Chemical Application for Produced Water Management

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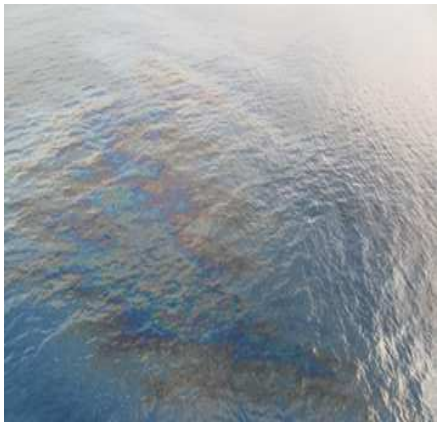
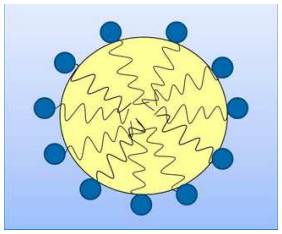
Impact of Poor Water Quality

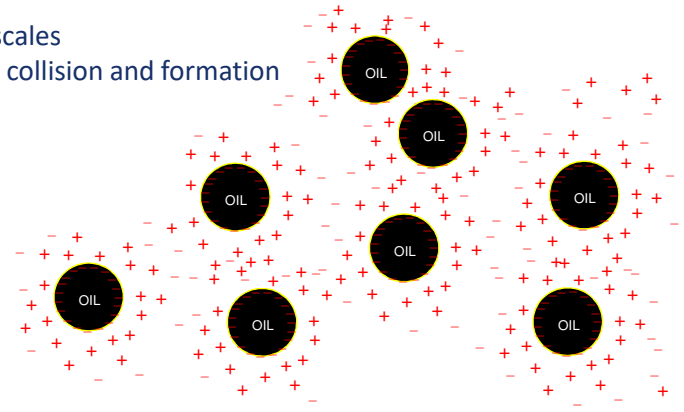
- Environmental impact when discharged overboard
- Compliance with regulations and legislative limits
- Compliance with internal targets set by producers
- Loss of production revenue
- Fouling of filters and membranes topside
- Loss of injectivity to reservoir and water flood wells



Causes of Water Continuous Emulsions

- Two immiscible fluids of different density
- To create a stable emulsion, we need….
- Emulsifying surfactants
- Naphthenates, asphaltenes, solids, scales
- Charge repulsion preventing droplet collision and formation of large buoyant droplets





Causes of Water Continuous Emulsion

- Energy
- Agitation and shear forces
- Shearing across valves, pressure drops through chokes and other equipment, pipeline bends, pumping equipment, such as ESPs.

- Water + Oil + Stabilising Surfactants + Shear Forces = Emulsion

Oil in Water Emulsions

- Loosely Entrained Emulsion
- Unstable
- High density difference between the oil water
- Medium / Light Oil + High TDS Brine
- Low viscosity water - continuous phase
- Will clean up over time without chemical
- If process equipment is sufficient only a low injection rate may be required
- Easy to tell it's water continuous
- Common in most conventional oil production systems

Stable Reverse Emulsion

- High concentration of dispersed oil evenly entrained throughout the water
- Low density differential between oil and water
- In EOR fields can be high viscosity water
- Highly stable, will not separate without chemical
- Higher ppm required
- Common in EOR fields, Polymer Flood, SAGD, Steam Flood
- How can we distinguish this from an oil continuous emulsion?

Classification of Water Treatment Chemicals

Coagulant

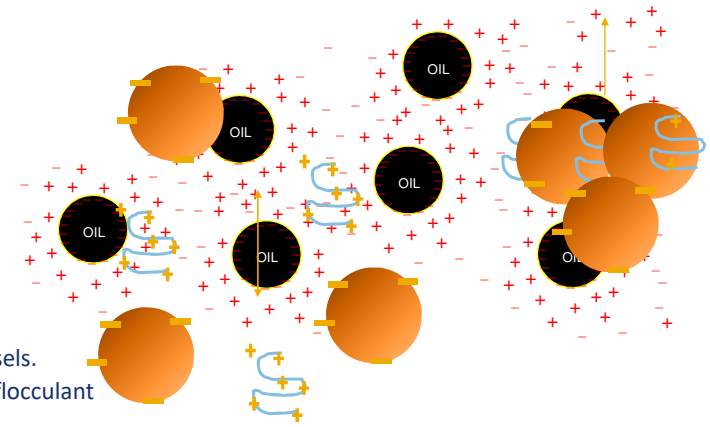
- Neutralises Charge
- Aqueous Solutions
- Generally High Cationic Charge
- Lower Molecular Weight

Flocculant

- Charge Action and Pulling Together Coagula and Droplets
- Invert Emulsion or Solution
- Low Cationic or Anionic
- Higher Molecular Weight

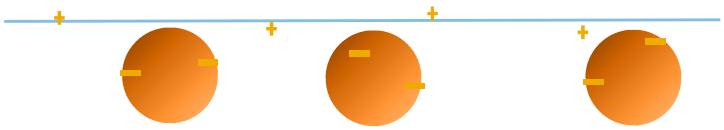
Coagulant Mode of Action

- Coagulant
  - Small chains
  - Coat particle surfaces
  - Patch Neutralisation
  - Let particles touch
  - Relies on droplet contact
- Coagula
  - Small and often unstable
  - Low buoyancy
  - Can be redispersed in turbulent vessels.
  - Require longer retention time than flocculant

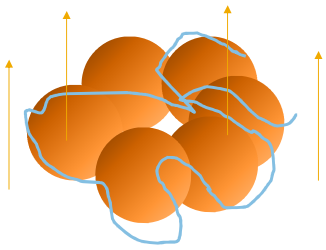


Flocculant Mode of Action

- Flocculant
  - Long chains
  - Are coated by droplet surfaces
  - Pull particles together



- Flocs
  - Stable and buoyant
  - Can clog some process equipment
  - Accumulate at oil water interface with recycling



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Nomenclature and Summary of Field Application

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Upstream – Reverse Breakers -Solution Polymer, Bridging Coagulants and Flocculants

Water removal during dehydration of crude oil, FWKO, separator vessels

Primary – De-oilers - Low / high molecular weight coagulants

API Separators, Plate Separators, Hydrocyclones

Secondary – Water Clarifiers – High Molecular Weight Flocculants

Gas Flotation Units

Final Treatment – Filter aids / Water Clarifiers – bridging coagulants

Filters

Polymer Flood Stabilised Emulsions

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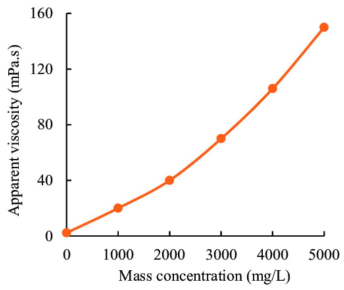
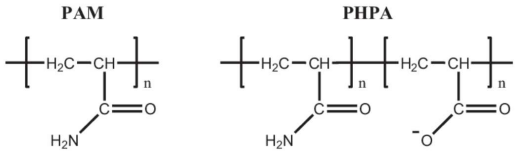
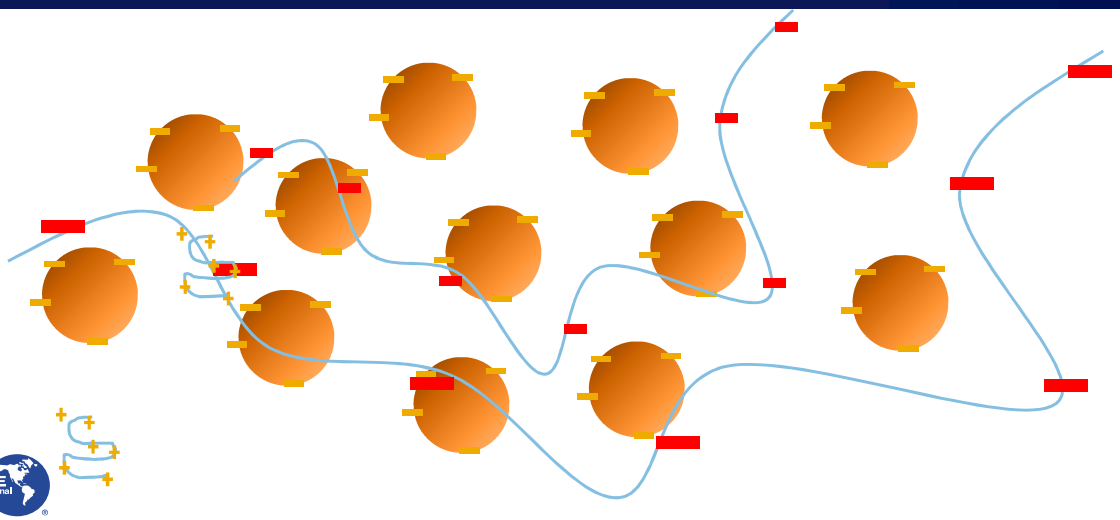
- Pose unique challenge for topside water treatment
- Aim to increase sweep efficiency of water in the reservoir by increasing viscosity of injection water through the addition of high molecular weight polymer
- Results in high viscosity produced water
- Addition of charged species - hydrolysed polyacrylamide (HPAM)



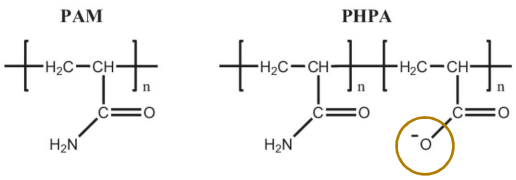


Polymer Flood Stabilised Emulsions



Polymer De-oiler Interaction

- Inefficient de-oiler usage due to interaction with HPAM instead of target oil droplets
- Interaction of cationic de-oiler molecule with HPAM can quickly lead to polymer dissolution from the water phase
- Polymer / hroughout the process le lenges
- Treatment o sludge tanks for batch trea emicals.



Changing from hydrolysed to partially hydrolysed state

Polymer De-oiler Interaction

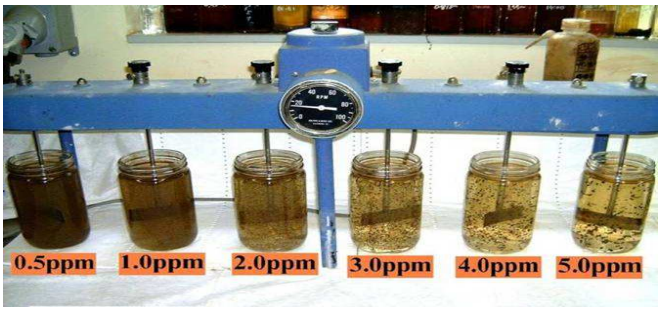
- Anionic or non-ionic de-oiler chemistries are preferred as charge is compatible with anionic HPAM. However……
- If dispersed oil droplets are negatively charged, anionic de-oilers will only further stabilise emulsion, so need to apply cationic product
- Cationic de-oiler are now specially selected using novel methodology to isolate products that can interact preferentially with dispersed oil, minimising binding with polymer and thus minimising polymer dissolution

Testing and Section of De-oilers

- Testing of de-oilers is carried out using a test method known as the “bottle test”
- Fresh produced water is taken from the system and candidate chemistries are screened by injection into the bottle at representative field injection rates.
- Temperatures, mixing and retention times of the process are replicated to ensure accurate selection.
- Product performance is ranked in several ways, with visual observations being the primary method.

Alternative Methods

- Skim Tanks or Surge Vessels
  - Gang stirred jar testing
  - Simulate low influent/effluent velocity with large volume

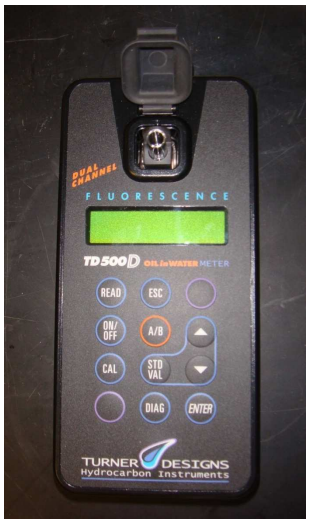


Flotation Test Methods

- Bench Model Flotation Cells

Quantitative Evaluation – Oil In Water

- Allows determination of oil in water
- Improves accuracy in sample comparison
- Requires hydrocarbon solvents to perform extraction
- For few samples, the testing is fast. Very slow on large samples
- Requires good laboratory skills to prevent misreads



Quantitative Evaluation – Turbidity

- Allows determination of water turbidity measured in Nephelometic Turbidity Units (NTU)
- Improves accuracy in sample comparison
- No extraction required
- Fast easy test
- Requires good laboratory skills to prevent misreads

Questions