Facilitating Compact Formulations with High Active Surfactants

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Presentation Outline

- Motivation & approach
- High Active Matter ("HAM") surfactant blends
- Prototype compact formulations
  - Selected test methods
  - Physical properties
  - Performance in laundry & dish applications
- Conclusions

Facilitating Compact Formulations – Motivation & Approach

- Liquid detergents continue to grow globally, becoming the form of choice in many markets

- Compact liquids have grown rapidly in EU and US over the last 3-5 years
  - Reduced packaging and reduced transportation of liquids
    - Reduced environmental impact and cost
  - 2x and 3x formulas have been accepted by consumers
    - Typically maximum ~50% active surfactant concentration

- How to achieve highly concentrated liquids (50-90% surfactant)?
  - Two complimentary approaches to avoid gel regions of concentrates
    1. Take advantage of particular surfactant structures for AES / AE blends
    2. High Active Matter (HAM) blend approach

Degrees of Freedom With AES/AE Blends

- Alcohol ether sulfate (AES):

$R - (OCH_2CH_2)_n - OSO_3^-$ Na^+ or TEA^+

Cation for neutralization

EO number

Hydrophobe MW

- Alcohol ethoxylate (AE):

$R - (OCH2CH2)_n - OH$

EO number

Hydrophobe MW

- AES / AE ratio

Nomenclature:

Alcohols made via modified OXO process

- AE 91-8 is $C_{9\text{-}11}$ - 8EO
- AE 25-3S is $C_{12\text{-}15}$ - 3EO - sulfate

Current higher active surfactant formulations :

- Use solvents and hydrotropes (for fluidity)
- Desired viscosity may be achieved through "structured liquids" and control of micelle structure

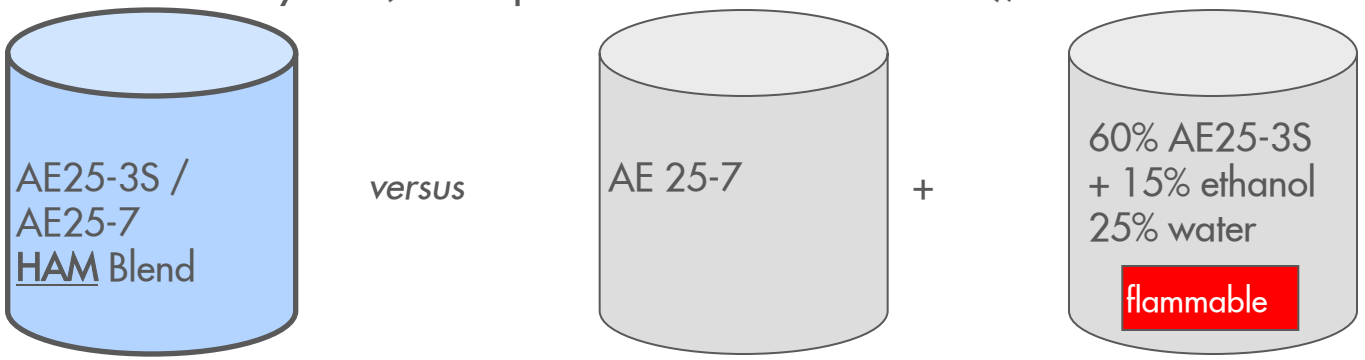
What is HAM?

High Active Matter (HAM) systems are:

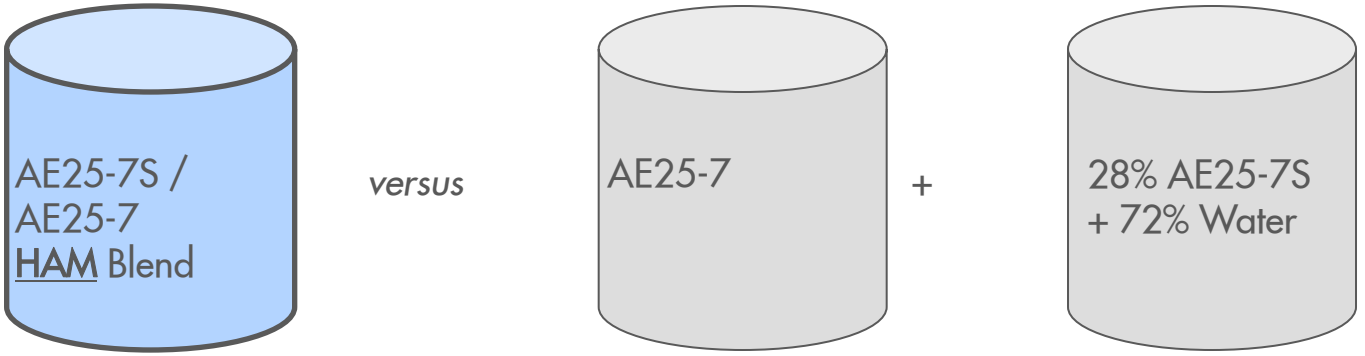
- 90+% AES/AE blends; balance water
- Prepared by one of two methods:

Key requirements:
•Good cleaning properties
•No gel formation when dissolved in water

1) React the AE with SO_3 then neutralize the AES with a mixture of concentrated base and alcohol ethoxylate (AE in place of water or ethanol), or



2) Under-Sulfate AE to yield a AES/AE mixture and neutralizing in concentrated base (e.g. NaOH or TEA).



Preparation of Two Different HAM Blends (Example)

HAM via Neutralization

$R_1O(CH_2CH_2O)_nH$

AE25-3

1.02 SO_3 ↓

$R_1O(CH_2CH_2O)_nSO_3H$

AE25-3S

Neutralization
50% $NaOH/H_2O$ +
$R_2O(CH_2CH_2O)_nH$
AE25-7 ↓

$R_1O(CH_2CH_2O)_nSO_3Na$ + $R_2O(CH_2CH_2O)_nH$ + H_2O	AE25-3S + AE25-7 + Water

HAM via Under-Sulfation

$R_1O(CH_2CH_2O)_nH$

AE25-7

0.70 SO_3 ↓

$R_1O(CH_2CH_2O)_nSO_3H$ + $R_2O(CH_2CH_2O)_nH$	AE25-7S + AE25-7

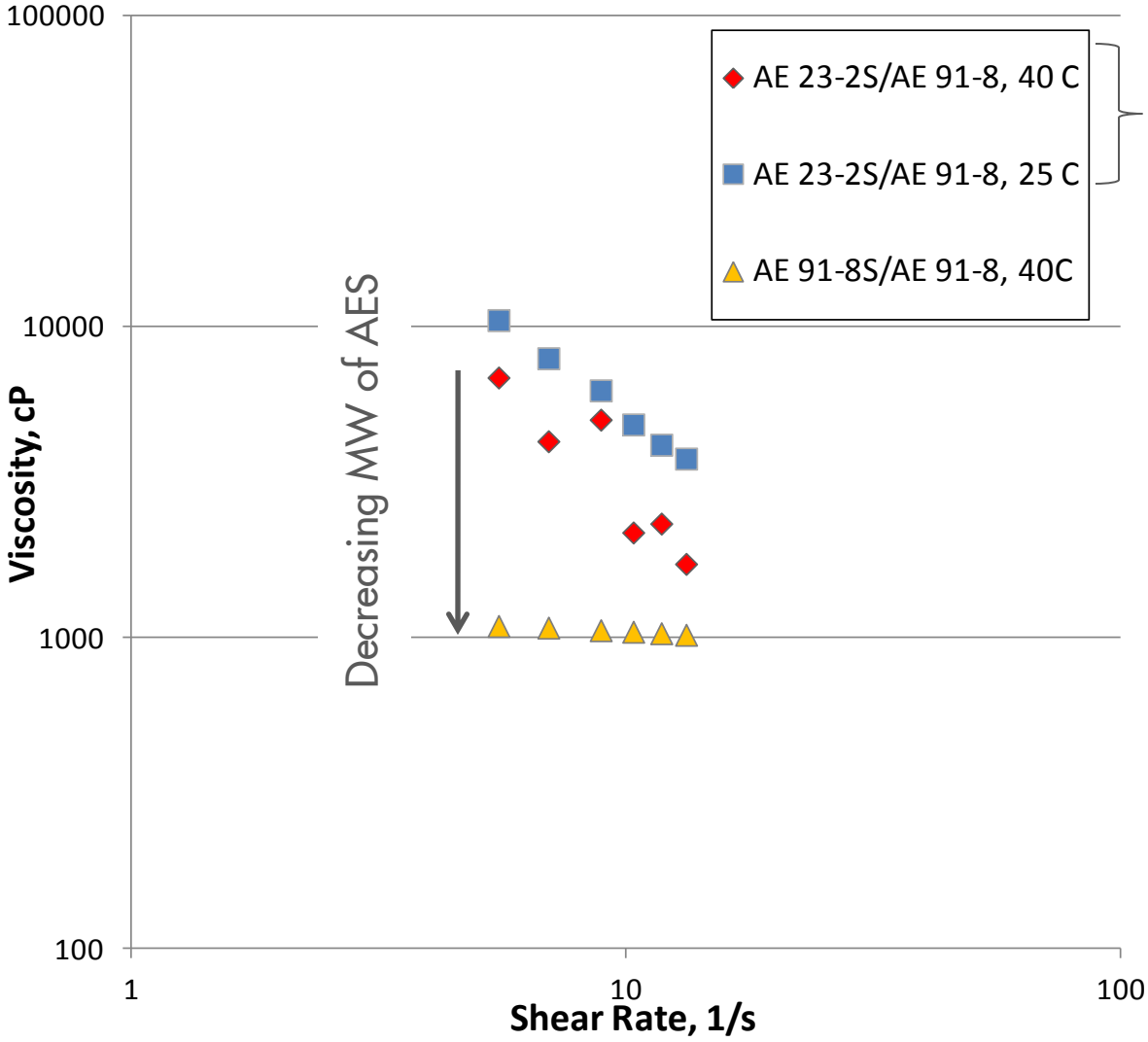
Neutralization
50% $NaOH/H_2O$ ↓

$R_1O(CH_2CH_2O)_nSO_3H$ + $R_2O(CH_2CH_2O)_nH$ + H2O	AE25-7S + AE25-7 + Water

Test Methods – Physical Properties

- Dynamic viscosity by Brookfield viscometer
  - Shear & temperature varied
- Dynamic solution time measurements
  - Measures time required to fully dissolve surfactant concentrate in water
    - 0.2 ml concentrate added with stirring to 50 ml water at 25 and 38°C
  - Dissolution times <5 min are considered acceptable in this "mild" test
    - In washing machine, mixing is more rigorous and shorter times expected
- Gel Region Measurement
  - Measures gel / liquid boundary for different water / concentrate ratios and temperatures
  - Temperature is reduced in stages from 80°C

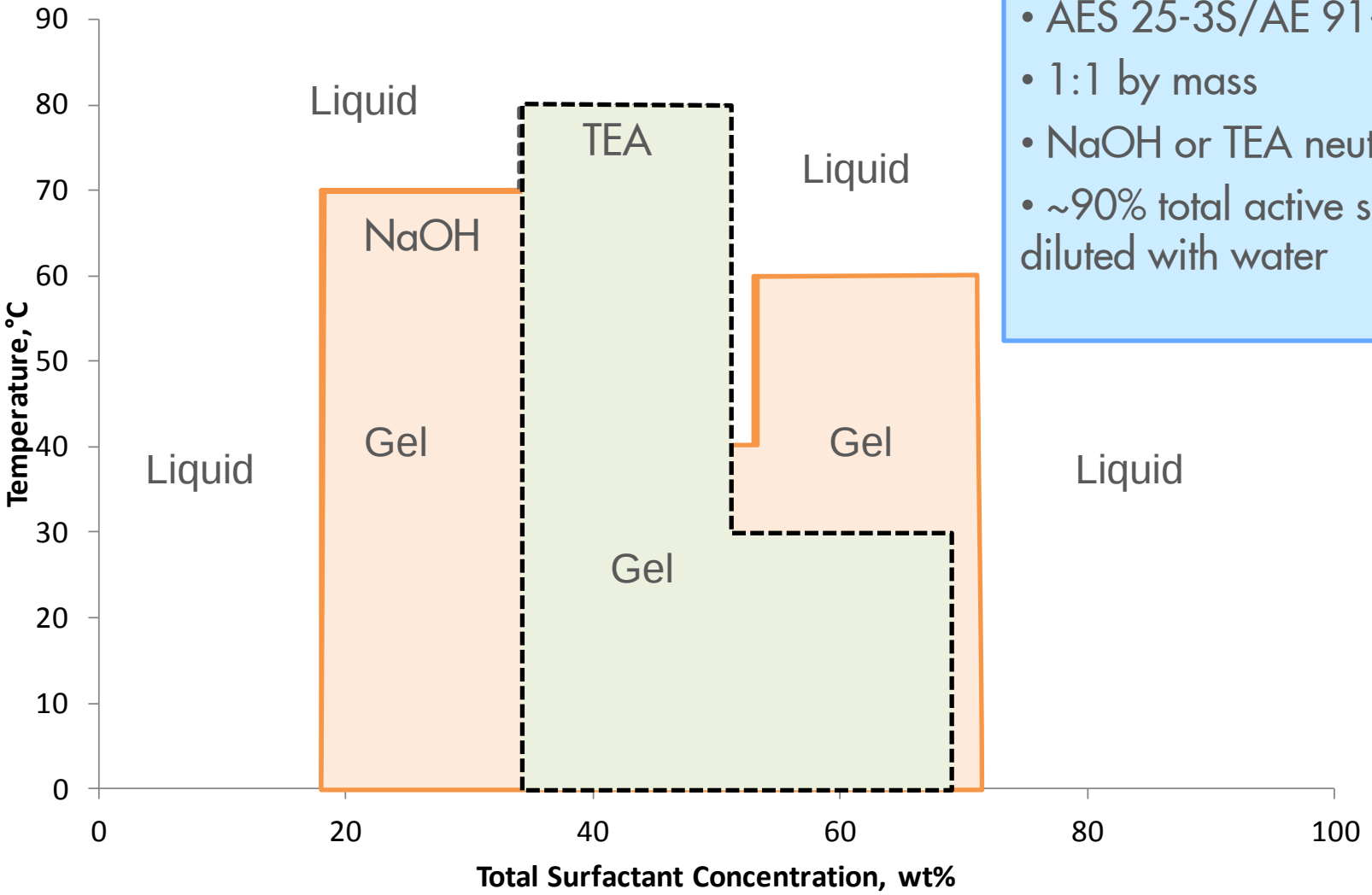
Viscosity of Surfactant Blends Facilitates Good Handling



Surfactant Blends :

- 2:1 AES:AE by mass
- ~90% total active surfactant

Gel Regions – Surfactants Neutralized with TEA are Fluid Over a Wider Range of Conditions

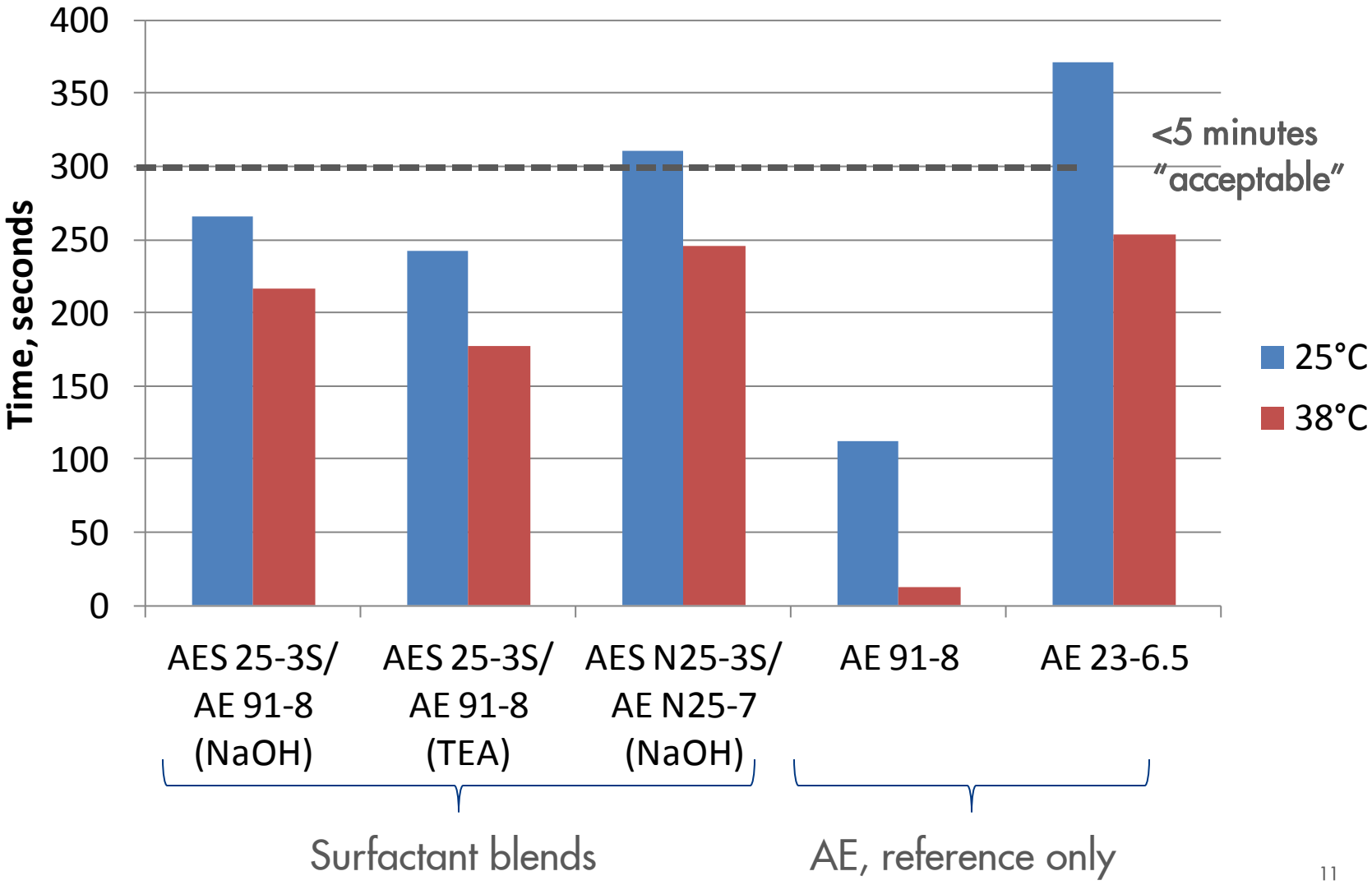


Surfactant Blends :

- AES 25-3S/AE 91-8
- 1:1 by mass
- NaOH or TEA neutralization
- ~90% total active surfactant, diluted with water

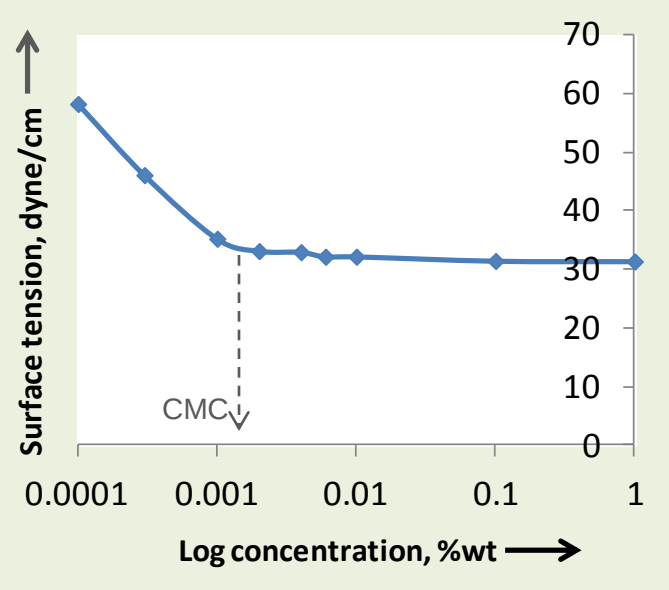
Solution Times – Low MW Alcohol Ethoxylate Facilitates Faster Dissolution

Solution times, surfactant blends are 2:1 anionic : nonionic by mass



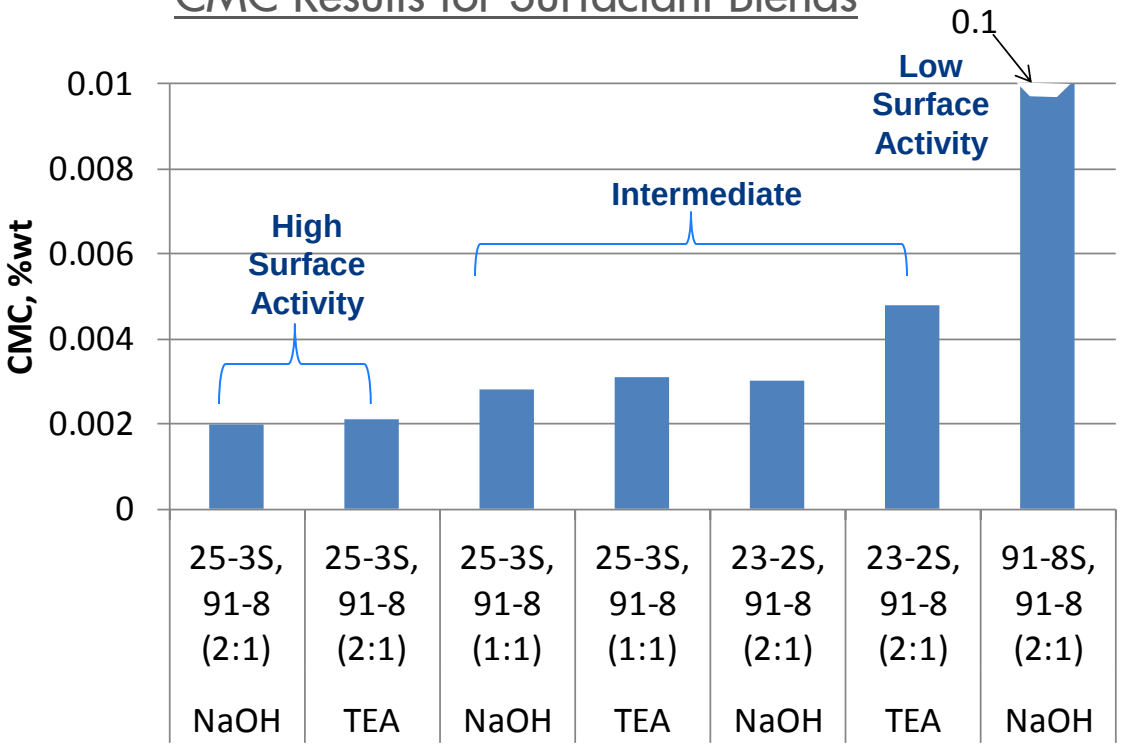
Surfactant Blends with C_{12-15} AES / Low MW AE gives Intermediate to High Surface Activity

Example CMC determination



CMC = Critical Micelle Concentration

CMC Results for Surfactant Blends

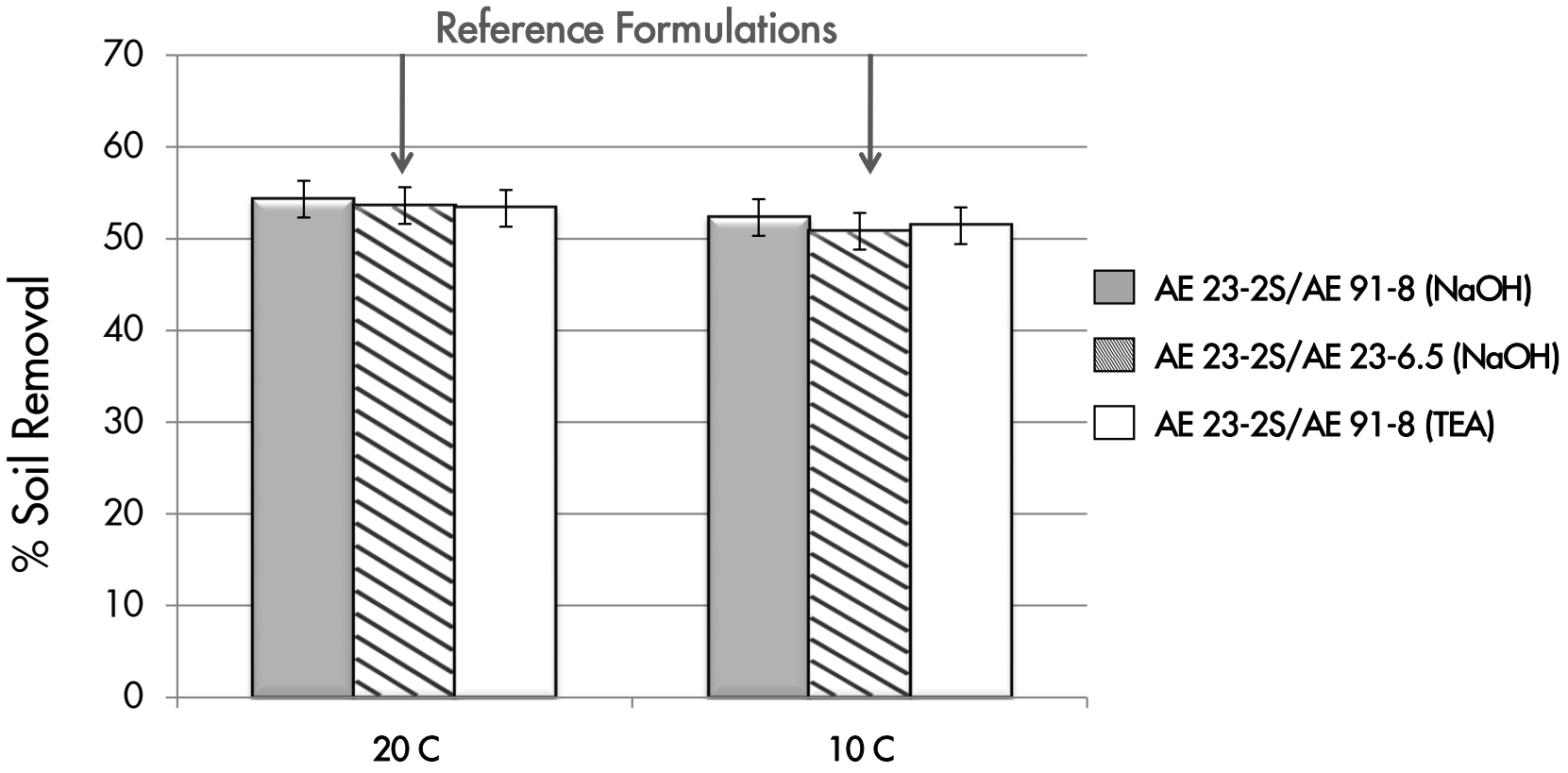


Surfactant Blends :

- ~90% total active surfactant
- Mass ratios 2:1 or 1:1 AES:AE
- NaOH or TEA neutralization

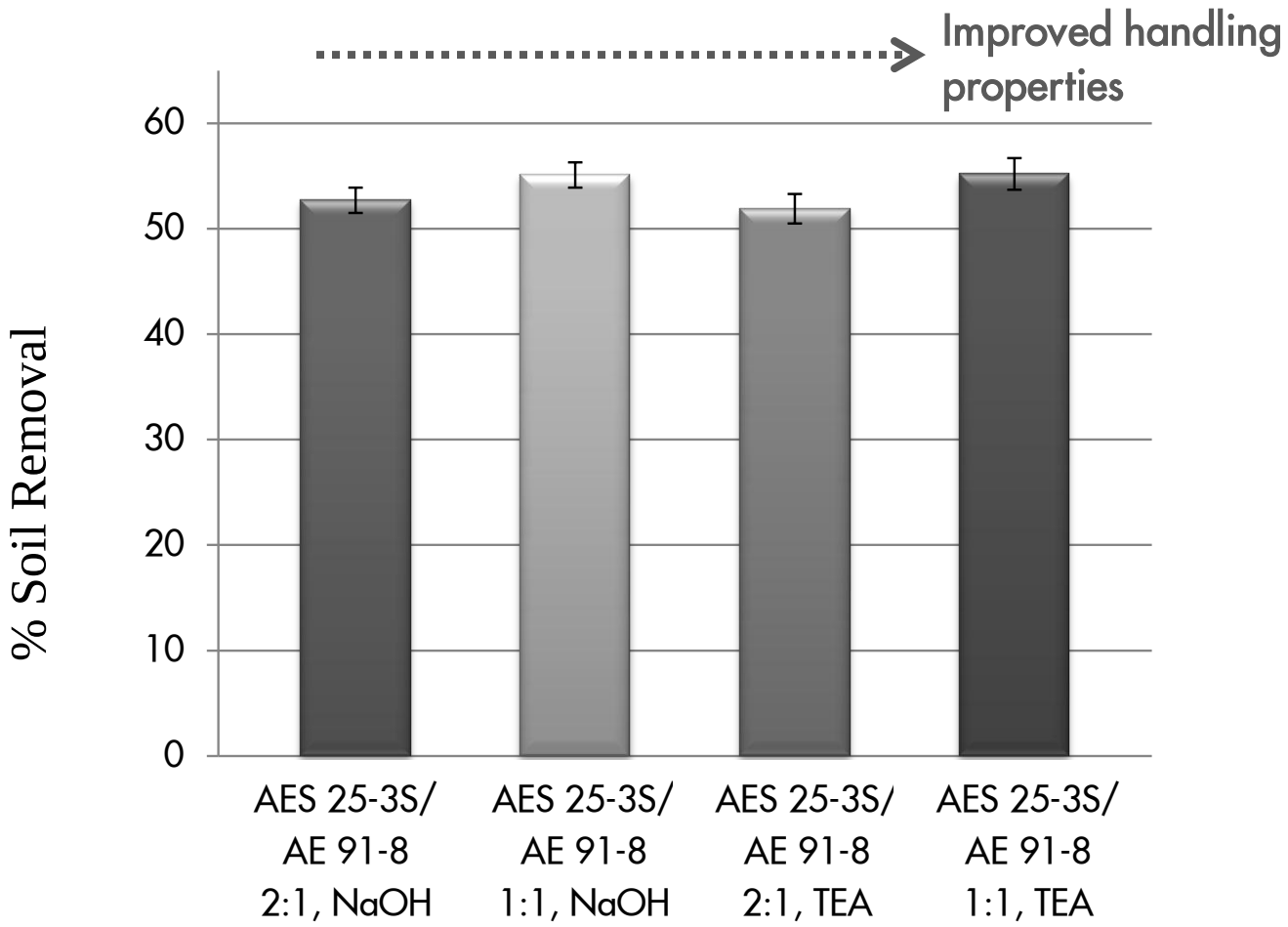
Surfactant blends with Low MW AE with TEA Clean Fabrics Effectively Relative to Blends of Traditional AE with NaOH

Detergency performance by reflectance detergency (15% active anionic, 3 g/L, 150 ppm hardness, dust sebum soil on polycotton fabric; blends are 2:1 anionic: nonionic)



AES / AE Combinations with AE 91-8 Clean Prototype Soils Effectively (and Give Added Benefit of Improved Handling)

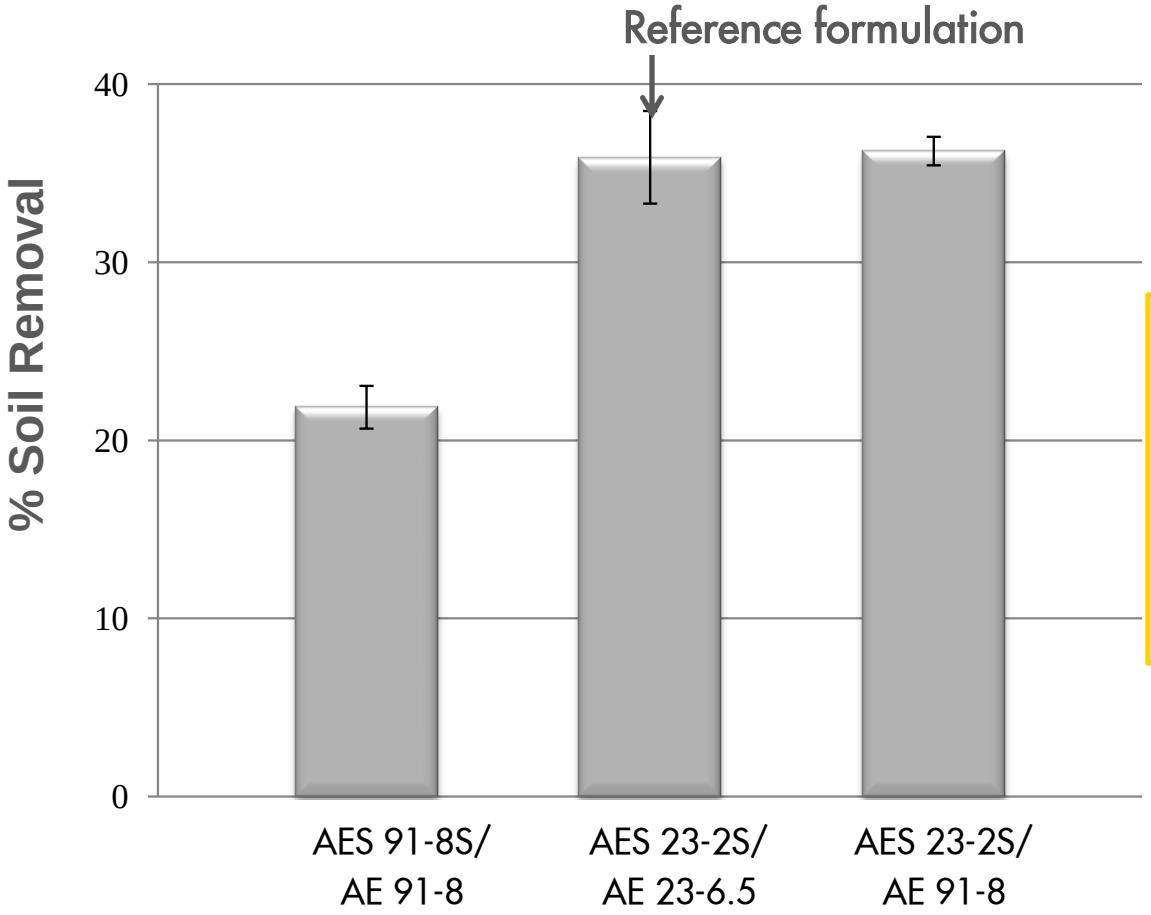
Detergency performance by reflectance detergency (15% total surfactant, 20°C , 3 g/L, 150 ppm hardness, dust sebum soil on polycotton fabric)



Surfactant Blend with Low MW AES shows Reduced Detergency Compared to Blends Containing C_{12-13} AES

Detergency performance by radiotracer detergency

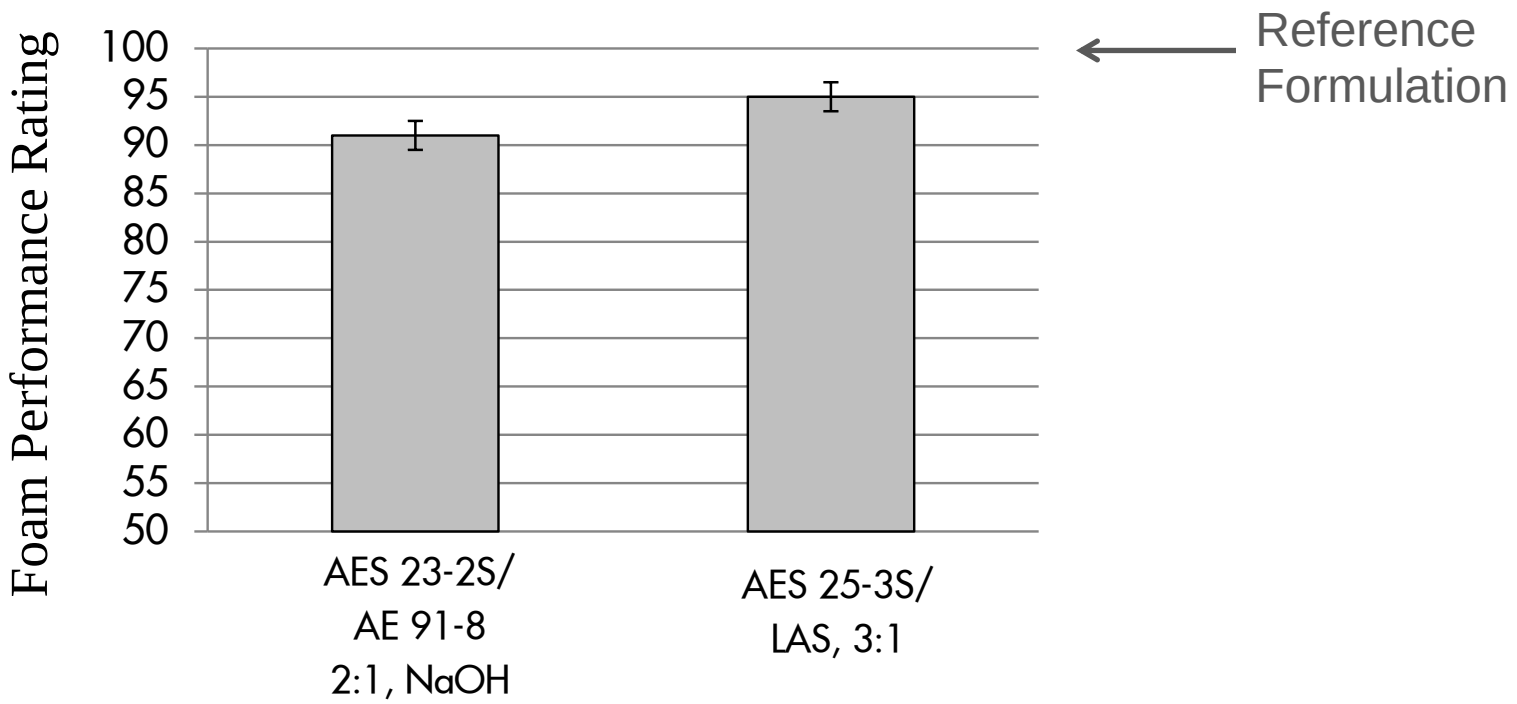
(15% active anionic, 3 g/L, 10°C, 150 ppm hardness, multisebum soil on polycotton fabric; blends are 2:1 anionic: nonionic neutralized with NaOH)



Recall:
AES 91-8S / AE 91-8 also gave the highest CMC (lowest surface activity) and the best fluidity

HAM AES/ AE Blends Provide Good Cleaning in Hand Dish Formulations

Dish performance by soil titration method (food soil mixture, 40°C; error bars represent +/- 1 standard deviation; FPR = 100 for the standard formulation)



- The two formulations give similar, high performance: switching LAS for AE 91-8 has little impact.
- The AES 23-2S / AE 91-8 formulation is quite fluid at 90% active and a candidate for a concentrated hand dish product.

Conclusions: Facilitating Compact Liquids through High Active Surfactants

- Formulations with "modified OXO" alcohol ethoxylates with lower molecular weight enable concentrated laundry liquids
  - $C_{9\text{-}11}$ versions of ~80% linear hydrophobes show effective performance and enhance handling properties
- HAM blends enable super concentrated liquids (~90+% active surfactant)
  - HAM blends can be made from a variety of AES and AEs to give good handling properties, without the use of volatile co-solvents
  - Dissolution times and handling of HAM blends are acceptable
- Higher active AES/AE blends (via HAM or conventional blending) demonstrate:
  - Improved handling properties whilst maintaining detergency performance seen wirh "traditional" surfactant systems
  - Good surface activity and cleaning performance where the AES is a higher MW hydrophobe and AE is lower MW ($C_{9\text{-}11}$), and :
    - Effective laundry detergency, even at lower temperature (10°C)
    - Comparable performance to conventional hand dish formulations

Acknowledgements

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Thank you for your attention!