CLEANING INNOVATION

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SP Technical Research Institute of Sweden

RI. SE INSTITUTES

10:45 Kemi

Hur fungerar egentligen de olika kemikalierna i rengöringsmedel?

- Mikael Kjellin från SP och
- Anders Karlsson, NOVADAN

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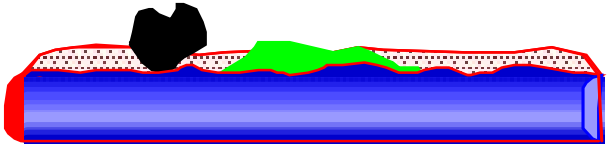
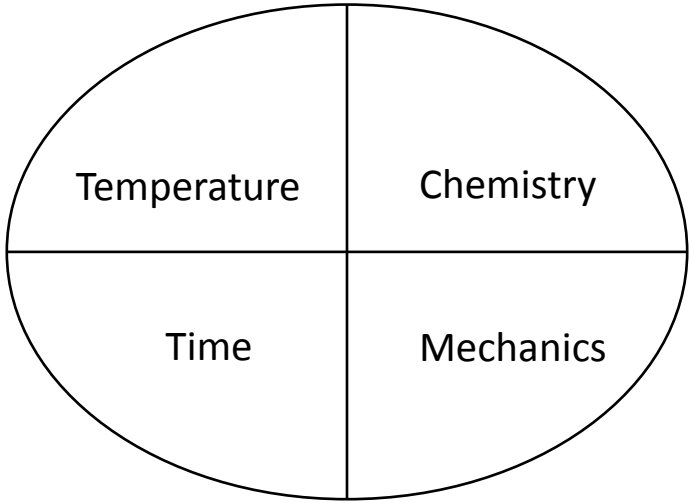
Important parameters for Cleaning



- Temperature
- Time
- Mechanical energy
- Chemistry. Concentration of active substances
- The 4 factors are excheangable, e.g. for shorter time increase the temperature. However be aware of surface corrosion.



Sinner's circle
Factors that effect the cleaning result.

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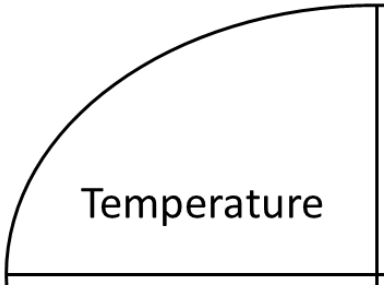
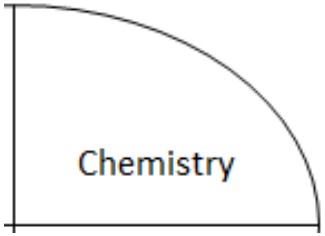
Temperature

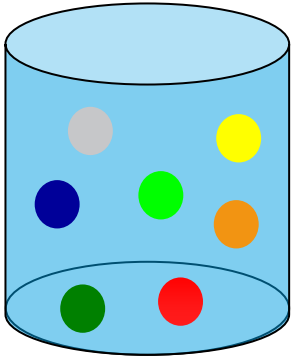


- Reduced viscosity of soil at higher temperature
- Proteins denature at high temperatures, and adhere tenaciously to surfaces. May build up in layers making it more difficult to remove.
- Cleaning effect of ingredients may be temperature dependent.
  - Surface tension and adsorption
  - Solubilisation

2. Chemical ingredients in cleaning formulations and their function.
Water based cleaning solutions are complex systems



- Alkaline salts, acids
- Complexing agents
- Corrosion inhibitors
- Hydrotropes
- Surfactants
- Antiredeposition agents
- Enzymes
- Antifoaming agents
- Biocides



Water quality:
Water hardness (calcium and magnesium salts) can interfere with chemicals used to remove soils.
Other materials may leave deposits on surfaces – barium sulfate, silica, iron.

Alkaline salts

- Increases pH
- Hydrolyze the dirt such as fats, proteins
- Impurities and surfaces are often negatively charged at high pH → electrostatic repulsion

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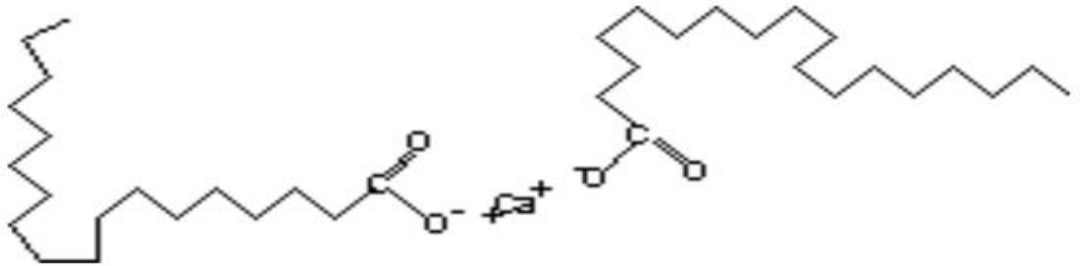
Complexing agents

- Reacts with hard ions to eliminate them from the solution
- Protects the surfactant from hard ions
- Reduces formation of calcium soaps from the saponification of fats
- Reduces precipitation



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Corrosion inhibitors

- Adsorbing onto the surface and protects
- Reduces the attack on metallic surfaces, stainless steel
- Example
  - Silicates, Phosphates, Phosphonates

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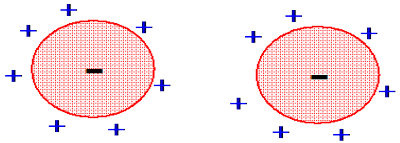
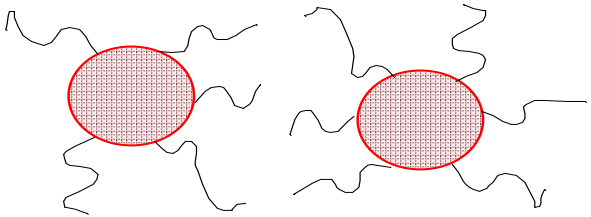
Antiredeposition agents

- Prevents redeposition av dispersed soil
- Gives rise to electrostatic repulsions
- Gives rise to steric repulsions
  - Phosphate
  - Citrate
  - Silicate
  - Polymers





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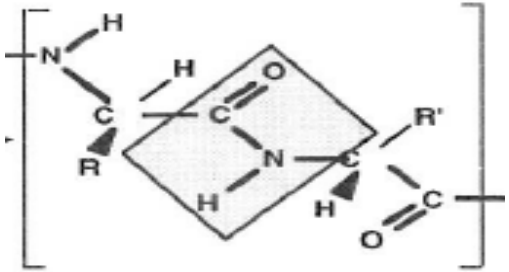
Enzymes

- Breaks down proteins, carbohydrates, fats
  - Protease (often reduces foaming due to reduction of surface active proteins
  - Amylas, Cellulas
  - Lipas (not as important as high pH)



Polypeptide chain

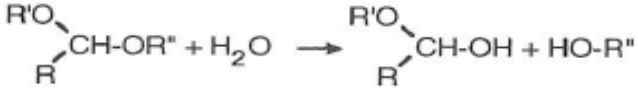
Proteases catalyze hydrolysis of peptide (amide) bonds

$$\text{R-CO-NH-R'} + H_2O \longrightarrow \text{R-COOH} + H_2NR'$$

Lipases catalyze hydrolysis of ester (triglycerides) bonds

$$\text{R-COOR'} + H_2O \longrightarrow \text{R-COOH} + \text{HO-R'}$$

Amylases and cellulases catalyze hydrolysis of acetals to hemiacetals

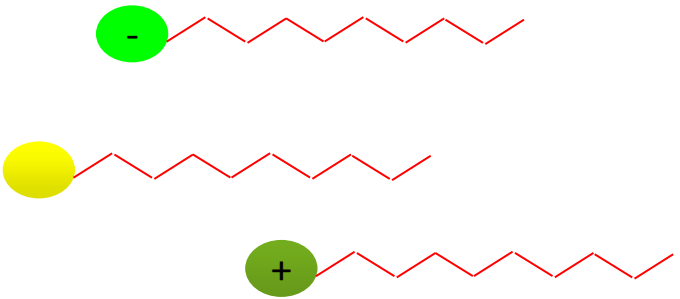


Hydrotropes

- Used to breaking down the liquid crystalline phases in the formulation
- Increase the solubility of organics in water
- Examples
  - Ethanol
  - Isopropanol
  - Glycol ethers
  - "Short-chain surfactants“-Ionic and anionic surfactants with short-chain hydrophobic part

Surfactants

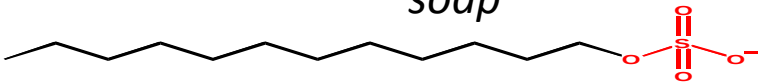
- Reduces surface tension
- Reduces interfacial tension between the soil and the cleaning solution.
- Improves wetting, i.e. makes the cleaning solution come into contact with the soil.
- Removes fat and soil.
  - Emulsification
  - Solubilisation



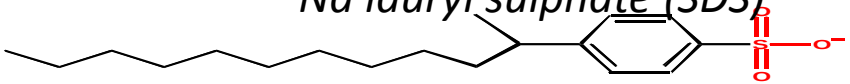
Anionic surfactants

- Largest group of surfactants. Cheapest.
- Sensitive to electrolytes (salt and Ca^{2+})
- Alkylether sulphates, lower cmc, compatible low pH and high hardness. Milder than other anionics.
- Phosphate esters; good wetting agents, corrosion inhibitors, antistatic properties

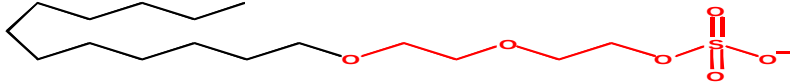
soap



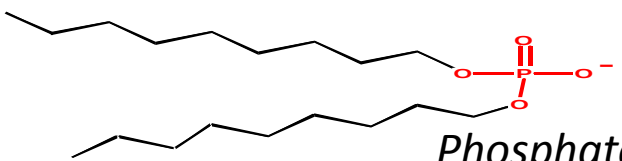
Na lauryl sulphate (SDS)



Linear alkyl benzene sulphonate (LABS)



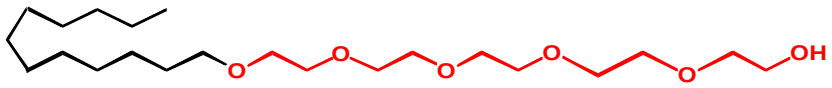
Alkyl ether sulphate



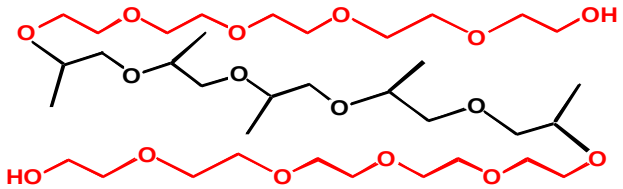
Phosphate ester

Nonionic surfactants

- Second largest group of surfactants
- Dominated by polyoxyethylene products
- Temperature sensitive: water solubility reduced at higher T
- Efficient at low concentrations
- Less sensitive to ionic strength and hard ions, Ca^{2+}.
- Insolubility temperature called cloud point (dependent on concentration and solvent).



Alkyl ethoxylate (AE, CxEy)



EO-PO blockpolymer

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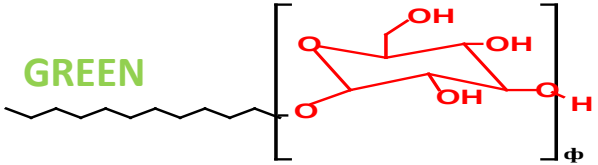
“New” nonionic/ionic surfactants

Development pushed by demands on
-low toxicity
-high biodegradability

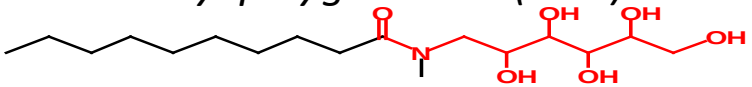
-additional functions (reactivity, inhibitors, desinfectant, hydrotropes..):

“MULTIFUNCTIONAL”

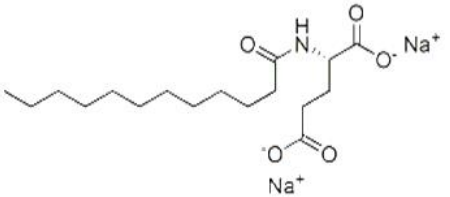
GREEN



Alkyl polyglucoside (APG)



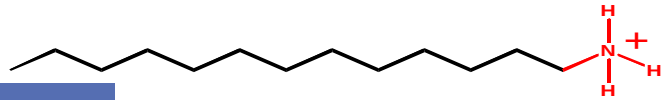
Alkyl glucamide



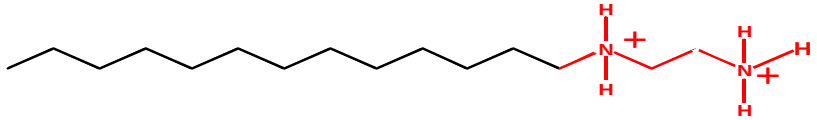
Sodium Cocoyl Glutamate /
Sodium Lauroyl Sarcosinate

Cationic surfactants

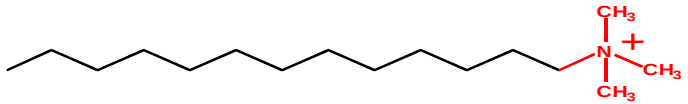
- Composed of a aminogroup as cationic head
- Adsorbs strongly to many surfaces, which often are negatively charged
- Used to modify a surface properties:
  - Textile softener
  - Hair conditioner
  - Adhesion promoter
  - Corrosion inhibitor
- Not compatible with anionic surfactants
- Often bactericidal



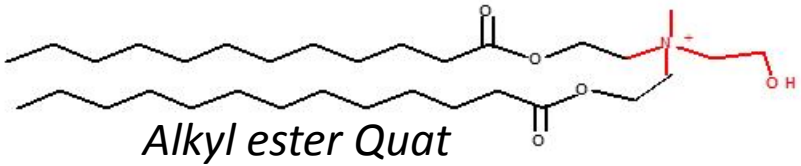
Alkyl amine salt



Alkyl diamine salt



Alkyl trimethyl ammonium salt (Quat)



Alkyl ester Quat

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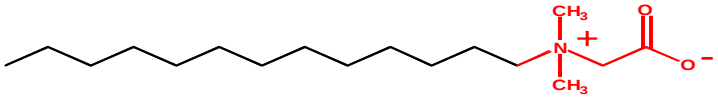
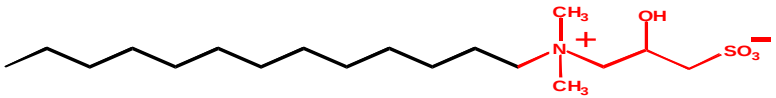
Zwitterionic surfactants

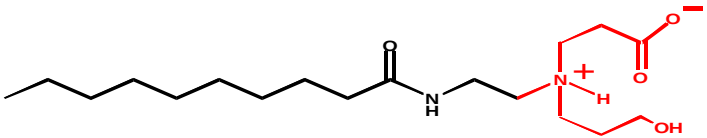
- Smallest group of surfactants
- Charge depends on pH
- Very mild and low irritation, used in shampoos etc.



Alkyl betaine



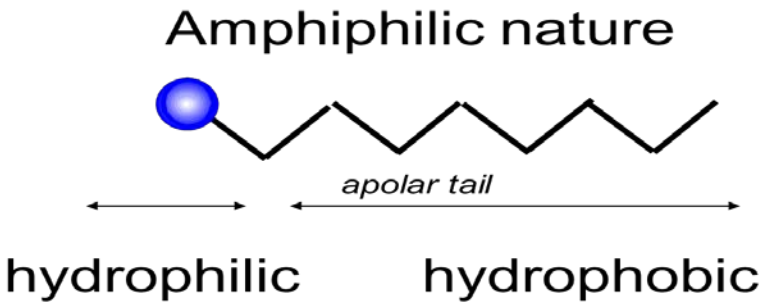
Alkyl sulphobetaine



Alkyl imidazoline

Classification of surfactants

1. HLB, Hydrophilic, Lipophilic Balance

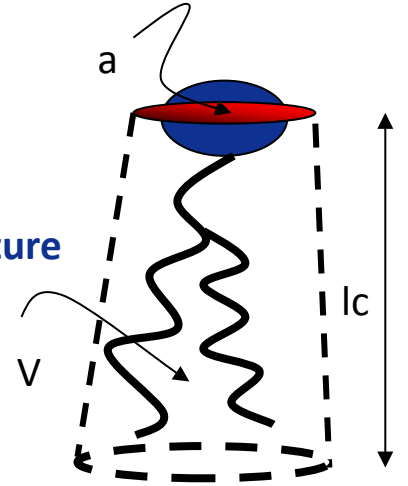


HLB	Appearance in aq.	Applications
1 - 3	No dispersibility	Dispersant in oil media
3 - 6	Poor dispersibility	W/O emulsifier
6 - 9	Milky dispersion	Wetting agent
9 - 14	Translucent solution	O/W emulsifier, detergent
14 - 20	Clear solution	Dispersant

2. CPP, Critical Packing Parameter

$$CPP = \frac{V}{a\, l_c}$$

CPP>1 for this structure



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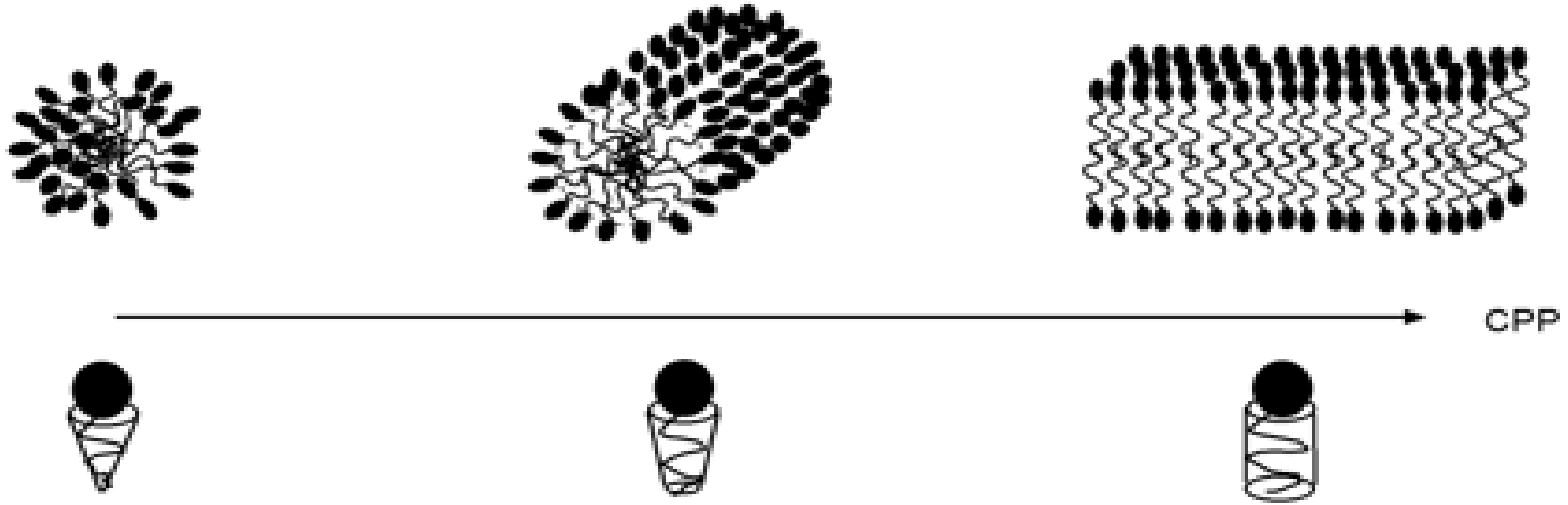
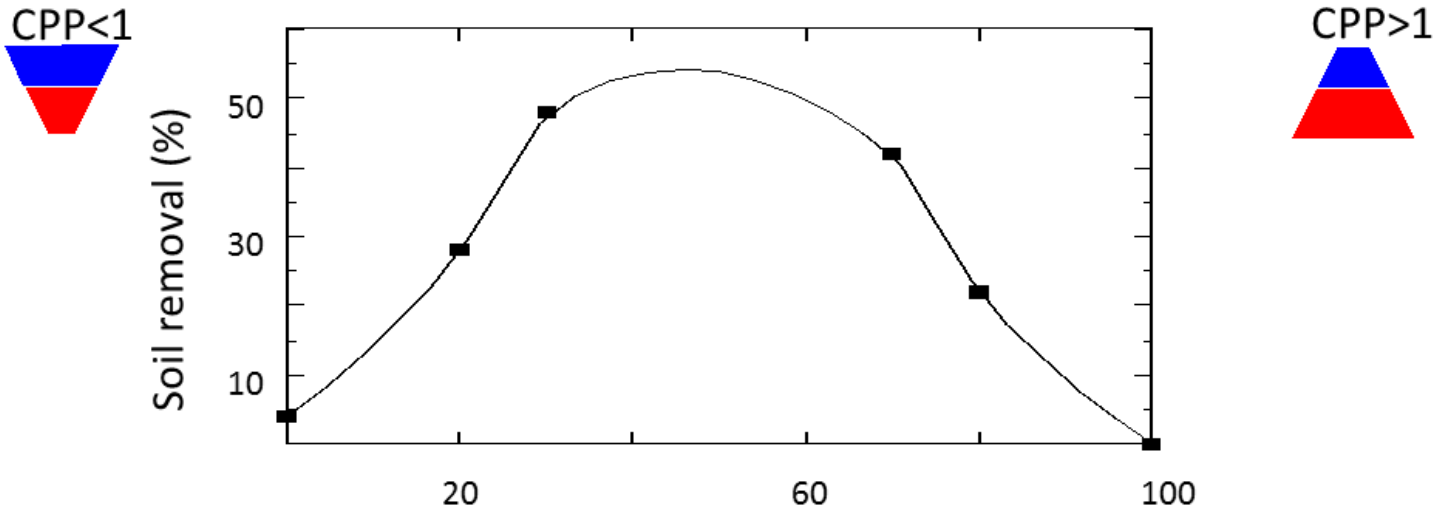
CPP determines aggregation in solution and surfaces. And also the cleaning effect.



Micelles: CPP < 1/3 Hexagonal: 1/3< CPP <1/2 Lamellar: CPP ≈ 1

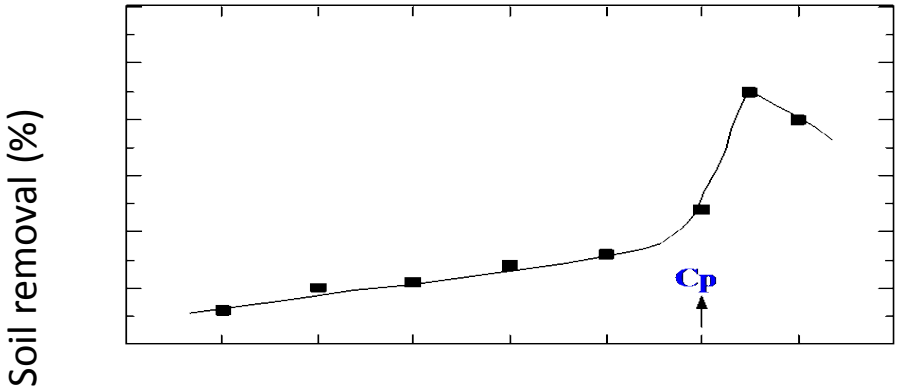
Critical packing parameter of the surfactant/surfactant mixture



Removal of oily soil as a function of percent $C_{12}E_4$ in a mixture with octylbenzene sulfonate.

Cleaning with single surfactant systems

- Cleaning efficiency is correlated with the cloud point of the surfactant



Removal of tripalmitin from PVC surface by 0.05 wt% $C_{12}E_6$.

Removal of tripalmitin from PVC by 0.05wt% $C_{12}E_6$.

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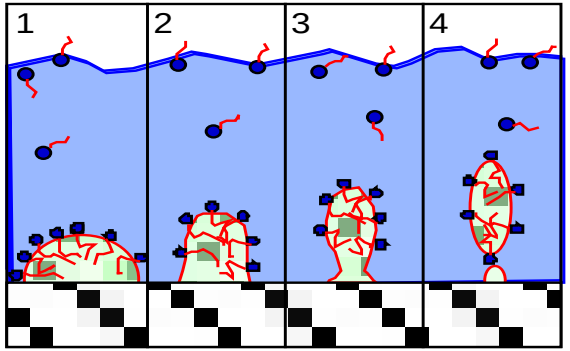
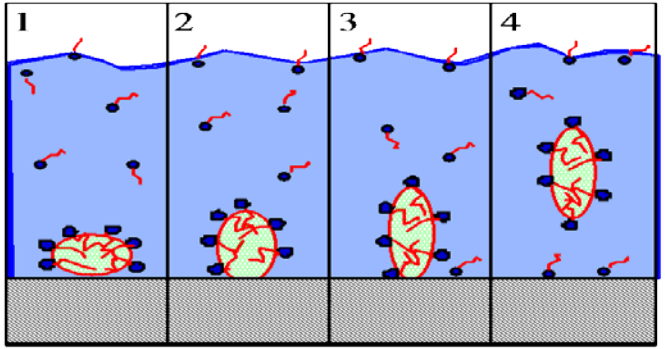
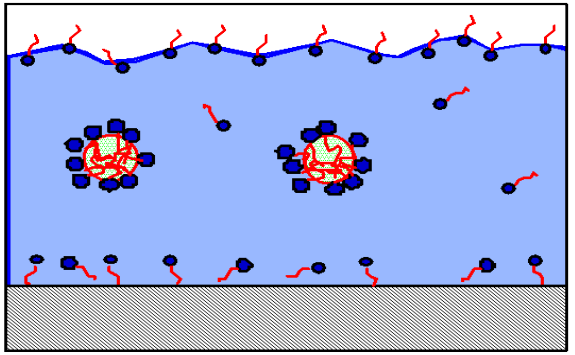
Cleaning mechanisms. Three major types.



Emulsification



Rolling-up



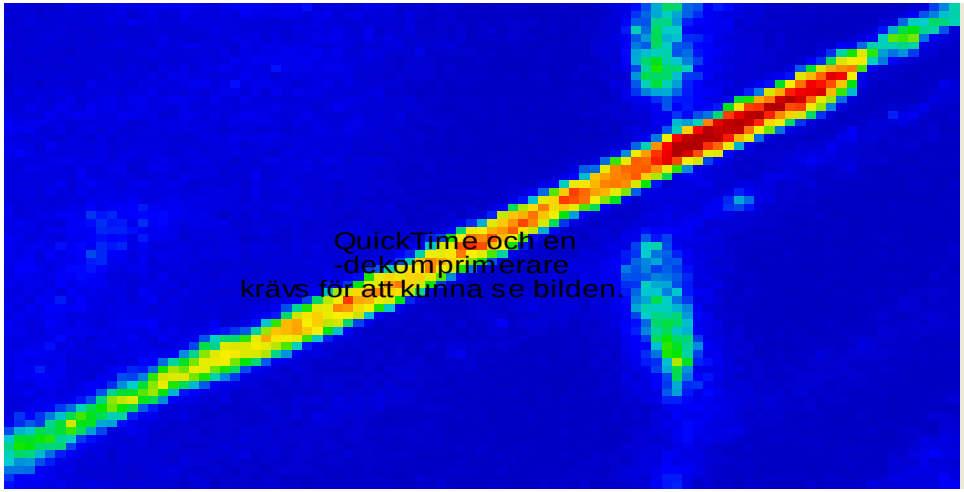
Solubilisation

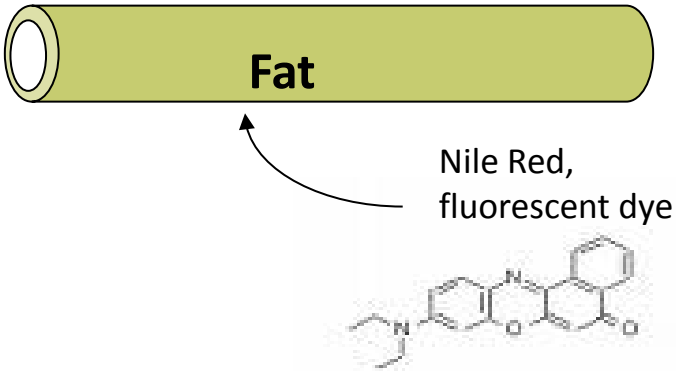
Imaging detergency with confocal microscopy,

Andreas Sonesson, Ulla Elofsson. Collaboration between YKI, KTH, Novozymes (Thomas Callisen)

Cotton fibre + olive oil

Cotton fibre





Cleaning solution:

300µM $C_{12}E_6$:LAS

⇒ ”roll up”-mechanism

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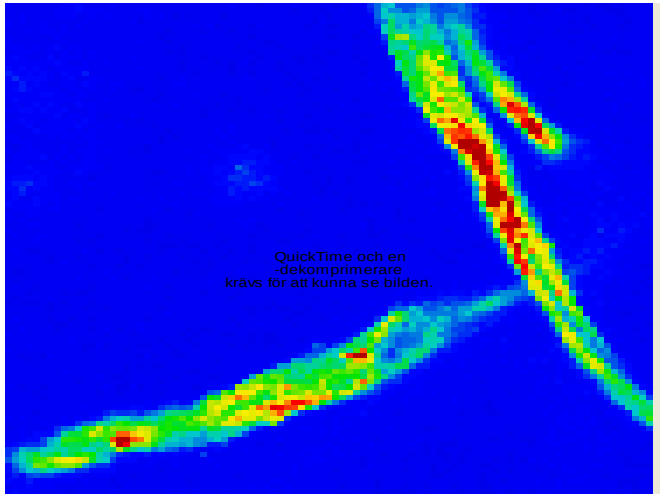
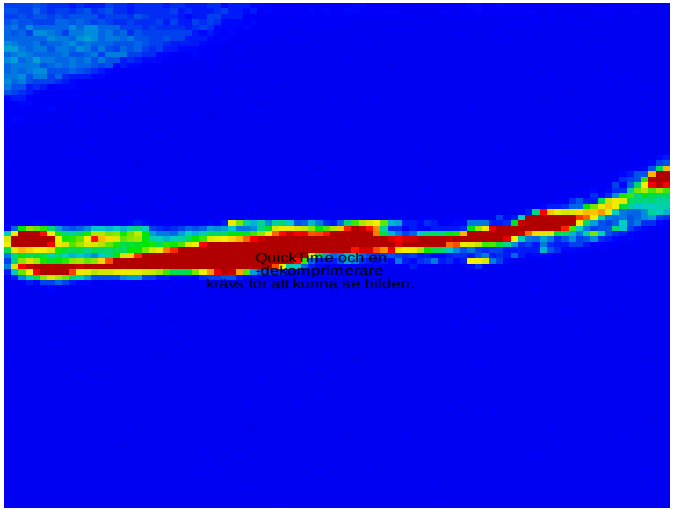
Cotton fibre + tri-C_{10}



Wash: 300µM $C_{12}E_6$:LAS

⇒ ”solubilization”

Cotton fibre + lard



Wash: 300µM $C_{12}E_6$:LAS + lipaser

⇒ ”emulsification”

Knowing the cleaning mechanisms help the design of new innovative products

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Formulering & Utvärdering av rengöringsmedel

Cleaning Innovation erbjuder innovativ formulering och utvärdering av rengöringsmedel.

Inom livsmedelsindustrin är effektiv rengöring särskilt viktigt av hygieniska skäl. Med effektivare formuleringar kan vi minimera rengöringstiden, sänka kostnaden, och minska miljöpåverkan.

Optimerad rengöringseffektivitet
Vi utvecklar och optimerar rengöringsformuleringar anpassade efter yta, smuts, och applikationsmetod. Detta minskar tiden för rengöring och maximerar produktionstiden.

Miljövänlig teknik
Vi hjälper till att omformulera rengöringsformuleringar med mer miljövänliga ingredienser, exempelvis förnyelsebara lösningsmedel och tensider.

Utvärdering av obereoende part
Vi erbjuder en oberoende vetenskaplig utvärdering av rengöringseffektivitet vilket är värdefullt för marknadsföring, för miljöcertifieringar, ex. Svanen.

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Kontakta: Mikael Kjellin, 010 - 516 60 56, mikael.kjellin@sp.se