

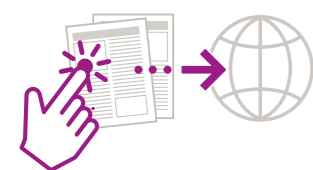
# OPTIMIZING CROP PROTECTION

## Formulations with Evonik Silica Products



interactive content

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Evonik's silica-based solutions increase the efficiency and sustainability of agricultural practices, leading to higher yields and lower environmental impact.

The increasing world population drives the need for more efficient and sustainable food production. With increasing resource demands and environmental challenges, applying optimized and stable crop protection formulations is one of the most important measures to meet these increasing requirements.

**By providing a wide range of silicon dioxide products, Evonik supports our customers to meet the following challenges:**

**Increasing Formulation Efficacy:**

- Higher active potency and quality with absorptive processing aids, reducing overall dosage required.
- Exceptional rheology control, ensuring stability of liquid and solid formulations.
- Optimized biological activity and availability.
- Enable on-target application of plant care formulations.

**Improving Safety and Sustainability:**

- Make products more sustainable by reducing application rate.
- Offer user-friendly systems, improve handling and application.
- Reduce solvent emission (VOC).
- Maximize long-term dispersion and emulsion stability.
- Compatible and synergistic with fertilizer systems.
- Guarantee safety in manufacture and handling.
- Reduce waste and effluent of all kinds.

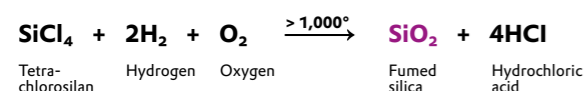
Evonik provides products for both solid and liquid formulations. With the choice of AEROSIL®, SIPERNAT® and ZEOFREE® products, as well as BREAKTHRU® Oil Enhancers, Dispersing Agents, Emulsifiers, Wetting Agents and Antifoams, Evonik provides the most comprehensive product portfolio worldwide.



### 1.1 Basic principles of AEROSIL® fumed silica and SIPERNAT® specialty silica

**AEROSIL® fumed silica:**

Hydrophilic and hydrophobic AEROSIL® grades are widely used in many liquid systems for viscosity control and anti-settling behavior. AEROSIL® fumed silica is a highly pure, very fine silicon dioxide, manufactured through a continuous flame hydrolysis process according to the following reaction.

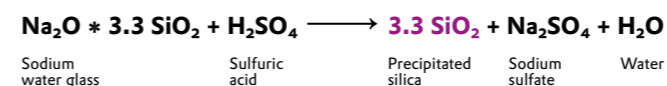


During the manufacturing process, the primary particles sinter together in chains known as aggregates. The surface of AEROSIL® fumed silica is characterized by the presence of silanol (Si-OH) groups. These groups are responsible for the above mentioned effects of AEROSIL® products in liquid systems.

When fumed silica is dispersed in a liquid, the silanol groups interact with each other and build up a reversible 3D network. Under mechanical stress (e. g. stirring or shaking) the structure is broken down again, the system becomes more fluid, and the viscosity drops. Once again at a rest, the 3D network builds up again and the viscosity returns to its original value. This process is known as thixotropy and it is represented schematically in Figure 1.

**SIPERNAT® specialty silica:**

In contrast to AEROSIL® fumed silica, SIPERNAT® specialty silica is manufactured in a wet process based on sodium silicate and sulfuric acid. The reaction of the precipitation process is shown below:



All SIPERNAT® products consist of primary particles which are linked together to form larger agglomerates. The agglomerates form a highly porous sponge-like structure which can absorb liquids into its pores. Utilization of these products can transform a moist and sticky ingredient into a free-flowing powder.

The porous structure of the SIPERNAT® grades enables them to absorb up to 3x their weight in liquid. Figure 2 shows schematically the porous structure of SIPERNAT® products.

Selection of these different silica types depends greatly on the formulation type and the application effect the formulator is trying to achieve. Frequently used applications are as carriers for liquid active ingredients, flow and anticaking aids for powdered agrochemical formulations, and, in particular, hydrophobic related silica, is used as humidity regulators in seed pellets.

*The carrier function of SIPERNAT® specialty silica is demonstrated here:*

[\\* Link to our carrier effect video](#)

Figure 1 Shear thinning effect of AEROSIL® fumed silica.

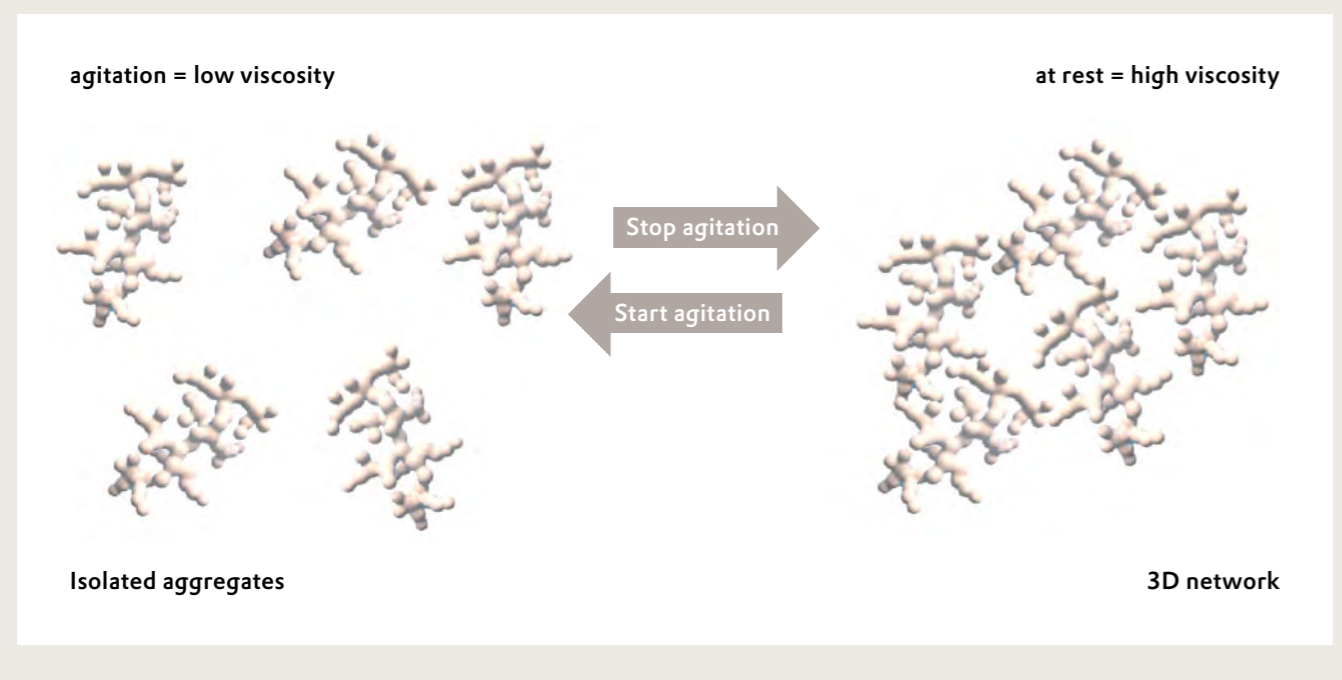
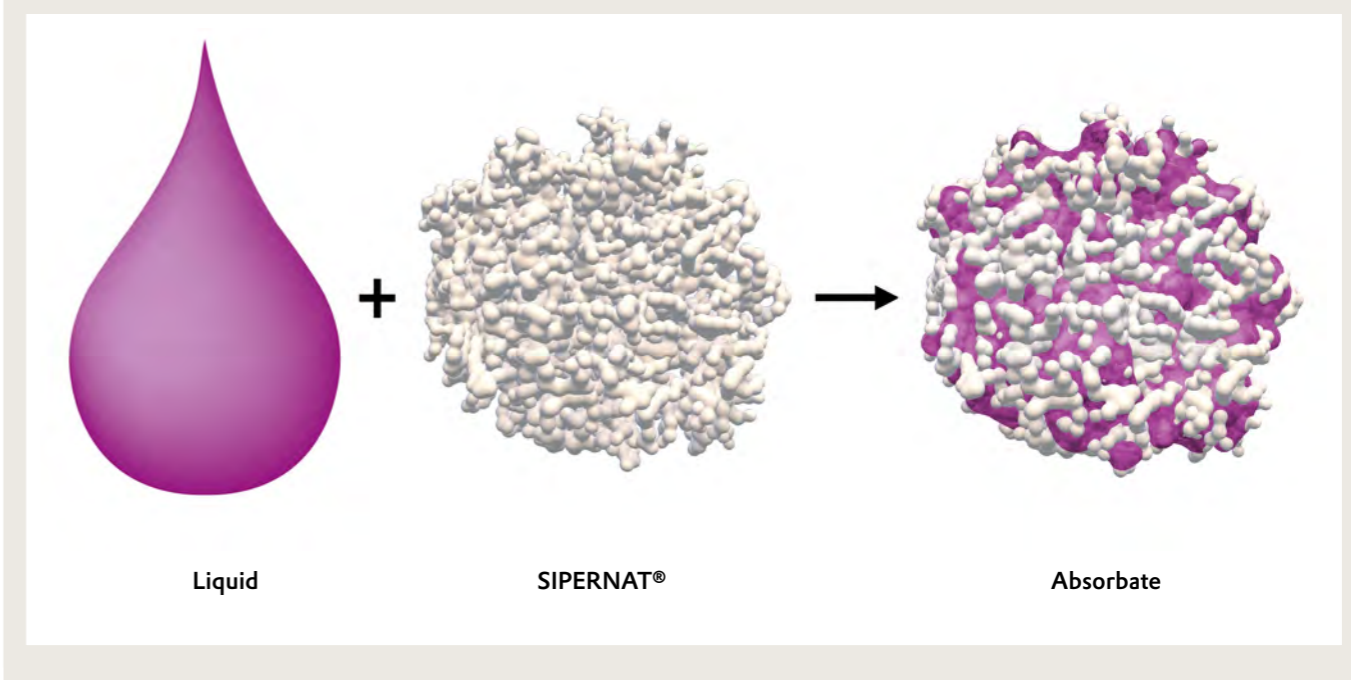


Figure 2 Schematic depiction of the absorption process and porous SIPERNAT® structure.





### 1.2 BREAKTHRU® additives

**BREAK-THRU®** is a registered trademark of Evonik Industries for certain organomodified siloxanes and other specialty surfactants\*. **BREAK-THRU®** additives are used e.g. as super-spreaders and penetrants in order to enhance the bio-efficacy by increasing the deposition and uptake of pesticides.

As a further benefit **BREAK-THRU®** enables a safeguarded pesticide performance at low water volumes and high application speeds. Besides the above mentioned applications **BREAK-THRU®** adjuvants are also used as oil enhancers as well as dispersants, antifoams or emulsifiers in pesticide formulations.

\* Technical Information Evonik Industries AG, Essen:

\* Additives for Pesticides Formulations

Liquid agrochemical formulations are a common, and often preferred, product form. These formulations are developed to improve safe handling of the active ingredients and enable lower concentrations of active ingredients.

Examples of liquid formulations are Emulsion in Water (EW), Oil Dispersions (OD) and Suspension Concentrates (SC). EW formulas usually require organic solvents causing high VOC emissions, SC formulas are based on water, and OD's often are formulated based on vegetable oils. Oil based dispersions (OD) are used when water sensitive actives need to be protected from premature decomposition.

In liquid formulations (such as SC's or OD's) there is a general need to protect the dispersed, insoluble active ingredient particles against sedimentation. This can be achieved by adjusting to the ideal visco-elastic properties. A balance must be achieved to prevent settling with a higher viscosity, but remain low enough to make sure packages can easily be emptied by the user without residue.

**AEROSIL®** fumed silica is a solution to these issues as it functions as a rheology modifier and anti-settling additive. As an efficient stabilizer, **AEROSIL®** products prevent the agglomeration of active ingredients helping to ensure that they are evenly distributed and have a long-term stability.

The performance of **AEROSIL®** fumed silica in liquid formulations is based on two mechanisms. First, the silica envelops the active ingredient and prevents re-agglomeration. Second, **AEROSIL®** fumed silica creates a 3D network giving visco-elastic properties to the liquid formulation, preventing sedimentation of the solid particles.

Our **AEROSIL®** fumed silica forms a continuous 3D network within the formulation which immobilizes and suspends the active ingredient preventing stability and sedimentation issues while imparting shear thinning properties.

Selecting the grade of **AEROSIL®** fumed silica to give a combined excellent anti-settling effect with a low shear viscosity is dependent on the formulation type.



## 2.1 Oil dispersion (OD) formulations

### How does AEROSIL® fumed silica prevent settling in liquid crop protection formulations?

Stability improvement, and overall crop protection efficacy, is often related to the prevention of settling of the active ingredients.

In the world of oil dispersion (OD) formulations, achieving in-can stability while maintaining ease of use is a persistent challenge for formulators. The diverse combinations of solvents and active ingredients in OD systems often lead to issues such as settling, re-agglomeration, and inconsistent performance during application. AEROSIL® fumed silica provides an effective solution to these challenges.

As a highly efficient anti-settling agent, AEROSIL® fumed silica helps formulators achieve the ideal balance between low shear viscosity for pourability and a tailored yield point to prevent settling. Its ability to form a reversible 3D network ensures that active ingredients remain evenly suspended during storage, while still allowing for easy dispersion when the product is diluted and applied in the field.

The silanol groups on the surface of AEROSIL® fumed silica enable the formation of an elastic 3D network that increases viscosity and yield point at rest. This network prevents active ingredients from settling over time, ensuring long-term in-can stability. Under mechanical stress – such as during filling, pumping, or pouring – the network temporarily breaks down, allowing the formulation to flow easily. This shear-thinning behavior ensures the product is both easy to handle and mix, while recovering its structure at rest to maintain stability.

According to the bead-spring model, the elastic part of a non-Newtonian fluid is described through the spring and the viscous part is given through the damper. The ratio of

the viscous to the elastic component defines the loss factor. Generally the elastic part should prevail in contrast to the viscous part to achieve a stable formulation.

Additionally, AEROSIL® fumed silica surrounds active ingredient particles, preventing re-agglomeration and promoting a homogeneous distribution. This enhances the formulation's performance tank-side, ensuring even dispersion and availability of the active ingredients for effective crop protection. For formulators working on OD systems, AEROSIL® fumed silica offers a reliable solution to the dual challenge of in-can stability and tank-side performance. By incorporating AEROSIL® products into your formulation, you can create a stable, pourable product that meets the practical needs of end-users while delivering the efficacy and consistency required for modern crop protection.

The end-user needs to disperse the concentrate containing an active ingredient in the solvent well before applying the liquid crop protection formulation directly on the field. The variety of solvent and active combinations found in OD formulations creates a real challenge for formulators. The use of AEROSIL® fumed silica within OD formulations helps to achieve great in-can stability and improved performance tank side.

### AEROSIL® fumed silica enables stable formulations within a broad temperature range

The long term stability of a formulation is defined by its visco-elastic properties and the homogeneous distribution of the active ingredient. The visco-elastic properties are given through both the yield point and the loss factor.

Table 1 shows the composition of an OD guide formulation based on an organic solvent containing the active ingredient Nicosulfuron which was stabilized through the addition of 4% AEROSIL® 380. A constant performance in terms of unique

Component	Chemical structure	wt.-%
Hydrocarbon Fluid	Organic solvent	66.5
BREAK-THRU® DA 655	Dispersing agent	5.0
TEGO® SMO V 80	Emulsifying agent	10.0
BREAK-THRU® EM TD 6	Emulsifying agent	10.0
Nicosulfuron	Active ingredient	4.5
AEROSIL® 380	Thickening agent	4.0

Table 1 Guide formulation containing AEROSIL® 380.

values characterizes the performance of Evonik's AEROSIL® fumed silica in the given OD formulation. Excellent pourability and a fast build-up of the elastic network of AEROSIL® fumed silica ensure convenient handling, in combination with the homogeneous dilution of the OD concentrate, before spraying on the field.

In addition to adequate shear thinning behavior and comparable loss factors at different storage conditions, a good anti-settling behavior is characteristic for a strong network of dispersed silica particles.

Manufacturing procedure: Premixing of all components (excluding thickening agent) in a 1000 ml bottle; generating vacuum in order to remove incorporated air bubbles at 500 rpm; 5.3 h milling time at 1500 rpm/ 20 °C in a bead mill

(VMA-Getzmann GmbH/Germany) - grinding balls ZrO<sub>2</sub>/Y<sub>2</sub>O<sub>3</sub>, size = 1 – 1.2 mm ((VMA-Getzmann GmbH/Germany); incorporation of thickening agent

AEROSIL® 380 at 500 rpm; dispersion of thickening agent for 10 min at 1500 rpm.

Generally, one of the most important values for the prediction of an OD formulation's stability is the above mentioned loss factor. Acceptable values are lower than one and indicate that the elastic part prevails in contrast to the viscous part.

Table 2 illustrates the unique values for the loss factor achieved by the addition of 4% AEROSIL® 380 for rheology control at both room temperature (RT) and 54 °C after a storage time of 14 days. The values of the loss factor obtained with AEROSIL® fumed silica are on a good level after the storage period of 14 days at RT as well as at 54 °C.

Rheology modifier	Concentration [%]	Loss factor at RT	Loss factor at 54 °C
AEROSIL® 380	4	0.29	0.29
AEROSIL® 380	5	0.27	0.32
Organically modified bentonite <sup>1</sup>	4	0.89	0.35

Table 2 Loss factors from OD formulations stored for 14 days at 54 °C and RT.

Measurement methods: Sample measurement by MCR 300 – Modular Compact Rheometer 300 – (Anton Paar GmbH/Germany); Loss factor was calculated by the method of amplitude sweep at 23 °C (Rheoplus Software RHEOPLUS/32 V 3.40; Anton Paar GmbH/Germany).

<sup>1</sup>NANOFIL® SE 3000 (organically modified nanodispersible layered silicate) Typical properties: Product form: Powder; Bulk density: 450 kg/m<sup>3</sup>; Median particle size D50 < 10 µm; Moisture content: < 3 %

Figure 3 shows the settling rate of AEROSIL® 380 added in certain concentrations. Increasing the amount of AEROSIL® fumed silica results in a lower settling rate. A higher addition of AEROSIL® 380 leads to an optimal visual result as well as to an easy to disperse OD formulation.

The test results showed clearly that the formulation containing AEROSIL® fumed silica show both, the described effect of shear thinning in combination with moderate yield point even at low shear rates as shown below in Figure 4.

Moreover the stabilizing structure of AEROSIL® fumed silica in the present OD formulation doesn't depend on the addition of any activator and does not require a certain temperature increase during the storage period.

Furthermore, the dispersing time of AEROSIL® 380 is very short with 10 to 15 minutes (q. v. Figure 12, p. 17). The lower dispersing time saves resources and costs in the manufacturing of liquid crop protection formulations.

**Benefits of AEROSIL® fumed silica at different storage temperatures**

**AEROSIL® fumed silica ...**

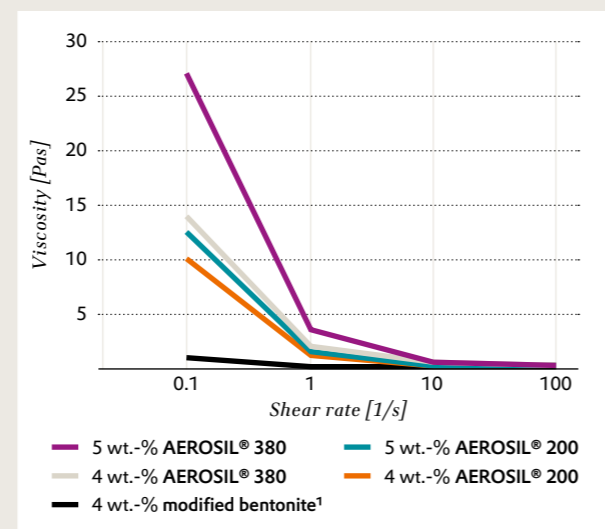
- Results in a moderate yield point  
**Benefit:** Easy emptying and cleaning of packaging
- Builds up a stable structure at 54 °C as well as at RT  
**Benefit:** Long term stability over a wide temperature range
- Shows optimal dispersibility for dispersion in water  
**Benefit:** Effective distribution on the field of the OD formulation

Figure 3 Sedimentation rate of different batches stored for 14 days at 54 °C.



The sedimentation rate was measured by a slide gauge and calculated in percent relating to the height of sample bottles Schott Duran 50 ml (SCHOTT AG/Germany) minus the height of the bottom (30 mm) of the sample bottles.

Figure 4 Viscosity values for AEROSIL® fumed silica vs. bentonite¹.



¹NANOFIL® SE 3000 (organically modified nanodispersible layered silicate)  
Typical properties: Product form: Powder; Bulk density: 450 kg/m³; Median particle size D50 < 10 µm; Moisture content: < 3 %

**Rheology control for mineral and vegetable oils using AEROSIL® fumed silica**

Mineral and natural oils containing active ingredients are easy to stabilize by hydrophilic or hydrophobic AEROSIL® grades. The right grade for preventing the settling of an active ingredient depends, amongst other things, on the polarity and the characteristics of the oil used. Generally, higher viscosities can be achieved in non-polar systems with hydrophilic silica products. Hydrophobic AEROSIL® grades are easier to disperse in oils and may be an option when maximum viscosity is not required. In non-polar to semi-polar systems, hydrophilic types are routinely used, in semi-polar to polar systems hydrophobic AEROSIL® types may be used.

AEROSIL® 200 dispersed in soybean oil can result in different viscosity levels depending on the concentration. Figure 5 demonstrates the typical shear thinning behavior of AEROSIL® fumed silica.

Figure 5 AEROSIL® 200 in soybean oil, measured at RT.

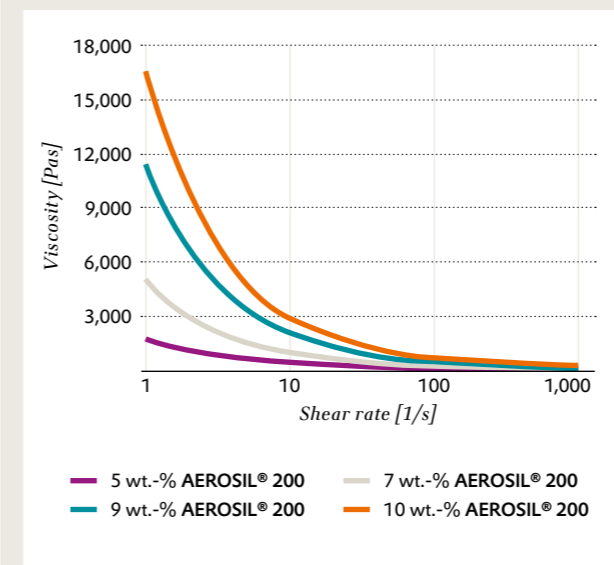
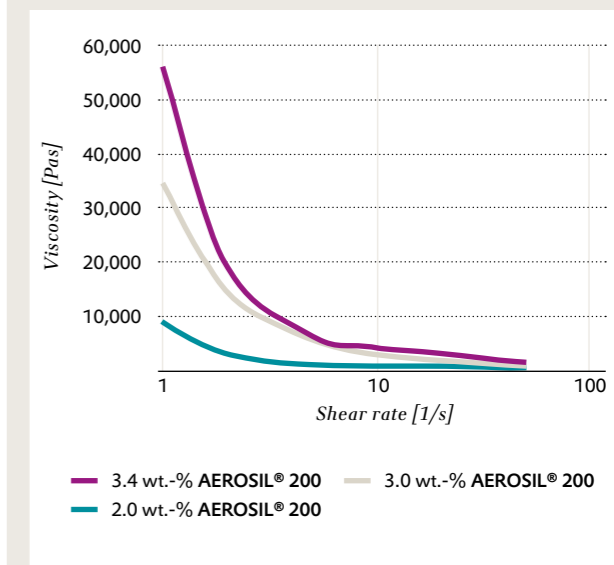


Figure 6 shows the thickening performance achieved using AEROSIL® 200 in paraffin oil. Higher viscosity levels in a non-polar oil can be reached with lower AEROSIL® 200 concentrations compared to more polar oils such as soybean.

In contrast to the hydrophilic AEROSIL® types recommended in non-polar to semi-polar systems, Evonik's hydrophobic grades like AEROSIL® R 974, AEROSIL® R 812 S or AEROSIL® R 202 are especially suitable for rheology control in polar systems. In general, hydrophobic silicas create a distinctively lower viscosity at a given concentration compared to the hydrophilic types because of their surface treatment. It is therefore possible to achieve stable formulations with a minimum shear viscosity for easy handling in the manufacturing process.

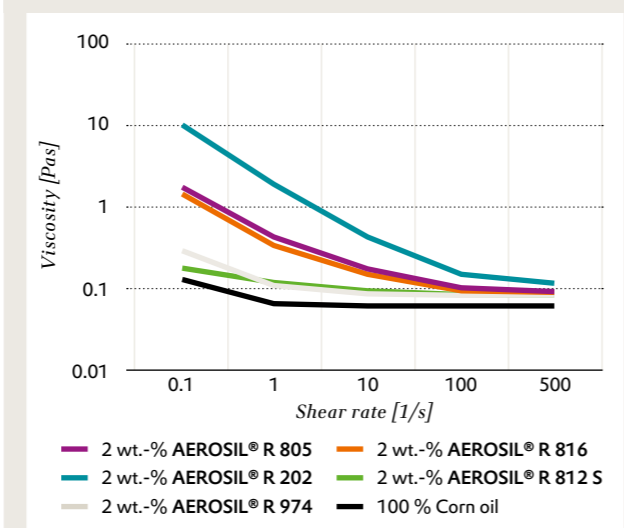
Figure 6 AEROSIL® 200 in paraffin oil measured at RT.



An example of the efficient use of hydrophobic AEROSIL® types is demonstrated in Figure 7. In each case, except the pure corn oil, an addition of 2.0 wt.% of different types of hydrophobic AEROSIL® grades leads to a higher viscosity level. The viscosity curve was measured after three days storage time. After a storage period of minimum 14 days at RT (in case of adding AEROSIL® R 812 S) almost no viscosity increase was detected. Furthermore, comparable viscosity levels were measured after storage time of 35 days by using AEROSIL® R 202 and even the same viscosity level after 63 days if adding AEROSIL® R 805 and AEROSIL® R 816. The huge range of different hydrophobic and hydrophilic grades of AEROSIL® fumed silica to be used in a number of different solvents like vegetable or synthetic oils offers a unique solution in order to stabilize formulations at nearly all viscosity levels on customers request without undesired post thickening effects.

With the addition of hydrophobic AEROSIL® fumed silica in corn oil, the yield point can be distinctively increased, leading to stabilization of incorporated solid active ingredients. High values of the storage modulus, which means a greater elastic part along with low values of the loss modulus, indicate a loss factor on a low level up to two month storage time. In the following Table 3 the results of using AEROSIL® R 805 and AEROSIL® R 202 dispersed in corn oil are summarized. In contrast to clay thickeners, AEROSIL® fumed silica can be

Figure 7 Hydrophobic AEROSIL® fumed silica in corn oil stored for 3 days and measured at RT.



used in OD formulations without being activated by water. AEROSIL® fumed silica is an amorphous synthetic product of consistently high quality that does not contain any dangerous crystalline impurities. Therefore it is less prone to quality fluctuations compared to natural products. This leads to a highly reliable quality in the production process of agro-chemical formulations.

AEROSIL® type	Concentration [%]	Yield point [Pa]	Storage modulus [Pa]	Loss modulus [Pa]	Loss factor
Corn oil	100	< 0.01	0.092	0.577	6.05
AEROSIL® R 805 <sup>1</sup>	5	1.272	119.6	37.14	0.31
AEROSIL® R 202 <sup>2</sup>	5	4.252	404.8	115	0.28

Table 3 Visco-elastic properties of AEROSIL® fumed silica in corn oil measured and stored at RT.

<sup>1</sup>Sample stored for 63 days at RT <sup>2</sup> Sample stored for 35 days at RT

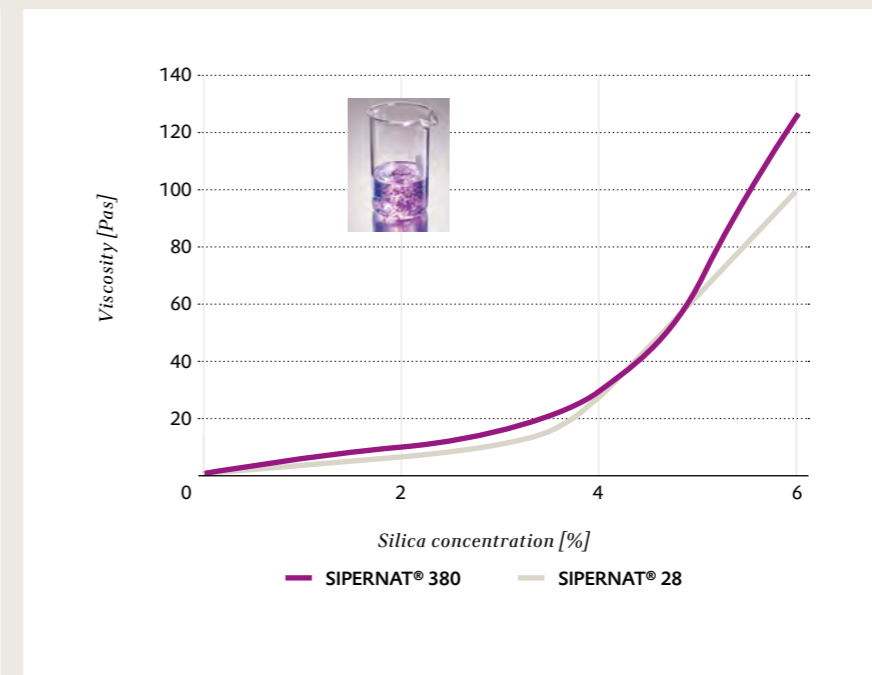
## 2.2 Rheology adjustment with easy to disperse SIPERNAT® 380

The right dispersion of AEROSIL® fumed silica is crucial to create a stable 3D network, leading to an overall stable formulation. In cases where a suitable dispersion equipment, such as a dissolver, a rotor-stator system or bead mill, is not available, a fine sized precipitated silica type can be used for establishing a network that keep solid actives in balance. SIPERNAT® 380, the easy to disperse alternative for stabilizing highly loaded oil-based suspension, can be incorporated without the need for high shear mixing equipment. Using a common stirrer, such as propeller stirrer, provides sufficient viscosity to improve the storage stability of dispersed actives. SIPERNAT® 380 delivers consistent viscosity during processing and enhanced storage stability for highly concentrated formulations. These advantages, combined with the

easy handling, makes SIPERNAT® 380 an alternative to fumed silica grades when proper dispersion equipment is not readily available.

In contrast to the dispersion conditions with AEROSIL® fumed silica products only a speed of 2,000 rpm applied for 15 min is recommended to obtain an adequate dispersion. To alleviate the dispersion step a pre-dispersion applied for 5 min at a speed of 500 rpm can help to wet the silica surface. The addition of 4 – 6 % of SIPERNAT® 380 is the minimum concentration to create a sufficient stability of the network. Higher viscosity levels can be obtained on demand as demonstrated in the diagram above where SIPERNAT® 380 is dispersed in paraffin oil.

Figure 8 Adequate thickening performance of SIPERNAT® 380 with less shear energy.



### 2.3 Suspension concentrates (SC) formulations

To demonstrate the influence of the parameters (shown in Figure 13 in chapter 2.5), Figure 9 shows how the yield point of a water-based AEROSIL® 200 suspension depends on the pre-adjusted pH-value and the surfactant concentration (sorbitan mono-oleate).

Similar to OD-formulations, AEROSIL® fumed silica establishes a yield point and prevents settling of active ingredients. Hydrophobic AEROSIL® types in particular combine a moderate shear viscosity with a sufficient yield point. These properties provide excellent suspension stabilization whilst enabling the formulation to be poured easily and ensuring a proper rinsing of the container.

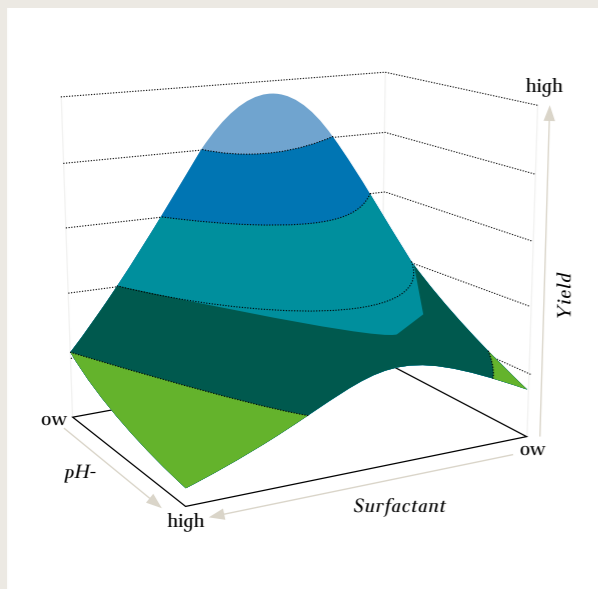
AEROSIL® fumed silica can be used in SC-formulations as a single thickener or in combination with organic thickeners such as xanthan gum to improve their temperature stability\*.

In contrast to organic thickeners, silica does not promote any microorganism growth due to its inorganic character. At a given surfactant concentration the yield point increases with lower pH values. At a given pH-value, there is an optimum surfactant concentration leading to the maximum yield point.

#### High loaded water-based formulations

In water based formulation the stabilization at elevated temperatures is a challenge. In the following guide formulation (Table 4), with an active ingredient concentration of 25%, the incorporation of AEROXIDE® ALU C significantly improves the suspension's resistance to separation, ensuring consistent particle size of the active and performance even under challenging conditions. This formulation maintains its integrity and homogeneity, highlighting the effectiveness of AEROXIDE® ALU C in stabilizing high-active ingredient systems.

Figure 9 Dependence of the yield point of a waterbased AEROSIL® 200 suspension on the pH-value and the surfactant concentration.



Component	Weight %
Azoxystrobin	25.00
BREAK-THRU® DA 647	3.50
BREAK-THRU® AF 9903	0.27
AEROXIDE® ALU C	4.00
Water	67.23
<b>Total</b>	<b>100.00</b>

Table 4 High loaded guide formulation stabilized with AEROXIDE® ALU C.

### 2.4 Emulsion in Water (EW) formulations, O/W & W/O

AEROSIL® fumed silica products can also be used to stabilize emulsions, such as oil-in-water as well as water-in-oil emulsions. Two types of AEROSIL® fumed silica are recommended in this application:

- AEROSIL® R 816 for oil-in-water emulsions. Added to the water phase.
- AEROSIL® R 974 for water-in-oil formulations. Added to the oil phase

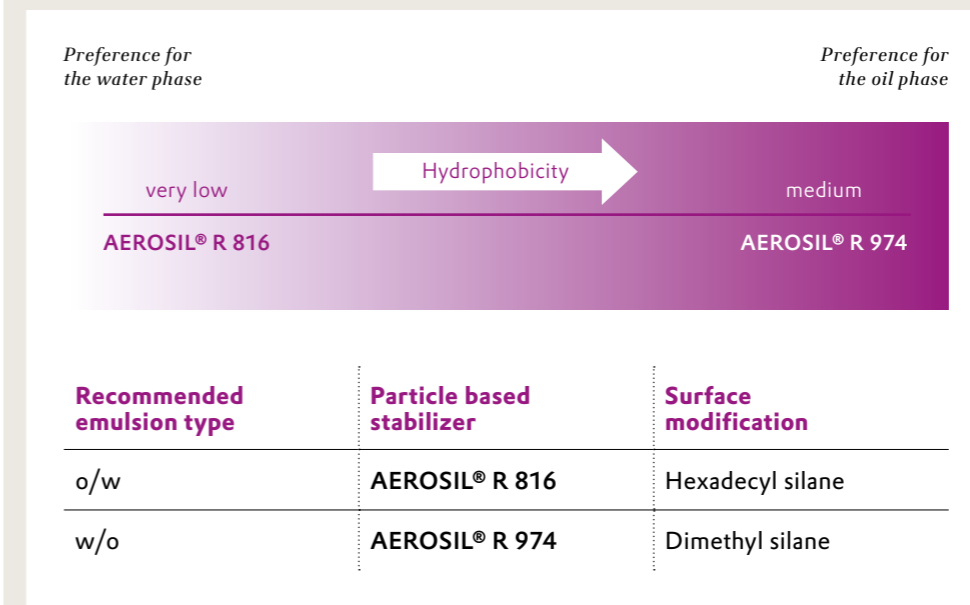
When dispersed in the respective continuous phase, the silica aggregates help to structure and restrict the inner phase droplet coalescence. These silica aggregates also adsorb to the oil-water interface and avoid droplet coalescence there.

To secure a decent distribution and wetting of AEROSIL® fumed silica the following steps to create a stable emulsion should be considered:

- Pre-dispersion of 1 – 2 % of AEROSIL® fumed silica in the continuous phase (gentle stirring)
- Optionally: Adding 0.1 – 0.2% Xanthan Gum into the oil phase whilst stirring and subsequent homogenization (for example at 5,000 – 10,000 rpm)
- Combining the oil phase with the thickened water phase whilst stirring
- Homogenization step the combined phases by applying a Rotor-Stator (Ultra-Turax) for 2 min at 20,000 rpm to create the emulsion

When clicking on the button a video shows the whole manufacturing process of an oil in water emulsion by incorporating AEROSIL® R 816.

Figure 10 Hydrophobic degree of AEROSIL® R 816 and AEROSIL® R 974.



\* Tadros, Th. F. "Surfactants in Agrochemicals" 1994 (Surfactant Science Series: 54)

## 2.5 How to disperse AEROSIL® fumed silica in liquid formulations

To get all the rheological benefits of AEROSIL® fumed silica, proper dispersing conditions and incorporating steps need to be considered. Best performance can be achieved by taking into account the following instructions:

### Influencing factors

- Shear intensity during the dispersing process
- Dispersing time
- Dispersing equipment
- Type of AEROSIL® fumed silica
- Addition sequence and wet-in
- Relation of blade size to vessel size in batch processes
- Air bubbles incorporated during the dispersing step

Energy input during mixing is of great importance. Too high of shear intensities may damage the structure of the AEROSIL® fumed silica, limiting the network-building characteristics of the silica. Although, too low of shear intensity leads to the poor distribution of silica particles in the liquid and insufficient wetting of the AEROSIL® product. By not mixing thoroughly with insufficient shear would result in a higher concentration of thickening agent required to obtain the desired viscosity.

Suitable devices for dispersing AEROSIL® products are high speed mixers such as a dissolver, rotor-stator mixer or bead mill. But the user has to keep in mind the differences in the energy input on the system generated by the respective dispersing devices. Figure 11 shows the different energy inputs when using different dispersing devices. If longer dispersing or milling times are needed – for example to mill down the active ingredient – the order of addition has to be adjusted and the right type of AEROSIL® fumed silica has to be chosen.

The dispersing time and the rotational speed of the dispersing equipment should be adjusted according to the type of AEROSIL®. Some types such as AEROSIL® 380 are more resistant against high shear forces than AEROSIL® 200. Higher surface area AEROSIL® grades such as AEROSIL® 300, 380, and AEROSIL® R 812 S require more energy-intensive mixing equipment for optimized dispersion. For most applications, peripheral velocity can be more than 7 m/sec using a dissolver or a rotor stator system.

In case of using a bead mill, a rough rule of thumb is that the dispersing time should be around 10 minutes at a tip speed of 4.6 m/s at the given ratio of blade to vessel size of 1:2 to 1:3. The amount of AEROSIL® fumed silica should be incorporated stepwise at a rotation speed of 500 rpm to pre-disperse it before high shear is applied. It is recommended that incorporation and dispersing step of AEROSIL® fumed silica should be the last step of the manufacturing process. Figure 12 shows the influence of the dispersing time using a bead mill for dispersion of certain types of AEROSIL® fumed silica vs. dispersing time of modified bentonite<sup>1</sup>.

The figure shows the advantage of shorter dispersing time when AEROSIL® fumed silica is used to avoid a damage of the established 3D network, reduces production time and therewith manufacturing costs. Air bubbles incorporated during the dispersion process should be removed by generating a vacuum. If a higher viscosity level is needed, this can be obtained through increasing the concentration of AEROSIL® fumed silica.

*A more comprehensive description of the successful use of AEROSIL® fumed silica in liquid systems is given in our Technical Information 1279.*

[🌟 Link to our rheology effect video](#)

Figure 11 Possible energy input of different dispersing devices.

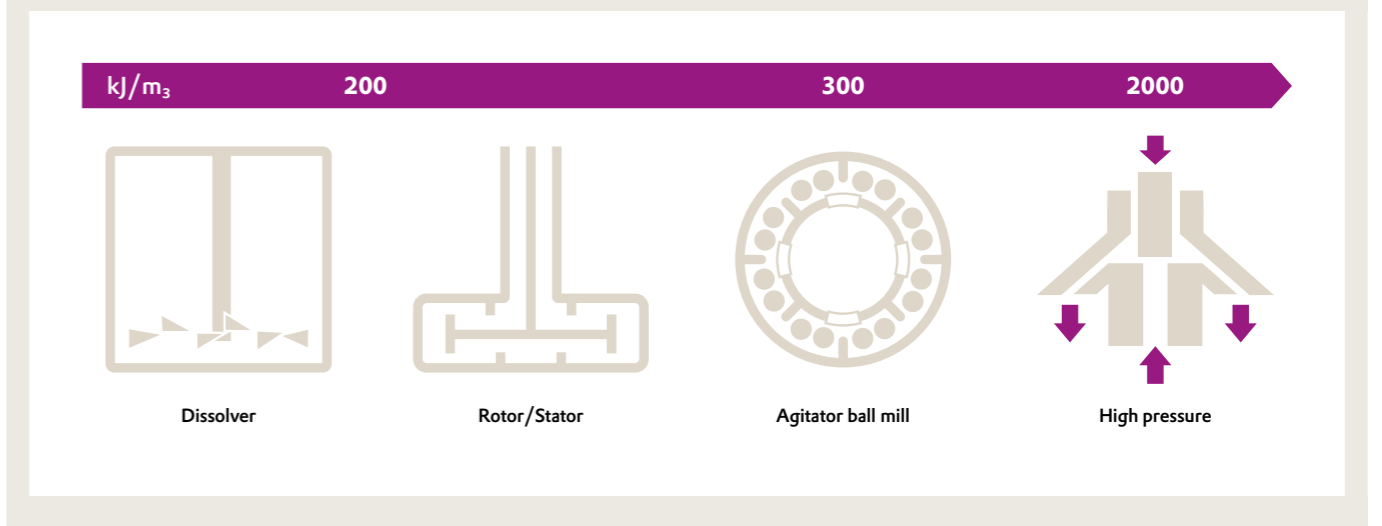
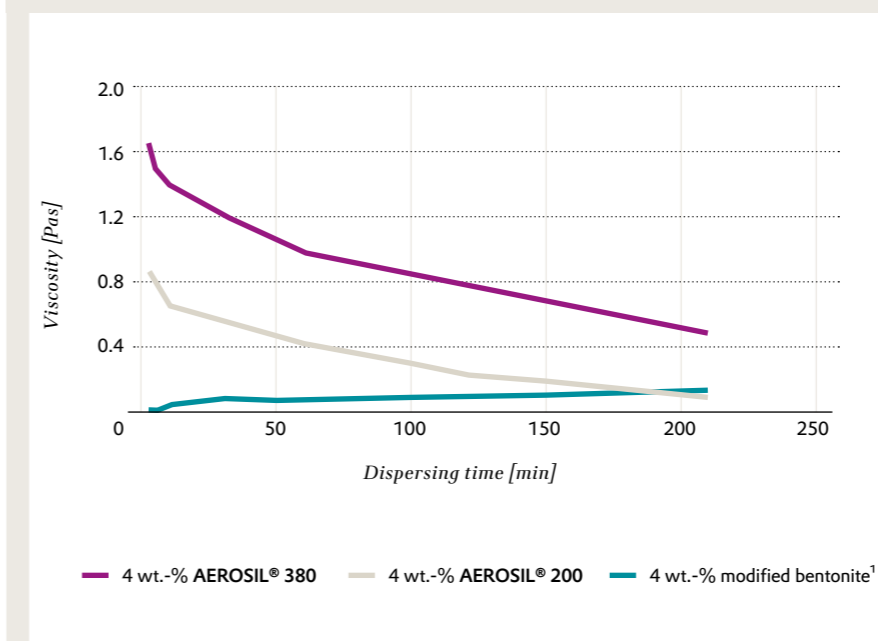


Figure 12 Dispersing time of different thickening agents using a bead mill.



<sup>1</sup>NANOFIL® SE 3000 (organically modified nanodispersible layered silicate)  
 Typical properties: Product form: Powder; Bulk density: 450 kg/m<sup>3</sup>;  
 Median particle size D50 < 10 µm; Moisture content: < 3 %.

## Selection of the right type of AEROSIL® fumed silica

Based on the broad range of Evonik's portfolio of AEROSIL® fumed silica for rheology control the selection of the right type is of vital importance.

The most effective AEROSIL® grade for a particular liquid crop protection formulation depends on a number of parameters, such as:

- Concentration and type of
  - Active ingredient
  - Surfactant
  - Other ingredients
- Particle size of active ingredient
- Density difference between oil matrix and active ingredient
- Temperature during dispersing process
- Shear intensity during the mixing process (time and shear rate)
- Polarity of the oil matrix

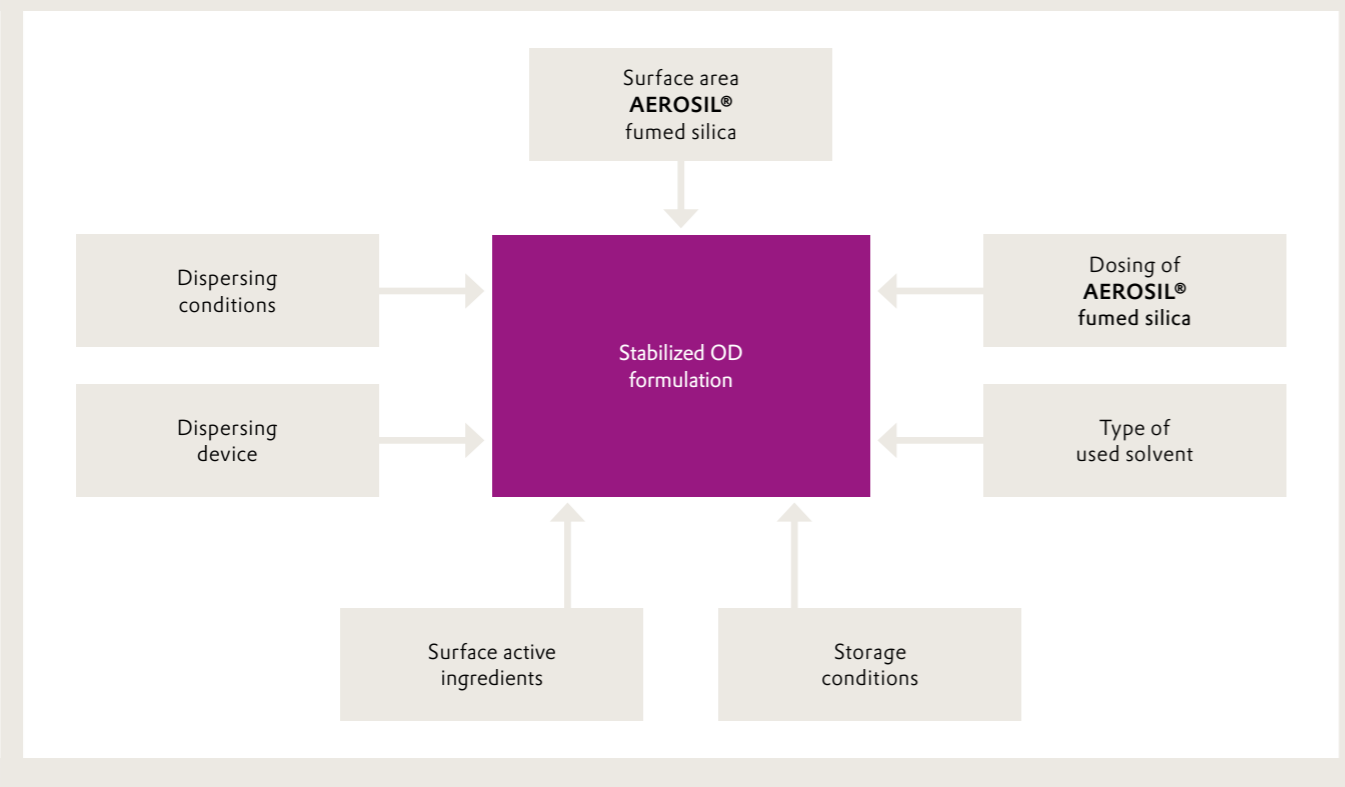
These parameters should be considered when using our products for viscosity control in liquid crop protection formulations in order to get the best performance with AEROSIL® fumed silica.

In Figure 13 the influencing factors to be considered for the stabilization of liquid formulations are summarized.

In general, the silanol groups of AEROSIL® fumed silica interact with each other in a solvent, building the 3D network that keep solid actives in balance and therewith stabilizes the formulations. However, the silanol groups can interact also with other surface active ingredients, such as dispersants, wetting agents and emulsifiers that are typically used in liquid crop protection formulations. There is a synergistic effect when using for example none-ionic and cationic surfactants because of their surface charge, chain length or hydroxy groups that can interact with the silanol groups of AEROSIL® fumed silica products. Surface active ingredients with a short



Figure 13 Influencing factors on stability of OD formulations.



chain-length can lead to a complete coverage of the silanol groups on the silica surface that may result in a lower final viscosity. A higher surface area of the incorporated AEROSIL® fumed silica type generally results in a higher viscosity level in the formulation because of a higher number of hydrogen bonding between the silanol groups located on the surface. For example the same concentration of AEROSIL® 380 creates a higher viscosity level compared to the addition of AEROSIL® 200 when applying adequate dispersion conditions. Moreover, the polarity of the oil used plays an important role.

In none-polar oils, such as mineral or paraffin oil the hydrophilic types (AEROSIL® 200 and AEROSIL® 380) create a higher viscosity level and the silica grades with a higher degree of hydrophobicity, such as AEROSIL® R 816, AEROSIL® R 972 and AEROSIL® R 974 establish a higher level of viscosity in oils with low polarity. When stabilizing solid actives in polar oils, such as triglycerides, the most hydrophobic silica types like AEROSIL® R 805, AEROSIL® R 812, AEROSIL® R 812 S and AEROSIL® R 202 are recommended to obtain a high viscosity level.

## 2.6 Key Benefits of AEROSIL® fumed silica in agricultural suspensions in liquid crop protection formulations

- **Prevents Settling & Enhances Dispersibility:** Maintains uniform suspension of active ingredients, preventing separation and ensuring optimal tank-side addition, as active ingredients are less prone to hard packing.
- **Efficient Processing:** Can be added directly to the mill-base before wet-milling, eliminating the typical activation step seen with gum thickeners and streamlining processing.
- **Robust Operating Range:** Its inorganic nature ensures compatibility under challenging conditions, such as low pH, high temperatures, and elevated active ingredient concentrations, while maintaining a defined yield structure essential for suspension.
- **No Need for Additional Biocides:** As an inorganic substance, it does not serve as a food source for mold and bacteria, simplifying formulation design and reducing the need for biocides.
- **Synergistic with Other Thickeners:** Fumed silica forms a robust shear-thinning 3D network that enhances formulation yield when combined with other viscosity modifiers, positively impacting overall suspension stability. It can be incorporated at room temperature without additional water.

AEROSIL® type	Description
AEROSIL® OX 50 AEROSIL® 200 AEROSIL® 300 AEROSIL® 380	Hydrophilic fumed silica, can be used as anti-settling agent / rheology modifier in SC's and OD's.
AEROSIL® COK 84	Mixture of fumed silica and fumed aluminium oxide, especially used in water based SC's and OD's.
AEROSIL® 150 AEROSIL® OX 50	Hydrophilic fumed silica with low BET surface area especially for the stabilization of high loaded, water-based formulations.
AEROSIL® R 972 AEROSIL® R 974 S AEROSIL® R 812 AEROSIL® R 812 S AEROSIL® R 805 AEROSIL® R 202	Hydrophobic fumed silica. Especially recommended in OD's for viscosity control.
AEROSIL® R 816 AEROSIL® R 974	Semi hydrophobic fumed silica for o/w emulsions and hydrophobic silica for w/o emulsions.
SIPERNAT® 380	Fine sized precipitated silica, easy to disperse without using shear mixing equipment.

Table 5 Overview of AEROSIL® fumed silica types for liquid crop protection formulations.

Solid agrochemical formulations have been known for many years in the industry. Examples for solid formulation types are wettable powders (WP), granules (GR) water dispersible granules (WG) and powdered fertilizer.

A clear advantage of granulated formulations is that they leave almost no product in the empty package, meaning less waste. However, powders may create dust, which is undesirable in terms of user safety. Therefore, powder formulations are more and more replaced by granule formulations or liquid systems.

AEROSIL®, SIPERNAT® and ZEOFREE® products are used in solid formulations as flow aids, anticaking agents, milling aids and as carriers for liquid active ingredients. WP formulations treated with AEROSIL®, SIPERNAT® and ZEOFREE®

products are dry, free-flowing and do not tend to cake on storage.

For spray formulations which need to be dispersed in water before use, our portfolio of small particle sized silicon dioxide can be used, ensuring the silica will stay suspended from the moment of dispersing the formulation until it is sprayed onto the field. Ensuring homogeneity in the formulation and no blockages in equipment such as spray nozzles.

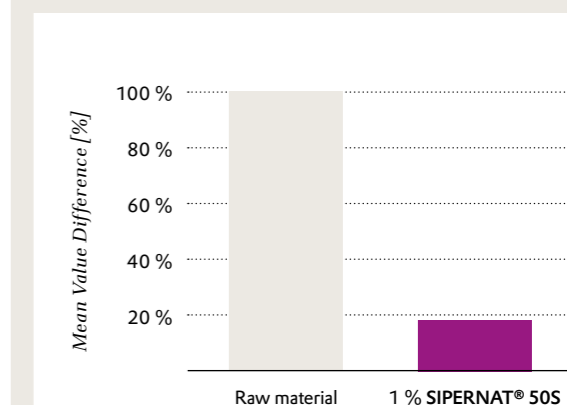
In granules for direct application in the field, large particle size silica can be advantageous. Those grades can be used as carrier for liquid or low melting actives, providing both a free flowing and non-caking absorbate. The granular shape of the absorbate is already predesigned with the silica. No additional granulation step is necessary.

## 3.1 Anticaking and flow improvement of hygroscopic products

AEROSIL® and SIPERNAT® products can help to keep hygroscopic substances, such as powdered or granulated NPK fertilizer, Urea, Humic Acid or Ammonium Sulphate free flowable in production and to avoid caking during storage. Only a small addition level of 0,1 – 0,3 % of hydrophobic silica, such as AEROSIL® R 972 and AEROSIL® R 812 S, can effectively reduce problems with the application of fertilizers. Hydrophilic silica, such as SIPERNAT® 50 S, is also an effective anticaking agent but need higher concentration levels of ~1 – 2 % depending on the degree of hygroscopicity. Additionally, the same selection of products are suitable for improving the flowability of fine sized fertilizer products. With a recommended silica concentration of around 0,5 – 1 % the flowability can be improved distinctively. Figure 14 illustrates an example of the anticaking performance of the high absorptive SIPERNAT® 50 S. Even with a lower silica concentration of 1 %, a distinctive reduction of caked material is achieved. This leads to a better handling of powdered and hydroscopic fertilizer after storage for example with the application of the fertilizer on the field as well as an immediate improvement of the flowability in the production process or whilst packaging.

[✨ Link to our anticaking effect video](#)

Figure 14 Improved caking behavior with high absorptive SIPERNAT® 50 S.



## 3.2 Wettable powder (WP) and water dispersible granules (WG)

**SIPERNAT®** specialty silica provides three main functionalities to wettable powder and water dispersible granule formulations:

- Highly efficient absorption of liquid actives: Solid formulations containing up to 75 % of liquid active ingredient can easily be prepared using suitable **SIPERNAT®** grades.
- Free flow additive/anticaking additive: 1 – 3 % of **AEROSIL®**, **SIPERNAT®** and **ZEOFREE®** products added to powder or granule formulations enhance the flowability greatly and avoid caking during storage.
- Milling aid: Adding up to 10 % of **SIPERNAT®** products facilitates the milling of low melting ingredients.

As a positive side effect, the suspensibility of the WP and WG at the point of use is much improved with the use of the fine sized **AEROSIL®**, **SIPERNAT®** or **ZEOFREE®** products.

## 3.3 Granules (GR)

Hydrophobic silica on the surface of granulates or dusts enables the formulator to increase stability in humid environments or to delay (“slow release”) the diffusion of the active ingredient.

The coarser and hydrophilic **SIPERNAT® 2200** or **ZEOFREE® 5170** is an ideal carrier for liquid or low melting actives to be converted to granules. Such carried actives are easy to be applied directly to the soil, will not create dust and reduce direct skin contact which facilitates their handling. **SIPERNAT® 2200** for example is able to absorb 190 ml liquid / 100 g silica still providing a dry and free flowing formulation because of its coarser and round shaped particle design.

## 3.4 Seed granulation

Seed treatment is a very efficient and eco-friendly method to protect seeds and seedlings against the most common diseases and vermin that are frequently present on fields used for agricultural purposes. An important seed treatment technology, seed granulation, reduces the entire amount of seed applied onto the field and maximizes yield at the same time.

With the help of **SIPERNAT®** specialty silica, especially **SIPERNAT® 22** and **SIPERNAT® 50**, the advantages of granulated seed can be further extended with regards to the ger-

mination, the germination duration as well as the seed emergence in the field. **SIPERNAT®** specialty silica facilitates water transport through the shell matrix into the core of the seed that would otherwise be hindered by the shell. Thus a comparable or better germination behavior versus common, non-granulated seed can be obtained. In the end special, newly developed and tailor-made seed treatments can differentiate themselves from the products being currently offered on the market.



### 3.5 Improved film coating by lowering the dust-off with Evonik's binder solution

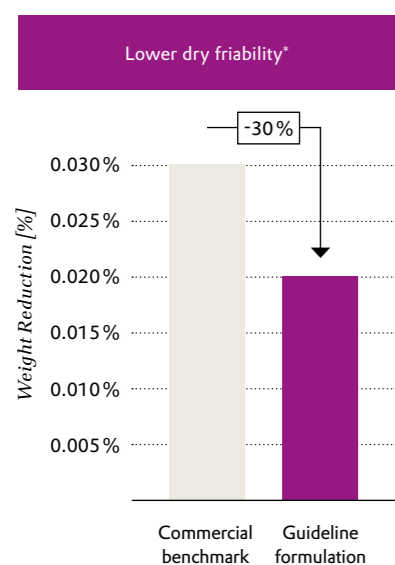
During production of coated seeds the rheological behavior of the liquid seed coating can be adjusted as required by **AEROSIL®** fumed silica as a process aid to stabilize incorporated solid particles. In the coated seeds hydrophobic **AEROSIL®** fumed silica or **SIPERNAT®** precipitated silica can control and slow down the penetration of moisture to the grain to protect them against mold. Improved film coating by lowering the dust-off with Evonik's binder solution. Next to the good adhesion and surface coverage of the coated seeds it is crucial to reduce the dust-off as well as the friability at once (see **Figure 15**).

Within a film coating processes a combination of **BREAK-THRU® BP 787** and **AEROSIL® 200** can be used as a biodegradable, microplastic free binder for conventional flowable concentrate (FS) to reduce the dust-off to a minimum. In comparison to the formulation containing **BREAK-THRU® 787** and **AEROSIL® 200** dosed at the given concentration as recommend in the guideline formulation as shown in **Table 6**. Both components can be mixed easily

mixed together and applied as binder in the film coating process. Besides the before mentioned benefits the application of the binder leads not only to an improved surface coverage it improves the flowability of the seeds in comparison to untreated seeds. Moreover, if only the flowability of coated and sticky seeds shall be improved the addition of for example 2 % of **SIPERNAT® 320** can make the coated seeds free flowable.

An overview of Evonik products and their typical applications for solid crop protection formulations is summarized in **Table 7**.

**Figure 15** Friability of wheat seeds coated with Evonik binder solution.



\* Results obtained from Innoveins/NL

Guideline Formulation	Function	Share
Fludioxonil	Fungicidal active	2.4 %
Difenoconazole	Fungicidal active	1.9 %
Tebuconazole	Fungicidal active	0.5 %
<b>BREAK-THRU® DA 647</b>	Dispersing agent	3 %
<b>BREAK-THRU® S 301</b>	Superspreader	3 %
Propylene glycol	Compatibilizer	2.5 %
Xanthan gum	Viscosity improver	0.3 %
Agrocer Red 112	Pigment	4 %
<b>Binder solution</b>		
<b>BREAK-THRU® BP 787</b>	Multifunctional carrier fluid with binder properties	10 %
<b>AEROSIL® 200</b>	Rheology modifier	2.5 %
Water		Q.S.

**Table 6** Evonik guideline formulation.

#### AEROSIL®, SIPERNAT®, and ZEOFREE® types

	Description
SIPERNAT® 22 <sup>1</sup> SIPERNAT® 50 <sup>1</sup> SIPERNAT® 22 S SIPERNAT® 50 S SIPERNAT® 320 SIPERNAT® 350 ZEOFREE® 5170	Hydrophilic specialty silica can be used as carrier in WP and WG formulation.
SIPERNAT® 22 S SIPERNAT® 50 S SIPERNAT® 350 AEROSIL® 200 SIPERNAT® 880 ZEOFREE® 5133	Hydrophilic specialty, hydrophilic fumed silica and hydrophilic Calcium Silicate to provide good properties as flow aid and anticaking agent in WP's and WG's.
SIPERNAT® 22 SIPERNAT® 50	Hydrophilic specialty silica especially appropriate as grinding aid in WP and WG formulations.
SIPERNAT® 2200 ZEOFREE® 5170	Micro-granular hydrophilic silica can be used as carrier for granules, which are directly applied to the field.
SIPERNAT® D 17	Hydrophobic specialty silica, can slow down the penetration of moisture, e. g. in seed coatings.
SIPERNAT® 320	Hydrophilic and medium sized precipitated silica to improve the flow-ability of coated seeds.
SIPERNAT® 22 SIPERNAT® 50	Hydrophilic specialty silica especially appropriate to improve the seed emergence, water supply and germination of granulated and incrustated small sized seeds.
AEROSIL® 200	Hydrophilic fumed silica that can be used in combination with <b>BREAKTHRU® BP 787</b> as binder solution to improve film coating and lowering the dust-off.
SIPERNAT® 50 S SIPERNAT® D 17 AEROSIL® R 812 S AEROSIL® R 972	Hydrophobic and hydrophilic, high absorptive and fine sized silica to improve the flowability and prevent caking of hygroscopic products.

**Table 7** Overview of **SIPERNAT®** specialty silica types for solid crop protection formulations.

<sup>1</sup> Grinding of the whole formulation is necessary

## 4 REGULATION AND REGISTRATION

The following table provides an overview of the listing of our products as inert ingredients under 40 CFR Part 180, including applicable sections under 40 CFR §180.xxx.

- To explore our complete agriculture portfolio and get the latest updates, please contact your local sales representative
- For details on additional product registrations specific to your country, your local sales contact will be happy to assist.

CAS-No	Product	OMRI	40 CFR
1344-28-1	AEROXIDE® Alu C		180.910
67762-90-7	AEROSIL® R 202 SIPERNAT® D 10 SIPERNAT® D 17		180.960
68611-44-9	<b>AEROSIL® R 972</b> <b>AEROSIL® R 974</b>	● ●	180.960
68909-20-6	AEROSIL® R 812 <b>AEROSIL® R 812 S</b>	●	180.960
112945-52-5	AEROSIL® COK 84		180.950
1344-00-9	SIPERNAT® 807 SIPERNAT® 820 A SIPERNAT® 823 A		180.910
1344-95-2	ZEOFREE® 5133		180.910 180.930
112926-00-8	<b>SIPERNAT® 22</b>	●	180.930
	<b>SIPERNAT® 22 S</b>	●	180.950
	SIPERNAT® 22 LS		
	SIPERNAT® 2200		
	<b>SIPERNAT® 310</b>	●	
	SIPERNAT® 320		
	SIPERNAT® 42		
	SIPERNAT® 42 S		
	<b>SIPERNAT® 50</b>	●	
	SIPERNAT® 50 S		
	SIPERNAT® 500 LS		
<b>SIPERNAT® 340</b>	●		
<b>SIPERNAT® 350</b>	●		
SIPERNAT® 380			
SIPERNAT® 45			
SIPERNAT® 45 S			
SIPERNAT® 37			
112945-52-5	AEROSIL® OX 50 AEROSIL® 150 <b>AEROSIL® 200</b> AEROSIL® 300 AEROSIL® 380	●	180.950
199876-45-4	AEROSIL® R 816		180.910

**Table 8** Listing of AEROSIL®, SIPERNAT® and ZEOFREE® products.

## 5 HANDLING, PACKAGING AND STORAGE

Customers can easily handle these products without creating dust, and process (i. e., convey, measure out, blend, etc.) them within solid or liquid systems. Silica and silicate products are largely chemically inert and their composition does not change, even over long periods of time. However, the relatively large surface area of these products can lead them to adsorb volatile substances. In the case of moisture, this

adsorption process is reversible. For this reason, we recommend storing all Evonik silica and silicate products in a dry location where they are protected from moisture or other organic vapors. For more detailed information on product handling, packaging and storage please contact your local sales organization.

## 6 CONTACT AND MORE INFORMATION

You may also use our website:

☀ [evonik.click/smarteffects-agriculture](https://evonik.click/smarteffects-agriculture)

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### Relevant literature

☀ *Technical Overview TO 28 Handling of synthetic silica and silicate, Evonik Industries, 2026*

☀ *Technical Information TI 1351 Evonik silicas and silicates as flow aids and anticaking agents*

- Tadros, Th. F.: Surfactants in agrochemicals , 1995 (Surfactant science series 54), Marcel Dekker
- Mezger, T.: The rheology handbook, Vincentz Network, 5.Aufl. 2020

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**The Silica and Silanes experts at Evonik – From elements to excellence.**