Foamability and Foam Stability of Several Surfactants Solutions: The Role of Salinity and Oil Presence

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Introduction

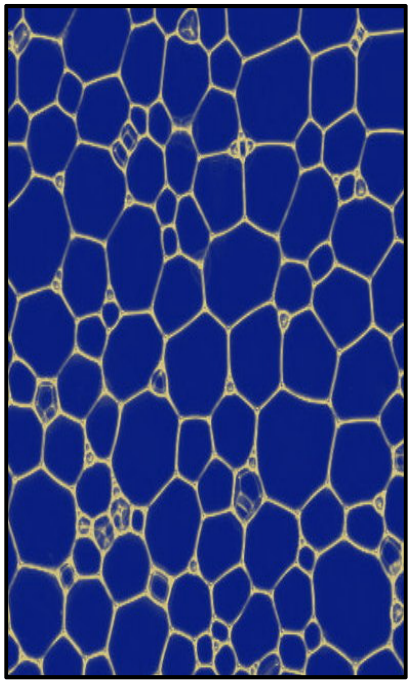
- Gas flooding is a common mean of improving oil recovery.
- Gases have high mobility causing gas bypass and gravity override of the resident oil leading to inefficient sweep.
- Foam injection was first introduced by Bond and Holbrook (1958) to overcome the high mobility associated with gas drive and to improve oil and the injected gases contact.
- Foam is generated by alternating or co-injection of gas and surfactant solution.

Introduction

- Foams are usually formed in systematic hexagonal texture.
- Foam is thermodynamically unstable, and thin liquid films stability is enhanced by surfactants to prevent bubble coalescence.
- Foams are generally described in terms of :

  Foamability: defined as the capacity of the surfactants to form foam irrespective of the special foam properties.

  Foam stability: defined as the variations of foam height or volume with time, immediately after foam generation.
- The two terms are interrelated and the more stable the foam films the greater is the solution's foamability.



Foam Texture

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Objectives

Screen several surfactants foamability and foam stability at

- different surfactant concentrations,
- different solution salinities and
- in presence and absence of crude oil.

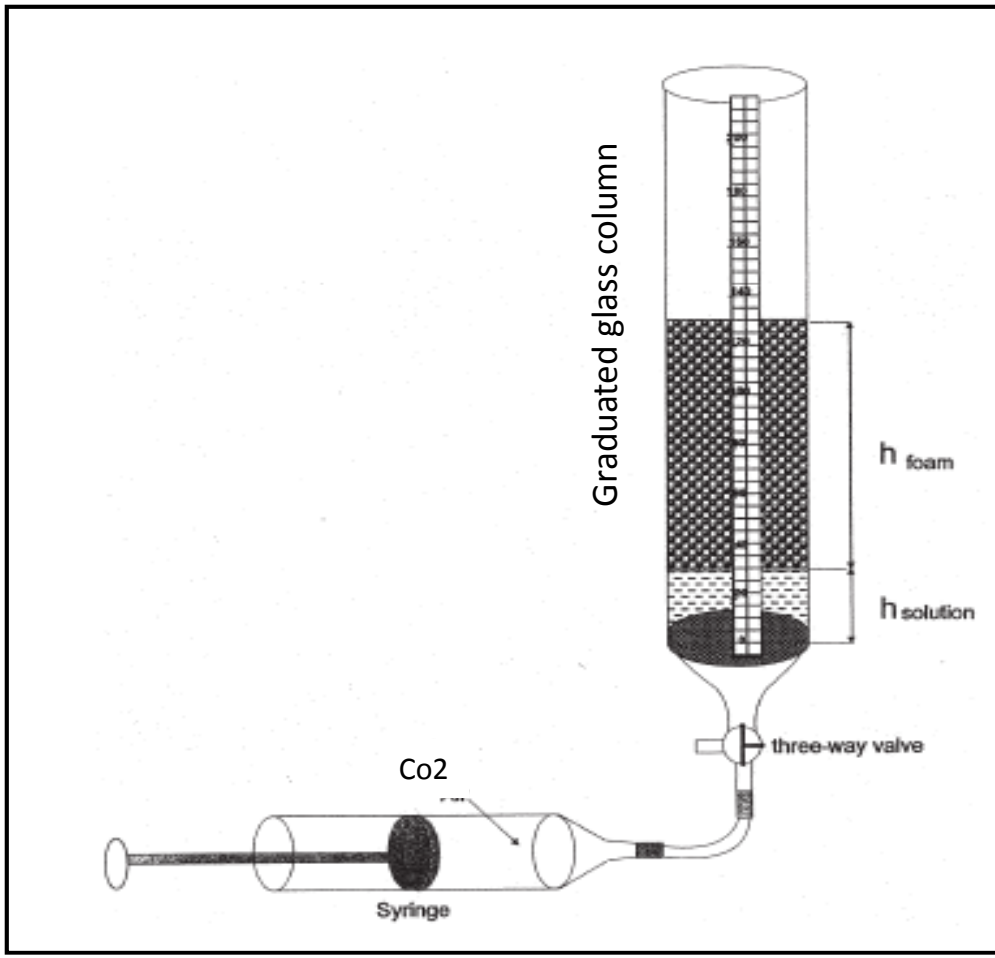
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Experimental Work

Foam stability of surfactant solutions was examined utilizing R5 method proposed by Lunkenheimera and Malysa (2003).

R5 is determined as the ratio of the foam height at five minutes after foaming (h_5) to the initial formed foam height (h_0).

Foams with R5 of 50% can be considered as metastable, whereas lower values of R5 indicate foams of low stability.



Materials

- Nonionic surfactants (Triton X-100, Triton X-405, Zonyl FSO, Noigen N-10 and Noigen N-20).
- Anionic surfactant (Hitenol H-10).
- Brine solutions of 4% and 10% salinities.
- Heavy crude oil (23 API, 90 cp).
- High purity Carbon Dioxide gas.

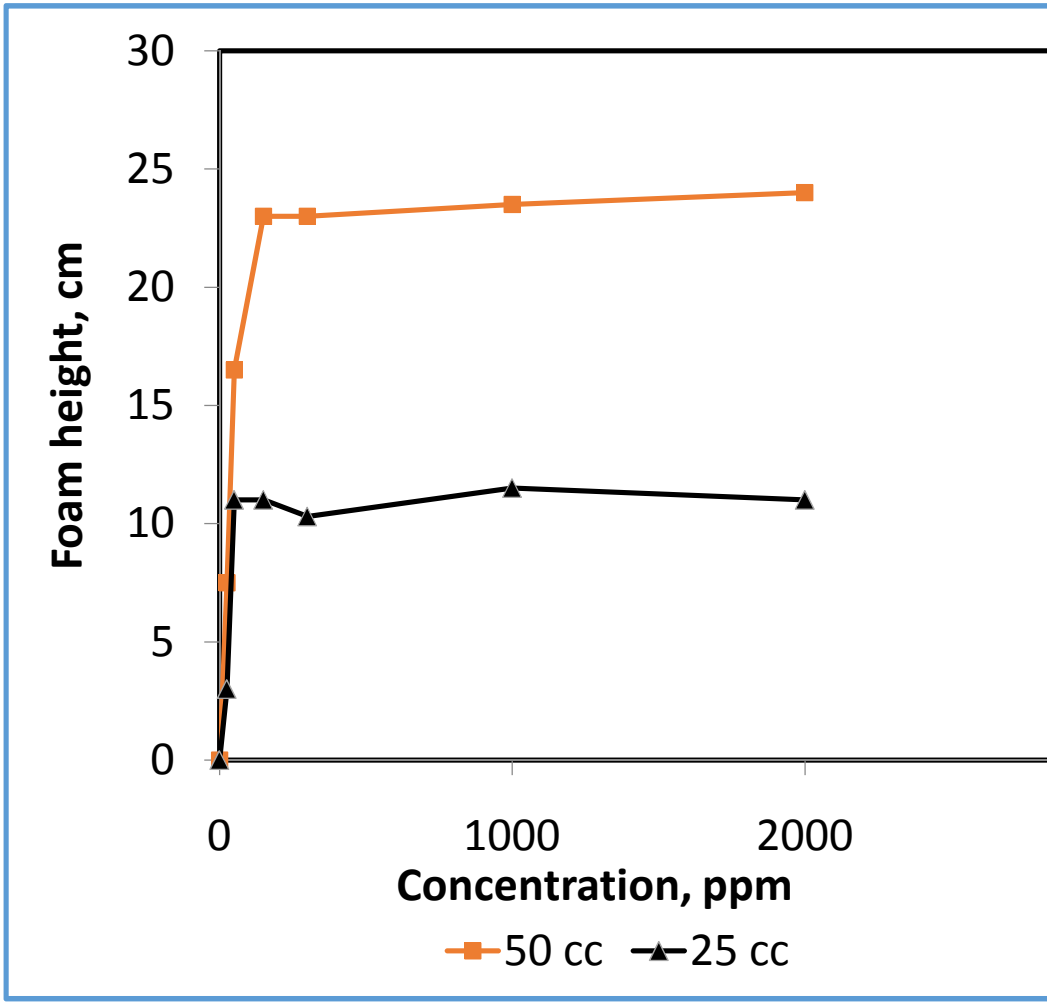
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Foamability of Hitenol H-10 Solutions

Hitenol H-10 Foam height shows a two times greater foam height when gas injection was doubled.

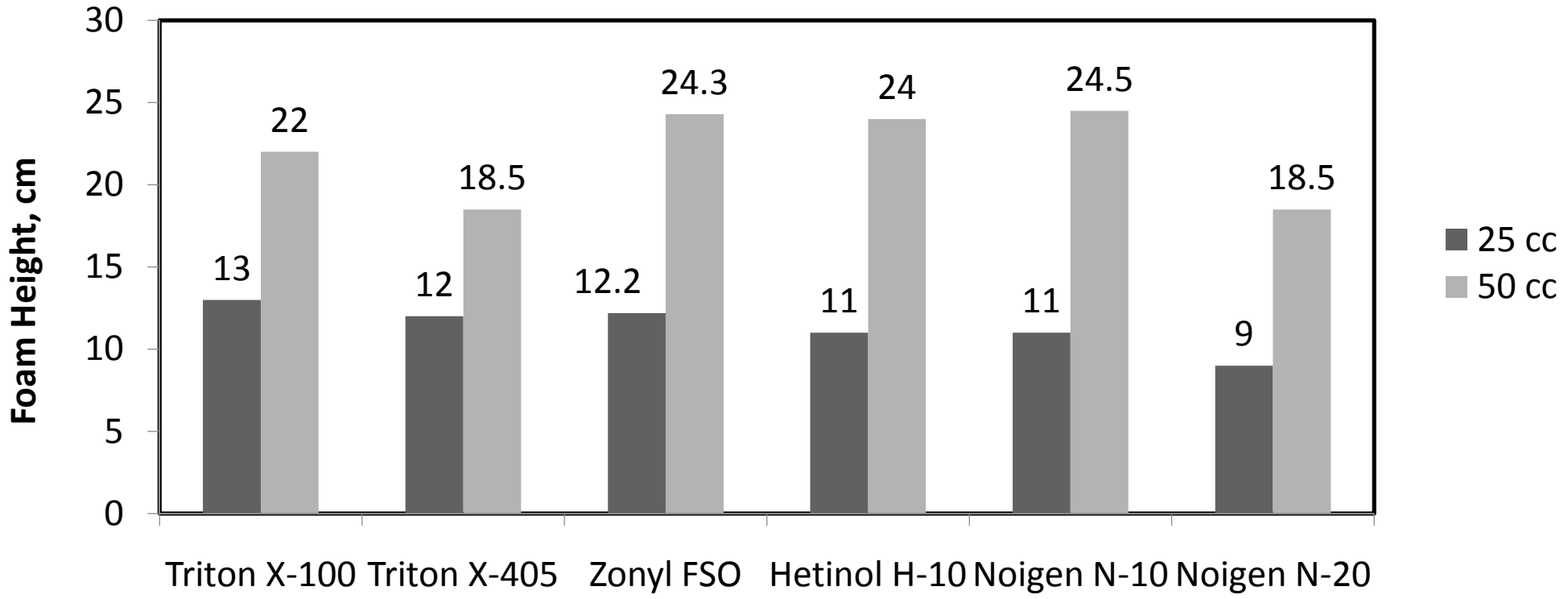
Initial foam volume is equivalent to the dispersed gas and solution volumes lifted by the foam.

Hence, a stable foam structure was formed with no significant rupture.



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Foamability of Screened Surfactants



All Surfactants showed good foamability during foam formation except for Triton X-405 where foam height was increased by only 50% when doubling gas rate .

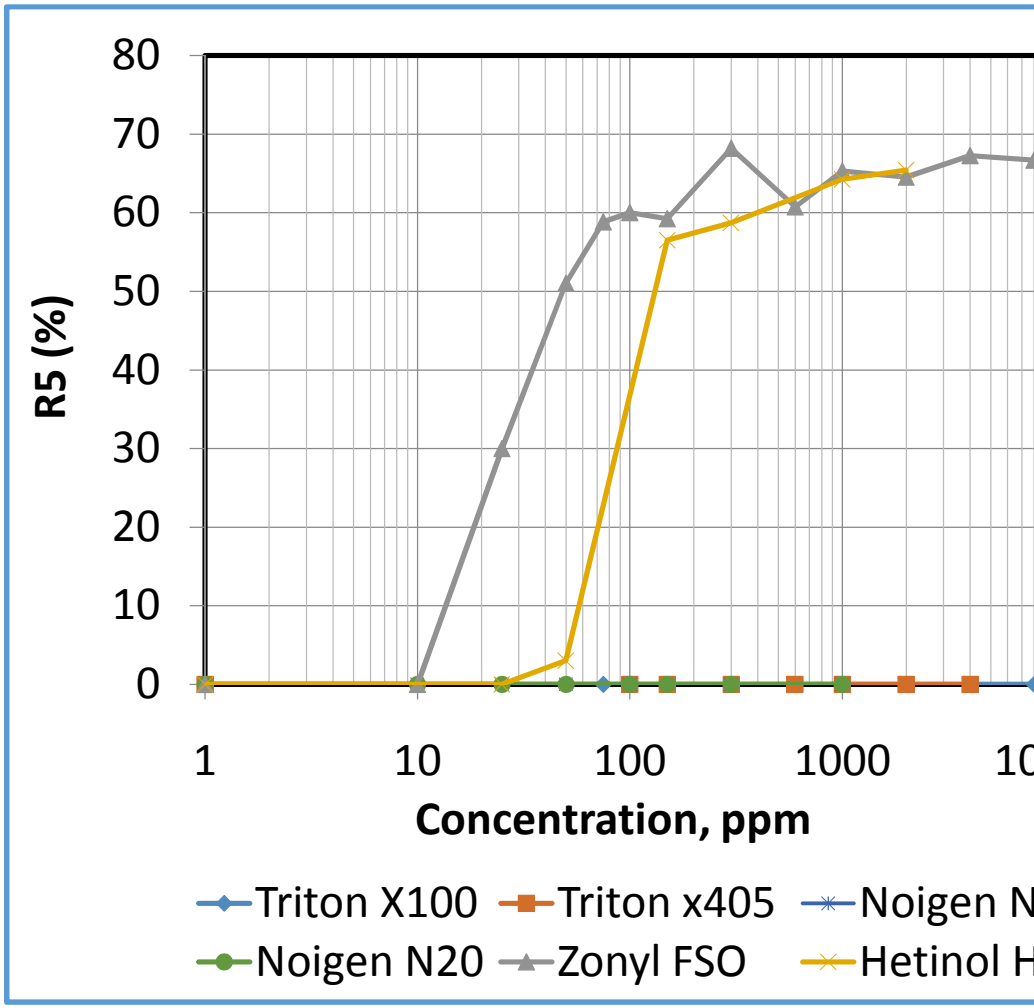
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Foam Stability of Screened Surfactants

onyl FSO and Hitenol H-10 are onsidered meta-stable as indicated y R5 > 50%.

onyl FSO required a wider range of oncentrations to reach stability ompared to Hitenol H-10 and that an be related to the different surface ctivities of the two surfactants.

ther surfactants are characterized as oor stability foamers with full foams upture in less than 5 minutes.



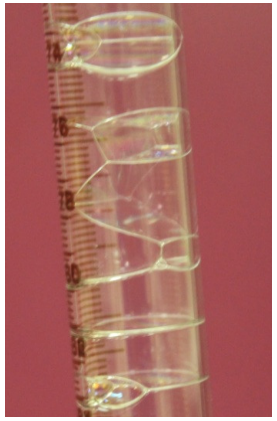
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Foam Structure at different Concentrations

igh concentration solutions were haracterized by fine and fairly niform distributed bubble size.

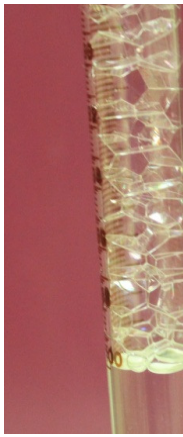
ower concentrations clearly reveals oam texture characterized by larger ubble sizes and broad distribution.

hese snapshots correlate well with he R5 tests shown earlier.

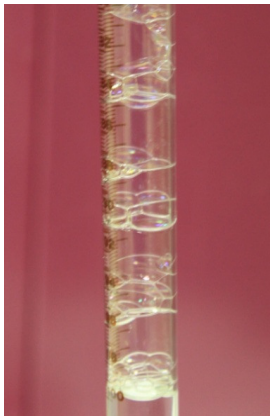


100 ppm

Zonyl FSO

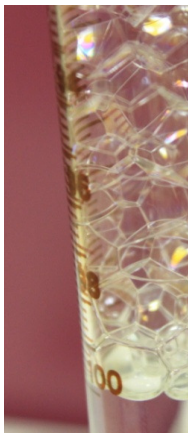


1000 p



50 ppm

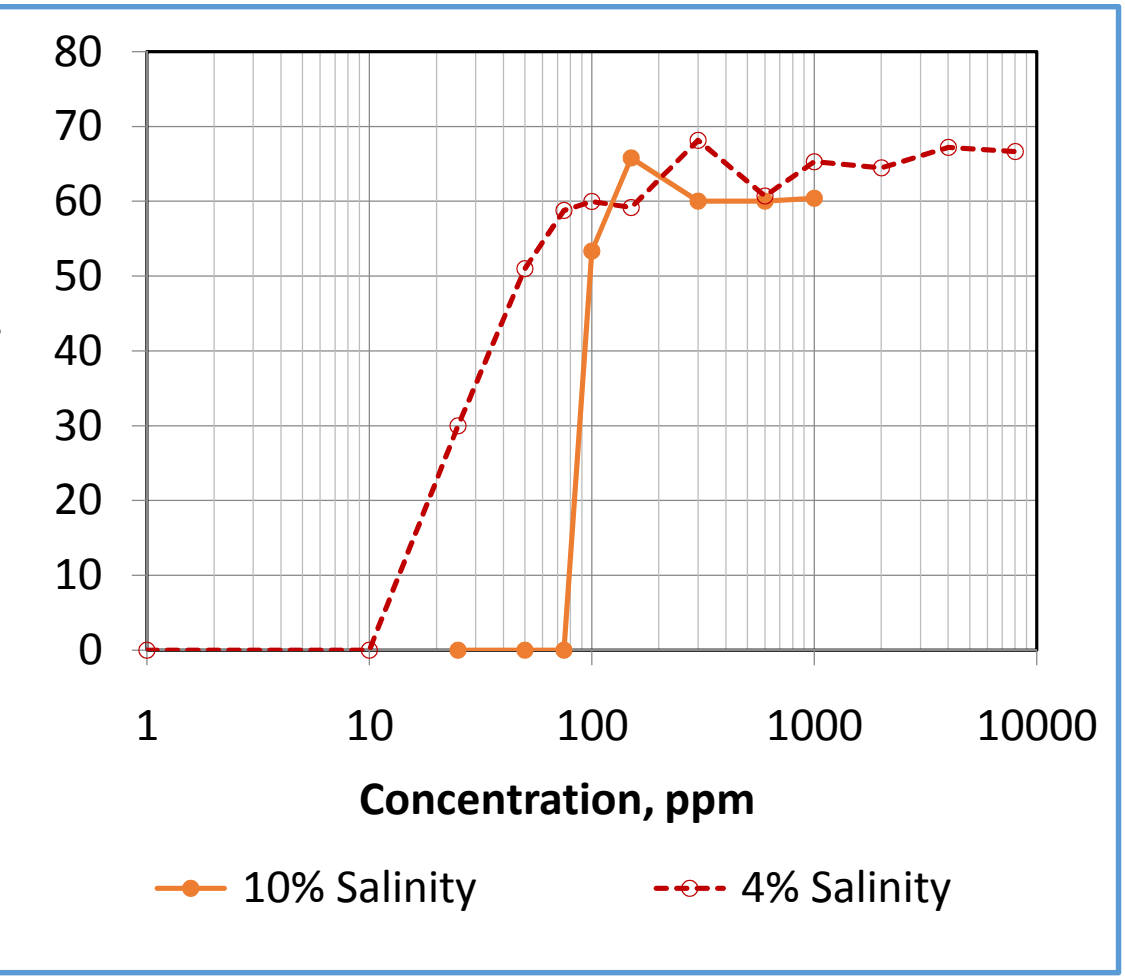
Hitenol H10

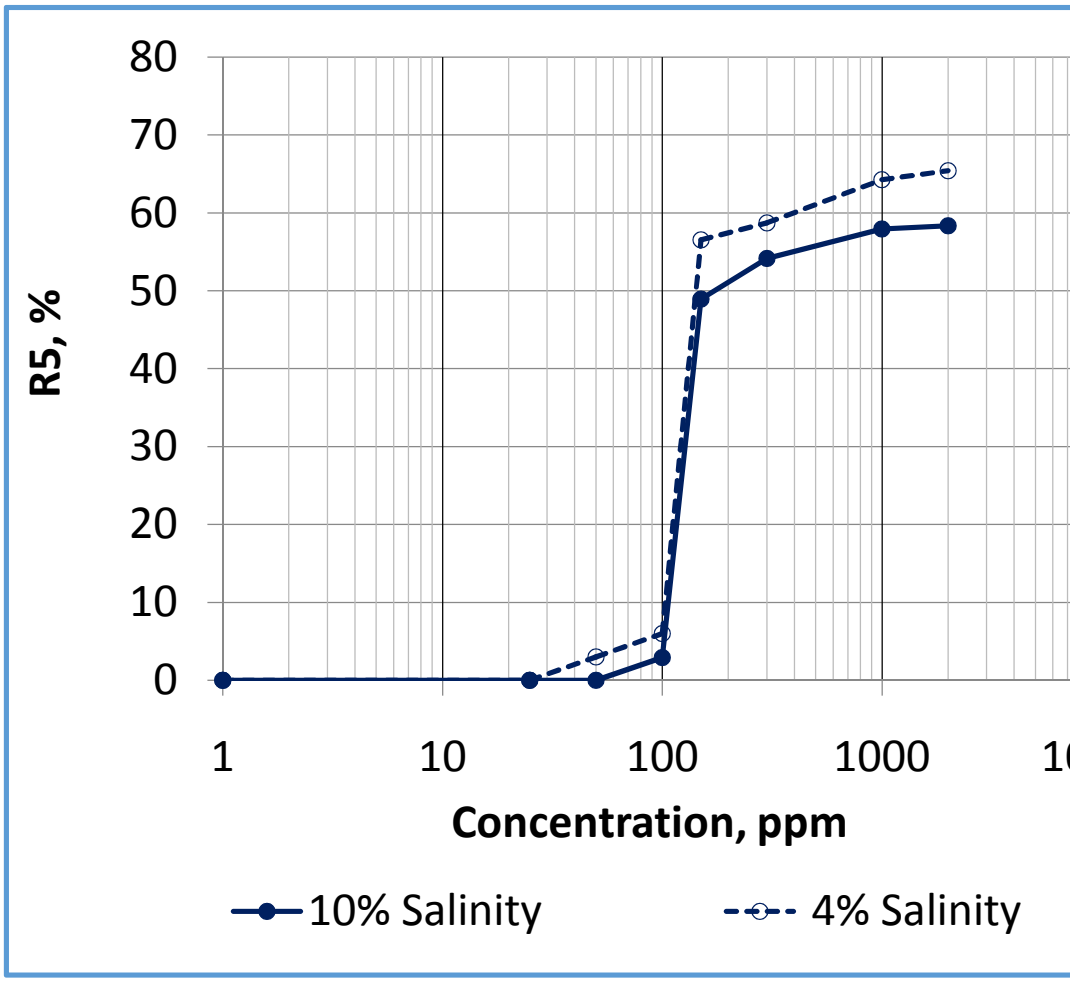


1000 p

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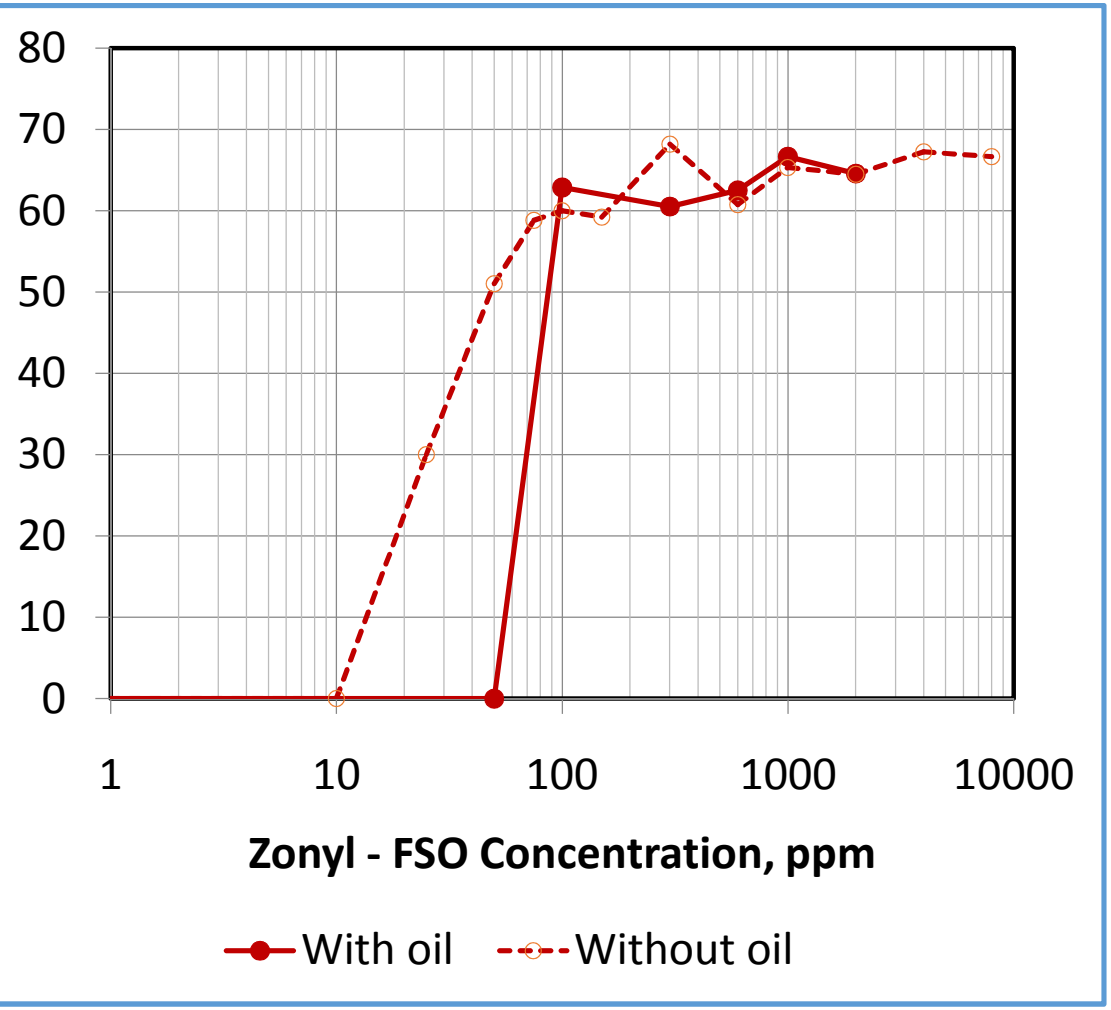
Effect of Solution Salinity

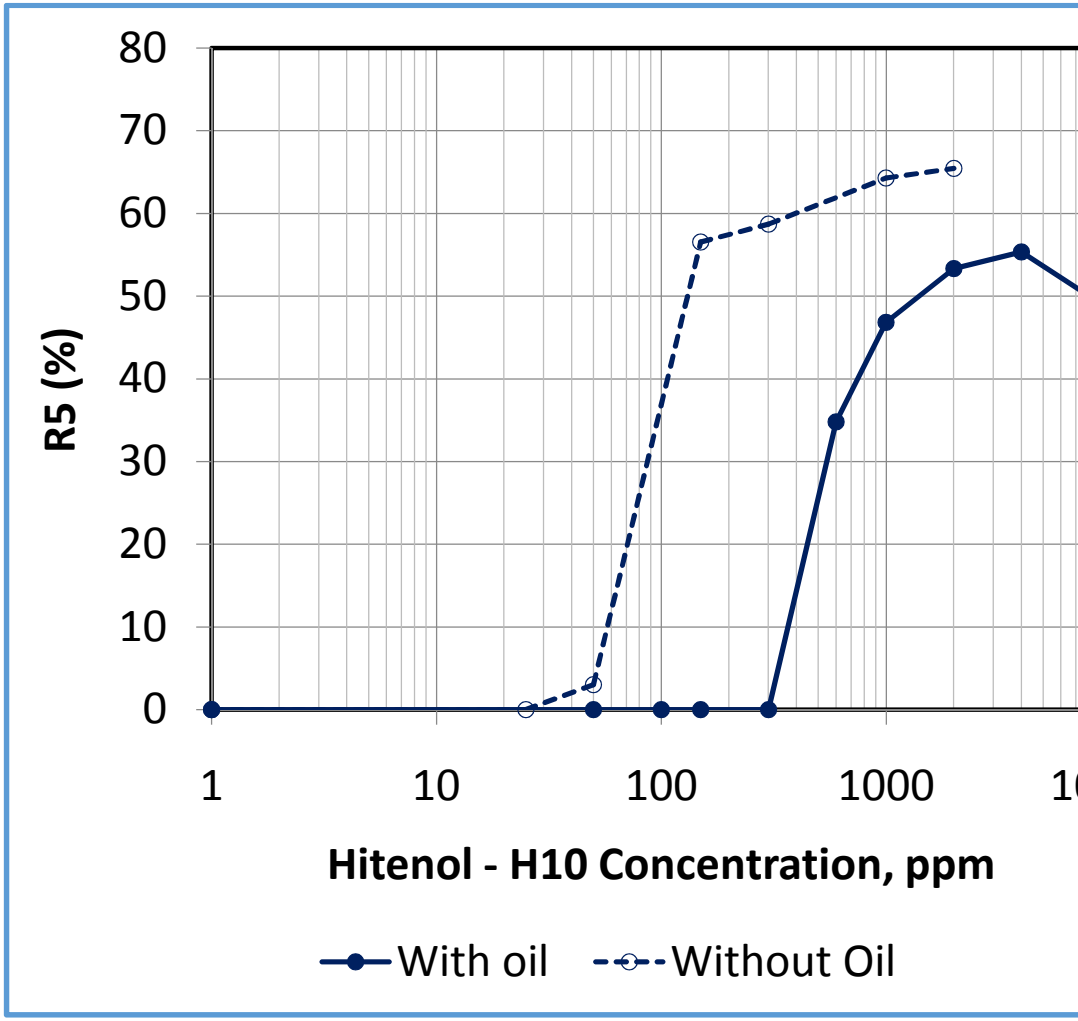




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Effect of Oil Presence





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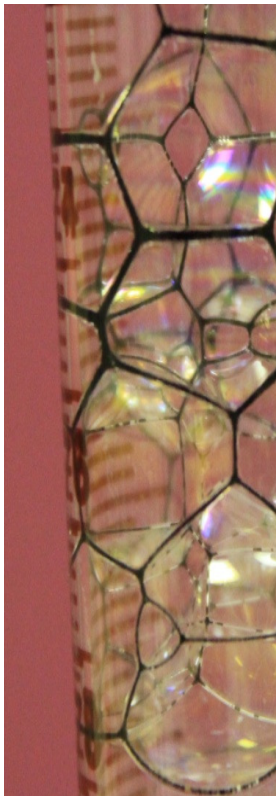
Foam Structure in Presence of Oil

Hitenol H-10 surfactant was able to carry oil upward inside the foam structure accumulating at the plateau borders but t drained out within short time frame.

To the contrary, Zonyl FSO showed good stability and oil lifting capacity at the lamellas skeleton and plateau boarders with no drainage



Zonyl FSO



Hitenol H

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Conclusion

- All surfactants except Triton X-405 showed good formability but Zonyl FSO and Hitenol H-10 surfactants provided the highest foam durability in absence of oil.
- Foamability and foam stability enhances as surfactants concentration increases.
- High concentration solutions were characterized by fine and fairly uniform distributed bubble size whereas lower concentrations clearly reveals larger bubble sizes and broad distribution.

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Conclusion

Salinity reduces foam stability at low concentrations of Zonyl FSO but
effect was seen at higher concentrations. Hitenol H-10 stability was
affected at different concentrations except for small drop on fo
durability at higher concentrations.

Presence of oil reduces Zonyl foam stability at low concentrations.
effect was observed above 100 ppm. Hitenol H-10 showed low stabi
at all concentrations range tested.

Hitenol H-10 surfactant was able to lift oil inside the foam structure
the plateau borders but it drained out within short time frame. Zonyl F
showed good stability and efficiency in lifting good portion of the oi
the lamellas skeleton and plateau boarders with no drainage.

Thank you