Nano Scale Organosilane Asphalt Applications

Association of Modified Asphalt Producers

2018

Geoffrey M. Rowe
Jerry A. Thayer
Doug Zuberer

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

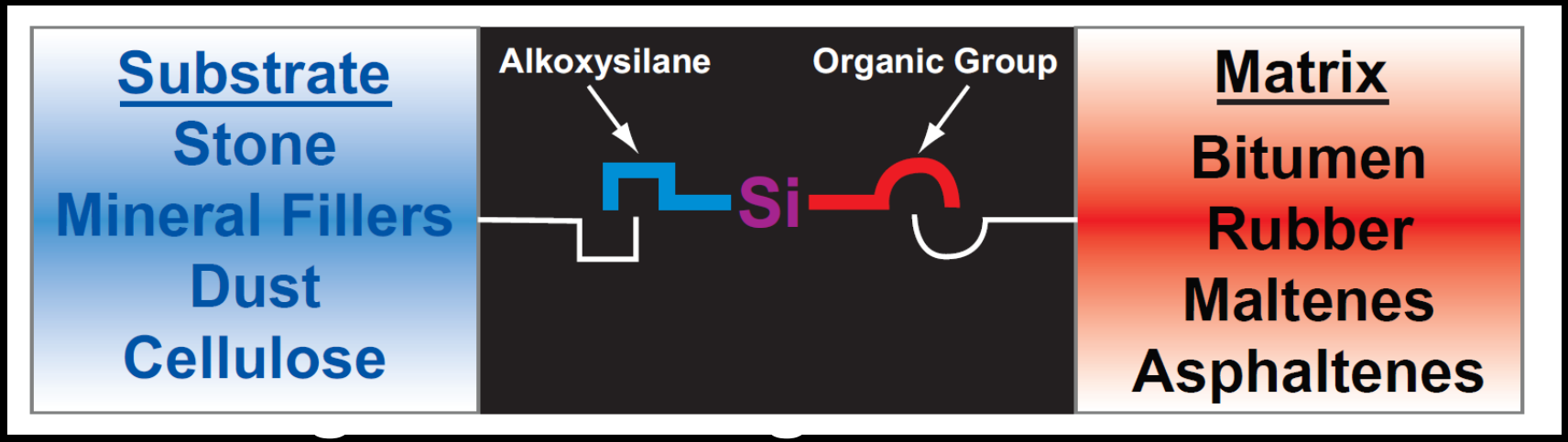
By using the right organosilane, a poorly adhering coating can be converted to a material that will maintain adhesion even if subjected to severe environmental conditions (e.g., high temperature, underwater immersion or UV radiation).

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 = 1×10^{-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

Organosilane



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 change the Performance Grade of the binder
- Does not change the Rotational Viscosity AASHTO T 316 at 135 C
- Improves complex modulus G*/Sinδ (binder stiffness) with the same visco-elastic response (phase angle) AASHTO T 315 DSR Test
- Penetration number may go down slightly
- Improves rut resistance (higher G*/Sinδ)
- Improved retention of elasticity as reflected by higher phase angle, in PAV aged asphalt binder
- Similar / Higher m-value at -12 ^{O}C (BBR Test AASHTO T 313), even though the G* shows consistently higher values at 64 ^{O}C

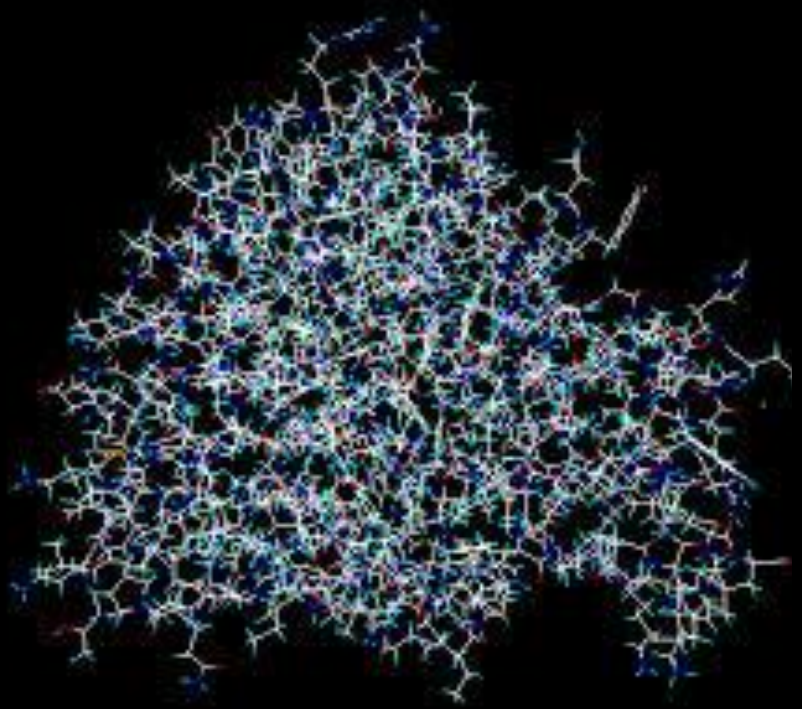
Source: NCAT

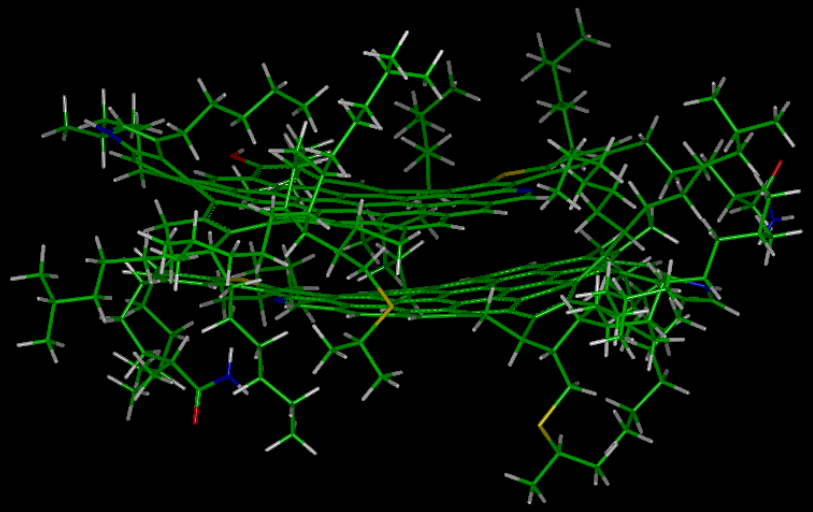
Organosilane Function in Asphalt Mix

- Aggregates are naturally hydrophylic due to polar surfaces created by SI-OH^- hydroxyl groups
- Organofunctional alkoxysilane 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 Inage Sources:

anusf.anu.edu.au

Dr. G.A. Mansoori

Organosilane Function in Bitumen

- Organosilane molecules attracted to polar sites of asphaltenes
- Micellize and isolate asphaltenes
- Apparent viscosity reduction of bitumen
- Pen number decease

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^{o}C
- Lowers compaction temp 35 - 40^{o}C
- Consistent compaction density over 90 – 100^{o}C range

PMA-Organosilane

- May be added to binder before polymer
- Reduced apparent viscosity
- Reduced stickiness
- Improved Compaction
- Enables increase of polymer % in the binder

CRMB-Organosilane

- Added to binder before CRMB
- Reduced Odor
- Fuel saving due to lower mixing temperature (10^0 C)
- Improved Compaction
- Enables increase of crumb rubber % in the binder
- Stripping resistance at par with PMB

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% - 0.15% 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 Technology

- Improved oxidation resistance
- Reduced water damage
- Higher densities at lower compaction temperatures
- Improved fatigue resistance
- Improved bleed resistance

THANK YOU

Questions?

Geoffrey Rowe, Ph.D., P.E.
GRowe@Abatech.com