SOLUTION PROVIDERS

SUPERIOR PERFORMANCE COOLANTS:
FROM EMULSIFIERS TO SOLUBILIZERS

Dr. Sabine Wohlfahrt – Technical Sales Manager
Chicago, February 21st 2019, Commercial Innovation Forum

THE TECHNOLOGY OF KAO SURFACTANTS IN METALWORKING FLUIDS
1. SOLUTIONS FOR TODAY’S CHALLENGES - KAO METALWORKING TOOLBOX

2. LOW FOAMING NONIONIC MAIN EMULSIFIERS

3. AKYPO® - ANIONIC CO-EMULSIFIERS / STABILIZER / SOLUBILIZER

COMBINING PERFORMANCE HIGHLIGHTS
SOLUTIONS FOR TODAY'S COOLANTS

KAO METALWORKING TOOLBOX
# TODAY’S CHALLENGES & MARKET REQUESTS

## Metalworking Fluid

### Long lifetime
- Water hardness, dissolved metal salts
- Light metals
- Fluid cleanliness
- Microbiology

### Low foaming
- High speed
- High pressure
- Smaller sump sizes

### Environmental friendly
- Efficient additives
- Mild labeling
- Longer fluid lifetime

### Key drivers
- Sustainability
- Cost reduction
- Customer satisfaction
- Higher value products
KAO METALWORKING EXPERTISE NORTH AMERICA SATISFYING CUSTOMER NEEDS

More than 45 years’ experience with AKYPO® technology in metalworking
- KAO Metalworking Toolbox
- Technical experienced R&D and sales team
- Fully equipped synthesis and formulation laboratory
- Solution providers
- Formulation support
- Global available products and distribution network

Distribution in North America
Focus in industrial lubricants
Knowledgeable sales and technical support team
# Surfactant and Emulsifiers

<table>
<thead>
<tr>
<th>Interface</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>O/W</td>
<td>Oil / Water</td>
</tr>
<tr>
<td>W/O</td>
<td>Emulsification</td>
</tr>
<tr>
<td></td>
<td>Metal / Water</td>
</tr>
<tr>
<td></td>
<td>Corrosion inhibitor</td>
</tr>
<tr>
<td></td>
<td>Air / Water</td>
</tr>
<tr>
<td></td>
<td>Foaming behavior</td>
</tr>
</tbody>
</table>

**Hydrophilic / polar head**

**Hydrophobic / nonpolar tail**
### Surfactant’s Great Influence on Formulations

**Surfactants**, including *Emulsifiers, Co-emulsifiers and Solubilizers*, have a great impact on formulations and their performance.

<table>
<thead>
<tr>
<th>Typical ingredients</th>
<th>Dosage [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lubricant</td>
<td>10 - 70</td>
</tr>
<tr>
<td>Water</td>
<td>10 - 70</td>
</tr>
<tr>
<td>Emulsifier</td>
<td>5 - 20</td>
</tr>
<tr>
<td>Stabilizer</td>
<td>1 - 16</td>
</tr>
<tr>
<td>Corrosion Inhibitor</td>
<td>3 - 10</td>
</tr>
<tr>
<td>Foam regulator</td>
<td>0 - 3</td>
</tr>
<tr>
<td>Biocides / Fungicides</td>
<td>&lt;2</td>
</tr>
</tbody>
</table>
KAO METALWORKING TOOLBOX
GLOBALLY REGISTERED SURFACTANTS FOR LUBRICANTS

C-chain  EO  PO  Flexible length  Hydroxyl (alcohol)  Ether carboxylic acid

KAO FINDET MB
AKYPO® ROX
Long alkyl chain (C_{16-18}) propoxylated – ethoxylated alcohols
Low foaming nonionic main emulsifier

AKYPO® RO
Long alkyl chain (C_{16-18}) ether carboxylic acid
Co-emulsifier / stabilizers
Lime soap dispersants

AKYPO® LF
Short alkyl chain (C_{4-8}) ether carboxylic acid
Low foaming solubilizers / hydrotropes
KAO FINDET MB AKYPO® ROX

LOW FOAMING NONIONIC MAIN EMULSIFIERS
ADVANTAGE OF PO-EO NONIONIC EMULSIFIERS

Standard EO-PO nonionic products

PO-EO nonionic products
KAO FINDET
AKYPO® ROX
Standard EO-PO nonionic products

- Defoaming
- Low emulsifier efficiency
  - High tendency for instable emulsions
- Mainly used in cleaning applications

PO-EO nonionic products

KAO FINDET MB AKYPO® ROX

- Low foaming compared to non-propoxylated nonionic emulsifiers
- High-efficiency emulsifiers
  - Stable emulsions
- Emulsifier for all kinds of applications, such as metalworking
- Wide base oil compatibility (mineral and vegetable oils, esters)
### ADVANTAGE OF KAO FINDET AND AKYPO® ROX EMULSIFIER EFFICACY

Semi synthetic formulation was prepared according to the upper part of the table without nonionic main emulsifier (top photo). X g of nonionic main emulsifier was added to the formulation to obtain a stable concentrate.

<table>
<thead>
<tr>
<th>g</th>
<th>Market reference Cetly/Oleyl alcohol ethoxylate (5 EO)</th>
<th>AKYPO® ROX RS-0606N (KAO FINDET MB-8012)</th>
<th>C₁₈ PO-EO nonionic emulsifier</th>
<th>C₁₈ EO-PO nonionic emulsifier</th>
<th>C₁₀ EO-PO nonionic emulsifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dodecanedioic acid</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Deionized water</td>
<td>41.6</td>
<td>41.6</td>
<td>41.6</td>
<td>41.6</td>
<td>41.6</td>
</tr>
<tr>
<td>Amino alcohol</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
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<tr>
<td>Mineral oil (naphtenic)</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Sodium sulfonate</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Tall oil fatty acid</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Phosphate ester ethoxylated</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Butoxypropanol</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>AKYPO® RO 50 VG</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
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<th>C₁₀ EO-PO nonionic emulsifier</th>
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</thead>
<tbody>
<tr>
<td>4.6</td>
<td>3.0</td>
<td>7.8</td>
<td>&gt; 15</td>
<td></td>
</tr>
</tbody>
</table>

AKYPO® ROX RS-0606N shows the best emulsifier efficacy.
Foam behavior with different emulsifier combinations was tested with 5% metalworking fluid emulsion at 178 ppm (10°dH) with a Krüss DFA100 Dynamic Foam Analyzer.
KAO FINDET MB AND AKYPO® ROX
LOW FOAMING NONIONIC MAIN EMULSIFIERS

Multifunctional low foaming nonionic emulsifiers designed to meet the severe conditions of metalworking applications.

**MAIN PROPERTIES**

- Low foaming nonionic emulsifier
- High-efficiency main emulsifier
- Excellent environmental profile
- Liquid and easy to formulate
- Synergistic effects with AKYPO® RO for optimized hard water stability and lime soap dispersion
- Globally registered

**PRODUCTS**

<table>
<thead>
<tr>
<th>HLB</th>
<th>KAO FINDET MB-212</th>
<th>5</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>AKYPO® ROX RS-0602N</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>AKYPO® ROX RS-0606N</td>
<td>8</td>
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<td></td>
<td>KAO FINDET MB-8012</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>AKYPO® ROX RC-0960N</td>
<td>11</td>
</tr>
</tbody>
</table>

KAO FINDET MB
AKYPO® ROX

New product
AKYPO® RO
HARD WATER AND ELECTROLYTE STABILITY
10% Product at 1500 ppm (ca. 85° dH) Mg$^{2+}$ water

Oleic acid

Na-sulfonate

Ethercarboxylic acid
AKYPO® RO 90 VG

Similar results with other metal ions such as Na$^+$, Ca$^{2+}$
Dispersion Power of AKYPO® RO

AKYPO® – LONGER LIFETIME METALWORKING FLUIDS

WITHOUT AKYPO®

WITH AKYPO®

AKYPO® Lime soap dispersant and co-emulsifier

Emulsion stability and foam control extend the life of metalworking fluids

Ideal dispersion

Agglomerates

Common primary emulsifier
Fatty acids: Coco, oleic, tall oil
Sulfonate

Process water, water hardness, water treatment
Ca²⁺, Mg²⁺, Na⁺,…
\[ \text{AKYPO® RO} \]
\[ \text{PERFORMANCE IN HARD WATER – CNOMO TEST} \]

**Without AKYPO®**

- heavy soaps
- Emulsion split

**With 2.5% AKYPO®**

- no soaps
- Emulsion intact

After 24 h circulation

@ 1000 ppm CaCO₃ (60°dH)

Soluble oil formulation without and with 2.5% AKYPO® RO 90 VG, 5% metalworking fluid emulsion.
### MAIN PROPERTIES

- Long alkyl chain (C_{16-18}) ether carboxylic acid
- Co-emulsifier / stabilizers
- Outstanding lime soap dispersion power
- Liquid and easy to formulate
- Globally registered

### APPLICATION BENEFITS

- Hard water and electrolyte stability extends lifetime of metalworking fluids
- Improves concentrate and emulsion stability
- Improves fluid cleanliness
- Helps the foam control
- Synergistic effects with AKYPO® LF and AKYPO® ROX / KAO FINDET

### PRODUCTS

- **AKYPO® RO 50 VG**
- **AKYPO® RO 90 VG**
- **AKYPO® TEC AM VG**
  Ready-to-use mixture that combines the benefits of AKYPO® RO 90 VG and AKYPO® LF 4 for easier handling.
AKYPO® LF
LOW FOAMING MULTIFUNCTIONAL SOLUBILIZERS

MAIN PROPERTIES

• Short alkyl chain (C₄-8) ether carboxylic acid
• Low foaming solubilizers / hydrotropes
• Outstanding electrolyte stability
• Liquid and easy to formulate
• Globally registered

APPLICATION BENEFITS

• Synergistic effects with AKYPO® RO by lime soap solubilization
• Improve tramp oil rejection
• Improve self emulsification of fluid
• Wettability modifiers supporting rinsing behavior
  • Adjustment of the drip off behavior
  • Improve removal of metal chips

PRODUCTS

• AKYPO® LF 1
• AKYPO® LF 2
• AKYPO® LF 4
• AKYPO® TEC AM VG
  Ready-to-use mixture that combines the benefits of AKYPO® RO 90 VG and AKYPO® LF 4 for easier handling.
AKYPO® TEC AM VG

COMBINING PERFORMANCE HIGHLIGHTS

AKYPO® TEC AM VG

Blend of AKYPO® RO 90 VG and AKYPO® LF 4

AKYPO® RO 90 VG
CO-EMULSIFIERS/STABILIZERS

\[ R = C_{16-18}, \quad n = 9 \]

AKYPO® LF 4
SOLUBILIZER

\[ R = C_{6-8}, \quad n = 3-8 \]

Ratio 1:1
Electrolyte stability of 10% emulsions of semi synthetic formulation (colored) with different emulsifier combinations was tested by increasing the electrolyte load, starting with demineralized water (0 ppm) and an increasing concentration of calcium. The formulations in the middle and at the right side include 2% AKYPO®, hence 0.2% in the shown emulsion.

AKYPO® increases the fluid’s longevity by ideal electrolyte stability
Foaming behavior of 5% metalworking fluid emulsions (semi synthetic) were tested at 270 ppm CaCO$_3$ (15°dH) with a Krüss DFA100 Dynamic Foam Analyzer. The formulations included 2% AKYPO® and fatty acids.

AKYPO® TEC AM VG shows the best performance in limited foam formation tendency combined with the fastest foam collapse rate.
Foaming behavior of 5% metalworking fluid emulsions (semi synthetic) were tested at 270 ppm CaCO$_3$ (15°dH) with a Krüss DFA100 Dynamic Foam Analyzer. The formulations included 2% AKYPO® and fatty acids.

AKYPO® TEC AM VG shows the best performance in limited foam formation tendency combined with the fastest foam collapse rate.
Foaming behavior of 5% metalworking fluid emulsions (semi synthetic) were tested at 270 ppm CaCO3 (15°dH) with a Krüss DFA100 Dynamic Foam Analyzer. The formulations included 2% AKYPO® and fatty acids.

AKYPO® TEC AM VG shows the most limited foam formation tendency combined with the fastest foam collapse rate.
KAO CHEMICALS EUROPE

PROVIDING SOLUTIONS

- **Main emulsifiers**
  - KAO FINDET
  - AKYPO® ROX
- **Co-emulsifiers**
  - AKYPO® RO
- **Solubilizers**
  - AKYPO® LF
- Further products
- Customized solutions

**Evaluating quality and performance**
- Foaming
- Emulsions and emulsion stability
- Corrosion
- Lubrication
- Basic surfactant and emulsion tests

**Product properties and design**
- Main emulsifiers
- Co-emulsifiers
- Solubilizers
- Further products
- Customized solutions

**Desire to provide ideal emulsifier solution**
- Guideline formulations
- Formulation support
- Design of experiments
THANK YOU

VERY MUCH FOR YOUR ATTENTION!

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