Asphalt Emulsions 101

Chris Lubbers
Technical Sales and Marketing Mgr
Kraton Polymers, LLC

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Introduction
Asphalt is a *thermoplastic* material that softens as it is heated and hardens when cooled.
Why Heat Asphalt? So It Can Be:

• Pumped and transported
• Blended with and coat aggregate
• Remain workable during
  • Transport, laydown, and compaction

Other Ways to Make Asphalt Workable:
Asphalt Emulsions – A History

• First developed in the early 1900s
• Early use in spray applications + dust palliatives
• Growth use relatively slow:
  • Limited by the type of available emulsions
  • General lack of knowledge
• Steady rise in volume since the 1970’s
Why Use Asphalt Emulsions?

- No petroleum solvent required to liquefy
- Little or no hydrocarbon emissions
- In most cases, used with no additional heat
- The ability to coat damp aggregate
- Can use cold materials at remote sites
- Wide variety of emulsion types available today
Asphalt Emulsions in Pavement Preservation (PP)

• Strategy of managing pavement condition to:
  • Maximize pavement lifespan at minimal cost

• Applies to all types of roads
  • Low volume local roads to heavy interstates

• Achieved by careful planning and selection
  • Right protective treatment (application)
Pavement Life Cycle Theory

Condition (PCI)

Maintenance
~$ 1.00/SY

Rehabilitation
>$10.00/SY

Reconstruction
>$$$$

70/60?

Time
Emulsion Chemistry
**Emulsion Chemistry**

• Emulsions are mixtures of
  • Two or more materials
  • Normally do not mix or blend together
  • Created via mechanical + chemical processes

• Some common examples
  • Mayonnaise, latex paint, ice cream
Asphalt Emulsions - Composition

• Three basic ingredients
  • Asphalt
  • Water
  • Emulsifying agent

• May contain other additives
  • Polymers
Basic Emulsion Ingredients – Asphalt

- Asphalt cement is basic ingredient
- Up to 50-75% of finished emulsion
- Hardness of base asphalt cement varies
  - Emulsion base ranges from 40–250 dmm PEN
  - No exact correlation bwn. asphalt props. and emulsification
- Climate may require harder or softer base
Basic Emulsion Ingredients – Water

• Second basic ingredient in an emulsion is water
  • Contribution cannot be minimized
  • Water may contain minerals or other matter
    • Can affect the production of stable emulsions
  • Water considered suitable for drinking,
    • Might NOT be suitable for emulsion production
Basic Emulsion Ingredients – Emulsifying Agents

• Surfactants
  • Adsorbed at interface between liquids and solid
  • Concentrate at interface based on their structure
    • Hydrophilic head towards more polar phase (H₂O)
    • Lipophilic tail towards less polar phase (asphalt)
  • Surfactant molecule or ion acts as bridge bwn. phases
Asphalt Emulsions – Emulsifying Agents

• Asphalt emulsions are classified into three categories
  • Anionic (-)
  • Cationic (+)
  • Nonionic (neutral)

Based on electrical charges surrounding asphalt particles
Emulsion Production
Producing the Emulsion - Emulsifying Equipment

- Basic equipment
  - High-speed, high-shear mechanical device
  - Usually colloid mill to shear asphalt into droplets

- Also required
  - Emulsifier solution tank
  - Heated asphalt tank
Producing the Emulsion – Emulsification Process

- Asphalt particle size vital factor for stable emulsion

Smaller than:

- 0.001 millimeter (1 micron) 20 percent
- 0.001–0.005 millimeter (1–5 microns) 57 percent
- 0.005–0.010 millimeter (5–10 microns) 23 percent
Emulsion Classification
Asphalt Emulsions – Classification by Set Rate

• How quickly do asphalt droplets coalesce?

• Two letter codes used to simplify + standardize
  • RS – Rapid Setting
  • MS – Medium Setting
  • SS – Slow Setting
  • QS – Quick Setting

• Relative terms only
Asphalt Emulsions - Classification by Set Rate

• RS Emulsions
  • Little/no ability to mix with aggregate

• MS Emulsions
  • Can mix with coarse but not fine aggregate

• SS and QS Emulsions
  • Can mix with fine aggregate
Sub-Classifications - Typical Applications

- **RS**
  - Rapid Setting
    - Chip Seals

- **MS**
  - Medium Setting
    - Plant Mixing
    - In-place Recycling

- **SS**
  - Slow Setting
    - Cold Mixes
    - Tack Coats

- **QS**
  - Quick Setting
    - Slurry Seals
    - Micro Surfacing
Asphalt Emulsions – Full Classification

• Identified by numbers and letters related to:
  • Particle charge (prefix)
  • Set rate (prefix)
  • Viscosity of liquid emulsion (suffix)
  • Hardness of base asphalt cements (suffix)
Hardness + Modification Suffixes

No suffix

- 100-200 pen high
- 40-90 pen (hard)
- > 200 pen (soft)

L
- Latex-modified

P
- Polymer-modified

R
- Recycling agent-mod.
Asphalt Emulsion Nomenclature

CRS-2P

CATIONIC

RAPID SETTING

POLYMER MODIFIED

HIGH VISCOSITY
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<th>Cationic Emulsion (ASTM D 2397, AASHTO M 208)</th>
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Asphalt Emulsions – Micro Surfacing Classification

• Micro surfacing often specifies CSS-1hP emulsion

• Meets ASTM and AASHTO CSS-1h requirements
  • With the exception of the cement mixing test

• Min. polymer content of 3% solids on asphalt
  • Enhances high temperature performance
  • Permits application in multiple stone depths:
Emulsion Application
Asphalt Emulsions – Breaking and Curing

• Breaking/Drying
  • Separation and evaporation of water

• Curing
  • Return of residual asphalt properties
  • Adhesion
  • Durability
Emulsions – Breaking

• Breaking
  • $\text{H}_2\text{O}$ separating from asphalt phase + evaporating

• Emulsions formulated to break according to app.

• Two breaking mechanisms
  • Chemical
**Emulsions - Breaking**

- Breaking
  - For SS grades = mechanism mainly evaporation
  - For MS + RS grades = mechanism mainly chemical
**Emulsions - Curing**

- *Curing* – Process whereby mechanical properties of the asphalt return after application
  - Water must completely evaporate
  - Asphalt particles must coalesce and bond to intended surface
  - Water fully removed by evaporation + absorption