



Breaking the Performance Trade-Offs: Advancing Low Foam Surfactant Performance

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Functional Chemist



Today's Agenda



**Low Foam
Surfactant
Market Overview**



**Structured-
Property-
Relationship**



**New Low Foam
Surfactant –
Science Behind**



**Case Study:
Metal Recycling
& Warewash**

North America Low Foam Opportunity: A focused subset of a large nonionic pool

~\$6.84B

North America low foam surfactants, 2023

~5.3% CAGR

2024 to 2030 published low foam forecast

~\$9.81B

North America low foam surfactants, 2030 forecast

Scope includes nonionic, amphoteric and other low foam chemistries

1

CIP & Food Processing

Fast drain, low carryover, caustic and neat stability

2

Metal Working & Parts Wash

Wetting and soil removal without foam-limited spray pressure

3

Textile, Paper & Coatings

Rapid wetting, low entrained air and process consistency

4

Auto laundry, Dish & Hard Surface

Low residue, fast rinse and concentrated product compatibility

Source: North America Low Foam Surfactants Market Outlook, 2030

SAM applies 60% to 75% to the published low foam TAM to represent industrial cleaning, CIP, metalworking, textile and paper processing, coatings, automatic laundry and dish.



Market Momentum Favors Low Foam Systems Built for Automation and Concentration



1

Automation becomes the demand engine

Automated washers, recirculating systems and CIP require controlled foam for spray action, pumps, sensors and cycle efficiency.

2

Concentrates move performance upstream

Higher-active products require solubility, electrolyte tolerance and stable dilution without a foam penalty.

3

Closed-loop operation raises the bar

Water reuse and repeated circulation reward low-residue systems that retain wetting and detergency under variable soil load.

4

Growth extends beyond the product

Food and dairy CIP, metal cleaning, industrial laundry, textile and paper, recycling process, and automatic vehicle care – all process involved.

*Balance foam control + wetting + cleaning + concentrated formulation
design for autonomous process, rather than optimizing foam in isolation*



Poll Question



What, if anything, makes you hesitant to use a low-foam surfactant?

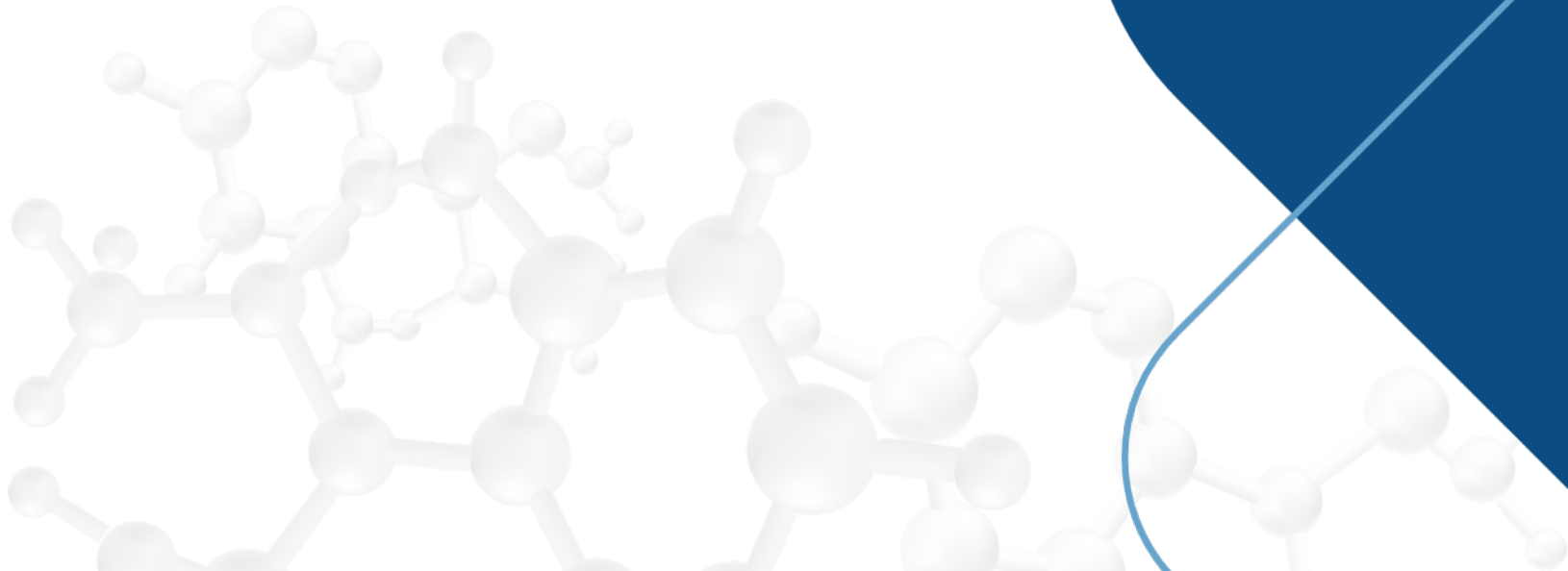
Answer options:

1. Concern about reduced performance such as slower wetting, or solubility/concentrate-stability limitations
2. Performance may vary with temperature or soil conditions
3. Cost or difficulty justifying a formulation change
4. Limited application data or uncertainty about product selection
5. Nothing, I already use low-foam surfactants





Recap: Structured-Property-Relationship of Low Foaming Nonionic Alkoxylate



Summary of Nonionic Alkoxylate Foam

Alcohol Ethoxylate



Moderate Foaming

PO-Extended Alkoxylate



Lower Foaming

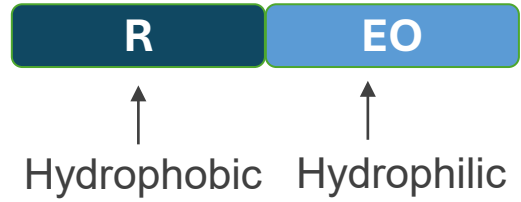
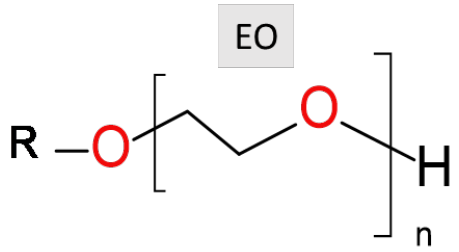
PO-Capped Alkoxylate



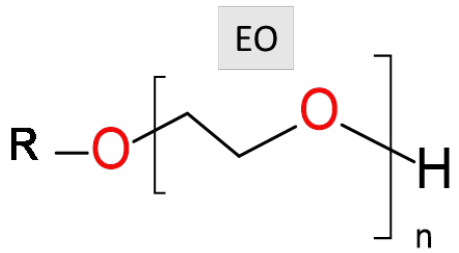
Low- to De-foaming



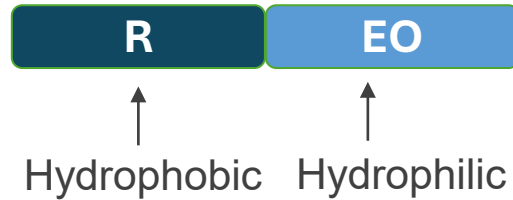
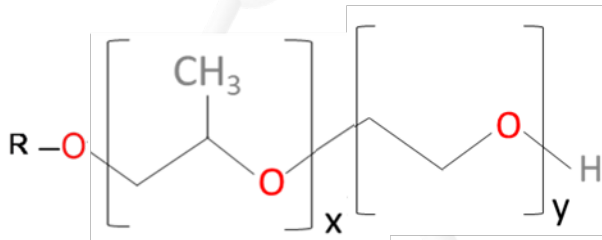
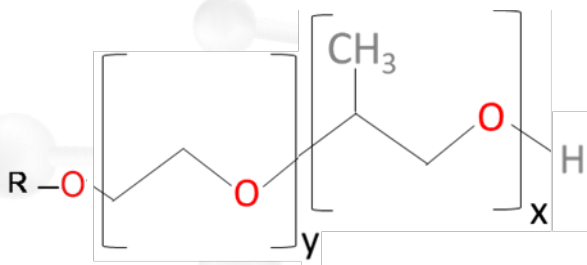
Effect of Structure



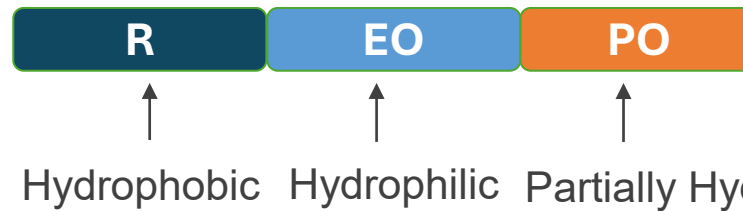
Effect of Structure



Alcohol Alkoxylate



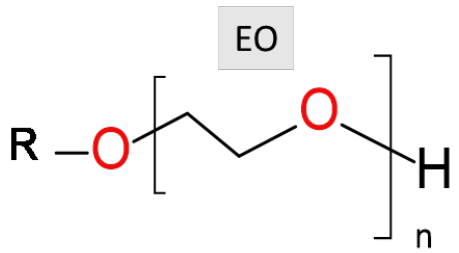
PO-Capped Alcohol Alkoxylate



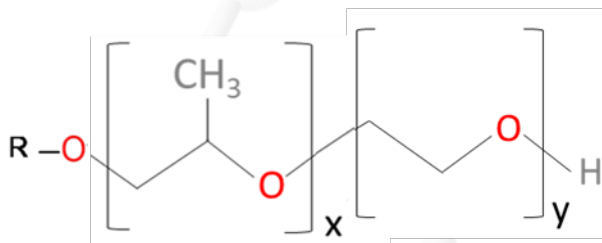
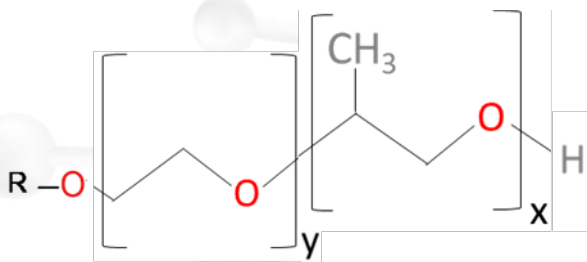
PO-Extended Alcohol Alkoxylate



Effect of Structure



Alcohol Alkoxylate



↑
Hydrophobic ↑
Hydrophilic



PO-Capped Alcohol Alkoxylate

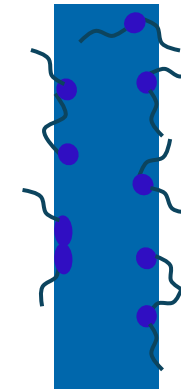


↑ ↑ ↑
Hydrophobic Hydrophilic Partially Hydrophilic

PO-Extended Alcohol Alkoxylate



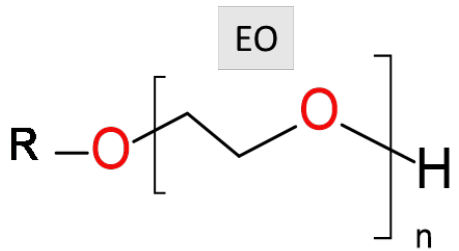
Adsorbed Layer Becomes Loosened



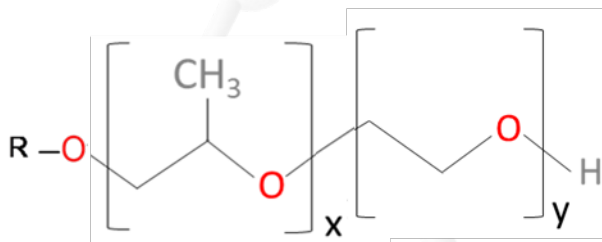
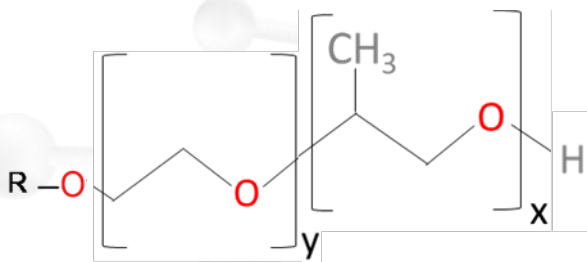
Unstable Film



Effect of Structure



Alcohol Alkoxylate



↑ ↑
Hydrophobic Hydrophilic



PO-Capped Alcohol Alkoxylate

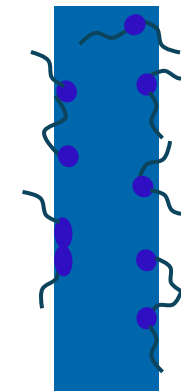


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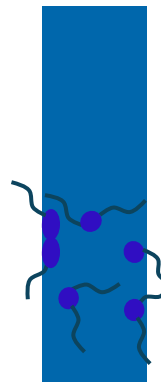
PO-Extended Alcohol Alkoxylate



Adsorbed Layer Becomes Loosened



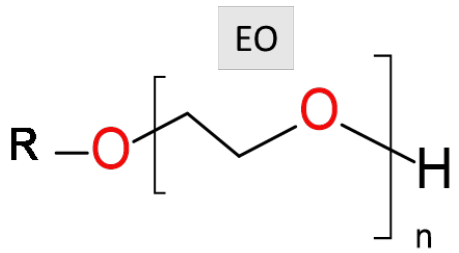
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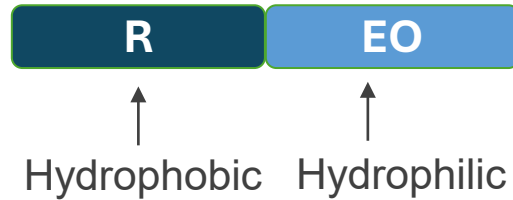
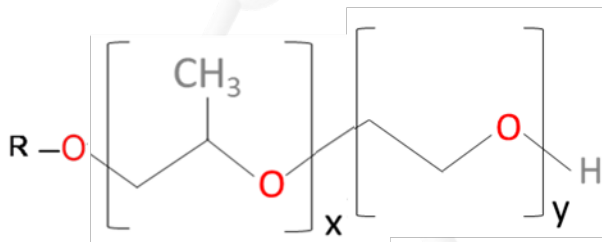
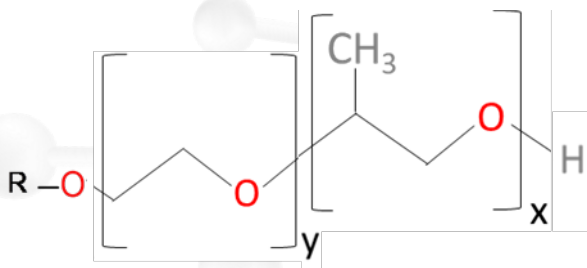
Faster Film Drainage



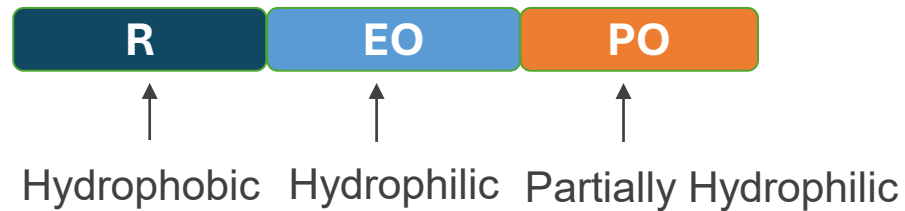
Effect of Structure



Alcohol Alkoxyate



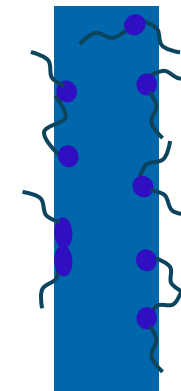
PO-Capped Alcohol Alkoxyate



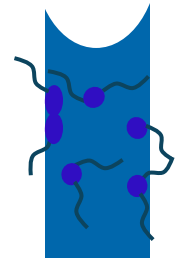
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Adsorbed Layer Becomes Loosened



Unstable Film



Faster Film Drainage



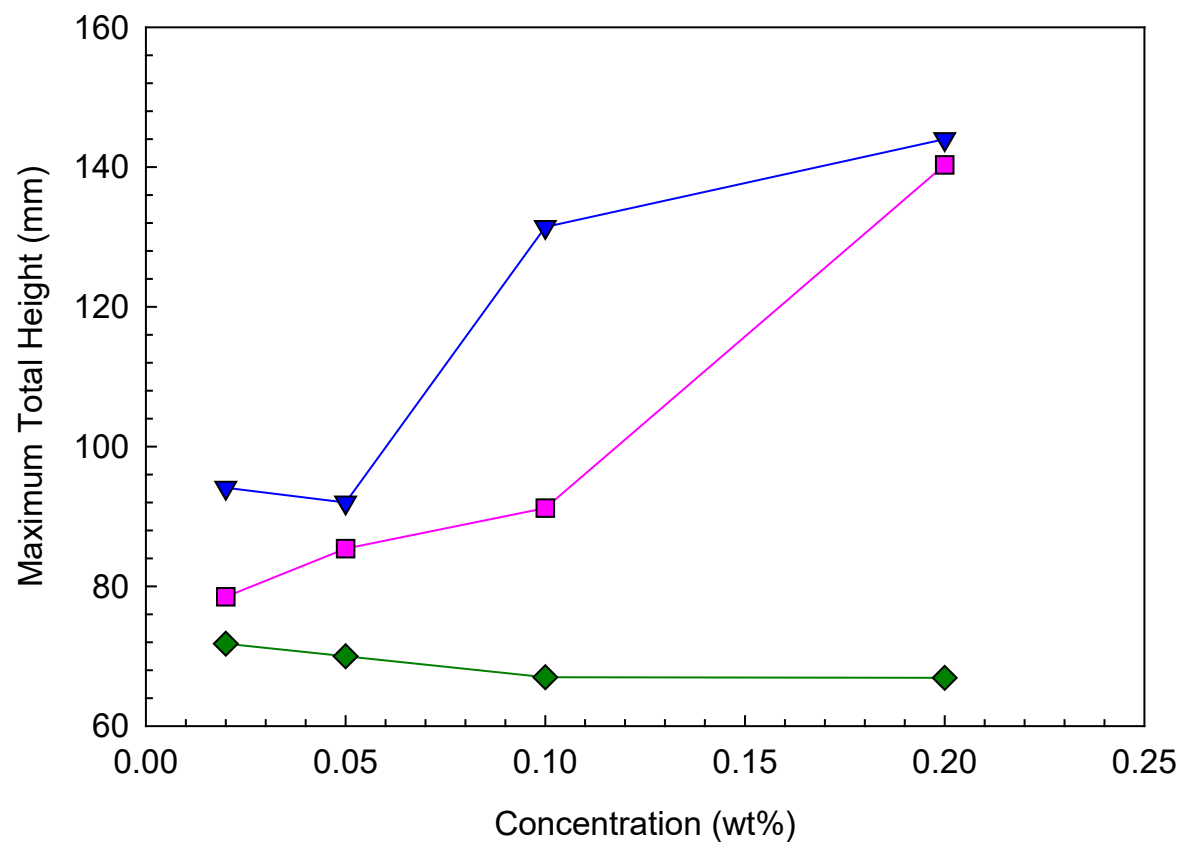
Mode of Defoaming



Mode of Defoaming



Foamability at 25°C vs Concentration

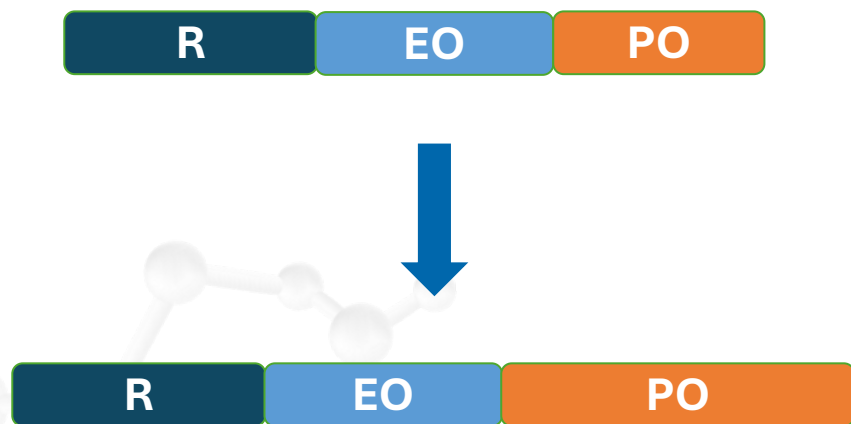


R EO PO

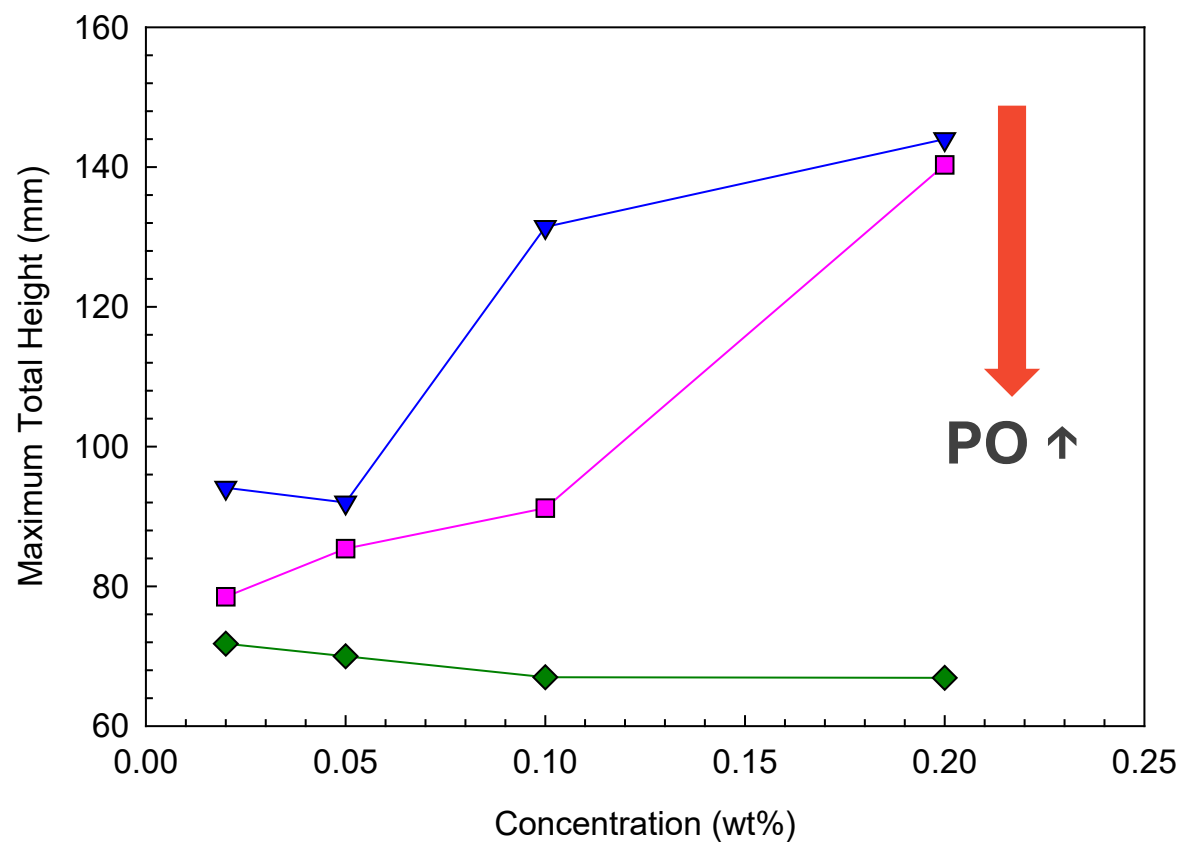


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Mode of Defoaming



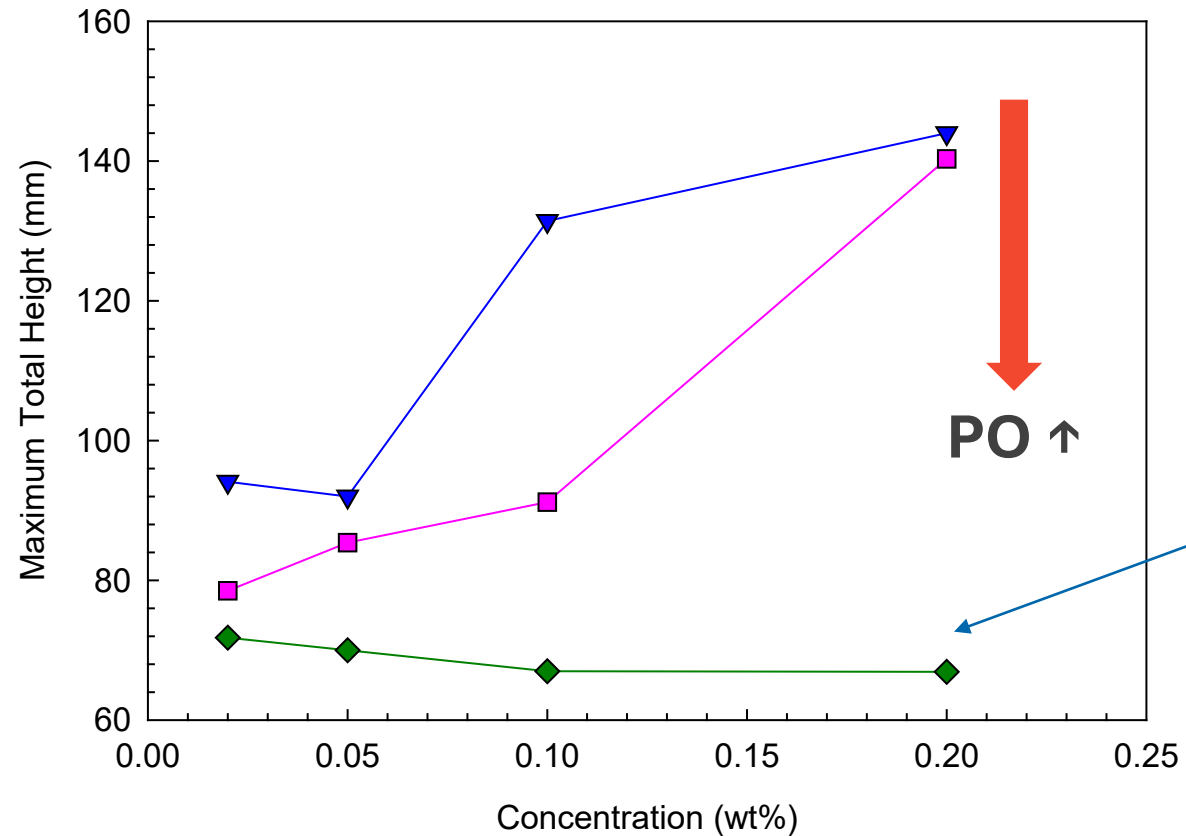
Foamability at 25°C vs Concentration



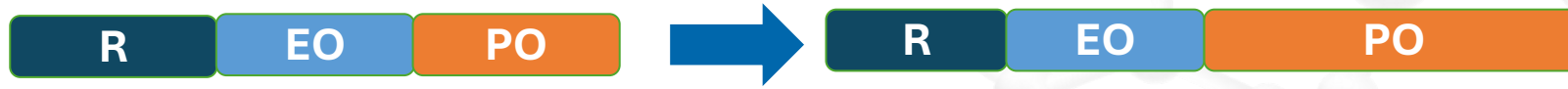
Mode of Defoaming

Negative Slope → Negative Foam Expansion → **Defoaming**

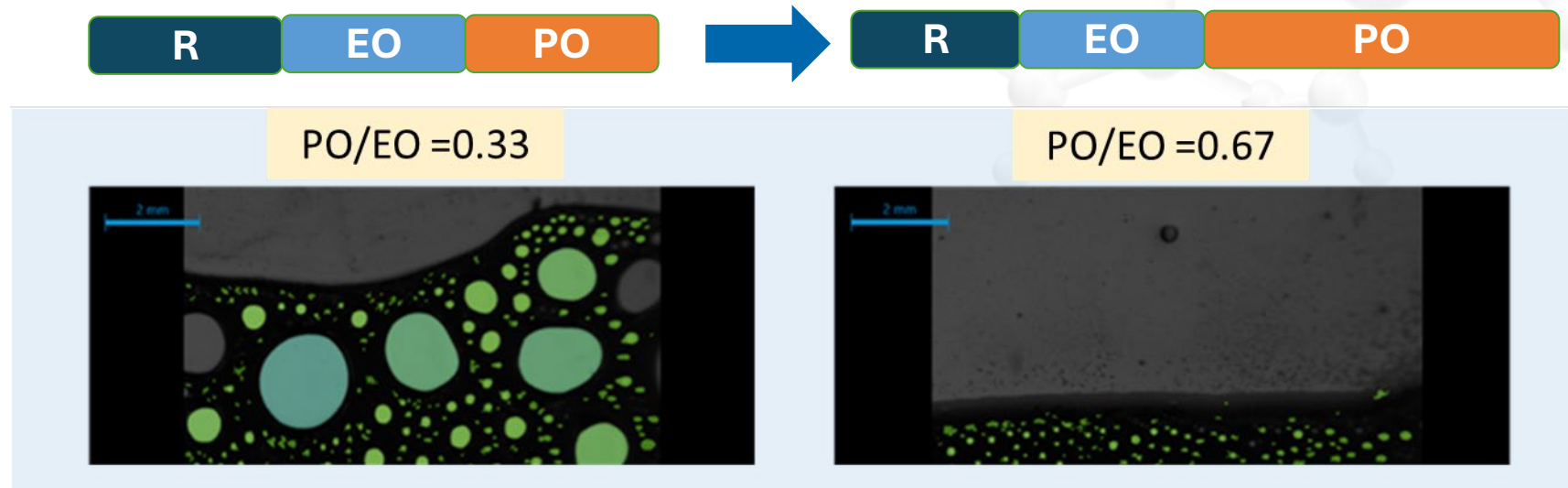
Foamability at 25°C vs Concentration



Solubility and Defoaming



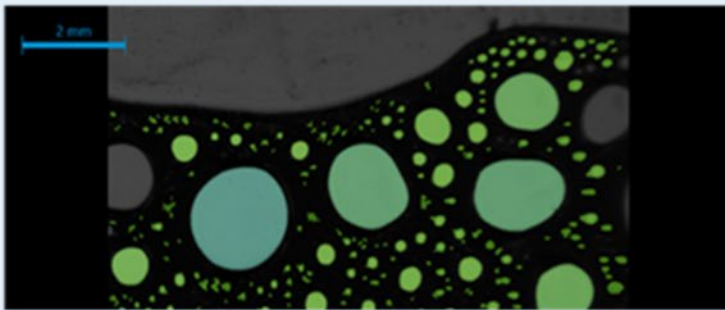
Solubility and Defoaming



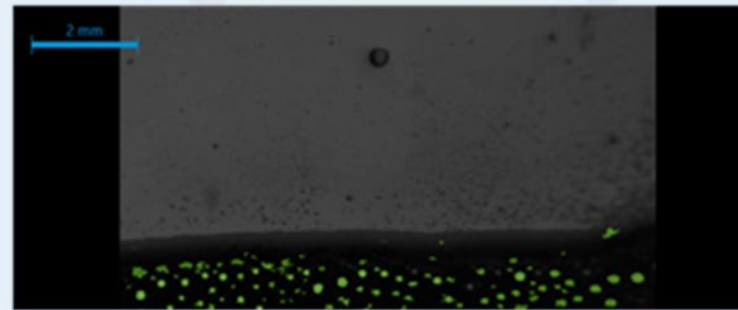
Solubility and Defoaming



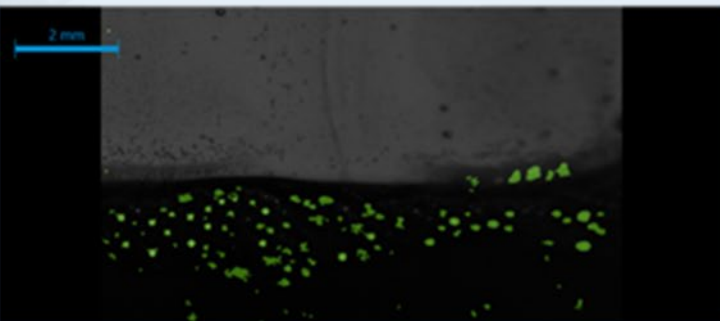
PO/EO = 0.33



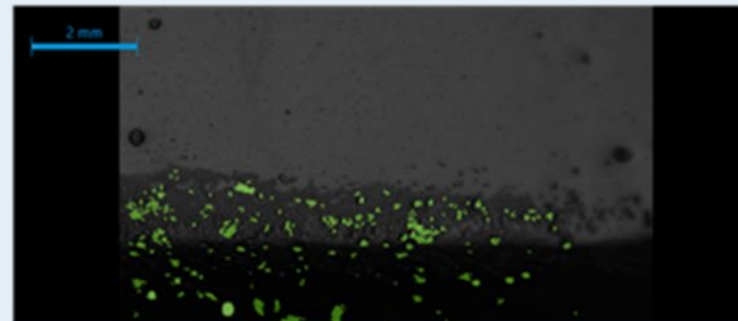
PO/EO = 0.67



PO/EO = 0.92



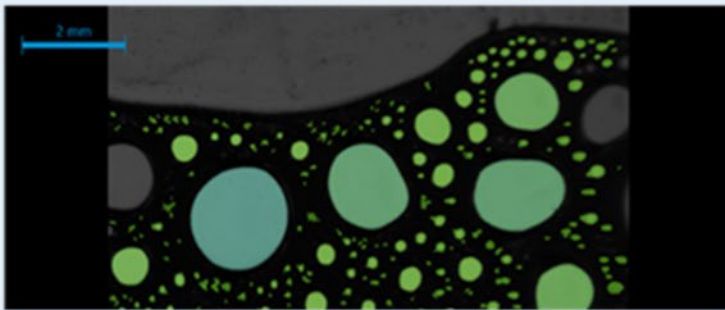
PO/EO = 1.42



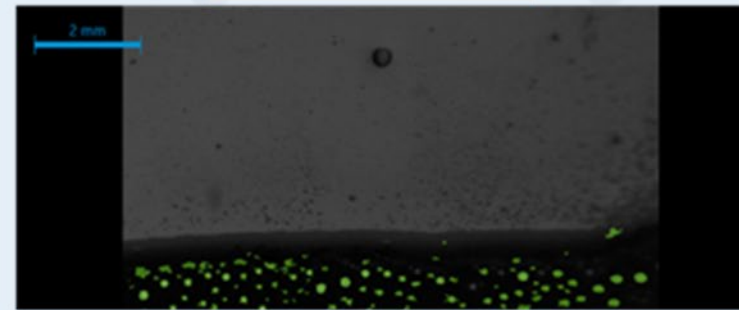
Solubility and Defoaming



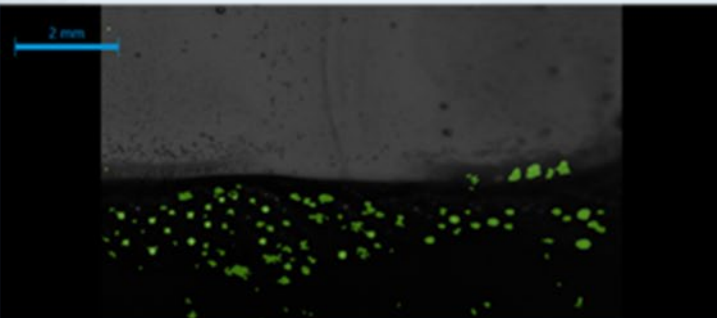
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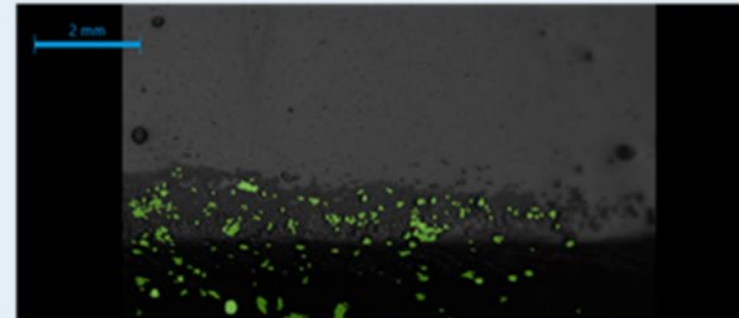
PO/EO = 0.67



PO/EO = 0.92



PO/EO = 1.42



Trade-off: Solubility vs Foam Control



Poll Question



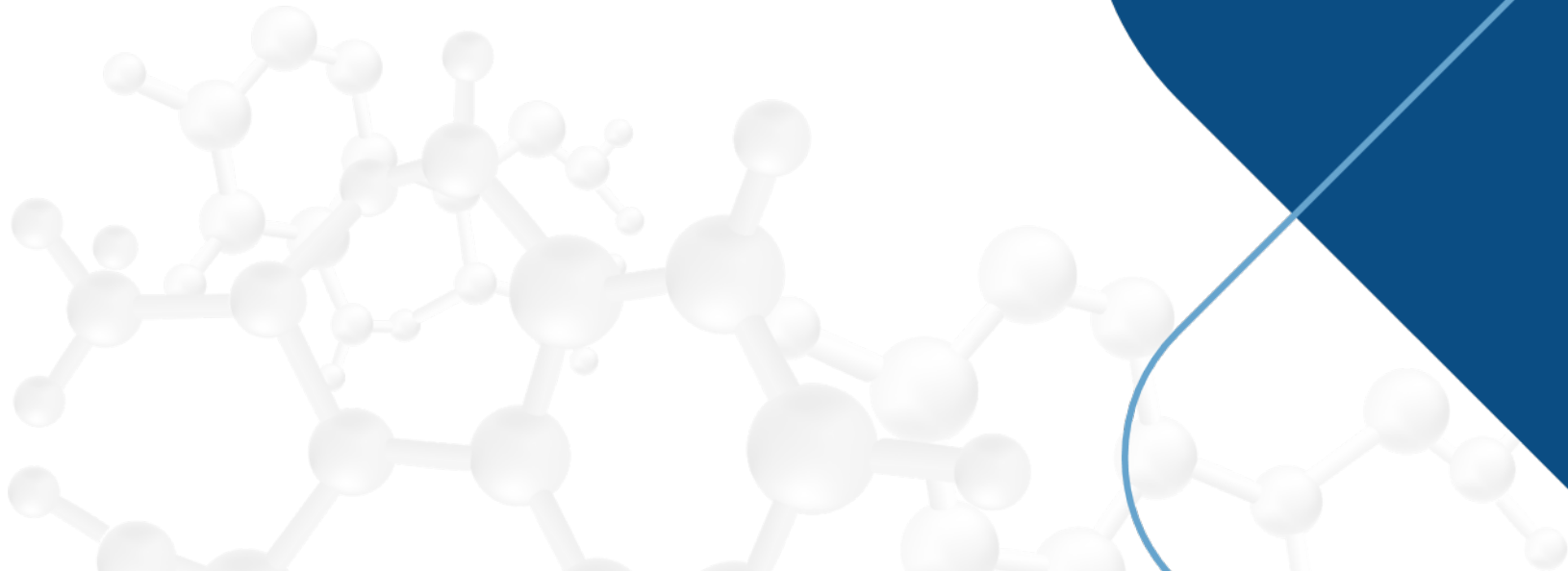
True or false: Lower foam always means sacrificing other performances such as cleaning, solubility?

Answer options:

1. True
2. False
3. I am not sure, and that is why I joined today



Introduction of Stepan's Novel Low Foam Surfactant



Innovation – How to Minimize Trade-off?

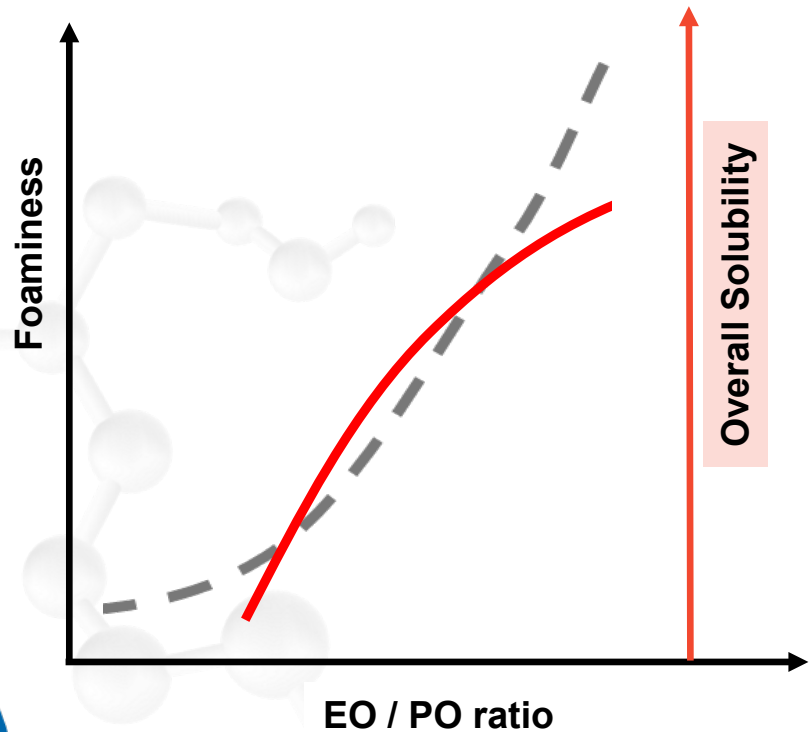
Existing Technology

PO-Capped Alcohol Alkoxylate

R

xEO

yPO



Innovation – How to Minimize Trade-off?

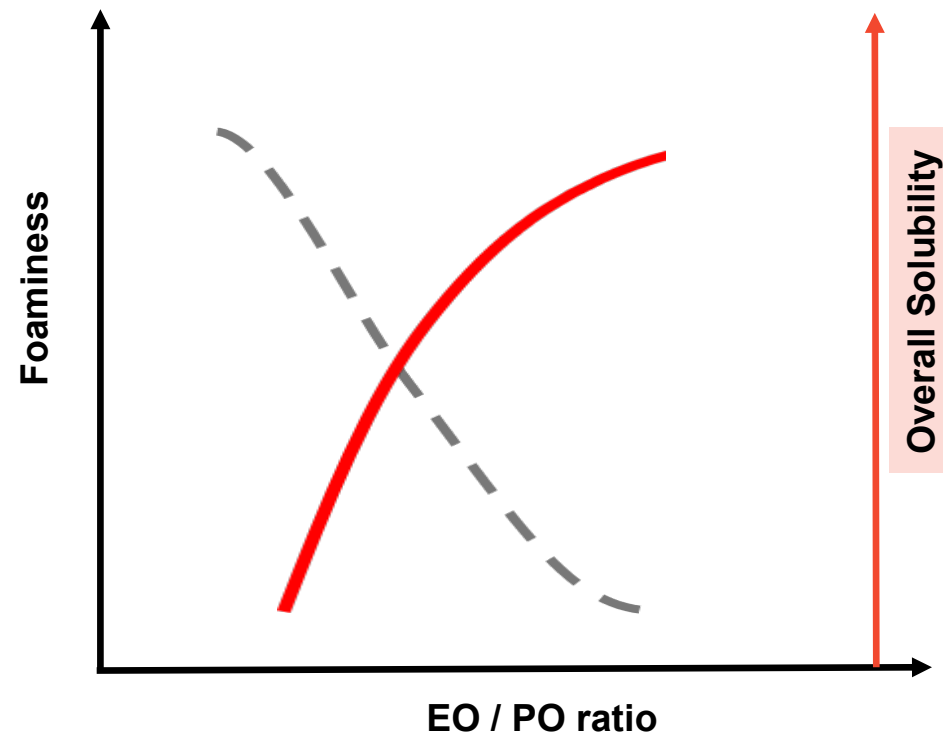
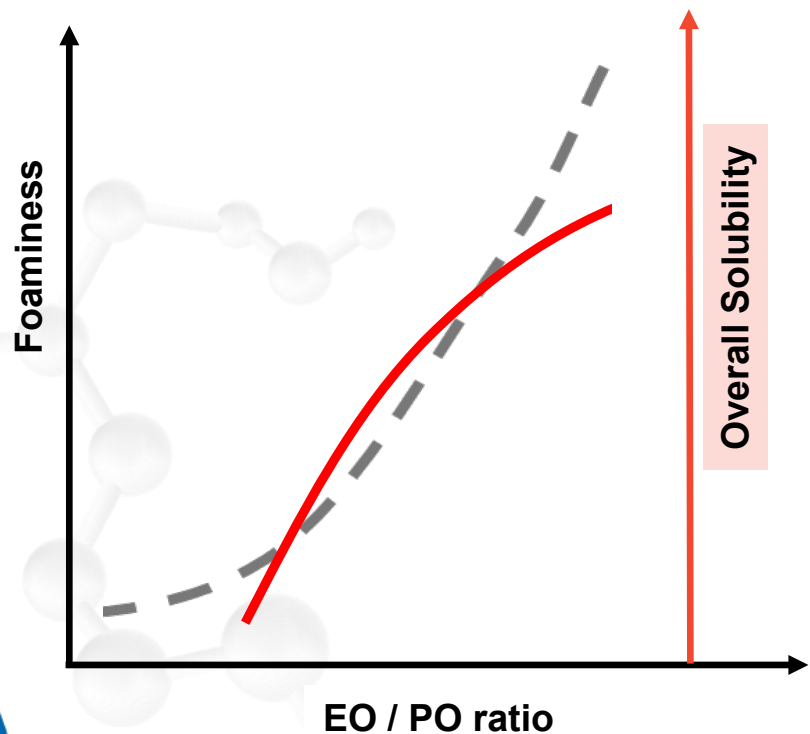
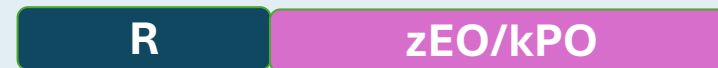
Existing Technology

PO-Capped Alcohol Alkoxylate



Novel Low Foam Surfactant

Novel Alkoxylate Surfactant



Unique Behavior of New Surfactant

Existing Technology

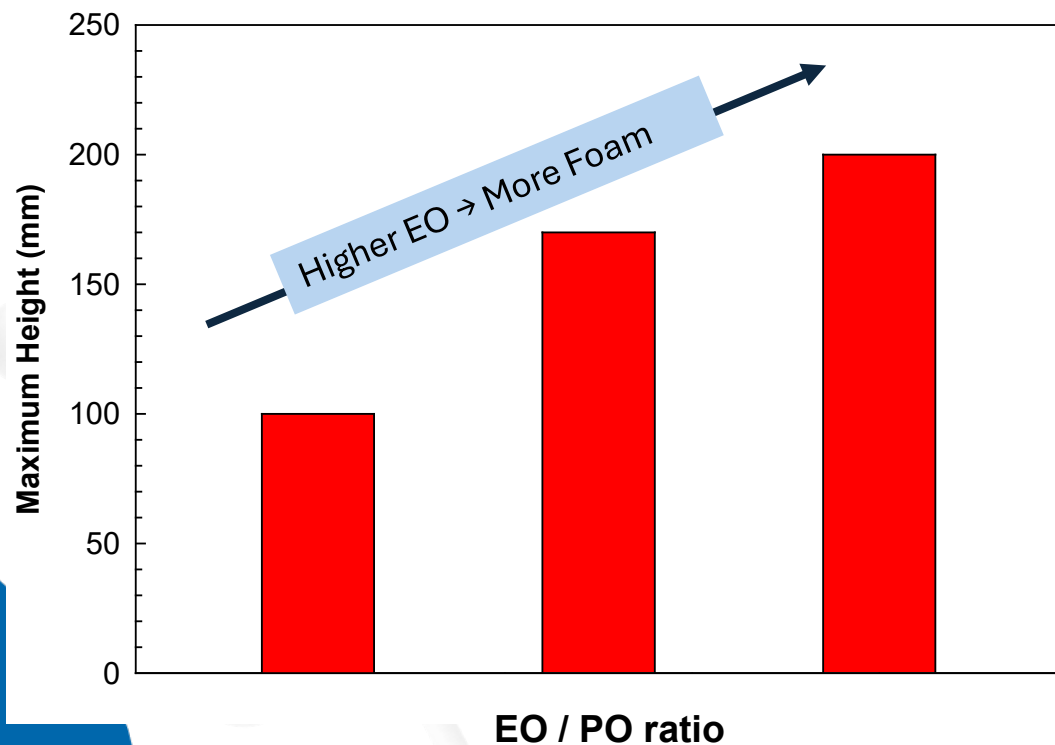
PO-Capped Alcohol Alkoxylate

C10

xEO

8PO

Maximum Foam Height during Sparging at 45 deg C



Unique Behavior of New Surfactant

Existing Technology

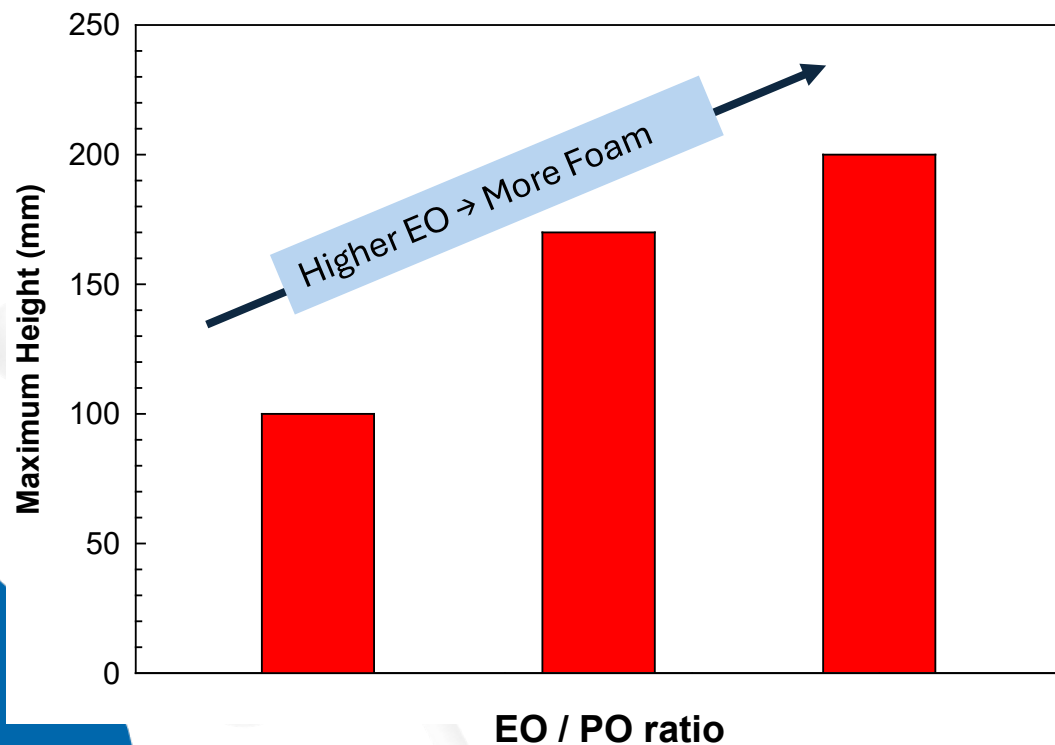
PO-Capped Alcohol Alkoxylate

C10

xEO

8PO

Maximum Foam Height during Sparging at 45 deg C



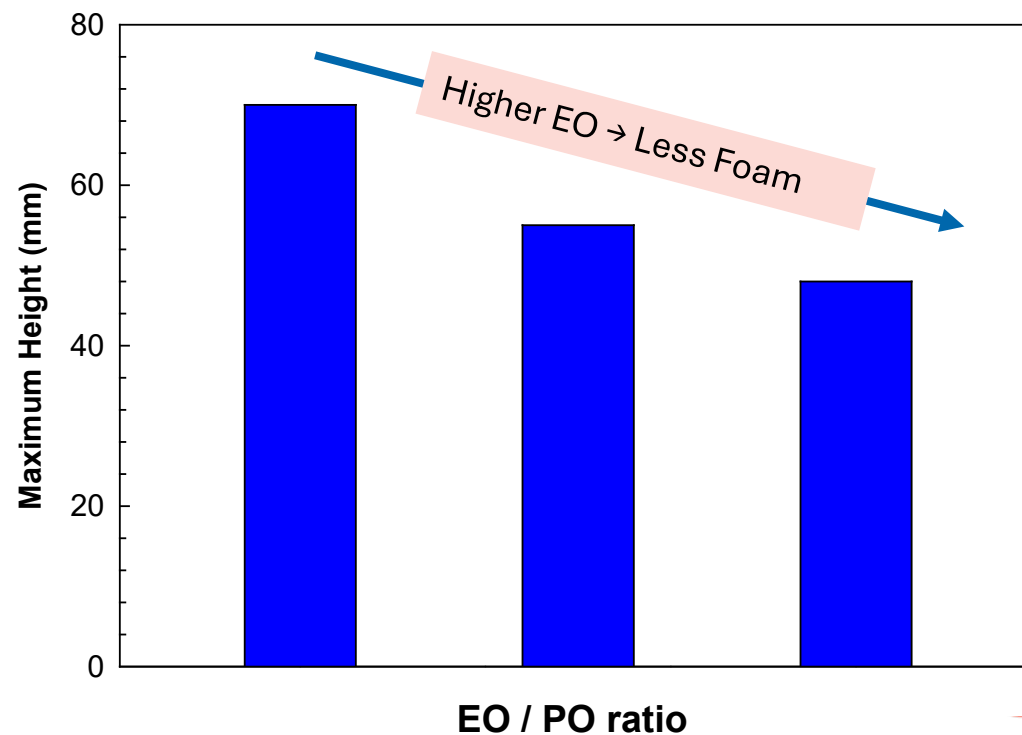
Novel Low Foam Surfactant

Novel Alkoxylate Surfactant

R

zEO/kPO

Maximum Foam Height during Sparging at 45 deg C



Mechanism Behind

R

EO

PO

PO-Capped Alcohol Alkoxylate at
elevated temperature



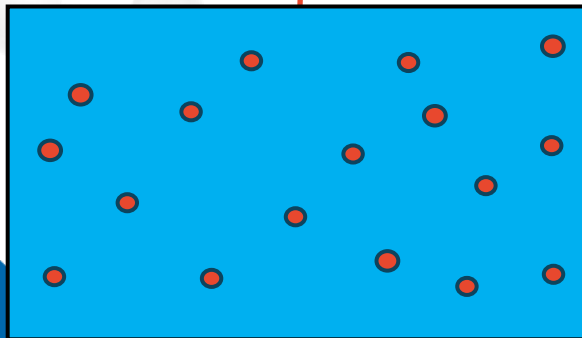
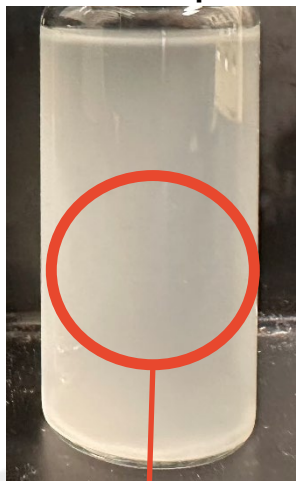
Mechanism Behind

R

EO

PO

PO-Capped Alcohol Alkoxylate at
elevated temperature



●: Insoluble portion of surfactant



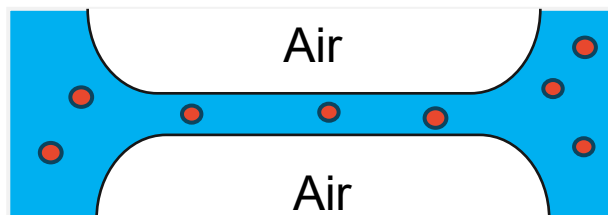
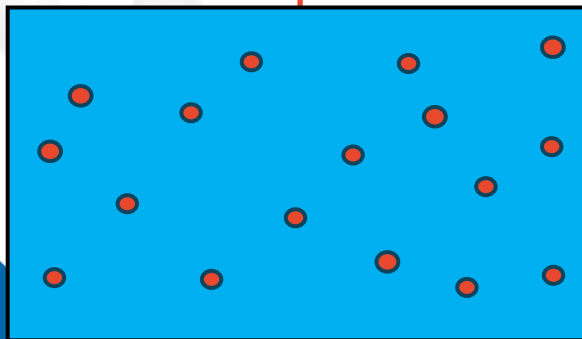
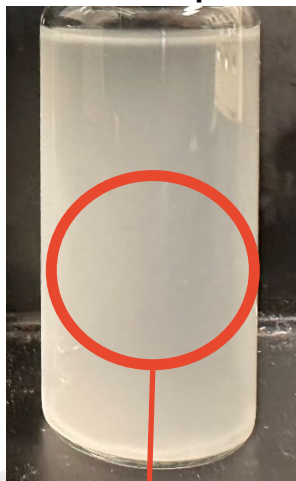
Mechanism Behind

R

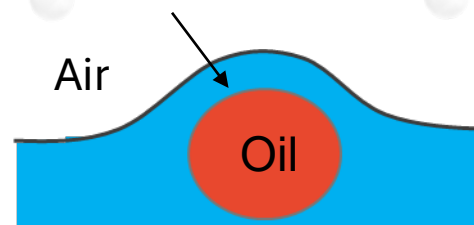
EO

PO

PO-Capped Alcohol Alkoxyate at elevated temperature



Pseudoemulsion film



●: Insoluble portion of surfactant



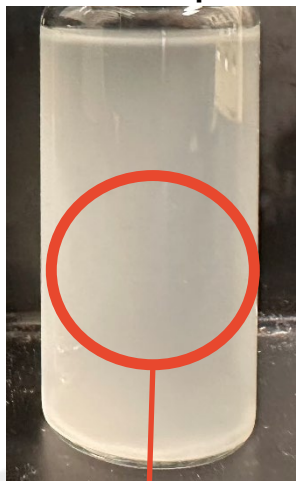
Mechanism Behind

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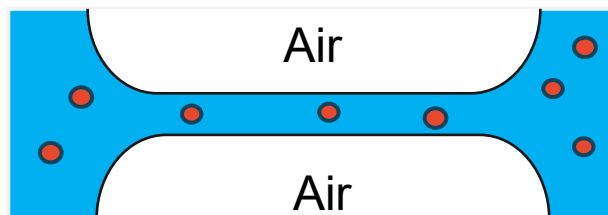
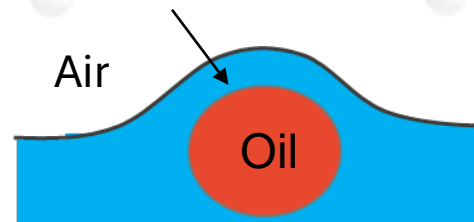
EO

PO

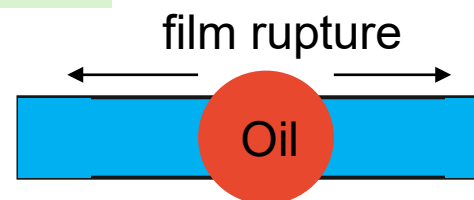
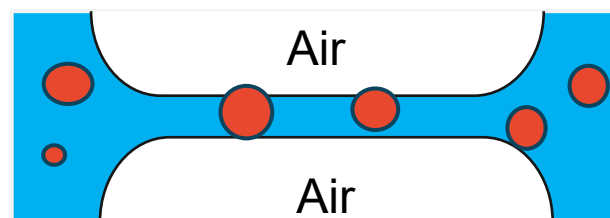
PO-Capped Alcohol Alkoxylate at elevated temperature



Pseudoemulsion film



"Mode of Defoaming"



●: Insoluble portion of surfactant



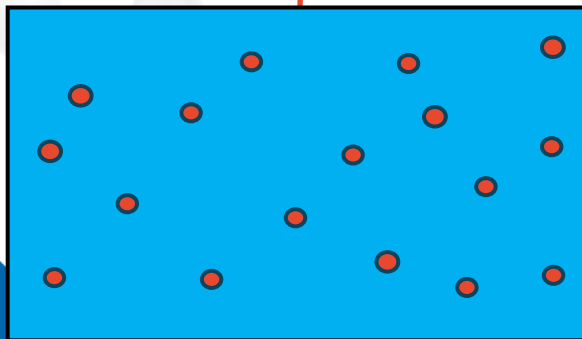
Mechanism Behind

R

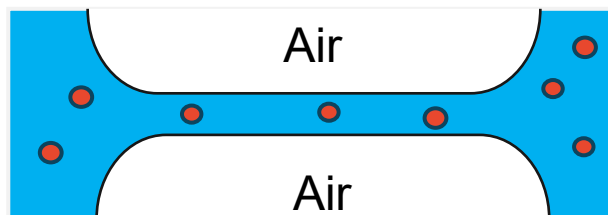
EO

PO

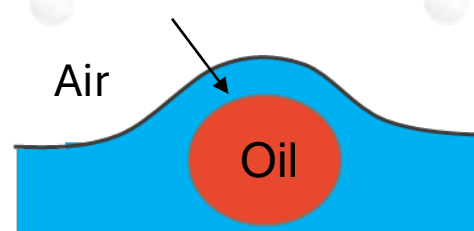
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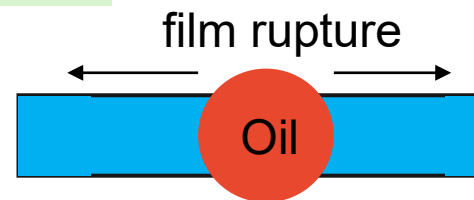
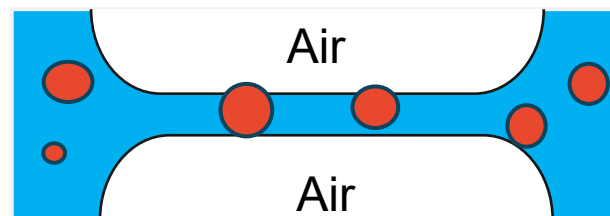
●: Insoluble portion of surfactant



Pseudoemulsion film



"Mode of Defoaming"



General Behavior - Stabilized



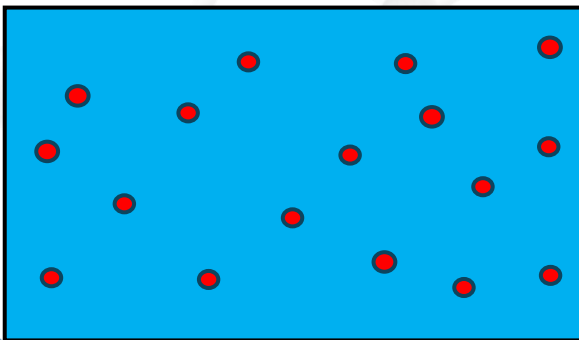
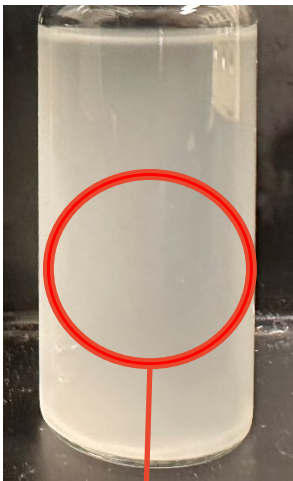
Novel Surfactant Behavior



Mechanistic Understanding: Kinetic Behavior



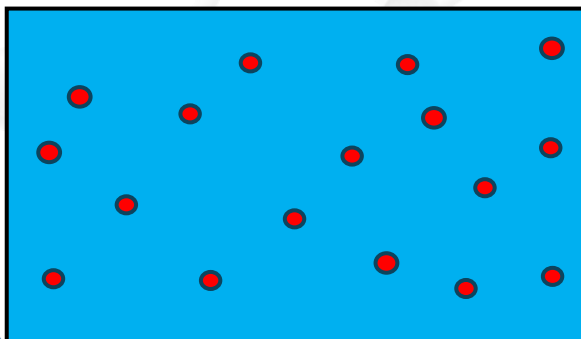
Mechanistic Understanding: Kinetic Behavior



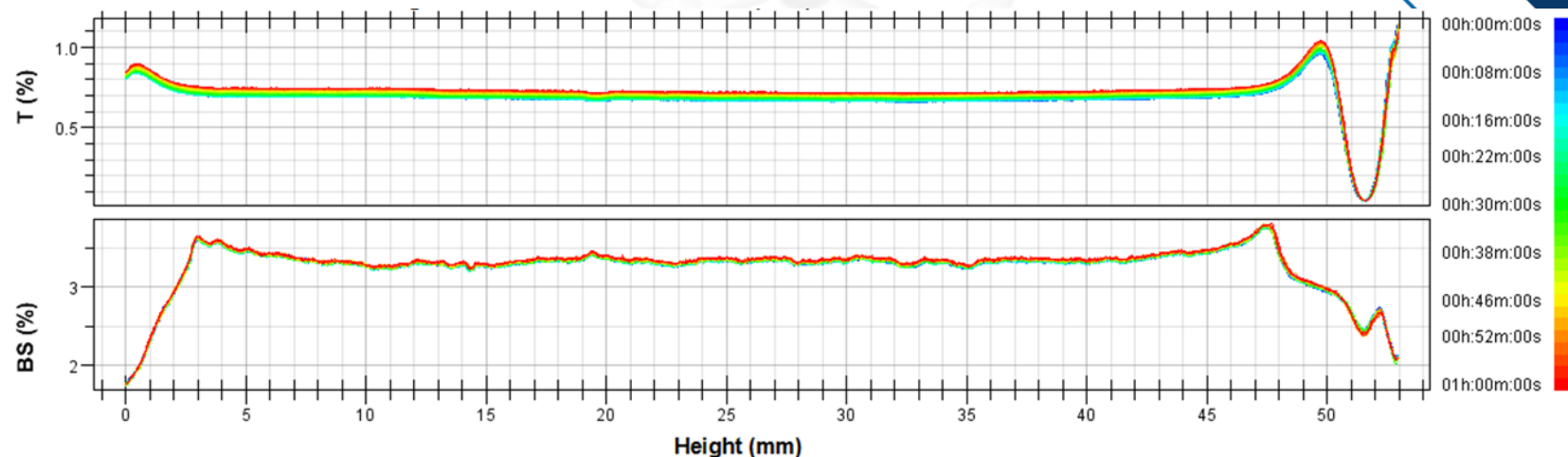
●: Insoluble portion of surfactant

Mechanistic Understanding: Kinetic Behavior

General Behavior - Stabilized

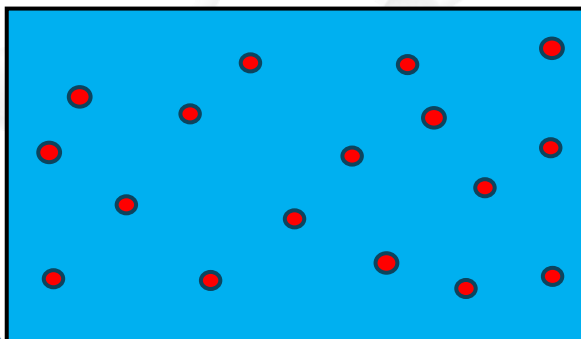


●: Insoluble portion of surfactant

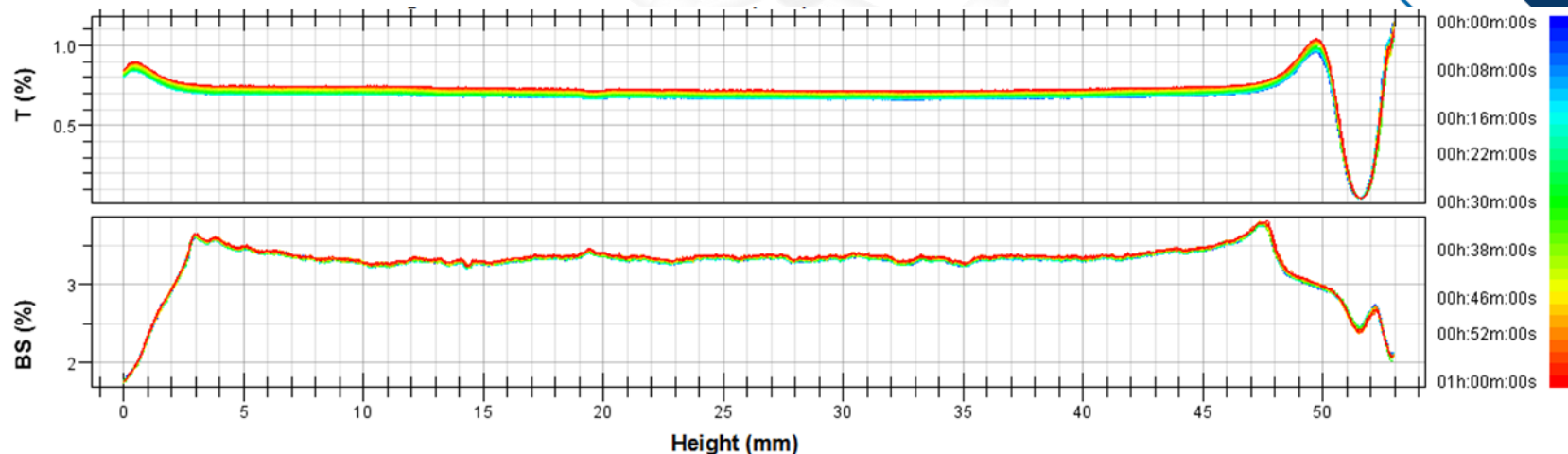


Mechanistic Understanding: Kinetic Behavior

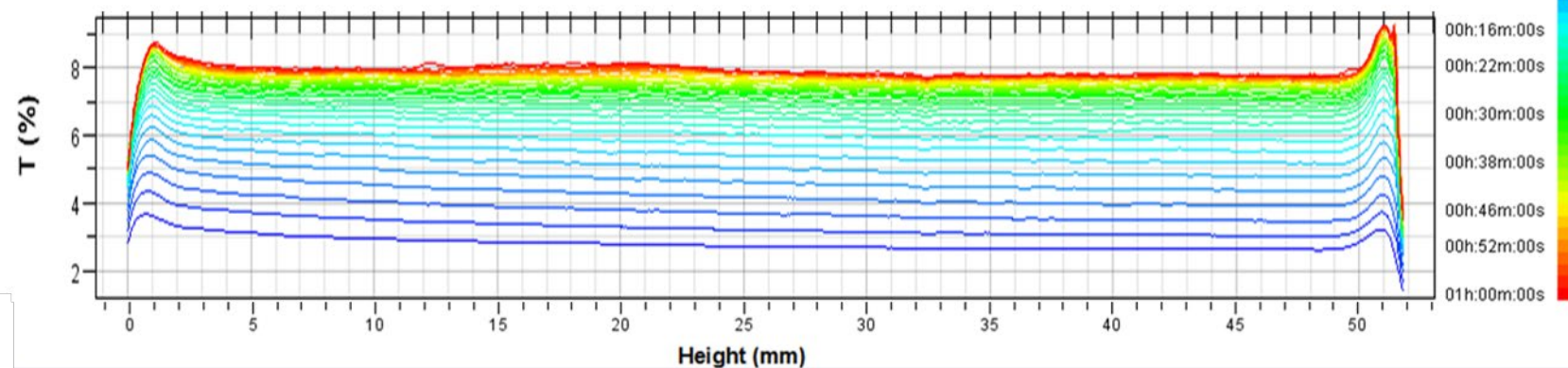
General Behavior - Stabilized



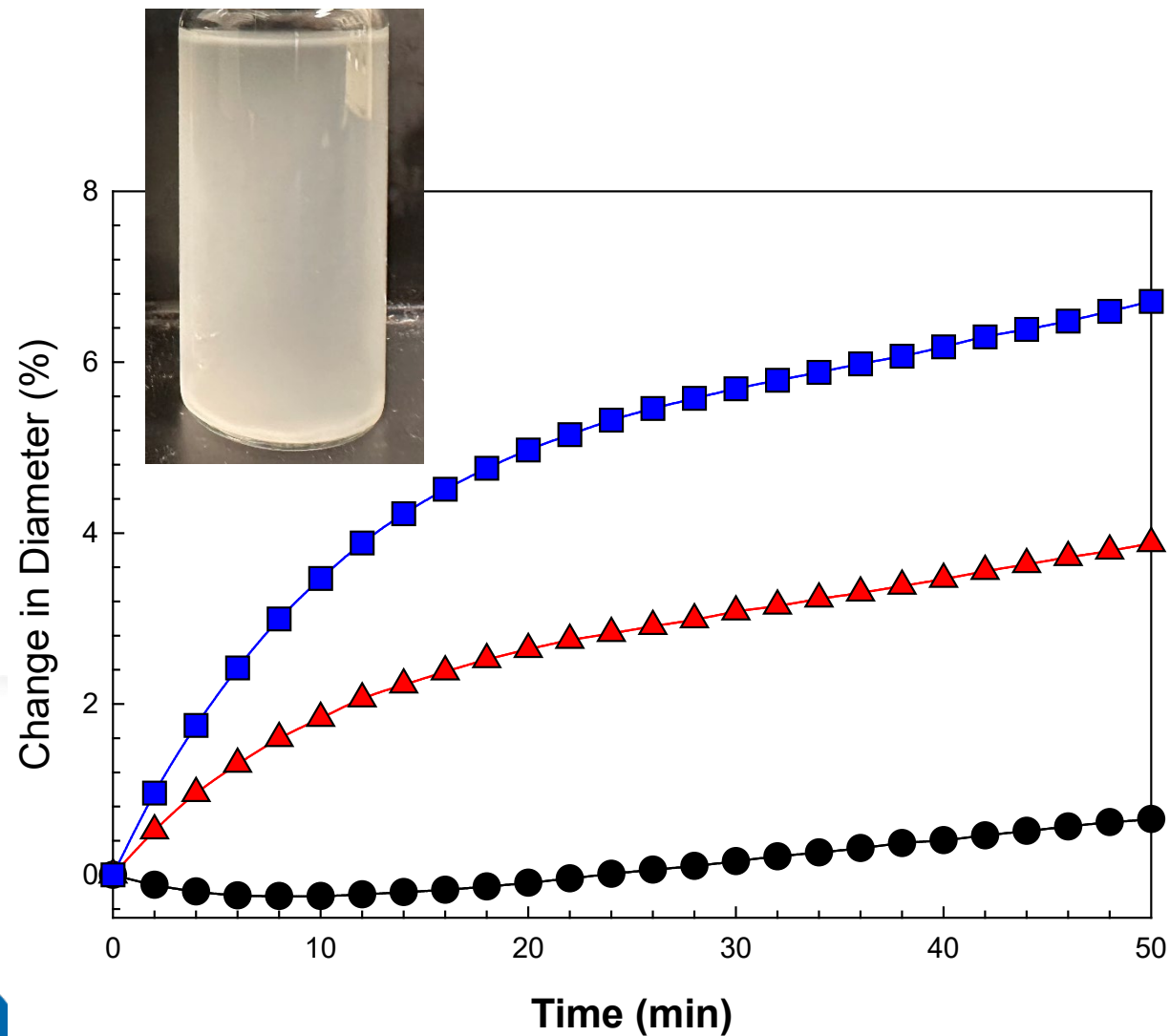
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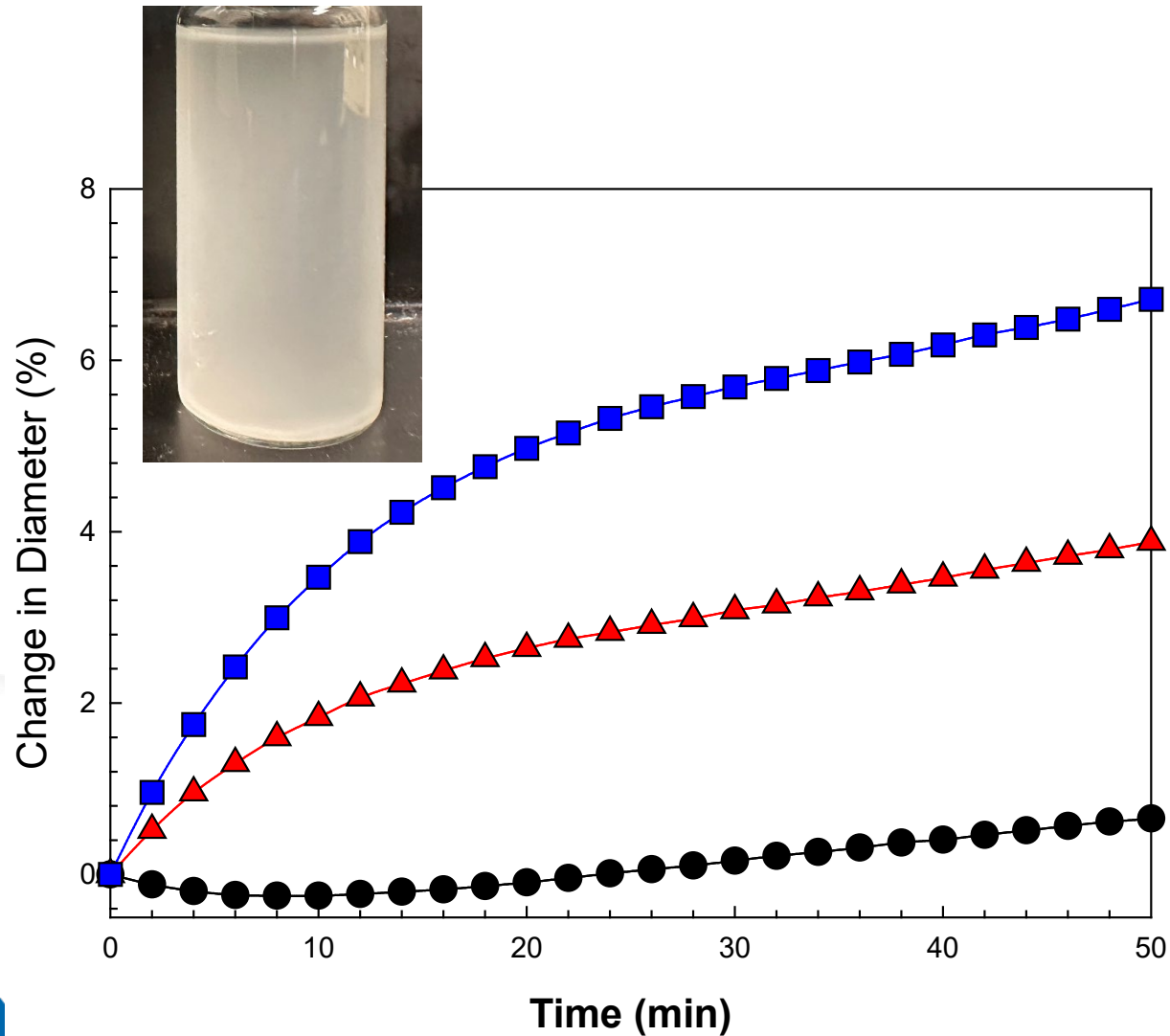
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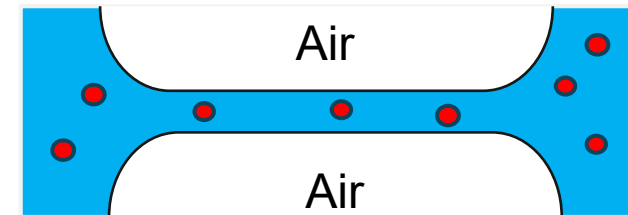
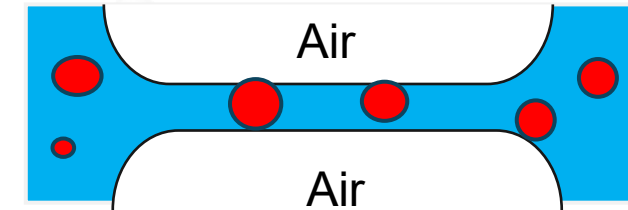
Mechanistic Understanding



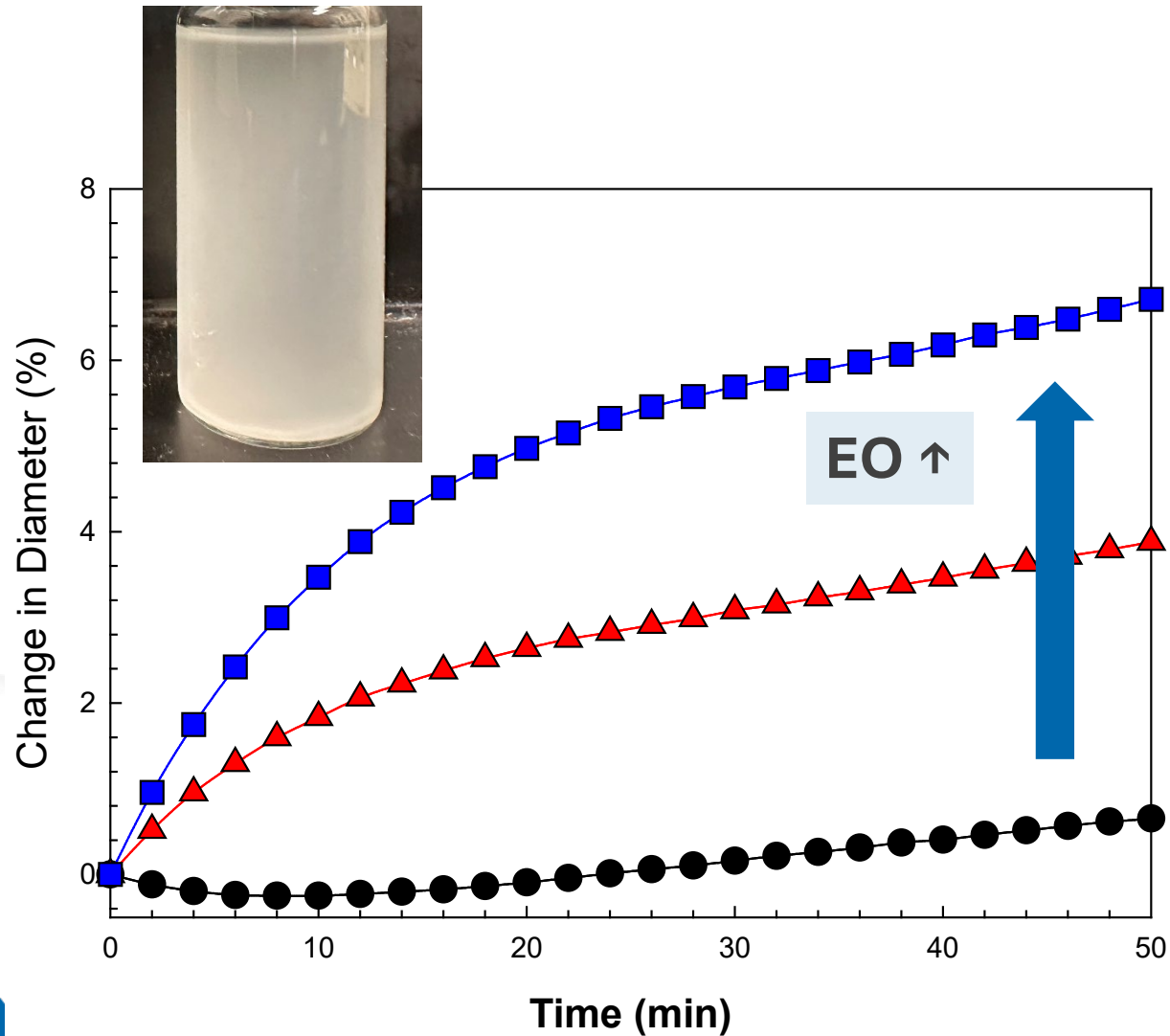
Mechanistic Understanding



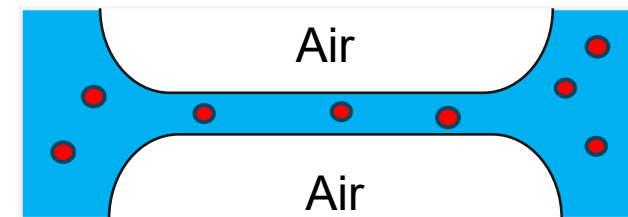
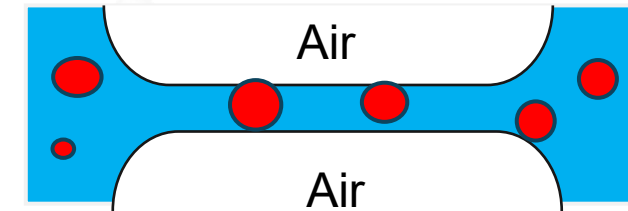
"Mode of Defoaming"



Mechanistic Understanding



"Mode of Defoaming"



Novel Low Foam Surfactant Technology

Solubility and Low Foaming

High HLB
ethoxylate

Low HLB
ethoxylate

Low Foam EO/PO
block copolymer

**New Low Foam
Surfactant Technology**



Novel Low Foam Surfactant Technology

Solubility and Low Foaming

High HLB
ethoxylate

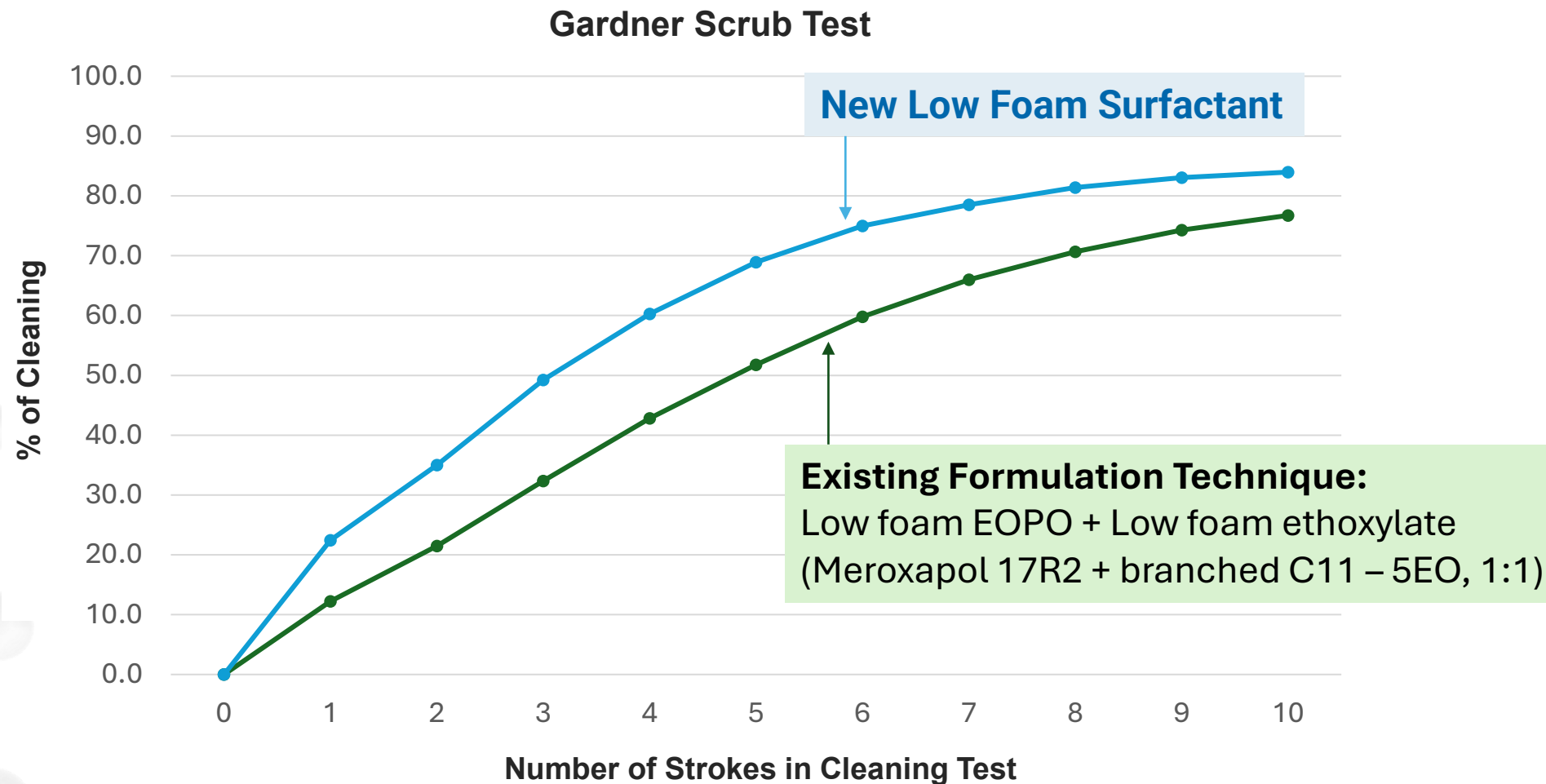
Low HLB
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**New Low Foam
Surfactant Technology**

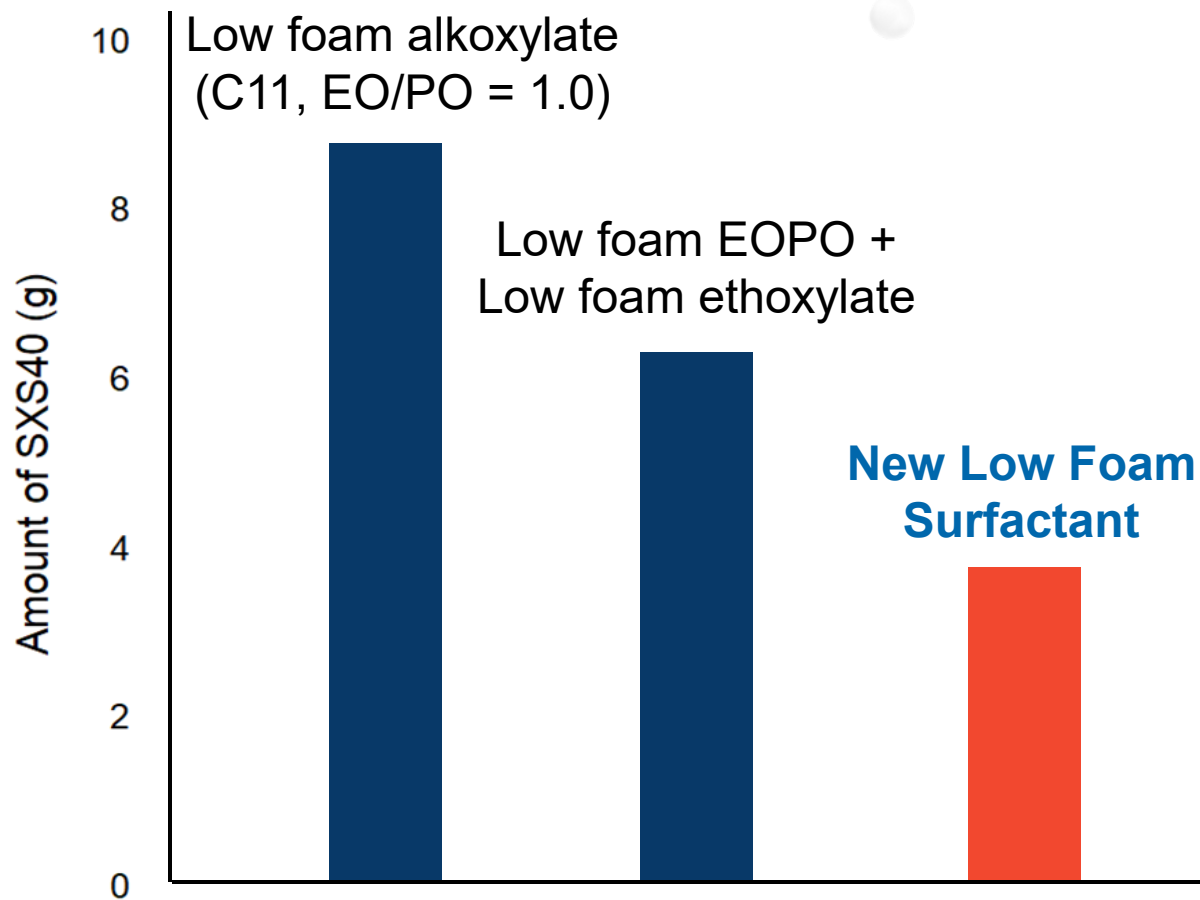


Cleaning Performance



Solubility in Concentrated Formulation

Required SXS-40 to solubilize 2% surfactant in 10% NaOH at ambient temperature, 100 g formulation



Choose the low-foam surfactant for the job

THE MAKON® NF PORTFOLIO

MAKON® NF-12

FAST-ACTION CLEANING WORKHORSE

BEST WHEN

Cleaning and rapid surface coverage are primary; operation is ambient to moderately warm; very low foam is required

WHY IT WINS

Rapid wetting + soil penetration; resists foam under prolonged agitation; completely non-foaming above 25°C.

BEST-FIT APPLICATIONS

spray / parts / metal cleaning • textile wetting

MAKON® NF-100

CONCENTRATE + AUTOMATION DIFFERENTIATOR

BEST WHEN

A highly concentrated, automatically dosed formulation needs more solubility while retaining good wetting and low foam across moderate - elevated temperatures

WHY IT WINS

100% active proprietary nonionic; designed as the portfolio bridge: increased solubility without giving up wetting or low-foam performance.

BEST-FIT APPLICATIONS

Concentrated industrial warewash • home dishwasher rinse aids • Automated process

MAKON® NF-180

FOAM SUPPRESSION + PERFORMANCE AID

BEST WHEN

Performance aid for persistent or soil-generated foam suppression, especially at elevated process temperature, and a compatible surfactant-based suppressor is preferred

WHY IT WINS

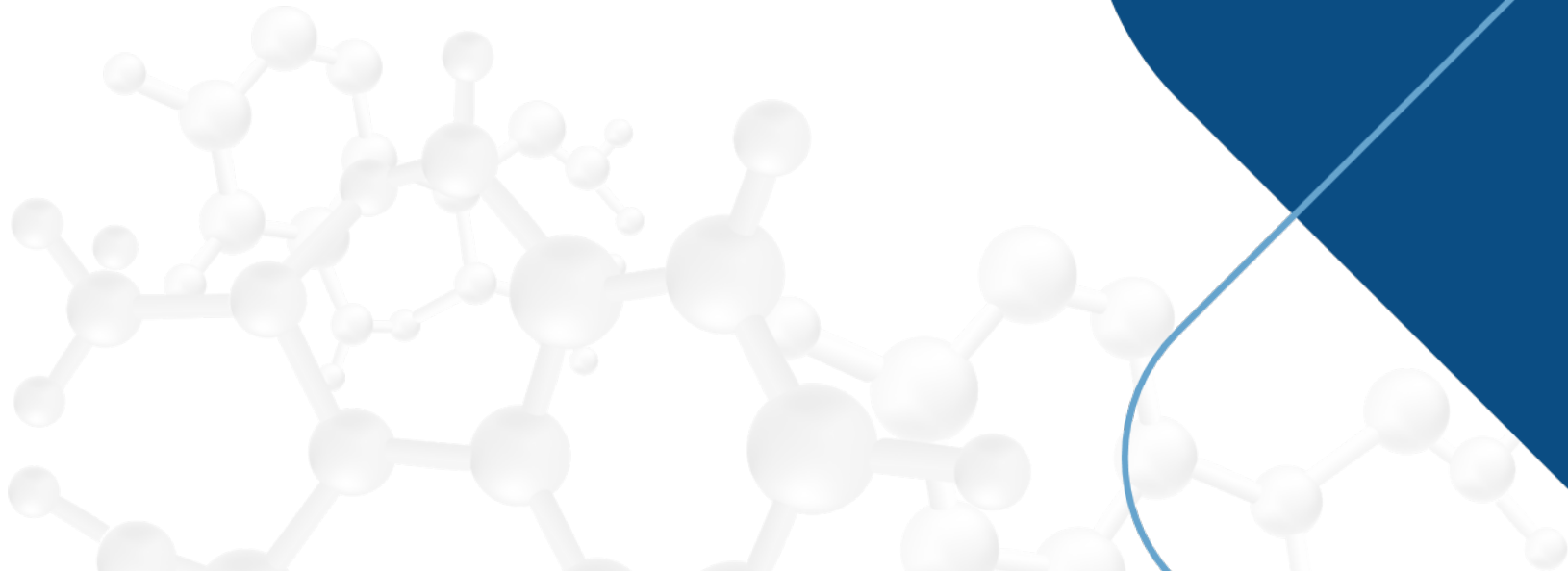
Low-to-no inherent foam plus strong foam-suppression behavior. Use as the foam-control component.

BEST-FIT APPLICATIONS

I&I • food processing • COP & CIP • kitchen hygiene • Closed-loop recirculating process

QUICK CHOICE Cleaning speed → MAKON NF-12 | Concentrate + automated process → MAKON NF-100 | Foam suppression → MAKON NF-180

New Low Foam Surfactant: Case Study



Case Study #1 – Metal Recycling Process

Situation

A customer in the sustainable goods market requested technical support to match the incumbent chemistry. Stepan tried to even improve the performance of **cleaning** and **surface wettability** alteration while maintaining **low foam** generation.

Objective

Deliver low foaming, high-performance metal recycling aid that provides superior value to incumbent chemistry.

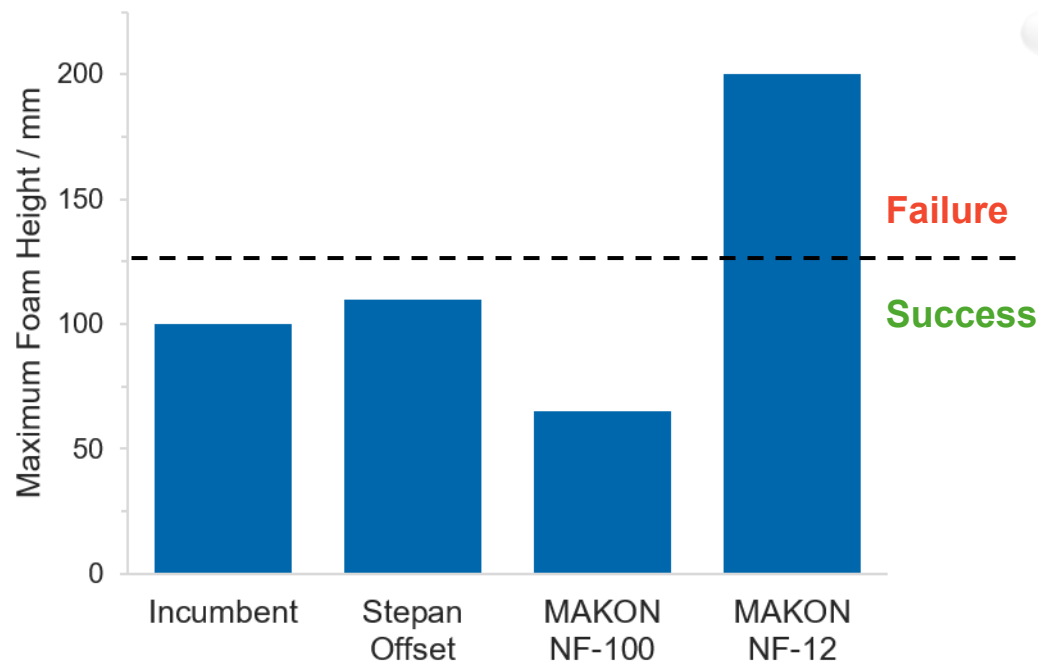


Case Study #1 – Metal Recycling Process

Concentrate formulation diluted to 0.1 wt % in acidic builder



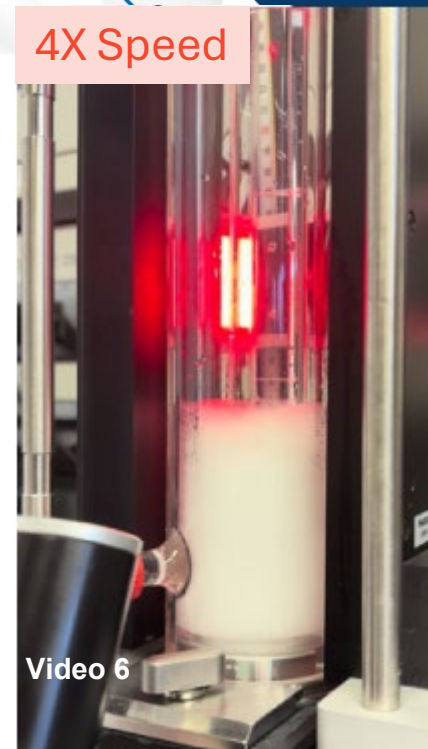
MAKON NF-100



Foaming at 60°C for 120 seconds



Video 5



Video 6

4X Speed



Case Study #1 – Metal Recycling Process

Procedure of Cleaning test

- Dilute concentrate formulation to 0.1 wt % in acidic builder
- Immerse metal coupons into cleaning solution at 40°C
- Sonicate 60 seconds
- Check wetting behavior with DI water rinse
- Surface brightness assessed via BYK glossmeter



30 sec

60 sec

120 sec



No wettability
change

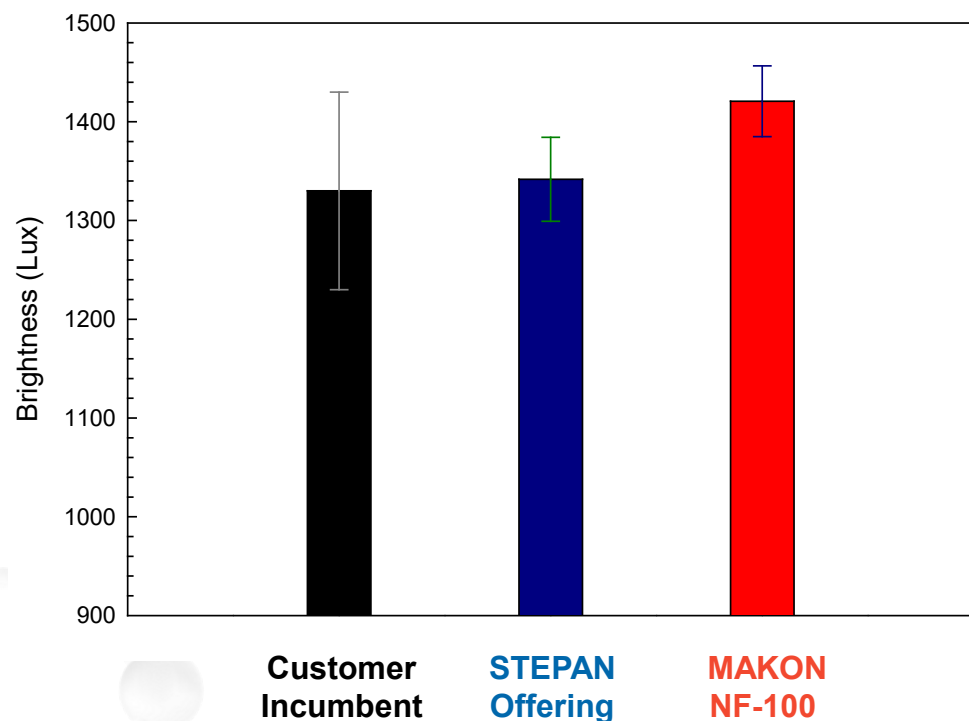


Sufficient
surface
modification
→ wettability
improves

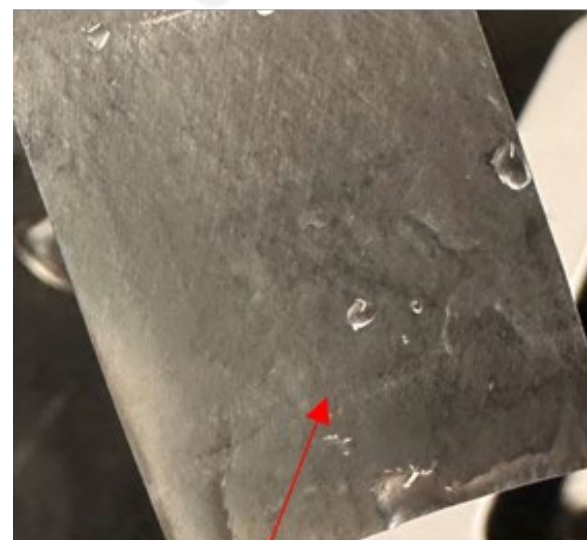


Case Study #1 – Metal Recycling Process

Cleaning Result: Surface Brightness



Functional Offset



Water film break

MAKON NF-100



Stable film formation



Case Study #2 – Industrial Warewash

Situation

Industrial warewash formulation required higher concentratability with optimized foaming and wetting behavior

Objective

Deliver more concentrated formulation that achieves higher performance than market incumbent



Case Study #2 – Industrial Warewash

Test Conditions: Concentrate is diluted 0.1 wt % in acidic build, 45-60°C

Pre-screening

- Immerse polypropylene coupon into solution for 60 seconds
- Record video when removing coupon
- Note wetting/de-wetting behavior

Application test / Countertop Dishwasher

- Pre-clean wares to ensure no residual soil present
- Weigh dry wares before test
- Run rapid cycle on countertop dishwasher
- Record video at low and high temperature cleaning
- Weigh wares after cycle has completed

BOM Industrial Rinse Aid

Ingredients	% by Weight	Functionality
Deionized Water	q.s. to 100.0	Diluent
Alkoxylate	11.3	Wetting Agent
Ethoxylate	3.7	Additive
STEPANATE® SXS	5.0	Hydrotrope
Food grade (+) Lactic Acid (88%)	4.5	Chelating Agent
Colorant	q.s.	Dye

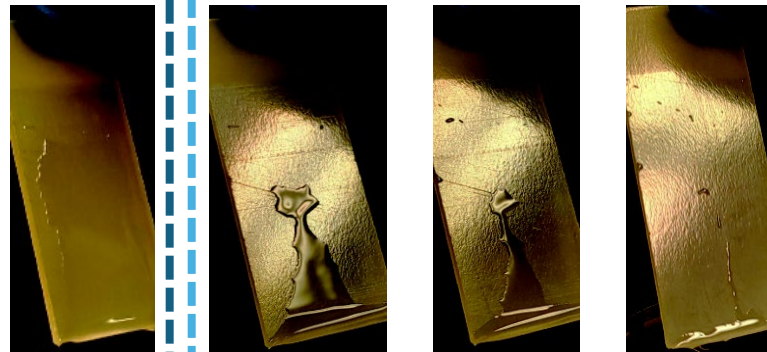


Case Study #2 – Industrial Warewash

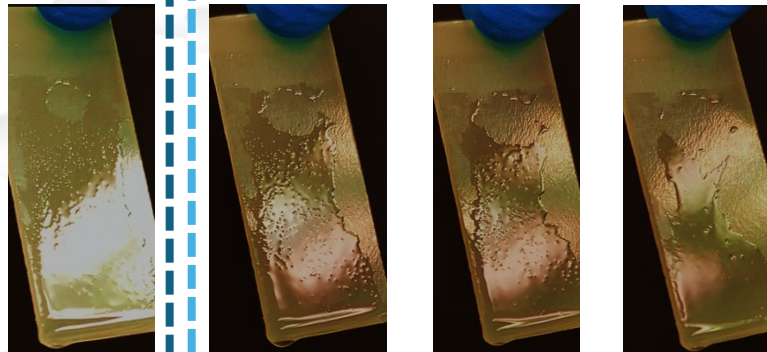
Pre-screen

Final Application Test

Formulation with
MAKON NF-100



Commercial
Product



Wetting and De-wetting at 60°C



Case Study #2 – Industrial Warewash

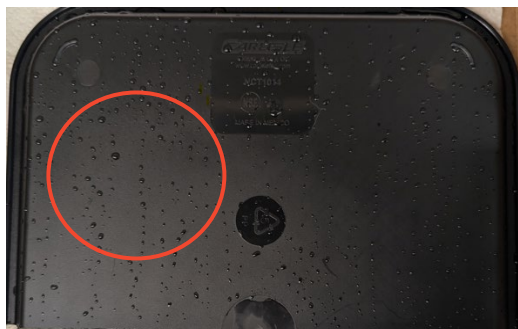


Good Performance

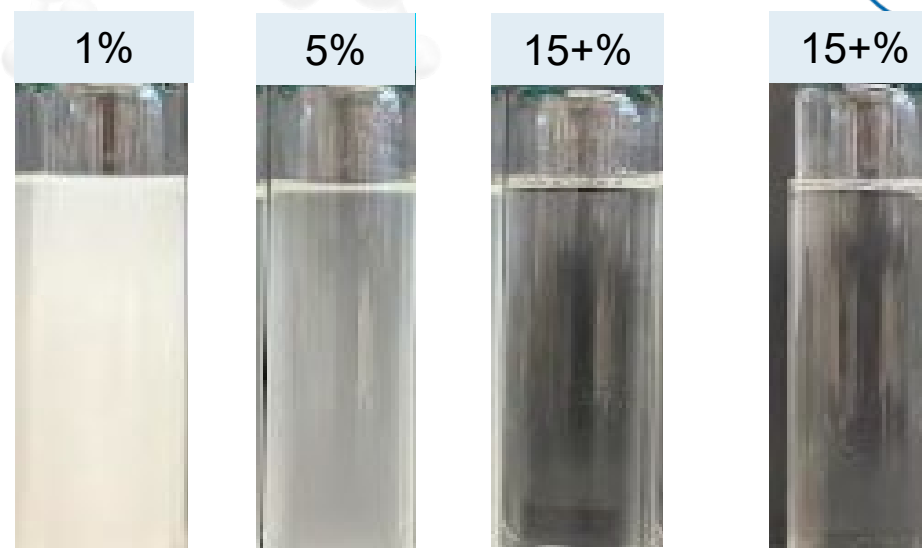
Droplet presence is minimal and dispersed over high surface area

Bad Performance

Large droplets that collect on surface, slower evaporation/less surface area



Increased Actives



MAKON NF-5, MAKON 25R2, MAKON NF-180 MAKON NF-100
MAKON NF-12 MAKON 17R2

Formulation without ethoxylate additive at ambient temperature



Case Study #2 – Industrial Warewash

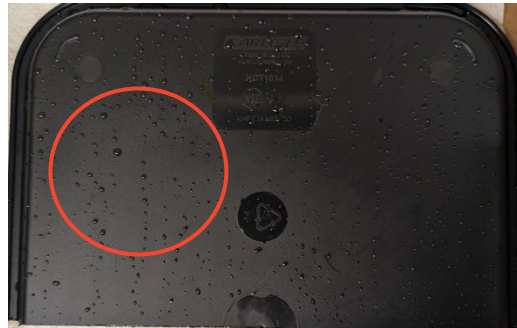


Good Performance

Droplet presence is minimal and dispersed over high surface area

Bad Performance

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Increased Actives →



MAKON NF-5,
MAKON NF-12



MAKON 25R2,
MAKON 17R2



MAKON NF-180



MAKON NF-100

MAKON NF-100 combines superior rinse aid performance with the flexibility to formulate at higher actives levels

Formulation without ethoxylate additive at ambient temperature



Poll Question



Other than these cases, where do you see (or want to see) the most value of MAKON NF-100 in your work?

Answer options:

1. Performance in food, beverage processing or dairy CIP/COP
2. Lubricants, metalworking related
3. Antifoamer Formulation, low foam emulsifier
4. Textile, paper, or coatings
5. I am exploring low-foam technology for a new application



Stepan Portfolio

Low Foam Surfactants

MAKON® NF-Series:

- MAKON NF-12
- MAKON NF-5
- MAKON NF-180
- MAKON NF-100

EO/PO Block Copolymers

Direct EO/PO:

- MAKON L-Series
- MAKON P-Series

Reverse EO/PO:

- MAKON 17R2
- MAKON 17R4
- MAKON 25R2

Low Foam Ethoxylates

Ethoxylated Alcohol:

- MAKON UD-Series
- MAKON TD-Series
- BIO-SOFT® DR-13



We're Here to Help!



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for Live Demonstrations or Formulation Troubleshooting**



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stepan.com**

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Alkoxylate Tech Video Series
Product Finder
Formulation Finder



**Engage with Our Technical Service
Team Online**

Submit an Inquiry
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Questions?



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