

TECHNICAL INFORMATION 1251

AEROSIL® and SIPERNAT® Silica: Versatile Raw Materials for Personal Care Formulations



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Introduction

Over the past fifty years, synthetic amorphous silica created by Evonik have been extensively used in the cosmetics and personal care industries. Evonik manufactures silica approved for personal care under two brand names – AEROSIL® and SIPERNAT®.

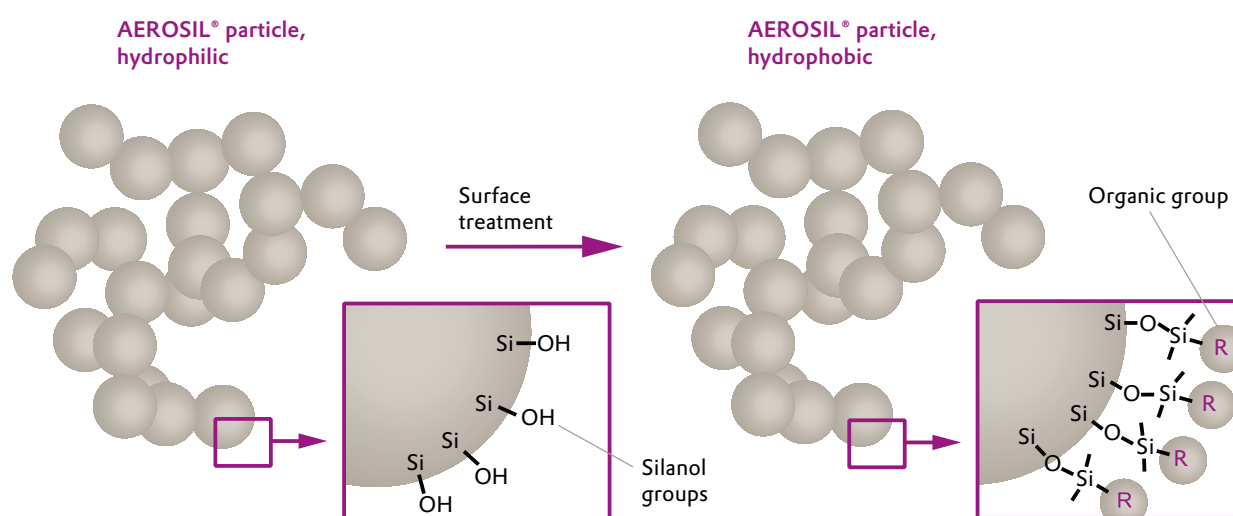
AEROSIL® fumed silica

AEROSIL® products are recognized in the personal care industry for their versatility and effectiveness, whether used to improve existing formulations or to develop new ones. Our products are characterized by their high purity and chemical

inertness, which are especially important in cosmetic applications. Our AEROSIL® fumed silica are available as untreated hydrophilic and surface treated hydrophobic "R" types.

Figure 1:

Diagram of a surface treatment transforming hydrophilic AEROSIL® into hydrophobic AEROSIL®

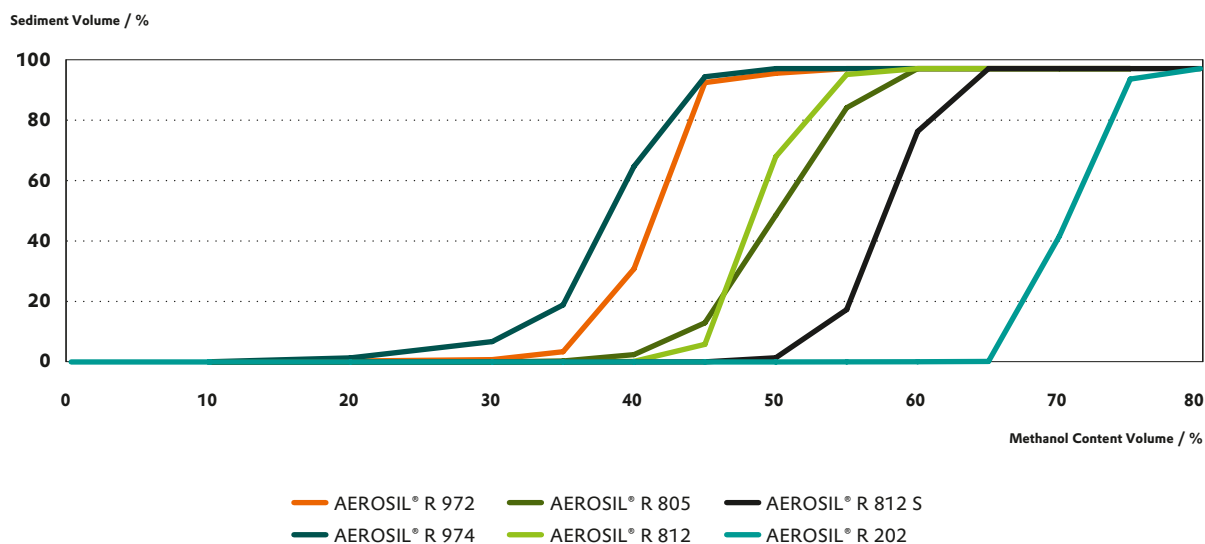


AEROSIL® fumed silica is a highly pure, very fine type of silicon dioxide. The manufacturing process is based on the flame hydrolysis of silicon tetrachloride. Synthesis temperatures above 1000 °C and complex particle dynamics lead to a fractal-like morphology of silicon dioxide. All AEROSIL® fumed silica products are completely amorphous as shown by x-ray diffraction.

The AEROSIL® "R" grades mentioned above have all been surface treated using different organosilanes. These treatments impart different degrees of hydrophobicity, which are quantified using methanol wettability (Figure 2).

Figure 2:

Relative hydrophobicity of various AEROSIL® products as related to their methanol wettability. The graph shows the wt. percentage of silica that remains unwetted out by a 50% methanol/water solution. The higher the percentage of silica remaining, the greater the hydrophobicity.



SIPERNAT® precipitated silica

SIPERNAT® specialty silica grades are synthetically manufactured in a liquid-phase precipitation process. Here, a solution of sodium silicate (also called “water glass”) is neutralized by sulfuric acid and as a result of the following chemical reaction, small particles of silicon dioxide are formed. After washing, filtering, and drying steps, one obtains micrometer-sized

aggregates with a sponge-like structure; the resultant silica is a fine, loose, white powder with high internal porosity. Like fumed silica, SIPERNAT® silica is amorphous. SIPERNAT® silica has versatile properties that make production processes and final products more efficient and may be used in many types of personal care applications.

INCI names

AEROSIL® (INCI: Silica or Silica ... silylate) and SIPERNAT® (INCI: Hydrated Silica) are not restricted for use in cosmetic formulations (European Cosmetic Regulation, EC 1223/2009). Hydrophilic AEROSIL® (INCI: Silica) and SIPERNAT® (INCI: Hydrated Silica) are regarded nature identical according to Natrue (www.natrue.com, annexes under Manufacturers - Natrue Criteria).

The following products are PCPC-listed and have been assigned INCI names:

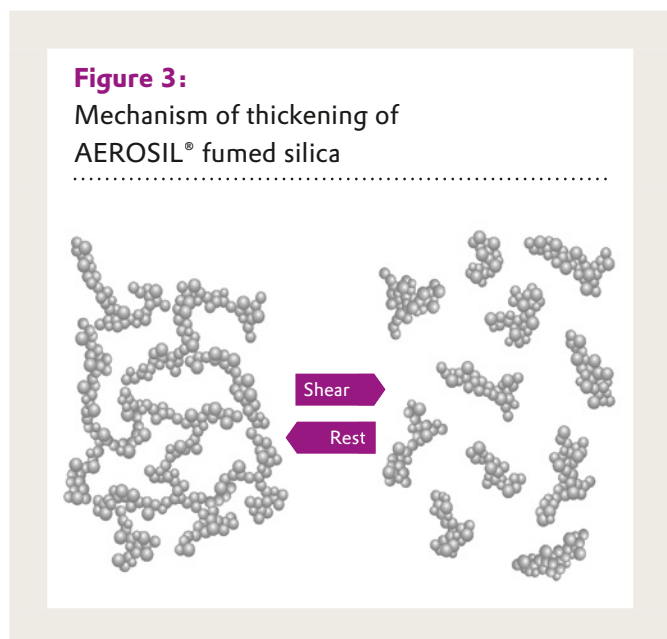
Silicas for Cosmetics and Personal Care - INCI names

PRODUCT NAME	INCI NAME
AEROSIL® 200	Silica
AEROSIL® 300	
AEROSIL® R 202	Silica dimethicone silylate
AEROSIL® R 972	Silica dimethyl silylate
AEROSIL® R 974	
AEROSIL® R 812	Silica silylate
AEROSIL® R 812 S	
AEROSIL® R 805	Silica caprylyl silylate
AEROSIL® R 816	Silica cetyl silylate
SIPERNAT® 22S	Hydrated silica
SIPERNAT® 22 LS	
SIPERNAT® 22 PC	
SIPERNAT® 2200 PC	
SIPERNAT® 11 PC	
SIPERNAT® 50S	
SIPERNAT® 500 LS	

Silica for Liquid Systems

RHEOLOGY MODIFIER

AEROSIL® fumed silica can be used as an efficient and reliable rheological aid. In a cosmetic formulation AEROSIL® will create a three dimensional network (Fig. 5) of agglomerated silica aggregates. Since this network can easily be broken down if external shear forces are applied, the resulting mixtures exhibit a thixotropic (non-Newtonian) behavior. The shear-thinning effect renders a gel that is easily spreadable during application to the skin without any dripping.



The most efficient AEROSIL® type to use is dependent on the matrix as well as the viscosity and rheology that needs to be achieved. As a general rule of thumb hydrophilic AEROSIL® grades perform better in non-polar oils (e. g. mineral oil, dimethicone, cyclomethicone). For more polar synthetic oils and vegetable oils, hydrophobic AEROSIL® types are often the better choice.

When looking at a cosmetic formulation it is necessary to consider the formulation as a whole since active ingredients, emollients, etc. may completely alter the thickening efficiency of AEROSIL®. The optimum product needs to be determined experimentally, taking other parameters like transparency, and gel stability into account.

For more information about thickening, please refer to our thickening fact sheet: AEROSIL® & SIPERNAT® Silica as Thickeners for Personal Care located at -

<http://www.aerosil.com>
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The AEROSIL® concentration required for thickening is dependent on the desired viscosity as well as on the matrix composition. Usually concentrations of 0.5 to 6 wt.-% are sufficient in the formulation.

A prerequisite for taking full advantage of the viscosity increasing effect of AEROSIL® is a proper dispersion of the silica in the matrix. As delivered, the products consist of agglomerates that need to be broken up so that the aggregate network can form in the oil.

To properly de-agglomerate the AEROSIL® products high shear mixing equipment like dissolvers or rotor stator mixers with a circumferential speed of at least 15 m/s is recommended.

Details on how to incorporate AEROSIL® into liquid systems can be found in TI 1279 – ‘Successful Use of AEROSIL® Fumed Silica in Liquid Systems’ which can be found at –

<http://www.aerosil.com>
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SUSPENSION AID

Many cosmetic products rely on the homogeneous dispersion of pigments or other insoluble substances in the formulation. Decorative cosmetics products like nail polish and lip gloss are typical examples where pigments need to be stabilized in a primarily organic matrix. Additionally, antiperspirant/deodorant creams and roll-ons require a homogeneous distribution of the active salts throughout the service life of the product.

AEROSIL® fumed silica can help to improve and stabilize such suspensions. The AEROSIL® network which builds in the formulation will incorporate the particles and stabilize them against settling.

RECOMMENDED PRODUCTS:

Depending on the system, both hydrophilic and hydrophobic AEROSIL® grades

Figure 4:

Schematic representation of pigment particles stabilized in a three-dimensional network of AEROSIL® fumed silica.

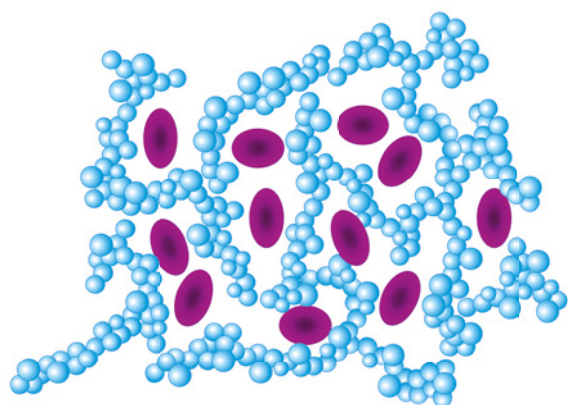
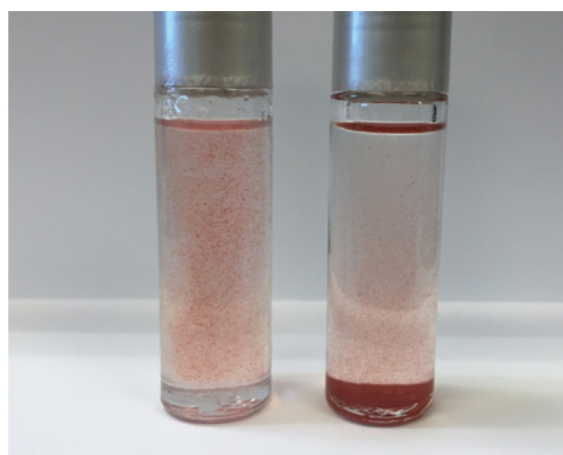


Figure 5:

A Lip Gloss formulation showing suspension of glitter using 5 wt. % AEROSIL® R 812 (left) and the control without silica (right)



EMULSIONS

Many personal care products such as lotions, creams and sunscreens are in the form of emulsions containing an aqueous phase and an oil phase. These phases are typically combined and stabilized using organic emulsifiers. As an alternative, some of our moderately hydrophobic fumed silica such as AEROSIL® R 816 and AEROSIL® R 974 can also be used to stabilize emulsions. The grade and concentration of silica is chosen based on the type of emulsion required (Oil-in-Water or Water-in-Oil), the total oil content in the formulation and the desired viscosity of the final product. Emulsions stabilized using particles in this manner are called 'Pickering' emulsions and can be extremely stable due to the creation of particle-stabilized micelles. Typical use rates of the silica for these applications is around 1 – 5 wt. percentage.

Another significant advantage of using silicas over emulsifiers such as waxes is the option of cold processing, since the AEROSIL® can be used at room temperature. This way, time- and energy-intensive heating and cooling of phases can be avoided. Pickering emulsions using AEROSIL® can be produced by typical high shear homogenizers common in the production of emulsions.

Silica can also be used along with other emulsifiers in an emulsion to adjust the viscosity and reduce the sensitivity of the formulation to changes in pH, temperature and electrolytes.

RECOMMENDED PRODUCTS:

- AEROSIL® R 816 (Oil-in-Water)
- AEROSIL® R 974 (Water-in-Oil)

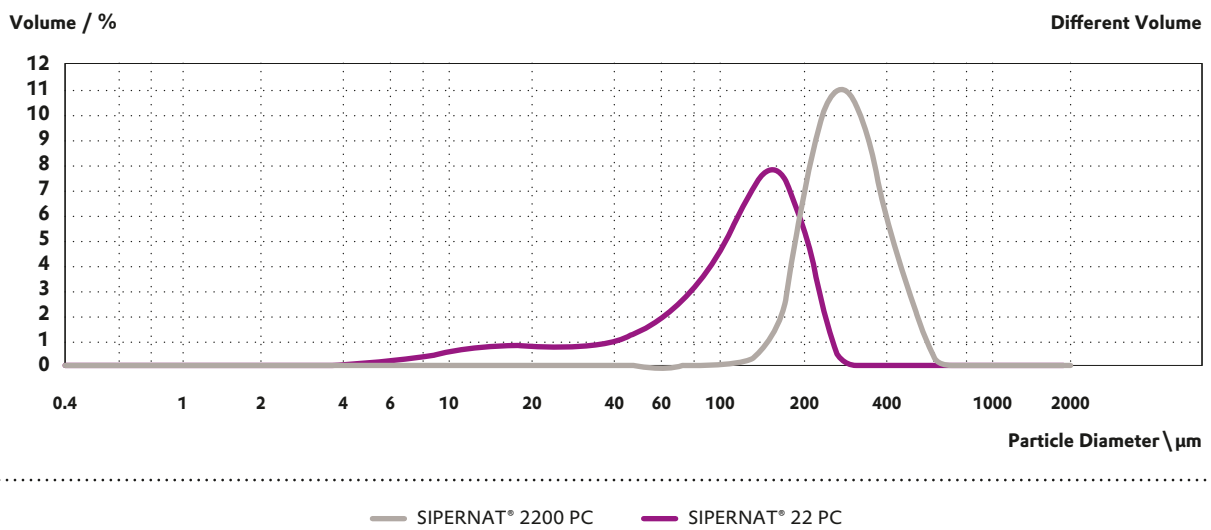
EXFOLIANT

Exfoliating body and facial cleanser formulations often rely on polyethylene beads to help rejuvenate the skin by removing dead cells. The growing discussion about plastic contamination in the environment and specifically in marine ecosystems have led to such microscopic polyethylene particles being phased out from a large number of products.

Out of the many eco-friendly alternatives that are currently being explored, SIPERNAT® hydrated silica stands out as a very economical solution, which overcomes the pressing environmental objections to plastic microspheres. Hydrated silica, because of its hydrophilic nature easily mixes into aqueous formulations. There is supporting evidence that hydrated silica particles stay suspended in the wastewater and are therefore easily removed in wastewater treatment plants.

Figure 6:

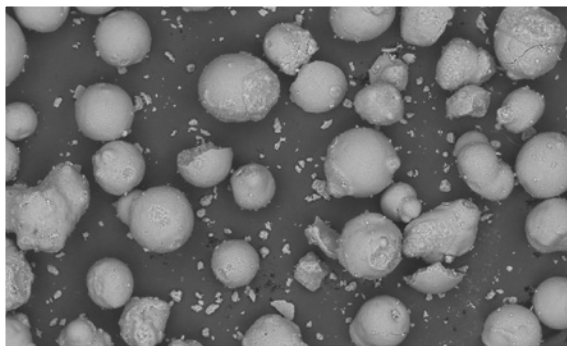
Particle size distribution of SIPERNAT® 22 PC and SIPERNAT® 2200 PC measured following ISO 13320-with a Coulter LS 230 instrument (Beckman Coulter, Brea (CA), USA)



As seen in the figure above both SIPERNAT® 22 PC (average particle size around 110 μm) and SIPERNAT® 2200 PC (average particle size around 320 μm) have a relatively narrow particle size distribution. This is in stark contrast to that of polyethylene beads. Figure 7 below shows the uniformity of spheres created in the manufacturing process of Evonik SIPERNAT® grades, whereas the PE beads are rough and vary in size and shape.

Figure 7:

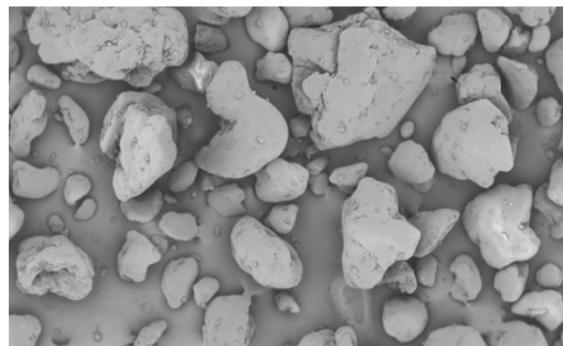
SEM micrograph of SIPERNAT® 2200 PC.



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Figure 8:

SEM micrograph of Polyethylene beads. Both pictures show product with an average particle size of 320µm.



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See Beauty Bulletin, Issue 4 for further information.

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RECOMMENDED PRODUCTS:

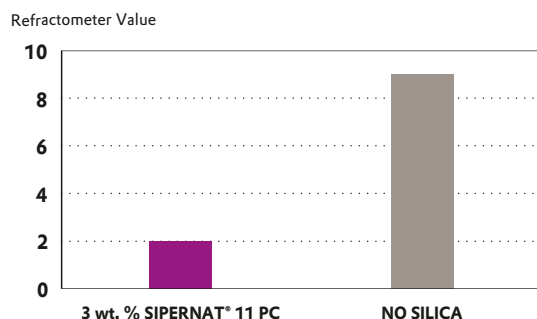
- SIPERNAT® 2200 PC
- SIPERNAT® 22 PC

MATTIFYING & SENSORY MODIFICATION

Adding silica to a formulation can lead to a mattifying effect by providing an irregular surface on the skin. Unlike smooth surfaces, irregular surfaces refract light away from the source and reduce the gloss. Gloss can also be reduced when absorptive silica is used. Due to its carrying capacity, silica can also bind oils that exude onto the skin which typically cause a glossy appearance.

SIPERNAT® 11 PC is particularly well suited to provide optical effects such as soft focus, optical blurring and mattifying. Figure 9 below shows the refractometer values of an Oil-in-Water lotion formulation with and without 3 wt. % SIPERNAT® 11 PC. The lotions were applied to artificial skin specimens, dried and tested using a gloss meter at an angle of 85°. The values clearly demonstrate the significant mattifying ability of the silica, which is mainly due to its low particle size ($\leq 10 \mu\text{m}$) and refractive index of 1.46. The small size also allows the deposition of these particles in wrinkles, enabling its use as a wrinkle-filler in anti-aging formulations.

Figure 9:
Refractometer values of an Oil-in-Water lotion with and without SIPERNAT® 11 PC



SIPERNAT® 11 PC is also well suited for use in skin care formulations to provide sensory modifications such as elegant skin feel and a natural, even appearance. SIPERNAT® 11 PC in both Oil-in-Water and Water-in-Oil formulations provides good spreadability, no whitening effect, improved skin absorption and dry feel after application.

For further information, please refer to Beauty Bulletin, Issue 6.

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RECOMMENDED PRODUCTS:

SIPERNAT® 11 PC (NATRUE and ECOCERT certified)

SULFATE-FREE SHAMPOO

Most conventional shampoos are water-based systems containing surfactants particularly sulfate-based surfactants such as SLS (Sodium Lauryl Sulfate). However, there has been a growing trend of sulfate-free products in the market due to concerns of scalp dryness and irritation and possible allergies or sensitivity to sulfate-based surfactants. These "sulfate-free" shampoos while beneficial to the hair, are notoriously challenging to thicken and stabilize and common thickening agents such as salt cannot be used. AEROSIL® fumed silica has been shown to provide the required viscosity to these formulations; the grade and usage level of the silica being optimized based on the desired performance of the final product.

RECOMMENDED PRODUCTS:

- AEROSIL® 200
- AEROSIL® 300

LIPSTICK

In liquid lipsticks, our silica acts as an oil gelling agent and structurant. The silica limits exudation or syneresis, while also providing a long-lasting and matte finish look. For wax/solid lipsticks, formulating with our silica helps improve payoff (transfer). It also enhances storage and temperature stability.

The Powder-to-Cream (P2C) concept (described under Silica in Powdered Systems) can also be used to create novel powder lipstick formulations.

RECOMMENDED PRODUCTS:

- AEROSIL® R 812 (liquid lipstick)
- AEROSIL® 200 (Wax lipstick)
- SIPERNAT® 500 LS (Wax lipstick, P2C Lipstick)
- AEROSIL® R 812 S (P2C lipstick)

Figure 10



Figure 11



Figure 10: Lipstick after high temperature storage (4 hours at 65 °C) Left: lipstick containing no silica has deformed due to temperature and has sweated out a large portion of oil. Center and right: lipsticks containing 2 % and 4% w / w SIPERNAT® 500 LS (respectively) have retained their shape and oil. **Figure 11:** Powder to cream lipstick formulation

MASCARA

In mascara formulations, our silica acts as a mattifying agent. It also helps with the spreadability of the mascara on the lashes. Finally, the silica helps with suspending pigments and increasing formula body.

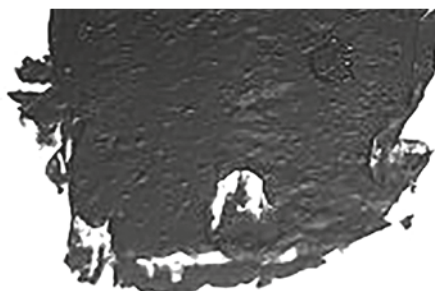
RECOMMENDED PRODUCTS:

AEROSIL® 200

Figure 12: Mascara formulation with AEROSIL® 200



1 wt. % AEROSIL® 200



without silica

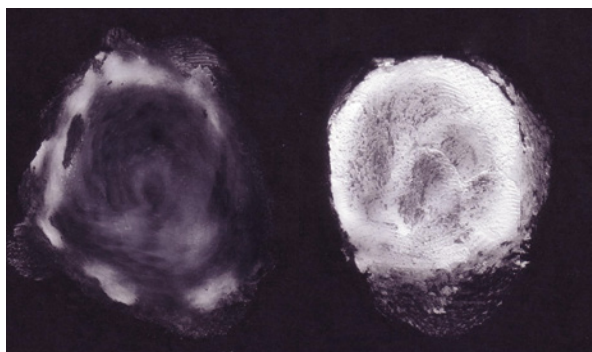
ANTIPERSPIRANT/DEODORANT

Our AEROSIL® line of products serve a number of different functions in antiperspirants and deodorants; they work well in sticks, roll-ons, and sprays. Our AEROSIL® products can be used as efficient suspending agents to prevent the agglomeration of Al/Zr salts. You can also eliminate hard settling/packing in sprays as well as prevent the clogging of spray nozzles. AEROSIL® is an effective gelling agent. It imparts a pleasantly dry skin feel with very low whitening.

STICK/ROLL ON

Our customers have been very pleased with the consumer acceptance of their products formulated with Evonik's AEROSIL® grades. They are a pure white color and show very little whitening. Compared to competitive products, less raw materials are required such as iron scavengers or other whitening agents. AEROSIL® helps with stick consistency and salt suspension/uniformity. It can also be used for rheology adjustment.

Figure 13



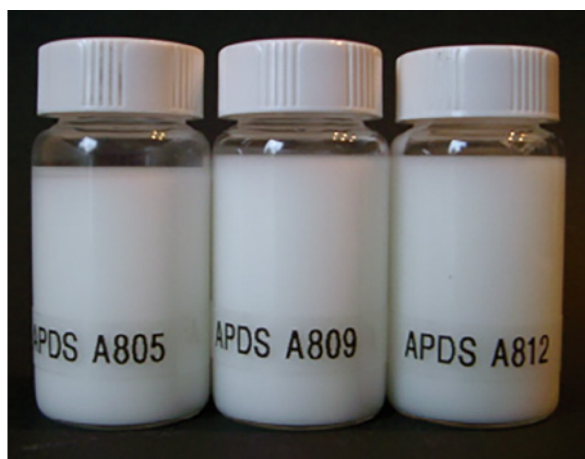
AP Stick with 3.0 wt.-% AEROSIL® R 972 (left), 3.0 wt.-% Bentone 38 V (right).
AEROSIL® formulations showed very little whitening compared to sticks containing Bentone (Elementis specialties)

SPRAY

Compared to Bentones, only 0.5 weight % AEROSIL® R 812 S is required to produce a stable bulk finished product. Additionally, the processing costs can be lowered as there is no need to re-disperse the material for processing. Formulations containing AEROSIL® exhibit lower whitening thereby creating

better consumer acceptance. AEROSIL® will keep the nozzle and feed tube clear and free from build-up. As seen in the pictures below, less shaking is required due to the anti-settling properties imparted by the AEROSIL®.

Figure 14



AEROSIL® spray bulk with 0.5, 0.9, and 1.2 wt-% AEROSIL® R 812 S
(left to right)

AEROSIL® spray bulk with 0.5, 0.9, and 1.2 wt-% BENTONE 38 V
(left to right)

AEROSIL® formulations (left) show no bulk separation, while sedimentation occurs in Bentonecontaining products

Aerosol Antiperspirant Spray formulations

INGREDIENT	INCI NAME	FORMULA A (wt. %)	FORMULA B (wt. %)
Cyclomethicone	Cyclopentasiloxane and Cyclohexasiloxane	2.3	2.3
Varonic APM	PPG-3 Myristyle Ether	2	2
Varonic APS	PPG-11 Stearyl Ether	2	2
Nature Therapy D41130 (Symrise)	Parfum (Fragrance)	0.2	0.2
AEROSIL® R 812 S	Silica silylate	0.5	-
Bentone 38V (organic derivative of a hectorite clay)		-	0.5
MicroDry 331	Aluminium Chlorohydrate	3	3
Isobutene	Isobutene	90	90

RECOMMENDED PRODUCTS:

- AEROSIL® R 812 S
- AEROSIL® R 972
- AEROSIL® R 974

Silica in Powder Systems

FREE FLOW

Powder make-up products for the face and eyes often contain irregularly shaped pigments or other ingredients that can cause poor flow. Poor flow can lead to formulations that are not homogenous and lead to difficulties during scale-up and processing. Silica acts as a particle spacer, preventing poor flow.

ANTI-CAKING

Hygroscopic materials, such as some of the minerals used in loose powder make-up, can attract and bind water causing the powdered cosmetic to cake or become cohesive. Silica can prevent this storage problem by preferentially absorbing water before it can affect the makeup.

CARRIERS

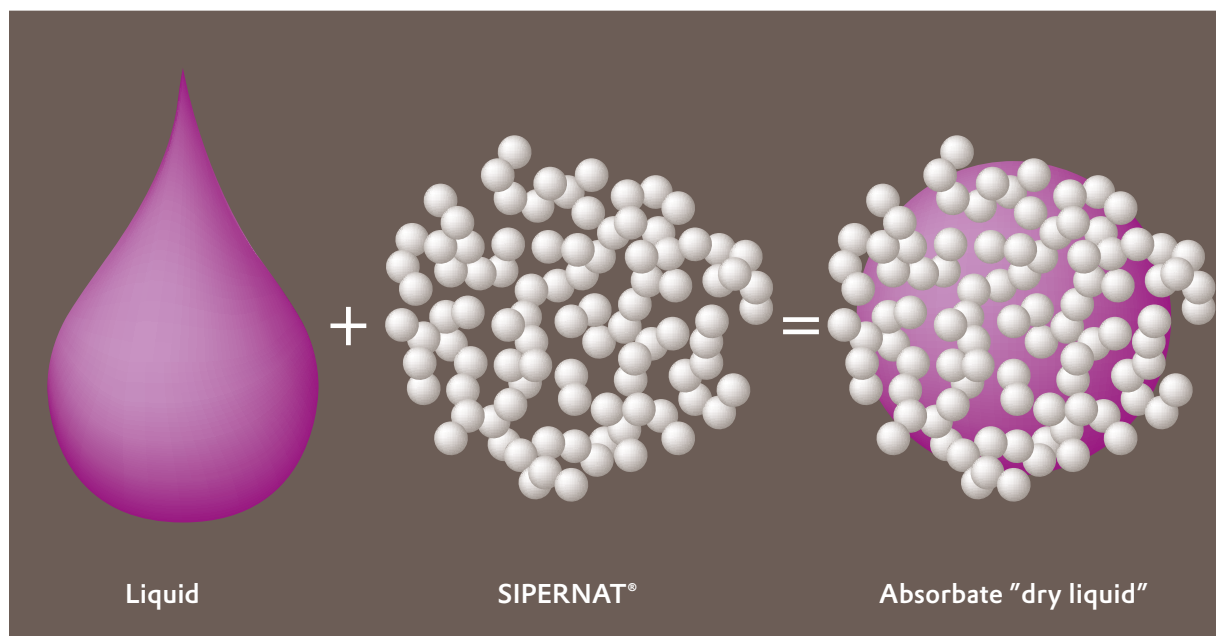
SIPERNAT® precipitated silica have high internal porosities and can be used to convert liquid formulations or ingredients to powder in the form of carriers. This concept can be used for liquid actives such as vitamins, fragrances, etc. or inerts that

need to be mixed with other powder ingredients in a formula. The absorption capacity of the silica depends on the size of the particles, pore structure and volume, and the moisture content. The absorption capacity of the SIPERNAT® grades are specified using the DOA test (ISO 19246), in which an absorptometer measures the increase in torque as Di-Octyl Adipate (DOA) is absorbed by a silica bed until it is saturated. The higher the DOA value, the greater the carrying capacity of the silica.

SUCCESSFUL PROCESSING OF CARRIERS

Low-shear mixing is key to successfully processing a carrier formulation. The silica bed needs to be in continuous motion during the production phase. This allows for maximum contact between the liquid that needs to be carried and the silica surface. Liquids should be uniformly dosed by either spray addition or atomization. Different release triggers can be designed such as carrier attrition, displacement and chemical changes. Powder-to-Cream Foundation is an example of release by displacement.

Figure 15



Encapsulation of an active using SIPERNAT®. The diagram above is a pictorial representation of our carrier technology.

RECOMMENDED PRODUCTS:

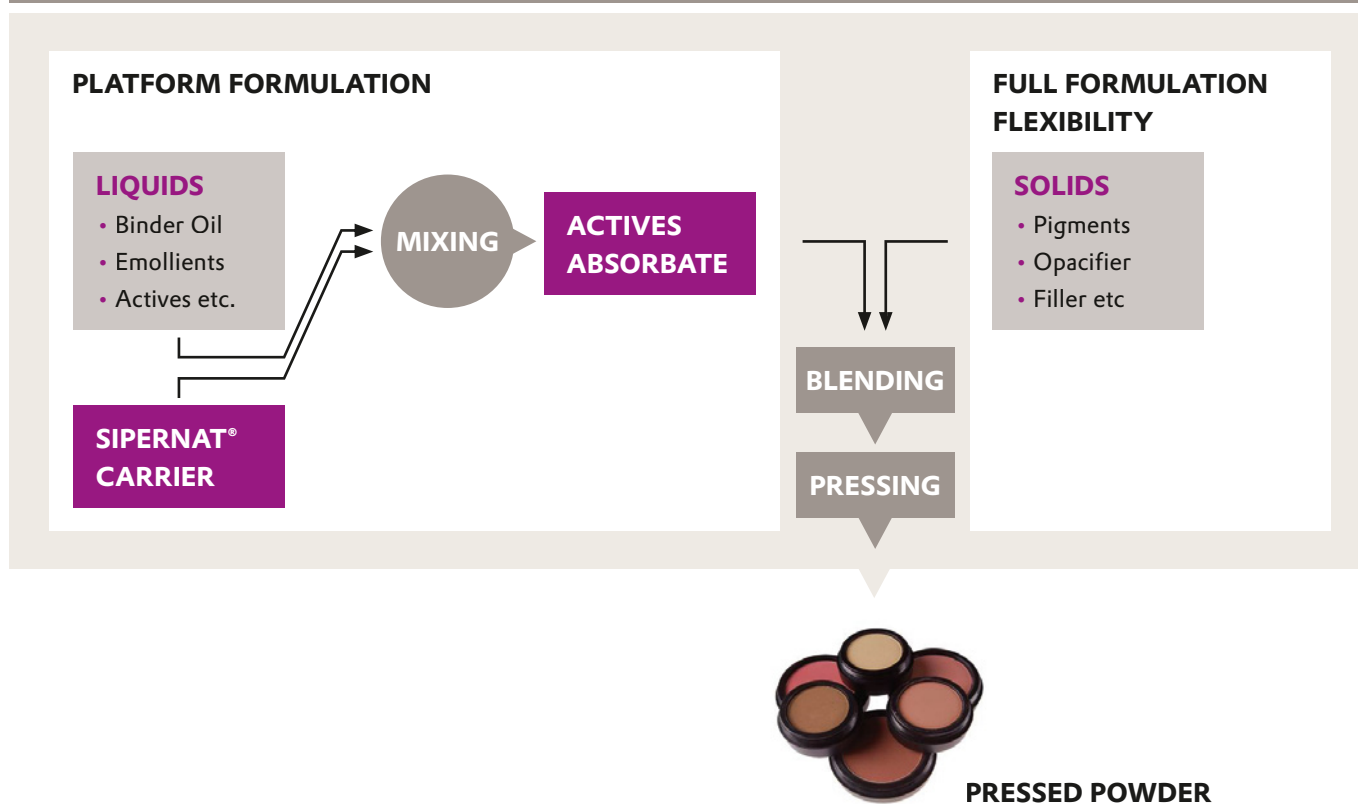
SIPERNAT® silica for carriers

PRODUCT NAME	DOA ABSORPTION (ml/100g) following ISO 19246	PARTICLE SIZE (d50, µm) following ISO	SPECIFIC SURFACE AREA (BET) (m²/g) following ISO 9277
SIPERNAT® 50	295	50	500
SIPERNAT® 50 S	280	18	500
SIPERNAT® 500 LS	270	10.5	500
SIPERNAT® 22 LS	235	9.0	180
SIPERNAT® 22 S	240	13.5	190

DRY BINDER

Dry Binder is an example of the carrier technology. Dry binders used for direct compaction have to exhibit adhesive and cohesive forces so that when compacted the particles agglomerate. Our SIPERNAT® carriers convert liquids into free-flowing absorbate powders. These carrier can easily be mixed into any powder formulation and absorb up to three times their own weight.

FIGURE 16: Schematic showing the use of SIPERNAT® silica as a carrier in a pressed powder formulation



DRY LIQUID ENCAPSULATION

"Dry Water/Dry Glycerin" is created by producing fine water and/or glycerin droplets in the presence of a hydrophobic AEROSIL® during a fast, high shear mixing process. While mixing, the fine droplets are coated by the hydrophobic silica, which prevents them from coalescing. The result is a powdered substance containing a very high percentage of liquids, typically referred to as "Dry Water/Dry Glycerin". For the sake of simplicity, the term Dry Liquid will be used to describe both water and glycerin.

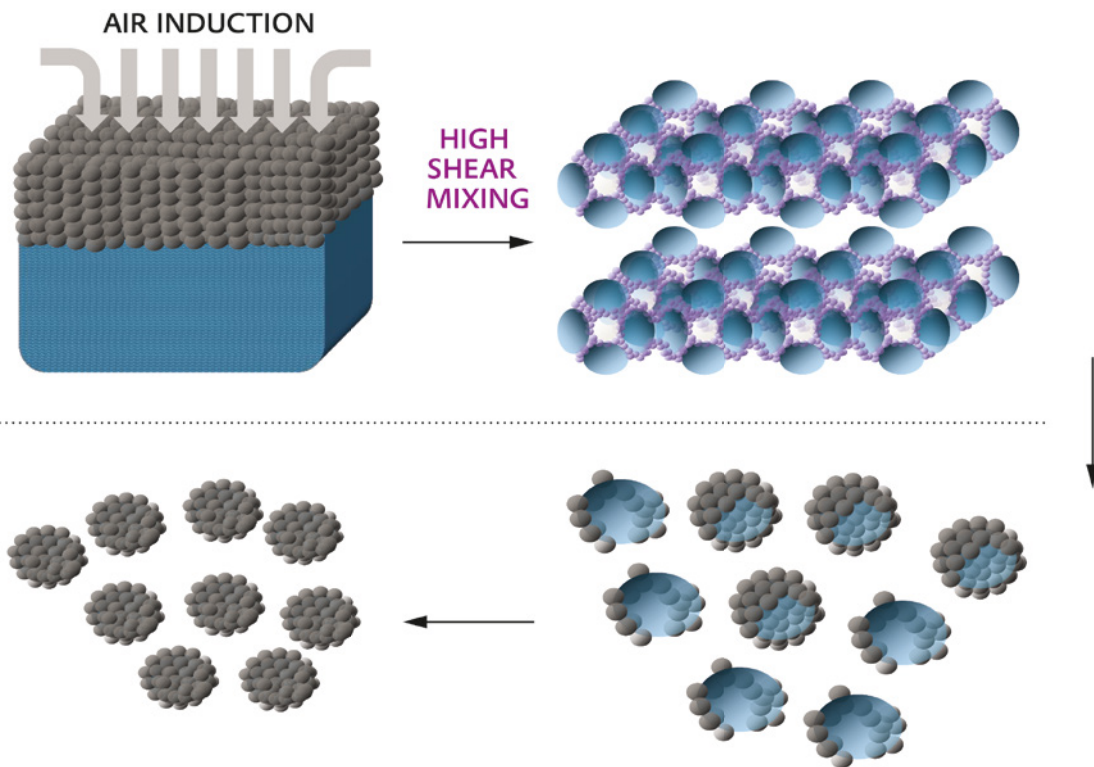
The Dry Liquid concept relies on the high surface tensions of water and glycerin. The extremely hydrophobic AEROSIL® particles will not be wetted by polar liquid droplets and instead form a coating on their surface, which prevents the droplets from coalescing. However, additives (such as surfactants) added to the aqueous phase can lower the surface tension or wet the silica, allowing it to mix with the aqueous phase.

This will be rapidly followed by droplet coalescence, which can lead to instability. Typically, the more non-polar the additive is, the more it will affect the surface tension and the less it can be added without the Dry Liquid becoming unstable.

Depending on the effect on the surface tension, the basic Dry Liquid concept allows for the incorporation of up to several percent of additives by weight before the formulation becomes unstable. This formulation type can be broken down easily with very low shear to release the aqueous phase, such as using a brush to apply the product.

Possible applications for Dry Liquid include bronzing, mattifying and hair styling powders. The Dry Liquid concept is also attractive to consumers and manufacturers since it offers the option of a new product form for existing formulations.

Figure 17



Dry Liquid Processing: A high shear mixing is used to break water into droplets and coat them with a highly hydrophobic silica resulting in discrete particles

RECOMMENDED PRODUCTS:

- AEROSIL® R 812 S
- AEROSIL® R 202

DRY SHAMPOO AND STYLING AIDS

AEROSIL® fumed silica has many applications in hair care products, particularly when used in a Dry Water – type formulation. Dry shampoos are popular products that provide a convenient way of hair cleansing during the day, and an easy alternative to time-consuming wet washing and drying. Combined with other powder ingredients, AEROSIL® provides a volumizing effect to styling aids, and since Dry Water contains mostly an aqueous phase by weight, the formulation also moisturizes the hair. Our Dry Shampoo formulation also contains SIPERNAT® 50 S, a highly absorbent precipitated silica which is used to absorb oils and reduce greasy appearance of the hair.

RECOMMENDED PRODUCTS:

- AEROSIL® R 812 S
- AEROSIL® R 202
- SIPERNAT® 50 S

POWDER-TO-CREAM (P2C)

Our Powder-to-Cream concept takes advantage of the moisturizing properties of dry water and couples it with our carrier technology in order to deliver unique properties to your formulations.

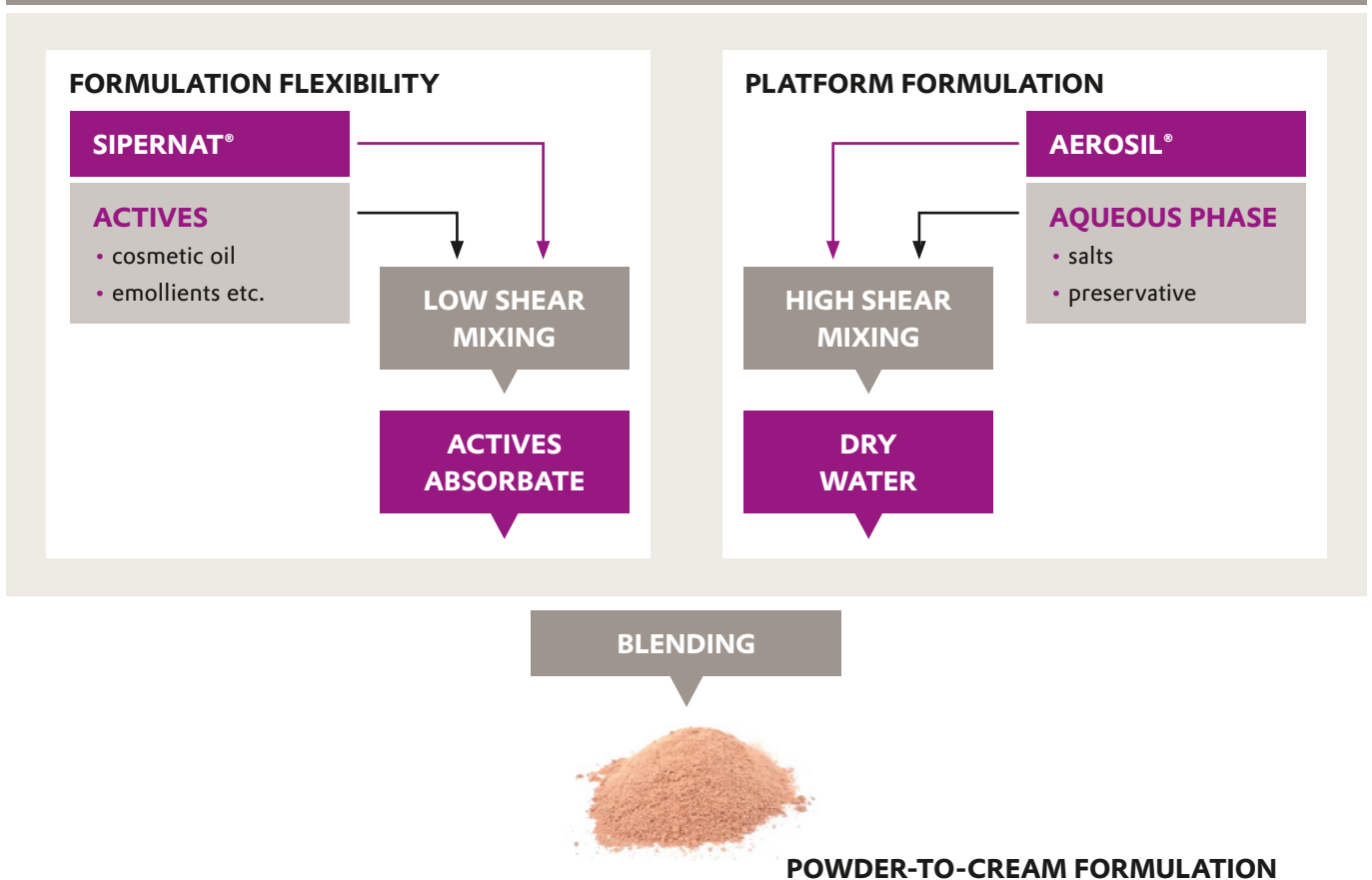
It allows the formulator greater flexibility by introducing a second component to the formulation. It also allows formulation flexibility to add actives via the actives absorbate component.

For more information, please see Beauty Bulletin, Issue 2.

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FIGURE 18: Schematic showing the use of both AEROSIL® and SIPERNAT® silica in a Powder-To-Cream formulation



The original Dry Liquid concept was limited to only a few percent of actives in order to achieve stability. This concept has been advanced in order to enable more formulation flexibility and much higher active concentrations. By using carrier silica, additives can be incorporated outside of the aqueous environment allowing for many more types of additives to be used successfully and amounts up to approximately 20 % by wt. while maintaining a stable powder.

As mentioned earlier, silica works very well as an absorptive carrier that will release the carried additive when in the presence of water. When under mechanical stress, Dry Water turns from a powder into water. This water liberates the additives out of the carrier silica, allowing for formulations that appear as a powder, but can be applied as a cream (Fig. 19).

Figure 19:

Powder-to-Cream formulation



For more information, please see TI 1394 Powder-to-Cream: An innovative concept for cosmetic formulations in powder form.

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RECOMMENDED PRODUCTS:

- AEROSIL® R 812 S
- AEROSIL® R 202
- SIPERNAT® 500 LS
- SIPERNAT® 11 PC

For all guide formulations containing Evonik silica products, please refer to our website -

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Silicas for Personal Care

PRODUCT NAME	SUSPENSION	CARRIERS	DRY BINDER	DRY WATER	POWDER-TO-CREAM	E+FOLIANT	MATTIFYING	EMULSION	DRY SHAMPOO	SULFATE-FREE SHAMPOO	LIPSTICK	ANTI-PERSPIRANT/DEODORANT		
												STICK/ROLL-ON	SPRAY	MASCARA
AEROSIL® 200	+									+	+			+
AEROSIL® 300	+									+		+		
AEROSIL® R 202				+	+				+					
AEROSIL® R 805	+													
AEROSIL® R 812 S				+	+				+		+		+	
AEROSIL® R 816								+						
AEROSIL® R 974								+				+		
AEROSIL® R 812	+										+			
AEROSIL® R 972												+		
SIPERNAT® 11 PC							+							
SIPERNAT® 22 LS		+	+		+									
SIPERNAT® 22 PC		+	+		+	+								
SIPERNAT® 2200 PC		+	+		+	+								
SIPERNAT® 500 LS		+	+		+						+			
SIPERNAT® 22S		+	+		+									
SIPERNAT® 50S		+	+		+				+					

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