Emulsion Chemistry 101

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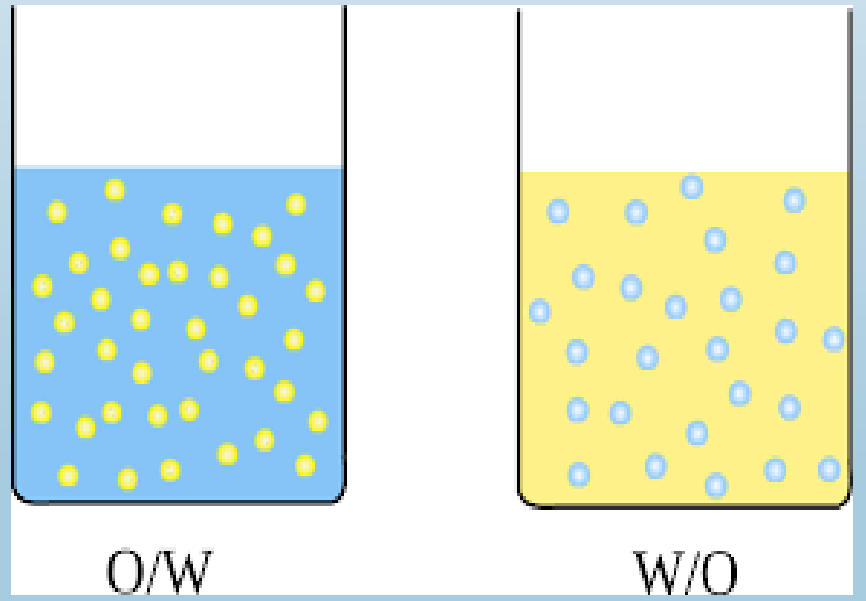
NATIONAL PAVEMENT PRESERVATION CONFERENCE
npc23
IMPACTS AND BENEFITS FROM PAVEMENT PRESERVATION
ncpp National Center for Pavement Preservation
MICHIGAN STATE UNIVERSITY
AASHTO TSP2 PAVEMENT PRESERVATION
ROCKY MOUNTAIN WEST PAVEMENT PRESERVATION PARTNERSHIP
SOUTHEAST PAVEMENT PRESERVATION PARTNERSHIP
MIDWESTERN PAVEMENT PRESERVATION PARTNERSHIP
NORTHEAST PAVEMENT PRESERVATION PARTNERSHIP

Emulsion Basics

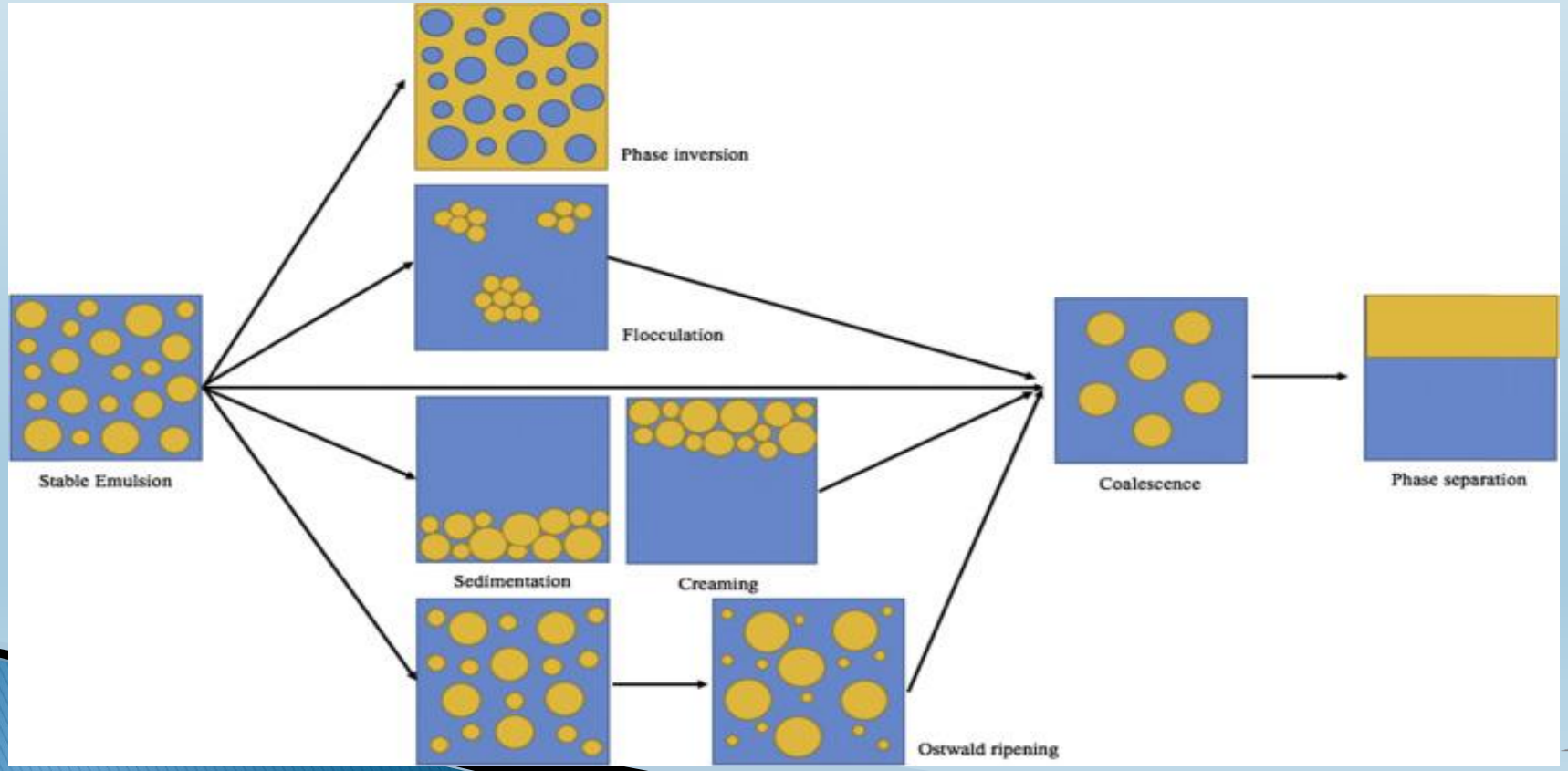
What is an Emulsion?

- Combination of two liquids that do not mix naturally – immiscible
- Droplets in a continuous phase
- Basic Emulsion Types
  - Oil in water – O/W
  - Water in Oil – W/O
  - O/W/O or W/O/W



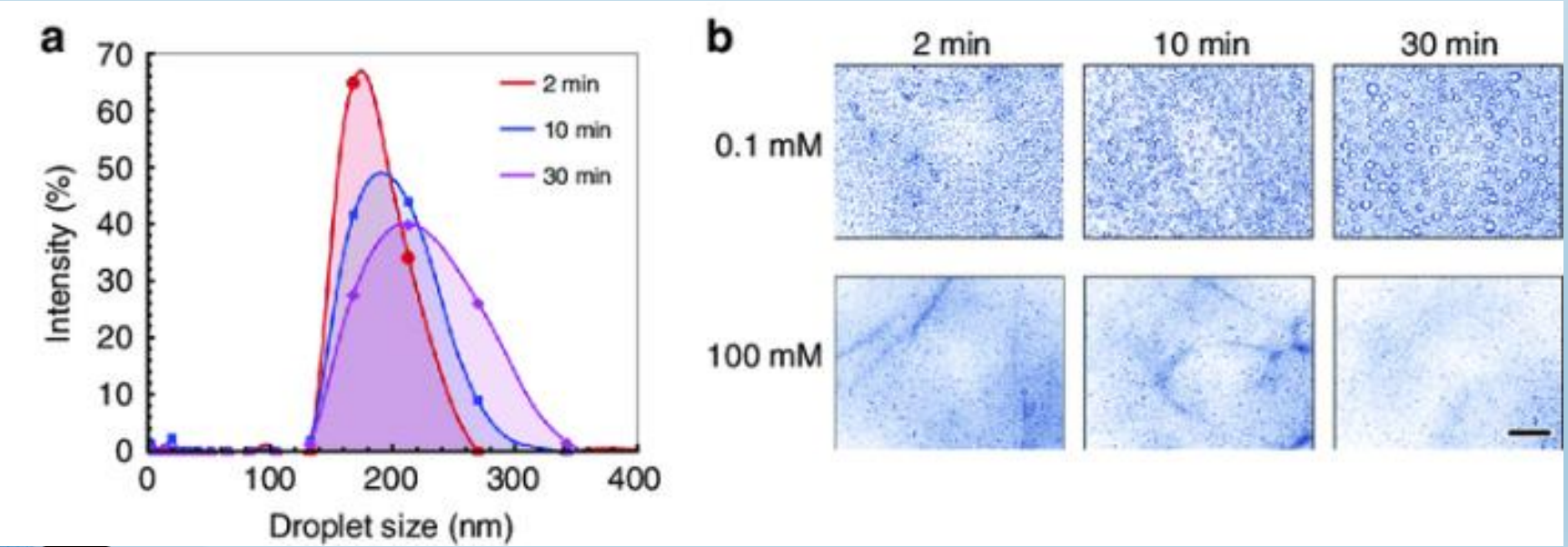
Emulsion Stability

- Stable
  - Droplets are uniformly and evenly suspended, and narrowly distributed
- Unstable
  - Droplets agglomerate and stick together.
  - Occurs when “energy” is out of balance – Mechanical - Chemical - Thermal



Particle Size and Distribution

- **Stable** emulsions have a narrow distribution and a small median size
- **Unstable** emulsions have a broad distribution and larger median size



Asphalt Emulsion Components

- **Asphalt**
- **Water**
- **Emulsifying Agent**
- Performance Extenders:
  - Polymers
  - Stabilizers
  - Coating Improvers
  - Antistrips
  - Break Control Agents

Asphalt Emulsion Components

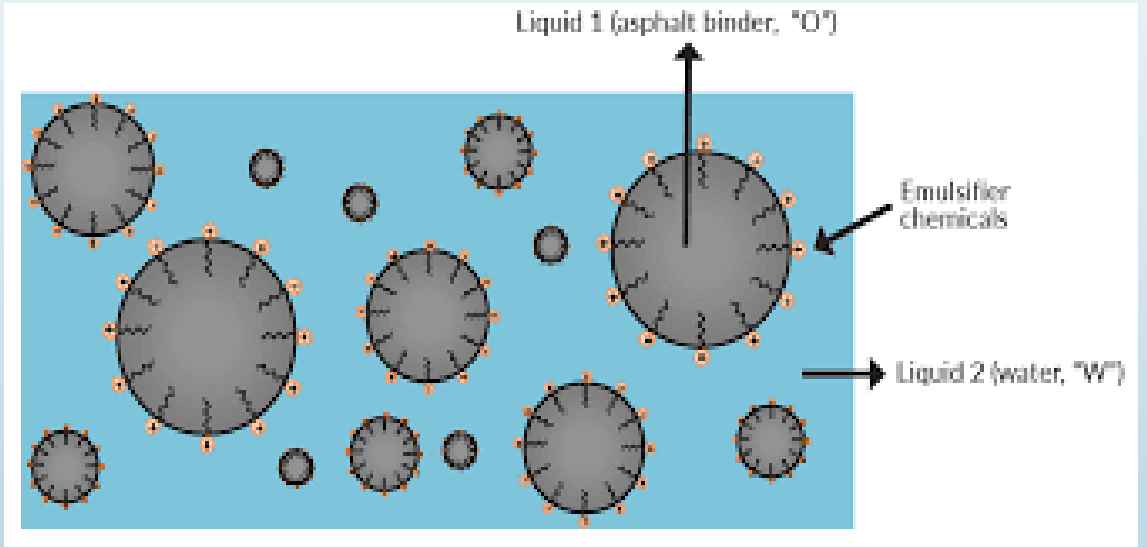
- **Asphalt**
  - Asphalt Binder is 50-75% of an Emulsion
  - Hardness of the base binder varies
  - Climate may require a harder or softer base binder
  - Compatibility of the emulsifier with the base binder is vital for stability

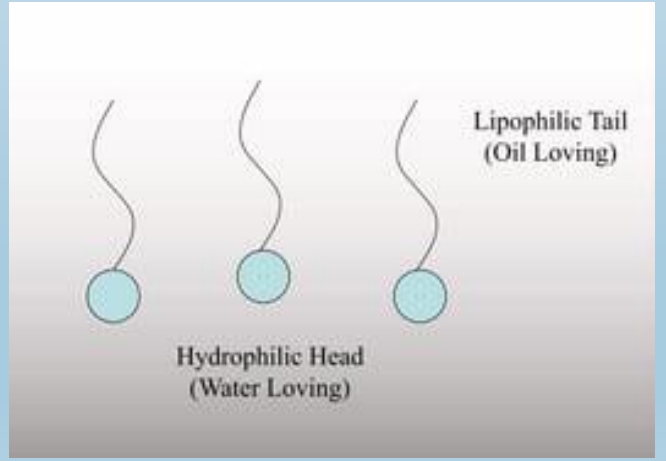
Asphalt Emulsion Components

- **Water**
  - Second largest component
  - Water quality is highly important
    - pH, mineral content can greatly affect emulsifiers

Asphalt Emulsion Components

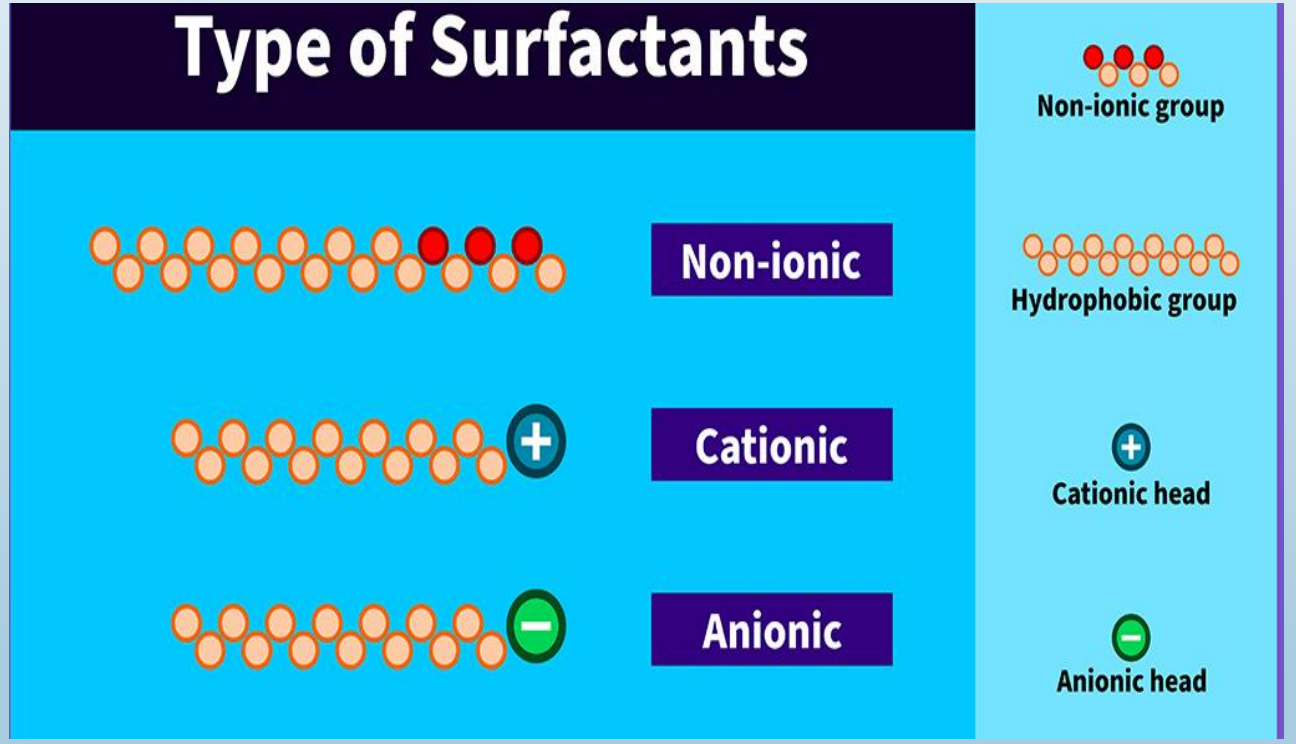
- **Emulsifier**
  - aka Surfactants
    - Adsorbed at the interface between liquids and solid
    - Concentrate at the interface based on chemical structure:
      - Hydrophilic head towards more polar phase (H_2O)
      - Lipophilic tail towards less polar phase (Asphalt)





Asphalt Emulsion Surfactants

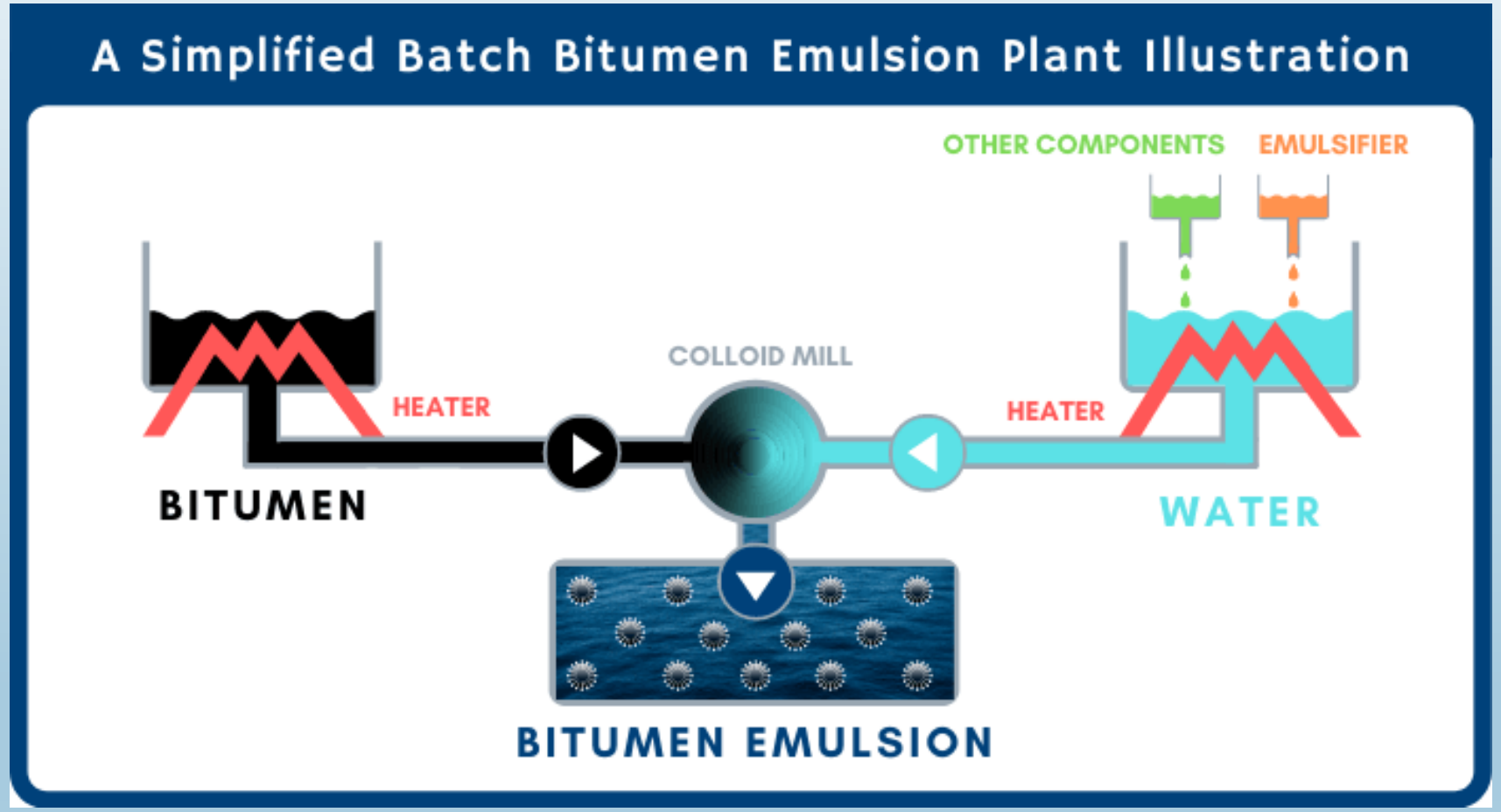
- **Non-ionic**
  - The hydrophilic group is covalent and polar and dissolves without ionization
- **Cationic**
  - Electrovalent and polar hydrocarbon group is part of the positively charged ion when the compound ionizes
- **Anionic**
  - Electrovalent and polar hydrocarbon group is part of the negatively charged ion when the compound ionizes.



Asphalt Emulsion Surfactant Types

- **Non-ionic**
  - Not typically used in the transportation industry
- **Cationic**
  - Most commonly fatty acid amines: diamines, imidazolines, and amidoamine that are converted to soap by reacting with hydrochloric acid. Others are fatty quaternary ammonium salts that do not need to react with acid to impart a positive charge
- **Anionic**
  - Most commonly carboxylic acids: wood-product derivatives like tall oils, rosins, and lignin. As well as sulfonates, fatty acids, and resin acids. These carboxylic acids are then saponified with sodium hydroxide or potassium hydroxide to impart the negative charge

Asphalt Emulsion Manufacturing Process

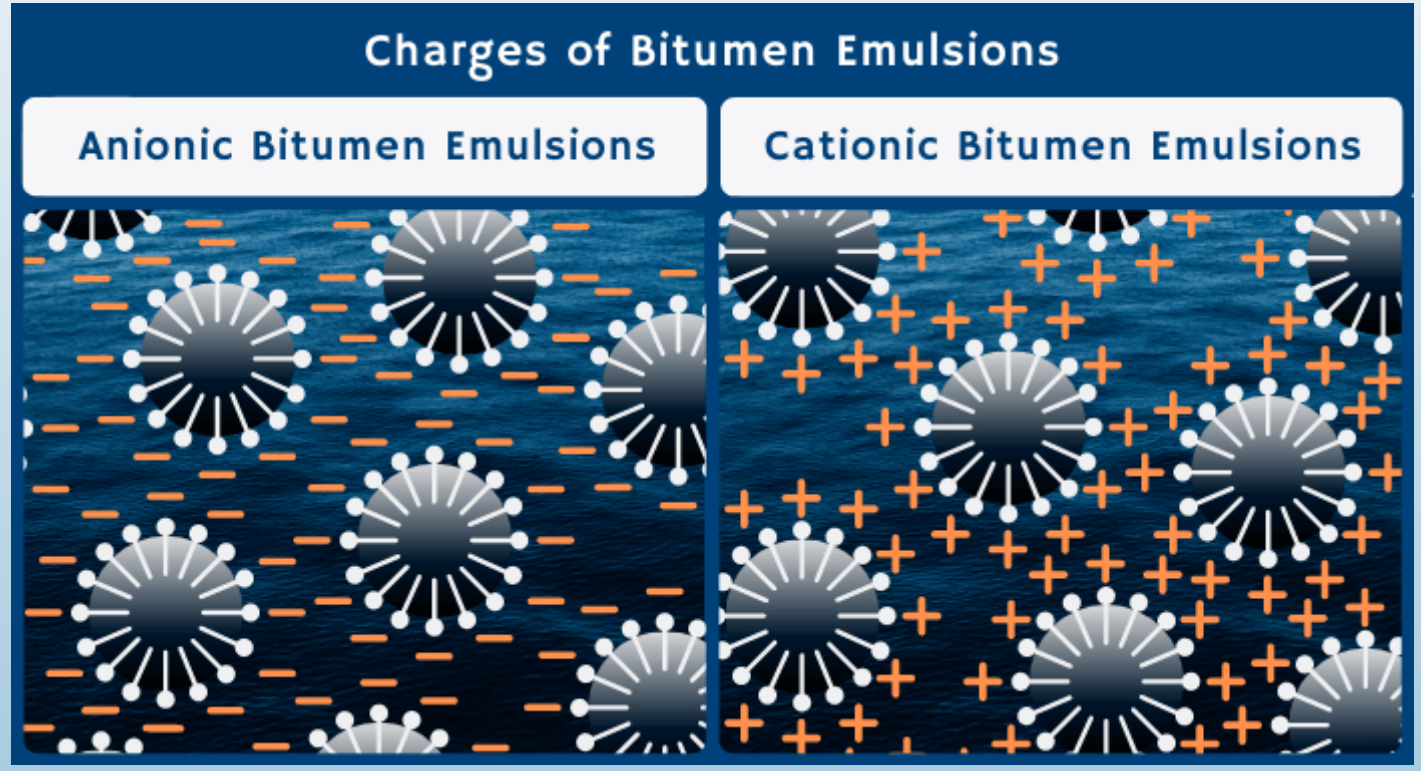


Asphalt Emulsion Manufacturing Process

- **Emulsifying Equipment**
  - High-Speed, High-Sheer mechanical device
  - Colloid Mill to sheer asphalt into droplets
  - Emulsifier Storage Tank
  - Heated Asphalt Tank
  - Pumps
  - Flow Metering Gauges

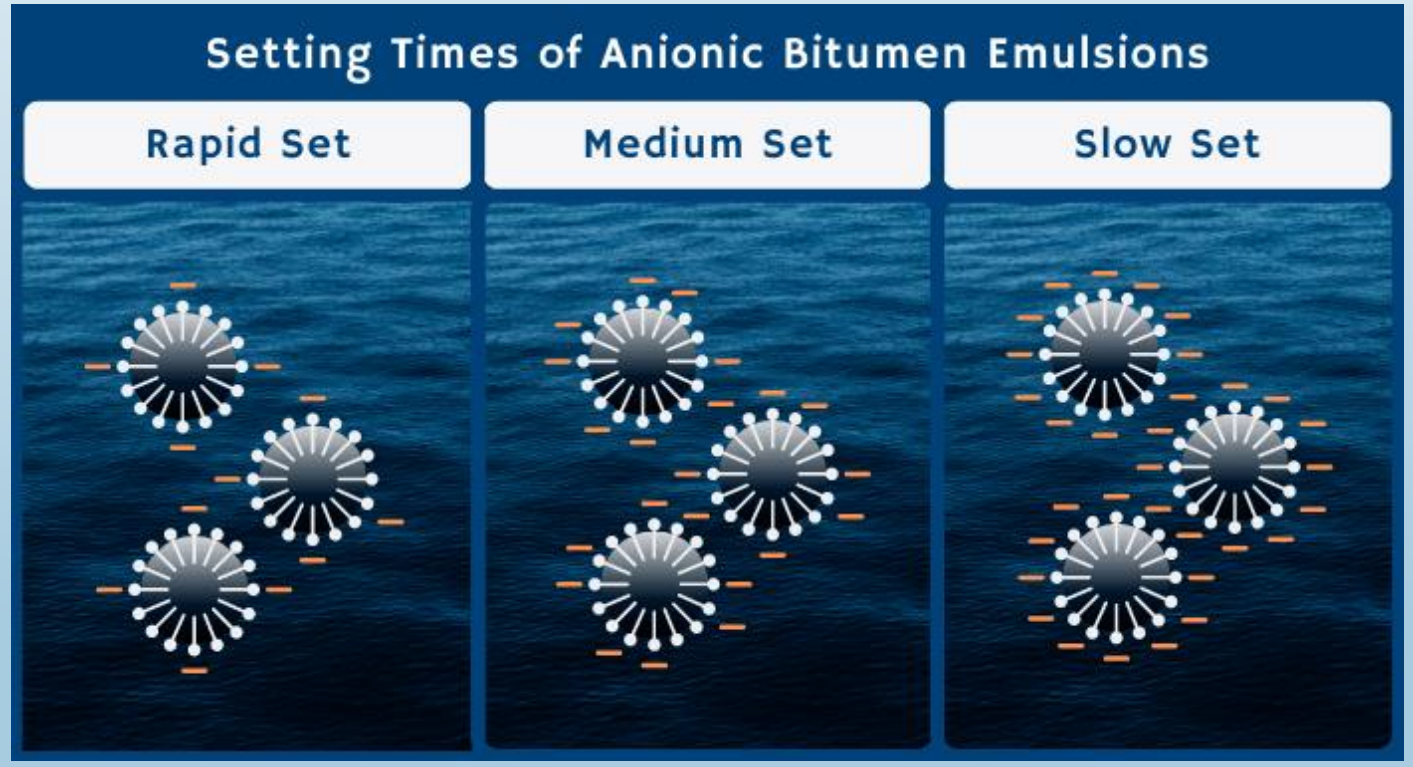
Asphalt Emulsion Classification

- **Anionic**
  - High pH, (-) charge, basic
- **Cationic**
  - High pH, (+) charge, acidic
- **Nonionic**
  - pH near 7, neutral charge, polar head



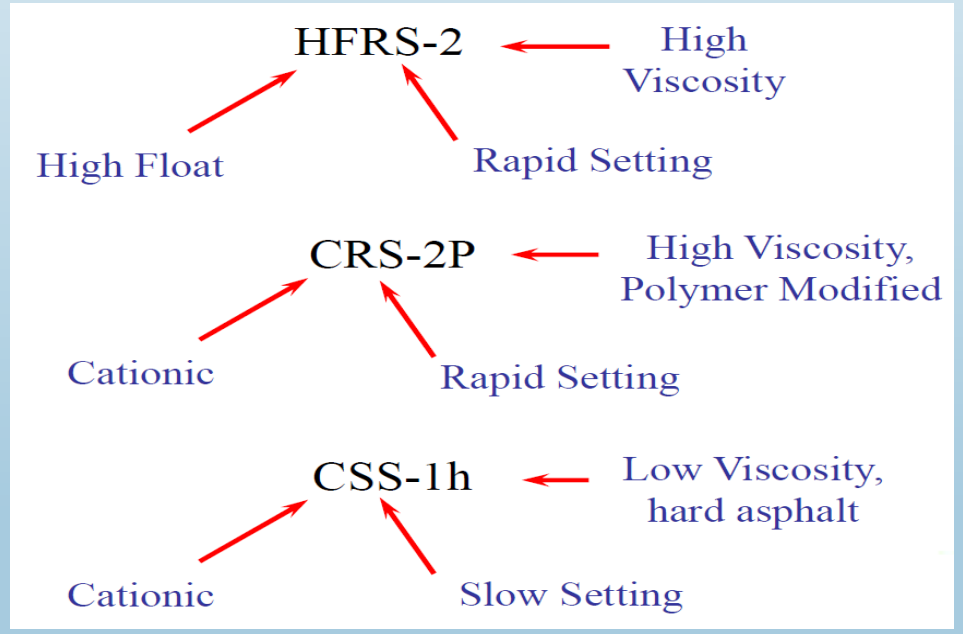
Emulsions are further classified by Set Rate

- How quickly the asphalt droplets coalesce
  - Rapid Setting – RS
  - Medium Setting – MS
  - Slow Setting – SS
  - Quick Setting – QS



Asphalt Emulsion Nomenclature

- Number and Letter System Designations
  - Particle Charge – ( ) Anionic or (C) Cationic
  - Set Rate – SS, MS, RS, QS
  - Viscosity of Liquid Emulsion –
    - -1 (thin 20-100 SFS)
    - -2 (thick 100-400 SFS)



Asphalt Emulsion Nomenclature

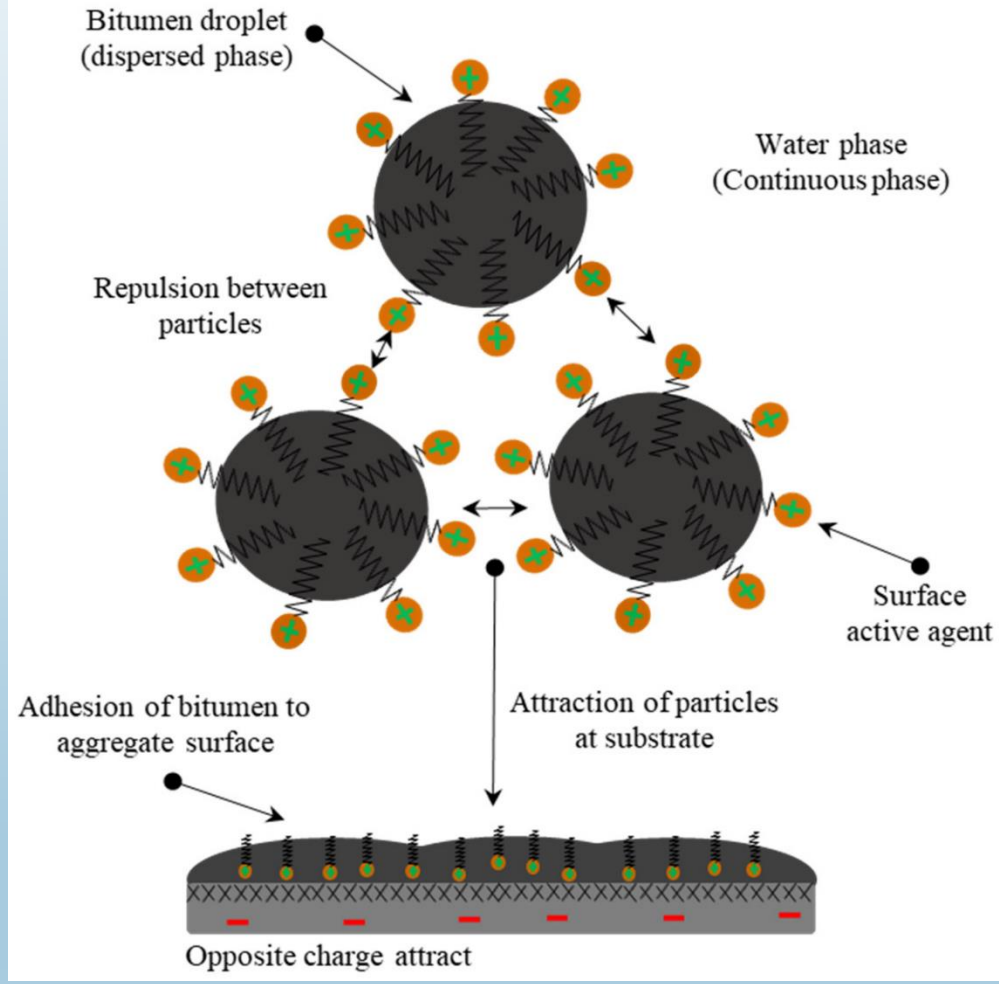
- Number and Letter System Designations
  - Hardness of Base Asphalt Binder –
    - no designation 100-200 dmm penetration
    - -h, hard 40-90 dmm penetration
    - -s, soft >200 dmm penetration
  - Latex or Polymer – (LM-), (PM-) , (-P)
  - High Float – (HF)
    - Produced to have a gel-like quality, provides a thicker asphalt film on the aggregate particles to slow the drain off of the emulsion

Asphalt Emulsion Breaking and Curing

- Breaking/Drying
  - Separation and Evaporation of Water
    - Water separating from the Asphalt Phase and Evaporating
    - Emulsions formulated to Break under Application Conditions
  - Typical Mechanisms of Break
    - Chemical
    - Physical or Evaporation
- Curing
  - Return of the residual asphalt properties
    - Adhesion
    - Durability
    - Water-Resistance

What Influences Breaking and Curing

- Absorption Rate of Aggregate
- Aggregate Moisture Content
- Aggregate Gradation – Surface Area
- Weather – Temperature, Humidity, & Wind
- Type and Amount of Emulsifying Agent
- Intensity of the Aggregate Charge
- Mechanical Manipulation and Rolling



Emulsion Specifications

- AASHTO Material Specifications
  - M140, Emulsified Asphalt
  - M208, Cationic Emulsified Asphalt
  - M316, Polymer-Modified Emulsified Asphalt
- AASHTO Test Methods
  - T59, Emulsified Asphalts
    - Includes references to additional AASHTO test methods
- AASHTO Guidance Documents
  - R5, Selection and Use of Emulsified Asphalt

Emulsion Testing

- Viscosity
  - Saybolt
  - Rotational Paddle
- Storage Stability/Settlement
- Demulsibility
- Sieve
- Cement Mixing
- Distillation
  - % Residue
    - Tests on Residue
      - Penetration
      - Ductility
      - Ash Content
      - Float Test

Emulsion Testing Importance

- Composition
  - Residue tests provide: Asphalt, Water, and Emulsifier portions
- Handling and Storage Properties
  - Viscosity, Storage Stability, and Sieve
- Reactivity
  - Demulsibility, Particle Charge and Cement Mixing
- Residue Properties
  - Penetration, Float, Ductility
- Performance Tests
  - Adhesion, Mix Designs, Application Specific Tests

Emulsion Benefits

- Emulsions are environmentally friendly and sustainable
- Emulsions are easy to handle and store
- Emulsions are formulated for the intended application
- Emulsions are economical
- Emulsions can be applied at ambient temperatures

Emulsion Use Summary

- Emulsions can be used in a variety of different applications
  - Tack coat
  - Prime coat
  - Dust mitigation
  - Pavement Preservation
    - Fog Seal
    - Chip Seal
    - Slurry Seal
    - Micro Surfacing
    - CIR/CCPR
    - FDR
    - Base Stabilization

Questions???

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