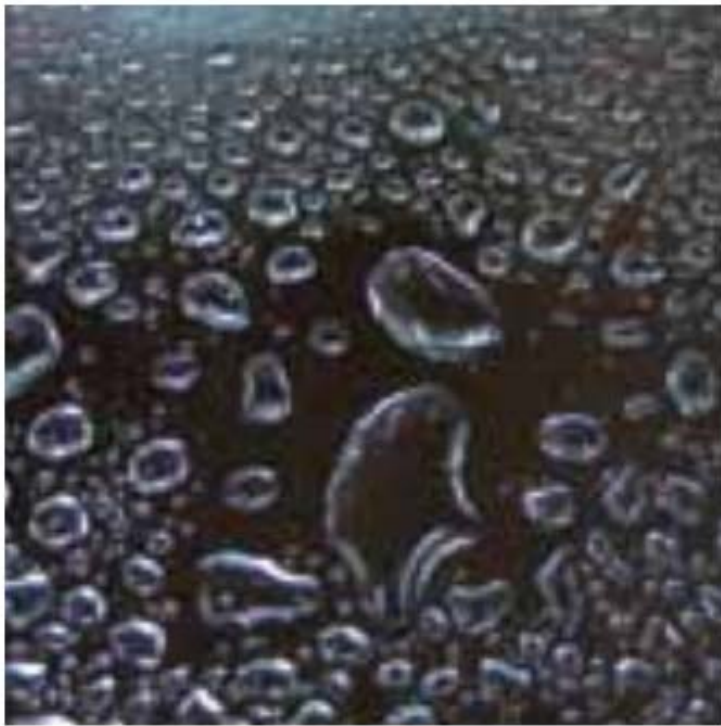


5  $\bullet\text{OH}$  free radicals called hydroxyls group on the surface of EcoClean.



6 The hydroxyls make the building surface super slick. Instead of beading up on the surface, the water collapses on the surface and runs off, undercutting dirt and grime.

# Reynobond with Ecoclean (cont.)



Panel without EcoClean



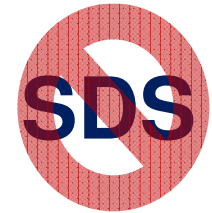
Panel with EcoClean

# GFRC Spray Coat and Reinforcement Mixes for shower walls, concrete countertops and fireplaces



The Xtreme Series uses cement, sand along with 3 types of fiber (PVA, Glass AR, and Nano)

# Nano zinc added to asphalt reduces hydrogen sulfide release



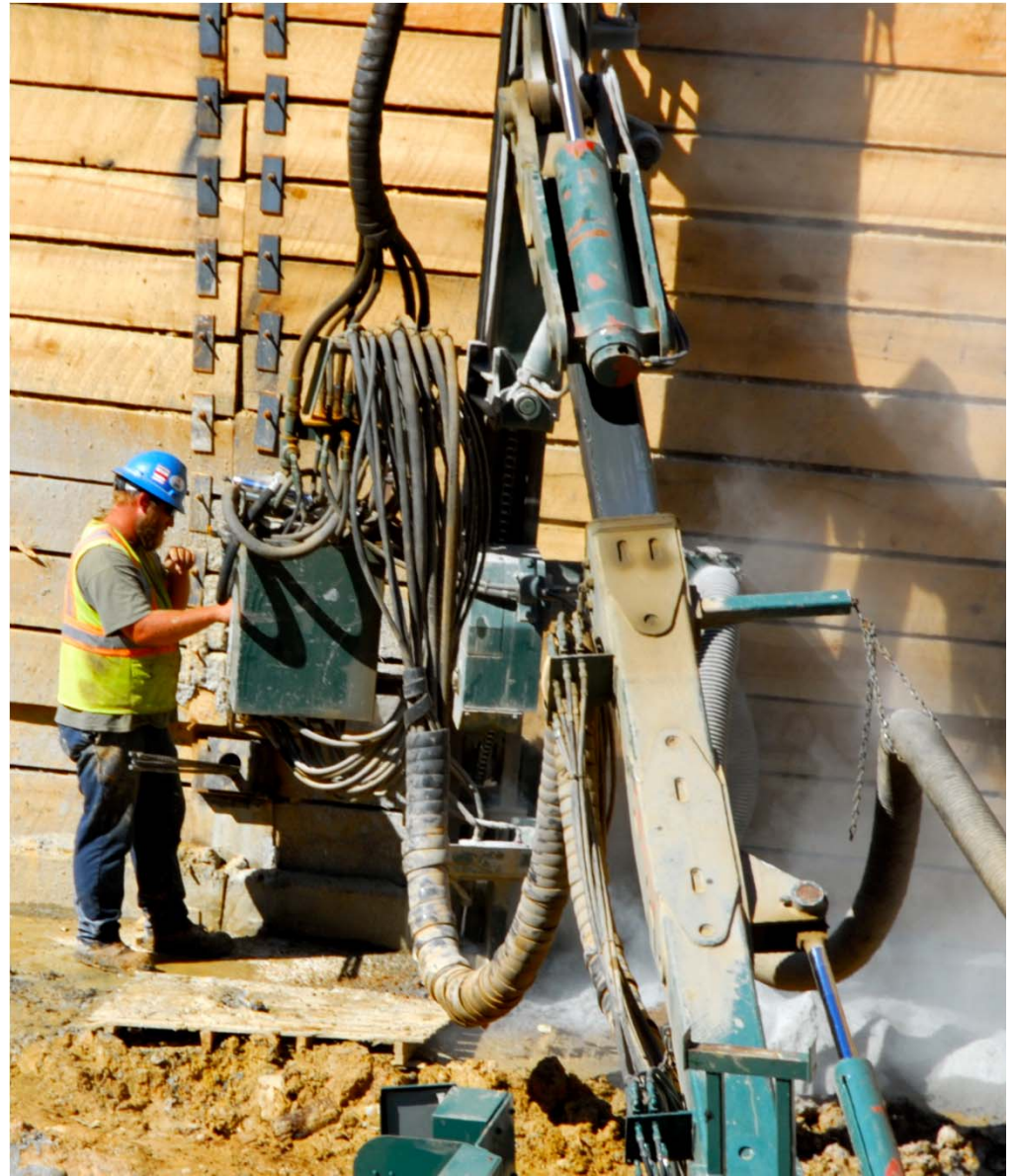
**LMGI Asphalt Additives**

# Uniqueness of construction work

## Topic 4



**In 2010, more than half of construction workers reported exposure to vapors, gas, dust or fumes twice a week or more**



**Liss GM, Petsonk EL, Linch KD [2010, Nov]. The construction industry. In: Occupational and Environmental Lung Diseases**

**Construction workers are 5-6% of non-farm labor force, but account for half of all occupational cancers**  
**(Construction Chart Book, 2013)**



Photo courtesy  
Mt. Sinai

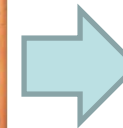
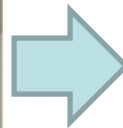
# Exposures must be considered over the life cycle of products

Production

Installation

Maintenance

Demolition



What happens with Hazcom? 

# Bystander exposures are much more prominent in construction



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



Int Arch Occup Environ Health (2009) 82:1043-1055

**“80% of the workers’ reps and 71% of the employers’ reps were not aware of the availability of nanomaterials and were ignorant as to whether they actually use nanomaterials at their workplace.”**

**2009 Survey of workers and employers in  
14 countries in Europe**

**Broekhuizen et al. 2011**

# 2013-2014, CPWR surveyed 79 worker-trainers with an average of **30 years in the trade**

Survey Respondent Characteristics	N	Mean	SD	Range
Years in trade	78	30.5	9.4	9-55
Years as a trainer	79	13.3	7.8	1-34

# Respondents represented 22 different trades

Primary Trade of Survey Respondents	Freq.	%
Cement Masons, Concrete Finishers, and Terrazzo Workers	23	29.1
Carpenters	14	17.7
Plasterers and Stucco Masons	9	11.4
Iron Workers	7	8.9
Insulation Workers	5	6.3
Painters	4	5.1
Brickmasons, Blockmasons, and Stonemasons	3	3.8
Electricians	2	2.5
Pipefitters, Plumbers	2	2.5
Other*	10	12.7

# Nearly half were not aware that nano had been applied to construction materials

	Yes	No
Aware that nanotechnology has been applied to construction materials?	41 (52%)	38 (48%)
Aware that construction products containing nanomaterials are commercially available in the USA?	38 (48%)	41 (52%)
Have you addressed nanotechnology in any training you have conducted?	9 (11%)	70 (89%)

# Only 3 out of 79 had heard of NIOSH's Nano RELs

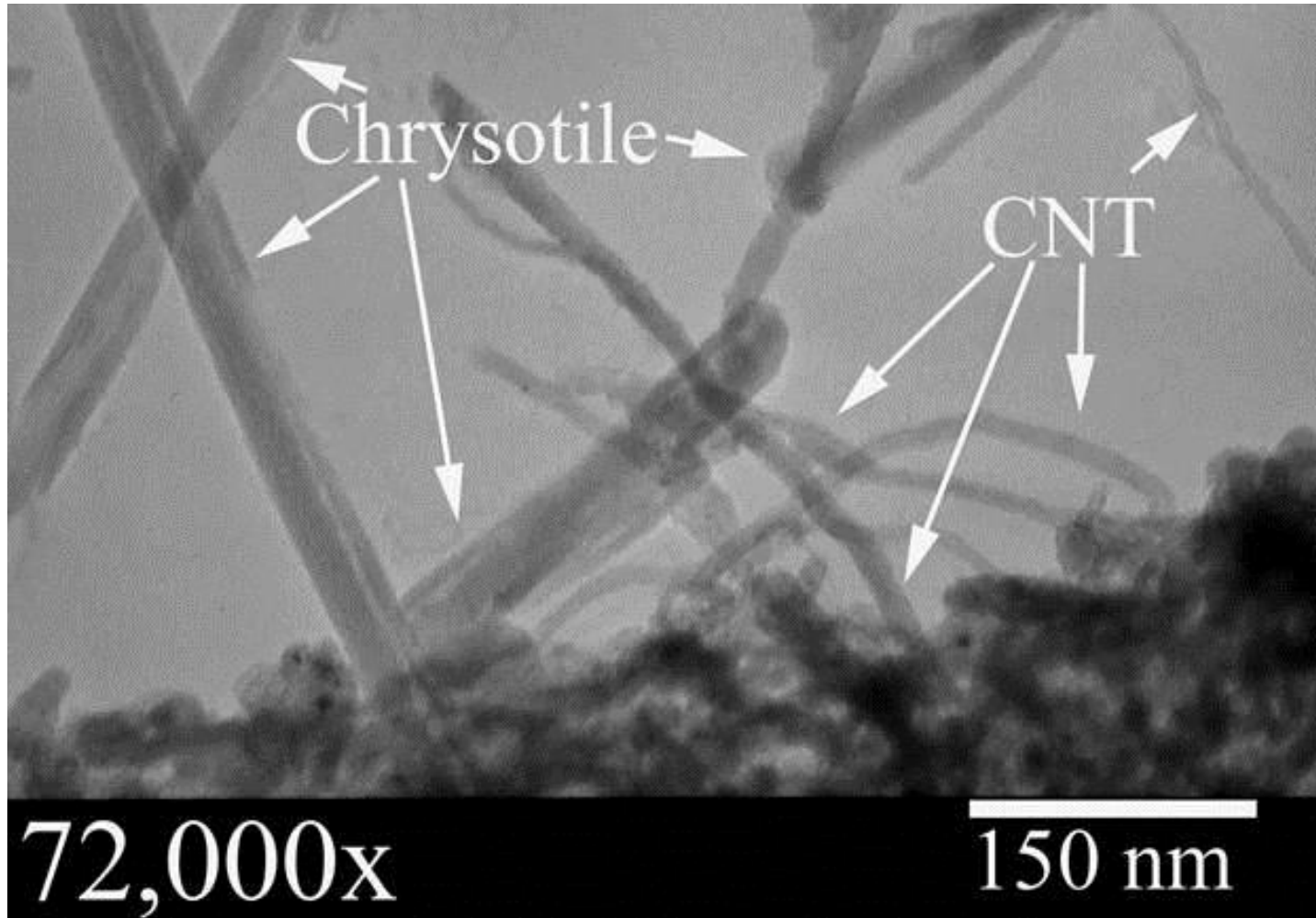
Nanomaterial	OEL (mg/m <sup>3</sup> )	Year
<b>Titanium dioxide</b>	<b>0.3 ultrafine 2.4 fine</b>	<b>2011</b>
<b>CNTs and nanofibers</b>	<b>0.001</b>	<b>2013</b>

# Workers exposure to nano in construction

## Topic 5



# Carbon nanotubes are smaller than asbestos fibers



# NI OSH's RELs are having a major impact in the absence of PELs

Nanomaterial	OEL (mg/m <sup>3</sup> )	Year
Titanium dioxide	0.3 ultrafine 2.4 fine	2011
CNTs and nanofibers	0.001	2013

**The Europeans are doing important work on nanorelease**

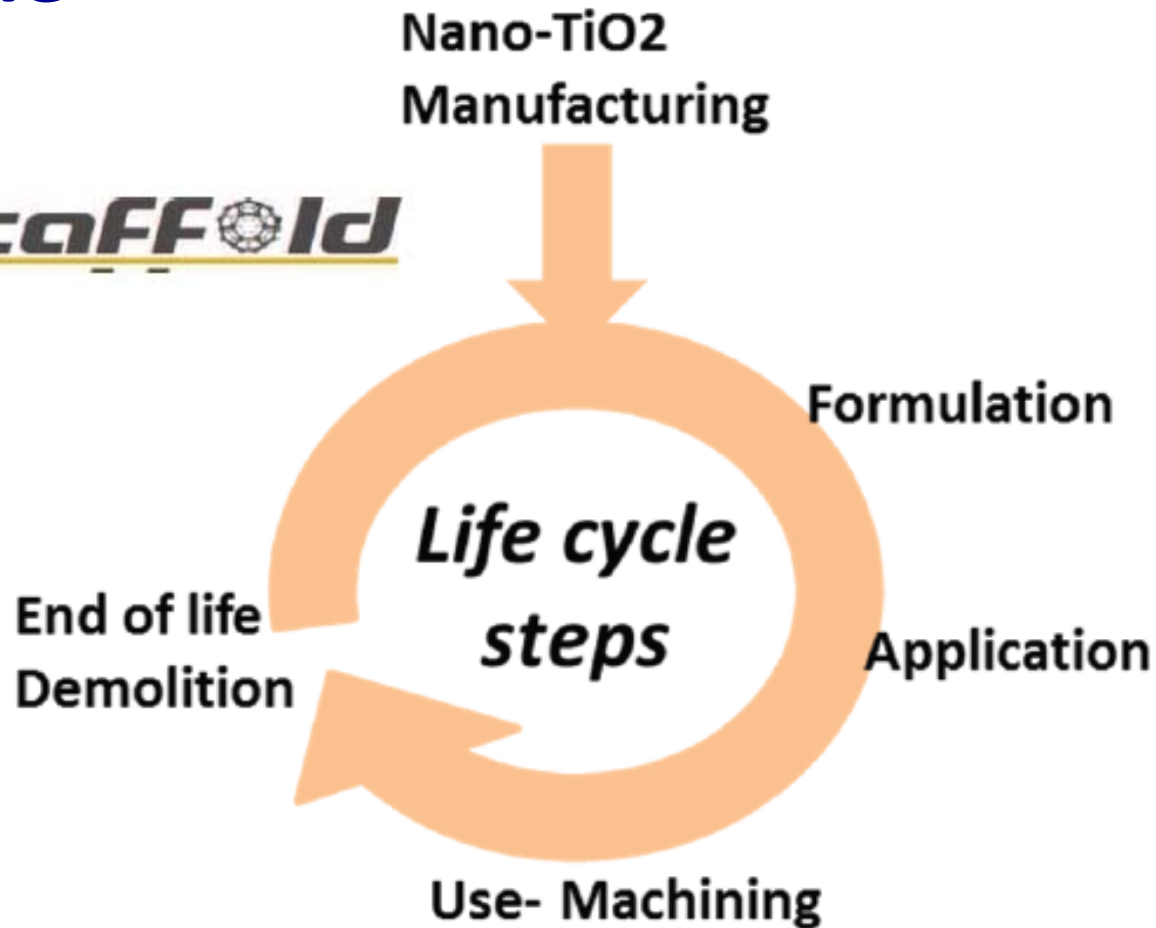


**NanoSafe2014 at Minatec in  
Grenoble, France**

# Vaquera et al. conducted worker exposure monitoring for TiO<sub>2</sub> during full lifecycle



**ScaFFold**



Graphic from Vaquera et al. Nanosafe 2014 presentation

# Sampled during manufacturing of 1 ton of each of 3 types of mortar



# Sampled during application, drilling and demo

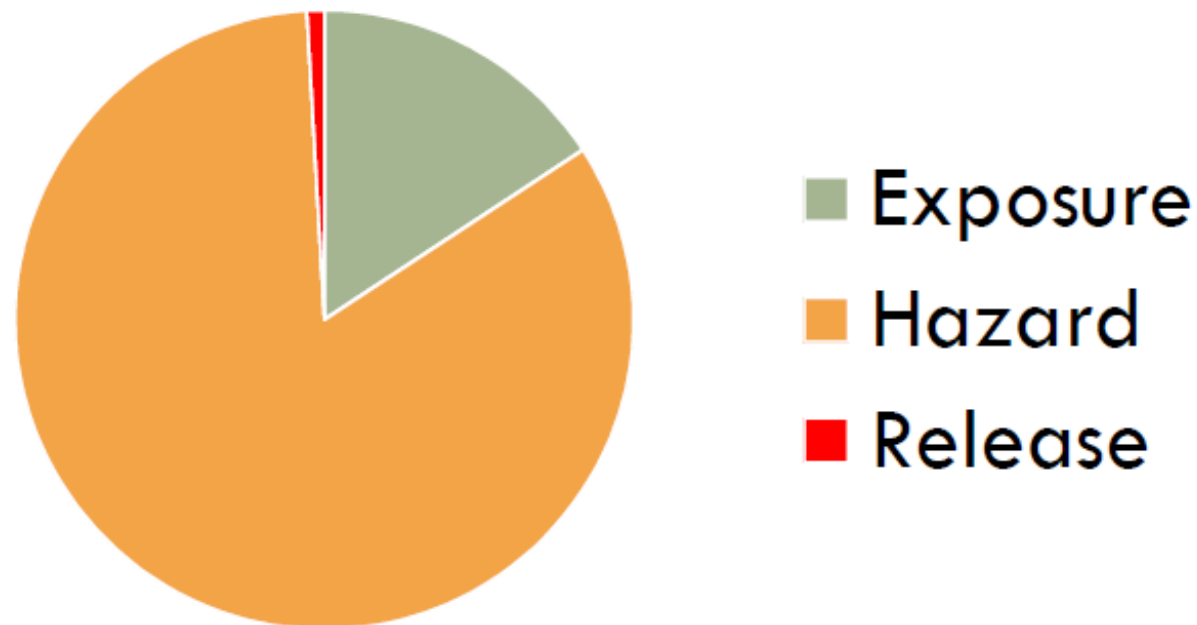


Photos from Vaquera .Nanosafe 2014

# Vaquera and colleagues concluded:

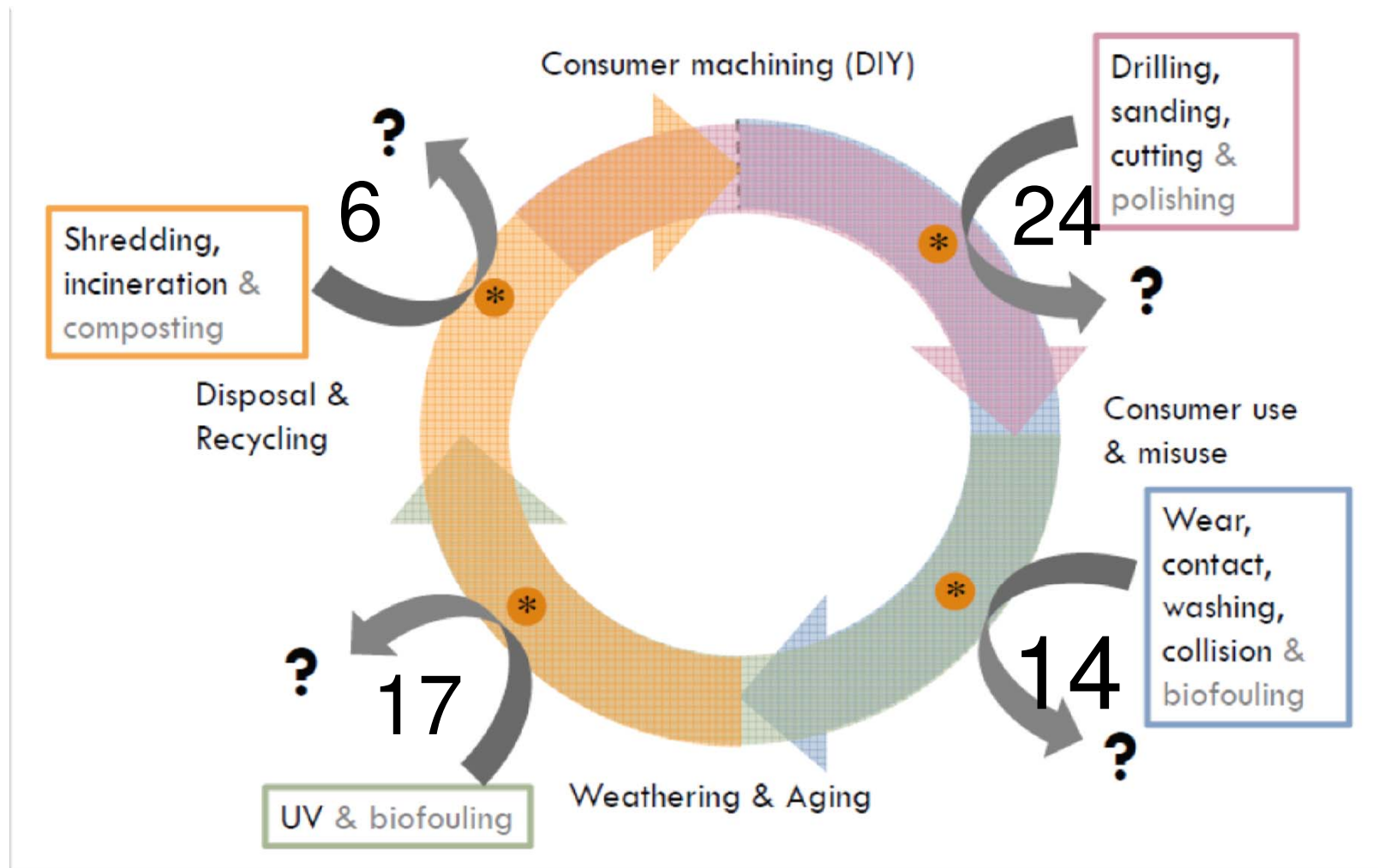
- TiO<sub>2</sub> exposures were well below the OELs for all scenarios (0.1 mg/m<sup>3</sup> Scaffold, 0.3 mg/m<sup>3</sup> NIOSH)
- Highest mass concentrations
  - Cleaning during manufacturing
  - Sol-gel spraying of depollutant on wall

# Froggett et al. presented a review of 54 studies on release of nanomaterials from solid nanocomposites



Froggett S, Clancy S, Boverhof D and Canady R (2014) *Particle and Fiber Toxicology*  
*Graphic from Froggett presentation NanoSafe 2014*

# The studies followed the full life cycle of nanocomposites

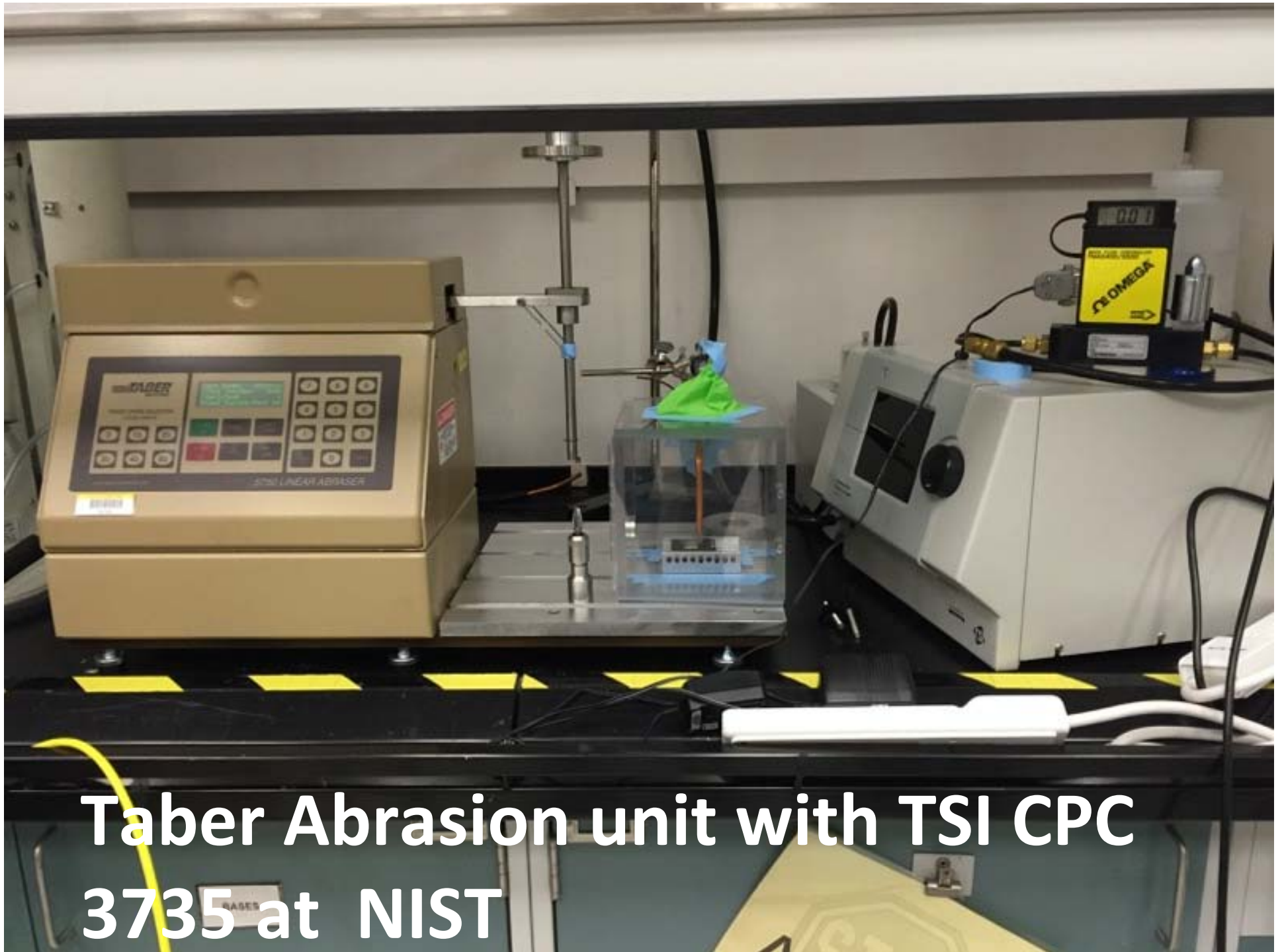


Froggett et al. (2014) *Particle and Fiber Toxicology*, Graphic from Froggett presentation NanoSafe 2014

## Froggett et al. found:

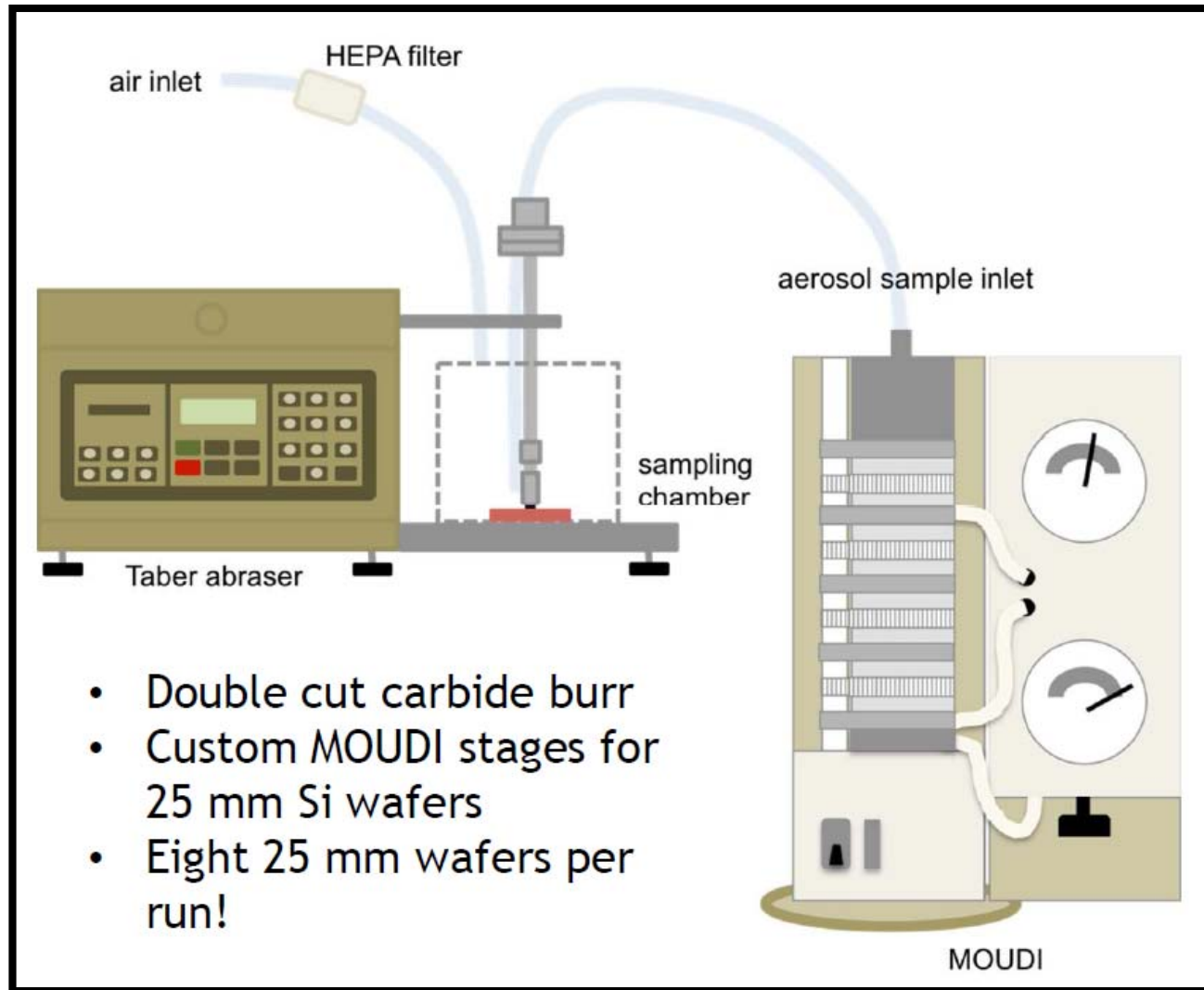
1. Release of fine and ultrafine matrix debris from both composites and nanocomposites is common under all release scenarios
2. Some of the debris contained the added nanomaterials either partially or fully embedded
3. Release of the added nanomaterials fully dissociated from the matrix has been detected *only occasionally*

Froggett S, Clancy S, Boverhof D and Canady R (2014) *Particle and Fiber Toxicology*



**Taber Abrasion unit with TSI CPC  
3735 at NIST**

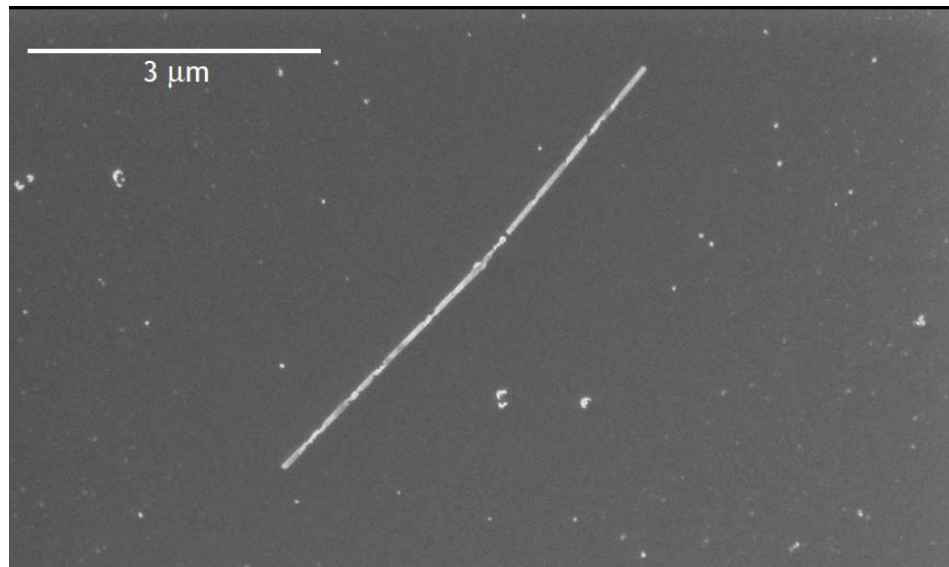
# NIST setup for linear abrasion testing



From Keana Scott's presentation at NanoSafe 2014

## Keana's Scott's conclusions:

- **“Free CNTs are seen but require further study.”**
- **Linear abrader coupled with MOUDI is a reasonable sampling approach.**



From Keana Scott's presentation at NanoSafe 2014

# CPWR and EPI conducted a range of sampling during the cutting, drilling and nailing of tiles



# We collected respirable dust, $\text{TiO}_2$ and TEM as well as CPC and OPC particle counts



# We conducted sampling during tile grinding with LEV on and off



**RIDGID 15-Amp 7 in.  
Angle Grinder**



**Ermator S26 HEPA  
Dust Extractor**



**Cut  
Buddy**

# We followed NIOSH Methods

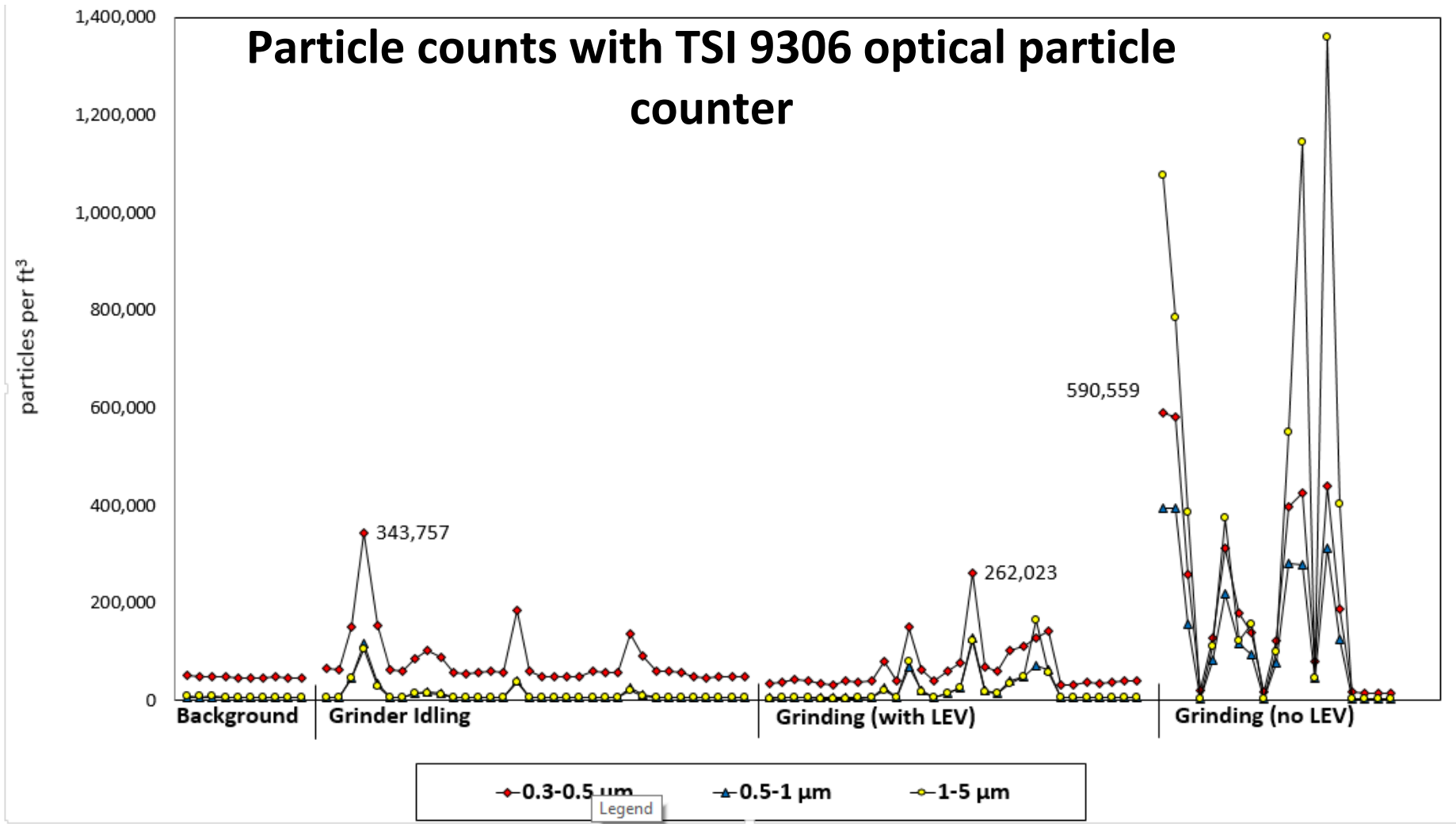
<b>Agent</b>	<b>Method</b>	<b>Media</b>
<b>Total Dust</b>	<b>0500</b>	<b>37-mm cassette with 5-micron pre-weighed, PVC filters</b>
<b>Titanium dioxide</b>	<b>7300</b>	<b>37-mm cassette with 5-micron pre-weighed, PVC filters</b>
<b>Titanium dioxide</b>	<b>7402 modified TEM</b>	<b>25mm open-face cassettes with 0.45-micron MCE filters</b>

## Most results were encouraging

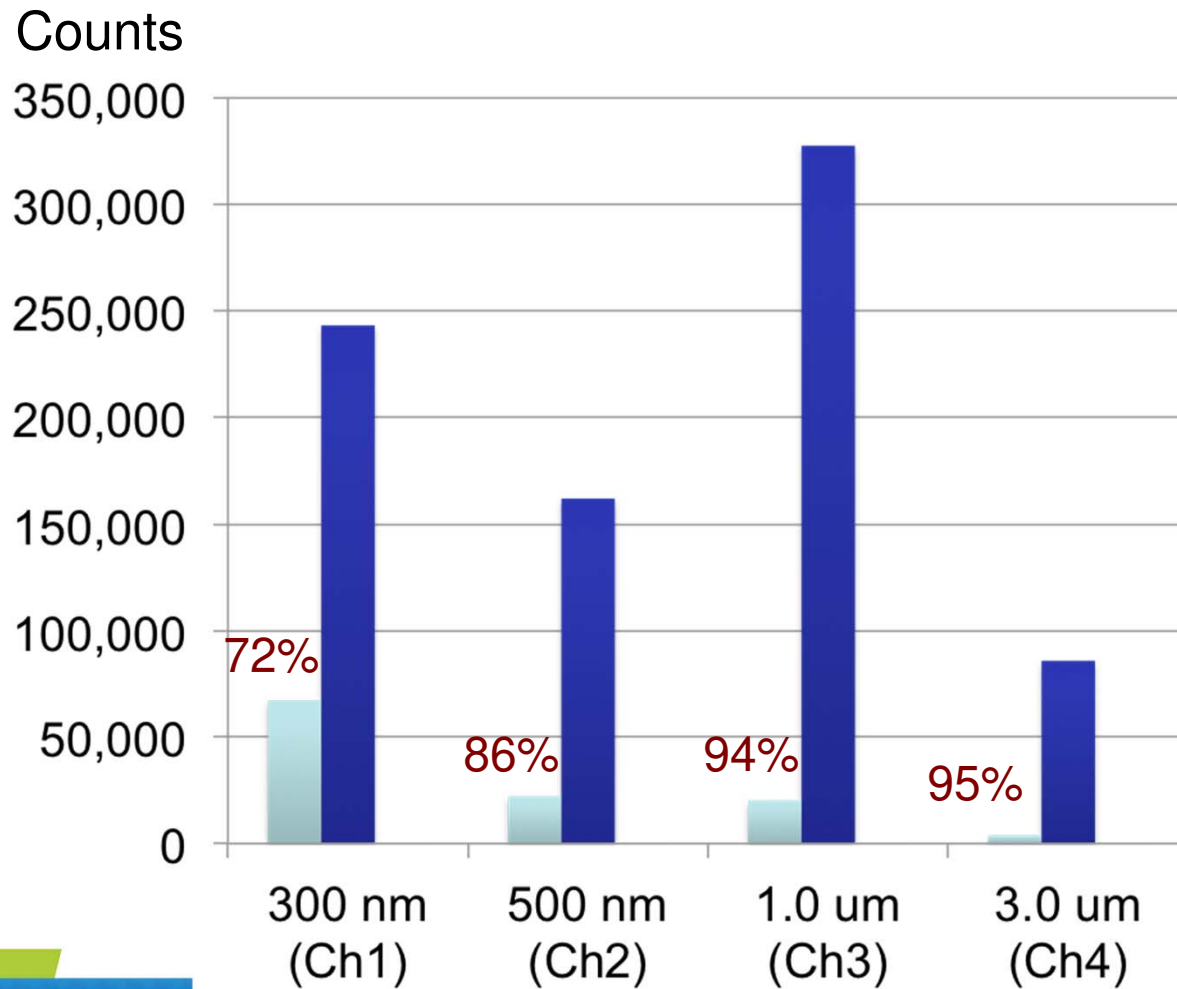
- All measurements were below the NIOSH REL for ultrafine  $\text{TiO}_2$  of  $0.3 \text{ mg/m}^3$
- Ventilation on the tool reduced respirable dust by roughly 50%



# Ventilation greatly reduced exposure



# Optical particle counts during surface grinding showed better LEV efficiency



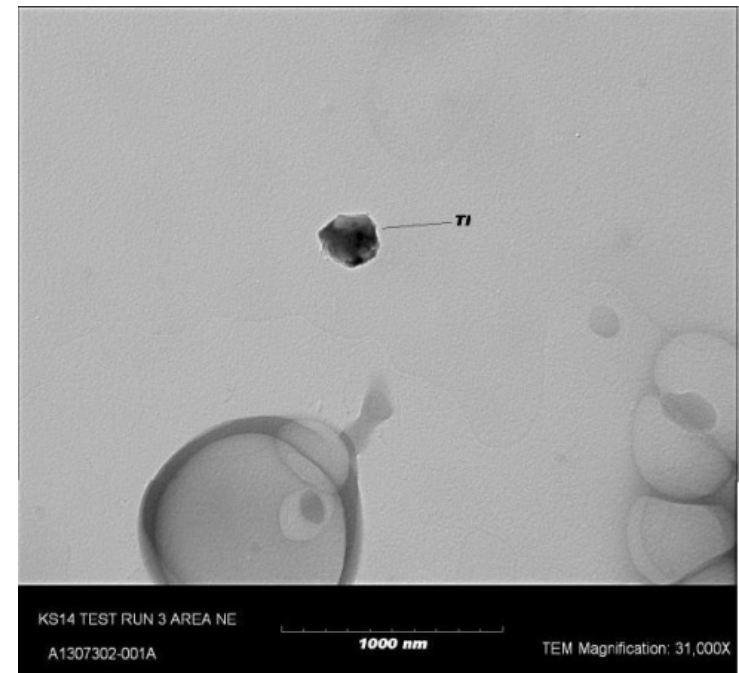
■ LEV On (Ave)  
■ LEV Off



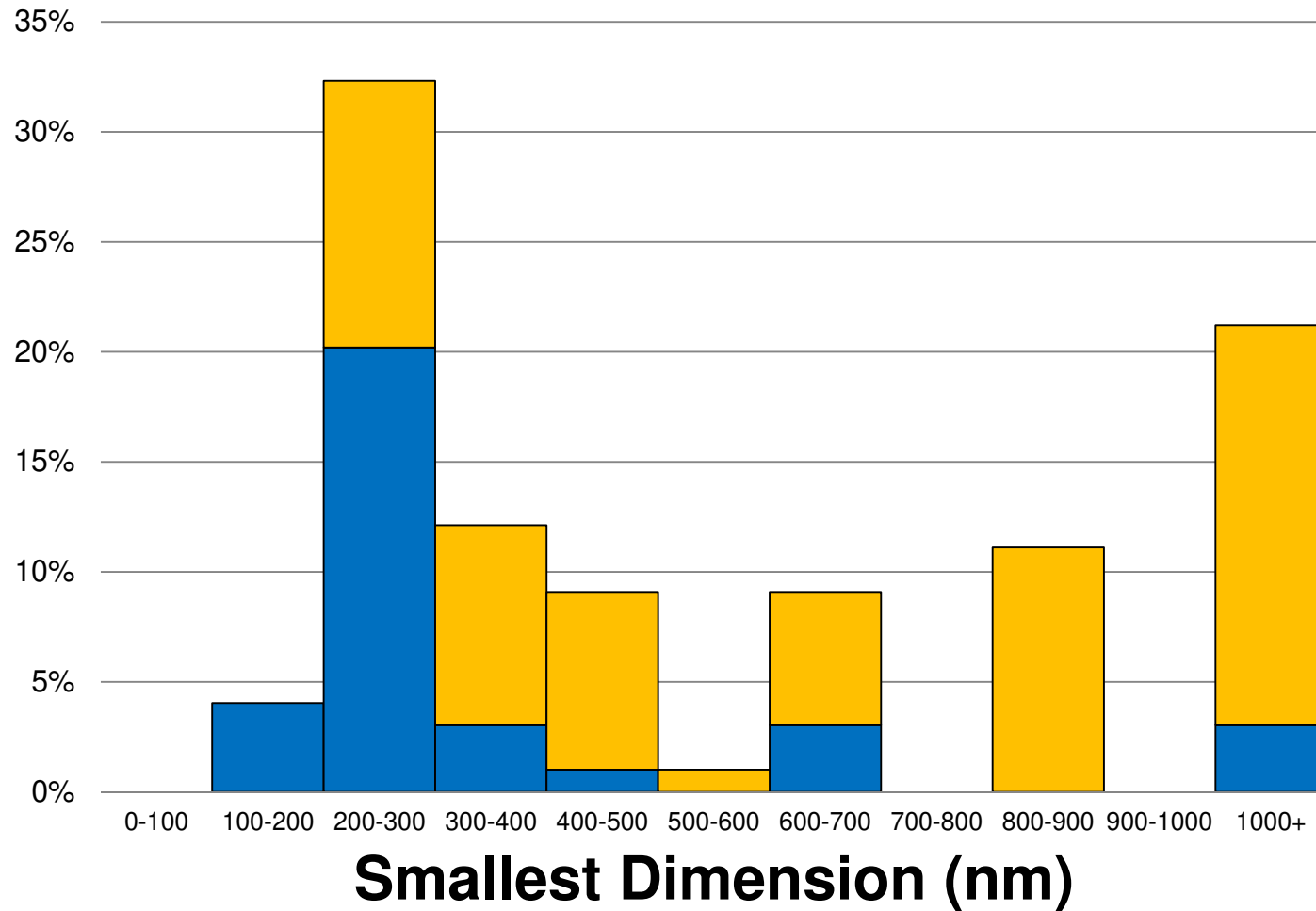
TSI 9306  
AeroTrack

**There were unagglomerated TiO<sub>2</sub> particles, however**

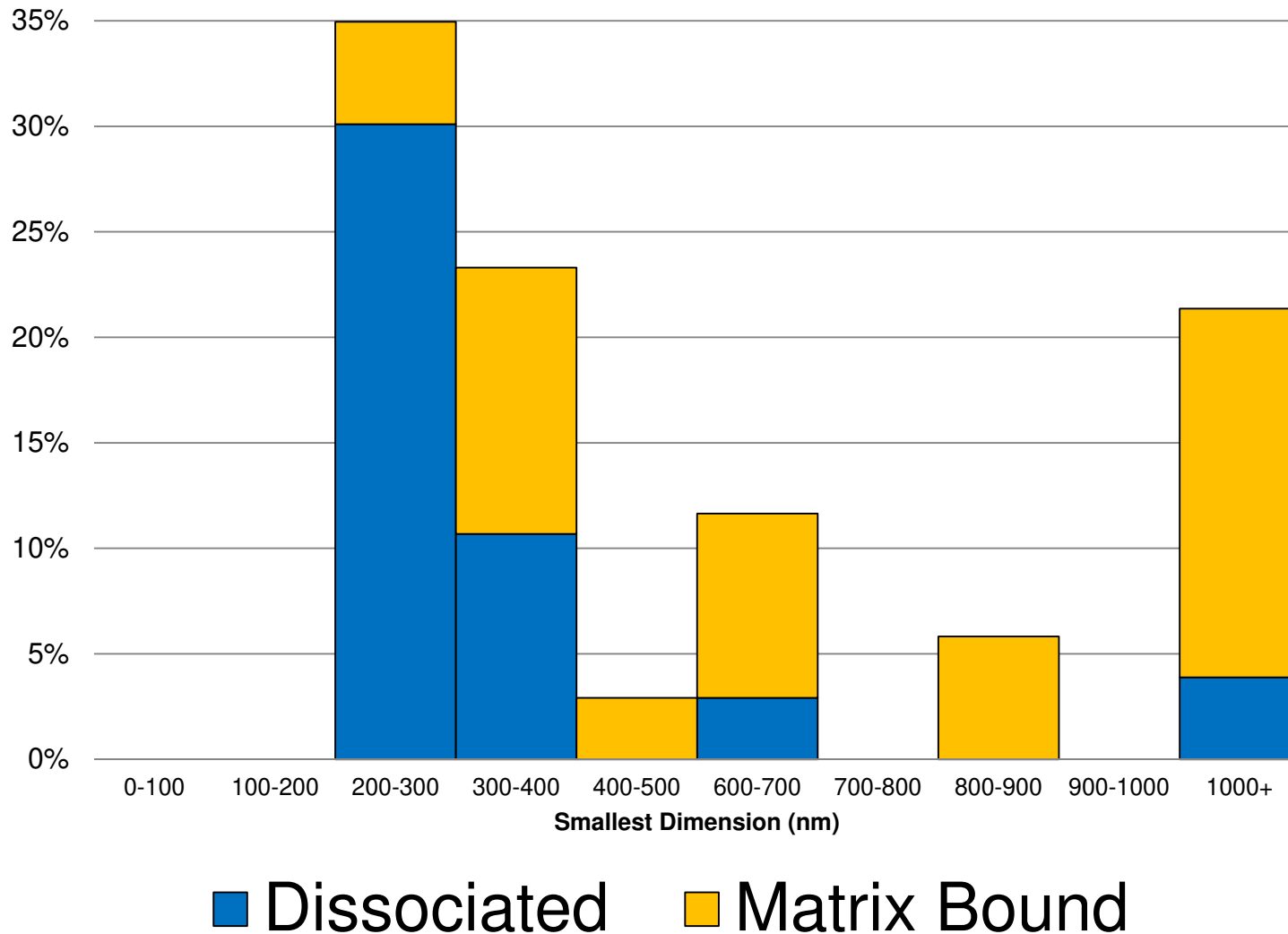
**41% of structures counted via TEM were free and not agglomerated**



# Size distribution of TiO<sub>2</sub> structures (n=99), TEM analysis, outdoor pilot area sample, cutting roof tile with LEV



# TiO<sub>2</sub> structures (n=103), TEM analysis, outdoor pilot area sample, cutting roof tile **with no LEV**



We next tested *cutting* in EPI's chamber using a Bosch saw with 12" blade and Ermator vacuum



2,900 ft<sup>3</sup>

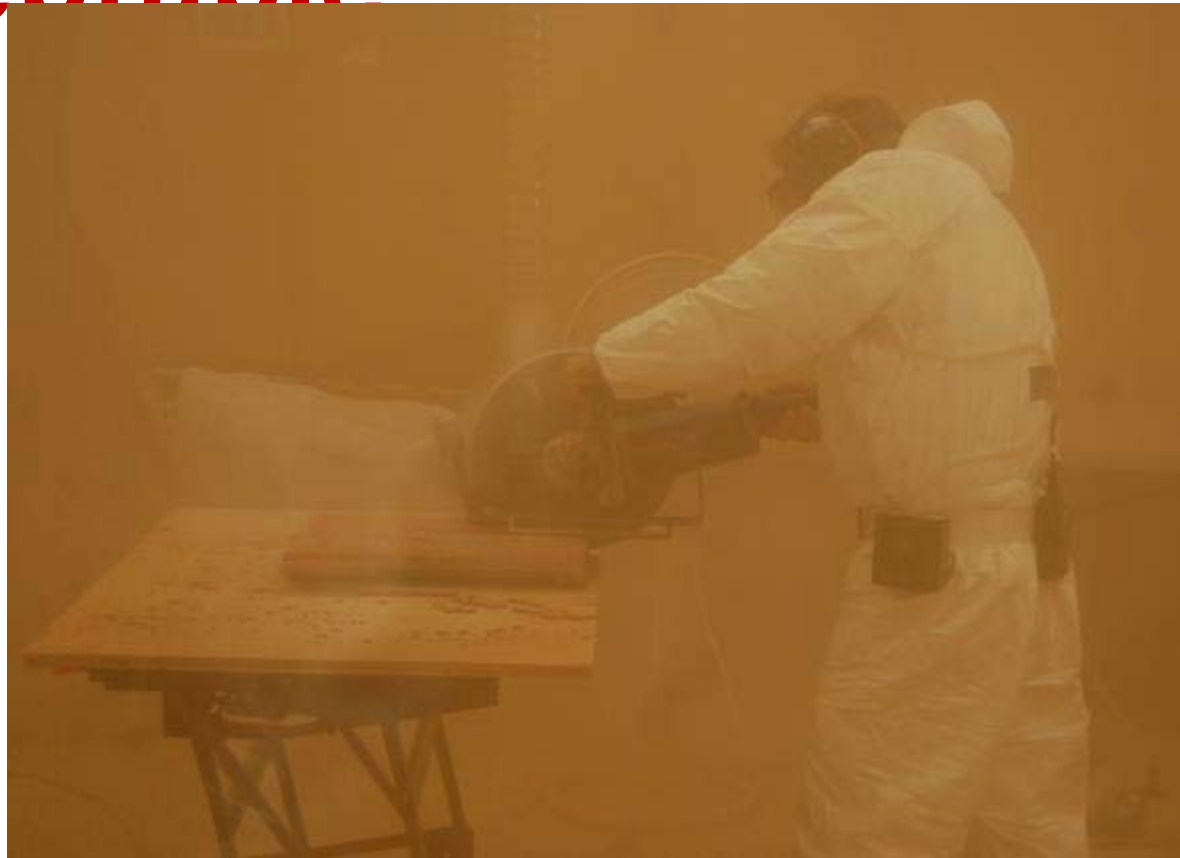
# Cutting across bevels was challenging for the ventilation



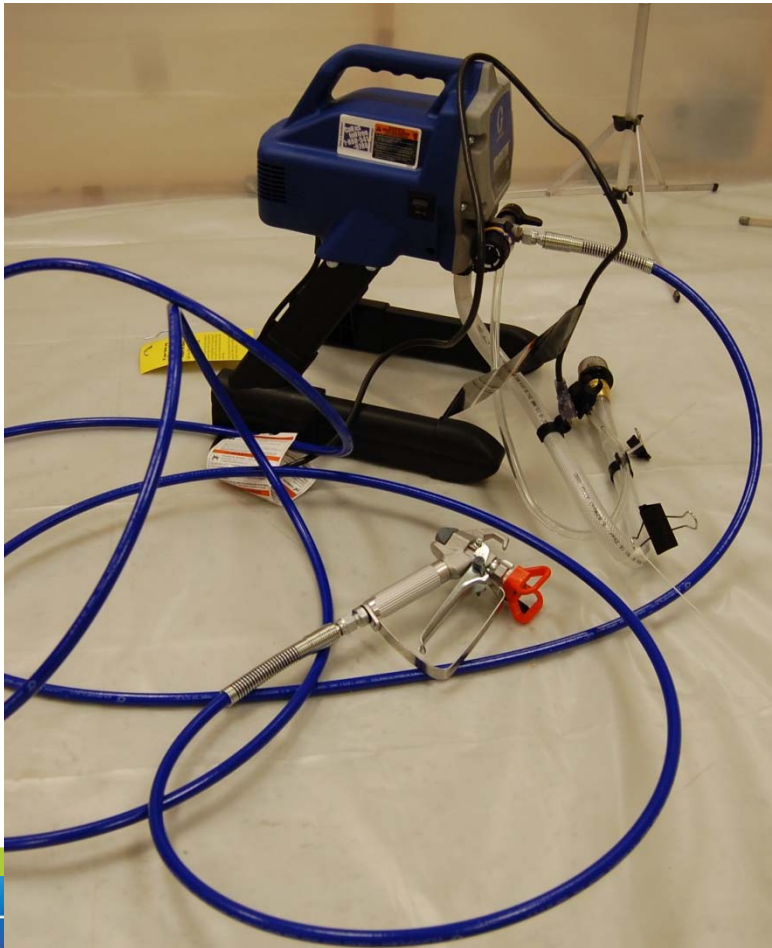
# Use of ventilation in chamber was quite effective (cutting longitudinally)

Sample	LEV On (mg/m <sup>3</sup> )	LEV Off (mg/m <sup>3</sup> )	% Reduction
Total dust (area)	19.79 (n=15)	675 (n =12)	97.1%
TiO <sub>2</sub> (area)	0.11 (n=15)	1.97 (n=12)	94.2%
Resp dust (personal)	4.44 (n=8)	81.17 (n=6)	94.5%
TiO <sub>2</sub> (personal)	0.04 (n = 8)	0.34 (n=6)	88.4%

**Dust levels without controls  
were extraordinarily high,  
but TiO<sub>2</sub> levels were still  
acceptable**



# Most recent sampling involved wood stain containing nano zinc oxide



“...using state of the art Nano-Technology”



This union painter was indispensable



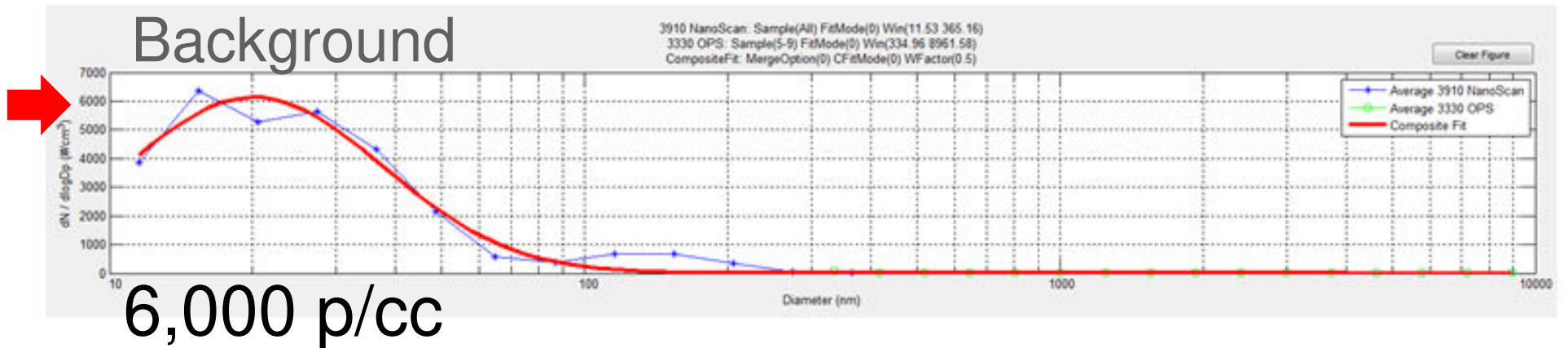


# Spraying produced considerable airborne mass (mg/m<sup>3</sup>)

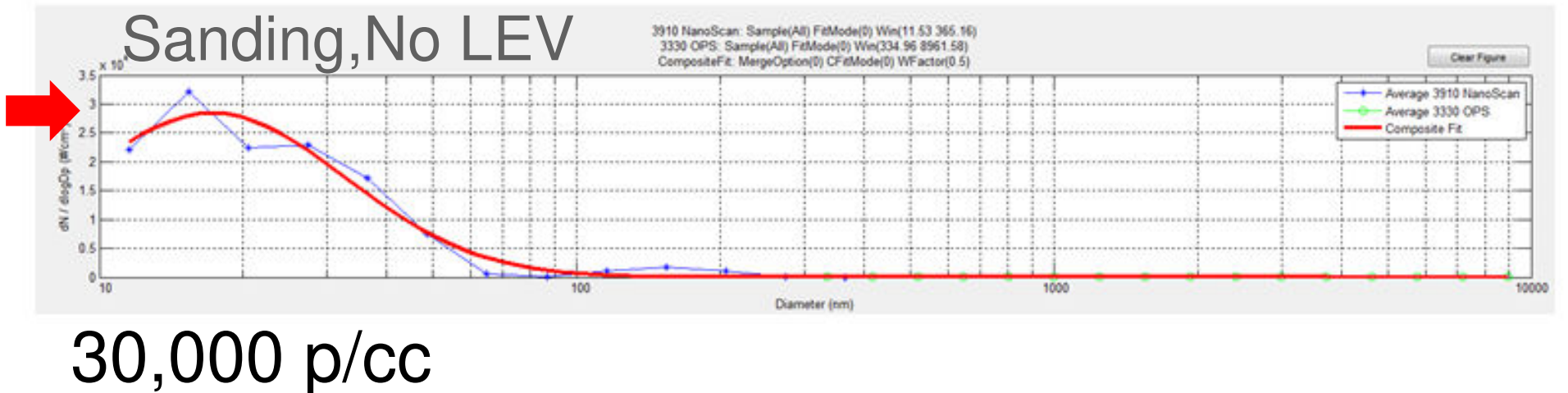
<b>N</b>	<b>Sample Location</b>	<b>Analyte</b>	<b>Measured Air Concentration (mean ± SD)</b>
<b>24</b>	<b>Area</b>	<b>Total Particulate</b>	<b>95.96 ± 14.31</b>
		<b>Zinc</b>	<b>2.26 ± 0.34</b>
<b>6</b>	<b>Personal</b>	<b>Total Particulate</b>	<b>84.33 ± 9.24</b>
		<b>Zinc</b>	<b>1.95 ± 0.19</b>
		<b>Respirable Particulate</b>	<b>20.00 ± 3.52</b>
		<b>Respirable Zinc</b>	<b>0.49 ± 0.09</b>

# This curve integrates data from TSI 3910 NanoScan and 3330 OPS

Activity	Run #	TSI File #	Board #	Date	Start Time	Stop Time
Background	16	38	12	12/17	18:03	18:07



Activity	Run #	TSI File #	Board #	Date	Start Time	Stop Time
No Bag, No LEV	16	39	12	12/17	18:09	18:19



# Describe the current state of hazard communication for nano

## Topic 6



# The new NI OSH REL for carbon nanotubes is 1 ug/ m<sup>3</sup>

## Section 1 Product Identification

Chemical Name: Carbon Fullerene  
 Formula: Carbon  
 Chemical Family: Synthetic Graphite  
 Synonyms: Carbon Nanotubes  
 CAS Number: 7782-42-5 (Graphite)

“Nuisance” dust standard for synthetic graphite:  
 15 mg/m<sup>3</sup> total  
 5 mg/m<sup>3</sup> resp

## Section 2 Composition and Information on Ingredients

Component	%	OSHA/PEL	ACGIH/TLV
Synthetic graphite	Up to 100%	15 mg/m <sup>3</sup> (total dust) 5 mg/m <sup>3</sup> (respirable fraction)	2 mg/m <sup>3</sup> TWA

**Workers may be at risk of  
lung lesions exposed to  
SWCNTs 20 days at 5  
mg/ m<sup>3</sup>**

**Shvedova et al., Am. J. Physiol. Lung  
Cell Mol. Physiol. 2005**

**The majority (67% ) of SDSs NI OSH collected in 2010-2011 “still provided insufficient data for communicating the potential hazards of ENM.”**

Date collected	Satisfactory	In Need of Improvement	In Need of Significant Improvement
2007-2008, n = 32	7 (21.8%)	13 (40.6%)	12 (37.5%)
2010-2011, n = 21	7 (33.3%)	10 (47.6%)	4 (19.1%)
2007-2008, recollected in 2010-2011, n = 23	4 (17.4%)	8 (34.8%)	11 (47.8%)

# Safe Work Australia found SDSs lacking (2010)

- Nano metals, metal oxides, silicates and carbon nanotubes
- (84%) were “not sufficient to fulfill an appropriate risk assessment”
- Many presented data for the bulk material



**ISO has published a 2012  
technical report for writing nano  
SDSs that is quite good!**

**ISO/TR 13329**

***Nanomaterials: Preparation of  
Material Safety Data Sheet (MSDS)***



# The ISO recommends an precautionary approach

Provide an SDS for nanomaterials and  
nanomaterial-containing products  
*regardless* of whether the material is  
classified as hazardous

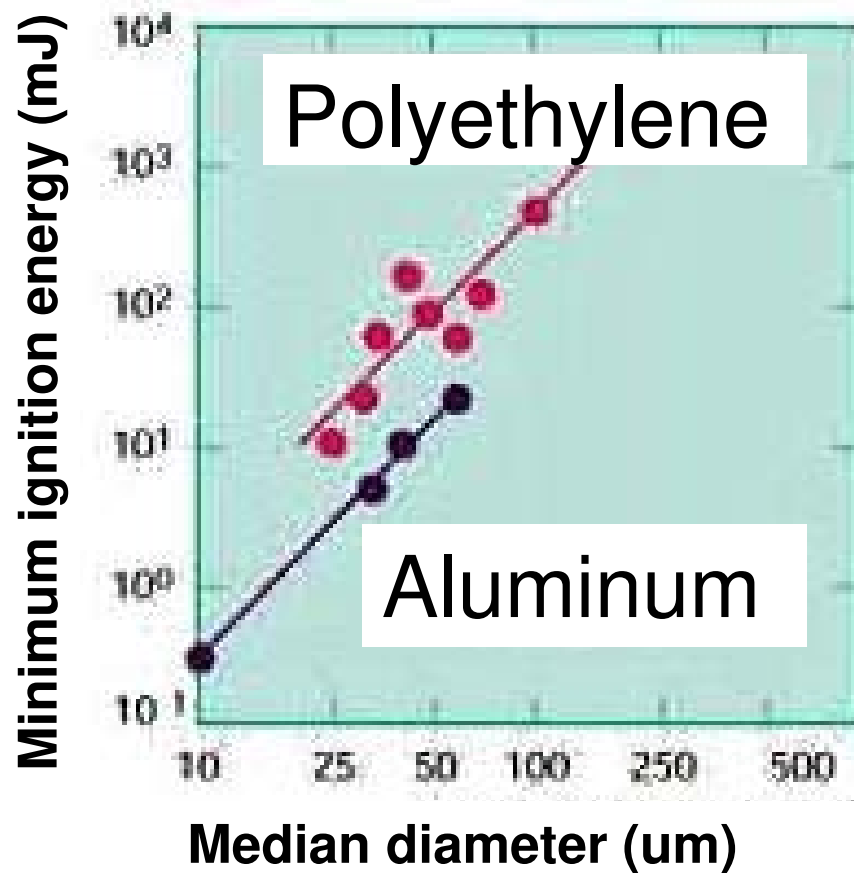


# Nano SDSs should consider fire risks

- Nano powders may show “unusually high reactivity for fire, explosion and catalytic reactions”
- Nanomaterials reactivity may not be anticipated based on chemical composition alone
- Decreasing particle size reduces minimum ignition energy



# Minimum ignition energy decreases exponentially with particle diameter



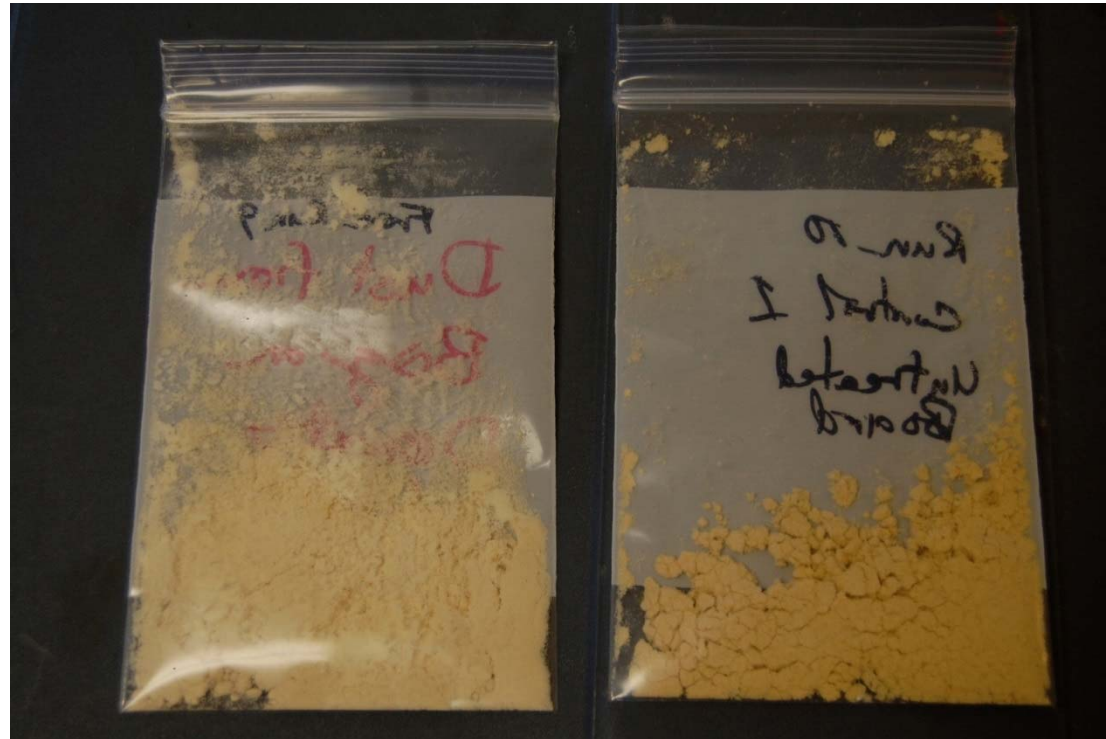
*Netherlands Organization for Applied Scientific Research*

# **We work closely with NIOSH's Office of Construction Safety and Health**



**Nura Sadeghpour, Dr. Christine Branche and Gavin West  
at latest sampling effort**

**We are working with NIOSH toxicologists who are planning in vivo tests with the dust**



**30,000 p/cc**

# Summary

1. Exposures to engineered nanoparticles in construction appear to be below OELs
2. Local exhaust ventilation can greatly reduce construction exposures, including to nano-objects
3. Standard agents shouldn't be ignored
4. Workers need to be better informed
5. Safety Data Sheets for nano products need to be greatly improved

# Thanks! Questions?

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**Director of Safety Research**

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**<http://www.elcosh.org>**

