ASPHALT EMULSIONS: NOMENCLATURE & WHAT MAKES THEM WORK

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OVERVIEW

• What makes an emulsion?
OVERVIEW

• What makes an emulsion?
• What breaks an emulsion?

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• What breaks an emulsion?
• The answer to ALL your questions!
OVERVIEW

• What makes an emulsion?
• Emulsion nomenclature
• Is rapid faster than quick?
• What breaks an emulsion?
• Break speed determining factors
• The answer to ALL your questions!
• Summary & conclusions

EMULSIONS

Definition – A suspension of small globules of one liquid dispersed in a second liquid with which the first will not mix

• Consists of a dispersed phase and a continuous phase
  – Milk (fat in water)
  – Mayonnaise (fat in oil)
  – Butter (water in fat)
ASPHALT EMULSIONS

- A dispersion of asphalt in water
  - Water is the continuous phase
  - Asphalt is the non-continuous or dispersed phase

What makes an emulsion?

**Necessary Components:**
- Asphalt
- Water
- Surfactants – Emulsifying Agents
- Mechanical Energy (Colloid Mill)

**Other Common Components**
- Additives
- Modifiers or Polymers
WHAT MAKES AN EMULSION?

**Emulsifiers, Surface active agents, or Surfactants**

**Definition**--a substance capable of reducing the surface tension of a liquid in which it is dissolved

- Obviously, water and oil do not mix…
- Emulsifiers allow this to occur by altering the surface tension (hand soap)

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**Emulsifying Agents:**

- Emulsifiers are chemical molecules that possess dual functionalities
  - Polar head, often electrically charged, which is hydrophilic, or “water loving”
  - Non-polar tail which is lipophilic, or “oil loving”
EMULSION COMPONENTS

Emulsifying Agents:

How do they Work?

• Emulsifier molecules adsorb at the interface between two liquids
• The head orientates towards more polar phase (water)
• The tail remains in the non-polar phase (oil)

As the key ingredient in suspending oil in water, emulsifiers greatly affect the performance and stability of the resulting emulsion

• The type of emulsion produced is controlled by the chemistry of the emulsifier
• Emulsifiers, and hence emulsions, are characterized by the head group of the molecule
EMULSION COMPONENTS

Emulsifying Agents:

- Cationic emulsifiers possess a positive charge on the head group
- Anionic emulsifiers possess a negative charge
- Nonionic emulsifiers do not possess a charge

Example of a cationic emulsifier:

\[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CO} \]

Head group:

\[ \text{NH}_2\text{CH}_2\text{CH}_2\text{NH} \]

Tail group:

\[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CO} \]
**EMULSION COMPONENTS**

**Emulsifying Agents:**

- Example of an anionic emulsifier

![Emulsifier structure](image)

For asphalt emulsions, the tails of the emulsifier adsorb around the asphalt droplet. The head groups protrude on the outside of each droplet.
EMULSION COMPONENTS

Similar charge or large head group size keeps asphalt droplets suspended and maintains emulsion stability

EMULSION NOMENCLATURE

Asphalt Emulsions are characterized with a systematic nomenclature, for example:

CHFRS-2hp
EMULSION NOMENCLATURE

CHFRS-2hp

Charge of the Emulsion Droplets
• If the first letter is a C, the emulsion is cationic
• If a “C” is not present, the emulsion is anionic
• Though fairly rare in paving applications, nonionics are typically named like anionic emulsions

EMULSION NOMENCLATURE

CHFRS-2hp

High Float
• “HF” indicates that the emulsion has High Float characteristics as indicated by the Float Test
• This high float characteristic provides a structured residue that aids in thicker aggregate films
EMULSION NOMENCLATURE

**CHFRS-2hp**

**Type of Emulsion**
- Next emulsions are named by how quickly the asphalt droplets coalesce
  - "RS" designates a Rapid Setting Emulsion
  - "MS" Medium Set
  - "SS" Slow Set
  - "QS" Quick Set

**Emulsion Viscosity**
- Emulsions are further described by their viscosity range
  - "1" signifies lower viscosity
  - "2" signifies higher viscosity
EMULSION NOMENCLATURE

CHFRS-2hp

Type of Asphalt
• A designation may follow the “1” or “2” that describes the type of asphalt used
  • “h” refers to a harder asphalt
  • “s” refers to a softer asphalt

Polymer Modification
• Polymer modified emulsions will often contain a letter at the end to signify that they are polymer modified
  • Most typically “P”, but occasionally “L”, “LM”, and “S” are also used
### EMULSION NOMENCLATURE

#### Common Anionic Emulsions:

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<thead>
<tr>
<th>Common Anionic Emulsions</th>
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<tbody>
<tr>
<td>RS-2</td>
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<tr>
<td>MS-2</td>
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<td>SS-1</td>
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<td>SS-1hlm</td>
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<tbody>
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</tr>
<tr>
<td>CQS-1h</td>
<td>CHFRS-2p</td>
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</tbody>
</table>
IS RAPID FASTER THAN QUICK?

TYPES OF EMULSIONS

Rapid Setting Emulsions:

- Emulsions designed to react and break quickly when in contact with roadway and aggregate
- Typically used in chip seal applications
- Rely mostly on a chemical break to revert to asphalt
TYPES OF EMULSIONS

Medium Setting Emulsions:

• Often called “mixing grade” emulsions
• These emulsions have increased stability to allow for better aggregate coating in mixing applications
• Often contain solvents to create stock-pile type mixes
• Rely primarily on evaporation for breaking

TYPES OF EMULSIONS

Slow Setting Emulsions:

• Emulsions formulated for stability and/or extended mix times
• Rely on evaporation for breaking
• Often used in tack coats, fog seals, and aggregate pre-coating
TYPES OF EMULSIONS

Quick Setting Emulsions:

- Emulsions formulated for specific use in Slurry Seal applications
- Specialized chemistry to allow for mixing with aggregate, but also quick breaking behavior
- Relies primarily on a chemical break

Micro-Surfacing Emulsion:

- Emulsions formulated for specific use in Micro-Surfacing
- The emulsion is carefully formulated to allow for mixing with aggregate, but also maintains quick setting behavior
- Often called CSS, but relies on a chemical break and is fast setting in the system
WHAT MAKES AN EMULSION BREAK?

HOW DOES AN EMULSION BREAK?

INITIAL CONDITION
SURFACTANT WETS THE AGGREGATE

ASPHALT DROPLETS ARE DESTABILIZED
AGGREGATE BECOMING “OIL WET”

ASPHALT DROPLETS WET AGGREGATE AND BEGIN TO FLOCCULATE
ASPHALT DROPLETS BEGIN TO COALESCE, GAINING MECHANICAL STRENGTH

ASPHALT FILM FORMS WITH THE SURFACTANT REMAINING AS AN ADHESION PROMOTER
BREAK SPEED DETERMINING FACTORS

• Emulsifier type (chemistry)
• Solution chemistry (pH, salt content, etc.)
• Ambient conditions
  • Temperature
  • Relative humidity
  • Wind conditions
• Surface condition (old/new, cracked/smooth, dry/wet)
• Application rate and uniformity
• Construction variables (application temperature, shear and temperature history of the emulsion, application equipment, etc.)
THE ANSWER TO ALL YOUR QUESTIONS

IT DEPENDS!
WHAT ABOUT VERY RAPID SET EMULSIONS?

- Essentially rapid set emulsions engineered to be stable at lower emulsifier content.

HEAD SCRATCHER:

- The fastest breaking emulsion known to me is a slow set emulsion
  - Breaking mechanism/speed not driven by emulsifier
  - Emulsifier still needed for emulsion stability
  - Nature of base binder drives speed of breaking
  - Can be very slow in cold humid conditions
  - Hard asphalt based non-tracking type tack coats and bond coats
SUMMARY AND CONCLUSIONS

- The rapid, medium, slow, and quick designations refer to the type and dosage of emulsifier which, as a general rule, do control the speed of breaking.

- In practice it is the “speed determining process” that controls the breaking speed of an emulsion. It can be temperature, humidity, emulsifier type and content, emulsion base chemistry, soap chemistry, pH and so on.

QUESTIONS?
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