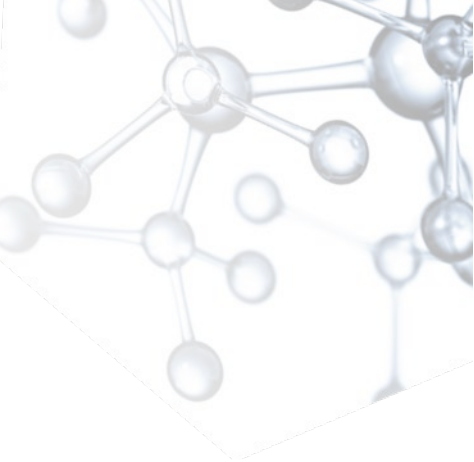
Stepan

Enhancing Cleaning Efficiency: A Look into Nonionic Surfactants

Presented by
Vanessa DeMarco
November 19, 2024

Agenda

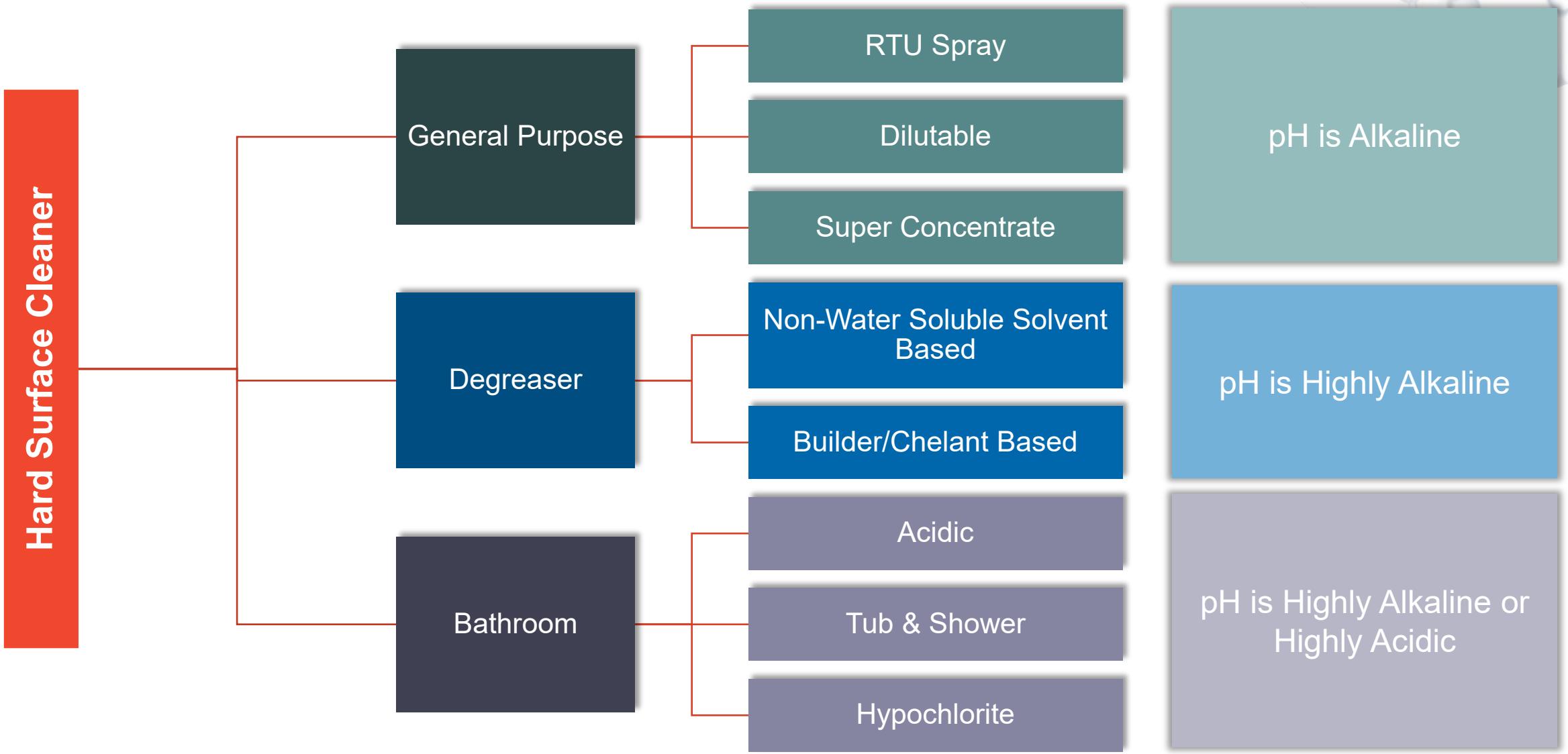


1. A Look at Nonionic Surfactants
2. Design of Experiments
3. Automated Cleaning Analysis
4. Stepan’s Nonionic Capabilities

What do we know about Nonionic Surfactants?

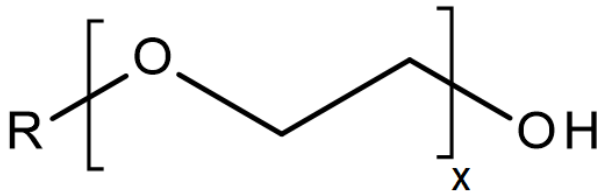
- Oily Soil Removal
- Excellent Wetting
- Low to Moderate Foam
- Good Emulsification
- Detergency on Synthetic Fabrics
- Hard Water Tolerance
- Compatible with Most Ingredients

The Role of Nonionic Surfactants



Nonionic Spotlight

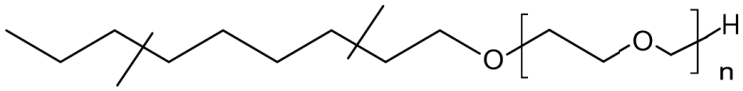
Semi Linear Alcohol Ethoxylates



BIO-SOFT® N- & EC-Series

- Fast Wetting
- Excellent Oily Soil Removal
- Detergency

Branched Alcohol Ethoxylates



MAKON® UD-Series

- Fast Wetting
- Non-gelling
- Fast Dissolution
- Excellent Degreasing

Agenda

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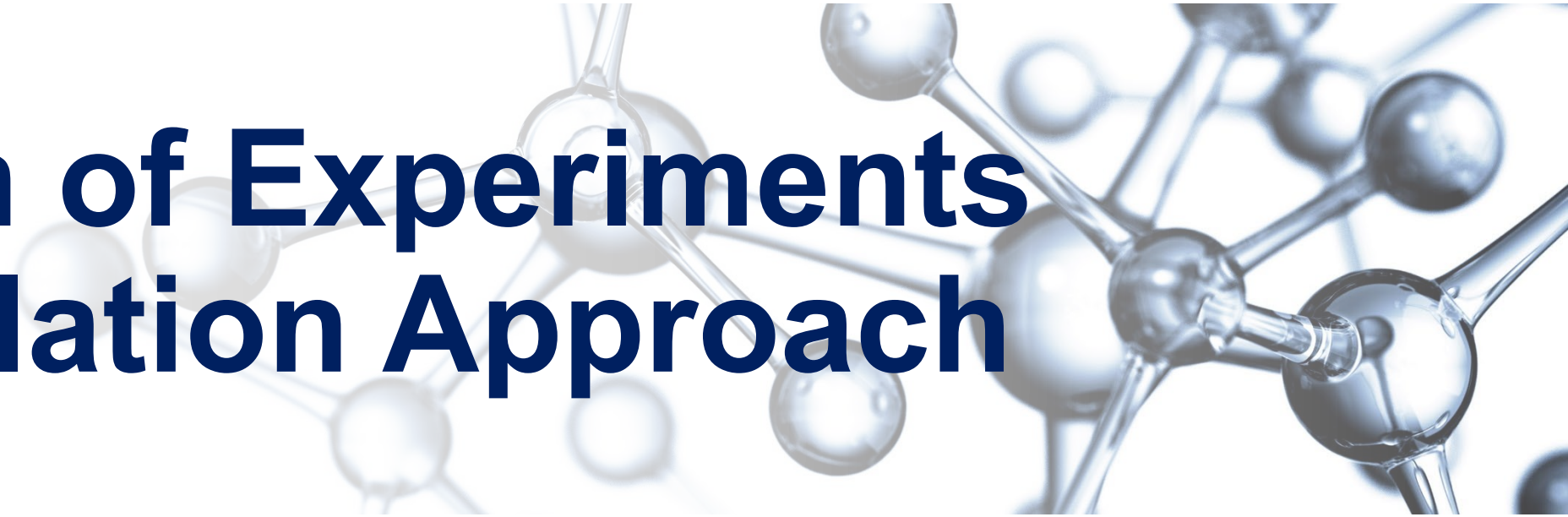
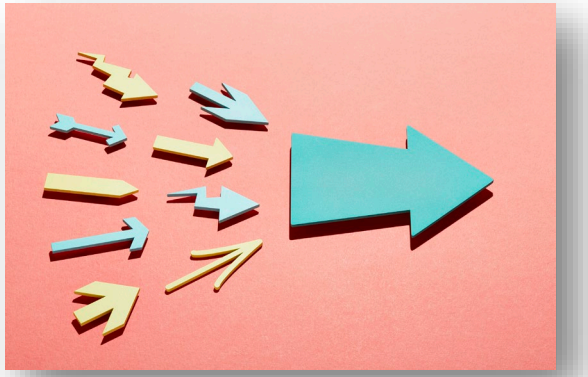
4. Stepan's Nonionic Capabilities

Design of Experiments Formulation Approach

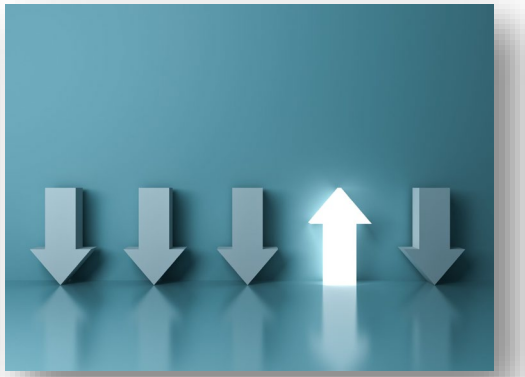


Why DOE

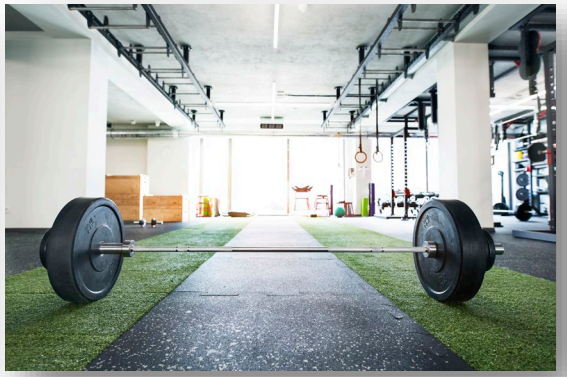
Efficiency



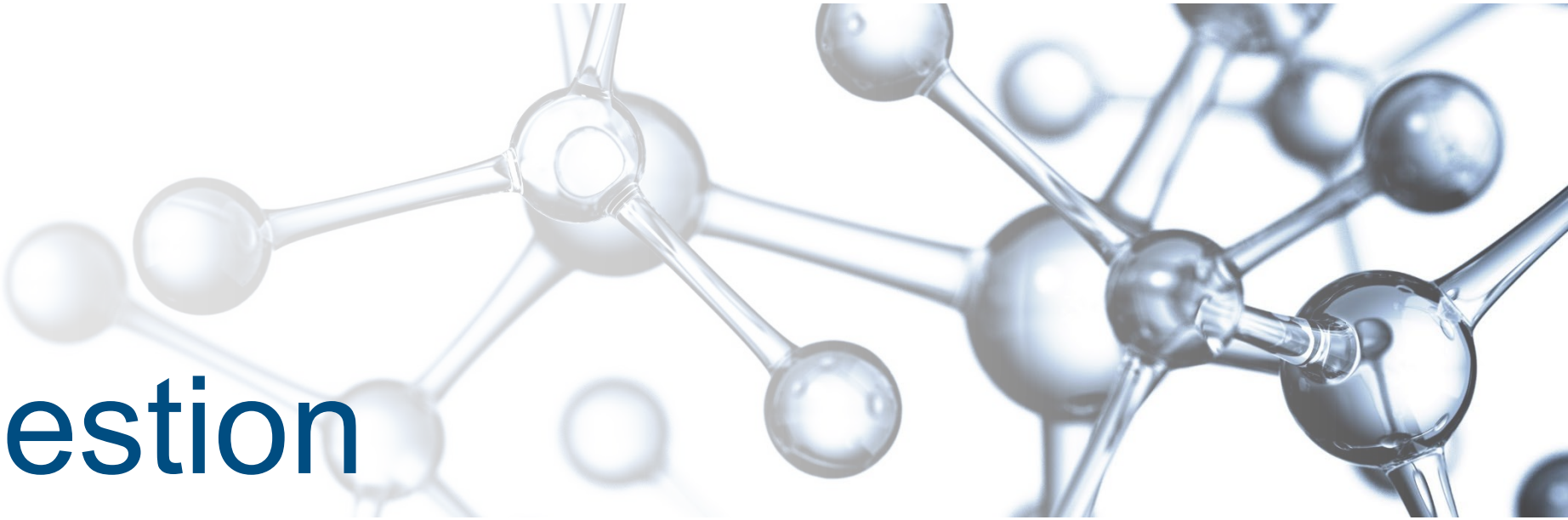
Optimization



Robustness



Comprehensive Analysis

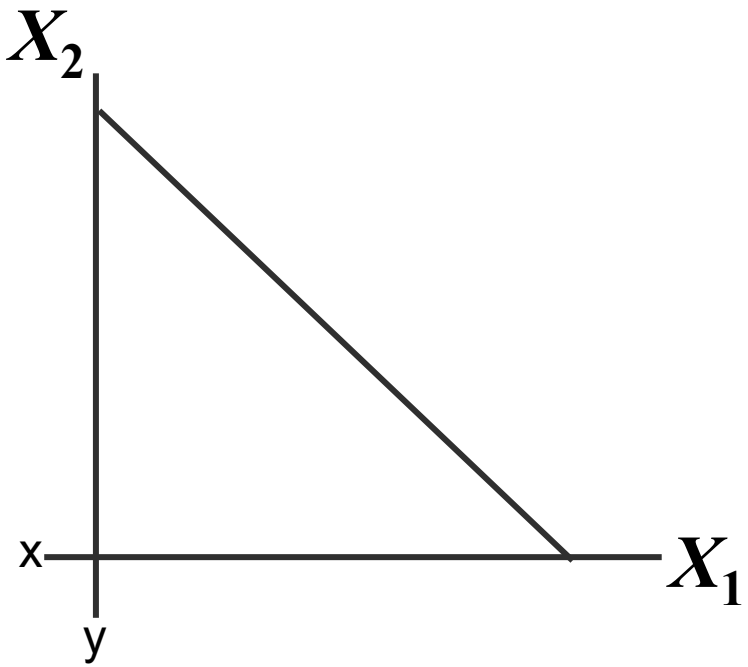


Poll Question

Have you worked with DOE for formulation?

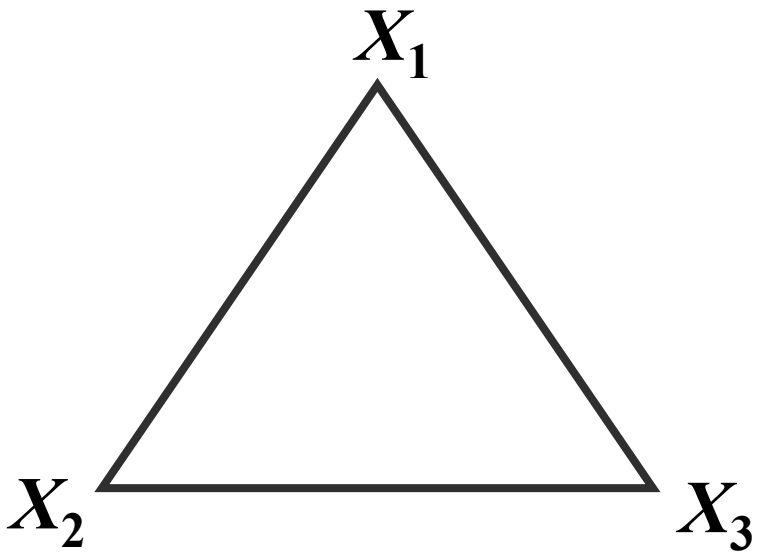
Mixture Designs

$$X_1 + X_2 = 100\%$$



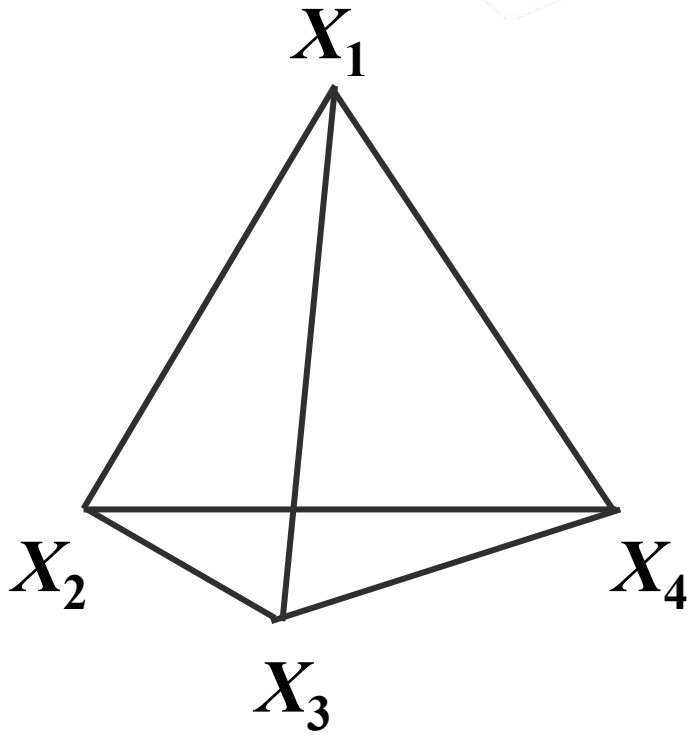
Two-Components
One Dimension

$$X_1 + X_2 + X_3 = 100\%$$



Three-Components
Two Dimensions

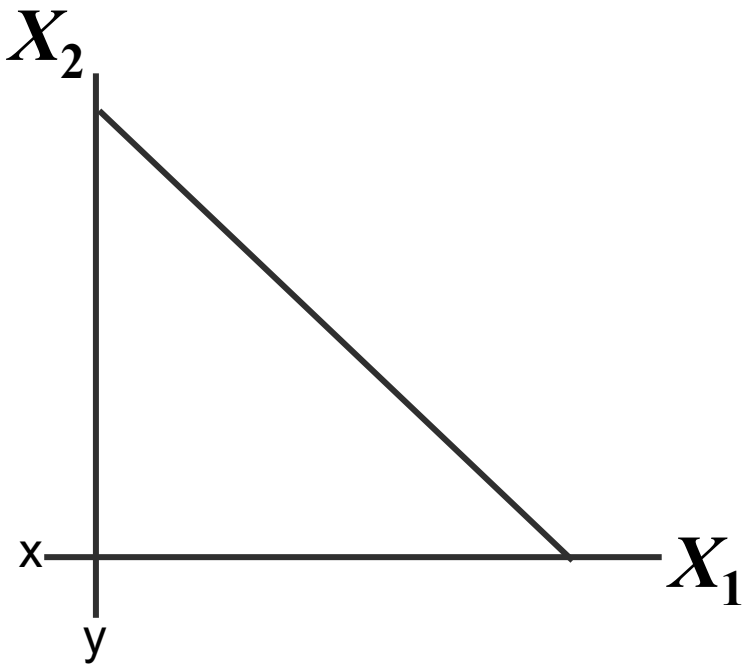
$$X_1 + X_2 + X_3 + X_4 = 100\%$$



Four-Components
Three Dimensions

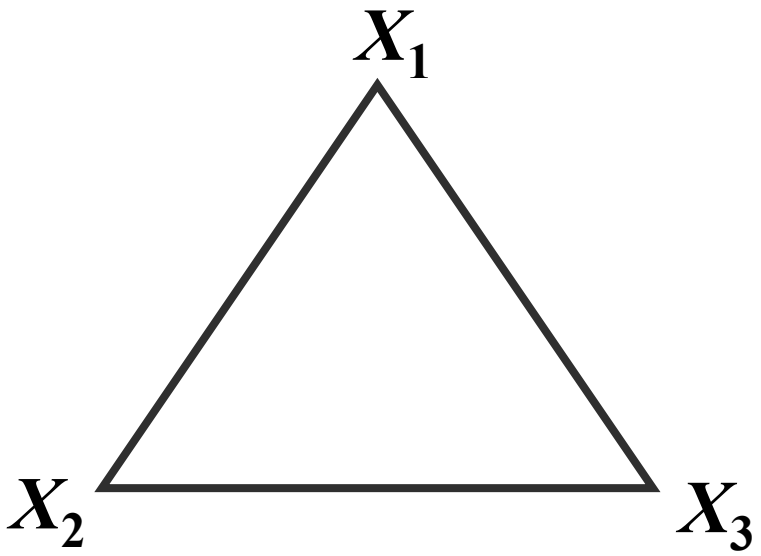
Mixture Designs

$$X_1 + X_2 = 100\%$$



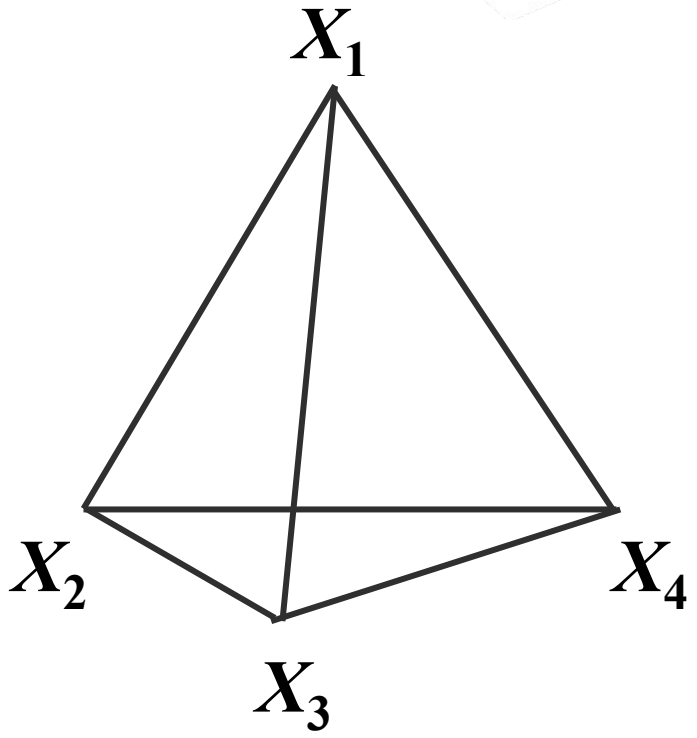
Two-Components
One Dimension

$$X_1 + X_2 + X_3 = 100\%$$



Three-Components
Two Dimensions

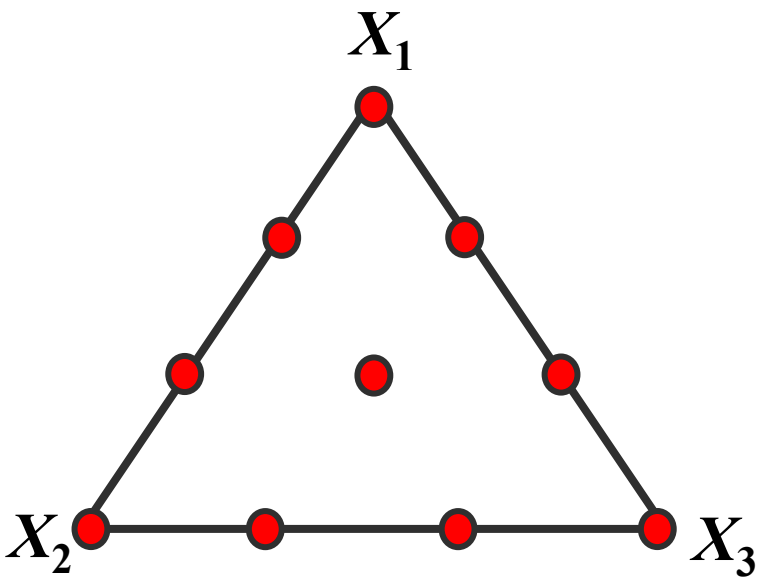
$$X_1 + X_2 + X_3 + X_4 = 100\%$$



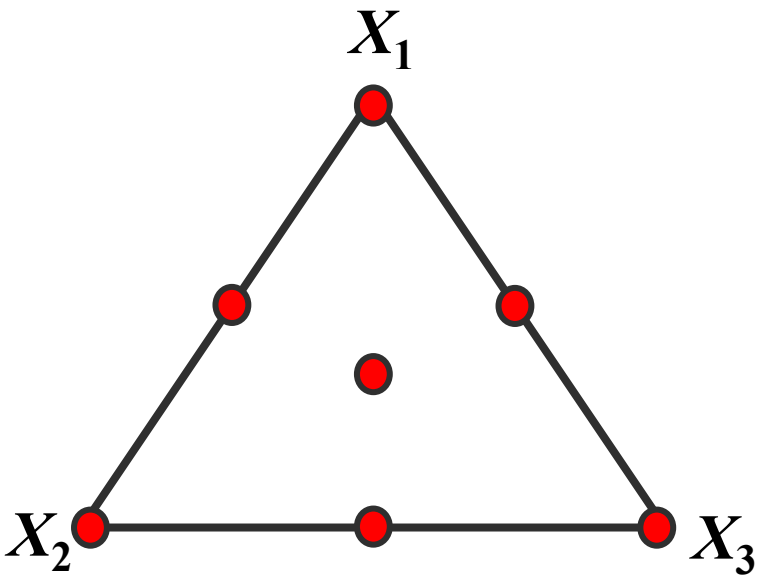
Four-Components
Three Dimensions

Design Strategies

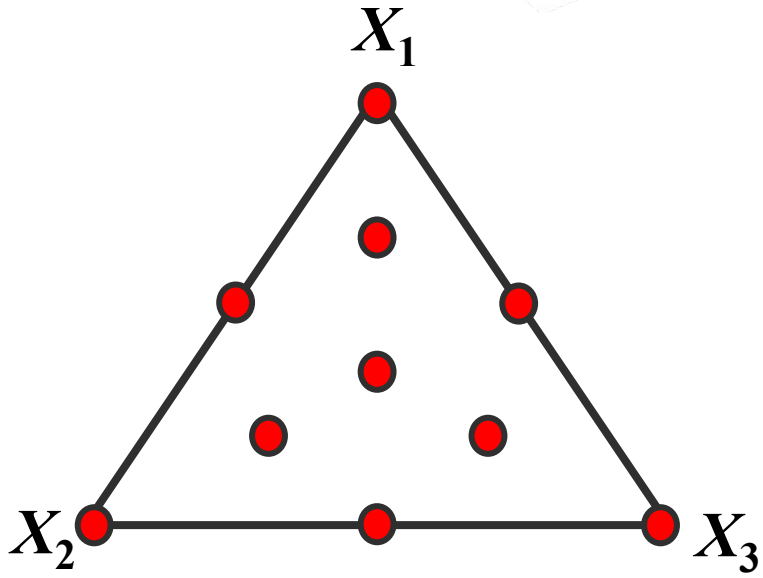
Lattice



Centroid

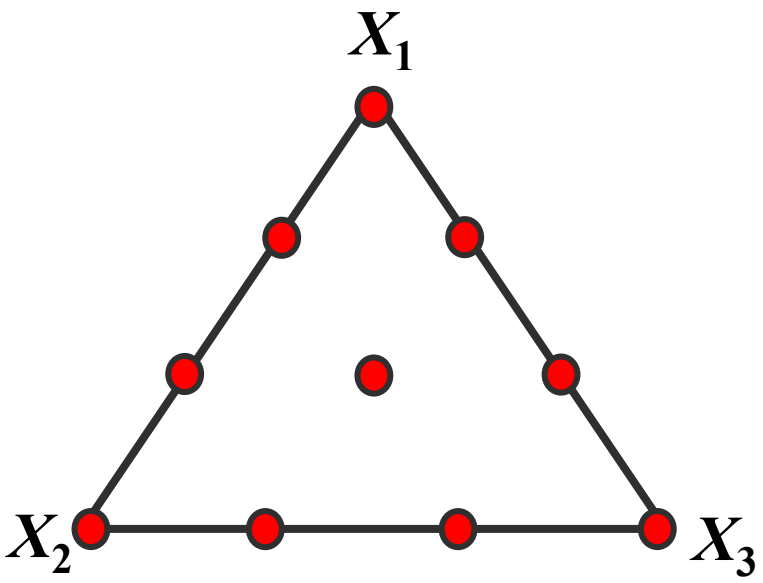


Screening

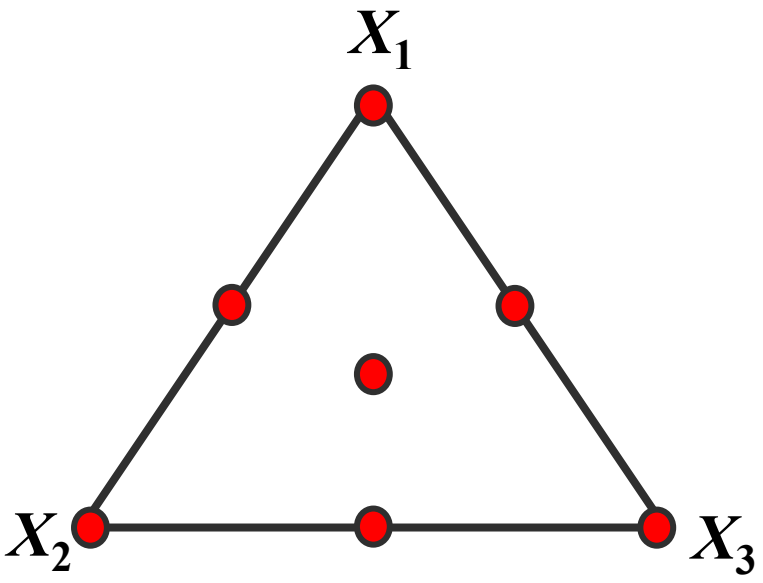


Design Strategies

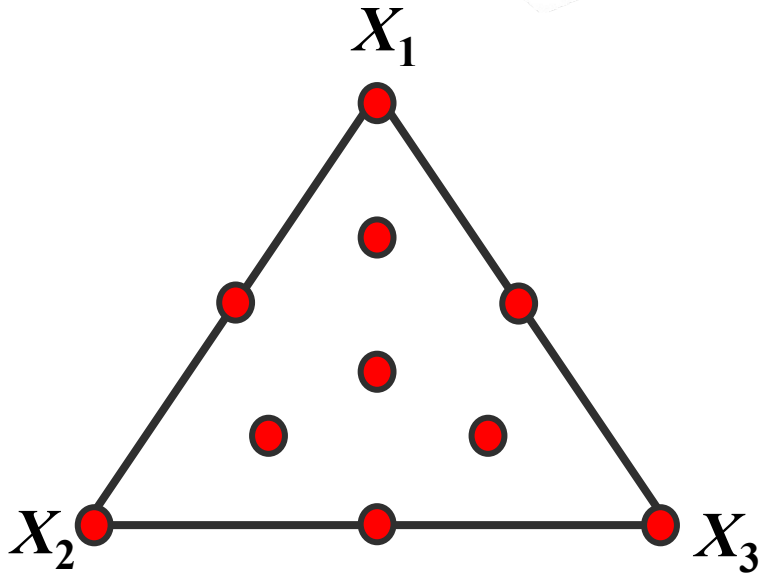
Lattice



Centroid



Screening



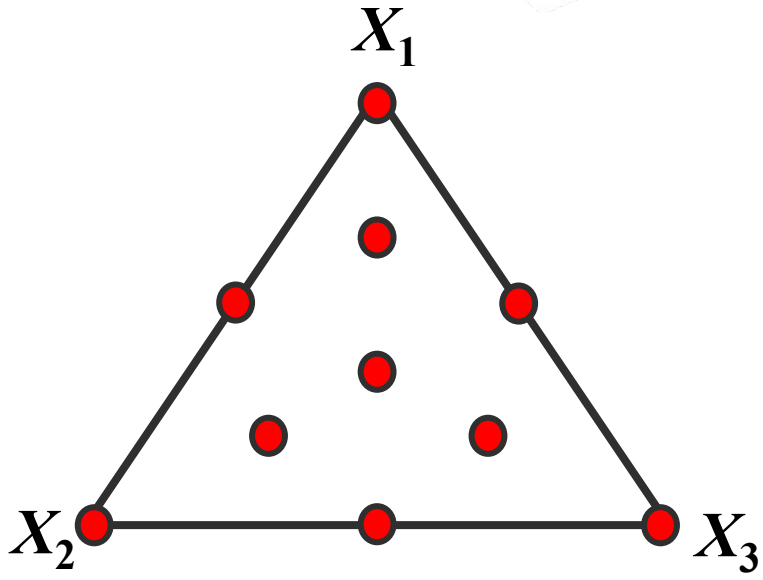
Want most information with least amount of formulations

Design Strategies

Lattice

Centroid

Screening



Screening Strategy

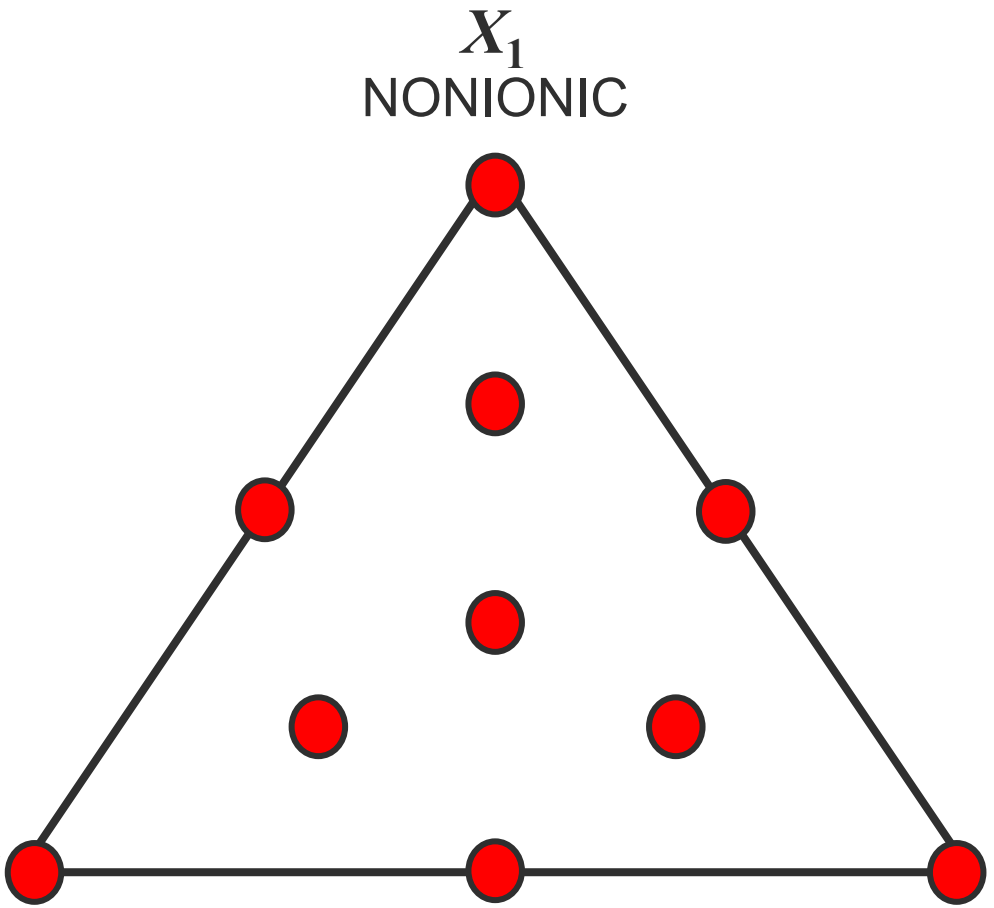
10 Design Points

$0 \leq X_1 \leq 1$

$0 \leq X_2 \leq 1$

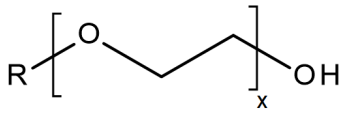
$0 \leq X_3 \leq 1$

$X_1 + X_2 + X_3 = 1$

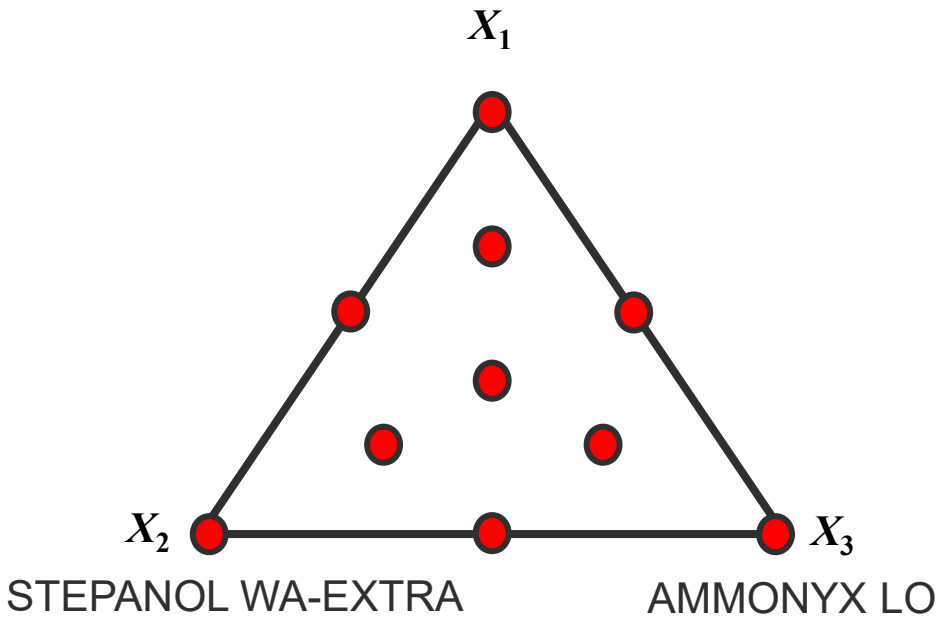


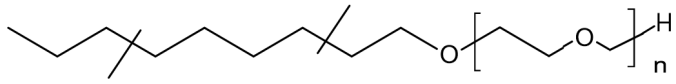
NONIONIC + STEPANOL WA-EXTRA + AMMONYX LO = 1% Active Formulation

Alkoxylate Investigation

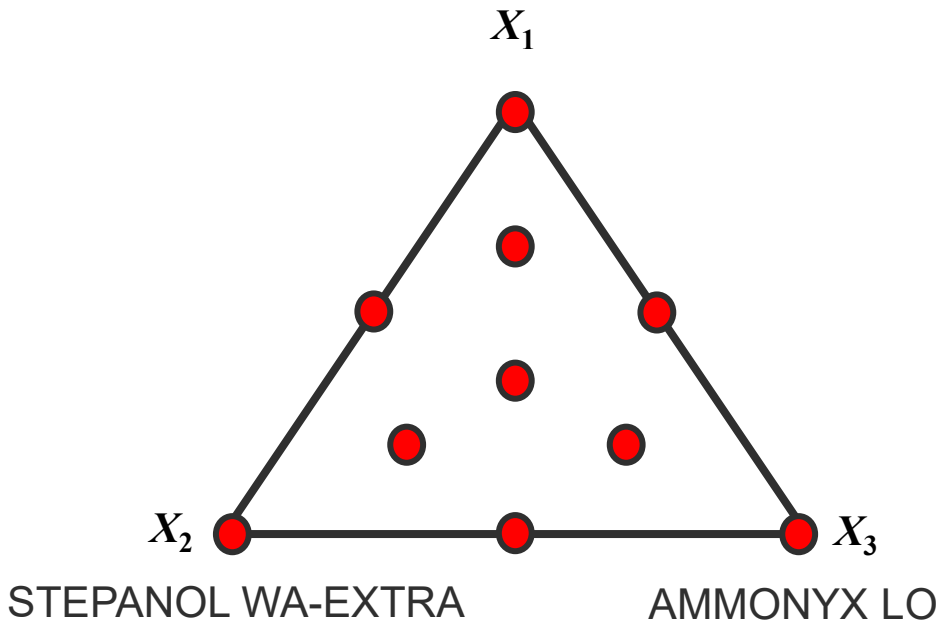


BIO-SOFT N91-6





MAKON UD-6



Dynamic Surface Tension

All Purpose Cleaning

Immersion Degreasing

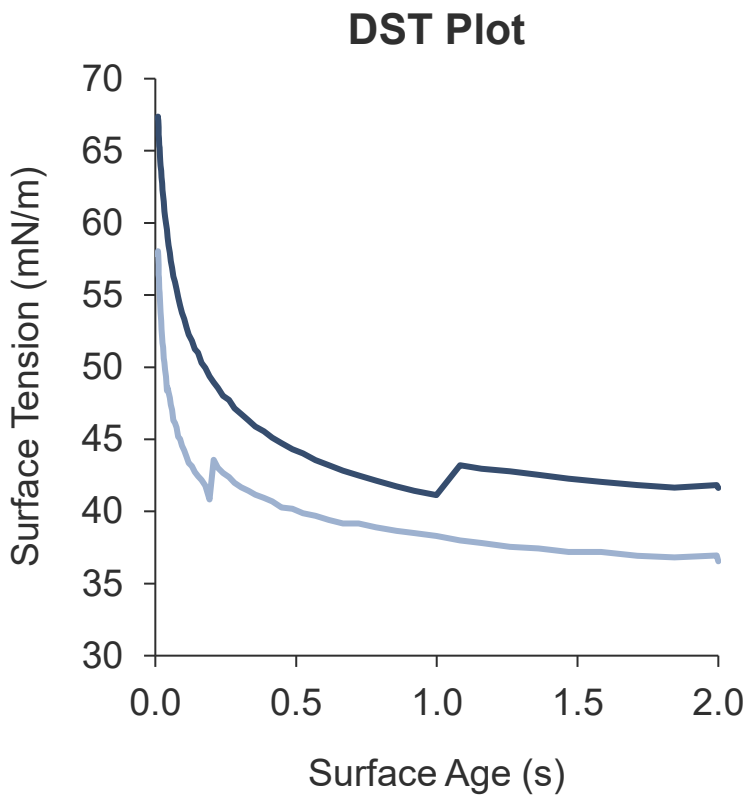
Dynamic Surface Tension

All Purpose Cleaning

Immersion Degreasing

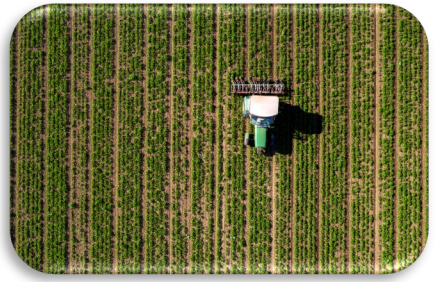
Dynamic Surface Tension

DST tells us how quickly a surfactant reduces the surface tension and its ability to wet a surface



Formulation Optimization

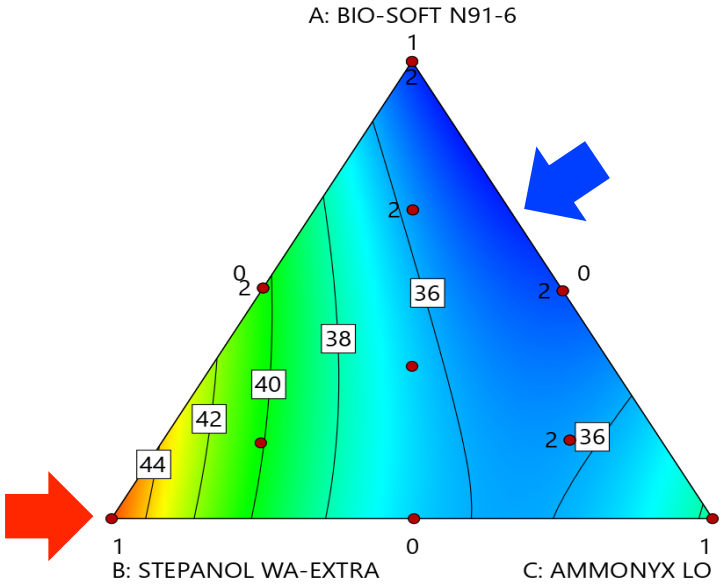
Maximize surface coverage for better cleaning results

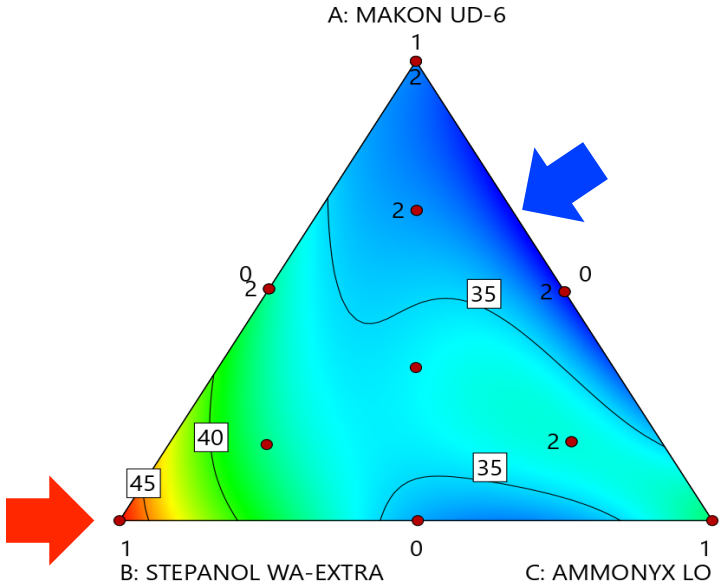


Maximize leaf coverage for better pesticide effectiveness

Improve spreadability and pigment dispersion in paints, inks, and coatings

Dynamic Surface Tension – 1s





In both formulation spaces, we see:

The **anionic** has the **highest** surface tension

The **nonionic** has the lowest surface tension, and therefore has the **best** dynamic surface tension **performance** of the 3 components

Both BIO-SOFT N91-6 and MAKON UD-6 improve the **wetting** and **spreadability** of your formulation

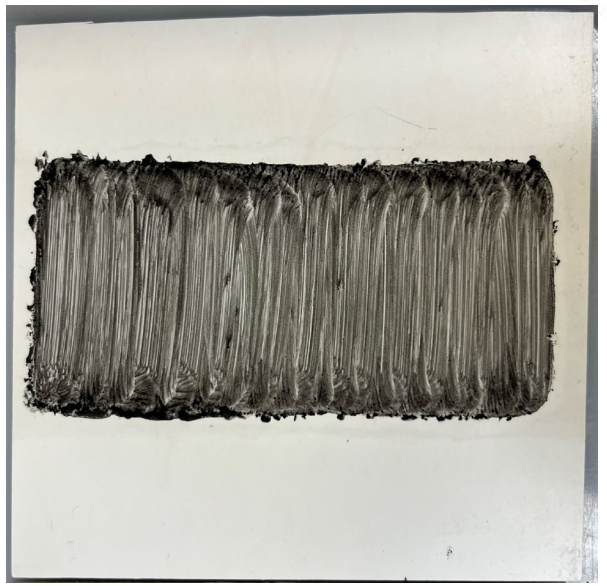
Dynamic Surface Tension

All Purpose Cleaning

Immersion Degreasing

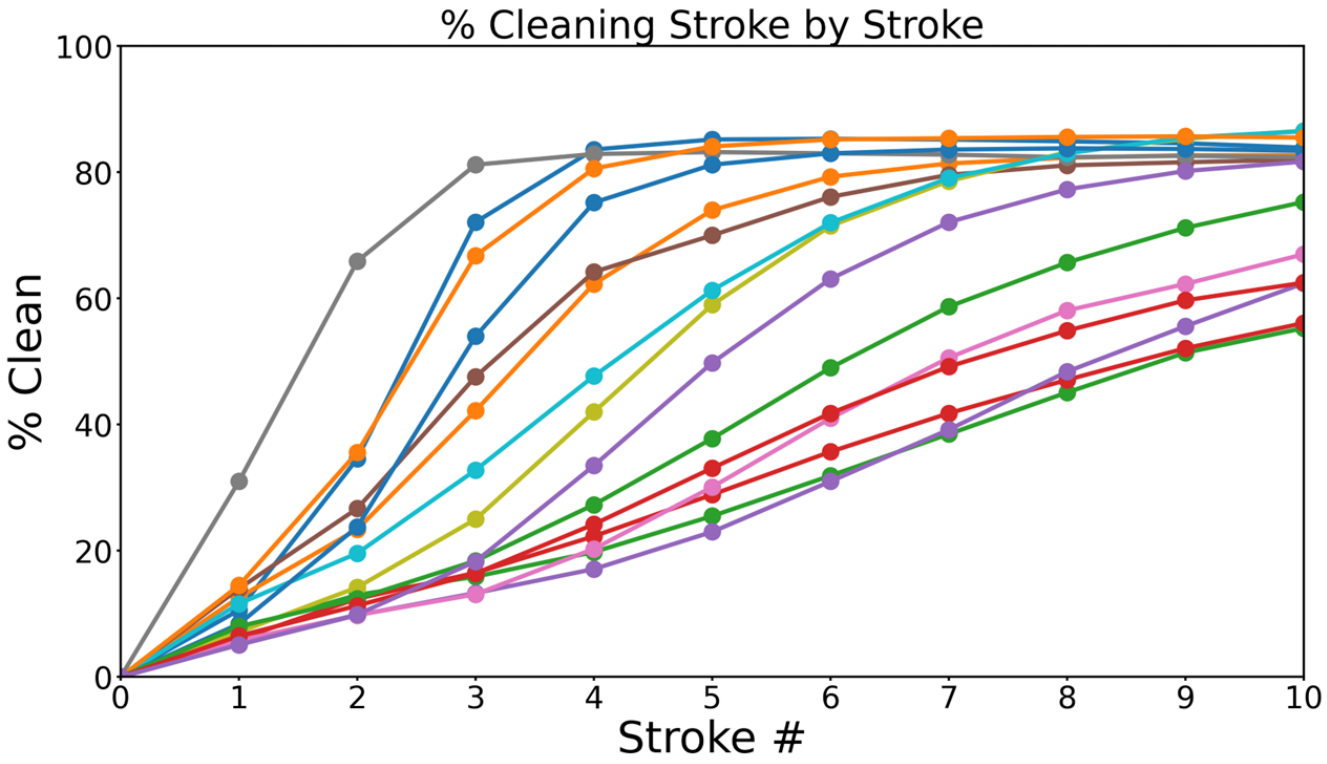
All Purpose Cleaning

Standardized Gardner Scrub Machine



Oily & Particulate Soil
Luma Scale

All Purpose Cleaning

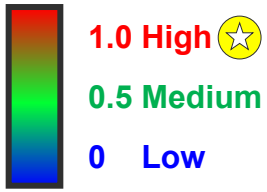


A stroke-by-stroke analysis gives us insight into the **speed** of cleaning

Consumers want to spend **less time** cleaning

Improve customer **confidence** in your cleaning product and ensure a **squeaky clean** surface!

Cleaning Stroke 5



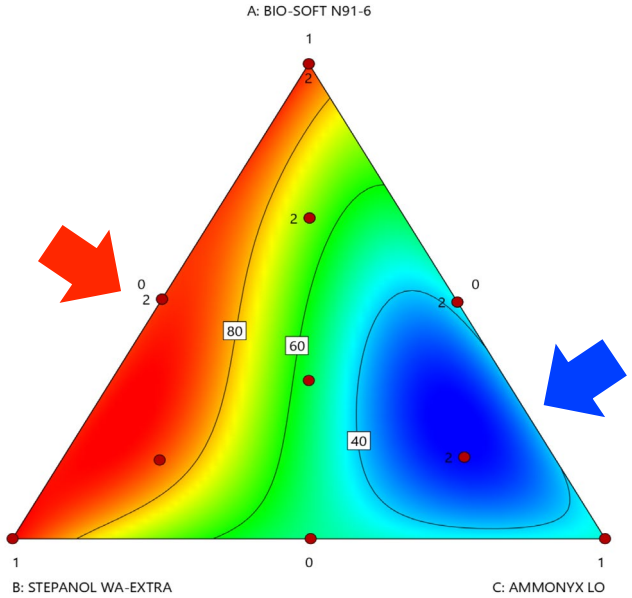
Legend

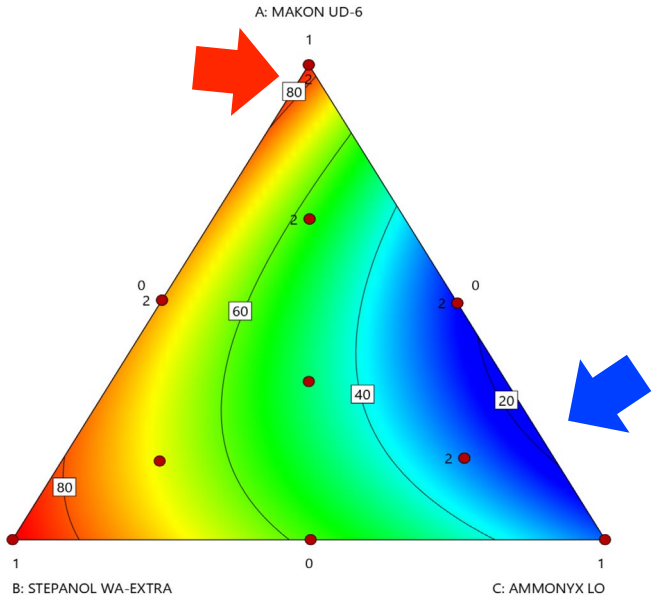
1.0 High

0.5 Medium

0 Low

Target: High, Red





Both the **nonionics** and **anionic** alone and in **combination** have excellent cleaning performance

Antagonism was observed between each **nonionic** and the **amphoteric** for this application

The **linear** alcohol ethoxylate has a larger area of high performance

BIO-SOFT N91-6 provides more **formulation flexibility** with other components for all purpose **oily and particulate** cleaning

Dynamic Surface Tension

All Purpose Cleaning

Immersion Degreasing

Immersion Degreasing

Heavy Duty Degreasing

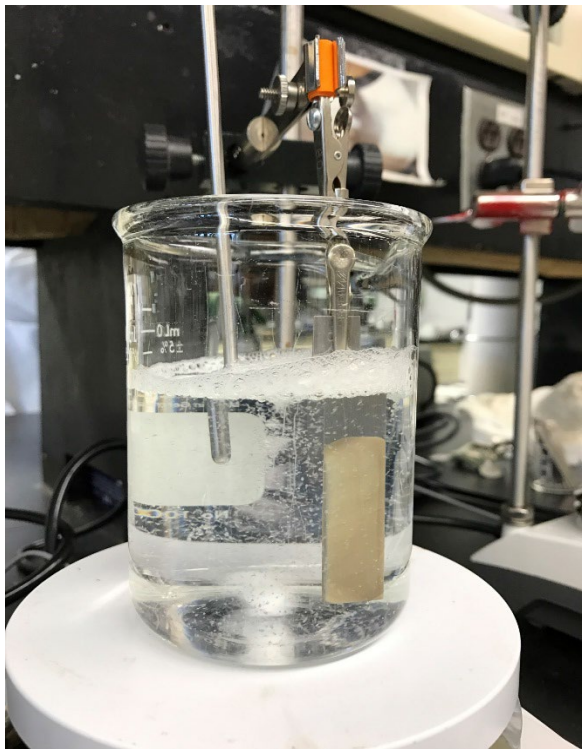
Clean In Place

Kitchen Grease

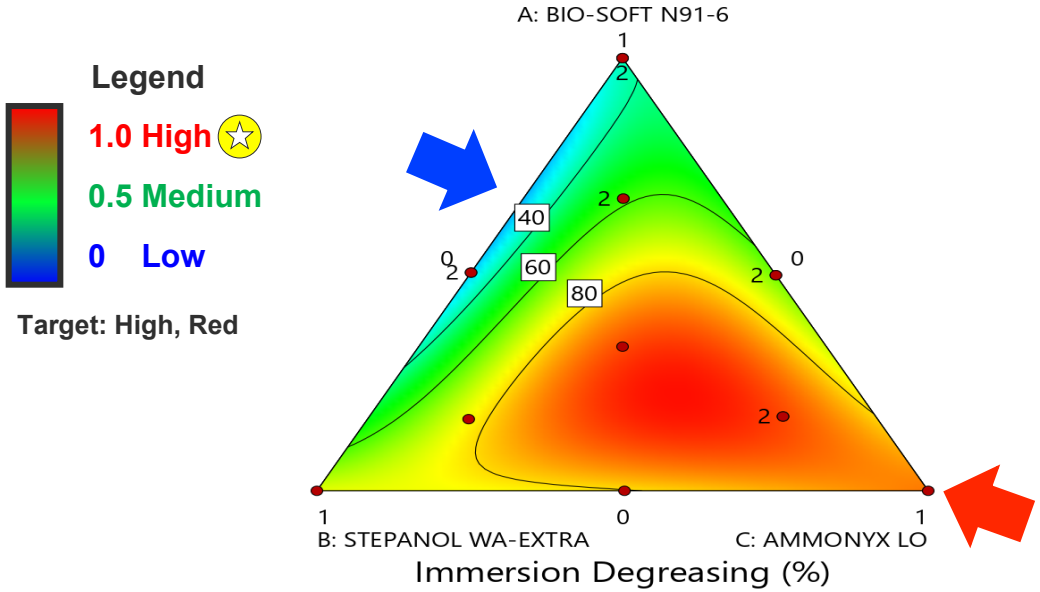
Touchless Car Wash

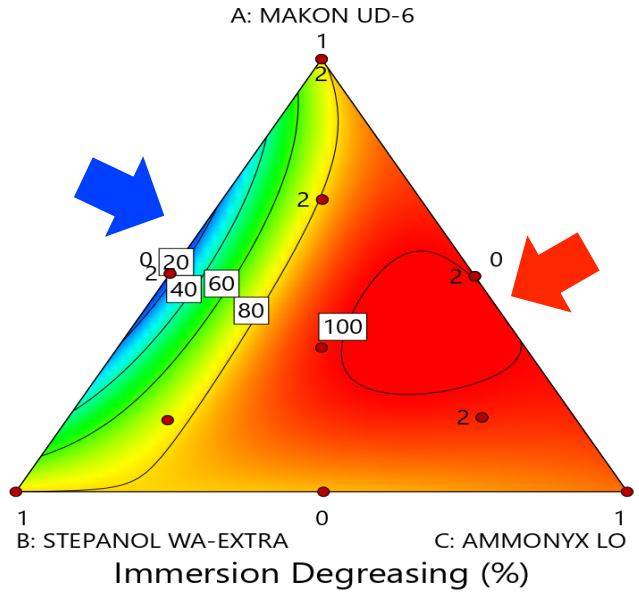
Dishwash

Test Set Up



Immersion Degreasing





Synergy was observed between each **nonionic** and the **amphoteric** for this application

Antagonism was observed between each **nonionic** and the **anionic** for this application

The **branched** alcohol ethoxylate has a larger area of high performance

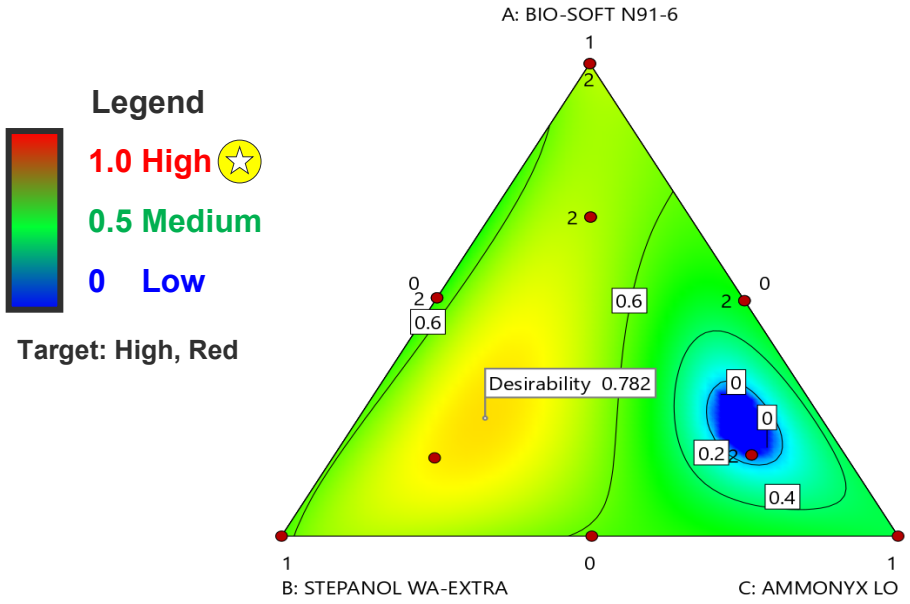
MAKON UD-6 provides more **degreasing** and more **formulation flexibility** with other components for degreasing applications

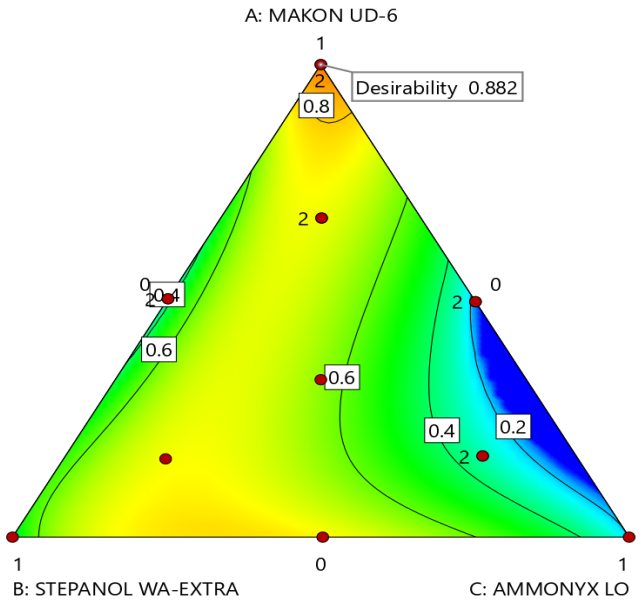
Dynamic Surface Tension

All Purpose Cleaning

Immersion Degreasing

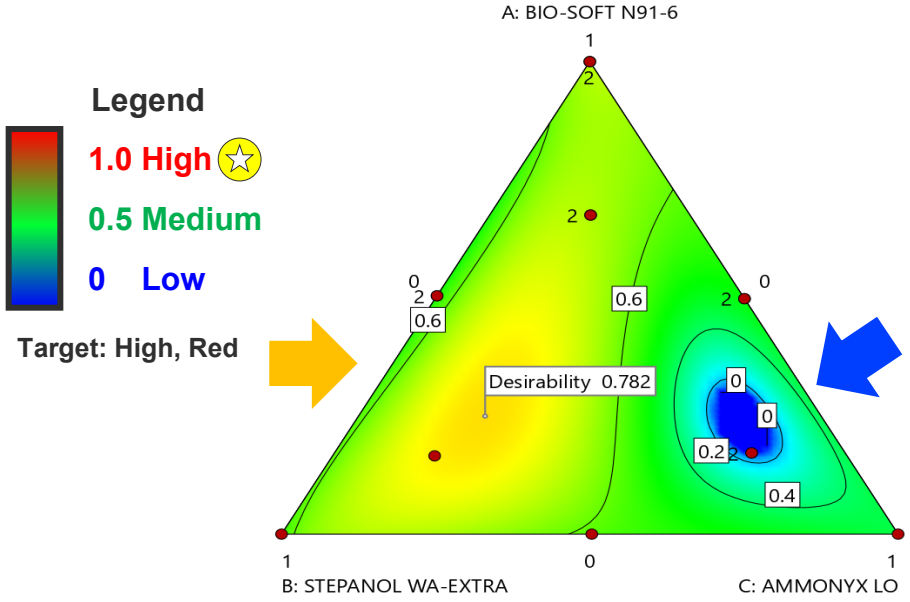
Desirability

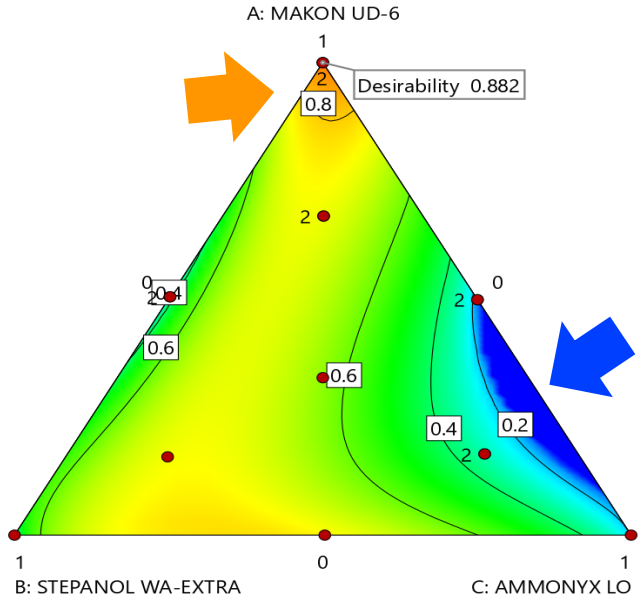




Response	Goal	Importance
DST at 1s	Minimize	3
Cleaning Stroke 5	Maximize	5
Immersion Degreasing	Maximize	5

Desirability





Response	Goal	Importance
DST at 1s	Minimize	3
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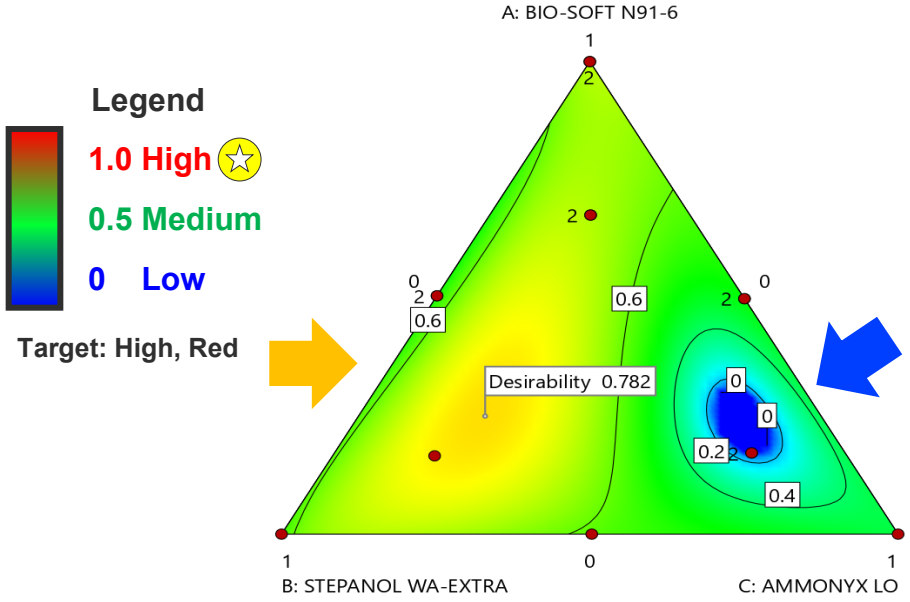
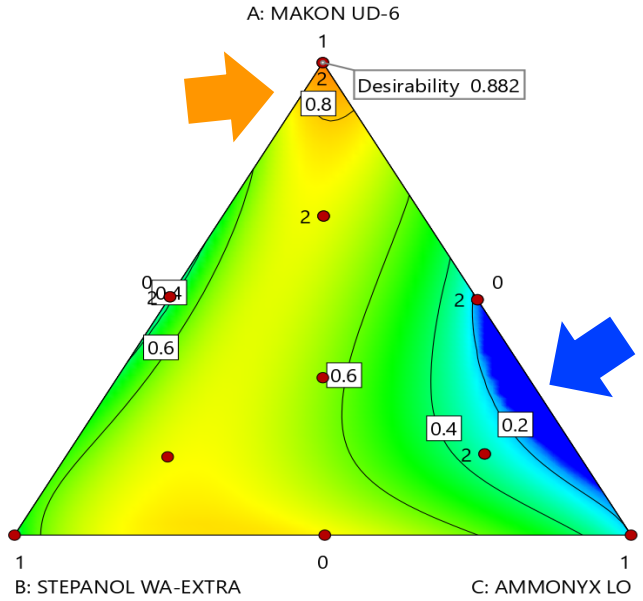
Immersion Degreasing	Maximize	5

BIO-SOFT N91-6: 0.78 Desirability
MAKON UD-6: 0.88 Desirability

Desirability





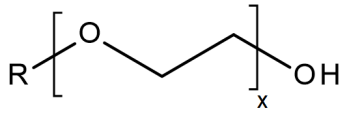
Response	Goal	Importance
DST at 1s	Minimize	3
Cleaning Stroke 5	Maximize	5
Immersion Degreasing	Maximize	5

BIO-SOFT N91-6: 0.78 Desirability
MAKON UD-6: 0.88 Desirability

For these specific response parameters

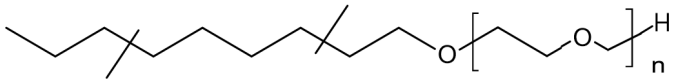
MAKON UD-6 provides the best formulation options and performance for all purpose cleaning and heavy-duty degreasing

Conclusions



BIO-SOFT N91-6

Semi Linear
Alcohol Ethoxylates

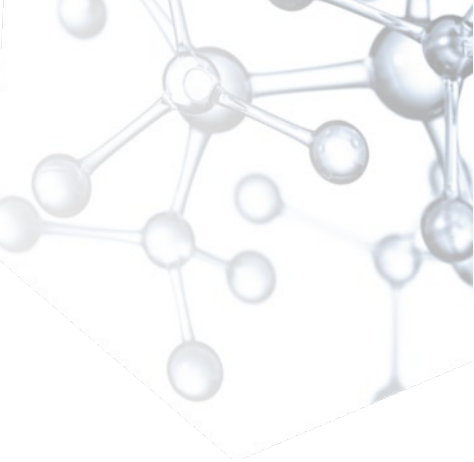


MAKON UD-6

Branched
Alcohol Ethoxylates

Application	BIO-SOFT N91-6	MAKON UD-6
Fast Surface Tension Reduction	Equal	Equal
Oily & Particulate Cleaning	Best	Great
Immersion Degreasing	Good	Best

DOE Tips



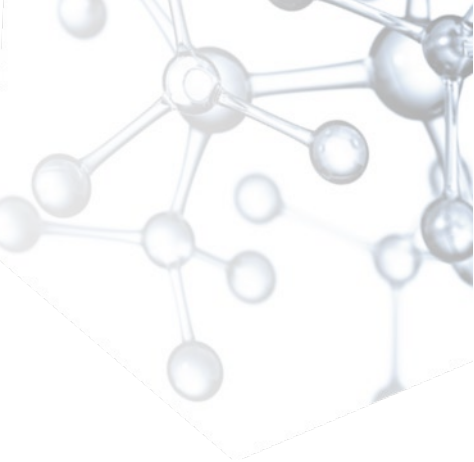
Subject Matter Knowledge is **KEY**

No existing information? → **screening model**

- Experimentation can be expensive
- Less work, less experiments
- Can determine which components have **no effect**
- Collect enough information for a successful DOE

You get out what you put in

Agenda



1. A Look at Nonionic Surfactants
2. Design of Experiments
3. Automated Cleaning Analysis
4. Stepan’s Nonionic Capabilities

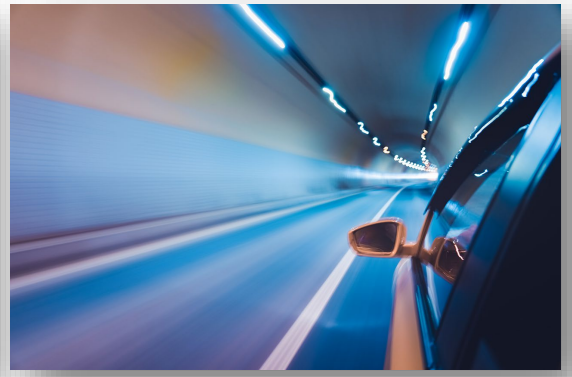
Evolving R&D with Automation

Value of Automation

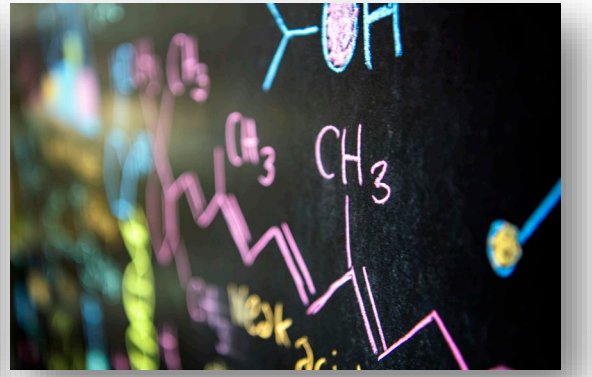
Save Time & Money

Reduce Error

High Throughput

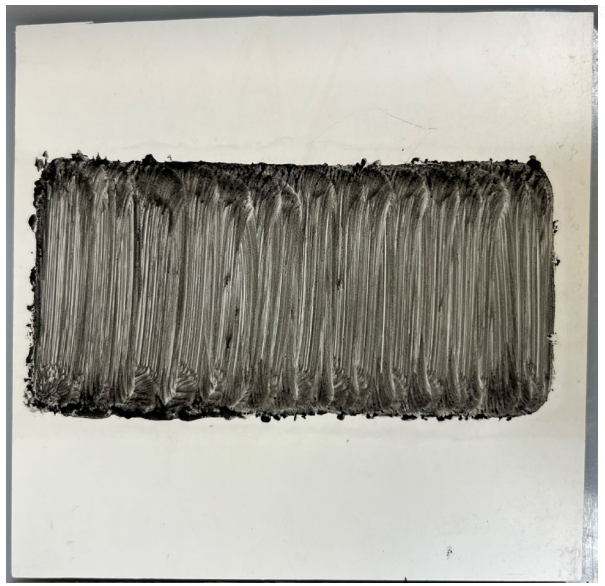


Enable Deep Work

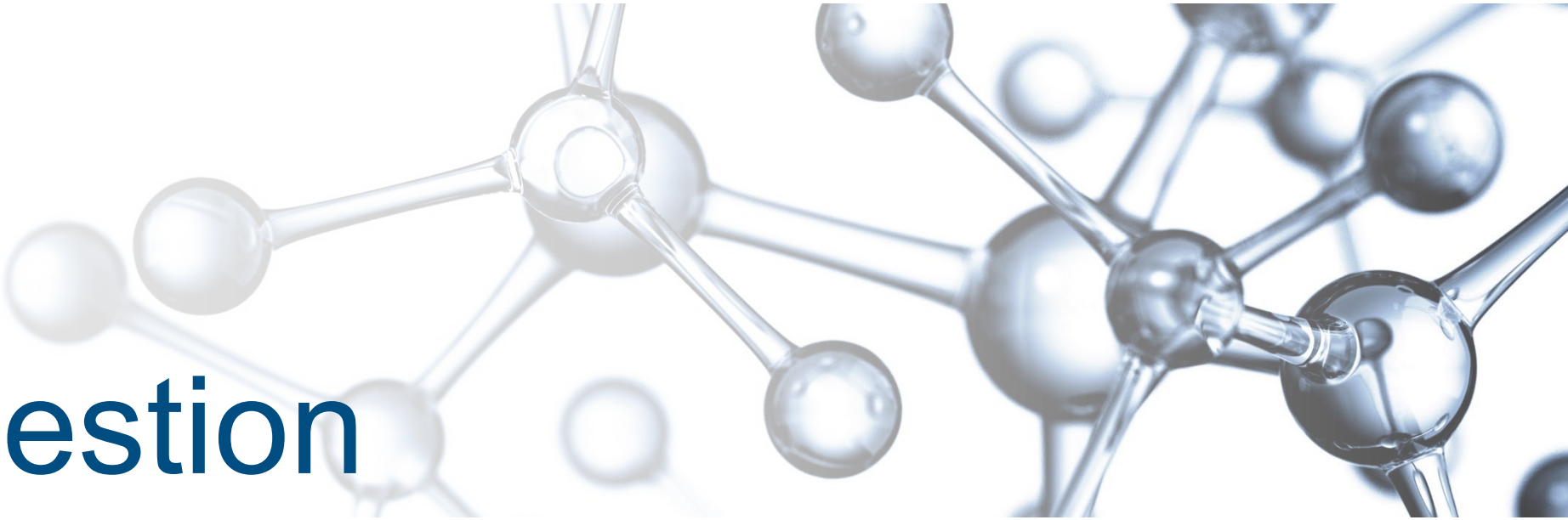


All Purpose Cleaning

Standardized Gardner Scrub Machine



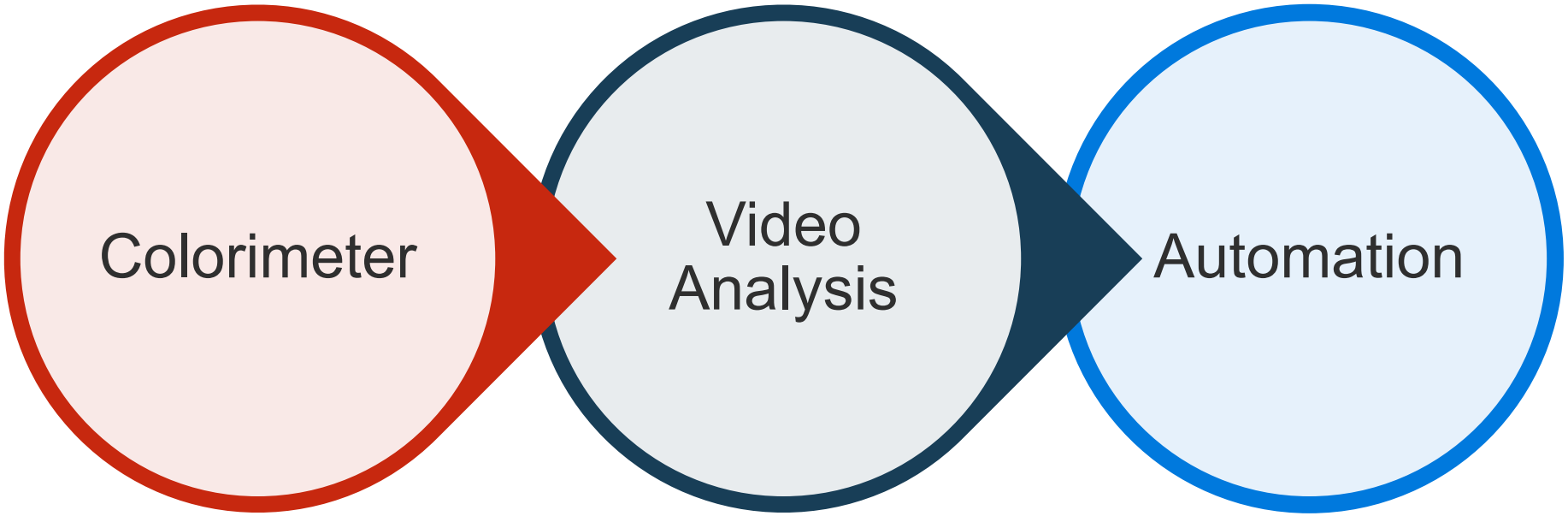
Oily & Particulate Soil
Luma Scale

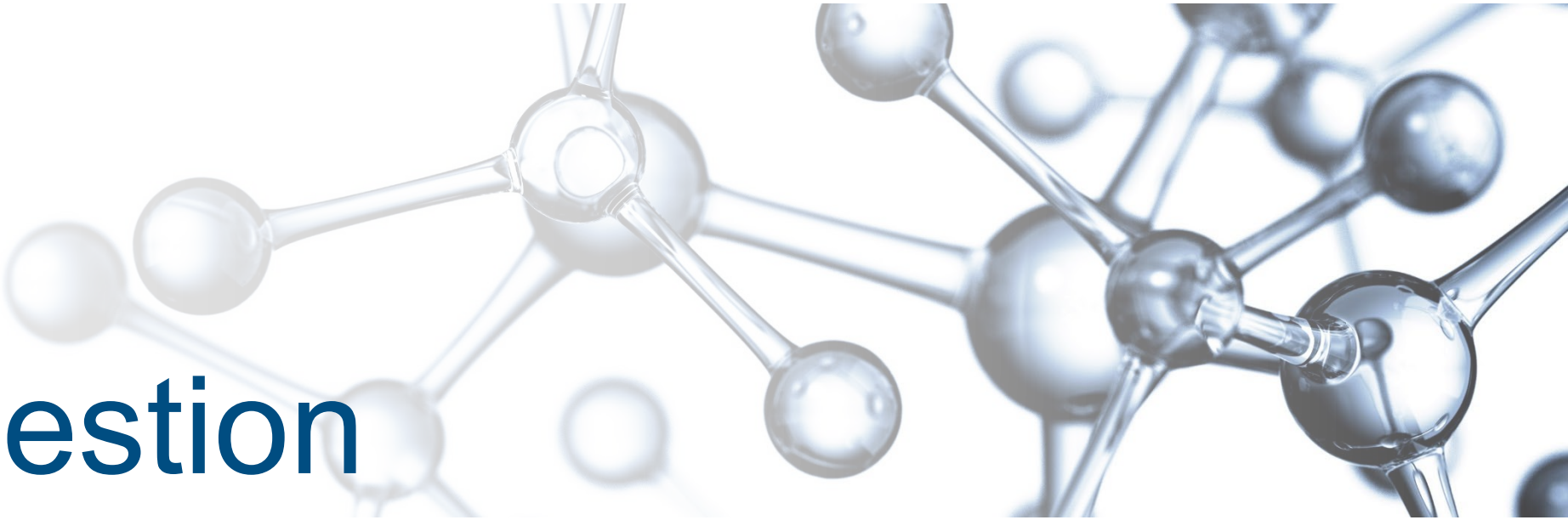


Poll Question

Have you used the cleaning test?

History of Cleaning Analysis

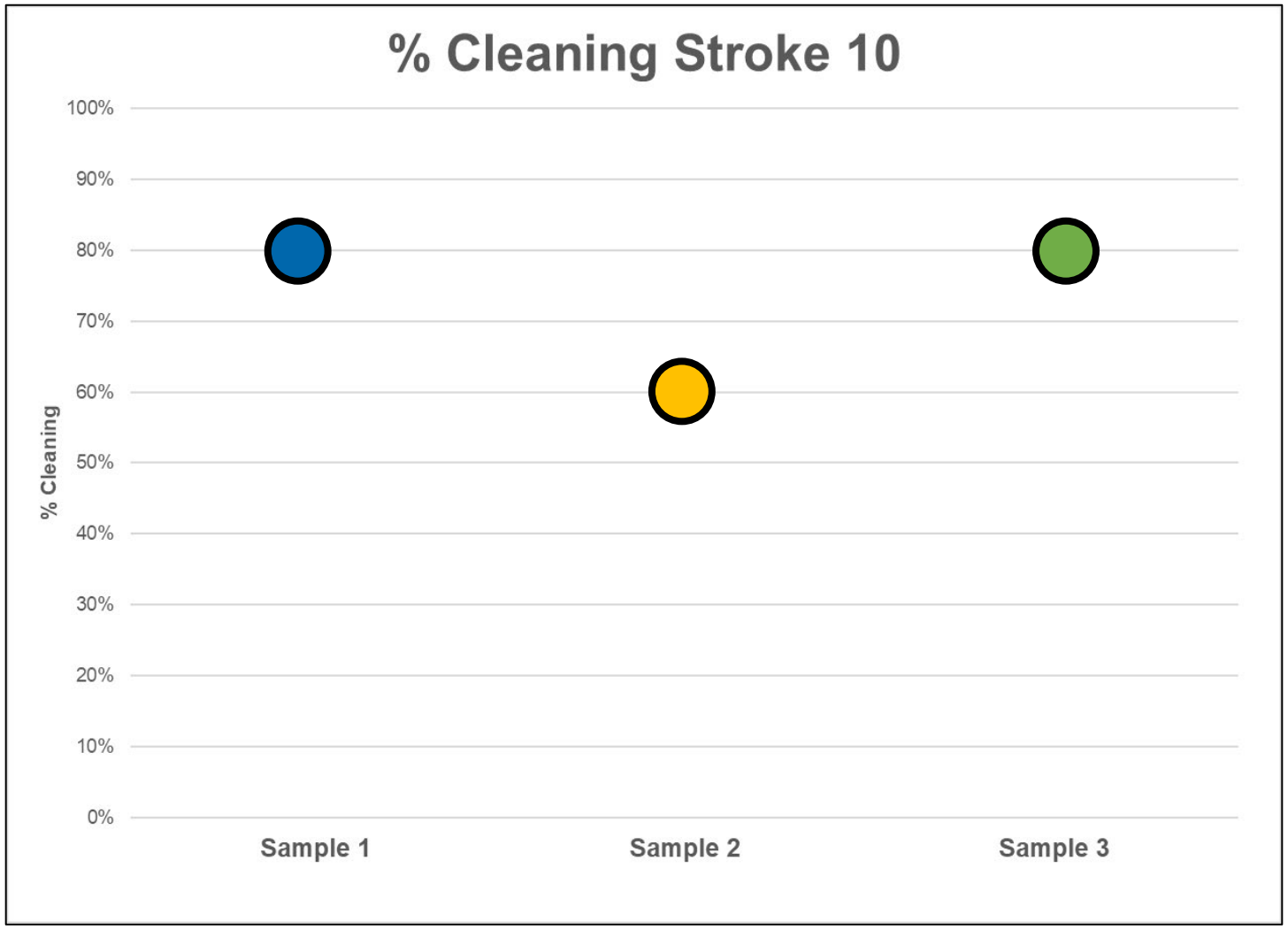




Poll Question

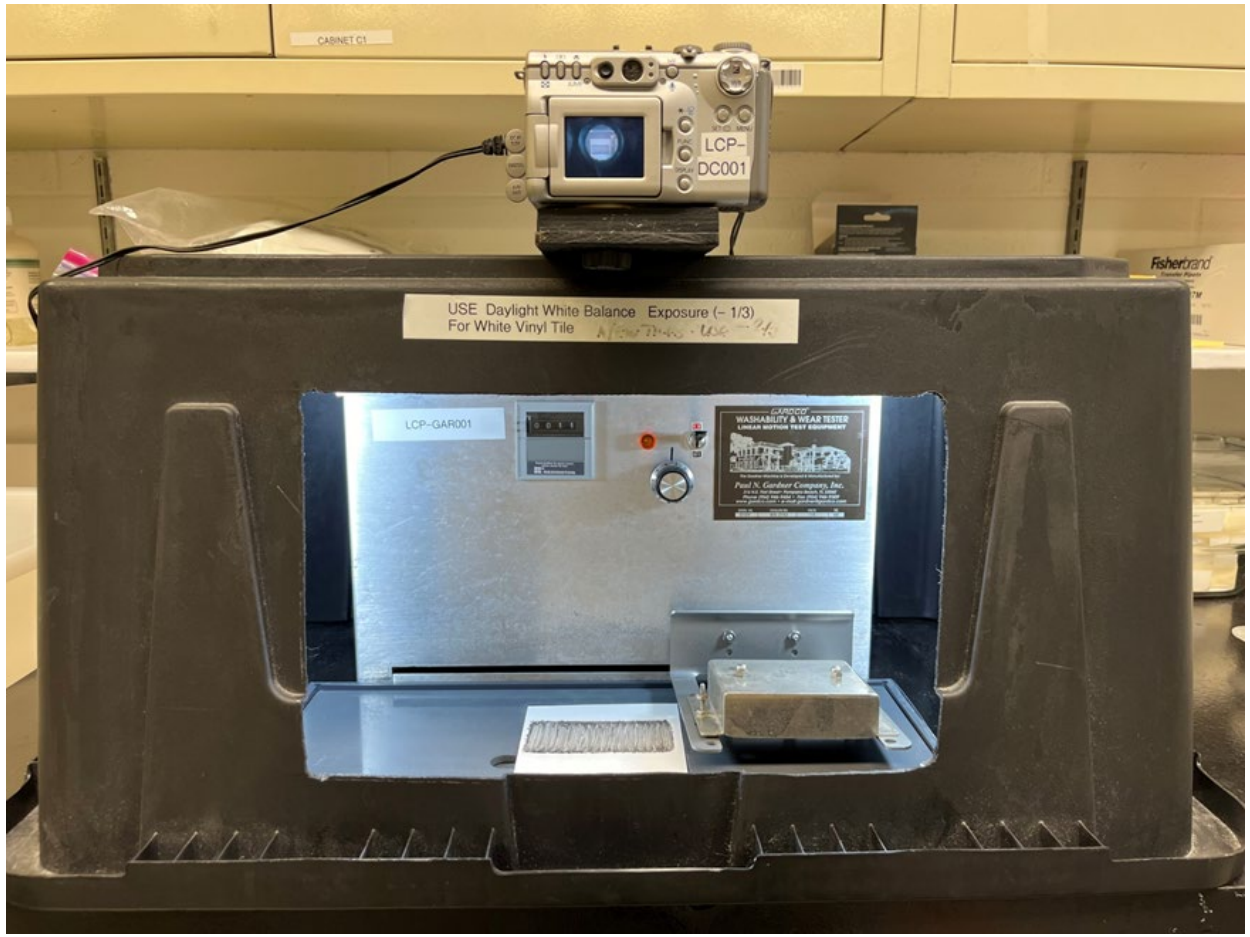
What cleaning analysis method do you currently use?

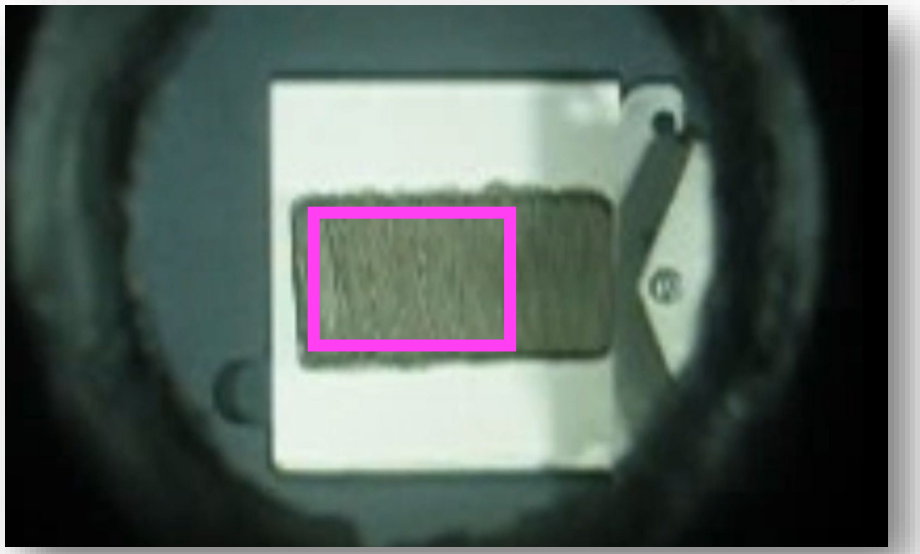
Colorimeter – Single Data Point



"Sample 1 and 3 have same performance"

Stroke by Stroke Cleaning



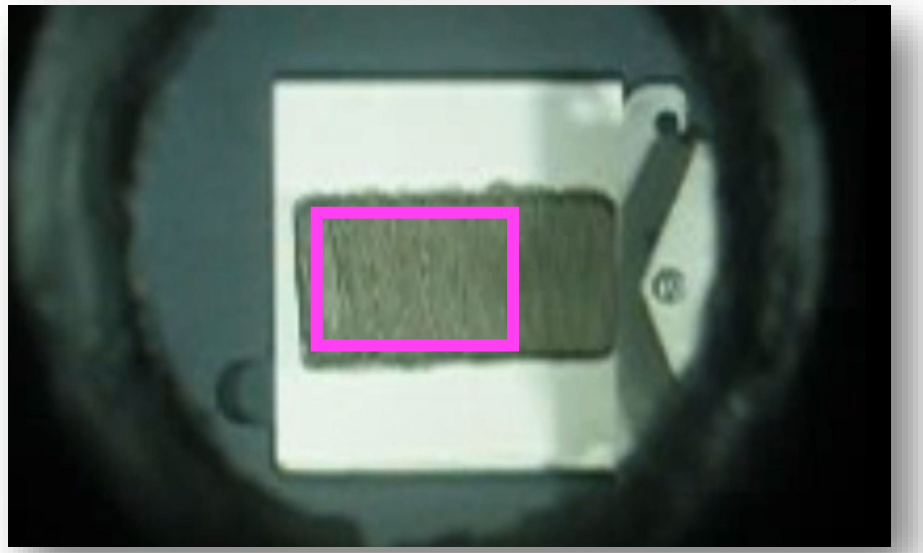


Oily & Particulate Soil
Luma Scale

Video Analysis

Video Analysis – Manual Process

- Luma values for each frame of video
- Manually select each cleaning stroke peak
- Manually enter values into excel template

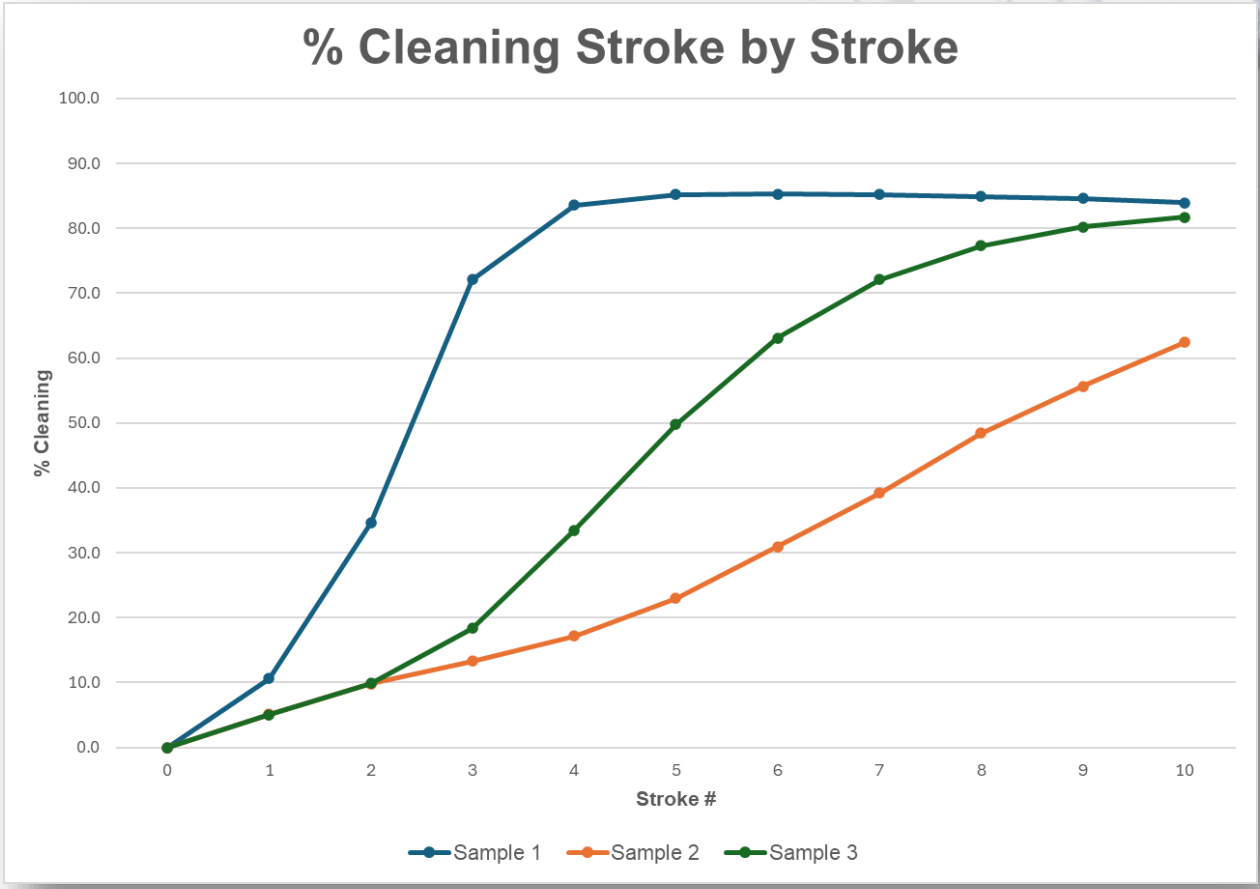


Oily & Particulate Soil
Luma Scale

Video Analysis

Video Analysis – Manual Process

- Luma values for each frame of video
- Manually select each cleaning stroke peak
- Manually enter values into excel template
- Excel template calculates % Cleaning
- Stroke by stroke cleaning curve
    - Speed of cleaning



Sample	0	1	2	3	4	5	6	7	8	9	10
Sample 1	0.0	10.6	34.6	72.1	83.6	85.2	85.3	85.2	84.9	84.6	83.9
Sample 2	0.0	5.1	9.8	13.3	17.1	23.0	31.0	39.2	48.4	55.6	62.4
Sample 3	0.0	5.1	9.9	18.3	33.5	49.8	63.1	72.1	77.3	80.2	81.7

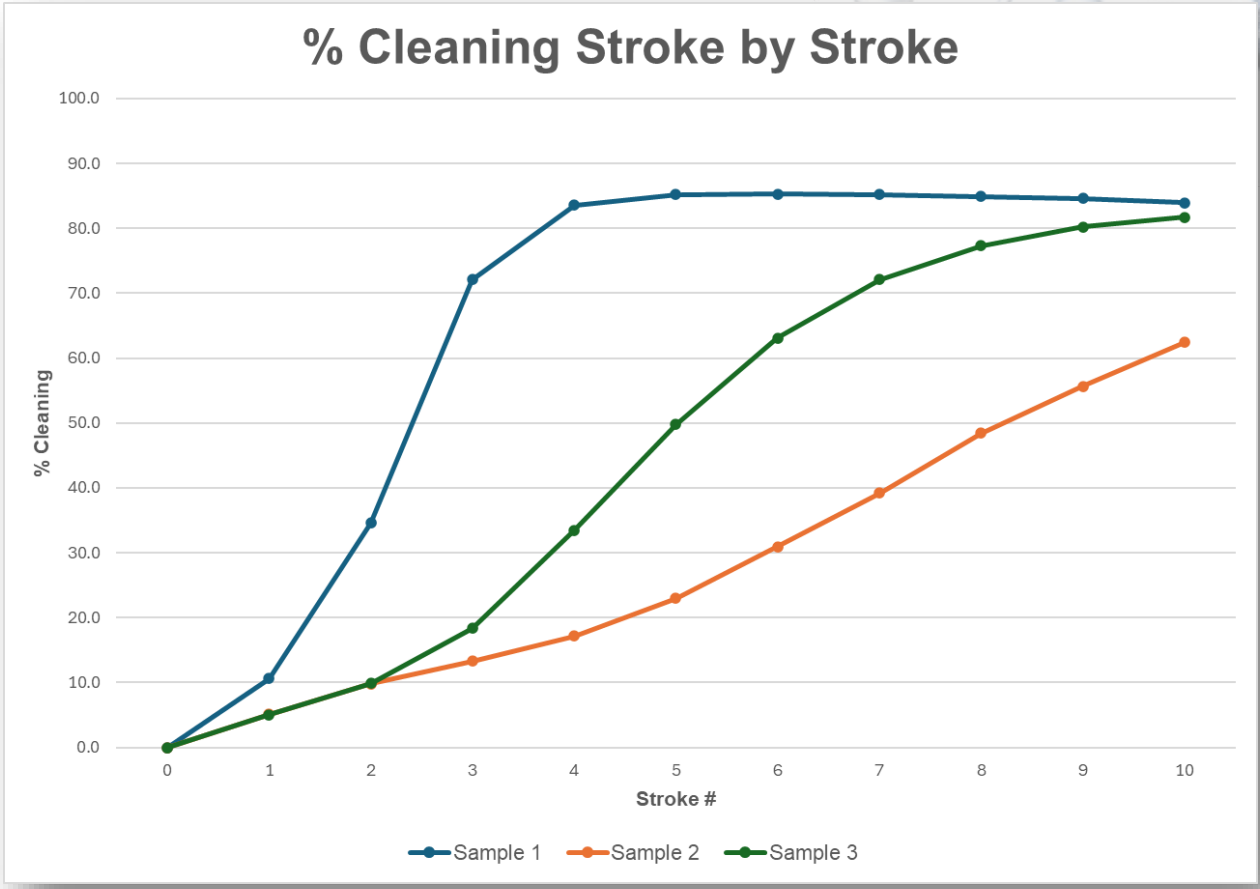
"Sample 1 has best cleaning performance"

Video Analysis

Video Analysis – Manual Process

- Luma values for each frame of video
- Manually select each cleaning stroke peak
- Manually enter values into excel template
- Excel template calculates % Cleaning
- Stroke by stroke cleaning curve
    - Speed of cleaning

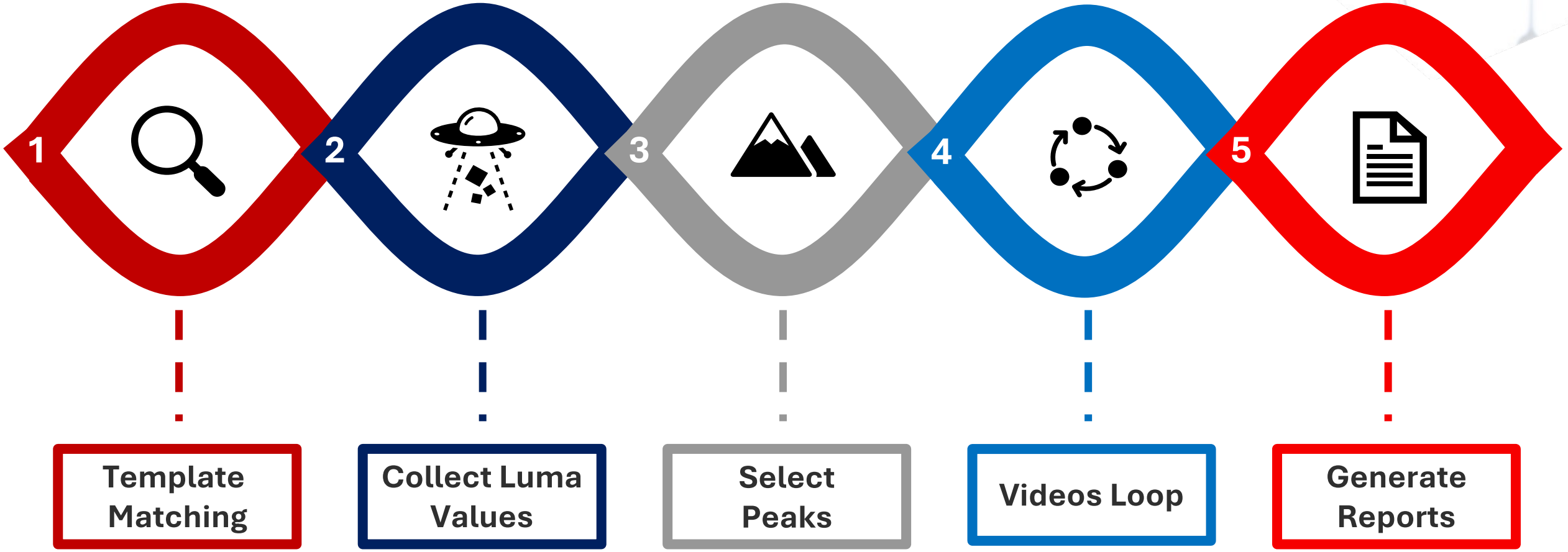
Huge Leap Forward in 2011!
Stepan was first to develop this stroke by stroke method



Sample	0	1	2	3	4	5	6	7	8	9	10
Sample 1	0.0	10.6	34.6	72.1	83.6	85.2	85.3	85.2	84.9	84.6	83.9
Sample 2	0.0	5.1	9.8	13.3	17.1	23.0	31.0	39.2	48.4	55.6	62.4
Sample 3	0.0	5.1	9.9	18.3	33.5	49.8	63.1	72.1	77.3	80.2	81.7

"Sample 1 has best cleaning performance"

Automated Cleaning Analysis

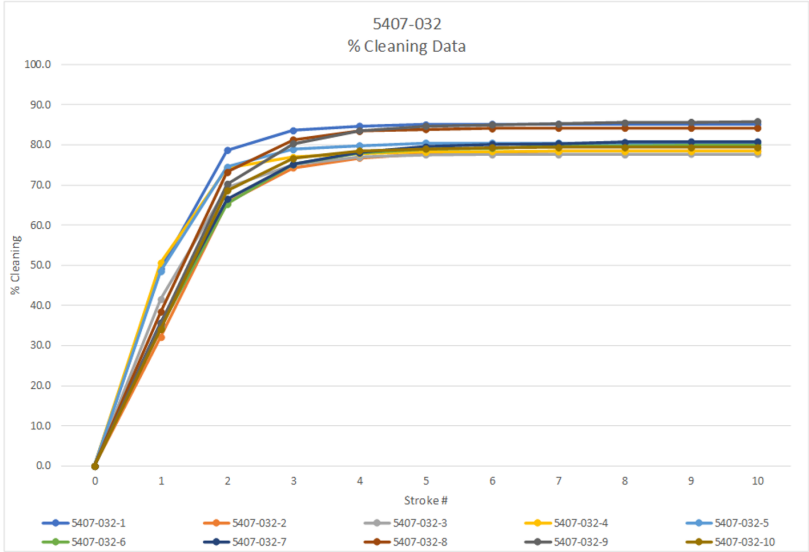


Generate Reports

% Clean Summary

Sample	1	2	3	4	5	6	7	8	9	10
5407-032-1 Run 1	34.2	78.8	84.9	85.5	86.6	86.5	86.7	86.8	86.4	86.1
5407-032-1 Run 2	56.4	81.1	84.6	85.7	86.1	86.1	86	86	86	85.7
5407-032-1 Run 3	57.6	78.9	82.2	83.2	83.4	83.1	83	82.8	82.8	82.2
5407-032-2 Run 1	29.4	61.4	70.8	73.3	74.9	75.5	75.6	76	76	75.8
5407-032-2 Run 2	30.2	63.2	71.4	74.2	75.1	75.1	75.6	75.6	75.3	75.4
5407-032-2 Run 3	33.6	72.7	82.2	84.3	85.3	85.8	85.7	85.8	85.6	85.2
5407-032-3 Run 1	40.4	66.4	72.6	74.6	75.6	75.8	75.7	75.6	75.8	75.6
5407-032-3 Run 2	34.7	64.9	70.4	72.7	73.4	73.3	73.4	73.4	73.4	73.4
5407-032-3 Run 3	52.2	80.9	85.6	86.6	86.5	86.6	86.6	86.5	86.5	86.5
5407-032-4 Run 1	43	76.5	79.6	79.8	80.3	80.2	80.5	80.2	80.5	80.4
5407-032-4 Run 2	52.6	76	80.1	80.9	80.7	81.3	81.1	81	80.9	81
5407-032-4 Run 3	46.1	73.7	76.6	77.3	77.7	77.6	77.4	77.4	77.4	77.6
5407-032-5 Run 1	44.3	75.7	79.7	80.3	81.1	80.6	80.9	80.6	80.4	80.2
5407-032-5 Run 2	59.5	81.1	84.6	85.3	85.2	85.2	85.2	84.9	84.6	84.6
5407-032-5 Run 3	39.5	76.1	82.2	83.4	84.2	84.1	84.1	83.7	83.8	83.6
5407-032-6 Run 1	35.3	71.8	80.1	82.3	82.9	83.3	83.6	83.7	83.8	83.8
5407-032-6 Run 2	46.8	77.7	82.5	83.7	84.2	84.1	84	83.8	84	83.8
5407-032-6 Run 3	19.1	51.6	67.2	72.5	74.3	75.1	75.7	75.8	75.9	75.8
5407-032-7 Run 1	26	63.4	72.6	75.3	76.1	76.5	76.6	76.3	76.6	76
5407-032-7 Run 2	58	81.2	87.3	88.5	89.3	89.6	89.4	89.3	89.3	89.3
5407-032-7 Run 3	24.1	61.4	72.4	77	79.6	80.7	81.1	82.1	82.1	82.6
5407-032-8 Run 1	20.3	65.1	77.5	80.1	80.6	81.1	80.9	81	80.8	80.8
5407-032-8 Run 2	56.2	81.3	85	86	85.9	86.3	86.1	86	86.1	86.1
5407-032-8 Run 3	28.1	71.9	81.9	84.4	84.8	85	85	84.8	84.9	84.4
5407-032-9 Run 1	29.2	66.3	78.8	82.7	82.9	83.4	83.6	83.7	83.5	83.6
5407-032-9 Run 2	41.7	74.5	82.7	85.9	86.9	87.2	87.7	88	88.1	88.1
5407-032-9 Run 3	23.2	67.4	81.5	85.7	87.2	87.8	87.8	88.3	88.3	88.8
5407-032-10 Run 1	28.4	65.2	71.5	72.2	72.4	72.9	72.3	72.3	72.1	72.1
5407-032-10 Run 2	61.6	85.1	87.9	88.4	88.6	88.4	88	87.8	87.6	87.4
5407-032-10 Run 3	12.7	57	71.9	75.6	76.7	77	77	77	76.9	76.6

Averages Summary



Sample	Trials	0	1	2	3	4	5	6	7	8	9	10
5407-032-1	3	0.0	49.1	78.7	83.6	84.6	85.1	85.2	85.2	85.2	85.2	85.2
5407-032-2	3	0.0	32.2	65.6	74.3	76.7	77.8	78.2	78.4	78.5	78.5	78.5
5407-032-3	3	0.0	41.5	69.4	75.1	77.0	77.6	77.6	77.6	77.6	77.7	77.7
5407-032-4	3	0.0	50.6	74.3	76.9	77.8	78.2	78.4	78.4	78.4	78.4	78.4
5407-032-5	3	0.0	48.5	74.5	78.9	79.8	80.4	80.4	80.4	80.4	80.4	80.4
5407-032-6	3	0.0	34.6	65.3	75.2	78.0	79.0	79.2	79.8	79.8	79.9	80.0
5407-032-7	3	0.0	35.7	66.5	75.1	78.1	79.6	80.1	80.3	80.7	80.7	80.8
5407-032-8	3	0.0	38.4	73.2	81.2	83.5	83.9	84.1	84.2	84.2	84.2	84.2
5407-032-9	3	0.0	35.4	70.2	80.3	83.5	84.7	85.0	85.2	85.6	85.6	85.8
5407-032-10	3	0.0	34.1	68.6	76.6	78.5	79.0	79.3	79.4	79.4	79.4	79.4

Analysis Time Reduced by

99.6%

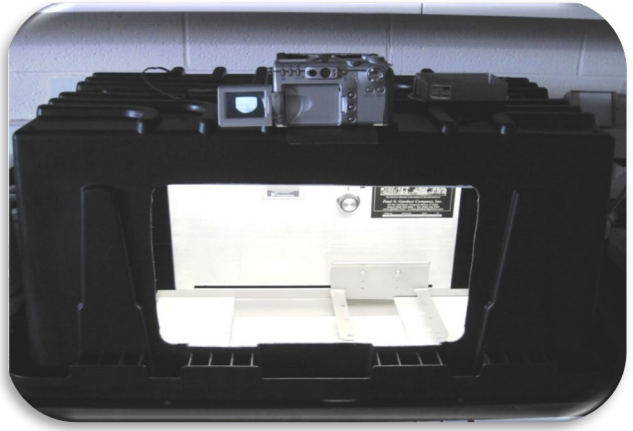
Testing Capacity Increased by

30%

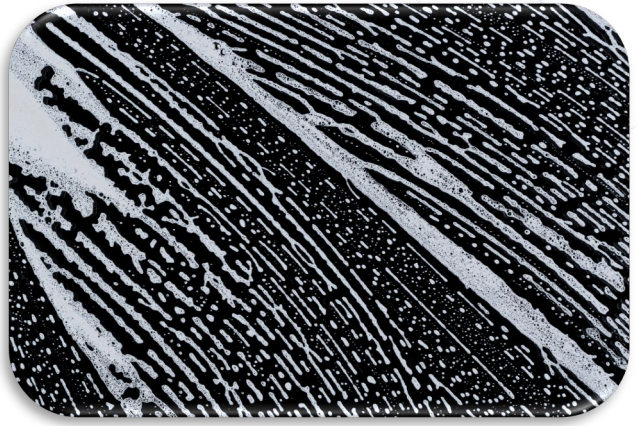
HSC Lab Capabilities

Formulation Support

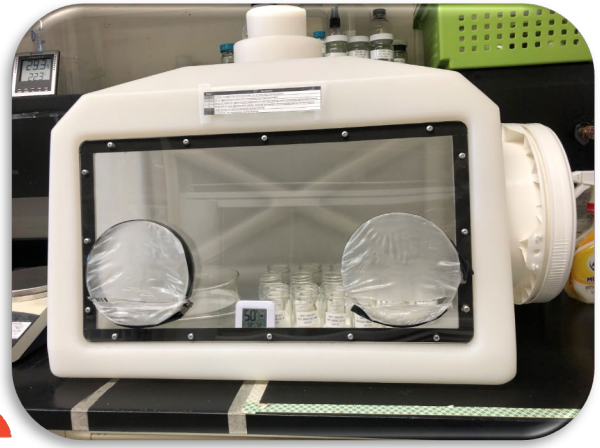
Gardner Cleaning with Automated Analysis



Film Streak



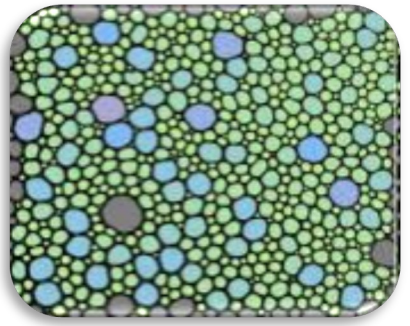
Humidity Chamber



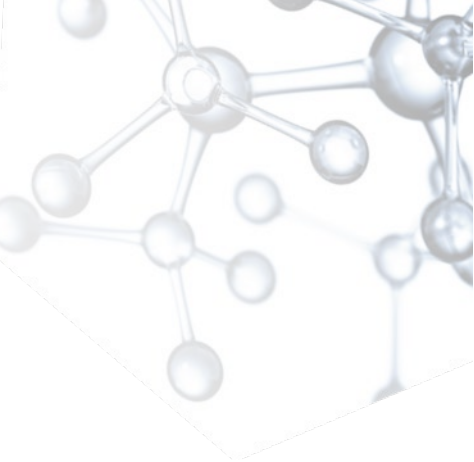
Surface Energy Analysis

Analytical Methodologies

Foam Morphology



Agenda



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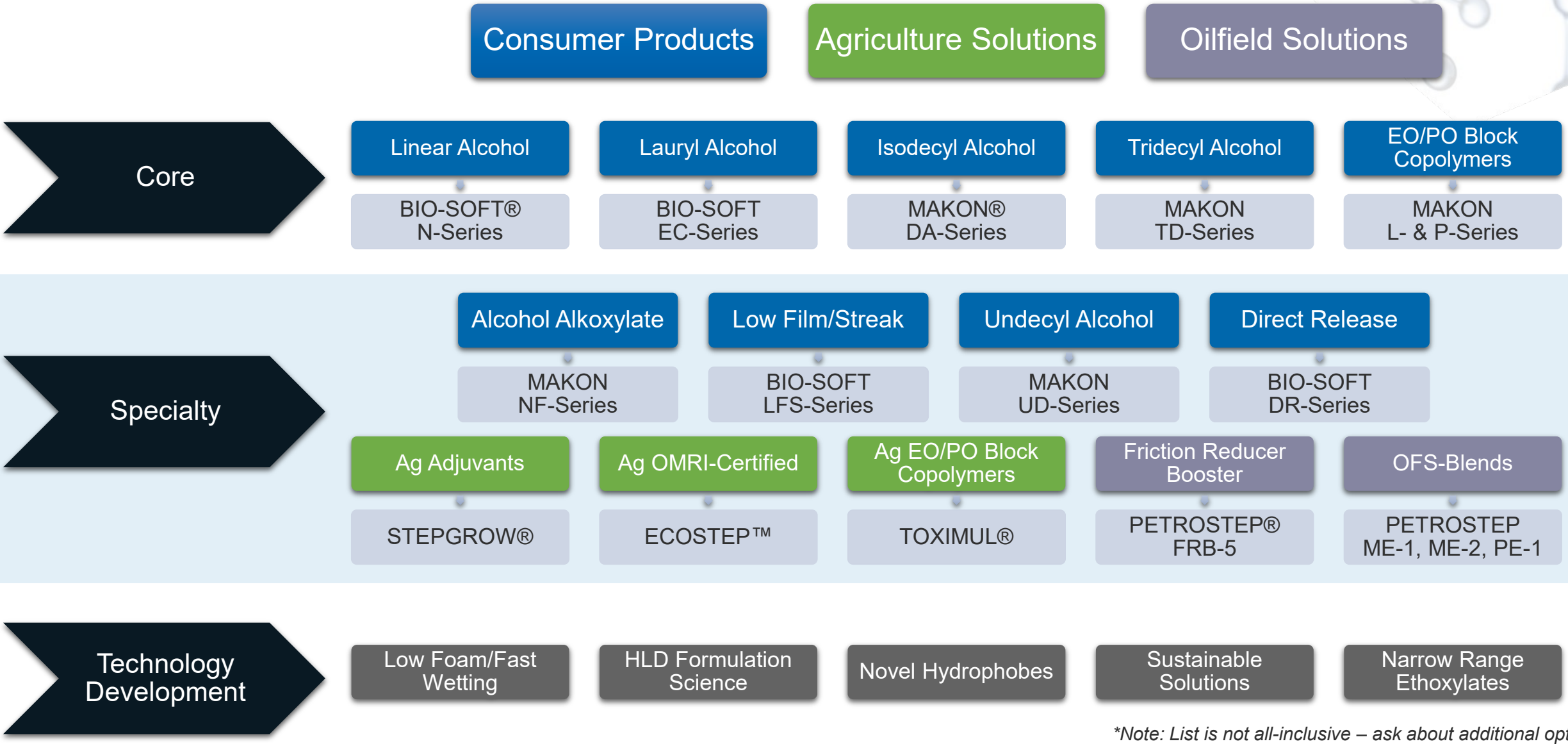
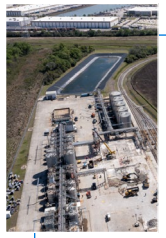
Product Line Highlights



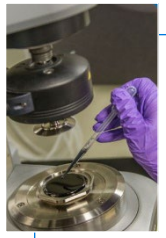
*Note: List is not all-inclusive – ask about additional options

Stepan as a Strategic Supplier in Nonionics



Expanding Network Capabilities

Product Portfolio



Surfactant Science

Customer Support

New State-of-the-Art Facility Dec 2024

Three Manufacturing Facilities

Four NA Packaged Warehouses

Improving Logistical Capabilities

Lab-Scale and Pilot-Scale Alkoxylation

Dedicated Alkoxylate Product Development R&D

200+ Products Across Many Hydrophobes; EO & PO Capabilities

Alkoxylation Plant Capabilities

Millsdale, IL

- EO & PO Capability
- Multiple Reactors
- On-Site Blending
- On-Site Packaging
- On-Site Warehousing

Winder, GA

- EO & PO Capability
- Dual Loop Reactor
- On-Site Blending – Functional Blends
- Ag Greenhouse

Pasadena, TX

- Startup Dec 2024
- EO & PO Capability
- 75 KTA Capacity
- Capacity Available for Growth
- State-of-the-Art Reactor Technology
- Filtration Capabilities
- Solid Catalyst Addition
- Rail & Truck Access
- Increased Storage Capabilities
- Site Expandability & Flexibility

Stepan

Thank you!

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