The Effect of Iron Bearing Minerals on Anionic Surfactant Retention in Chemical Enhanced Oil Recovery Applications

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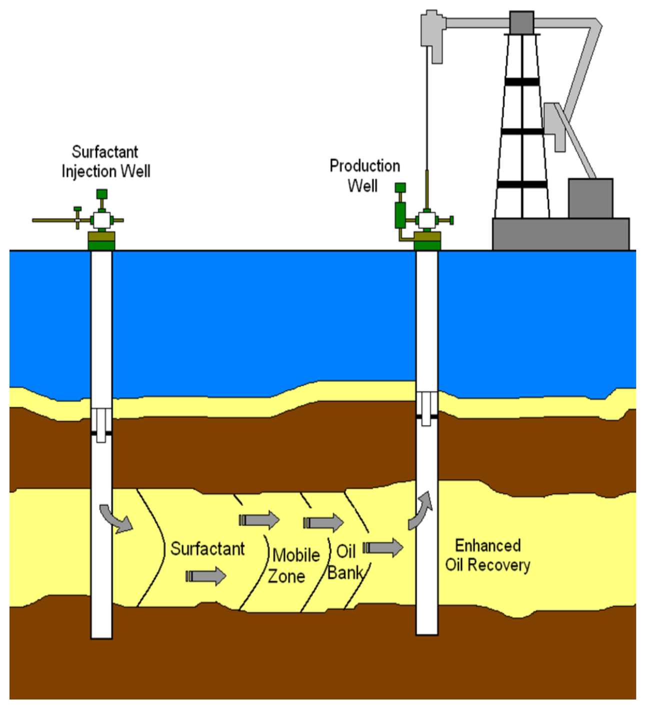
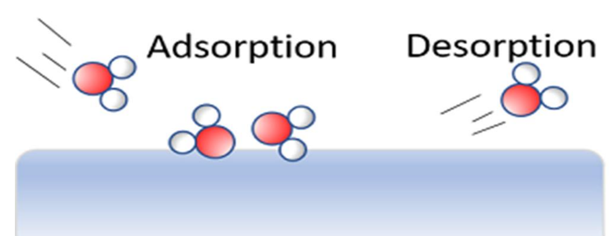
Background



- In chemical enhanced oil recovery (EOR), some chemicals such as surfactants, co-solvents, polymers are commonly used. This work focuses on anionic surfactant injection.
- Surfactant molecules will interacts with brine and oil to form a microelmusion phase that reduce the interfacial tension between oil and brine. Droplets of oil are formed to create an oil bank. Once the oil bank is sufficient and oil mobility increase, more oil will flow to the production well.
- Anionic surfactant is commonly used because most of the clay present in the reservoirs have a negative charge. Having the same charge will avoid surfactant molecules being attracted to the clay surface.



- In some reservoirs, there is the presence of positive-charged minerals. Some amount of surfactant will tend to stay on the surface of the rock. This is called adsorption effect.
- Adsorption and desorption (partitioning) are two opposite processes. After injecting a slug of surfactant, some molecules may desorp and leave the surface of the rock.

Experiment Setup

- Iron bearing clay mineral: siderite (iron carbonate)
- Main component of the cores: silica sand (SG = 2.65)
- Surfactant concentration: 1%
- Siderite concentration: 0%, 2.5%, 5%, 7.5%, and 10%
- Main steps: synthetic core fabrication, core reduction, surfactant injection, and produced surfactant concentration detection

Synthetic Core Fabrication

- Core composition: 92.5% silica sand, 7.5% siderite
- Particle size: 149 – 173µm
- Core diameter: 1.5 in
- Core length: 12.4 in
- It is important to use synthetic core instead of field samples to eliminate potential effects that the porosity, permeability, particle size distribution, and heterogeneity may have on the adsorption results.

Core Reduction

$$Fe^{3+} + e^{-} \underset{\text{Oxidation}}{\overset{\text{Reduction}}{\rightleftharpoons}} Fe^{2+}$$

- Nitrogen gas used to remove remaining moisture in the core. The oven was set at 150F to assist drying process.
- The porosity is determined by recording change in pressure, volume and temperature of gas through the pore space.
- Argon gas used to bubble into flow accumulators or any liquid that used to inject into the system to remove as much oxygen as possible.
- The core is initially saturated with brine. The permeability is determine by flowing brine at different flow rates and measuring the pressure drop with flow rate.
  Sodium dithionite solution was injected at a slow rate to reduce the iron cation from Fe^{3+} to Fe^{2+}.

$$S_2O_4^{2-} + Fe^{3+} + 2H_2O \xrightarrow{\text{yields}} 2SO_3^{2-} + 2Fe^{2+} + 4H^{+}$$

- The redox potential was measured to determine if the reduced stage has been reached or not.

Surfactant Injection

Flow rate: 0.069mL/m

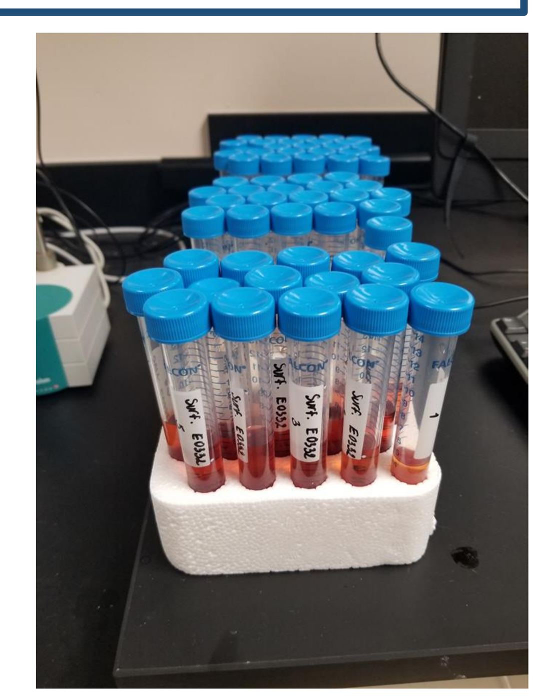
Temperature: 100°F

Surfactant injection: 24 hours

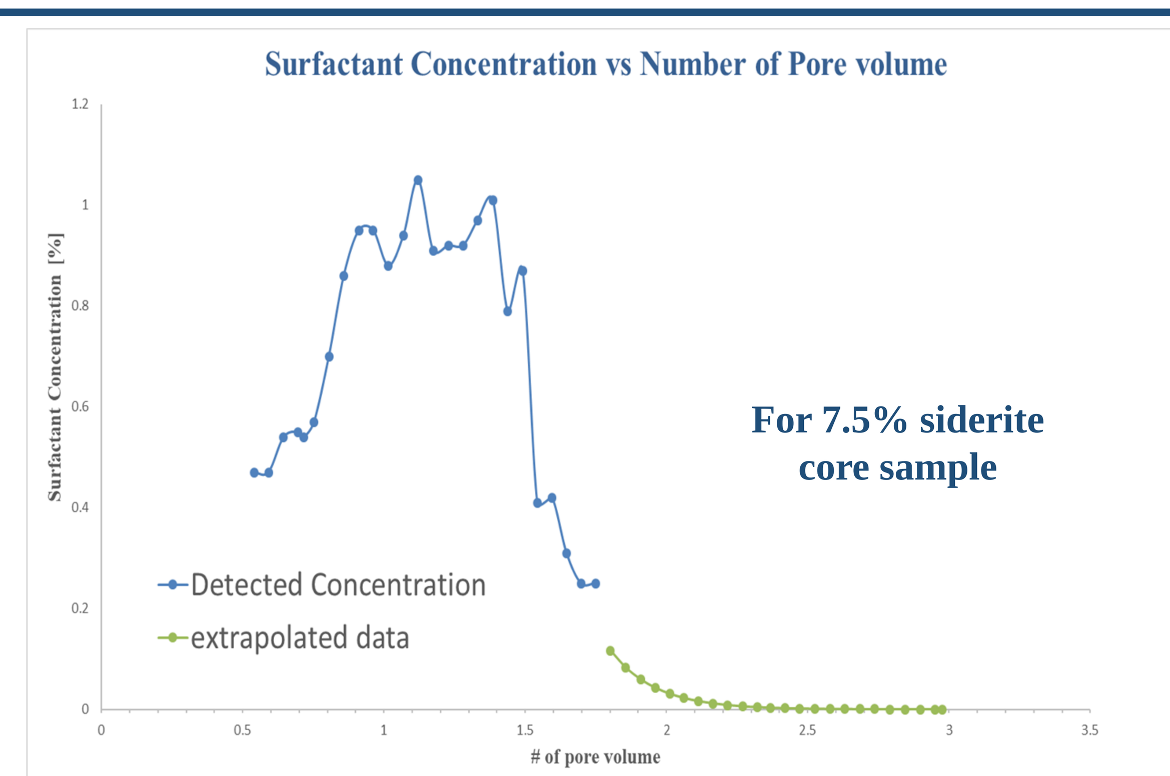
Total surfactant injected: 90.36 mL

Sample collection: Every 100 minutes

Brine injection: More than 3 days.



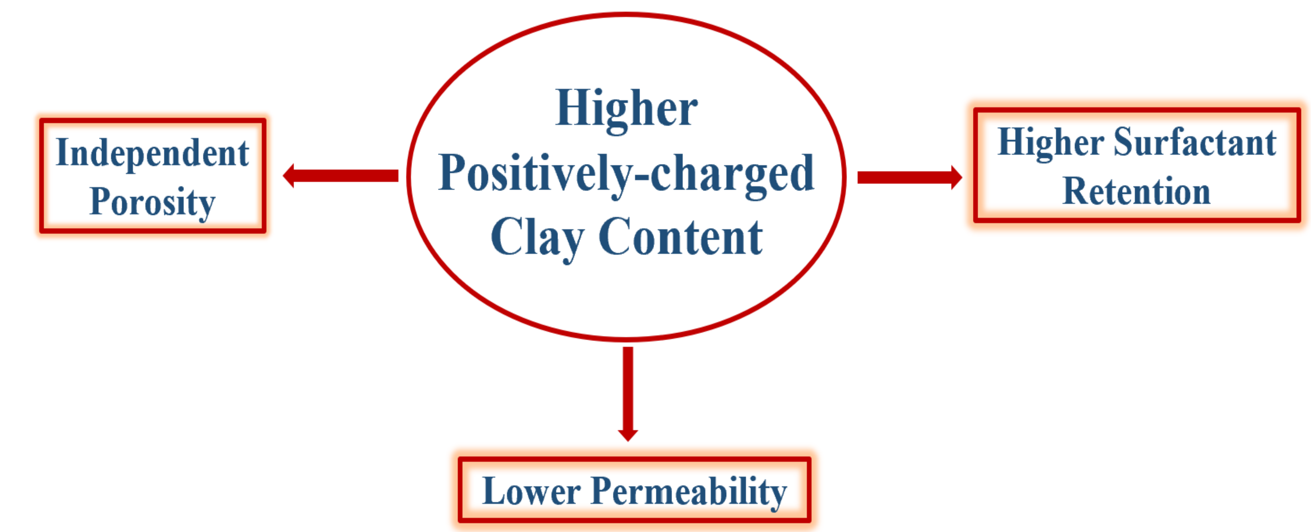
Concentration Detection



- Surfactant retention is the difference between the total surfactant injected into the system and the surfactant produced.
- There are two machines use to detect the surfactant concentration of produced liquid: Auto Titration Machine and Evaporative Light Scattering Detector.
- For tube with low concentration that cannot be detected by the machine, exponential decline model is used to extrapolate the data

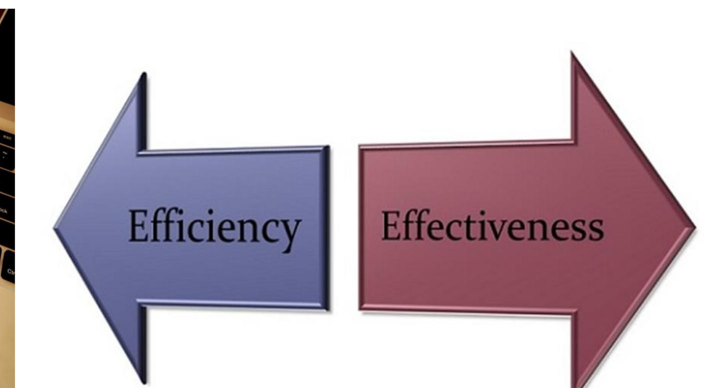
Results and Discussion

- As the siderite contents increases, there is no correlation between the porosity and the amount of positively-charged minerals in the reservoir.. This makes sense because when we created the synthetic cores, sand and siderite particles were well-sorted so that the grain sizes are the same.



- Looking at the permeability, there is a trend of decreasing permeability as the siderite content increases. One reason for this trend is the effect of the charged siderite particles on the flow of (polar) water through the cores.
- A trend of increasing surfactant retention with higher clay content was also observed when comparing data of 0%, 2.5 and 5% of siderite.

Applications



- In chemical EOR, the expenses in chemicals is an economic concern. The lost of surfactant due to adsorption may require a significant increase in surfactant injection.
- Comparing the cost of this method over the cost of other EOR methods, the efficiency of anionic surfactant will be determined.
- In short, the end goal of this work is provide a reference for oil and gas companies to make corresponding decisions to maximize the effectiveness of anionic surfactant and minimize production costs.

References

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