DELTA specialties

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Additives Guide

FOAM CONTROL ADDITIVES

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*I*n many stages of production, handling and application, air can be incorporated and then finely dispersed into resins, lacquers, and paints. Introduced air or gas will form spherical bubbles in the liquid phase.

In pure liquids, foam is not stable. Foam is only stable in systems containing surfactant-like substances such as wetting agents, or certain surface control additives needed to improve important properties of the paint. All these surfactants have in common the fact they can migrate to the air/liquid interface of the paint, thereby reducing the surface tension.

CAUSES OF FOAM

Foam is a stable dispersion of a gas in a liquid medium that results when a surfactant layer forms around air bubbles and entrains them within it.

Air can be incorporated into a coating by:

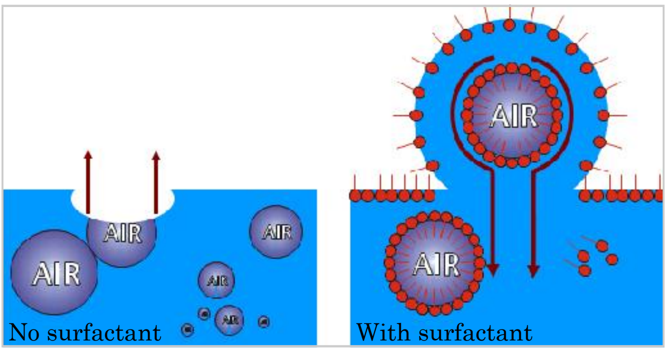
- Mixing during the polymer/pigment grinding and let-down steps
- Pumping during package filling
- Shear or spraying during application

Effective foam control additives are beneficial in preventing or reducing many common coating problems such as:

- Viscosity increase and loss of mechanical shearing power during milling resulting in smaller batch sizes and poor pigment/polymer dispersion
- Volume increase during the let-down and mixing steps leading to overflowing
- Slower package-filling rates due to inefficient pumping
- Air incorporation during transport and handling
- Slower printing-press speeds or lower pressures during spraying
- Surface defects on coated substrates resulting in poor appearance, reduction in gloss or less substrate protection

Stable foams occur when surfactants are present forming an interfacial layer around air bubbles that are entrained in the coating medium.

In surfactant-free solutions, these bubbles will move up to the surface because of their lower density.



At the surface, formation of a so-called lamella takes place, the gas bubble still containing a layer of liquid on the outside.

The liquid in the lamella flows down and then out. The size of the lamella gets smaller while the thickness of the liquid layer around the gas bubble is reduced.

Ordinarily, the lamella will burst at a thickness of approximately 10 nm. This process is called a "drainage effect" and in pure liquids, will occur instantaneously.

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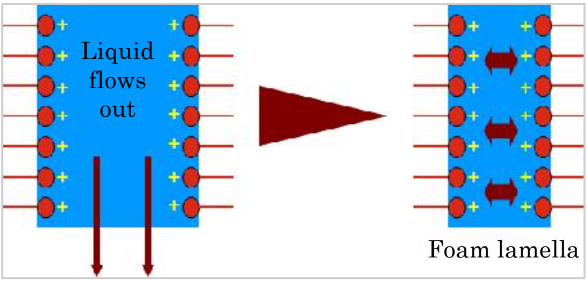
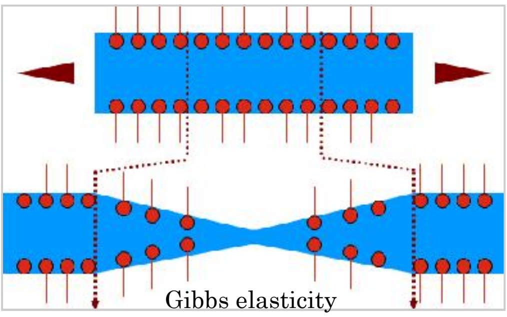
FOAM STABILIZATION MECHANISMS

Foam is stabilized by different mechanisms via action of surfactants:

- The bubbles come closer together as a result of the gravitational forces allowing the liquid to flow out of the foam and the lamella to become thinner and thinner (Drainage & Marangoni effects)
- The presence of ionic surfactant molecules at the surface creates electrostatic repulsion (electrostatic repulsion)
- The foam lamella exhibits a higher elasticity due to a stretching effect caused by the presence of surfactant molecules (Gibbs elasticity)





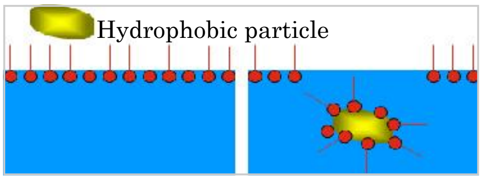
DEFOAMING MECHANISM

The principle of inhibiting or destroying foam (defoaming) is generally based on an overcoming of the stabilizing mechanisms. Foam control additives (FCA) possess properties which are opposite to those needed for foam stabilisation.

The term foam control agent is a collecting name for antifoams, defoamers and air-releasing agents. An antifoam is used to prevent foam formation. A defoamer is added to an existing foam to destroy the foam formed on the surface. Air-releasing agents assist the air bubbles in the liquid to rise to the surface.

FCA works on the foam lamella during or immediately after their formation:

- The finely dispersed FCA droplets penetrate into the foam lamella and spread itself out into the shape of a duplex film. The resulting increase of surface tension causes the lamella to break
- The FCA droplet penetrates the lamella and forms a mixed monomolecular film there, which leads to a lower cohesion compared to the previously existing one and causes lamella to break
- In case of FCAs containing hydrophobic particles there is a third possible mechanism. These hydrophobic particles reach the surface of lamella and on the top of the lamella they adsorb surfactant molecules. The lamella is deprived of the surfactants and breaks



DEFOAMING PROCESS

Foam control additives function by a variety of mechanisms to prevent or rupture foam.
Their individual efficiency is determined by 3 key factors:

- Insolubility in the foaming medium. The insolubility of a FCA is important for the movement of the FCA to the lamella
- Low surface tension, so that they can be uniformly dispersed throughout the formulation
- Ability to penetrate into the foam wall (or lamella)

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The 3 basic processes by which foam control additives disrupt foam are:

- Entering
- Spreading
- Bursting

For good entering and spreading, the entering coefficient **E** and the spreading coefficient **S** have to be positive. These two coefficients are defined as follows:

$$E = (\gamma_{FM} - \gamma_{FCA}) + \gamma_{FM/FCL} > 0$$

$$S = (\gamma_{FM} - \gamma_{FCA}) - \gamma_{FM/FCL} > 0$$

γ_{FM} being the surface tension of the foaming media (liquid)
γ_{FCA} being the surface tension of the foam control additive
$\gamma_{FM/FCL}$ being the interfacial tension between the foaming media and FCA

Examples (water-based system):

	Surface tension (mN/m)		
Liquids	γ_{FM}	γ_{FCA}	$\gamma_{FM/FCL}$
Water	72.8	-	-
Benzene	-	28.9	35.0
n-Octanol	-	27.5	08.5
n-Octane	-	21.8	50.8
n-Hexadecane	-	30.0	52.1

Liquids	**E**	**S**	
Benzene	78.5	08.8	*Enters, slow spreading*
n-Octanol	53.7	36.7	*Enters, rapid spreading*
n-Octane	101.7	00.7	*Enters, barely spreads*
n-Hexadecane	94.8	-09.4	*Enters, no spreading*

Only n-Octanol both enters and spreads rapidly and thus can be considered a good foam coontrol additive for water-based systems.

COMPOSITION OF A FOAM CONTROL ADDITIVE

Typical foam control additives consist of the following components:

- Carrier fluids: They act to transfer the generally hydrophobic active substance uniformly into the hydrophilic medium. Typical carrier fluids include aliphatic and aromatic mineral oils, solvent blends, and water in the case of pre-emulsified defoamers
- Surface active agents: They bring the active substance to the air interface and into contact with the stabilized foam structure. These substances work by having a general incompatibility with the formulation and disrupt the spreading mechanism for stabilizing foam. The most often used substances showing incompatible spreading include fatty acid esters and amides, glycols, silicones, and modified silicones
- Active substances: They adsorb surfactant ingredients present in the formulation and destabilize foam. Hydrophobic particles such as metal soaps, waxes and hydrophobic fumed silica are adsorption compounds for foam destruction

CHOOSING A FOAM CONTROL ADDITIVE

For solvent-based and solvent-free systems, polysiloxanes, polyacrylates and polyolefins are effective.

Pure polysiloxanes are also suitable but critical in terms of their compatibility, which can cause cratering. The best balance between compatibility and incompatibility is achieved through organically-modified polysiloxanes.

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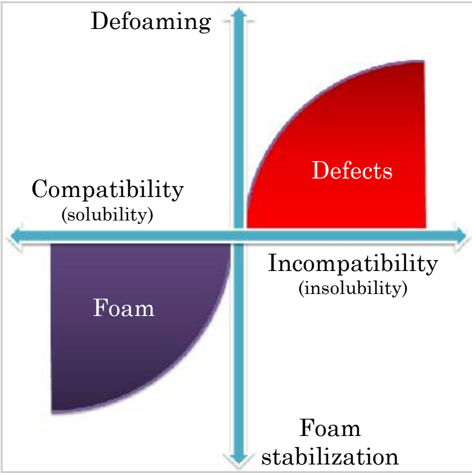
Modification of the polysiloxane backbone with fluorine results in the so-called fluoro-silicones knwon for their very low surface tension and strong defoaming properties.



For waterborne systems, a wider range of chemical structures can be used due to the generally higher surface tension of these systems.

Foam control additives for waterborne systems can generally be based upon:

- Mineral oil: As opposed to solvent-based systems, the spreading of mineral oils in water-based systems is sufficient to act as a foam control additive. In the presence of hydrophobic particles, the mineral oil acts in addition as carrier for these particles, like hydrophobic silica or metallic soaps. Because of the yellowing of the paint by the use of aromatic mineral oil, aliphatic mineral oil is preferred.
- Silicone: Both dimethylpolysiloxanes and modified polysiloxanes can be used as foam control agents in water-based systems

An important point to consider is the incorporation of the foam control additive in the paint system. Since they are not soluble in the system, a good distribution of the active substance is necessary. This can be controlled by the mixing speed and time, otherwise craters can be formed or loss of defoaming efficiency is observed.

Since the performance of a foam control additive is difficult to predict due to the variety of raw materials used in a paint formulation and the application method, evaluation of your own system is indispensable.

The stirring or shaking tests are based on the incorporation of air in a system. After this air incorporation, the samples can be analysed on weight or volume. The foam reduction over time of these stirred or shaked samples can also be observed. These tests give the effectiveness of the foam control additive during the manufacturing process.

The roll test can be used to control the foam behaviour during the application of the paint. After application of the paint with a roller on a testpaper, the wet and dry film is analyzed on surface defects.

PRODUCT SELECTION GUIDE

DELTA specialties offers a comprehensive range of foam control additives (silicone-free and silicone-based) to help you get rid of foam and achieve foam-free formulations in coatings, printing inks and plastics (composite).

The table in the next page will help you choose the foam control additive that is most suited or potentially suited for your resin system. Should you need to access our technical data sheets, either retrieve them from our website www.deltaspwll.com or send us an e-mail at info@deltaspwll.com.

Some think business opportunities, we think business partnerships

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