Defoamers & Antifoams

Scientific Information
From
SSC Industries
Topics

• Defoamer Theory
• Defoamer Practice
• Defoamer types
• Determining system constraints
• Historical antifoams
• Material handling
• Application strategy

• Laboratory
• Defoamer screening methods
  – Which method is best?
  – “knockdown”
  – Persistence
  – Spreading
Terms to Know

- Foam
- Defoamer
- Antifoam
- Surfactant
- Surface tension
- Viscosity
- Coalescence
Foam

- Dispersion of a gas in a liquid
- Pure liquids do not produce stable foam
- Surfactant required
What factors affect foam stability?

• Surface area
• Surface tension
• Viscosity
• Temperature
• Concentration
• pH
Foam Stability

- Polyhedral foam is very stable.
- Formed by the lamellar drainage between spherical bubbles and the resulting stabilization by electrostatic repulsion.
- Further stabilized by certain solids
Other factors

- Viscosity - higher viscosity, more gas entrapment
- Temperature - higher temp, reduced foam stability
- pH - higher pH, usually greater foam stability
Defoamers vs. Antifoams

- Defoamers destabilize an existing foam.
- Antifoams are added to a system to prevent the formation of a stable foam.
SURFACTANT
(SODIUM PALMITATE)

\[ \text{Na}^+ \text{ OOC}^- \quad (\text{CH}_2)_{14} \text{ CH}_3 \]

Water-soluble (hydrophilic) \hspace{1cm} Water-insoluble (hydrophobic)

Surface active agents have a hydrophilic end and hydrophobic end. Surfactants concentrate at hydrophilic/hydrophobic interfaces.
Surface Tension

Elasticity = 2A \frac{(d\gamma)}{(dA)}

where

A = surface area of liquid film
\gamma = surface tension of liquid film
Factors affecting surface tension

- Surfactant concentration
- Surface viscosity
- Electric charge effects
- Marangoni Effect (self-healing films)
# Defoamer Surface Tension

<table>
<thead>
<tr>
<th></th>
<th>Surface Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicone</td>
<td>21 - 25 dynes/cm²</td>
</tr>
<tr>
<td>Paraffinic oil</td>
<td>31 - 34 dynes/cm²</td>
</tr>
<tr>
<td>Naphthenic oil</td>
<td>34 - 40 dynes/cm²</td>
</tr>
<tr>
<td>Water</td>
<td>60 - 70 dynes/cm²</td>
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</tbody>
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Viscosity

Rate of bubble rise = $k \frac{r^2}{\eta}$

where

$r =$ radius of bubbles

$\eta =$ viscosity of the liquid
Effect of Defoamer on Coalescence

Without Defoamer

With Defoamer
Nomenclature of Silicon Materials

- **SILICON**
  The basic metal. Symbol: Si

- **SILICA**
  The oxide form of the metal, produced in powder form. Can be hydrophobized with 5 - 35% by weight silicone fluid. Symbol: SiO₂

- **SILICATE**
  The sodium, calcium, magnesium, aluminum, etc., form of silica. May be soluble (Na form) or insoluble (CaO, MgO, BaO, Al₂O₃ - forms). Generally soluble at pH>10. Symbol: [Na₂O]ₓ[SiO₂]ᵧ

- **SILICONE**
  Normally, the methylated polymer form of silica. The low viscosity fluid forms are used in defoamers. Symbol: (CH₃)₃SiO[(CH₃)₂SiO]ₓSi(CH₃)₃
Why use a defoamer?

- Effect on production
- Housecleaning
- Environmental
- End product quality
Why so many different defoamers?

- Different foaming conditions
- Additive restrictions due to side effects
  - silicone
  - oil
  - particulates
  - surfactants
A Balancing Act

• “Selective incompatibility”

• The goal is to defoam or prevent foam formation with minimum side effects in the process.
Defoamer types

- Water-based
- Solvent-based
- Oil-based (with or w/out particles)
- Oil in water emulsions
- Silicone emulsions
- Silicone concentrates
- Polymer
Water-based Defoamers

- Only used in industrial applications or in effluent systems where temperatures are at or below 135°F.

- Shelf life is dependent on storage conditions and agitation.
Defoamer/Antifoam Selection Constraints

- Ecology
- Economy
- Efficiency
Defoamer selection process

- End product
- Questions I need to ask
- Component restrictions?
- Environmental
- Regulatory
End product

- What is the customer making?
- Could defoamer get in the finished product?
- Is the process loop closed or open?
- If effluent application, is the water further treated prior to discharge?
Questions

- pH
- Temperature
- Viscosity of the foaming media
- Dissolved and suspended solids
- What is causing foam stabilization?
Environmental

• Effluent- no “sheen” on the river
• Air pollution- VOC’s
For example, all products used in the manufacture of paper must be FDA-approved under 21 CFR 176.170, 176.180, and/or 176.210.

Food grade defoamers must be approved under 21 CFR 173.340.

Some applications need Kosher certification.
Defoamers Must:

- Be insoluble in the medium to be defoamed
- have a positive entering coefficient
- have a positive spreading coefficient
Shelf Life

- Dependent on storage, agitation, temperature
- Water-based are subject to water evaporation, causing thickening and crusting
- Particle suspensions (40-303 type)
  - Do not lose activity if made homogenous
- Clear blends are stable indefinitely in sealed containers.
Material Handling

• Provisions for re-circulation or agitation are essential for most defoamers.

• Positive displacement piston pumps will handle varying viscosities and head pressures.
How to Apply

- If possible, add at a point of agitation
- Multiple feed points are better than one
- Dilution lines
- Spray systems
- Drip feed at a last resort!
LAB

- On-site screening
  - Foam re-circulator
  - Jar tests
  - Grad. Cylinder
- Knockdown
- Persistence
- Spreading
Dosage

• Lab dosage does not correlate with actual field dosage.
• This is due to capillary action and film stabilization by the container wall.
• Relative comparisons can be made with the incumbent defoamer.