

Bursting the Bubble- Foam Killers

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The term defoamer describes a product that is added to control pre-existing foam. An extremely diverse set of chemical formulations can be effective either to prevent (anti-foam) or to destroy foam once it has formed (defoamer). Actually the distinction between the two terms is commonly ignored. Hence the word 'defoamer' is most commonly used.

A foam is essentially an aggregate of bubbles (Fig. 1 & Fig. 2). More precisely, it is a dispersion of gas in liquid, where liquid forms the continuous phase. The phenomenon of foaming is primarily governed by the properties of the interfaces involved and foaming is always accompanied by an increase in the interfacial area of the system, and hence its total free energy. Foams are basically unstable and therefore self-destroying and their stability is, among other factors, determined by the gas/liquid interfacial free energy.

The inherent characteristic of a defoamer is that it is surface-active but highly insoluble in water, with an extremely high surface area. Thus it has to be formulated so that it is dispersed as tiny droplets in the form of an emulsion. The surface-active components provide it with the ability to spread very rapidly into any air-water interface that it encounters.

The spreading action of defoamers causes a chemical or mechanical shock to the surface, which in turn destabilises the foam. The above consideration of antifoaming merely as a spreading phenomenon is overly restrictive and suffers from several limitations. For example, it is known that many materials

spread without showing marked defoaming and others do not spread but nevertheless act as antifoams.

Depending on the particular antifoam and the foaming system, one can expect differences in the relative importance of these factors:

1. Dispersion of antifoam in the foaming solution
2. Transport of antifoam droplets from bulk to the bubble interface
3. Entry of the droplet into the gas/liquid interface
4. Spreading
5. Bubble rupture

CHOICE OF AN ANTIFOAM

Knowledge of the type of surfactants present facilitates the choice of the antifoam, but it provides only a partial mechanistic insight into the performance and performance requirements of the antifoam. The following are the main criteria for such of antifoam.

1. The state of the foaming system its homogeneity
2. The solution viscosity
3. The surfactant concentration in relationship to the critical micelle concentration (CMC)
4. The surfactant type: ionic, nonionic, or mixed
5. The solution surface tension
6. The operating temperature
7. The solution pH

During textile processing we encounter foam during all wet-processing stages, such as desizing, bleaching, scouring, dyeing & finishing, etc. Due to the diverse conditions during processing of

textiles, careful selection of defoamers is needed, based on factors like pH, temperature, type of machine, shear forces, and the foaming media.



Fig. 1 Foam Structure

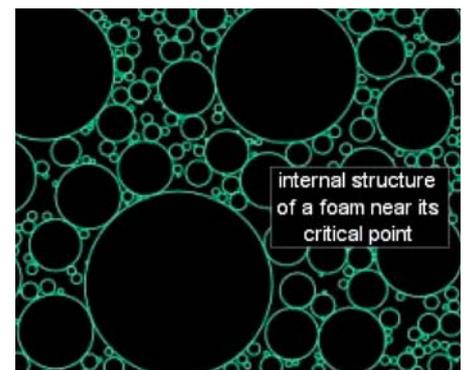


Fig. 2 Foam Structure

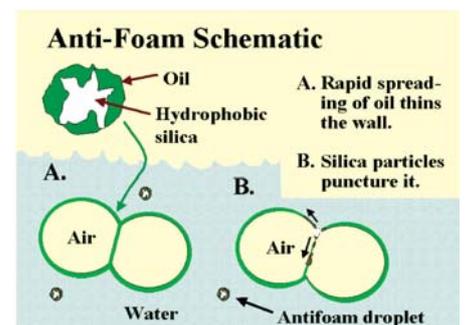


Fig. 3 Mechanism of Defoaming

Broadly considered, defoamers used in textile processing can be divided into two main categories: (i) Non-silicone and (ii) Silicone oil-based defoamers.

Non-silicone oil defoamers can be further classified based on active raw material:

- Mineral oil
- Alkyl phosphate
- Block copolymers of ethylene oxide/propylene oxide
- Vegetable oil

a) Mineral Oil

Saradefoam is a mineral-oil based defoamer along with metallic soaps and fumed silica particles. The function of such particles is to puncture the foam surface, causing it to coalesce when the defoamer spreads at the interface (Fig. 3). These non-silicone defoamers have a limitation, in that they do not perform at high alkalinity and high temperature.

The efficiency of non-silicone defoamers is rightly perceived to be lower than silicone antifoams; however they do not give rise to the 'much dreaded silicone oil spots'. They are also significantly inexpensive as compared to silicone-based defoamers. Non-silicone



Fig.4 Defoaming action



Fig.5 Deaeration

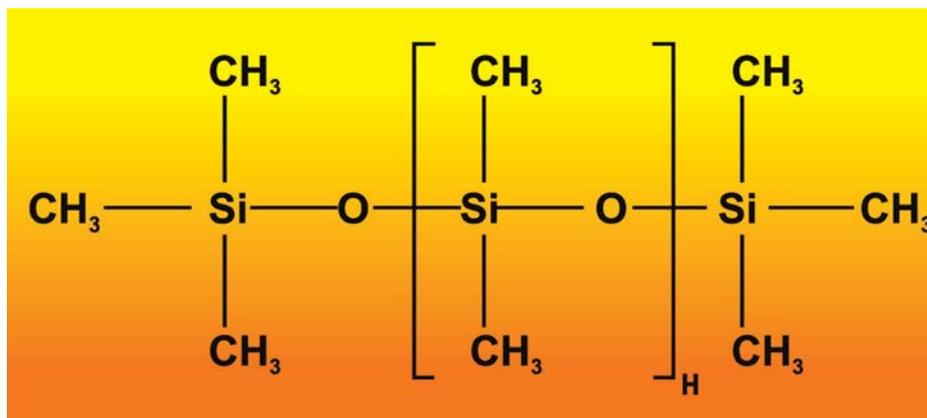


Fig. 6 Structure of Poly Di-Methyl Siloxane

defoamers do not exhibit any detrimental influence on textile processes such as pretreatment, dyeing, finishing, etc. They can be used along with functional finishes like flame retardants and, in most cases, with water-repellents or fluorochemicals.

b) Alkyl Phosphate

Alkyl phosphates are insoluble in water and hence made dispersible by usage of selected surfactants. When such an emulsified product is added in water it rapidly causes displacement of air and allows quick wetting and sinking, thus preventing fabric floatation. They show excellent alkali stability as they are phosphate esters. These foam-control agents are more accurately called deaerating wetting agents (Fig 5).

c) EO/PO Block Copolymers

These are organic surfactants, which are essentially soluble in aqueous media at room temperature. They are also called unfilled antifoams. These polyglycols can be based on PEO or on fatty acids, fatty alcohols, alkyl phenols, silicones, etc, as the primary hydrophobe.

Such polyglycols exhibit inverse water solubility (cp) at room temperature, depending on PO content. The cp of such polymers can be suitably engineered by varying the quantity of PO and EO until it becomes insoluble in a media at a desired temperature. Above this temperature such products have antifoaming properties for that media.

Polyglycols, being readily soluble in water at room temperature, are easily removed by a simple cold wash. They

can be used as shear-stable antifoams, which are active as foam-control agents above their cloud point.

d) Vegetable Oil

These are also termed VOC-free antifoams/defoamers. These defoamers are well suited for deaeration and foam control in latex paints, emulsion polymers, textile and paper processing. The active components are based on renewable raw materials. Such products typically contain small quantities of silicones and/or some synthetic waxes in addition to the vegetable oils. They are compatible with flame retardants and most textile-finishing agents.

Silicone defoamers can be further classified as:

- Classical fine emulsions of activated poly-dimethyl siloxane
- High-efficiency alkali-, electrolyte- and pH-stable emulsions
- Surfactant-compatible defoamers
- Transient antifoams

(i) Classical Fine Emulsions

Classical silicone defoamers are based on poly-dimethyl siloxane of varying molecular weight, filled/preactivated with fumed or precipitated silica and then suitably emulsified for its application in aqueous media for textile processing. The efficiency of such antifoam emulsions depends on several formulating variables, ie. particle size, surfactant type and silicone actives.

It has been found that silicone antifoams with a particle size less than 2 microns show very poor antifoam efficiency. This is because

the antifoam droplet is too well emulsified and is not able to orient at the liquid air interface. On the other hand, antifoam emulsions with a particle size greater than 50 microns have poor shelf and storage stability. They are highly efficient antifoams/defoamers, showing excellent performance even at low dosages; however due to the strong hydrophobic nature of poly-dimethyl siloxane, these emulsions are susceptible to shear, pH and temperature, resulting in difficult-to-remove oil stains. Hence these silicone defoamers are best suited for low-turbulence machines, ambient temperatures and weakly acidic to weakly alkaline aqueous baths. Sarasil-D is one such product, developed by Sarex.

(ii) Alkali Stable Emulsions

The shortcomings of activated poly-dimethyl siloxane lead to the requirement for high-efficiency, shear-stable emulsions, exhibiting robust stability to pH, electrolyte and temperature. These were derived by functional modification of the silicone fluid and by better emulsification techniques. Sarasil JS is one such product, available as ready-to-use 10-15% emulsions. Sarex has been able to offer a concentrated version of such a defoamer, ie. 40% dilutable by blending

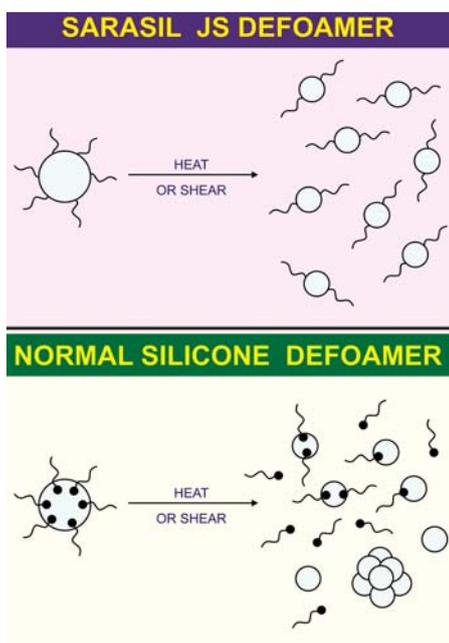


Fig. 7

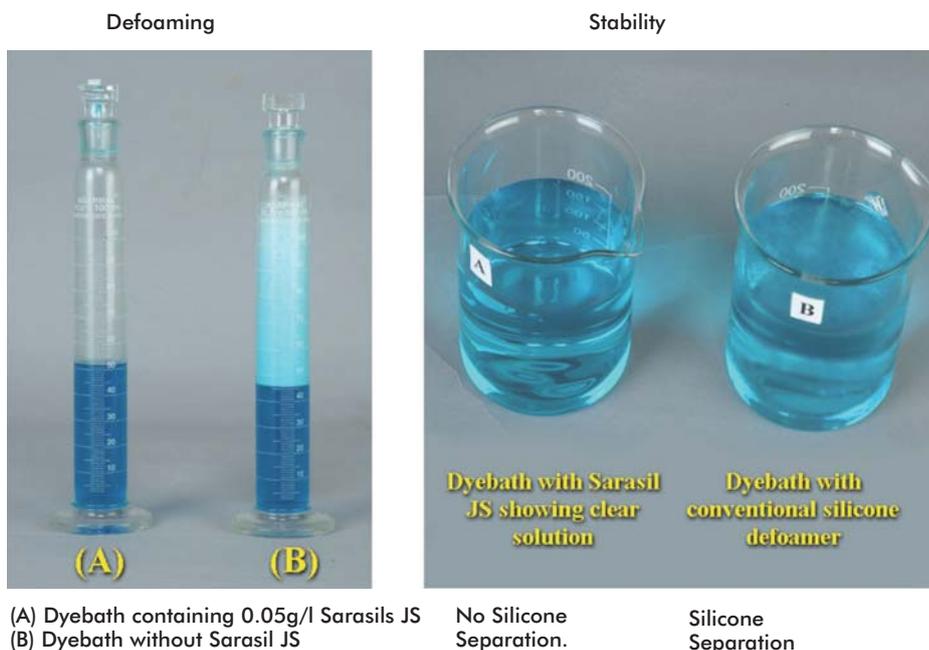


Fig. 8

with water in the presence of a rheology modifier, making it a boon for formulators and bulk consumers.

(iii) Surfactant Compatible Defoamers

Among surfactant-stable defoamers, Sarasil DET (Conc) is an example of a high-efficiency antifoam, designed to make low-foam systems when incorporated at extremely small dosages.

Faster production cycles have resulted in the prominence of high-turbulence equipment like soft-flows, jet dyeing and continuous systems. Conventional scouring, dyeing and finishing agents generate a lot of foam, resulting in fabric entanglement and dry foam spots. Hence the need for low-foam detergents and scouring agents and other wet-process auxiliaries.

Conventional silicone antifoams, when used in these detergent/wetting-agent formulations, exhibit poor compatibility, leading to unstable blends, which tend to separate and also make the formulation turbid-to-hazy.

Sarasil DET (Conc) has been able to overcome the above limitation and, when added to these nonionic surfactant formulations, gives a stable, homogeneous dispersion, exhibiting low-foaming characteristics for such surfactants.

(iv) Transient Antifoams

Most of the antifoams used in industry

demonstrate a general decline in their activity with time, in a given foaming medium. The extent of decay, of course, depends upon the composition of the antifoam, its mode of use, the solution conditions and the ageing time.

However, the majority of these antifoams are left with enough activity to interfere with foaming operation even after prolonged using time in the medium. In this connection, a transient antifoam has been defined as an antifoam composition, which, exerting its action in a given medium, completely loses its activity so that the medium resumes its normal foaming characteristics after a specified active life. Such antifoams are applicable to many industrial operations, such as sampling, where foaming needs to be inhibited, but only for a short period of time, and subsequent full-foaming power is critical to the product performance. It is under these conditions that transient antifoams have utility.

Thus, there is a wide choice of antifoams available to textile processors, and a suitable antifoam must be identified, depending upon the type of situation encountered. Alas! There is no master key. A key must be found to fit a particular lock, and it's the same for antifoams.

Performance and not chemistry or cost should be the selection criteria. ○