The Chemistry of Membrane Cleaning

International Products CORPORATION
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Company Overview

International Products Corporation (IPC), incorporated in 1923, manufactures specialty chemicals. IPC has over 30 years experience making and selling membrane cleaners and formulated lubricants to industry.

IPC is the proud recipient of the 2013 Environmental Innovation award by the Suppliers Partnership for the Environment.

All products are manufactured in the New Jersey headquarters and are available worldwide.

International Products Corporation is an ISO 9001:2008 certified company

Company Headquarters

Distributor Locations

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The Chemistry of Membrane Cleaners Agenda

- The Mechanism of Fouling
- Cleaners' Mechanisms of Action
- Functional Groups
- Types of Surfactants
- Micelles
- Formulated Cleaners
  - Types
  - Purpose of each ingredient
- Detergency factors
- Match cleaner to soil
- Green Initiative

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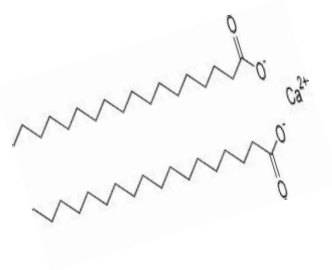
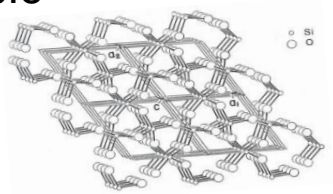
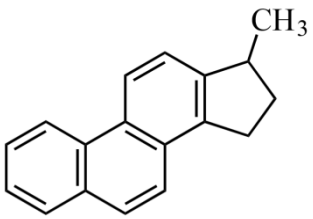
Membrane Fouling



- Mechanisms – Membranes are negatively charged
  - Hydrophobic Attraction
    - Van der Waal forces of high MW soils create a hydrophobic attraction to negative membrane surface
      - 12 to 1 rule
        - » C12 or higher and maximum of one functional group
          - Proteins, Biofilm, Natural Organic Matter (NOM), polymers



    - Electrostatic repulsion overcome by hydrophobic attraction
  - Multivalent cations attraction



    Ca^{2+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Mg^{2+}, Si^{2+} . . . .
      - Salt bridges – multivalent cations allow for a denser soil layer to coat the membrane
        - » Carbonates, Silica, Oxides, Sulfates, Inorganics
- Fouling begets fouling

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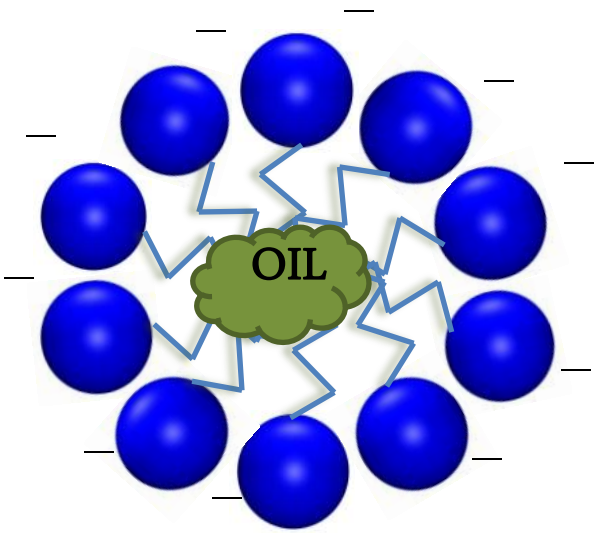
Cleaning Mechanism

- Introduce functional groups to the fouling layer
  - Creates an electrostatic repulsion from the membrane surface
    - Strong enough to displace hydrophobic attraction
  - Hydrophilic in nature
  - Polarity



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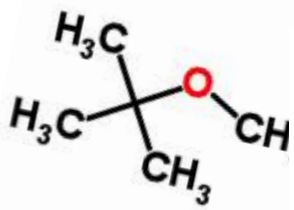
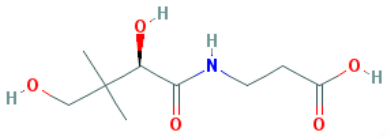
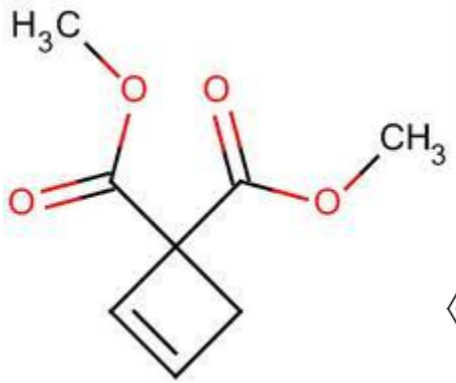
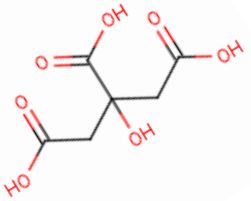
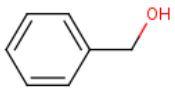
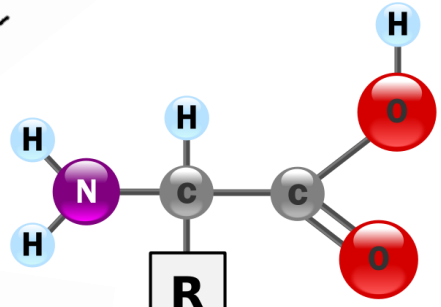
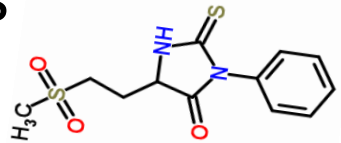
Functional Groups

- Polar, charges
- Combination of different atoms
  - Esters
  - Ethers
  - Amides
  - Amines
  - Alcohols
  - Sulfone
  - Acids
- Combination of functional groups

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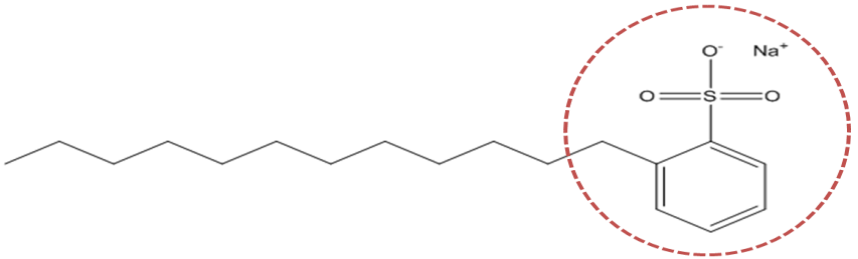
Surfactant Types

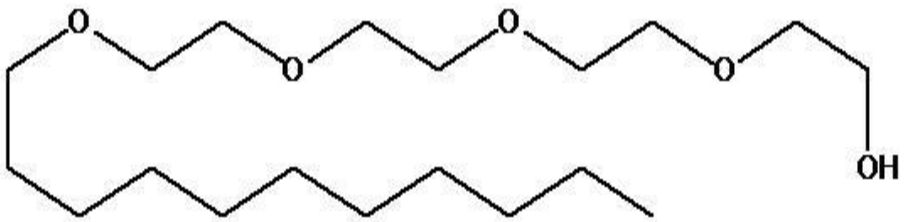
- Anionic:

  "***An*** appropriate choice"



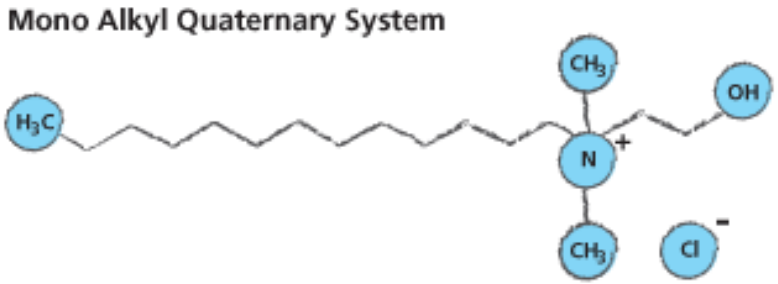
- Nonionic:

  "***No*** Problem"



- Cationic:

  "***Catastrophe!***"



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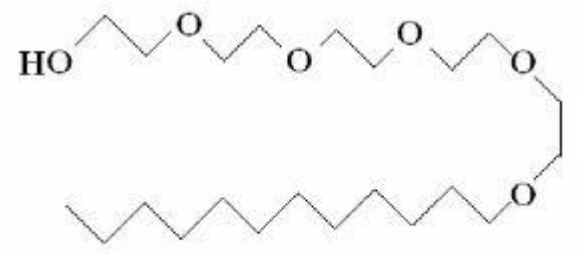
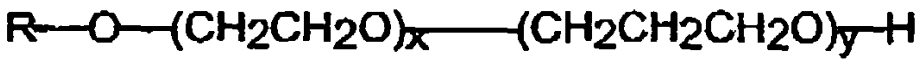
Nonionics

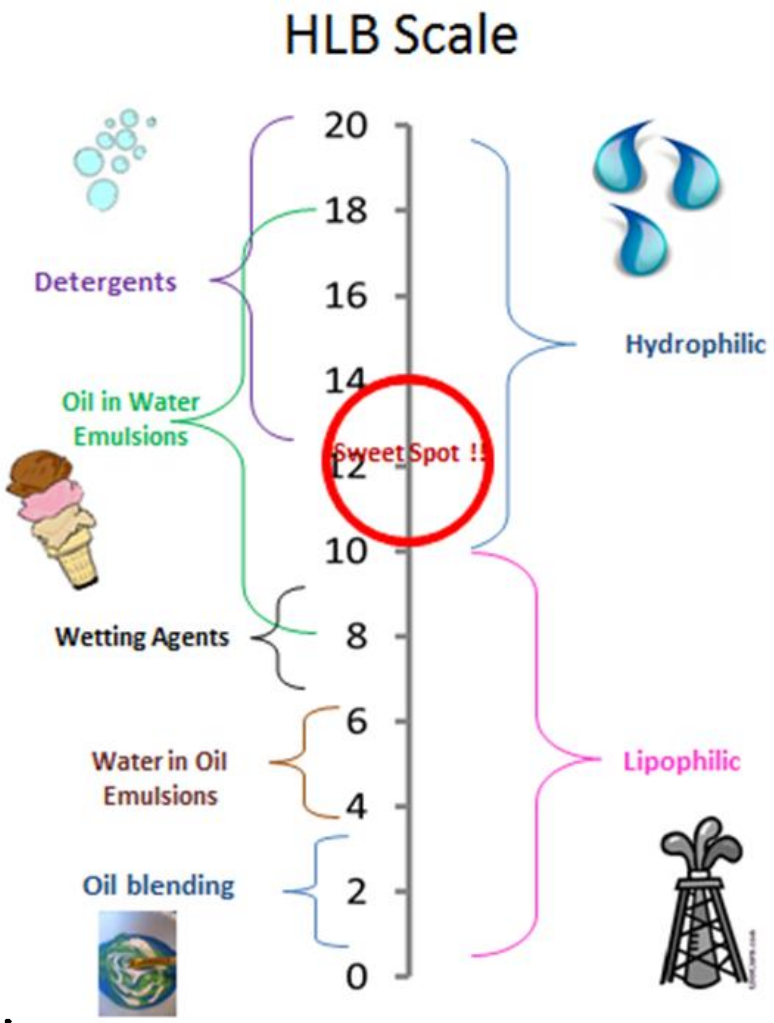
- No formal charge
- EO vs PO
- Hydrophilic – Lipophilic Balance

$HLB = 20 * (MW_{Hydro} / MW_{Total})$



Polyoxyethylene (5) lauryl ether





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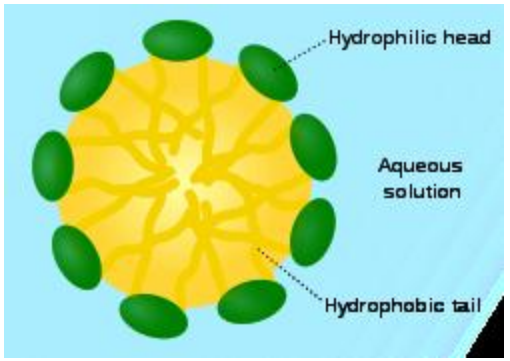
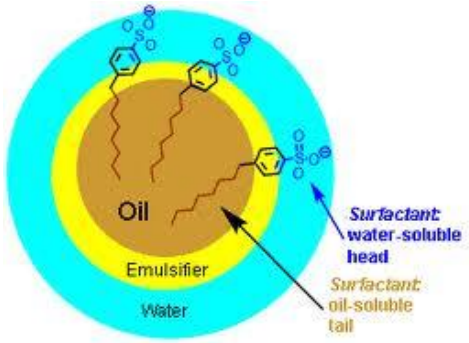
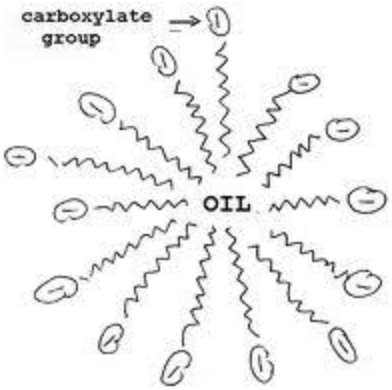
Micelles

- Orientation of surfactant around an oil droplet
- Suspends oil in water
- Different types
  - o/w
  - w/o
  - o/w/o
- CMC threshold
  - Lowest surface tension







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Typical Cleaner Formulation

- Carrier / Fillers
  - Water, sodium carbonate / sodium bicarbonate
- Builder
  - Keeps pH buffered
  - NaOH, KOH, EDTA, citric, etc.
- Anionic Surfactants
- Nonionic Surfactants
- Rust inhibitor
  - Phosphates, silicates, amines, azoles, nitrites
- Chelants, dispersants, anti-scalants
- Enzymes
- Hydrotropes

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Ingredients

INGREDIENT	PURPOSE	EXAMPLE	COMMENTS
Carrier	Filler	Water Sodium Carbonate / Sodium Bicarbonate	Reduce hazard Reduce Cost Stability
Builders	Keep pH at a certain value Ties up metals in water High pH Low pH	Sodium Hydroxide, Sodium citrate, sodium borate, potassium hydroxide, silicates, phosphates Citric acid, nitric acid, lactic acid, glycolic acid, hydrochloric acid	High pH – target foulants: organics Low pH – inorganics, metals, oxides, scale
Surfactants	Responsible for the cleaning Functional groups Lower surface tension	Anionic Nonionic (Cationic)	Unlimited choices Synergy
Hydrotropes	Allows builders and surfactants to coexist	Sodium xylene sulfonate Imidazolines	Single purpose only Some claim multi-functionality

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Ingredients (cont.)

INGREDIENT	Purpose	Example	Comments
Enzymes	Catalyze soil	Protease Amylase Lipase Cellulase	Room temperature reaction Time-consuming Delicate – need other ingredients Expensive Green
Solvents	Solubility of soil	Glycol ethers Ethanol IPA	Compatibility Issues Environmental Issues Health Issues Not common in membrane cleaners
Additives	Additional benefits	Preservatives Corrosion inhibitors Anti-Stats	

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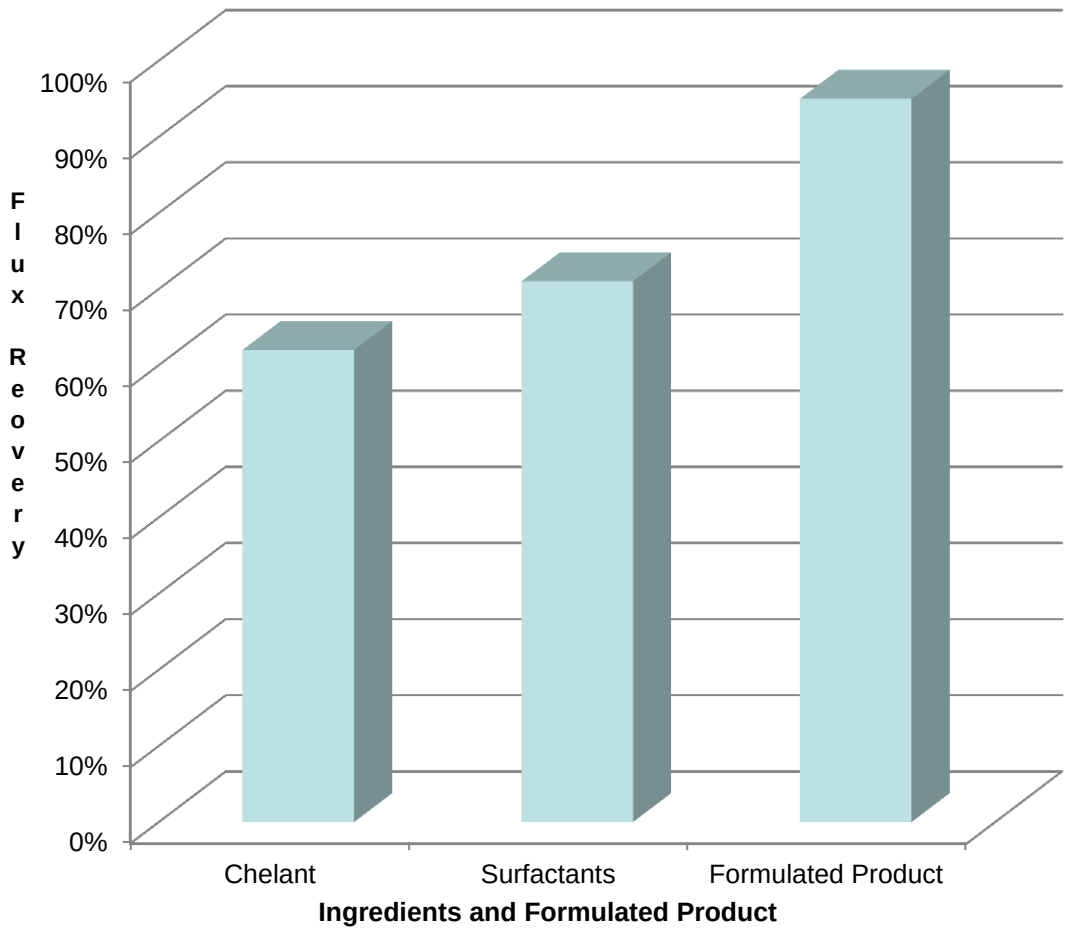
Synergy of Formulated Membrane Cleaner



1 + 1 = 3!

Conclusion :

The formulated cleaner has better results than its individual components.

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Cleaners

- Acid
  - pH < 4
- Alkaline
  - pH > 9
- Neutral
  - pH = 7 (pH 5 – 7)
- Others
  - Bleaches
  - Disinfectants

pH	Examples of solutions
0	Battery acid, strong hydrofluoric acid
1	Hydrochloric acid secreted by stomach lining
2	Lemon juice, gastric acid, vinegar
3	Grapefruit juice, orange juice, soda
4	Tomato juice, acid rain
5	Soft drinking water, black coffee
6	Urine, saliva
7	“Pure” water
8	Sea water
9	Baking soda
10	Great Salt Lake, milk of magnesia
11	Ammonia solution
12	Soapy water
13	Bleach, oven cleaner
14	Liquid drain cleaner

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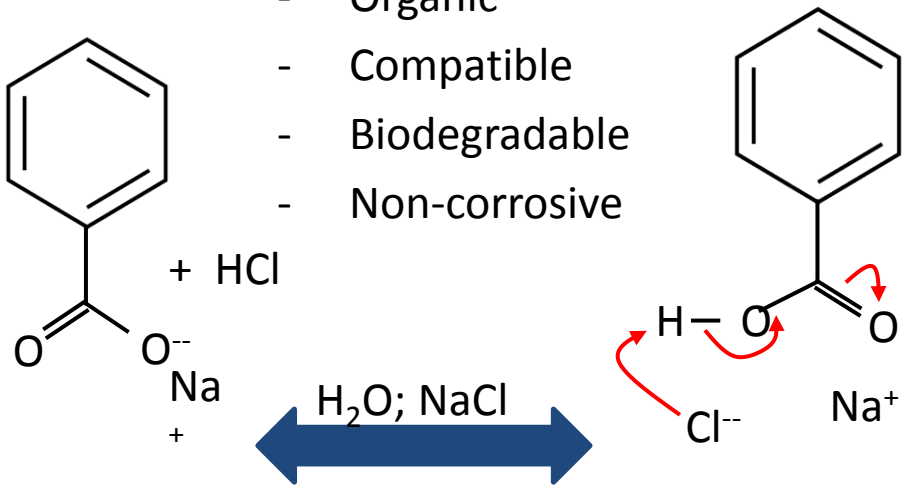
Alkaline and Acid

Alkaline Cleaners

- pH > 9
- Effective against oils and greases
- Surfactants and Builders
  - Anionic and nonionic surfactants
    - Dissolve/emulsify oils and greases
  - Builders and alkalinity
    - Improves detergency
    - Improves water quality
    - Allows surfactants to work better
    - Contributes to carbonate scale

Acid Cleaners

- pH < 4
- Effective against metals *(iron, calcium, magnesium),* oxides, inorganics, scale
- Citric Acid
  - Safe choice of acid
    - Organic
    - Compatible
    - Biodegradable
    - Non-corrosive



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Detergency Factors

- Water Quality
- Cleaning Time
- Concentration
- **Temperature**
- Agitation
- Sequence
- Match cleaner to soil

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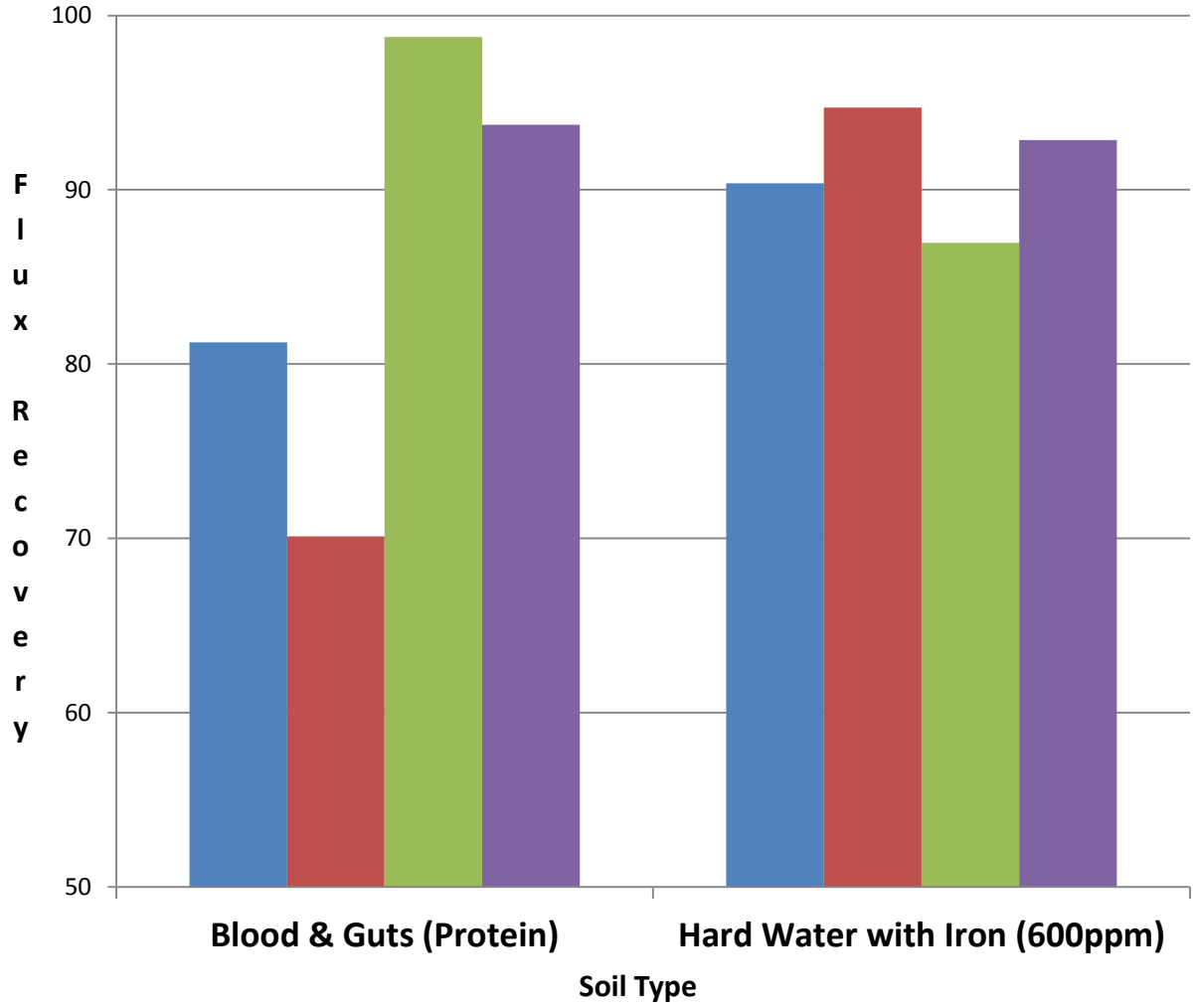
Match Cleaner Soil to Type



Conclusion:

It is important to match your cleaner to your soil – different cleaners perform better on different soils.

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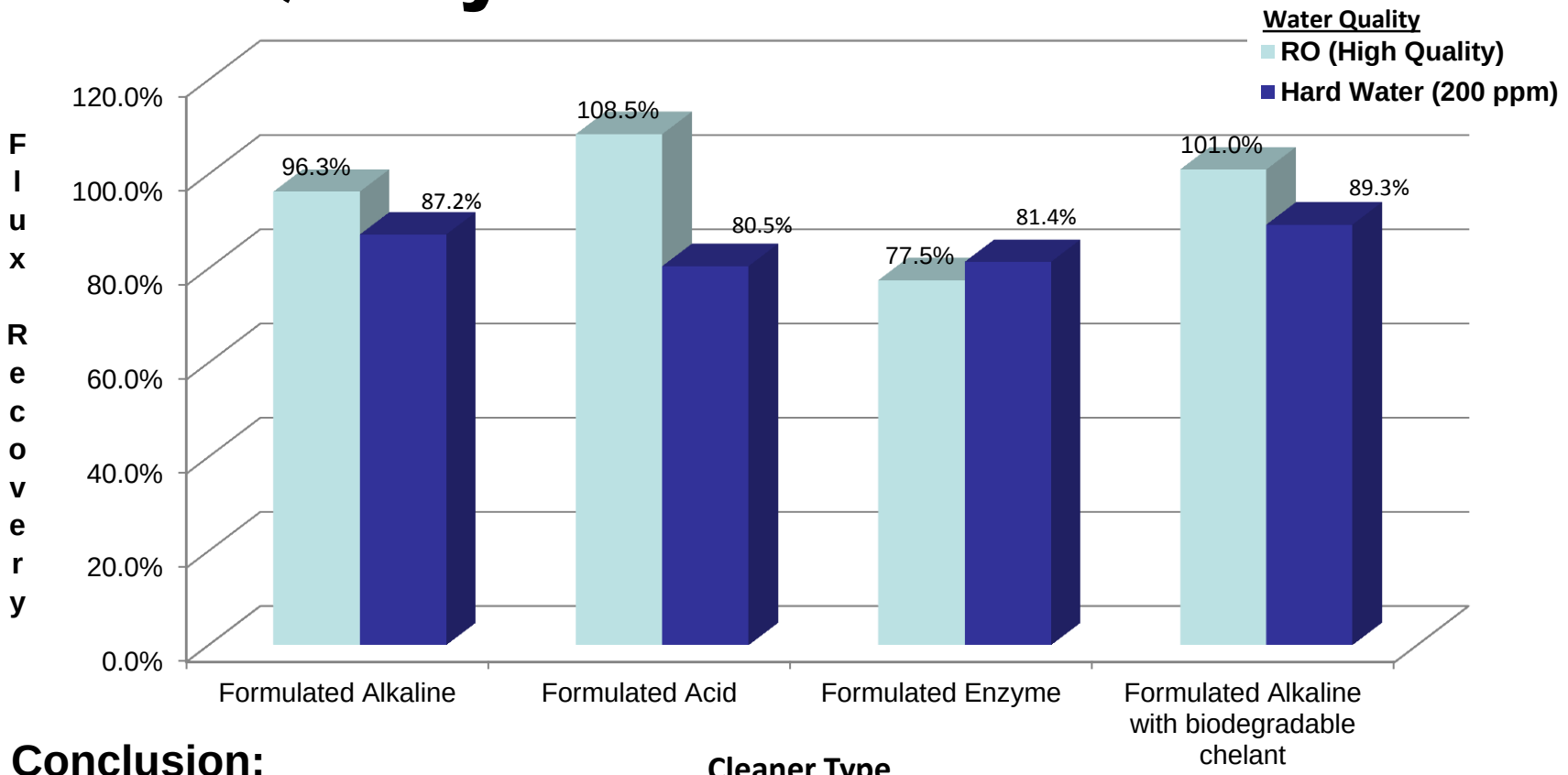
Flux Recovery by Cleaner Type and by Water Quality



Conclusion:

1. Water quality affects detergency.
2. Match cleaner to soil

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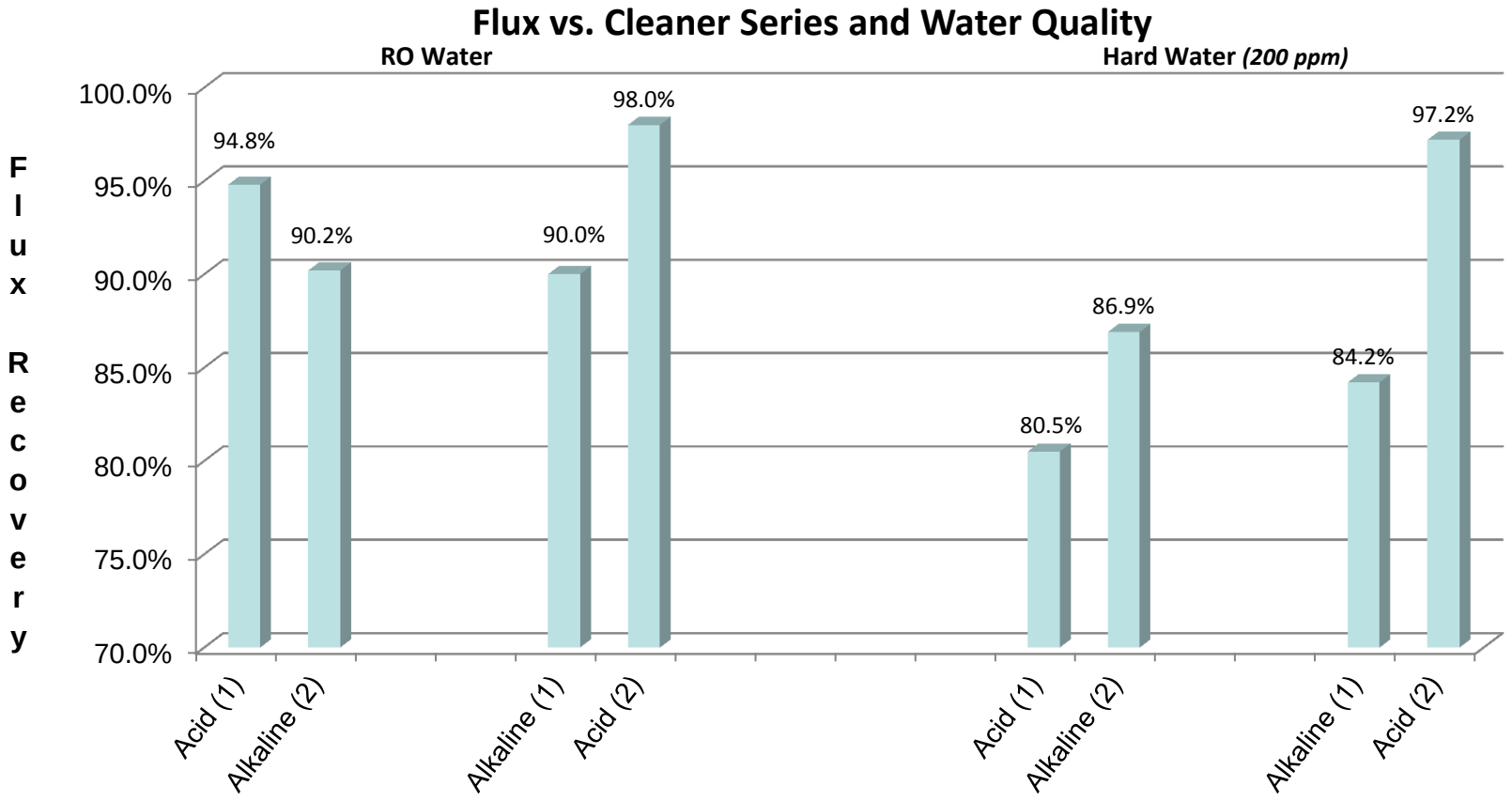
The Effects of Using Cleaners in Series



Conclusion:

1. Water quality affects flux.
2. Alkaline followed by acid is best in this trial.

What's Next?

- Optimal concentration of cleaners

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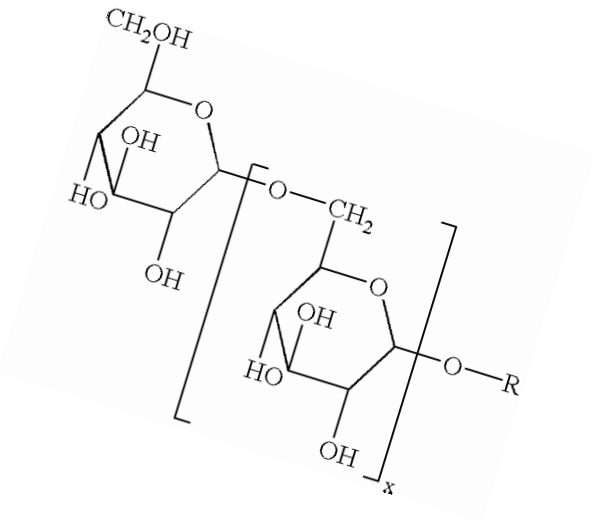
Green Initiative

- Shift to renewable ingredients
  - No petroleum, tallows
  - Palm, Castor, Coconut oils,
  - Sugar-based Surfactants
  - Enzyme technology
- Biodegradability
  - EDTA and its salts
- Corn-derived Ethanol
- Phosphates, Boric acid, Mineral acids
- Milder pHs
  - Acid Cleaner: pH 3.0
  - Alkaline Cleaner: pH 10.5
- REACH driven



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Membrane Cleaning

- Still only considered a “Polishing”
- Preventive Maintenance is key
  - High surface area of membranes
    - Infinite number of adhesion areas
      - Can never be completely cleaned

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