

AEROSIL® fumed silica –

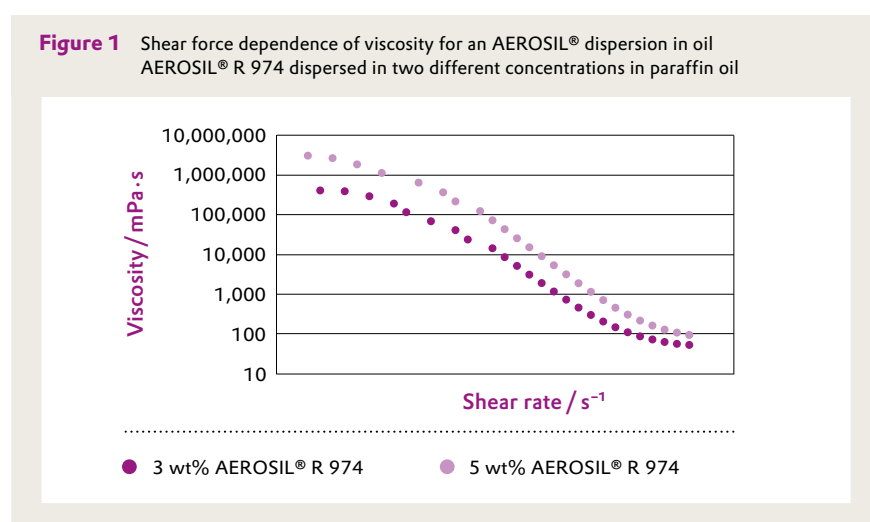
Efficient and versatile rheology additives
for Personal Care formulations



The effect of AEROSIL® fumed silica on the rheological properties of Personal Care formulations is well recognized and has been exploited in a range of different formulation challenges.

AEROSIL® fumed silica dispersed in an oil matrix can strongly increase its viscosity and profoundly influence its rheology. The more silica that is added to the oil matrix the more viscous the formulation becomes. The resulting dispersion develops non-Newtonian flow behavior and becomes shear thinning and thixotropic.

Figure 1 shows the shear dependence of an emollient with added silica thickeners.



Due to the modified rheology a formulation containing silica will not drip from a tube or a jar. With the higher shear forces employed on application, however, it becomes easily spreadable on the skin.

The composition of the liquid matrix is the key parameter for the performance of AEROSIL® rheology additives: A silica that works with one oil composition may prove much less effective in another.

However, with the wide range of hydrophilic and surface modified hydrophobic AEROSIL® products available, an efficient rheology additive can be selected for almost any emollient.

Hydrophilic AEROSIL® products are especially recommended for natural formulations following either Cosmos or Natrue standards.

Table 1 Hydrophilic AEROSIL® fumed silica rheology additives and certifications for natural formulations

Product	INCI-name	Specific surface area BET / (m ² /g)	Cosmos	Natrue ¹	Natural origin index (acc. to ISO 16128) ²
AEROSIL® 200	Silica	175 - 225	X	approved	1
AEROSIL® 300	Silica	270 - 330	X	approved	1

¹ Classification as “nature identical mineral” according to Annex 2 (version 3.7), available from www.natrue.org under <http://www.natrue.org/information-for/manufacturers/natrue-criteria/>

² Based on the categorization of Silica as “derived mineral ingredients” according to annex D in ISO 16128-1 and the assessment of “derived minerals” according to table 1 in ISO 16128-2.

Table 2 Surface-modified, hydrophobic AEROSIL® fumed silica rheology additives

Product	INCI-name	Surface modified by	Hydrophobicity	Specific surface area BET / (m ² /g)
AEROSIL® R 202	Silica dimethicone silylate	Polydimethylsiloxane	Very high	80–120
AEROSIL® R 805	Silica caprylyl silylate	Organosilane	High	125–175
AEROSIL® R 812	Silica silylate	Hexamethyldisilazane	High	230–290
AEROSIL® R 812 S	Silica silylate	Hexamethyldisilazane	High	195–245
AEROSIL® R 816	Silica cetyl silylate	Hexadecylsilane	Low	170–210
AEROSIL® R 972	Silica dimethyl silylate	Dimethyldichlorosilane	Moderate	90–130
AEROSIL® R 974	Silica dimethyl silylate	Dimethyldichlorosilane	Moderate	150–190

For selected emollients, information on the efficiency of the AEROSIL® fumed silica rheology additives is given in Table 3. The large number of different oils used for cosmetic applications makes it impossible to include information for each and every emollient. Furthermore, personal care formulations rarely consist of just one emollient. The following rules of thumb may therefore be useful:

Matrix with low polarity	Hydrophilic AEROSIL® fumed silica: AEROSIL® 200, AEROSIL® 300 AEROSIL® grades with low to moderate hydrophobicity: AEROSIL® R 816, AEROSIL® R 974
Highly polar matrix	Strongly hydrophobic AEROSIL® fumed silica: AEROSIL® R 202, AEROSIL® R 805, AEROSIL® R 812 S
Matrix composed of natural triglycerides	Strongly hydrophobic AEROSIL® fumed silica: AEROSIL® R 202, AEROSIL® R 805, AEROSIL® R 812 S or AEROSIL® R 816

With highly efficient AEROSIL® fumed silica additives, rheological performance tends to be very sensitive to concentration. If variable effects are observed it may be useful to use a less efficient rheology additive, depending on the desired rheological profile.

Table 3 Recommendations for AEROSIL® rheology additives for selected emollients.
 Viscosity values for 6 wt% dispersions of the respective AEROSIL® fumed silica, measured at 20–25 °C with a Brookfield viscometer

Emollient	INCI name	Viscosity of pure oil / mPa·s	AEROSIL® 200	AEROSIL® 300
ABIL® 350	Dimethicone	340		
Argan oil	Argania spinosa kernel oil	80		
Caprylic/capric triglyceride	Caprylic/capric triglyceride	25	CLEAR	CLEAR
Castor oil	Ricinus communis oil	750		
Cyclopentasiloxane	Cyclopentasiloxane	5		
Joboba oil	Simmondsia chinensis seed oil	60	CLEAR	CLEAR
Macadamia oil	Macadamia ternifolia seed oil	60	CLEAR	
Mineral oil	Mineral oil	40		
Olive oil	Olea europaea oil	90	CLEAR	CLEAR
Paraffin oil	Paraffinum liquidum	40	CLEAR	CLEAR
Polyethylene glycol	PEG-8	100	CLEAR	
Rapeseed oil	Brassica campestris oleifera oil	70	CLEAR	
Soybean oil	Glycine soja oil	80	CLEAR	
Sunflower oil	Helianthus annuus seed oil	50		
Sweet almond oil	Prunus amygdalus dulcis	70		
TEGOSOFT® CI	Cetearyl isononanoate	20	CLEAR	
TEGOSOFT® CO	Cetyl ethylhexanoate	20		
TEGOSOFT® DEC	Diethylhexyl carbonate	5		
TEGOSOFT® E	PPG-15 stearyl ether	80		
TEGOSOFT® HP	Isocetyl palmitate	30		
TEGOSOFT® OP	Ethylhexyl palmitate	10	CLEAR	
TEGOSOFT® TN	C12 – 15 alkyl benzoate	10		
Vaseline	Petrolatum	160		

Viscosity rating (mPa·s):

CLEAR: possibility of transparent formulations



AEROSIL® R 202 AEROSIL® R 805 AEROSIL® R 812 S AEROSIL® R 816 AEROSIL® R 972 AEROSIL® R 974

CLEAR			CLEAR	CLEAR	CLEAR
	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR
	CLEAR		CLEAR	CLEAR	
	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR
	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR
	CLEAR	CLEAR	CLEAR	CLEAR	
			CLEAR		CLEAR
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CLEAR	CLEAR		CLEAR	CLEAR	CLEAR
		CLEAR		CLEAR	CLEAR
			CLEAR	CLEAR	CLEAR

Processing recommendations

To take full advantage of the rheological effect of AEROSIL® fumed silica the fine silica powder needs to be well dispersed in the liquid matrix. Equipment with strong shear forces such as rotor stator mixers or Cowles blade stirrers should preferably be used. The high shear forces break down the AEROSIL® agglomerates that are present in the materials as delivered. On dispersion, these large secondary structures are reduced to smaller structures. The breaking down of the larger AEROSIL® agglomerates not only contributes to the stability of the dispersion but can also improve its clarity. Depending on the individual situation, it may be possible to process AEROSIL® with equipment using lower shear forces.

Wetting of the silica at low shear prior to the high shear dispersion process helps to prevent dust formation. It may be necessary to perform the dispersion process under vacuum to prevent air being entrapped in the possibly highly viscous mixture.

Special requirements

To produce **transparent oil** formulations with AEROSIL® fumed silica, the refractive index of the oil matrix must match that of the silica (1.45–1.46). The clarity of the formulation can be optimized by good dispersion of the silica in the oil and by avoiding entrapment of air bubbles in the gel. In certain cases, choosing a different AEROSIL® fumed silica may also strongly affect the clarity (see **Figure 2**).

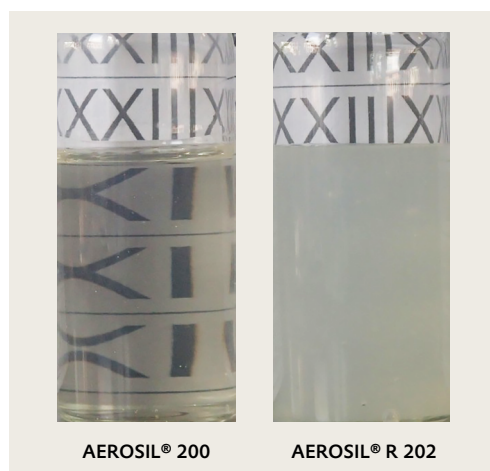


Figure 2 Dispersions of 3 wt% AEROSIL® fumed silica in castor oil

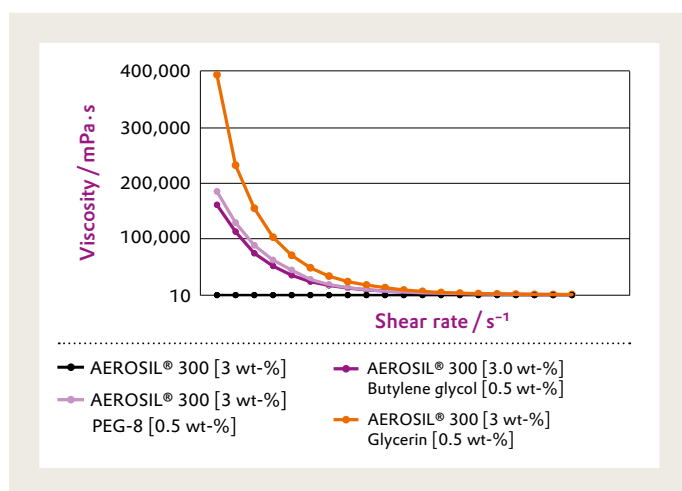


Figure 3

Effect of viscosity boosters on the viscosities produced with hydrophilic AEROSIL® fumed silica. Viscosities of mixtures of TEGOSOFT® M (INCI-name: Isopropyl myristate) and AEROSIL® 300 with and without viscosity boosters

The thickening efficiency of hydrophilic AEROSIL® products can be strongly increased by adding viscosity boosters such as polyethylene glycol (PEG), glycerin, or butylene glycol. **Figure 3** shows an example of the effect observed for TEGOSOFT® M (INCI name: Isopropyl myristate), where hydrophilic AEROSIL® 300 alone has no effect on the viscosity. However, addition of relatively small amounts of a booster leads to a strong increase in viscosity, and shear thinning behavior is observed. The use of viscosity boosters can help formulators select a hydrophilic AEROSIL® rheology additive conforming to natural cosmetics standards (e. g., Cosmos or Natrue) that would not be effective without the booster.

Further benefits of AEROSIL® fumed silica as rheology modifier

The high viscosities that silica thickeners induce in oil-based formulations can also be used to stabilize dispersions of other particles, such as pigments or antiperspirant salts, to prevent sedimentation (see Figure 4). In aerosol formulations this anti-settling effect helps prevent clogging of the spray nozzle by agglomerated solids.

As the rheological effect is not dependent on temperature, AEROSIL® silica thickeners can significantly improve the temperature stability of oil based pigmented formulations, for example in color cosmetics (see Figure 5).



Figure 4 Particle stabilization effect of AEROSIL® silica thickened oil.
Left: colored glass beads in the pure oil.
Right: glass beads in the same oil with added AEROSIL® fumed silica.



Figure 5 Heat stabilization of a lipstick by adding AEROSIL®. The lipsticks have the same composition.
Left: Lipstick after storage at 50 °C for 24 h.
Right: lipstick containing 4 wt% AEROSIL® 200

The increased viscosity imparted by hydrophobic AEROSIL® fumed silica thickeners to a homogeneous oil improves the stability of W/O emulsions. AEROSIL® fumed silica products that are moderately to strongly hydrophobic need to be used to prevent migration of silica into the aqueous phase.

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