Additives in concrete and other construction materials

Challenges in metrology, characterization, and implications

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elcosh NANO
Construction Nanomaterial Inventory

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Product Categories

Abrasive blasting media (1)	Additives for asphalt (4)
Additives for coatings (39)	Additives for concrete/cement (27)
Adhesives (13)	Boiler additives (1)
Caulking (2)	Cement-based (29)
Coatings - glass/ceramic (40)	Coatings - metal (45)
Coatings - mineral surfaces (145)	Coatings - multi-surface (125)
Coatings - paints (38)	Coatings - wood (37)
Drywall (1)	Fasteners (1)
Flooring (18)	Fuel Additives (1)
Glass and solar panels (17)	Grout (3)
HVAC (5)	Insulation - Electrical (1)
Insulation - Heat/Frost (35)	Interior Design (1)
Joint Sealants (3)	Lighting (2)
Lubricants (19)	Lumber (6)
Metal (10)	Miscellaneous (15)
Patching compounds (17)	Prepregs (4)
Roofing (17)	Soil Stabilizers (2)
Surface preparation (15)	Thermal spray coating materials (11)
Weatherproofing membranes (4)	Welding (10)

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) ™

Product Link

click to view product

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-CURE™ 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-CURE™ 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_2O_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

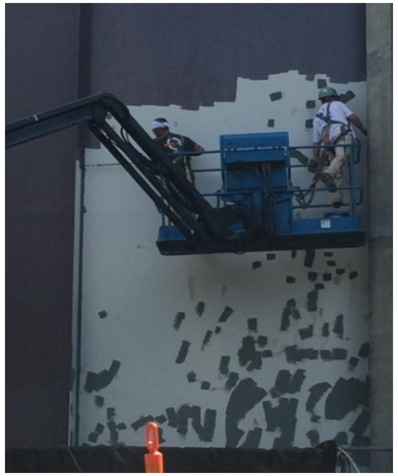
Mid-coat

Epoxy-based reactive systems

Top-coat

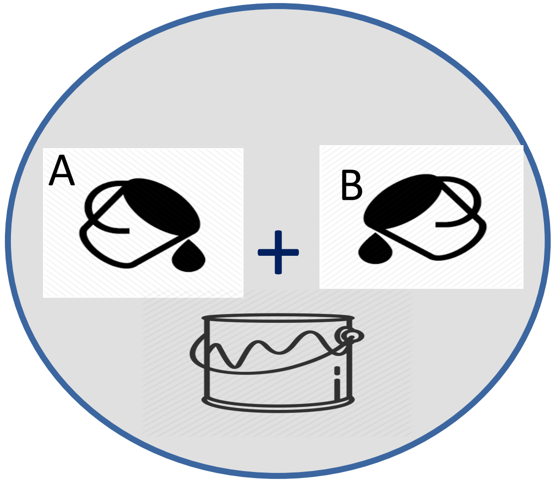
Aliphatic isocyanate-based reactive systems

Reactive Systems: Steel structure coatings example



Part A

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



Spray painting & roller/brush appl.

Part B

HARDENERS:
AMINES (10+ types)
& Polyols

SOLVENTS
(10+)

Nano FILLERS
Zn, TiO_2,Fe_2O_3,
nano/Quartz, etc.

CATALYSTS

Other additives

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**

NEPCOAT Qualified Products List A

for Protective Coatings for
NEW and 100% BARE EXISTING Steel for Bridges

NTPEP System No.	Coats	3-COAT SYSTEM TESTED AND ACCEPTED	Slip Coef Class	Manuf'r Coating DFT (min/max) mil	micron	VOC Tested g/L	QPL Accepted Dates
NEPCOAT LIST A - INORGANIC Zinc Rich Primer / Epoxy or Urethane Intermediate / Aliphatic Urethane Finish							
SSC(09)-01		SHERWIN WILLIAMS COMPANY					
	Primer	Zinc Clad® DOT Inorganic Zinc Rich Primer					
	Interm	Steel Spec Epoxy Intermediate					
	Topcoat	High Solids Polyurethane					
	[1] Footnote	4 mils max DFT, 48 hours min cure, 4% max thi					
SSC(12)-03*		CARBOLINE COMPANY					
	Primer	Carbozinc® 11 HS Inorganic Zinc Primer					
	Interm	Carboguard® 893 Epoxy Intermediate					
	Topcoat	Carbothane 133 LV Aliphatic Polyurethane					
	[1] Footnote	6 mils max DFT, 19 hrs min cure, 12% max thin					

NEPCOAT Qualified Products List B

for Protective Coatings for
NEW and 100% BARE EXISTING Steel for Bridges

NTPEP System No.	Coats	3-COAT SYSTEM TESTED AND ACCEPTED	Slip Coef Class	Manuf'r Coating DFT (min/max) mil	micron	VOC Tested g/L	QPL Accepted Dates
NEPCOAT LIST B - ORGANIC Zinc Rich Primer / Epoxy or Urethane Intermediate / Aliphatic Urethane Finish							
SSC(10)-03		PPG/AMERON					from
	Primer	Amercoat® 68HS Zinc Rich Epoxy Primer	B [1]	3-5	75-125	276	12/14/2011
	Interm	Amercoat® 399 Fast Drying Epoxy		4-8	100-200	177	until mtg.
	Topcoat	Amercoat® 450H Gloss Aliphatic Polyurethane		2-5	50-125	306	fall 2018
	[1] Footnote	3 mils max DFT, 7 days min cure, 3% vol max thin					
SSC(10)-05		WASSER HIGH TECH COATINGS					from
	Primer	MC-Zinc 100	Ø	3-5	75-125	115 es	4/03/12
	Interm	MC-Miomastic 100	no	3-5	75-125	173 es	until mtg.
	Topcoat	MC-Ferrox A 100	report	2-4	50-100	144 es	spring 2019
	Ø Footnote	No data reported.					
SSC(11)-01		SHERWIN WILLIAMS COMPANY					from
		Zinc Clad® III HS Organic Zinc Rich Epoxy Primer	A [1]	3-5	75-125	337	10/02/12
		Spec Epoxy Intermediate		3-8	75-200	293	until mtg.
		lids Polyurethane		3-5	75-125	288	fall 2019
		s max DFT, 7 days min cure, zero thinner					
		RNATIONAL PAINT INC					from
		inc® 315B Epoxy Zinc Rich	B [1]	2-6	50-150	304	10/02/12
		ard 475HS Epoxy		4-8	100-200	187	until mtg.
		hane® 870 UHS		3-5	75-125	242 es	fall 2019
		s max DFT, 48 hours min cure, zero thinner					
		B continues)					

NEPCOAT Qualified Products List C

for Protective Coatings for
NEW and 100% BARE EXISTING Steel for Bridges

NTPEP System No.	Coats	2-COAT SYSTEM TESTED AND ACCEPTED	Slip Coef Class	Manuf'r Coating DFT (min/max) mil	micron	VOC Tested g/L	QPL Accepted Dates
NEPCOAT LIST C - ORGANIC Zinc Rich Primer / --- / Topcoat							

NEPCOAT Qualified Products List D

for Protective Coatings for
NEW and 100% BARE EXISTING Steel for Bridges

NTPEP System No.	Coats	2-COAT SYSTEM TESTED AND ACCEPTED	Slip Coef Class	Manuf'r Coating DFT (min/max) mil	micron	VOC Tested g/L	QPL Accepted Dates
NEPCOAT LIST D - INORGANIC Zinc Rich Primer / --- / Topcoat							

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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*

* Song Y, Li X, Du X (2009) Exposure to nanoparticles is related to pleural effusion, pulmonary fibrosis and granuloma. Eur Respir J 34: 559-567

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….