Sophorolipids –
A new class of Surfactants

SEPAWA Nordic 2015 – May 5th
Oliver Kaumanns
• Introduction to sophorolipids
  • Chemical caracteristica
  • Foam test set up
• Area of applications & results
  • Pure sophorolipid
  • Sophorolipid in formulation
    • ADW (foam and grease removal)
    • HSD
    • Laundry
• Your take home messages
• Your questions
What are sophorolipids?
An introduction
Our economic practices and our products are always in accordance with our responsibility for future generations.

- Focus on the use phase of our products
- Energy and water savings
- Waste reduction
- Renewable resources and recycling
- **Affordable biosurfactants**
- Special branding
Decades of experience with industrial fermentation processes
Leading supplier of biotechnologically produced feed amino acids
> 300 MEUR turnover with biotechnologically produced products
Science to Business center (S2B Bio) dedicated to biotechnology in Evonik’s Strategic Innovation Unit Creavis
Portfolio of fermentation derived ingredients for cosmetic applications
Global production through fermentation network
Biosurfactants – Surfactants produced by microorganisms

Bacteria/Yeast → Fermentation → Isolation → (Raw) product(s)

Biosurfactants have a number of advantages:

- Unique and sophisticated structures/properties
- Produced from renewable resources
- Extremely good skin compatibility
- Non-toxic and highly biodegradable

Sophorolipids – A new class of Surfactants
Fermentation with Candida Bombicola

Sophorolipid’s general fermentation pathway

Sophorolipid
(mainly lactonic form)
Hydrolytic cleavage of the sophorolipid lactone

Lactone Form
- Hardly water soluble
- Low foaming

Acid Form
- Highly water soluble
- High(er) foaming
“Sophorolipid” is typically a complex mixture of at least two glycolipids made by partial hydrolysis of the water insoluble sophorolipid lactone form:

- Complex mixture with C\textsubscript{16}-C\textsubscript{18} saturated or (poly)unsaturated carbon chain with 0 - 2 acetyl group
- Properties depend strongly (but not only) on ratio of lactone to acid form
- „The“ one and only sophorolipid does not exist
## A typical composition of a sophorolipid produced by Evonik

<table>
<thead>
<tr>
<th>Properties</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>brownish, aqueous liquid</td>
</tr>
<tr>
<td>Dry matter (DM)</td>
<td>40 – 45 w.-%</td>
</tr>
<tr>
<td>Active SL</td>
<td>&gt; 90% of DM</td>
</tr>
<tr>
<td>Lactone : Acid ratio</td>
<td>40 : 60</td>
</tr>
<tr>
<td>Free fatty acid</td>
<td>&lt; 0.2 w.-%</td>
</tr>
<tr>
<td>pH</td>
<td>5 - 6</td>
</tr>
<tr>
<td>Viscosity</td>
<td>100 – 150 mPas</td>
</tr>
<tr>
<td>Density</td>
<td>1.00 – 1.10 g/mL</td>
</tr>
<tr>
<td>Biodegradability</td>
<td>Complete (100%)</td>
</tr>
</tbody>
</table>

(Values based on dry matter)
Unique Performance
Sophorolipids

- Evonik’s Sophorolipid exhibits superior performance versus other commercially available sophorolipids
- Readily biodegradable and produced from renewable feedstock
- Excellent water-hardness tolerance
- Superior mildness compared to conventional surfactants
- Synergistic effect with other surfactants
- Foaming properties can be altered for each application
- Excellent grease and oil removal
Results
Areas of application & test results

Manual Dish Wash

Hard Surface Cleaning

Laundry

Sophorolipids – A new class of Surfactants
Foam evolution of pure sophorolipids
A comparison
Consumer perception

“The longer the foam lasts the better the performance“

Requirements

- Sufficient foam during foam creation (clean conditions)
- Persistent foam during cleaning process (dirty conditions)
Foaming of pure sophorolipid (SL) without dirt load

➤ Evonik SL superior to market sophorolipid regarding flash foam and foam stability

Conditions: pH = 7, c = 0.2 g/L, T = 40 °C
SL composition varies depending on educts and production process

Compositions based on dry matter

Evonik SL
- Acid: 67 w-%
- Lactone: 26 w-%
- Other: 7 w-%

Market SL
- Acid: 19 w-%
- Lactone: 20 w-%
- Ester: 56 w-%
- Other: 5 w-%
Free fatty acid and ratio lactone/oleic acid influences the foaming behavior

<table>
<thead>
<tr>
<th></th>
<th>Evonik SL</th>
<th>Market SL (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio Lactone/Acid (rel.-%)</td>
<td>30:70</td>
<td>80/20 (*)</td>
</tr>
<tr>
<td><strong>Free oleic acid</strong> (w.-%)</td>
<td>0.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Ratio Lactone/free oleic acid (based on absolute w.-%)</td>
<td>60</td>
<td>16</td>
</tr>
</tbody>
</table>

(*) Methyl ester and lactone summarized as lactone
Evonik SL shows significantly higher foaming power than market SL

- The foaming behavior can be influenced by controlling residual fatty acid content
- The higher the excess of lactone the better foaming
Foam evolution of sophorolipids in formulation
Areas of application & test results

Manual Dish Wash

Hard Surface Cleaning

Laundry
Hand dish wash liquids in Europe comprise SLES and AO/APG/betaine

**Primary surfactant:**

- ~ 10 – 30 w.-%
  - Sodium laurylether sulfate (SLES)

**Secondary surfactant:**

- ~ 1 – 5 w.-%
  - Amineoxide
  - Alkylpolyglycosides (APG)
  - Cocoamidopropyl betaine (CAPB)

**Objective**

Higher formulation efficiency replacing betaine (NBA) by Evonik SL
Our target is to show higher efficiency replacing betaine by sophorolipids

- Studies based on formulations with SLES as primary surfactant
- Secondary surfactant: CAPB and/or sophorolipid
- Relative ratio of primary and secondary surfactants 70:30
Foaming performance in ternary mixtures SLES/CAPB/SL (70/X/Y) Y = 15% superior

Foam volume [ml]

Conditions: pH not adjusted, used as is, 0.2 g/L active material

Sophorolipids – A new class of Surfactants
Evonik SL containing formulations outperform market SL

Conditions: pH not adjusted, used as is, 0.2 g/L active material

Sophorolipids – A new class of Surfactants
Evonik SL containing formulations outperform market SL

- Evonik SL allows for up to 30% higher foam evolution by replacing (relative) 50% betaine
- Evonik SL is superior to competitor sophorolipid in formulation without dirt, on olive oil and high fat soil

Conditions: pH not adjusted, used as is, 0.2 g/L active material

Sophorolipids – A new class of Surfactants
Grease removal
Grease removal efficacy improved over commercially available HDW

- Market HDW (CAPB containing)
- SLES-CAPB 70:30
- SLES-SL (L30/A70) 70:30
- SLES-CAPB-SL (L30/A70) 70:15:15
- SLES-CAPB-SL (Market SL)

Grease removal efficacy improved up to 30% replacing 50% betaine by Evonik SL

Conditions: 40°C, pH not adjusted, internal method
Efficient hand dish wash liquid formulation with Sophorolipid

<table>
<thead>
<tr>
<th>Hand Dish Wash Liquid</th>
<th>% w/w</th>
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<tbody>
<tr>
<td>Sodium laurylether sulfate (70%)</td>
<td>15.0</td>
</tr>
<tr>
<td>Cocoamidopropyl betaine (47%)</td>
<td>4.8</td>
</tr>
<tr>
<td><strong>Evonik SL (42%)</strong></td>
<td>5.4</td>
</tr>
<tr>
<td>Xanthan Gum</td>
<td>0.2</td>
</tr>
<tr>
<td>Water (Dye, Perfume, Preservative)</td>
<td>ad. 100</td>
</tr>
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- Superior foaming behavior than market product
- Higher grease removal efficacy than market product
Value arguments

- New technology (innovation)
- Formulation performance improvement (up to 30%)
  - Flash foam, foam stability, grease removal
- 100% biodegradability
- CLP-free raw material
Value arguments

- Less severe formulation hazard classification
- Use in Ecolabel formulations
- New claims and promotion opportunities
- Close the “performance” gap to market leaders
- Increase market share
- Contribution to own corporate responsibility goals
- Contribution to sustainability targets
Areas of application & test results

- Manual Dish Wash
- Hard Surface Cleaning
- Laundry

Sophorolipids – A new class of Surfactants
Hard surface cleaning efficacy of sophorolipid without mechanical impact

Evonik SL exhibits higher cleaning performance than other secondary surfactants on stainless steel plates soiled with a motor oil/paraffin mixture.
Areas of application & test results

- Manual Dish Wash
- Hard Surface Cleaning
- Laundry (& ADW)
The water hardness “issue”

- Loss of surfactant by lime soap precipitation
- Important for regions with high water hardness (e.g. MENA)
- Addition of builder necessary in laundry detergents
- Potentially important to ADW formulations
Excellent water hardness tolerance of sophorolipids

**Water hardness:** 40° dH (0.8 g CaCl₂/L)

**Surfactant:** 0.5 w.-%

SDS = sodium dodecyl sulfate; SDBS = sodium dodecyl benzene sulfonate

Sophorolipids – A new class of Surfactants
No loss of surface active sophorolipid during washing by precipitation

<table>
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<th>Water Hardness</th>
<th>10° dH</th>
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<tbody>
<tr>
<td>Water Temperature</td>
<td>40°C</td>
</tr>
<tr>
<td>Surfactant Conc.</td>
<td>0.03 w.-%</td>
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<tr>
<td>Ratio (w/w) liquor/fabric</td>
<td>5:1</td>
</tr>
<tr>
<td>Time</td>
<td>30 min.</td>
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**Method**
Fabric (terry towel) was soaked in washing liquor & squeezed out.

Determination of surfactant conc. in washing liquor by HPLC

**Residual surfactant in liquor**

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<th>Surfactant in liquor [rel-%]</th>
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<tr>
<td>SL Acid ((L_0A_{100}))</td>
</tr>
<tr>
<td>SDBS</td>
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- Evonik SL potentially allows to partially / completely replace conventional builder systems

Residual surfactant in liquor

- SL Acid \( (L_0A_{100}) \)
- SDBS
- There is not „the one and only” Sophorolipid
- (Foam) properties of sophorolipids strongly depend on composition (lactone, acid, free acid)
- The less oleic acid the higher foam volume
- Properties can be fine-tuned especially with regard to foaming

- Proportional betaine replacement (50% CAPB) best choice (synergies)
- Evonik SL superior to market SL w/o soil, olive oil, high fat soil (~28% foam increase at same active)
- High grease removal efficacy (+28 % over SLES/CAPB)
- High grease removal efficacy (3 times larger than market SL)

- Evonik SL exhibits better cleaning performance than other secondary surfactants

- Excellent hard water tolerance
- Potential to exchange existing builder systems
Do you have questions?