Realizing Performance Benefits Through Alcohol-Based Surfactant Optimization

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Introduction

- A wide range of technical and economic criteria are considered when selecting surfactants for consumer cleaning products.

- Key surfactant properties that influence performance include:
  - Solubility
  - Hard water tolerance
  - Emulsification and detergency

- Different surfactants may be used to address market trends, such as liquid formulations and lower temperature laundry. Common surfactants include:
  - Anionic: alcohol sulfate (AS), alcohol ethoxysulfate (AES), linear alkylbenzene sulfonate (LAS)
  - Nonionic: alcohol ethoxylate

- Synergies between these surfactants can offer new formulation options, in both laundry and hand dish products.
**Surfactant Physical Properties Influence Performance: Mixed Surfactant Systems Provide Opportunities – (I)**

<table>
<thead>
<tr>
<th>Anionic</th>
<th>Krafft Temp. (°C)</th>
<th>Hardness tolerance (ppm Ca$^{2+}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAS</td>
<td>0 - 5</td>
<td>100 - 150</td>
</tr>
<tr>
<td>AS 1215</td>
<td>20 – 30</td>
<td>50 - 150</td>
</tr>
<tr>
<td>AE 1213-2S</td>
<td>&lt; 5</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>AE 1215-3S</td>
<td>&lt; 5</td>
<td>&gt;1000</td>
</tr>
</tbody>
</table>

**Krafft Temperature:**
- Lower values give improved low temperature storage and reduced need for hydrotropes
  - AES has benefits

**Hard water tolerance:**
- Exhibited as precipitation with divalent ions
  - LAS and AS are similar and relatively poor (low ppm Ca ions)
  - AES gives substantial improvements
Surfactant Physical Properties Influence Performance: Mixed Surfactant Systems Provide Opportunities – (II)

<table>
<thead>
<tr>
<th>Nonionic</th>
<th>Cloud Point (°C)</th>
<th>Pour Point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE 1213-6.5</td>
<td>41</td>
<td>15</td>
</tr>
<tr>
<td>AE 1215-7</td>
<td>49</td>
<td>20</td>
</tr>
</tbody>
</table>

Alcohol ethoxylate properties:
- Good oily soil detergency
- Suitable cloud points for effective cleaning, particularly in the presence of monovalent electrolytes
- Outstanding tolerance to divalent ions (hard water)

<table>
<thead>
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<th>Nomenclature</th>
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</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>AE 1213-2S</td>
</tr>
<tr>
<td>AS 1215</td>
</tr>
</tbody>
</table>

These alcohol based surfactants are based on modified OXO alcohols, which contain ~20% 2-alkyl branching.
Alcohol Sulfates Give Comparable Soil Removal to LAS in Prototype Heavy Duty Powders

**Component** | %w
---|---
Anionic | 20
Nonionic | 1
Zeolite | 28
Carbonate | 25
Silicate | 7
Sulfate | 20

**Anionic: LAS or AS**

**Dosage:** 1 g/L

**Wash:** 35 °C

**Hardness:** 100 ppm

**Soil:** Radiolabeled synthetic sweat on polycotton fabric

**Method:** Radiotracer method, published by Shell, shown to correlate with dust-sebum soil measured by reflectance
Alcohol Ethoxylates Combined with LAS Boost Liquid
Laundry Performance at Low Temperature

Total surfactant: 10%
Anionic : LAS
Nonionic : AE 1215-7
Dosage : 3 g/L
Wash : 20 °C
Hardness : 150 ppm
Other : 5% citrate, 5% TEA
Soils : Dust sebum
Fabrics : Cotton and polycotton
Method : Reflectance
Ethoxylated Surfactant Mixtures Give Options for Boosting Laundry Liquid Performance at Low Temperature

Total surfactant: 15%
Anionic: LAS, AE 1213-2S
Nonionic: AE 1213-6.5
Dosage: 3 g/L
Wash: 20 °C
Hardness: 150 ppm
Other: 5% citrate, 5% TEA
Soil: Radiolabeled synthetic sweat on polycotton fabric
Method: Radiotracer method, published by Shell, shown to correlate with dust-sebum soil measured by reflectance

Average % Soil Removal

Mass Fraction of LAS/AES/AE
Mixtures of Alcohol Ethoxysulfates and LAS Demonstrate Synergy in Liquid Dish Performance

**Formulation**: 6% total surfactant, no foam booster

**Temperature**: 40 °C

**Method**: Foam persistence is observed as food soil is added to a dish wash formulation. The performance ratio is relative to a dish wash standard and reflects the capability of the formulation to emulsify soil.
Conclusions

- Physical properties of alcohol-based surfactants enable effective cleaning at a variety of conditions, alone or in combination with LAS.

- Alcohol sulfates show comparable cleaning to LAS in prototype powder formulations.

- In liquid laundry:
  - Combining alcohol ethoxylate with LAS improves detergency performance even when total surfactant content is held constant
  - Surfactant mixtures that include alcohol ethoxylate and alcohol ethoxysulfate surfactants show formulation synergy and performance benefits

- In hand dish, mixed alcohol ethoxysulfate and LAS systems improve performance.

- In summary, surfactants based on alcohols and ethoxylated derivatives are good options for a variety of household formulations.