Structurally evolving ‘flat solid’/oil interfacial self assembled surfactant structure steadily enforces peculiarities into oil spreading behavior – Lubricant Formulations

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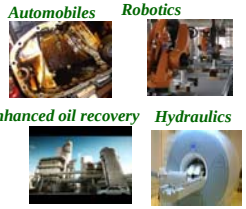
Introduction

Challenges
- Control over flow behavior
- Better performance with less surfactants

Surfactants

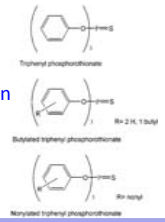
How surfactant structural properties relate to oil flow behavior



Oil + Surfactant system

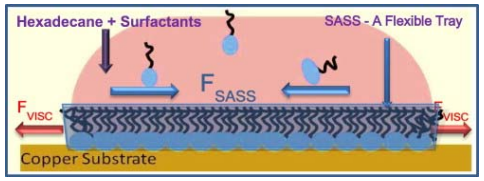
Oil
- Hexadecane

Surfactants
- Typhenylphosphothion
- Doecanol
- Docecylamine
- Dodecanethiol
- Lauric acid

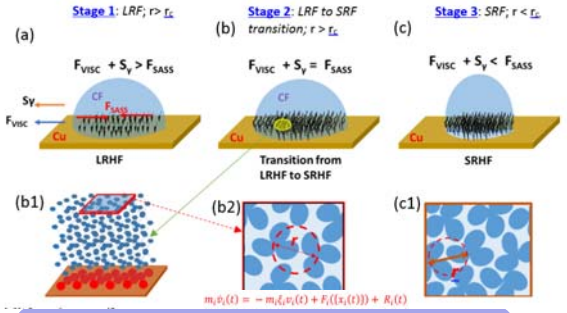


Approach

$$R(t) = \Omega^{\frac{3}{10}}(\sigma/\eta)^{\frac{1}{10}}t^{\frac{1}{10}}$$

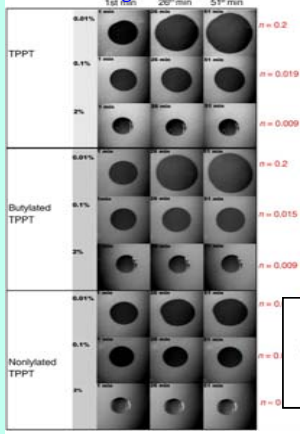


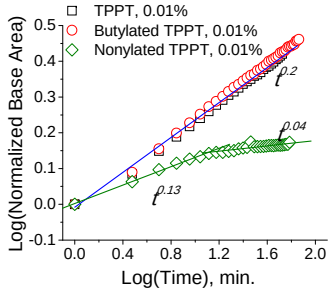
Concepts

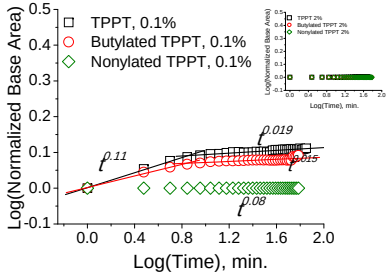


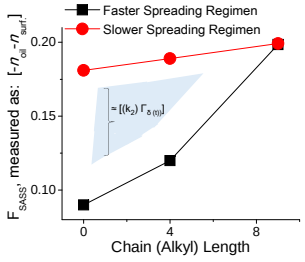
Results

Forces owing to SASS









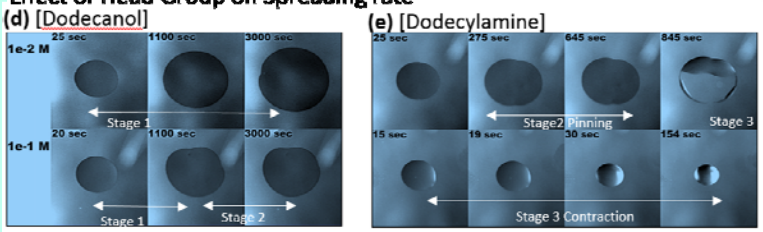
$$\Gamma_{\delta(t)} = lC_t\, e^{\left(\frac{\Delta G_0}{RT}\right)} = lC_0 \frac{A_0}{\left[A_0 + \Delta\left[\Omega^{\frac{3}{10}}\left(\frac{\sigma}{\eta}\right)^{\frac{1}{10}}t^n\right]\right]} e^{\left(\frac{\Delta G_0}{RT}\right)}$$

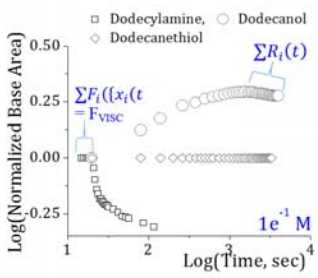
Kinematic viscosity of hexadecane as a function of chain-length (0–9) and concentration (0.01–2 wt.%).

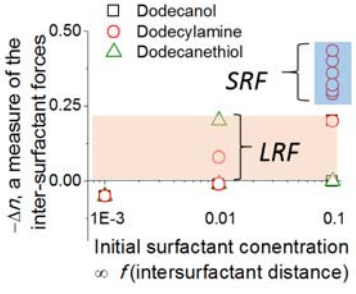
Chain length	Kinematic viscosity (centistokes, cs) vs. surfactant concentrations		
	0.01 wt.%	0.10 wt.%	2 wt.%
0	4.458	4.698	5.158
4	4.558	4.498	5.258
9	4.498	4.598	5.158

$$S_t = F_{VISC} - \left[\left(k_1 + k_{2(t)}\right)\Gamma_{\delta(t)}\right]$$

Effect of Head Group on Spreading rate







Discussion

- Surfactant types imparts specificity
  - Forces owing to interfacial ***SELF-ASSEMBLED SURFACTANT STRUTURE (SASS)***
    - Head group functionality and Chain length
- Spreading Forces = Viscous Forces + Surface tension forces
  - + Self assembly forces = F_{SASS}
- Spreading rate is slower with longer surfactants
  - Adsorption density - higher for longer surfactants
- Two stages in spreading
  - Viscous forces
  - Surfactant arrangement in SASS
    - **SASS restructuring**

Conclusions

Spreading rate is reduced
Surfactants having higher adsorption rate
Surfactant molecular rearrangement plays a key role in inter-surfactant forces
Long range forces, Short range forces

References

Bingquan Li , Ponisseril Somasundaran , Partha Patra, Advances in Colloid and Interface Science,, 2014