Novel Corrosion Control Coating Utilizing Carbon Nanotechnology

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### 12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited

### 13. SUPPLEMENTARY NOTES

**2009 U.S. Army Corrosion Summit, 3-5 Feb, Clearwater Beach, FL**

### 15. SUBJECT TERMS

### 16. SECURITY CLASSIFICATION OF:

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### 17. LIMITATION OF ABSTRACT

Same as Report (SAR)

### 18. NUMBER OF PAGES

22

### 19a. NAME OF RESPONSIBLE PERSON

Standard Form 298 (Rev. 8-98)

Proscribed by ANSI Std Z39-18
R&D Goal

Develop best available & user-friendly coating systems for protecting steel infrastructure from corrosion:

System #1  3-Coat system $\geq$ best 3-coat Zn rich system

System #2  2-Coat system $=$ best 3-coat Zn rich system

System #3  1-Coat DTM $>$ best 1-Coat DTM alternative
Novel Epoxy Paint System

- 3-Coat Epoxy Paint System
  - Epoxy primer formulated with
    - Zinc dust
    - Single Wall Carbon Nanotubes (SWNT)
  - Epoxy Intermediate Coat
  - Polyurethane topcoat
- Dual barrier coating and cathodic coating protection for steel
- Shifts the potential to cathodic potential in the event of a coating defect
- Aluminum can be used in place of the zinc
Dual Purpose Technology

- First, produce the toughest most resilient barrier coating
- Second, shift the potential of the environment to a less corrosive cathodic potential
- Outperforms barrier coating only technology
Function of Single Wall Carbon Nanotubes (SWNT)

- Produce galvanic reactivity of the substrate
- Facilitate electron transfer through the binder
- Reinforce / Toughen Binder
How?

• Pioneered by Nobel Laureate Richard Smalley

• Structure
  – electrical
  – mechanical properties

• Current-carrying capacity
  – 1,000x greater than copper

• Tensile strength
  – 50x greater than steel
Barrier / Electrical Properties

- Carbon Nanotube Ropes
  - strength of the carbon-carbon bonds builds an extended network of Carbon Nanotube Ropes
- Reinforce / Stiffen / Toughen
- Electron Path
  - through the binder
  - between the cathodic substrate and anodic sacrificial metals

SEM Micrographs courtesy of Unidym, Inc., Houston, Texas
Barrier Properties

Traditional Zinc-Rich Primer

TESLAN™ Primer

Lower Pigment Loading = Better Adhesion & Stronger Film
Corrosion Testing

- Outdoor exposure and weathering - ASTM D1014
- Fresh water immersion testing - ASTM D870
- Salt water immersion testing – ASTM D870
3-coat Epoxy System

• Graded “10” of “10” after 3-years of testing (25,000+ hours)
  
  – No undercutting
  
  – evaluation criterion in accordance with ASTM D1654
Epoxy Primer

- **Bullet-Hole Testing** iaw AASHTO M-300
  - White metal blasted 1 ½ - inch diameter
  - Immersed in 5% Salt Water Solution
  - Demonstrates Cathodic Potential
  - Cathodic Throwing Power

500+ Hours
Durability

Impact Resistance

ASTM G14 Falling Weight

Bend / Tensile Strength

ASTM D522 Mandrel Bend Test
Benefits

• Improved integrity of barrier films due to
  – lower pigment loading
  – SWNT reinforcement

• Improved durability and modulus under stress; impact, abrasion and flexing

• Cathodic corrosion protection in the event of a coating defect
Benefits (cont.)

- More resistant to heat and UV
- Weight reduction via
  - lower metal content
  - reduced film thickness
- Better aesthetics, color and gloss with lower loadings and ability to pigment
- Less vulnerable to pore, coating break, and other coating defects
- Less susceptible to poor adhesion due to inadequate surface preparation
Benefits (cont.)

- 3-coat performance with a 2-coats
  - Structural integrity with lower metal loading
  - Eliminate intermediate coat build
  - Compatibility with high performance topcoat
- Reduction of film thickness
- Potential of single coat direct to metal system outperforming traditional 2 and 3 coat systems
- Longer service life
- Lower overall costs
Environmental Benefits

• Lower zinc and associated lead levels (approximately 50% reduction) with zinc system
• Total elimination of heavy metals using the aluminum system
• Easy to formulate high-solids coating systems
• Longer service life and waste reduction
Application Methods

- All conventional wet coating methods
  - Spraying
  - Brushing
  - Rolling
  - Coil coating
- Powder Coating (under development)
Fields of Use

• Aerospace and Defense
  – Marine coatings
  – Lightweight performance coatings
  – Zinc-chromate alternative
  – Plating alternative
  – Steel hardware & structures

• Petrochemical Industry
  – Offshore rigs
  – Oil tankers
  – Pipelines / transmission lines
  – Drilling / refinery / plant maintenance coatings

• Locks & Dams
Current Project

- Title: “Inherently Conductive Additives for Reducing the Zinc Dust Content In Corrosion–Inhibiting Primers for Steel”
- 3-Coat epoxy/polyurethane system applied December 2008 to a fuel tank at Ft. Bragg, NC
- Corrosion coupon test rack in place
- Coating and coupons will be monitored for 2 years +
Project Outcomes

- DOD Specification & Standard Development
- Implementation Army – wide
- Expand to other services
Conclusion

• **INNOVATIVE EPOXY/POLYURETHANE SYSTEM USING SWNT UNDER EVALUATION**

• Characteristics
  – Toughness & durability
  – Corrosion protection

• Benefits vs. traditional system
  – Lower metal content
  – Lower pigment loading
  – Lower weight
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