Nano Scale Organosilane
Asphalt Applications

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Organosilane Chemistry

• Developed over 50 years ago by Dow Corning for Epoxy/Fiberglass systems
• Unique capability to form covalent bonds between inorganic and organic compounds.
• Inherent stability and flexibility of the siloxane (Si-O-Si) bond provides multiple benefits in bituminous applications.
Organosilane Chemistry

By using the right organosilane, a poorly adhering coating can be converted to a material that will maintain adhesion even if subjected to severe environmental conditions (e.g., high temperature, underwater immersion or UV radiation).

Source: Organosilane Technology in Coating Applications: Review and Perspectives, Thierry Materne, Global Silane Technology, et. Al. Dow Corning Corporation
Nano Scale Organosilane Chemistry

• Nano Scale structures are under 100 nm
• Nanometer = 1 x 10^{-9} meters
• Comparable Dimensions
  • Sheet of paper thickness = 100,000 nm
  • Human hair = 80,000 – 100,000 nm
  • 200 Sieve = 0.075 mm = 75,000 nm
Dual-Reactive Organosilanes Bond Inorganic and Organic Substances

Asphalt Mix Applications:

• Nano Scale allows bonding to dust and fines
• Complete coating of the entire aggregate surface

Source: Organosilane Technology in Coating Applications: Review and Perspectives, Thierry Materne, Global Silane Technology, et. Al. Dow Corning Corporation
Organosilane Chemistry

- Si forms four covalent bonds
- Silicon Functional Groups bond to aggregate
- Organofunctional groups bond to bitumen
- Chemical bonding of the bitumen-aggregate system decreases moisture susceptibility
Organosilane Effect on Asphalt Binder

- Does not effect the Performance grade of the binder
- No change to high temperature DSR values
- No change in low temperature BBR values
- Does not effect the Rotational Viscosity AASHTO T 316
Organosilane Function in Asphalt Mix

- Aggregates are naturally hydrophobic due to polar surfaces created by Si-OH- hydroxyl groups
- Organofunctional alkoxy silane reacts at the aggregate–bitumen interface
- Forms Si-O-Si bonds that are non-polar
  - Aggregates repel water
  - Easily wetted by bitumen
Asphalt Binder Composition

Asphalt microstructure is a three dimensional association of polar Asphaltenes (5-15%), dispersed in non-polar Maltenes (85-95%)

Asphaltene Image Sources: Dr. G.A. Mansoori
Organosilane Function in Bitumen

- Organosilane molecules attracted to polar sites of asphaltenes
- Micellize and isolate asphaltenes
- May reduce viscosity of bitumen
- Pen number decrease
- Non-toxic and odor-less
- Soluble with water/foaming systems
Organosilane Function in Asphalt Mixtures

- Binds asphaltenes to aggregate surfaces
  - Allows easier movement of aggregate
  - Decreases asphaltene build-up on plant
  - Acts as a compaction aid/WMA additive
- Lowers mixing temp 10 -15°C
- Lowers compaction temp 35 - 40°C
- Consistent compaction density over 90 – 100°C range
PMA & CRMB using Organosilane

- Can be used effectively as a compaction aid with PMA and Crumb rubber mix designs
- Does not negatively affect the performance properties
- May be added to binder before or after addition of polymer & rubber
- May reduce apparent viscosities
- Reduced stickiness with rubber
- May reduce odor in rubber work
Multiple applications in asphalt materials

• Asphalt Paving – antistrip / compaction aide
• PMA modification aide
• Crack sealants
• Adhesives
• Subgrade waterproofing
Organosilane Asphalt Binder Dose

- 0.03% - 0.10% of asphalt binder weight for antistrip
  - Higher Silica materials = higher dose
  - Higher fines – higher dose
  - Higher asphaltenes – higher dose

- 0.05% - 0.10% of asphalt binder weight for warm mix / compaction aid
  - Higher asphaltenes – higher dose
  - Higher PMA – higher dose
  - Higher Silica – higher dose
  - Higher fines – higher dose
Life Cycle Extension

Organosilane Nano Technology Enables

• Improved oxidation resistance
• Reduced water damage
• Higher densities at lower compaction temperatures
• Improved fatigue resistance
• Improved bleed resistance
QUESTIONS?

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