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Case study

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The effect of surfactant alkyl structure on cold water detergency

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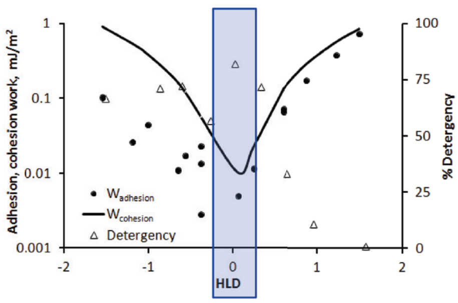
Abstract

An investigation was carried out for evaluating the effect of surfactant alkyl structure on cold water detergency performance by comparing linear and branched alkyl ethoxylates. The surfactants were chosen based on their characteristic curvature and the premise that, at the phase inversion temperature, ultralow interfacial tension and consequently emulsification mechanism dominate detergency performance. The efficiency of two commercial-grade ethoxylates was compared using poly/cotton fabric swatches stained with dyed hexadecane with the use of Terg-O-Tometer.

Introduction and Objectives

Alkyl ethoxylate surfactants are often used in laundry detergents, dishwashing detergents and other cleaning products. The cleaning performance of oily stains with these and other surfactants can be traced back to three detergency mechanisms: roll-up, associated to the fabric's wetting condition; emulsification, related to the low interfacial tension between the oil and the surfactant solution; and the presence of micelles near the fabric-oil interface, which solubilize the oil when the interfacial tension is low or ultralow. Experimental studies indicate that all three detergency mechanisms are aided, for different reasons, when the formulation approaches the microemulsion phase inversion point. Therefore, it is the objective of this work to compare detergency of branched and linear alkyl ethoxylates designed to have a microemulsion phase inversion point at conditions of cold water detergency.



Data of Thompson, L., . J. Colloid Interface Sci. (1994), 163, 61-73.
HLD calculated for the conditions used by Thompson

Hydrophilic-lipophilic-difference (HLD)

Microemulsion phase inversion (or net zero curvature point) can be determined using phase scans (VLCI internal testing method), often supported by the hydrophilic-lipophilic-difference (HLD) framework. The HLD is a quantitative indicator used to estimate the approach to the point of phase inversion (HLD=0) considering the surfactant and oil hydrophobicity, the electrolyte concentration, the temperature and the presence of co-surfactants or co-solvents:

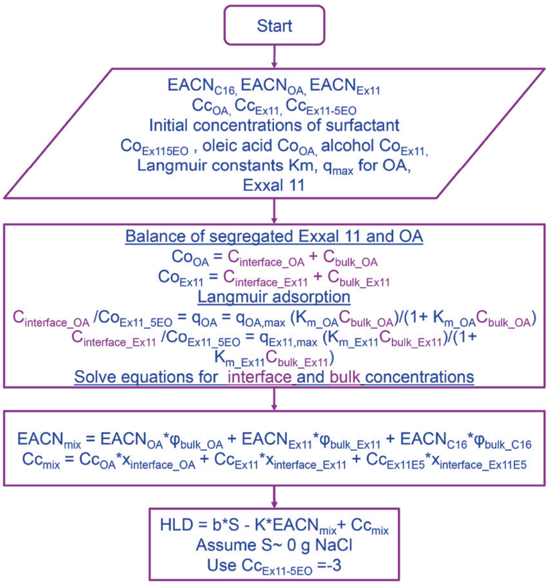
$$HLD= b * S - k * EACN + Cc + CT \quad (T-25°C)$$

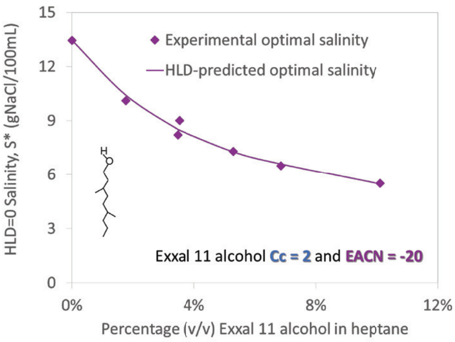
where Cc is the characteristic curvature of the surfactant and EACN is the equivalent alkane carbon number of the oil. The values of k, b and cT are constants that depend on the surfactant and T is the temperature of the system in Celsius.

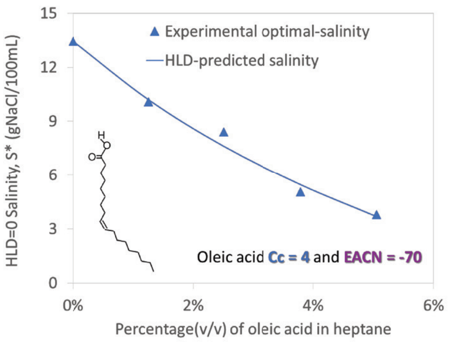
Complexity of the studied system

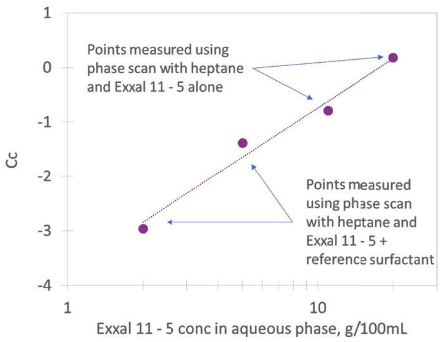
To design more realistic systems for detergency evaluation, hexadecane containing varying concentrations of oleic acid was used as a model oil in this work. To increase the solubilization capacity of hexadecane, free alcohol as lipophilic linker was added. The presence of oleic acid as a surrogate for free fatty acids in the oil and Exxal™ 11 alcohol as lipophilic linker in the surfactant formulation introduce two polar oil species in the system. Ghayour and Acosta (2019 AOCS annual meeting) proposed that polar oils like long chain fatty acids and alcohols can be described by the HLD equation if one considers that a portion of the polar oil segregates to the interface, behaving like a surfactant, and one portion remains in the oil.

Furthermore, contrary to monodisperse surfactants, commercial alcohol ethoxylates show strong characteristic curvature dependency on concentration. With regards to complexity of the system, the flow chart below was used to calculate HLD of the system at different concentrations of oleic acid.



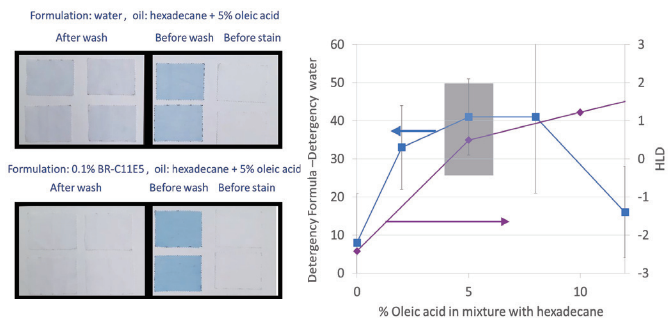






Detergency determination

Detergency measurements were performed using stained 3 × 4in fabric swatches. The staining was done by immersing the 65/35 poly/cotton fabric swatches in a hexadecane solution containing different levels of oleic acid and then dried under a ventilated hood for 24 hours prior to use. The detergency studies were performed using a model 7243 Terg-O-Tometer US Testing machine and ASTM standard D3050-98, "Standard Guide for Measuring Soil Removal from Artificially Soiled Fabrics". The fabric swatches were washed with the detergent in a 0.1% weight dosage in 1 L of water with a 10-min wash/5-min rinse cycle. The images of washed swatches were taken and analyzed using Image J software.



$$\% \text{ Detergency} = \frac{(\text{grey level washed} - \text{grey level dirty})*100\%}{(\text{grey level clean} - \text{grey level dirty})}$$

Alcohol	EO	Detergency
Exxal 11	5	85±10%
SL C-11	5	68±20%

Conclusions

- HLD methodology can provide effective guidance for formulation development for cold water detergency
- Branched alkyl ethoxylates offer enhanced cold water detergency performance when compared to semi-linear counterparts due to their superior dynamic properties