SILICA INGREDIENTS FOR VERSATILE AND EFFICIENT DEFOAMER FORMULATIONS

EVONIK
Leading Beyond Chemistry

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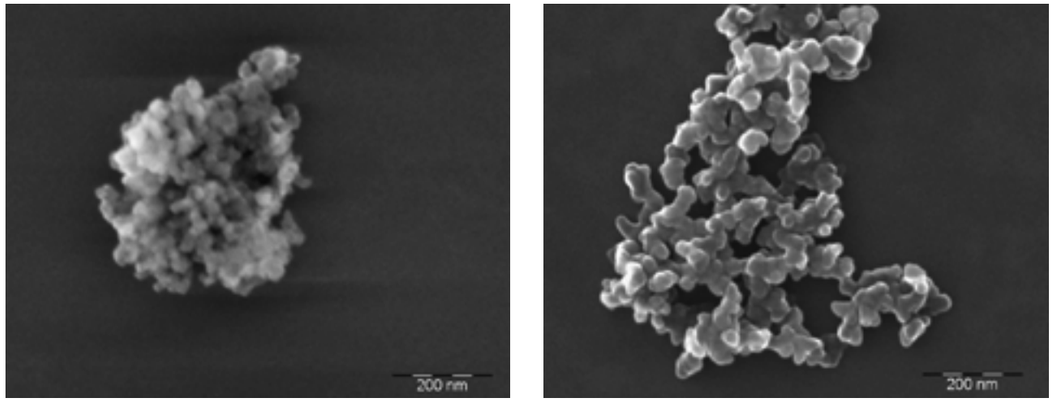
Introduction

Delicacies such as ice cream, mousse au chocolat and cappuccino milk foam are examples of how foams enrich our everyday life. In contrast, unintended foaming can create severe problems in industrial processing.

Examples are found in many sectors of production, e.g., in the textile, paper, construction and chemical industries. Foam may impede manufacturing processes by reducing the usable volume of containers or by causing pumping problems. Foam formation can also affect the quality of paints & coatings, construction materials (e.g., floor screed) or consumer detergent products.
To prevent foam induced production issues, effective defoamer formulations are employed that need to be compatible with the manufacturing process and the final product, work at low concentrations and have high efficiency even under extreme conditions (high temperature, high pH, high shear forces).
Evonik has been partnering with the industry in providing a wide range of functionalities enabled by silica that boost the defoaming activity, absorptive silica carriers to produce powdered formulations and silica thickeners to modify the rheology of defoamer formulations. Our customers take advantage of the broad portfolio of hydrophilic and hydrophobic AEROSIL® fumed as well as SIPERNAT® and ZEOFREE® precipitated silica products. Evonik proudly offers a product portfolio which is unmatched by any other producer in the world.

1 Evonik Silica: versatile ingredients for defoamer formulations



[1] Pictures published in Cryst. Res. Technol., 1–20 (2015) / DOI 10.1002/crat.201500040

FIGURE 1:
Scanning electron microscope (SEM) images of a precipitated (left) and fumed silica (right) [1]

EVONIK IS THE ONLY GLOBAL PRODUCER THAT MASTERED BOTH THE PRECIPITATION AND FLAME HYDROLYSIS PATHWAYS FOR SILICA PRODUCTION. HYDROPHILIC SIPERNAT® AND ZEOFREE® PRECIPITATED AS WELL AS AEROSIL® FUMED SILICA PRODUCTS RESULT FROM THESE PROCESS TECHNOLOGIES.

The precipitated and fumed silica materials are based on different particle structures as shown in **figure 1**. Aggregates of both silica classes are composed of round shaped primary particles which are interconnected through bridges made of the same material. While AEROSIL® aggregates have an open elongated, branched chain structure, the aggregates of SIPERNAT® or ZEOFREE® have a denser cluster-like appearance. Aggregates of both silica types tend to agglomerate, giving rise to the form of the finished product in the package.

The more compact structure of the precipitated silica aggregates results in particles which have nanometer sized pores in them. These pores can be used to absorb any kind of liquid so that the material can be used as a carrier. As the absorbed liquids are typically only weakly bound to silica, they can easily leave the carrier and made available for any desired effects. Powder defoamers are a typical product group that relies on the absorption of liquids on SIPERNAT® or ZEOFREE® silica.

AEROSIL® fumed silica and SIPERNAT® precipitated silica with extremely small particles after thorough dispersion to break up the agglomerates have a strong influence on the rheological properties of the base liquids. The materials can therefore be used to modify the viscosity and by this stabilize defoamer formulations.

Both SIPERNAT® or ZEOFREE® and AEROSIL® can be modified to become hydrophobic (water-repellent) by a subsequent treatment with reactive organosilane or -siloxane reagents. These molecules chemically bind to the silanol groups present on the surface of the hydrophilic materials, forming a hydrophobic shell on the surface of the silica particles (**figure 2**).
By using various kinds of organosilanes or -siloxanes for treatment, products of different degrees of hydrophobicity result. In contrast to their hydrophilic counterparts, hydrophobic silica in not wetted by water and does not mix with aqueous solutions (**figure 3**).
Hydrophobic silica products are well known boosters for defoamer formulations. Hydrophobic AEROSIL® can also be used as a rheological additive for defoamer formulations.

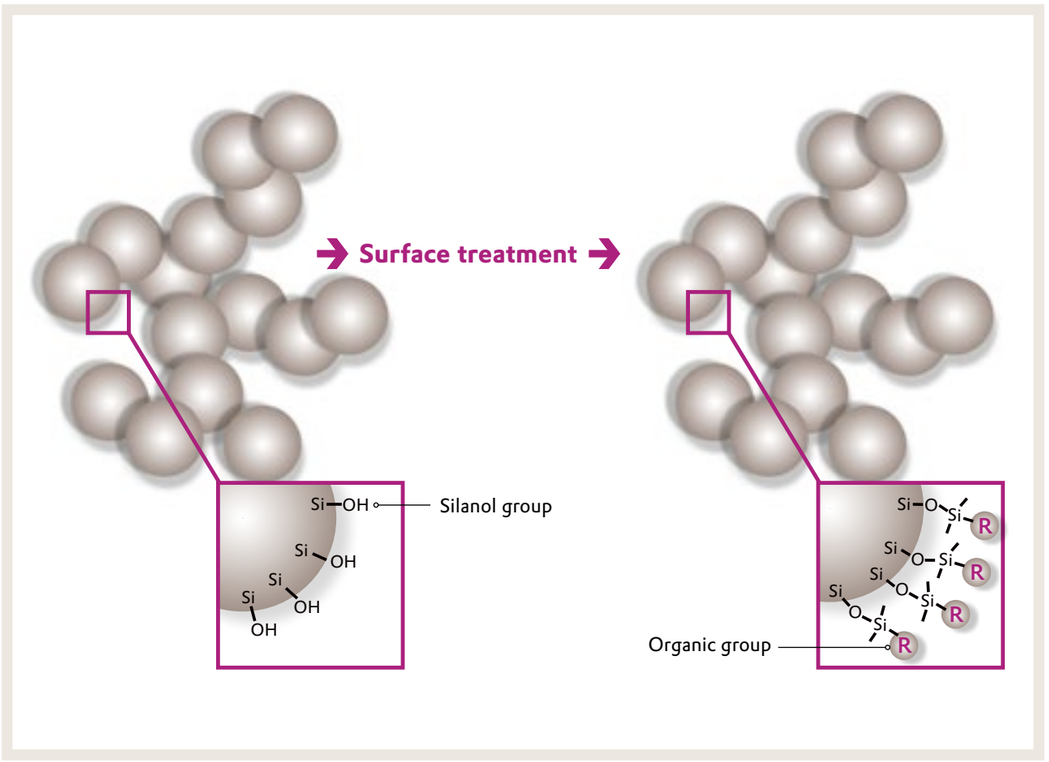


FIGURE 2: Hydrophobic (water-repellent) treatment of silica.

FIGURE 3: Behavior with water for hydrophilic (left) and hydrophobic (right) silica products.

2 Silica defoamer boosters from Evonik

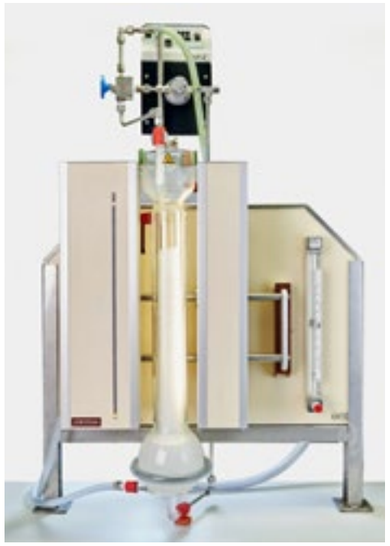


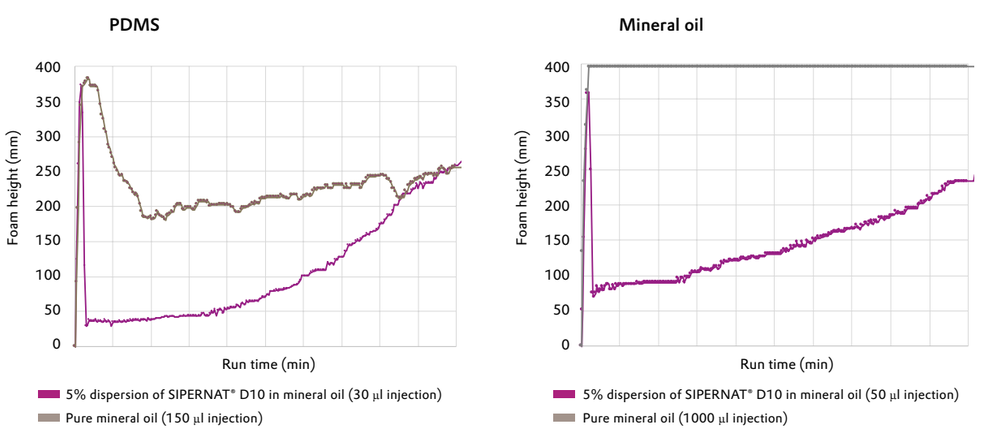
FIGURE 4:
Contifoam device for testing of defoamer formulations.

Most high-quality defoamer are manufactured with water insoluble oils as their bases. Although many different oils can theoretically be used, popular liquids used in the industry include mineral oils (paraffinic, naphthenic) for their favorable economics and various kinds of polydimethylsiloxanes (PDMS) for their high efficiency. For sustainability reasons and for special applications also polyether siloxanes, plant oils or fatty acid alcohols are used. For easier spreading or ease of dosage, the base oils are formulated with additives or turned into emulsions.

The efficiency of defoamer formulations can be assessed by different techniques. Often a test medium is made to foam, and the test formulation is added to the foaming mixture. The drop in the foam height as well as the time needed to bring the foam back to a certain level ("hold down time") are important parameters to assess the efficiency of the formulation. Equipment like the Contifoam[2] device shown in **figure 4** can be used for this purpose.

Hydrophobic silica particles are important components of defoamer formulations as they boost the ability to fight foam. **Figure 5** compares the defoaming action of pure polydimethylsiloxane (PDMS) and mineral oil against dispersions of only 5 wt.-% of SIPERNAT® D 10 in the same oils. In case of PDMS, an injection of 150 µl of the pure oil gives an equivalent hold down time as just 30 µl of a 5 wt.-% dispersion of SIPERNAT® D 10 in the same oil. In the case of mineral oil, the pure oil even at an injection of 1000 µl does not have any effect on the foam. Adding just 5 wt.-% of SIPERNAT® D 10 to the same oil, a pronounced kick down and a long hold down of the foam is observed when dosing only 30 µl of that dispersion. Hydrophobic SIPERNAT® D 10 dramatically boosts the defoaming action of both base oils and helps reduce the necessary defoamer dosage to minimize possible unwanted effects of defoamer addition and the impact on the environment.

FIGURE 5:
Comparison of using pure PDMS and mineral oils on a foaming aqueous solution against 5 wt.-% dispersions of SIPERNAT® D 10 in the same base oil. Tests were performed in a Contifoam test system, with a foaming solution of a model detergent, using Finavestan A50B (Total Deutschland GmbH) representing a mineral oil and Xiameter PMX-200 silicone oil (Dow Chemical) as an example for PDMS.



Foams are two phase systems of gas bubbles trapped in a liquid matrix. A picture of a foam and a schematic representation of a foam are given in **figure 6**. Ignoring exceptional cases such as solvent foams or foams stabilized by proteins, the liquid typically is an aqueous solution in which surfactant molecules concentrate at the gas-liquid phase boundary to stabilize the foam. Initially, there is a high amount of entrapped liquid in the foam which drains with time, thinning the plateau border in the foam.

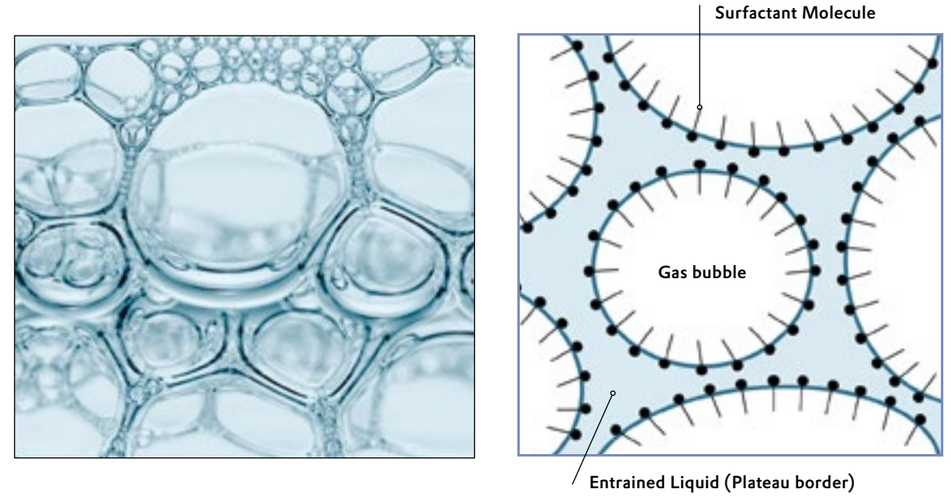


FIGURE 6:
Picture of a foam and schematic representation of a foam.

To destabilize the dual phase foam system, droplets of a defoamer formulation need to penetrate the plateau border. Defoamer formulations therefore need to be able to form small droplets on contact with the aqueous surrounding.
There are several different theories about how exactly these droplets function to destroy foams, but none of these theories have found general acceptance. Several excellent review articles are available that describe the different approaches [3]. Although the mechanistic view on the defoaming action may be different, all authors unanimously agree on the hydrophobic silica particles having a decisive role in the defoaming action of oil based defoamer formulations.

There are two ways how hydrophobic silica particles can be included in defoamer formulations:

- **Dispersion of ready-made hydrophobic silica in an oil formulation**
- **Dispersion of hydrophilic silica which is then subjected to a hydrophobic treatment in an oil formulation.**

Evonik offers both ready-made hydrophobic silica products for simple addition to defoamer formulations as well as reactive silica for defoamer manufacturers that decide to do the hydrophobic treatment in their formulation by themselves.

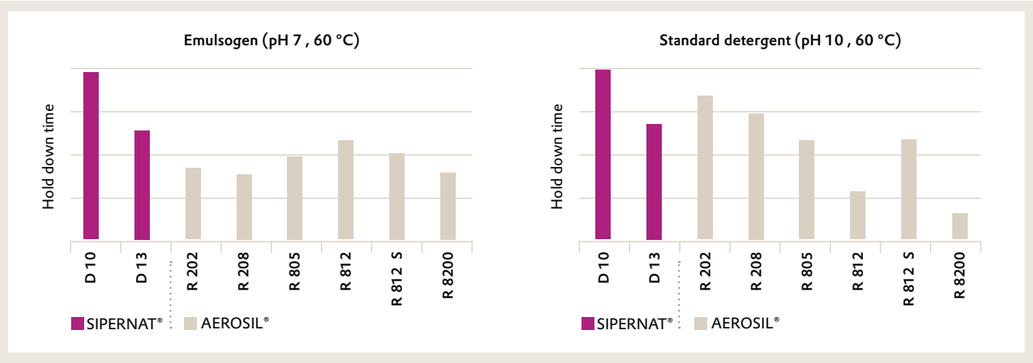
2.1 READY-MADE HYDROPHOBIC SILICA BOOSTERS FOR SIMPLE ADDITION TO DEFOAMER FORMULATIONS

As requirements on defoamer formulations are dependent on the intended use case, Evonik offers a wide range of hydrophobic SIPERNAT® and AEROSIL® products to choose from. The available products are listed in **table 1**.
The efficiency of a defoamer formulation depends on its composition and the foaming medium it is used for. Regarding the composition, not only the hydrophobic silica and the base oil but also additives influence the defoaming efficiency of the formulation.
The targeted use cases for the defoamer can cover a wide span of different conditions. Important parameters are the pH and temperatures of the foaming liquid as well as the identity of the foam creator. It is not possible to cover the number of variables and their possible combinations in this brochure. However, some important considerations can be briefly addressed here:

1. Type of hydrophobic SIPERNAT® precipitated or AEROSIL® fumed silica used in the formulation

The difference in the defoaming activity of 5 wt.-% dispersions of hydrophobic silica products in a polydimethylsiloxane base oil is shown in **figure 7** for two different foaming solutions. Depending on the foaming medium that is targeted, a variation of the type of defoamer booster may be useful to benefit from the full potential of these materials. Since defoamers are formulated for many different use cases, testing more than one silica for the specific application is recommended.

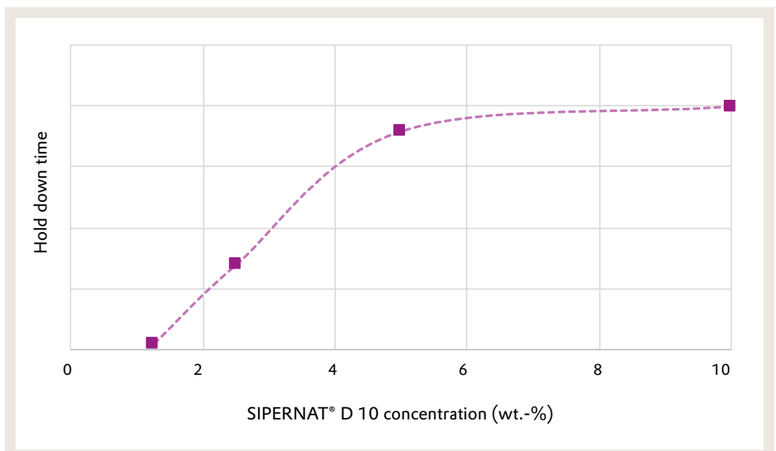
FIGURE 7:
Defoaming activity of 5 wt.-% dispersions of hydrophobic SIPERNAT® precipitated and AEROSIL® fumed silica tested as the hold down time in two different foaming environments. Tested in PMDS (Xiameter PMX-200 silicone fluid (100 cSt)).
Left: aqueous solution of an anionic surfactant (Emulsogen EPA 1954) at pH 7 and 60 °C.
Right: aqueous solution of ECE standard[5] detergent solution at pH 10 and 60 °C.



2. Concentration of the hydrophobic silica in the formulation

How much of a specific ingredient needs to be added to a formulation is an important question for every formulator. Although this question needs to be addressed for every specific formulation, **figure 8** contains information on the effect of different concentrations of SIPERNAT® D 10 in simple mineral oil formulation on the hold down time.
Even small concentrations of SIPERNAT® D 10 improve the defoaming ability in this specific use case and the activity increases with increasing silica concentration. However, there is an optimal silica concentration for boosting the activity of the formulation. Above that concentration adding more SIPERNAT® D 10 does not result in equivalent performance gain.

FIGURE 8:
Dependence of the hold down time on the concentration of SIPERNAT® D 10 in mineral oil (Finavestan A50B) tested in a foaming solution based on ECE standard detergent at pH 10 and 60 °C.



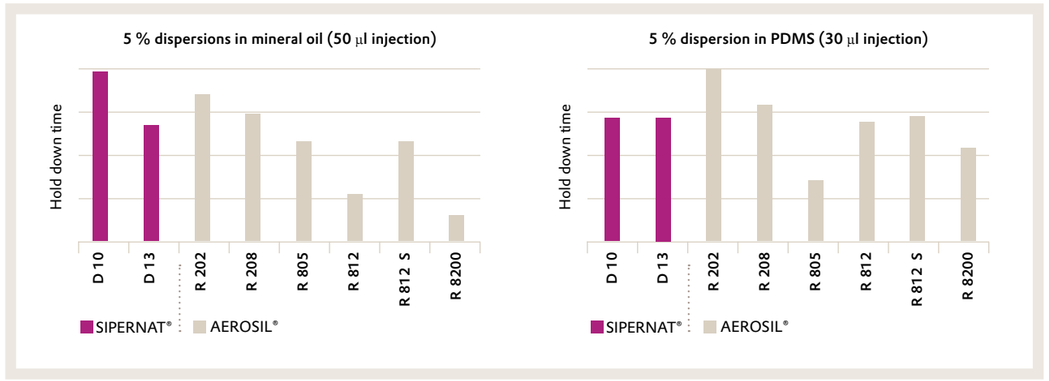


FIGURE 9:
Defoaming activity of 5 wt.-% dispersions of hydrophobic SIPERNAT® precipitated and AEROSIL® fumed silica tested as the hold down time in Finavestan A50B mineral oil and Xiameter PMX-200 silicone fluid (100 cSt) tested in a foaming solution of ECE standard detergent at pH 10 and 60 °C.

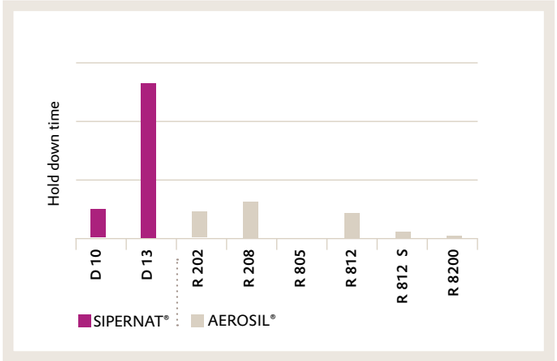
3. Type of base oil used in the formulation

The effect of the base oil in the formulation is shown for mineral oil and PDMS oil in **figure 9**. Although the strongly hydrophobic PDMS modified SIPERNAT® D 10, SIPERNAT® D 13, AEROSIL® R 202 and AEROSIL® R 208 efficiently boost the defoaming action in both oils, there are differences in the individual performance. While SIPERNAT® D 10 is the most effective product in mineral oil, PDMS treated AEROSIL® R 202 and AEROSIL® R 208 have slightly better performance in PDMS.

4. Defoamer for extreme pH and temperature conditions

Defoamers for applications having very high pH and temperatures as common in paper manufacturing are among the most challenging to formulate. **Figure 10** shows the defoaming activity of the hydrophobic booster silica at these aggressive conditions of the foaming medium. AEROSIL® and SIPERNAT® silica grades modified with PDMS work best and SIPERNAT® D 13 is the best performing product of the series.

FIGURE 10:
Defoaming activity of emulsified 5 wt.-% dispersions of hydrophobic SIPERNAT® precipitated and AEROSIL® fumed silica tested as the hold down time in a foaming solution of ECE standard detergent at pH 13 and 80 °C.



Briefly, SIPERNAT® D 10 is the most versatile defoamer booster as it offers excellent performance over a wide range of applications. Next to SIPERNAT® D 10 strongly hydrophobic silica grades such as SIPERNAT® D 13 and AEROSIL® R 202 are recommended for applications with high pH conditions. For applications with extreme pH values above pH 10 and high temperatures as encountered e.g., in paper production, SIPERNAT® D 13 is the product of choice.

Most hydrophobic SIPERNAT® and AEROSIL® products are suitable for defoamer products used in food contact applications. However, as regulations tend to change, please contact your regional technical expert to clarify the latest status. Product recommendations for applications falling under food, personal care and pharmaceutical regulations are also available.

Processing recommendations

- To take full advantage of hydrophobic silica boosters, a good dispersion of the silica in the formulation is necessary. The precipitated silica products SIPERNAT® D 10 and SIPERNAT® D 13 can be dispersed by intensive mixing with toothed blade or rotor stator mixers. For dispersion of the fumed silica AEROSIL® materials, the use of rotor stator mixers with even higher shear forces is recommended.
- For preparation of PDMS based O/W emulsions, it is not necessary to disperse the hydrophobic silica in the oil first, simply emulsify a mixture of all ingredients.
- AEROSIL® may increase the viscosity of some base oils. The viscosity of the dispersion can further increase on storage due to the formation of thixotropic gels. If this occurs, use either SIPERNAT® D 10 or SIPERNAT® D 13 or choose an alternative AEROSIL® having a different level of hydrophobicity in the formulation.

Table 1: Ready-made hydrophobic silica defoamer boosters

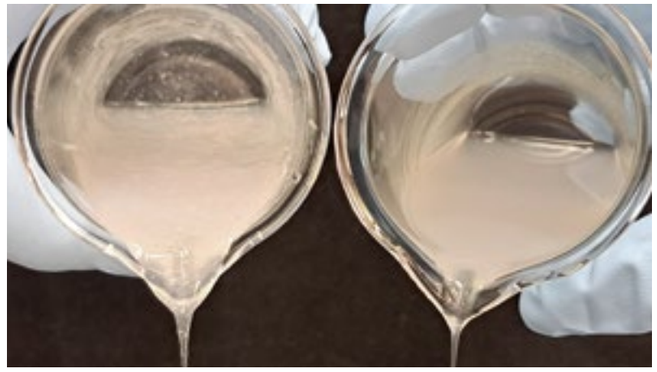
Product	Hydrophobic agent	Level of hydrophobicity	Regional availability		
			Americas	Asia	EMEA[1]
AEROSIL® R 972	Dimethyl dichlorosilane	Medium	X	X	X
AEROSIL® R 974	Dimethyl dichlorosilane	Medium	X		
AEROSIL® R 104	Octamethylcyclotetrasiloxane	Medium	X		
AEROSIL® R 106	Octamethylcyclotetrasiloxane	Medium	X		
AEROSIL® R 805	Octyl silane	High	X		
AEROSIL® R 8200	Hexamethyl disilazane	High	X		
AEROSIL® R 812	Hexamethyl disilazane	High	X	X	X
AEROSIL® R 812 S	Hexamethyl disilazane	High	X	X	X
AEROSIL® R 208	Polydimethyl siloxane	Very high	X	X	X
AEROSIL® R 202	Polydimethyl siloxane	Very high	X	X	X
SIPERNAT® D 10	Polydimethyl siloxane	Very high	X	X	X
SIPERNAT® D 13	Polydimethyl siloxane	Highest	X	X	X

[1] Europe, Middle East & Africa

2.2 REACTIVE SILICA FOR HYDROPHOBIC TREATMENT IN THE DEFOAMER FORMULATION

In addition to ready-made hydrophobized silica that only needs dispersion in the oil phase of the defoamer formulation, Evonik also offers reactive hydrophilic SIPERNAT® and ZEOFREE® precipitated and AEROSIL® fumed silica products with suitable particle size which producers can use to render them hydrophobic by themselves. Although the process is not exceedingly complex, it requires know-how, suitable equipment, energy input and time to come to suitable and reliable results. Typically, polydimethylsiloxane (PDMS) is used as the agent for treatment. The reaction can either be run in pure PDMS or PDMS can be added to a dispersion of the selected hydrophilic silica in the base oil of the defoamer formulation. For effective modification, it is recommended to use a hydrophilic silica with an alkaline pH which is either available already activated by Evonik (e.g., SIPERNAT® 383 DS, SIPERNAT® 35) or the pH adjustment needs to be done by the producer (e.g., SIPERNAT® 320 DS, AEROSIL® 200). The modification process needs to be adapted and optimized for the specific formulation. Some general guidelines on this are given in the formulation recommendations.

FIGURE 11:
Appearance of the batch prior to and after hydrophobization.
Left: SIPERNAT® 383 DS dispersion prior to hydrophobization (α-dispersion)
Right: SIPERNAT® 383 DS dispersion after hydrophobization (β-dispersion)



Formulation and processing recommendations

- PDMS with short chain length (viscosity in the range between 50 and 500 mPa s) are preferred for their higher reactivity in the modification process.
- It is recommended to effectively stir the mixture and use elevated temperature (100-200 °C).
- The initial dispersion of the hydrophilic silica in the oil or oil mixture – often referred to as α-dispersion - may have a high gel-like viscosity. During the modification the viscosity will drop as the silica becomes more hydrophobic and the final product – often referred to as β-dispersion - is produced (**figure 11**).
- The time needed for the modification is dependent on several conditions (e.g., reaction temperature, composition of the mixture, reactivity of the silica and the reagent used for the modification) but often is in the range of several hours.

For more information on the hydrophobization process and a comparison between SIPERNAT® D 10 as a hydrophobic ready-made defoamer booster and a material produced by the in-situ hydrophobization process please refer to our TI 1382 "Comparison of SIPERNAT® D 10 with in-situ hydrophobized fumed silica" which is available on our webpage.

Table 2 summarizes the silica products for in-situ hydrophobization. The particle size of the different silica products and the pH are suitable selection criteria for the choice of the right silica for your application. As products such as SIPERNAT® 35, SIPERNAT® 36, SIPERNAT® 38 and SIPERNAT® 383 DS feature already high pH, these are easier to use since no further activation for the water repellent treatment is required. Products with more neutral or even acidic pH require a suitable catalyst for the reaction.

Table 2: Reactive silica for hydrophobic treatment in the defoamer formulation

Product	pH (4 or 5 % in water)[1]	Particle size (d_{50})[2] [µm]	Regional availability		
			Americas	Asia	EMEA[3]
AEROSIL® 200	4.1	n.a.	X	X	X
SIPERNAT® 35	8.6	9.0	X	X	
SIPERNAT® 36	8.5	8.8	X		
SIPERNAT® 38	8.5	≤ 4.5	X	X	
SIPERNAT® 320 DS	6.2	7.5	X	X	X
SIPERNAT® 383 DS	8.3	7.5	X	X	X
ZEOFREE® 80	7.0	12		X	
ZEOFREE® 80 D	7.5	12.5	X		X

[1] According to ISO 787-9, aqueous dispersions with 4 wt.-% silica are used for AEROSIL® fumed silica and 5 wt.-% for SIPERNAT® precipitated silica.
[2] Laser diffraction after dispersion in water according to ISO 13320 using either Horiba or Coulter equipment. For fumed silica, no reproducible particle sizes can be measured by laser diffraction.
[3] Europe, Middle East & Africa

3 Silica rheology additives for defoamer formulations

To increase the storage stability of defoamer compounds containing dispersed booster or other particles in an oil-based liquid, the sedimentation stability of the particles sometimes needs to be increased. Adding AEROSIL® fumed or SIPERNAT® 380 precipitated silica to such preparations increases their viscosity and prevents sedimentation. **Table 3** contains suitable products for this purpose. The selection of the best silica rheology additive needs to be done empirically because small concentration of additives can change the viscosity and rheological behavior. Guidelines and processing recommendations based on experiences with pure oils are given in the formulation recommendations.

Processing recommendations

- All recommended rheology additives contain agglomerates of very fine particles. To take full advantage of the efficiency of the products, high shear dispersion using either toothed blade or rotor stator mixers is necessary.
- The higher the concentration of the silica rheology additive, the stronger is the effect on rheology.
- Typically, silica products with higher specific surface area have stronger effect on the viscosity and rheology of the formulation. As an example, AEROSIL® 200 has a stronger effect than AEROSIL® 90, AEROSIL® R 974 is more efficient than AEROSIL® R 972. This can be used either to find a more efficient rheology modifier or also to select a material which does not give too high viscosity increase at a given concentration.
- For non-polar oils such as PDMS and mineral oil hydrophilic AEROSIL® fumed silica and SIPERNAT® 380 are very efficient rheology additives. However, AEROSIL® R 972 or AEROSIL® R 974 can also be used if a hydrophobic product is preferred or if the hydrophilic products have a too strong of an effect on the viscosity.
- For more polar oils such triglycerides (e.g., plant oils), AEROSIL® R 202 is often a good choice to modify the rheology.

In unusual cases where this overall guidance does not help with your formulation task, please turn to the technical expert in your region.

Table 3: Silica rheology additives for oil formulations

Product	Hydrophilic/hydrophobic	Specific surface area (BET, N_2), Multipoint [m^2/g]	Regional availability		
			Americas	Asia	EMEA[1]
AEROSIL® 90	Hydrophilic	90			X
AEROSIL® 150	Hydrophilic	150		X	
AEROSIL® 200	Hydrophilic	200	X	X	X
AEROSIL® R 972	Hydrophobic	110	X	X	X
AEROSIL® R 974	Hydrophobic	170	X	X	X
AEROSIL® R 202	Hydrophobic	100	X	X	X
SIPERNAT® 380	Hydrophilic	165	X	X	X

[1] Europe, Middle East & Africa

4 SIPERNAT® and ZEOFREE® precipitated silica carriers for powder defoamer formulations

Some defoamer applications, for example for building materials such as concrete, screed, grout, putty, or tile cement, require powdered formulations. Absorptive SIPERNAT® or ZEOFREE® products can turn liquid defoamer preparations into powders. As discussed earlier, these products have a sponge-like porous structure. The pores have sizes in the range between 10 and 150 nm and suck up any kind of liquid due to high capillary forces. The speed of absorption depends not only on parameters of the silica carrier such as the pore and particle size but also on the viscosity of the liquid. The smaller the pores of the silica, the higher are the capillary forces and therefore the faster is the absorption. Bigger silica particles are slower in absorption as the liquid needs to penetrate deeper into the core of the particles. Highly viscous liquids are more difficult to absorb because of their resistance to flow into the pores. Speeding up the absorption of such liquids decreasing the viscosity by increasing the temperature of the liquid is recommended.

Table 4 gives an overview of the different silica carriers Evonik offers to the industry. The products have varying absorption capacities, particle sizes and powder densities which are the most important parameters to select the right product for your formulation.

Table 4: SIPERNAT® and ZEOFREE® silica carriers (typical values, not a specification)

Product	Absorption capacity [1]		Particle size (d_{50}) [2]	Powder density		Regional availability		
	DOA absorption [ml/100 g silica]	Linseed Oil absorption [ml/100 g silica]	[µm]	Tamped density [3] [g/l]	Bulk density [g/l]	Americas	Asia	EMEA[4]
SIPERNAT® 22	235		120	245		X	X	X
SIPERNAT® 22 S	235		14.0	100		X	X	X
SIPERNAT® 2200	225		320	250		X	X	X
SIPERNAT® 33	≥ 255		≥ 105	215			X	X
SIPERNAT® 45	285		25	150		X		X
SIPERNAT® 50	295		50	175		X	X	X
SIPERNAT® 320	195		n. n.	210				X
SIPERNAT® 340	235		20.0	160		X		
ZEOFREE® 5161 A	260	230	85		170	X	X	X
ZEOFREE® 5170		160	250		330	X		

1 DOA absorption is determined with dioctyl adipate as the liquid following ISO 19246. Linseed oil absorption is determined with linseed oil as the liquid on the dried carrier following ISO 787-5.
2 The particle size is measured by laser diffraction following ISO 13320.
3 The tamped is determined following ISO 787-11.
4 Europe, Middle East & Africa

- **ABSORPTION CAPACITY**
  The absorption capacity of a powder can be determined either by the linseed oil or the dioctyl adipate (DOA) absorption test. Both tests determine the amount of the respective oil that can be absorbed on specified quantity of the carrier. The test and the determination of the endpoint differ from one method to the other.
  In one test, the linseed oil is added dropwise to the silica under mixing by hand until the appearance of clumps signals the maximum oil absorption. Although the test relies on hand stirring, experienced operators obtain reproducible results.

In the DOA absorption test, dioctyl adipate is added dropwise to the silica in a kneader. The power input for the kneading is observed and drastic changes define the end point of the experiment and the maximum absorption capacity.
The DOA absorption method usually leads to higher absorption capacities than the linseed oil absorption test. For using silica on a technical scale, it is advisable not to try to reach the maximum absorption given by any of the analytical methods due to less effective mixing.

- **PARTICLE SIZE**
  The particle size of the silica products is determined by static laser diffraction after dispersion in water. The determined particle size therefore is not necessarily representative for the dry material that customers find in the packaging but a good measure to compare different products with each other.
  For producers of powder defoamer the particle size of a silica carrier indicates important handling properties such the ability of the powder to flow and the tendency to generate dust. Products with bigger particles typically flow better and produce less dust on handling. As the porosity of the silica extends through the complete particle, products with higher particle sizes are usually slower in absorbing liquids.

- **POWDER DENSITY**
  The density of the powder is simply measured by pouring a defined mass of the product in a graduated cylinder and reading the volume. Since products with small particles need time for the air to escape, it is necessary to wait for a defined time to be able to compare different silica products with each other. The density determined in this fashion is referred to as the bulk density.
  Especially for products with smaller particles, it is better to read the volume after a defined number of taps of the graduated cylinder. This guarantees that most of the air has been removed. The density resulting from the volume reading after tapping is referred to as tapped (or tamped) density. The tamped density is higher than the bulk density. The density of silica influences the necessary packaging size for the final powder defoamer and the tendency for dust generation.

The targeted application properties of the powder defoamer and the available equipment for the absorption of the liquid on the silica carrier determine the selection of the silica carrier. For the absorption of the liquid formulation on the carrier, please refer to general guidelines under Formulation and Processing Recommendations which may help you to produce an even better powder defoamer product.

Processing Recommendations

- Low shear mixers such as ploughshare or paddle mixers are preferred for processing. To avoid damaging the pore structure of the silica, the use of high shear chopper blades or intensifiers that sometimes are included in these mixers should be limited.
- For homogeneous distribution of the liquid on the carrier silica, the liquid should be added in small droplets, preferably by spraying it on the mixed silica bed in the mixer. Spraying the liquid on the mixing tools should be avoided to avoid lump formation.
- Highly viscous liquids can be easier processed if they are heated up to temperatures high enough to significantly decrease their viscosity.

FIGURE 12:
Examples of absorbates of the same liquid prepared with different shear forces.
Left: low shear mixing
Right: high shear mixing

REFERENCES

[1] Pictures published in Cryst. Res. Technol., 1–20 (2015)

[2] Produced by Ing. Franz Raab – Datentechnik, Berg bei Rohrbach, Austria.

[3] P.R. Garret, Defoaming, theory and industrial applications, in Surfactant Science Series Vol. 45 (1993), Marcel Dekker Inc.; R. Aveyard, P. Cooper, P.D.I. Fletcher, C.E. Rutherford, Langmuir 9 (1993) 604 -613, doi.org/10.1021/la00026a041; K.G. Marinova, N.D. Denkov, P. Branlard, Y. Giraud, M. Deruelle, Langmuir 18 (2002) 3399 – 3403, doi.org/10.1021/la0115841; N. D. Denkov, Langmuir 20 (2004) 9463 – 9505, doi.org/10.1021/la049676o.

[4] Emulsogen EPA 1954 is a product by Clariant AG.

[5] ECE standard detergent is a product of DEK GmbH and conforms to ISO 105-C08/C09.

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