CLARIANT

Post Machining Cleaning – How to Pick the Right Surfactant For the Job

Houston STLE Section
October 2022

Stephanie Cole
Care Chemicals
Industrial Lubricants
14.10.2022

stle

what is precious to you?

Todays Takeaway

Challenge your surfactant manufacturers and formulators to design a surfactant that addresses the unique pain points of your customer

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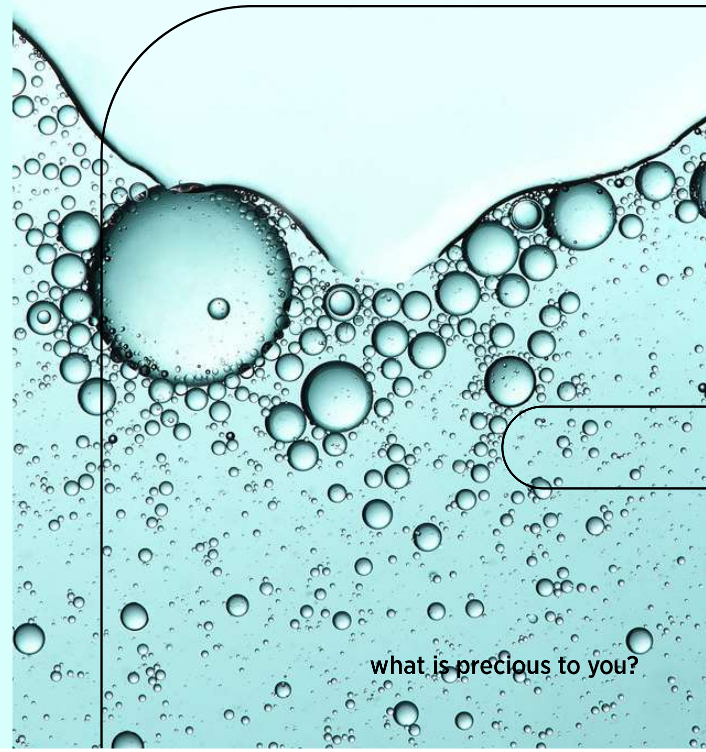

Agenda

- About Clariant
- Trends and market drivers
- Customizable nonionic surfactants
- Case Study
- Testing
- Overview of results

About Clariant

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Customizable nonionic surfactants

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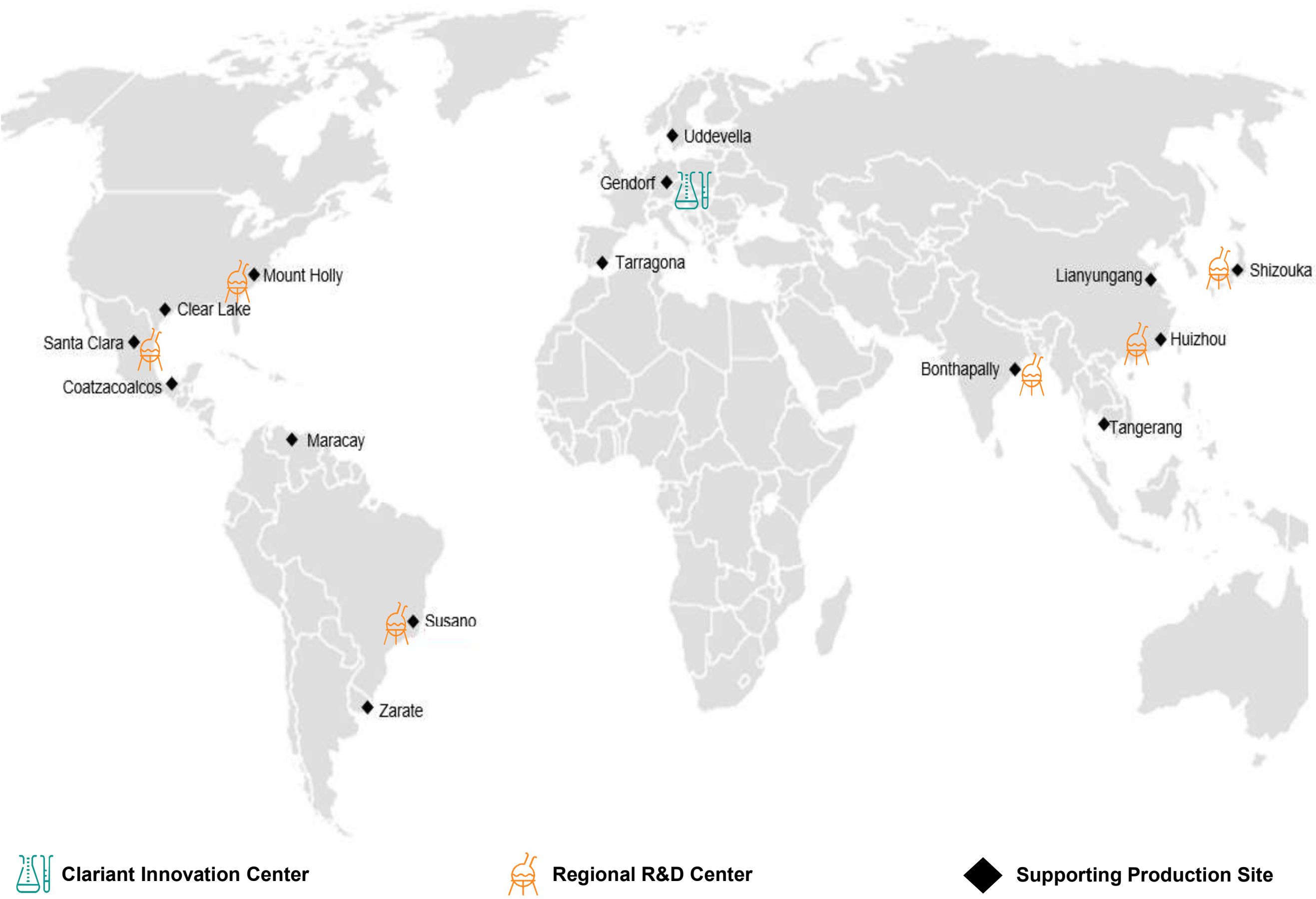


BUSINESS UNITS

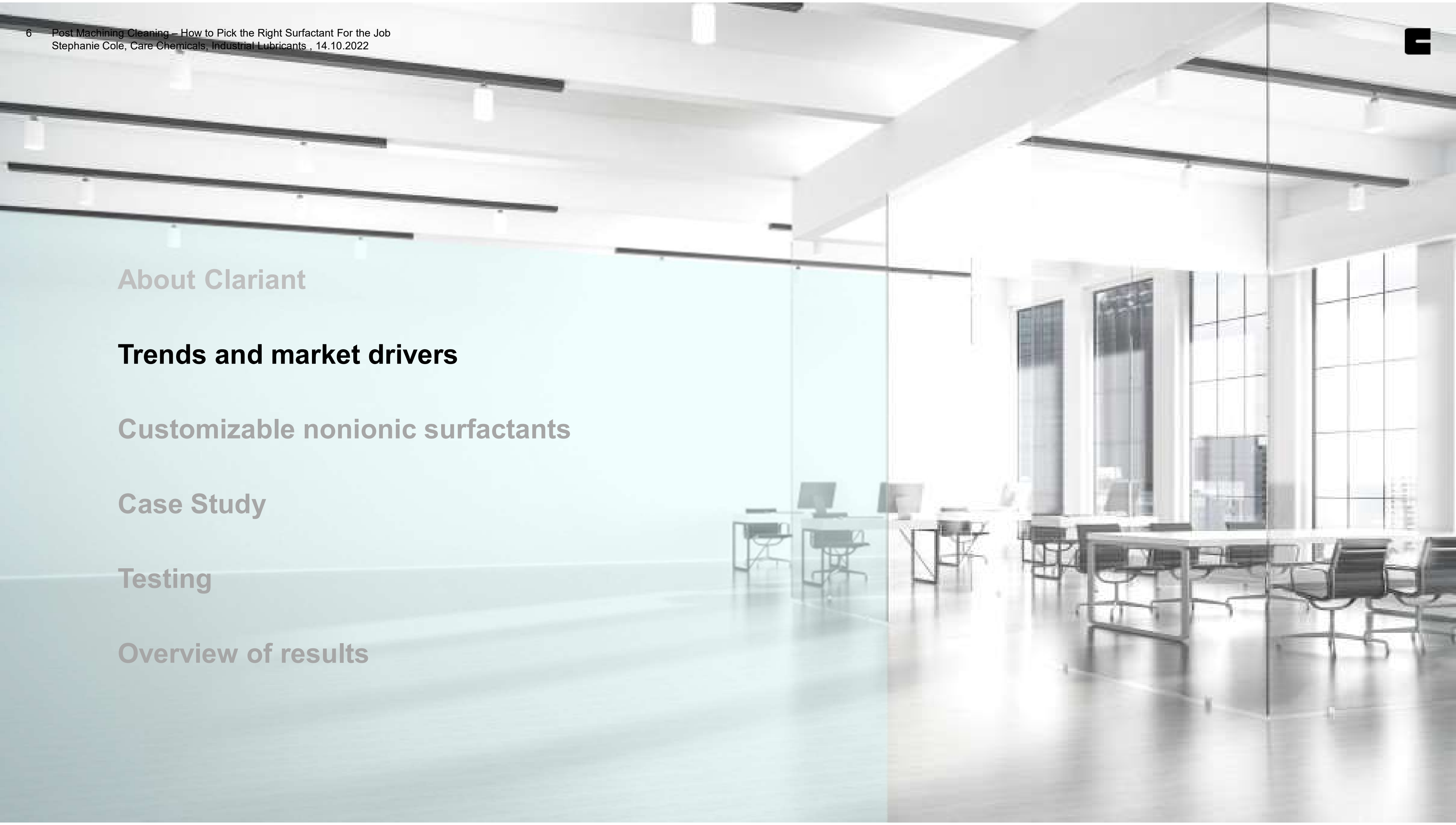
Care Chemicals	Catalysis	Natural Resources

BUSINESS SEGMENTS

Consumer Care	**Industrial Applications**	Base Products

BUSINESS LINES

Aviation	Construction	Crop Solutions
EO/PO Derivatives	**Industrial Lubricants**	Paints and Coatings



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Metal Cleaning Market

Cleaning metal and protecting it against rust or corrosion is important, regardless of if the surface is to be painted or left uncoated

Metal has a reputation for being difficult to clean and a burden to maintain, but many specialized products are emerging to make metal-care tasks easier and more effective

The metal cleaning market is currently experiencing unprecedented growth; largely due to the rise of precision parts which require more critical levels of clean within more complex geometries

The global metal cleaning chemicals market size by value is projected to reach

USD 16.5 billion by 2025

at a CAGR of 5.0%*

*Markets & Markets Metal Cleaning Chemical report

Variables to Consider

CLEANING PROCESS

· Soak · Ultrasonic · Immersion · Spray

POTENTIAL CONTAMINANTS

· Corrosion inhibitors / rust preventatives · Cutting oils · Metal working fluids

· Burnt hydrocarbons · Metal oxides · Dust / air contaminants · Human contamination

AQUEOUS CLEANER TYPE

· High alkaline · Mild alkaline · Neutral · Acidic

Types of Aqueous Cleaners & Applications

High Alkaline Cleaner	Mild Alkaline Cleaner	Neutral Cleaner	Acidic Cleaner	Rinse
pH >12	**pH 10-12**	**pH 6-8**	**pH <6**	**pH --**
Processes: Initial cleaning step Soak Spray Dip Immersion Ultrasonic	**Processes:** Initial cleaning step Soak Spray Dip Immersion Ultrasonic	**Processes:** Initial cleaning step Soak Spray Dip Immersion Ultrasonic	**Processes:** Preparation step Soak Post-cleaning step	**Processes:** Preparation step Soak Post-cleaning step
Contaminants: Waxes Oils Greases	**Contaminants:** Waxes Oils Greases	**Contaminants:** Surface-layer soils	**Contaminants:** Metal oxides	**Contaminants:** Removal of cleaner
Metal Type*: Ferrous	**Metal Type*:** Ferrous Nonferrous	**Metal Type*** Ferrous Nonferrous	**Metal Type*** Ferrous Nonferrous	**Metal Type*** Ferrous Nonferrous

*Formulation dependent

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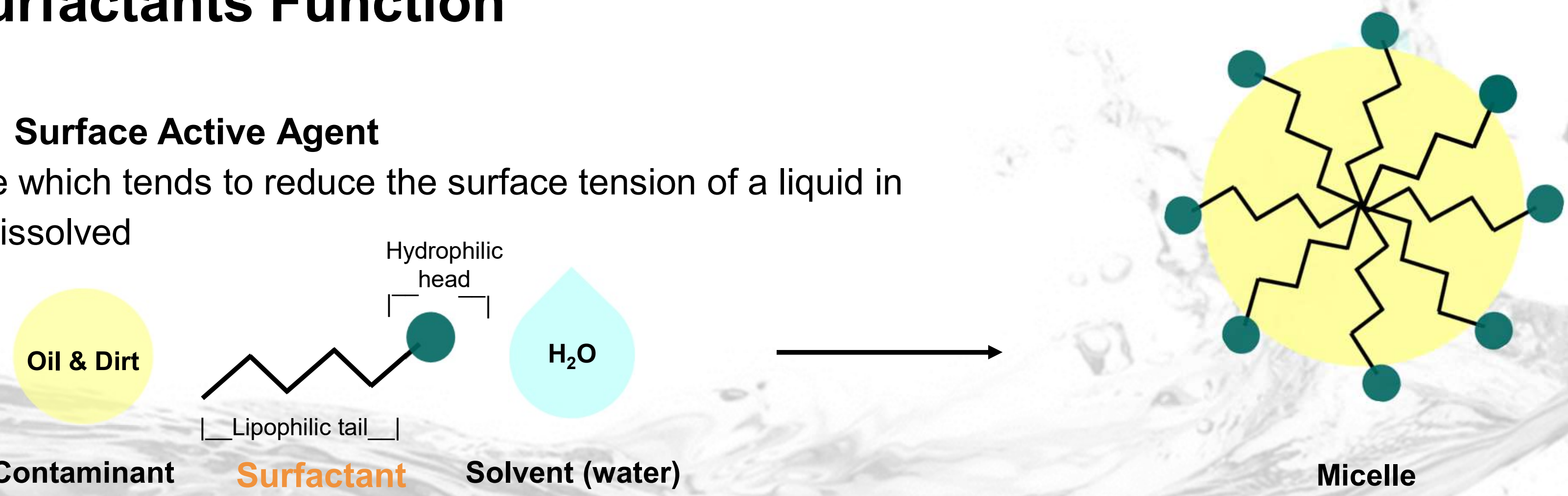
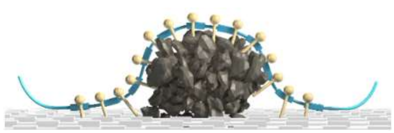
How Surfactants Function

Surfactant: Surface Active Agent
a substance which tends to reduce the surface tension of a liquid in which it is dissolved



1. Lipophilic tail reaches the soil

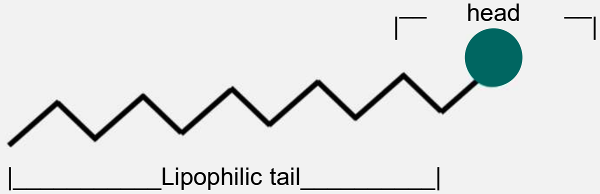


2. Soil starts separating from the metal surface

3. Soil detaches from surface inside a micelle

Surfactant types

Nonionic surfactant:



- Neutral charge
- Emulsification & wetting properties

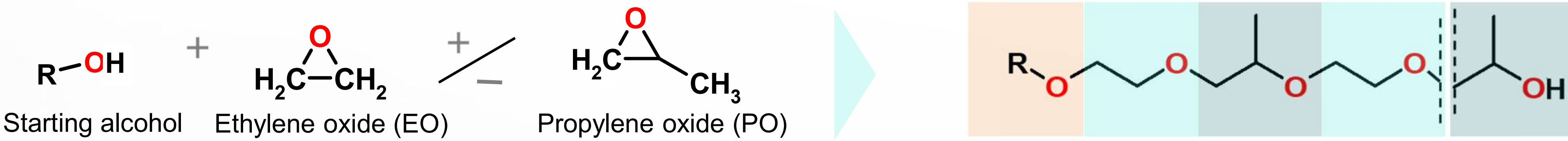
Anionic surfactant:

- Negative charge
- Lifts and suspends soils

Cationic surfactant:

- Positive charge
- Antistatic properties

Components of a Nonionic Surfactant & How They're Made



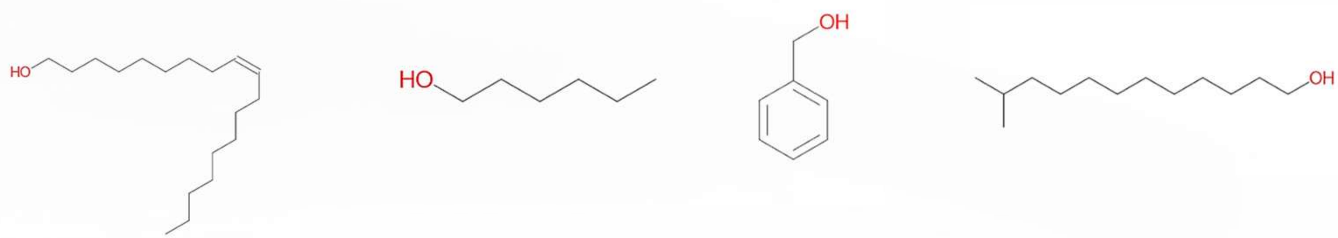
Final surfactant

Customizable Options:

ETHOXYLATION / ALKOXYLATION

STARTING ALCOHOL

CHAIN LENGTH



TERMINOLOGY

Alkoxylated alcohol = EO & PO added to an alcohol

Ethoxylated alcohol = only EO added to an alcohol

Propoxylated alcohol = only PO added to an alcohol

Surfactant Structure Evaluation

WATER SOLUBILITY

How easy a surfactant is going to be to formulate with

CLOUD POINT

The temperature at which a surfactant's cleaning performance will decrease

HLB

What contaminants your surfactant will be capable of removing & how it will remove them

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Case Study: Evaluate Surfactant Physical Characteristics

	Nonionic Surfactant A	Nonionic Surfactant B	Nonionic Surfactant C	Nonionic Surfactant D	Nonionic Surfactant E	Nonionic Surfactant F
Starting alcohol	Aromatic $<C_{10}$	Linear $<C_{10}$	Linear $>C_{10}$	Branched $>C_{10}$	Branched $>C_{10}$	Linear $>C_{10}$
EO	<5 mols	<5 mols	<5 mols	<5 mols	>5 mols	>5 mols
PO	0	0	0	0	0	<5 mols
Water Soluble (5% in DMW)	Yes	Yes	No	No	Yes	Yes
Cloud Point (1% in DMW)	>100˚C (>212˚F)	>100˚C (>212˚F)	70 - 72˚C* (158 -162˚F)	67 - 69˚C* (152 -156˚F)	73 - 75˚C (163-167˚F)	39 - 42˚C (102 - 108˚F)
HLB	12	14	11	11	14	13

*Cloud Point (5g in 25g, 25% BDG

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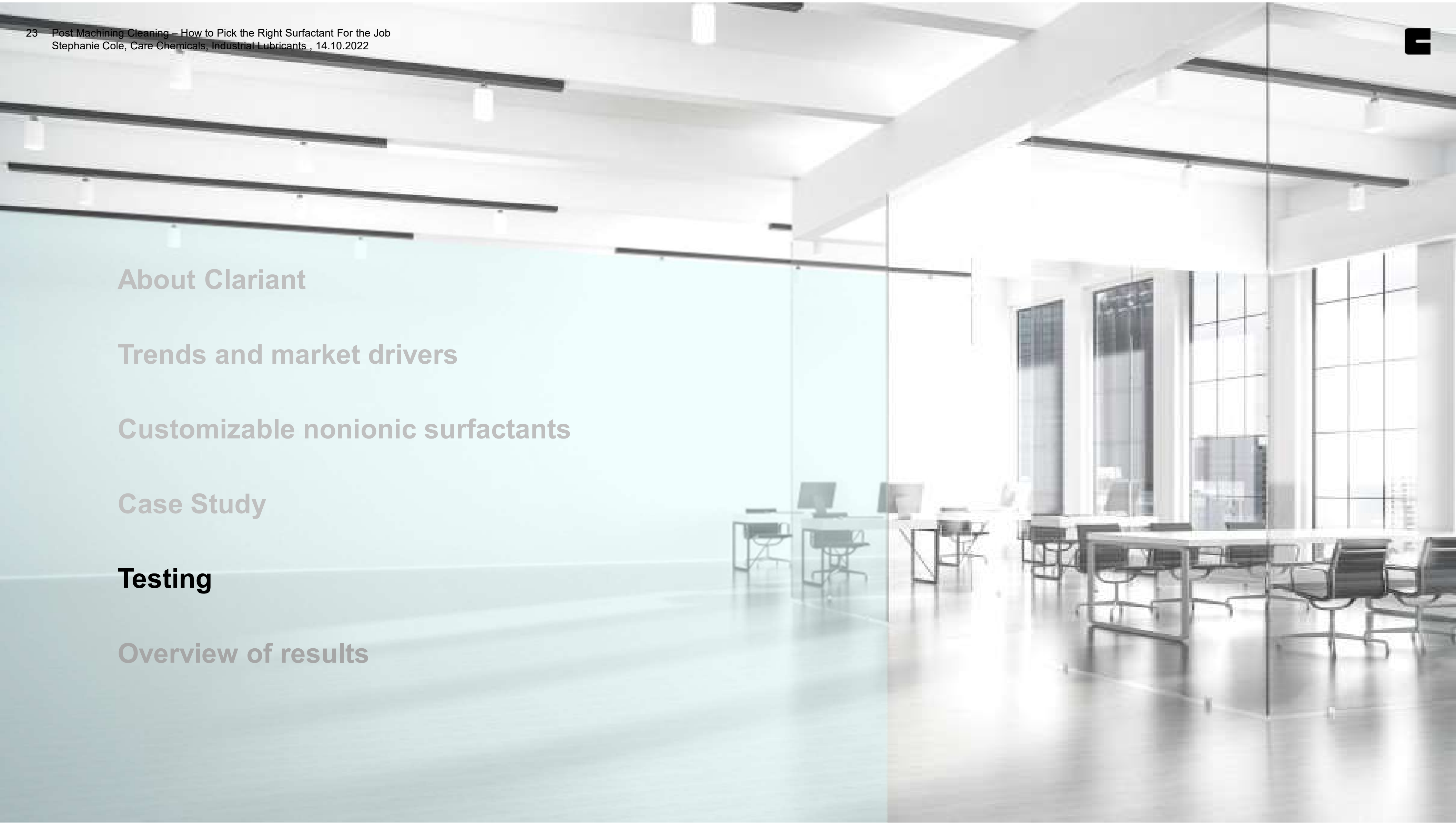

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Surfactant Performance Tests

DEGREASING

Proof of concept degreasing test to evaluate surfactant's rough degreasing / cleaning power

EMULSIFICATION / OIL REJECTION

Introduction of foreign oils to evaluate surfactant's emulsification or oil rejection properties

FOAMING

Agitation of a solution via apparatus to measure foam growth & decay rates

Validate Performance- Degreasing Procedure Evaluation of a Surfactant's Cleansing Power

Equipment
304 SS 1"x3"x.032" coupon
Stir bar
Stir plate – take note of RPM
150 mL beaker

Soil Formulation	
25-35%	Water displacing commodity chemical
25-35%	Anti-wear hydraulic oil (ex: AW 32)
25-35%	Cutting, grinding fluid that is oil based (ex: honing oil)
1-4%	Carbon black
1-4%	Iron oxide

	Cleaner Formulation	
Control	70-80%	Water
Control	1-10%	Alkaline component (ex: NaOH or KOH)
Control	2-10%	Coupling agent (ex: glycol)
	2-10%	Surfactant

	Test Procedure *To be performed in duplicate
Coupon prep	Clean two coupons with IPA and weigh individually, once dry
Coupon prep	Apply three coats of soil to each coupon, ensuring each is covered completely with an even layer of soil
Coupon prep	Bake coupons at 40˚C (105˚F) for 30 minutes
Coupon prep	Allow coupons to cool to RT and weigh each to determine amount of soil applied
Cleaner prep	Dilute cleaner formulation and control to 5% with tap water
Cleaner prep	Transfer 115 g of each solution to individual 150 mL beakers with stir rods
Cleaner prep	Allow cleaner and control solutions to mix gently without vortex formation
Cleaning & evaluation	Gently place coupons in respective solutions, ensuring not to disturb stir bar
Cleaning & evaluation	Allow coupons to soak for 30 minutes as the solutions gently pass over coupon
Cleaning & evaluation	Remove coupons from respective beakers and quickly dunk in clean tap water 3X
Cleaning & evaluation	Allow coupons to dry for 30 minutes in 105˚C oven
Cleaning & evaluation	Allow coupons to cool to RT and weigh each coupon for final masses to determine the respective percentages of soil removed

Validate Performance- Degreasing Results
Evaluation of a Surfactant's Cleansing Power

Photo 1: degreasing test of one surfactant in process, in foreground, and another surfactant starting in background

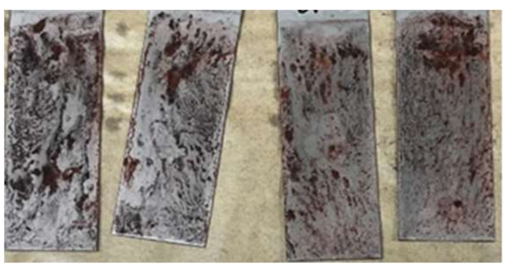
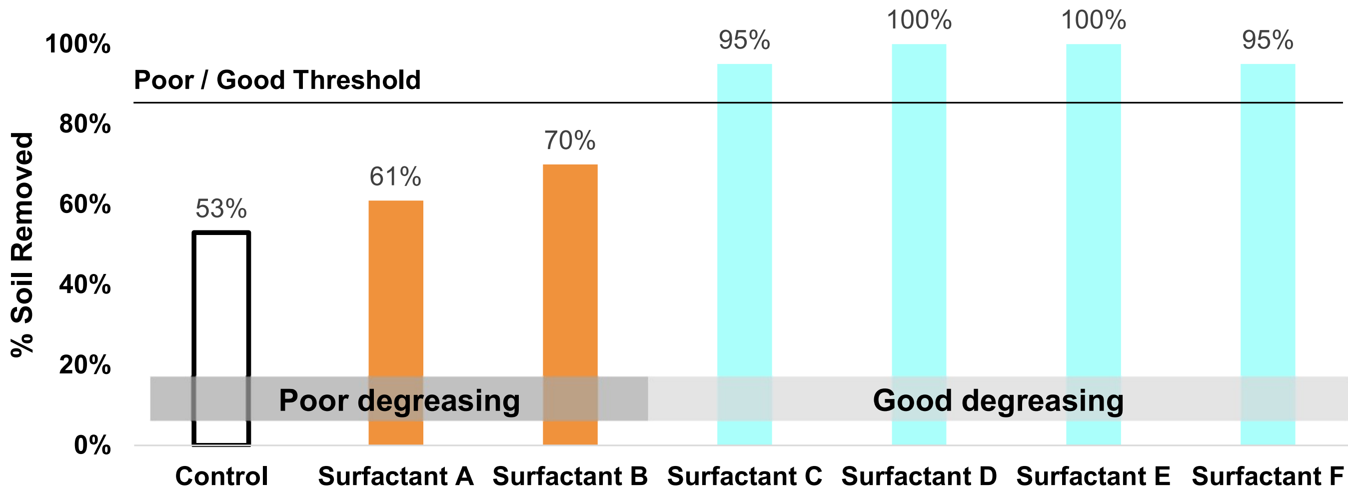


Photo 2: degreasing test completed for two surfactants and their respective coupons after simulated rinsing



Starting Alcohol	Aromatic	Short chain linear	Longer chain linear	Branched	Branched	Linear
Addition		< 5 mol EO	< 5 mol EO	<5 mol EO	>5 mol EO	EO/PO

CLEANING IMPLICATIONS:

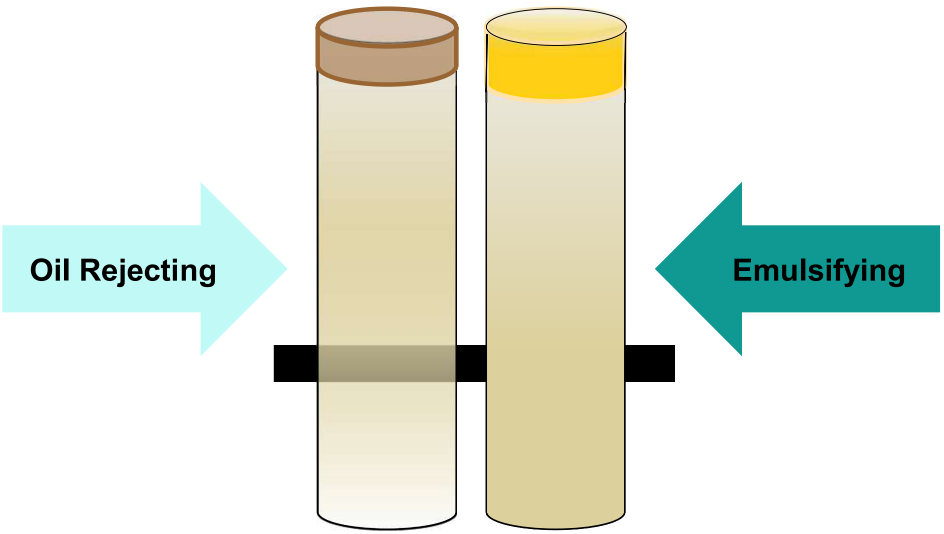
- Long chain, linear and branched surfactants (C,D,E & F) out-performed short chain, linear and aromatic surfactants (A & B)
- Branched alcohols (D & E) slightly outperformed linear equivalents (C & F)

Validate Performance- Emulsification/Oil Rejection Procedure
How a Surfactant will Handle Introduction of a Foreign Oil

Experiment Steps/Considerations
Prepare a 1% surfactant + DI water solution
Fill a 100 mL graduated cylinder with 97 mL of surfactant solution
Add 3 mL of honing oil
Invert closed graduated cylinder 10X
Allow solution to rest
Begin recording visual observations of oil-cleaner solution interaction 1. Initial observation 2. 15 min 3. 30 min 4. 1 hour (final reading)

General observation rules:

- If the solution below the interface is clear, surfactant has poor emulsification properties but good oil rejection properties
- If the layer below the interface is slightly hazy, surfactant moderate emulsification properties
- If the layer below the interface is opaque, surfactant has excellent emulsification properties



Ideal for systems with skimmers in place for removing oil contaminants so a cleaner can be recycled

Ideal for systems in which a part is being submerged, like dip immersion and ultrasonic cleaning systems

Validate Performance- Emulsification / Oil Rejection Procedure
How a Surfactant will Handle Introduction of a Foreign Oil

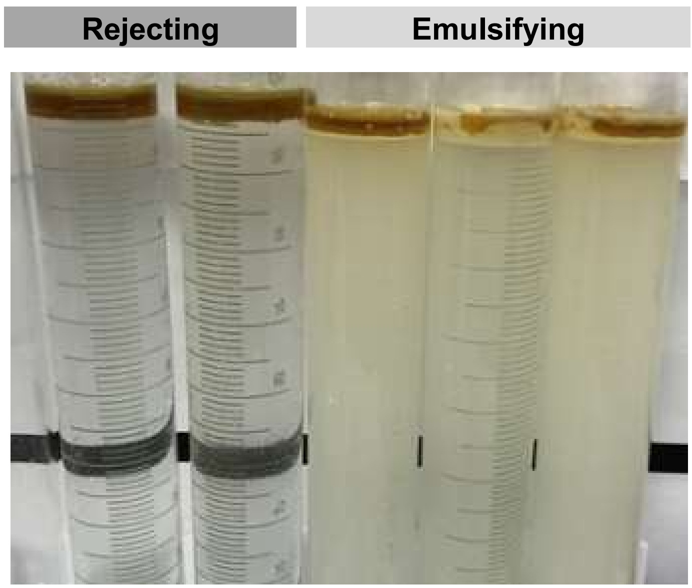


Photo 1: Emulsification / oil rejection test results for five surfactants. The two surfactants on the left show strong oil rejecting properties; the three surfactants on the right show strong emulsification properties.

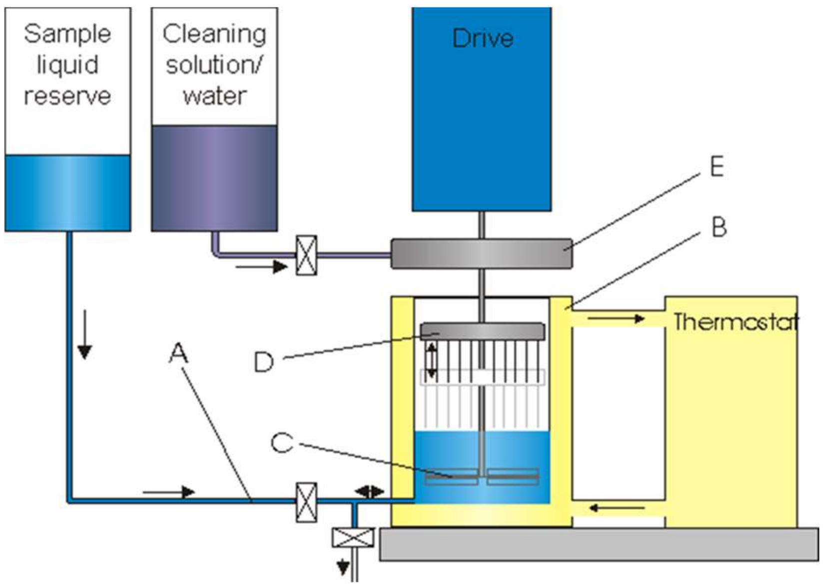
		Results:
Surfactant A	Aromatic, short chain, low EO	Rejecting
Surfactant B	Linear, short chain, low EO	Rejecting
Surfactant C	Linear, long chain, low EO	Emulsifying
Surfactant D	Branched, long chain, low EO	Rejecting
Surfactant E	Branched, long chain, high EO	Emulsifying
Surfactant F	Linear, long chain, high EO, low PO	Emulsifying

CLEANING IMPLICATIONS:

- Long chain, linear surfactants, like C, are better at emulsifying oil than short chain, linear and aromatic surfactants (A & B)
- Higher amounts of EO seem to improve emulsification properties (D vs. E)

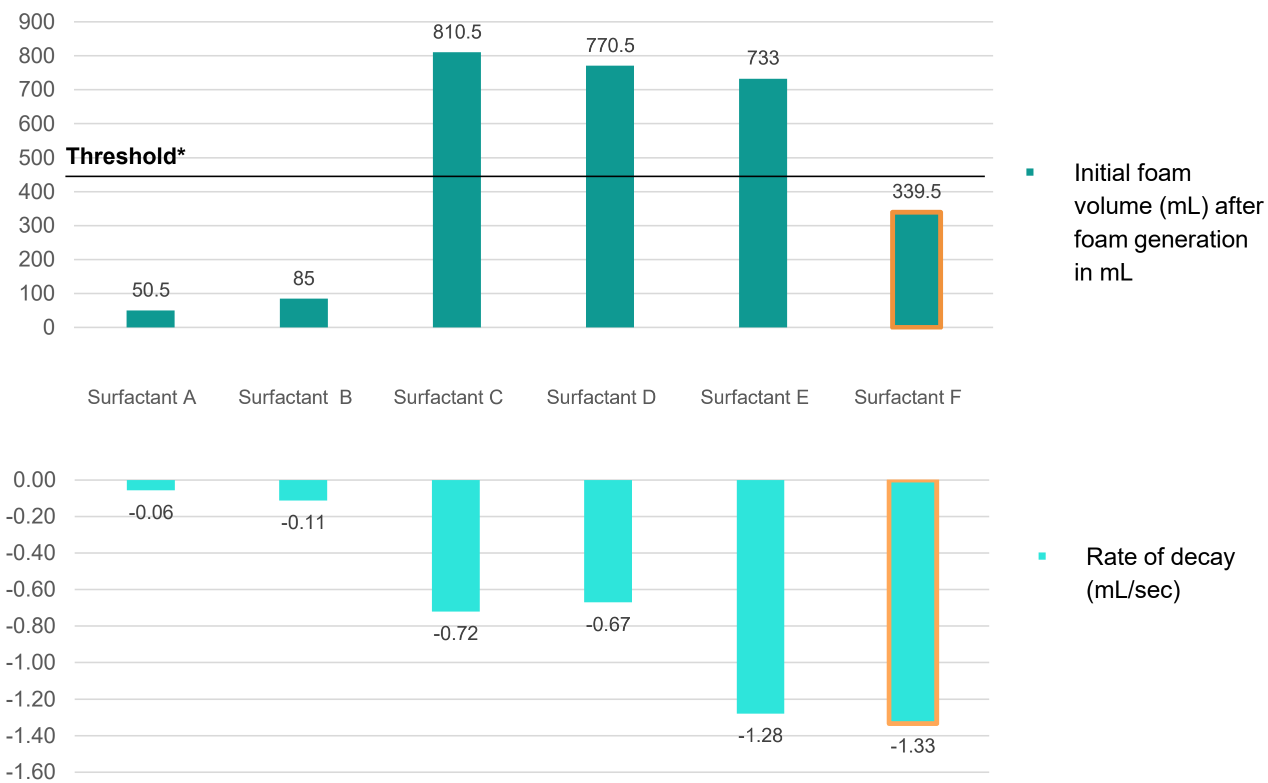
Validate Performance- Foam Build & Decay Procedure
A Surfactant’s Suitability for Spray Processes

Testing Parameters	
Temperature	20 °C
Fill Volume	250 mL
Rotor Speed	1200 rpm
Surfactant Concentration	0.1 %
Foam Generation	
Stirring Interval	10 s
Number of Stirring Intervals	30 x
Foam Decay	
Measuring	30 s
Total Time	10 min



SITA Foam Analyzer: R-2000

Validate Performance- Foam Build & Decay Results
A Surfactant's Suitability for Spray Processes



Results:

Surfactant A	Low
Surfactant B	Low
Surfactant C	High
Surfactant D	High
Surfactant E	High
Surfactant F	Low

CLEANING IMPLICATIONS:

- Long chain, linear & branched surfactants generate more foam
- Increasing EO slows build and increases decay
- PO significantly suppresses foam generation

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Overview

	Starting Alcohol			Addition of Alkoxylates	
	Aromatics	**Branched**	**Long Chain**	**Ethoxylation (EO)**	**Propoxylation (PO)**
Cleaning Implications	**Solvent-type properties**	Disperses contaminants the in solution Improved wetting & rinsing	Works well with mechanical action May require higher amounts of a coupler	Improves emulsification properties Increases operating temperatures Disperses contaminants the in solution	Lowers foam generation

	Application
Degreasing	Long-chain, linear, and branched surfactants are the best performers at degreasing
Foaming	Long-chain, linear & branched surfactants generate more foam PO significantly suppresses foam generation Aromatics as starting alcohols lead to lower foaming surfactants
Emulsification	Long chain, linear surfactants are better at emulsifying oil than short chain, linear and aromatic surfactants Higher amounts of EO improves emulsification properties

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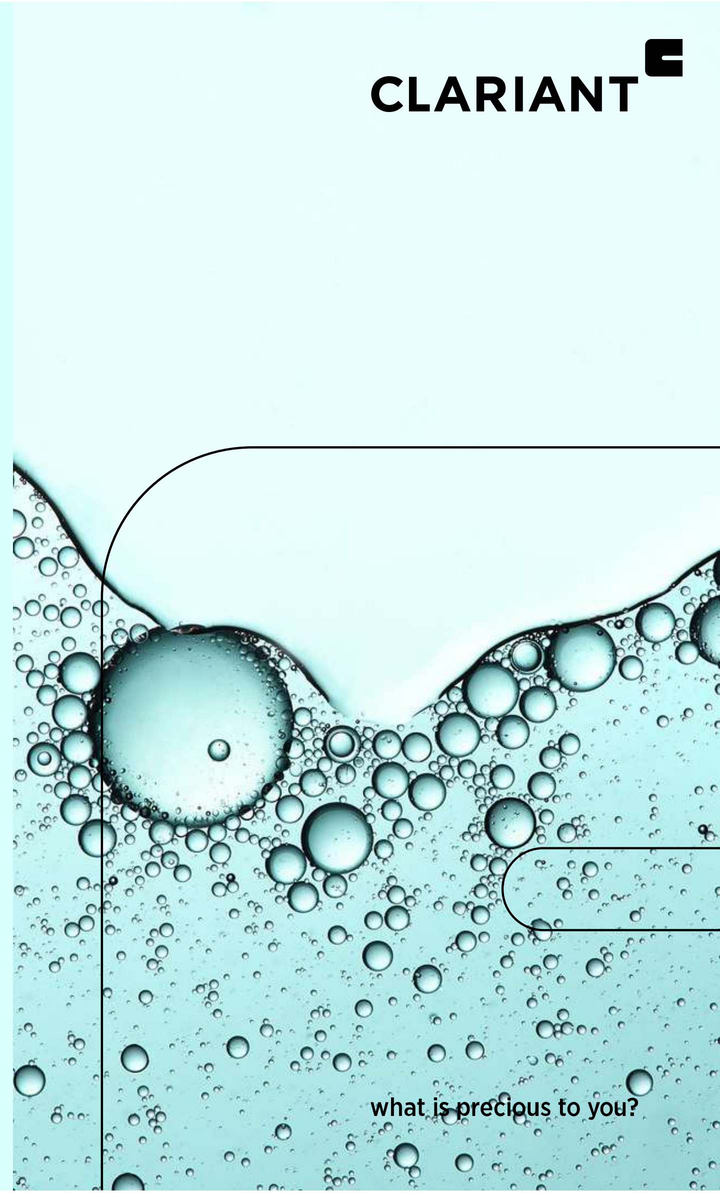
Post Machining Cleaning – How to Pick the Right Surfactant For the Job

Challenge your surfactant manufacturers and formulators to design a surfactant that addresses the unique pain points of your customer



CLARIANT

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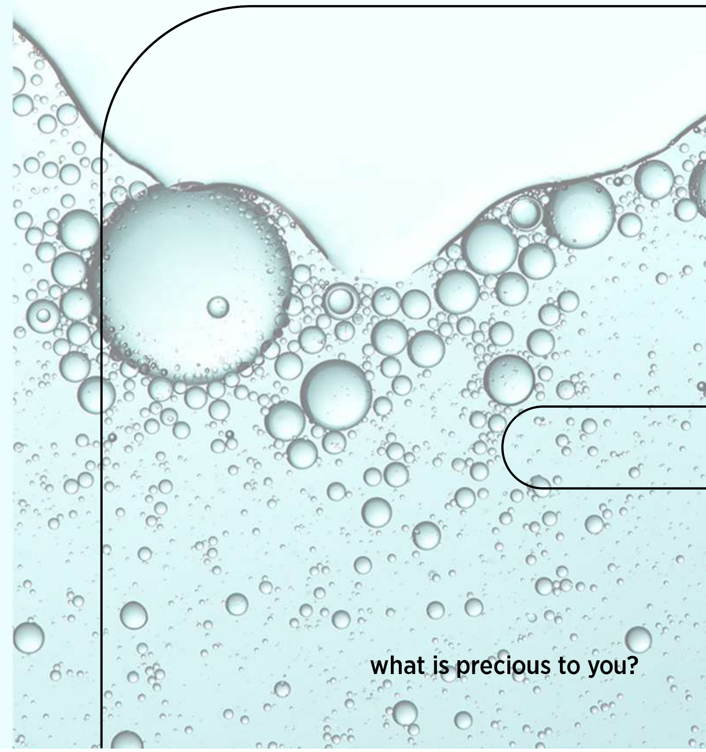

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