Additives in concrete and other construction materials

Challenges in metrology, characterization, and implications

Dhimiter Bello, ScD, MSc

Professor, Biomedical and Nutritional Sciences
Associate dean for research and graduate studies
Zuckerberg College of Health Sciences
UMass Lowell
**Product Categories**

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<th>Category</th>
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<td>Abrasive blasting media</td>
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<td>Thermal spray coating materials</td>
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<td>Welding</td>
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**Most frequent nano applications in COATINGS:**

- Coatings - Mineral surfaces, 145
- Coatings - Multisurface, 125
- Additives in coatings, 39
- Coatings – glass/ceramic, 40
- Coatings – paints, 38
- Wood, 37
- Insulation – heat/frost, 35
- Additives for concrete/cement, 27

**Many thanks to:**
CPWR – Center for Construction Research and Training and NIOSH; & Bruce Lippy and Gavin West (of CPWR)!

And for funding us two 5-yr cycles to investigate reactive chemical systems in construction
Additives in asphalt and concrete

- SWCNT, > 5um long
- Amorphous silicas
- Calcium silicate
- Zn NPs
- Graphene and functionalized graphenes
- Nanocellulose
- Organo-silanes
- Proprietary additives (e.g. FASS-DRI)™

**Category:** Additives for asphalt

**Description:**
FASS-DRI Pavement Sealer Additive is the result of an exciting break-through in additive chemistry. It enables you to open parking lots to traffic in as little as 30 minutes. Jobs can be completed faster - lots can be striped quicker for reduced down times. The technology behind Fass-Dri Pavement Sealer Additive enables sealers to dry from the bottom up as opposed to skinning over and trapping moisture within the sealer film. It drives moisture out resulting in rapid curing.

**Typical Use:**
Ideal for coal tar emulsion, asphalt emulsion, or blended sealers.

**Apparent use of Nanotechnology:** Unspecified use of nanotechnology

**Reason for Inclusion:**
*NANO-CUBE™ TECHNOLOGY FOR ASPHALT AND COAL TAR BASED PAVEMENT SEALERS

FASS-DRI™ PSA (Pavement Sealer Additive) is a technically advanced formula designed to enhance performance and handling characteristics of pavement sealers. NANO-CUBE™ Technology works to drive moisture out of the coating, for faster dry times and advanced curing. FASS-DRI™ PSA is fortified with a sand suspension additive (SSA) ensuring better viscosity control and smooth consistent material over a broad range of designs.” (see technical data sheet)
Additives in Coatings/Paints

• Graphene
• MWCNTs
• Metal oxide nanoparticles
  • Al$_2$O$_3$, surface modified silica, ZnO, CeO$_2$, SiC, TiO$_2$, CaCO$_3$
• 3-D (proprietary polymer networks: nano – clear coatings
• Several proprietary nanoparticle additives for improved barrier resistance, hydrophobicity, antimicrobial activity in paints, etc.
  • Nano shield
Real-world nano experiences to leverage for advanced materials/technologies

- Nano-additives in advanced polymer nanocomposites synthesis and processing
  - *Multiple pubs investigating exposure-disease in workers*

- Engineered nanomaterial additives in toners
  - Multiple pubs exploring PCM properties, chemistry, and toxicology

- Industrial steel structure coatings in construction
  - Multiple pubs/years investigating product chemistry, exposures, biomonitoring, PPE testing, and impact on workers’ health
Coating systems as a practical example

- The general industrial coatings sector is expected to reach 8.9 million metric tons in paints/coatings and $23B value in global sales by 2020;
- More than 56,000 bridges in the United States are in need of repair or replacement;
- Industrial painter = Class 1 human carcinogen by IARC! (No idea what agents cause cancers)
- Little field research focusing on implications

Process: Sequential coating layers

- **Sand blasting to clean the surface**
- **Primer coating**
  - High solids, Zn-rich, epoxy rich - polyamide formulation
- **Mid-coat**
  - Epoxy-based reactive systems
- **Top-coat**
  - Aliphatic isocyanate-based reactive systems
Reactive Systems: Steel structure coatings example

**Part A**

- **EPOXY** (BADGE)
  - or
  - **ISOCYANATE** (pHDI, pMDI, pTDI, + proprietary hybrid chemistries)

**Part B**

- **HARDENERS:**
  - AMINES (10+ types) & Polyols

- **SOLVENTS** (10+)

- **Nano FILLERS**
  - Zn, TiO$_2$, Fe$_2$O$_3$, nano/Quartz, etc.

- **CATALYSTS**

- **Other additives**

Spray painting & roller/brush appl.
Qualified coating products for use on highway bridge steel by Northeast Protective Coating Committee (NEPCOAT)

- List A - Inorganic primer three coat system
  - 6 products
- List B - Organic primer three coat system
  - 22 products
- List C - Organic primer two coat system
- List D - Inorganic primer three coat system
Some lessons from nanotechnologies of the past two decades

1. Formulations that have penetrated the market are often tested and certified as superior performance products – e.g. paints used in industrial steel structure coatings

Q1: How does the addition of nano/advanced material in a formulation transform properties of the product? Is nano = transformative in materials properties?

We should also ask with the same level of urgency:

Q2: How does the addition of nano/advanced material in a formulation impact toxicity/safety of a product along the product lifecycle?
Some lessons from nanotechnologies of the past decades

2. Nano additives are only one component of largely complex and poorly understood mixtures

• Assessment of risk lags evaluation of product performance by many years

• Not meaningful or useful to single them out for the purposes of risk/health impact assessment

• Investigation of toxicity and PCM properties of raw nano /advanced material is only a starting point – necessary but not sufficient

• Nano component – sometimes blamed inappropriately for toxicity
  • Remember the Song et al 2008 paper on nanotechnologies*

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Some lessons from nanotechnologies of the past decades

3. New methods, tools, and platforms are needed to meet the challenge of metrology/PCM characterization of nano/advances materials in commercial formulations

- Alteration of PCM properties of advanced / nano material in complex products due to matrix effects
- Alteration of product properties due to nano /advanced material additive
- Assays to assess risk from exposures to nano-enables products along their life cycle
  - CPSC and NIOSH to be commended for funding research in this space (3-D printing, NP from tonners etc., e-cig, etc.)
- Test methods to assess PPE performance under realistic conditions – penetration and permeation tests for gloves and garments example
Some lessons from nanotechnologies of the past decades

4. We are not good at predicting future risks / liabilities

a. Sandblasting of existing paints on steels structures from 30+ yrs. ago
   Regulatory driver – Pb exposure; Still poorly controlled
b. Construction a leading consumer of PFAS – just emerging

1. Surface cleaning / sand blasting
For consideration

- How to handle the ‘proprietary’ nature of nano/advanced formulations
- Who is responsible for funding/developing methods for characterization of nano/advanced materials in new commercial formulations?
- Is there room for standardization of test methods for characterization of these new ‘nano or proprietary additives’?
- Who is responsible for developing test methods for evaluation of PPE performance of emerging advanced materials/products?
Thank you!

Serious and meaningful discussion on these topics is the best insurance policy for harvesting the greatest benefits of new technologies in the long-term!

And minimizing future liabilities....