
EVONIK
Leading Beyond Chemistry
131
EP
EXPERTISE
SILICA FOR AGRICULTURE

Small Particles, Big Solutions: Silica for Agrochemical and Biological Formulations

Ana Maria Sandoval
ana.sandoval@evonik.com
Sales Manager – Smart Effects
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Evonik Silica

Small Particles, Big Solutions



1

Evonik Silica Technologies for Agriculture: Key Features

2

Evonik Fumed Silica Technology: Rheology Control and Liquid Stability

3

Formulation examples

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Evonik Silica

Small Particles, Big Solutions



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Evonik Silica Technologies for Agriculture: Key Features

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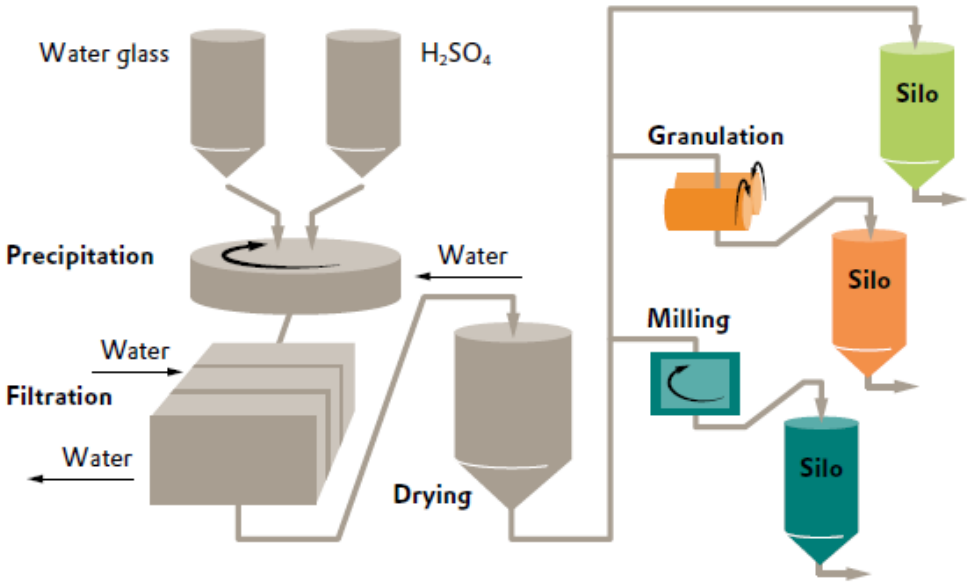
Evonik Fumed Silica Technology: Rheology Control and Liquid Stability

3

Formulation examples

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Precipitated silica process SIPERNAT®

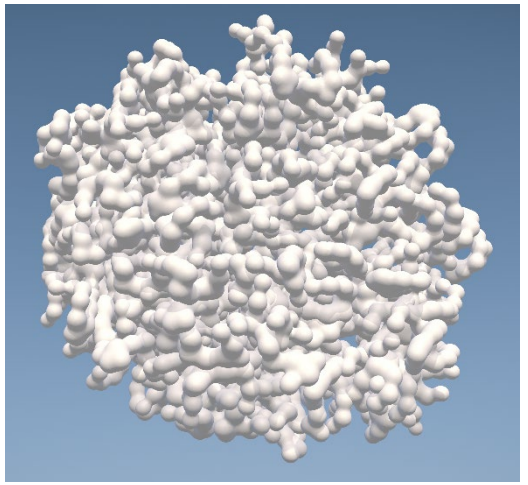


Process
- Aqueous solution process
- Precipitation of silica

$$Na_2O * 3.3\ SiO_2 + H_2SO_4 \longrightarrow SiO_2 + Na_2SO_4 + H_2O$$

By-product
- Sodium sulfate

Structure
- primary particles which are linked together to form larger agglomerates.
- highly porous sponge-like structure
- amorphous

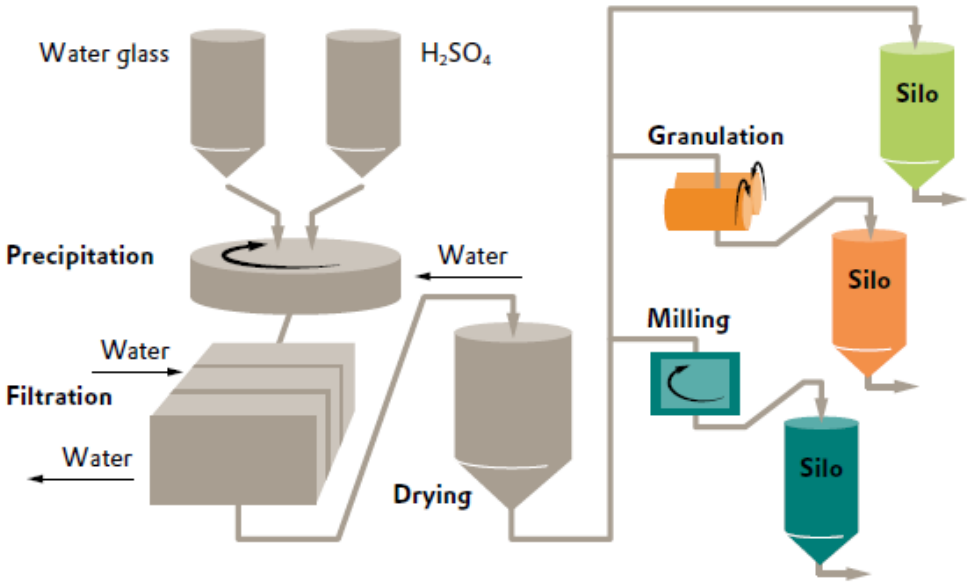


Precipitated silica

- Large particle size.
- Si02 > 97%
- Can be surface treated e.g. PDMS-treated.

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Precipitated silica process SIPERNAT®



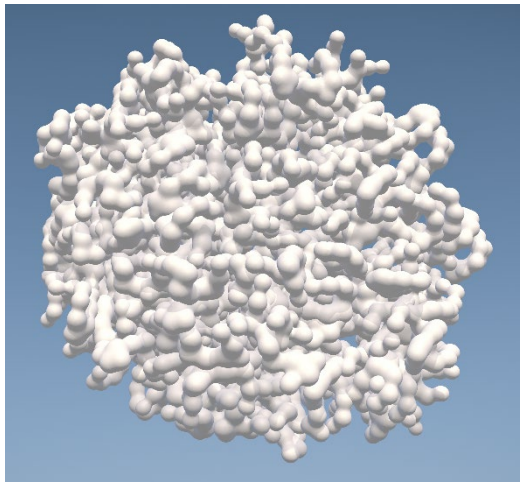
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Solid formulations
WP, WG

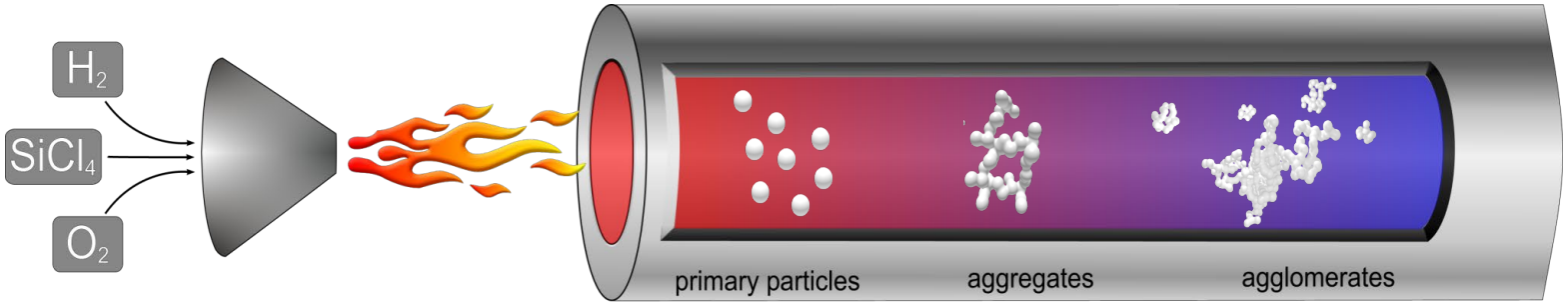


Precipitated silica

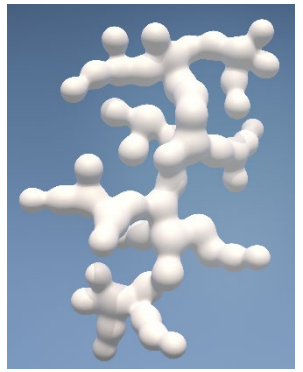
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Fumed silica process: AEROSIL®



$$2H_2 + O_2 \longrightarrow 2H_2O$$
$$SiCl_4 + 2H_2O \longrightarrow SiO_2 + 4HCl$$



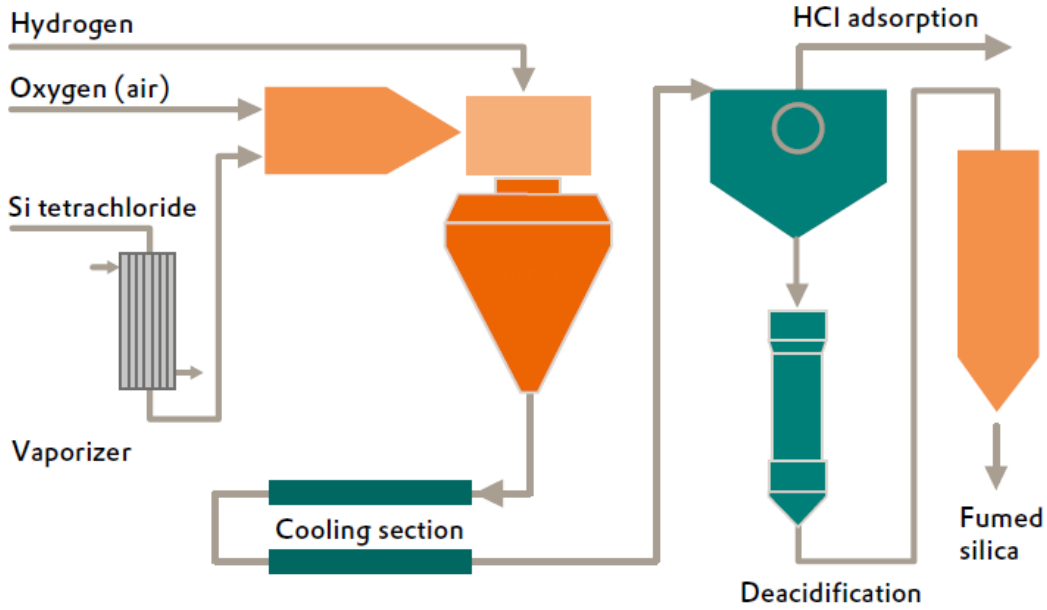
Fumed Silica

- Nano particles.
- Si02 > 99%

Process
- High temperature gas phase process
- Flame hydrolysis of silicon tetrachloride

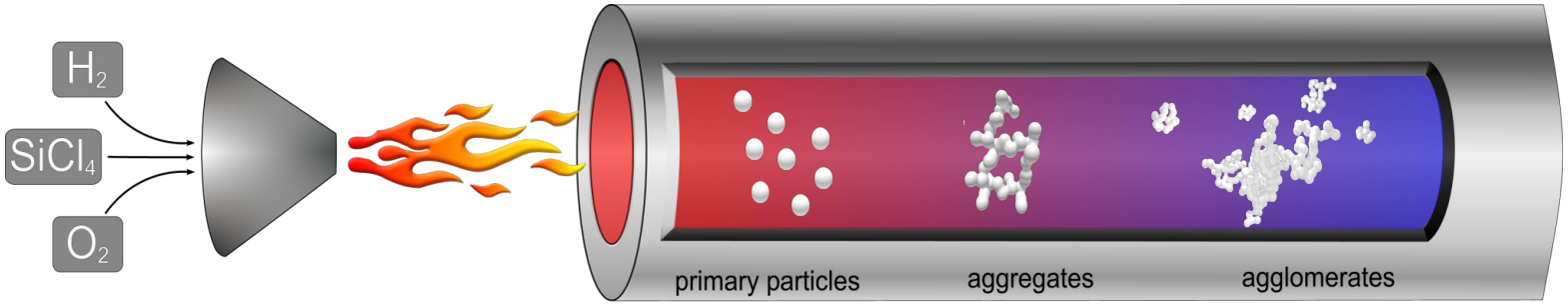
By-product
- Hydrogen chloride

Structure
- Three dimensional, agglomerated structure, predominantly chain-like, branched, amorphous

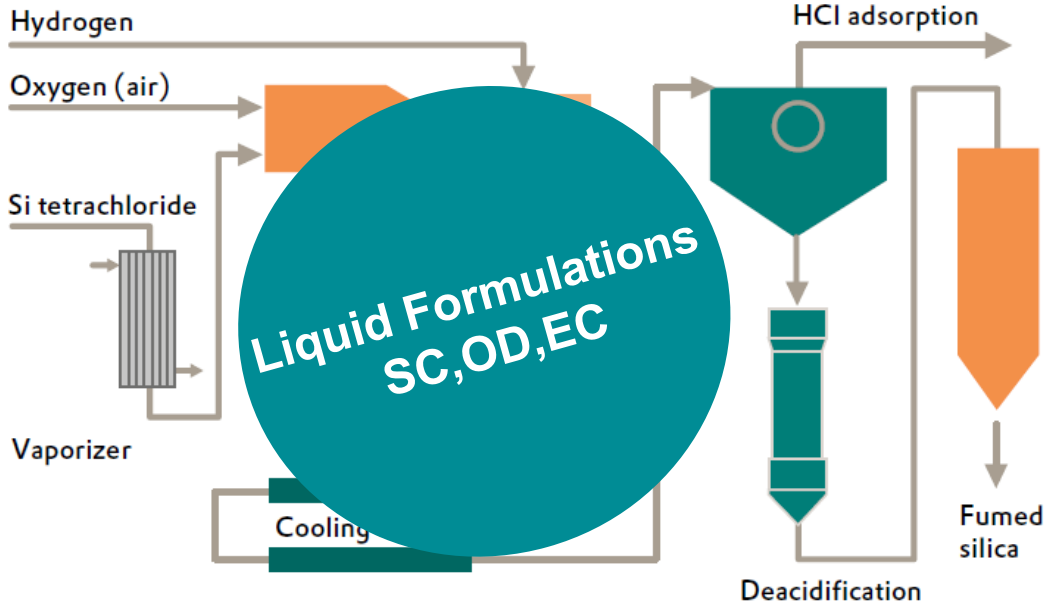


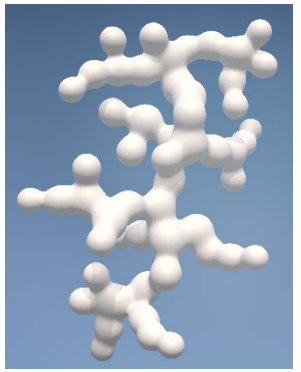
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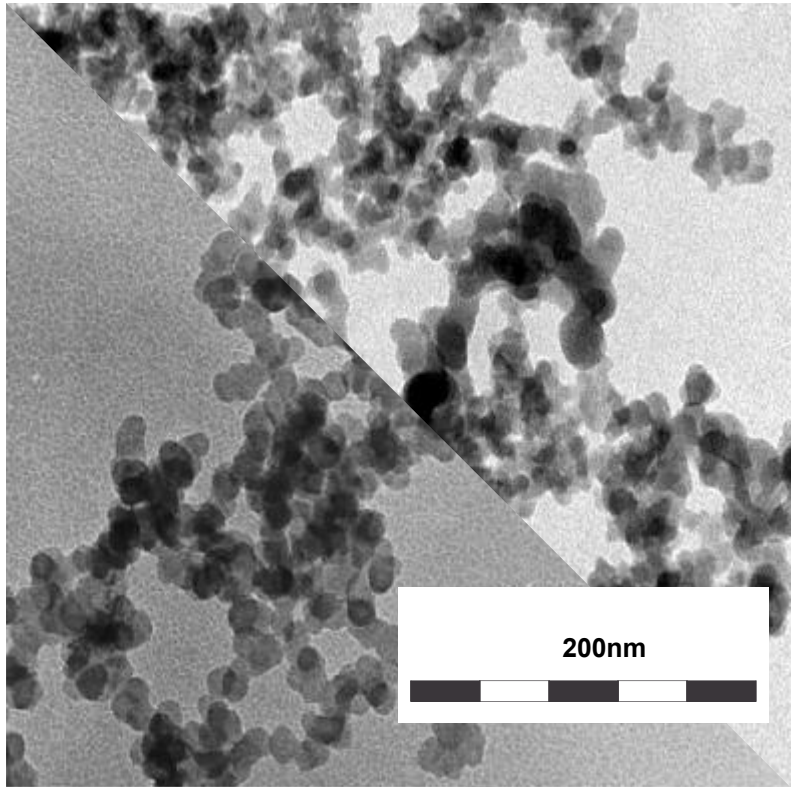
Amorphous silicon dioxide exists in nature

Evonik silica products

- of completely amorphous structure
- are not bio-persistent
- do not accumulate in the body
- are a part of the natural geological cycle of silica



Picture of horsetail,
a plant with high silica content



TEM of silica from horsetail (left)
and synthetic silica (right)

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AEROSIL® and SIPERNAT®
OMRI-Listed Grades for Biological Formulators

AEROSIL®
- AEROSIL® 200
- AEROSIL® R 972
- AEROSIL® R 974
- AEROSIL® R 812 S

AERODISP®
- AERODISP® W 7520
- AERODISP® W 7622

SIPERNAT®
- SIPERNAT® 22
- SIPERNAT® 22 S
- SIPERNAT® 50
- SIPERNAT® 350
- SIPERNAT® 807 A

OMRI® LISTED For Organic Use

AEROSIL® AEROSIL® fumed silica

SIPERNAT® SIPERNAT® precipitated silica

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Silica for the optimization of Crop Protection and Biological Formulations.

How can Silica improve formulations

- Rheology control
- Emulsion Stabilization
- Anti settling
- Anti caking
- Free flow
- Carrier
- Spray Drying
- Moisture Protection
- Encapsulation
- Granulation
- Seed Coating

- Abamectin
- Acetamiprid
- Atrazine
- Azoxystrobin
- Chlorothalonil
- Difenoconazole
- Imidacloprid
- Mancozeb
- Metsulfuron-methyl
- Nicosulfuron
- Propiconazole
- Rimsulfuron
- Natural oils
- Sulfur

- Soluble liquid (SL)
- Emulsifiable concentrate (EC)
- Emulsion in water (EW)
- Micro-emulsions (MEC)
- Suspension concentrate (SC)
- Suspension-emulsion (SE)
- Oil dispersion (OD)
- Water-dispersible granules (WDG)
- Wettable-powders (WP)

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- **Encapsulation**
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- Emulsion in water (EW)
- Micro-emulsions (MEC)
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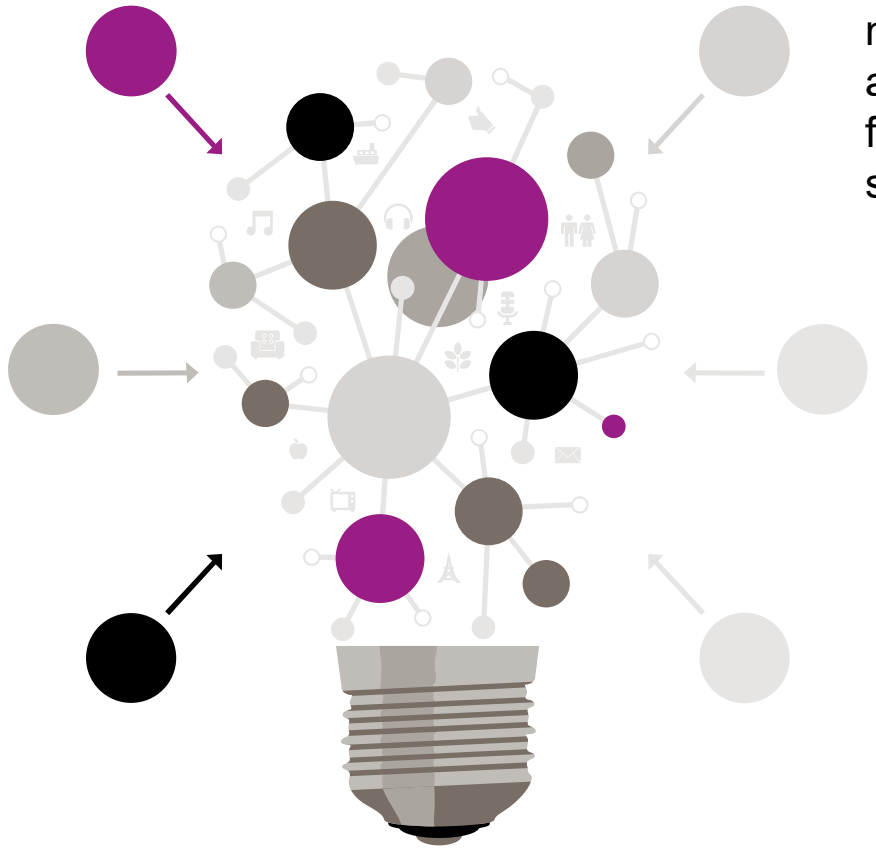
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Major Formulation Challenges Liquid formulations:
Stability, Rheology, and Biological Performance

Maintain stable and uniform **active ingredient suspension** to prevent sedimentation and preserve efficacy.

Achieve **optimal rheology** by balancing viscosity, suspension stability, pumpability, and application performance

Maintaining long-term **physical stability** while preventing sedimentation and ensuring easy redispersion.



Biological Viability: Preserve microorganism viability and activity by minimizing formulation and environmental stress throughout storage.

Ensure **formulation compatibility** across ingredients, to prevent instability and performance loss.

Support commercial viability through robust **long-term storage** stability.

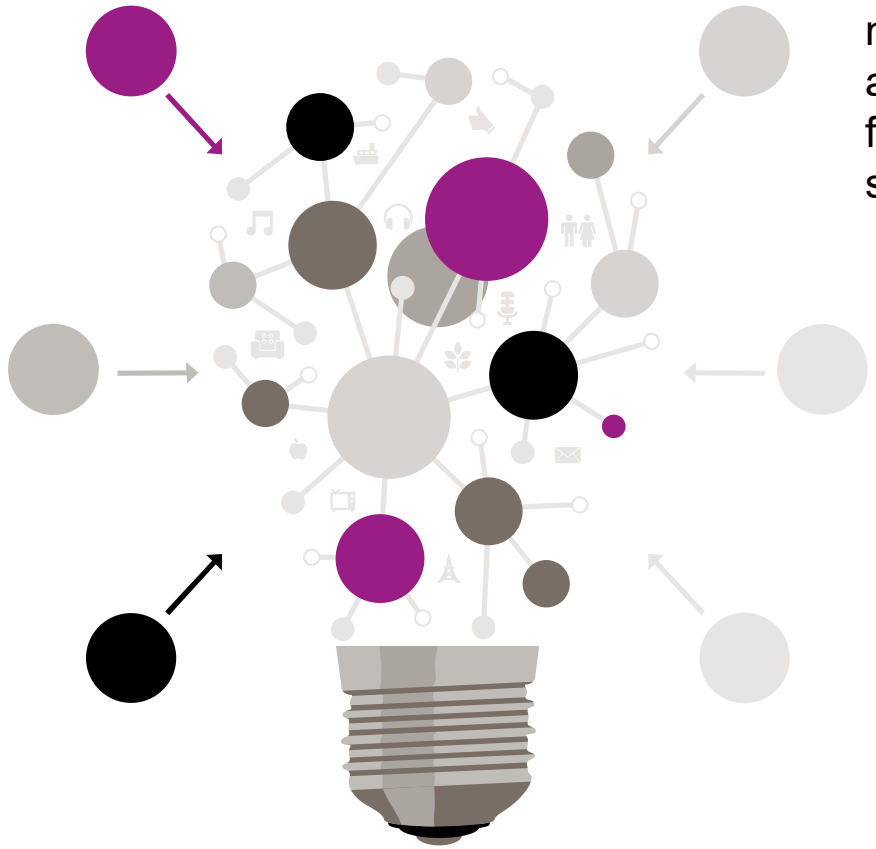
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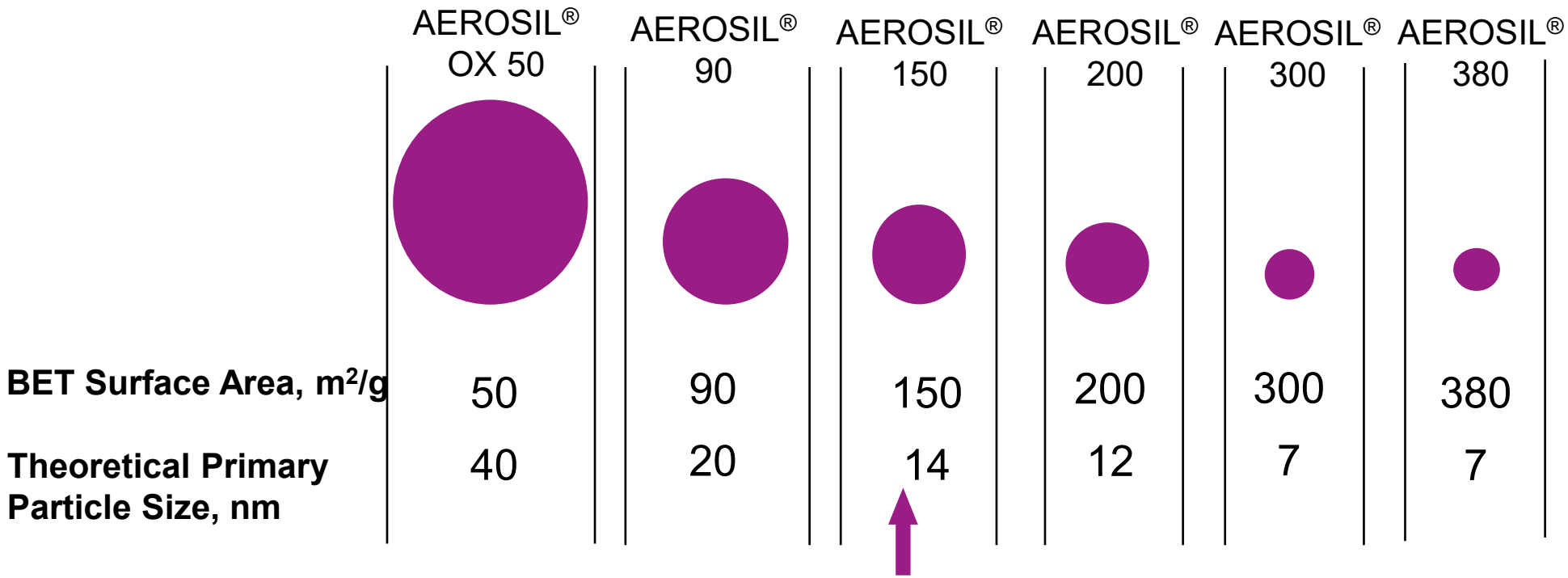
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Solving Liquid Formulation Challenges with Evonik Fumed Silica

1. Particle design Hydrophilic fumed grades



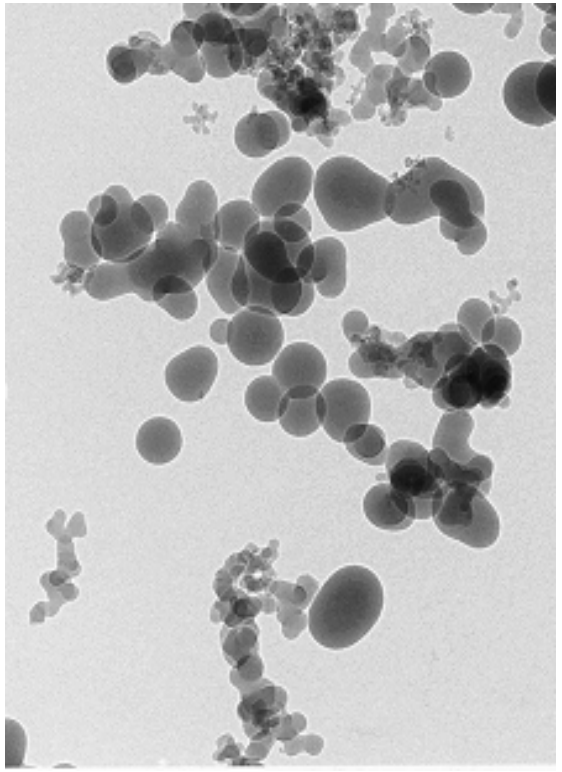
- Balanced thickening and dispersibility
- Higher surface area gives better transparency
- Lower surface area allows for higher filler loading

EVONIK Leading Beyond Chemistry

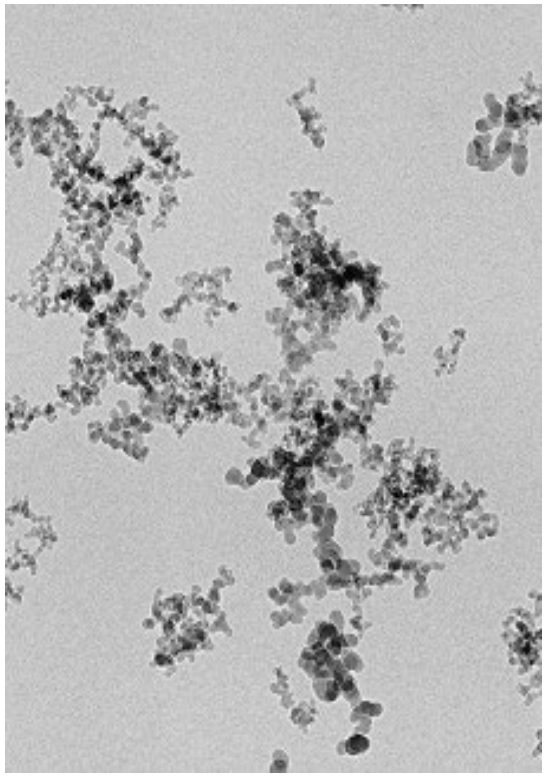
Solving Liquid Formulation Challenges with Evonik Fumed Silica

1. Particle design Hydrophilic fumed grades

500 nm



AEROSIL® OX 50



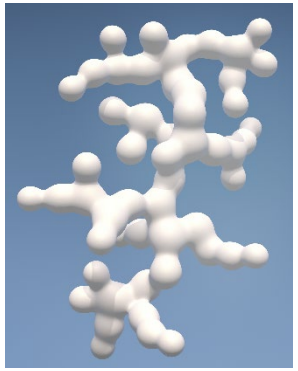
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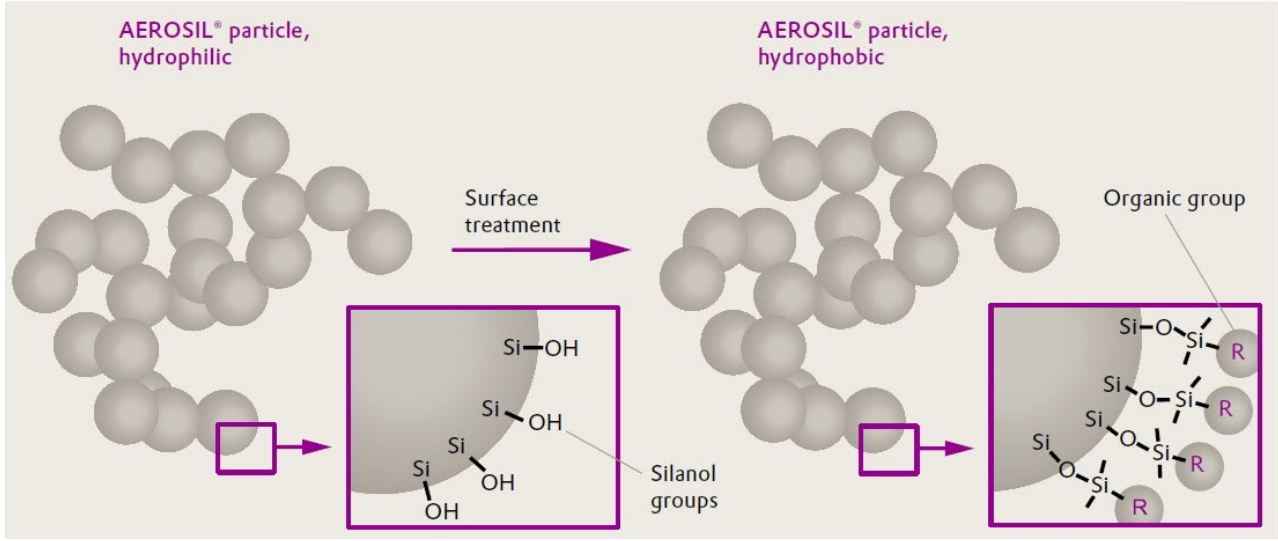
AEROSIL® 200

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Solving Liquid Formulation Challenges with Evonik Fumed Silica

2. Hydrophobic and Hydrophilic grades





water with hydrophilic silica



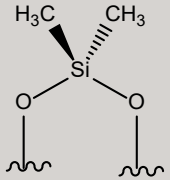
water with hydrophobic silica

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Solving Liquid Formulation Challenges with Evonik Fumed Silica

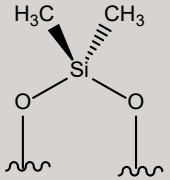
2. Hydrophobic grades Fumed silica AEROSIL® Surface modified

AEROSIL® R 972
AEROSIL® R 974



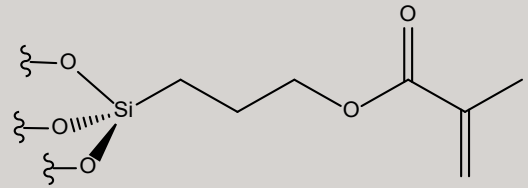
Dimethyldichlorsilane

AEROSIL® R 104
AEROSIL® R 106



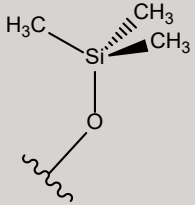
Octamethyltetracyclosiloxane

AEROSIL® R 711



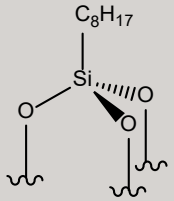
Methacryloxypropyltrimethoxysilane

AEROSIL® R 812
AEROSIL® R 812S



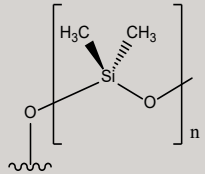
Hexamethyldisilazane

AEROSIL® R 805



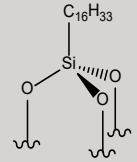
Octyltrimethoxysilane

AEROSIL® R 202
AEROSIL® R 208



Polysiloxane

AEROSIL® R 816



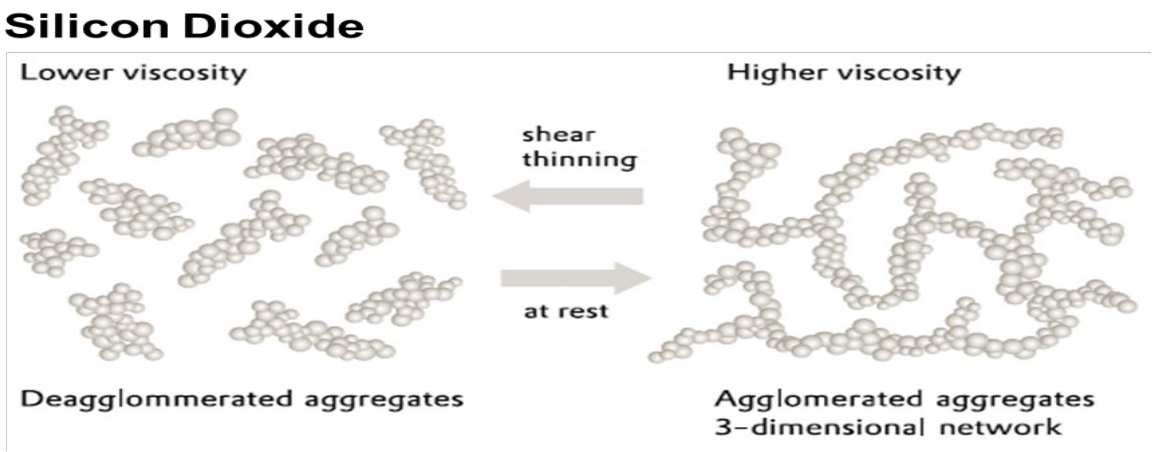
Hexadecyltrimethoxysilane

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Solving Liquid Formulation Challenges with Evonik Fumed Silica

3. Mechanism of Action: Shear Thinning Nature of AEROSIL® Fumed Silica





- **AEROSIL® fumed silica creates a 3D network giving visco-elastic properties to the liquid formulation, preventing sedimentation of the solid particles.**

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Solving Liquid Formulation Challenges with Evonik Fumed Silica

3. Mechanism of Action: Shear Thinning Nature of AEROSIL® Fumed Silica

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Solving Liquid Formulation Challenges with Evonik Fumed Silica

3. Mechanism of Action: Hydrophobic Fumed Silica

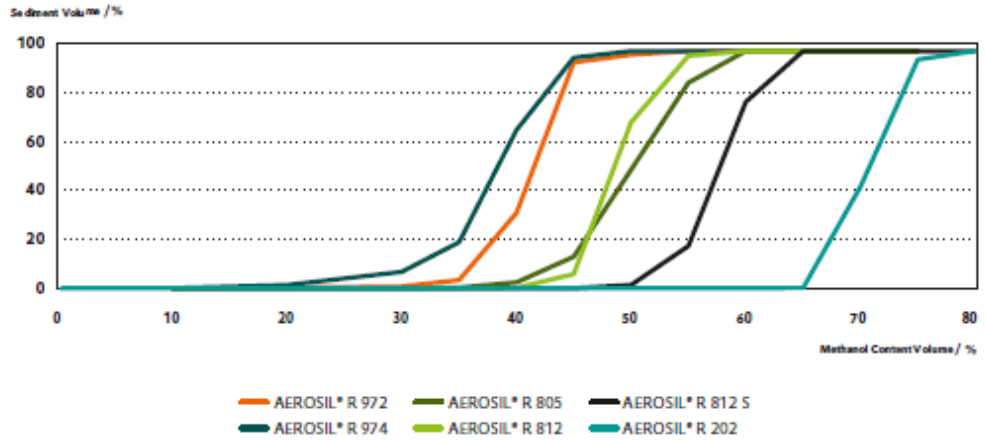


Figure 10 Hydrophobic degree of AEROSIL® R 816 and AEROSIL® R 974.

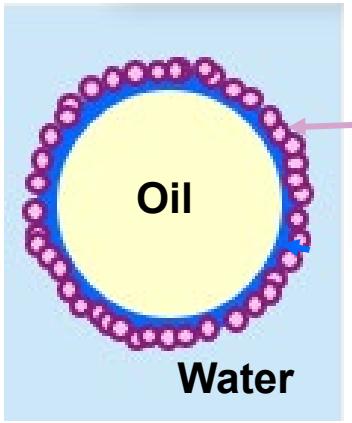
Preference for the water phase — *Preference for the oil phase*

Hydrophobicity: very low → medium

AEROSIL® R 816 — AEROSIL® R 974

Recommended emulsion type	Particle based stabilizer	Surface modification
o/w	AEROSIL® R 816	Hexadecyl silane
w/o	AEROSIL® R 974	Dimethyl silane

O/W Emulsion



AEROSIL® R 816

interface

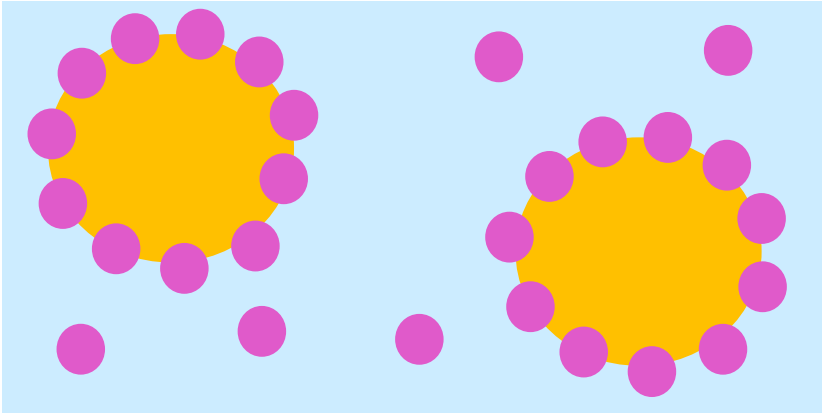
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Solving Liquid Formulation Challenges with Evonik Fumed Silica

3. Mechanism of Action: fumed silica envelops active ingredient and prevents re-agglomeration

AEROSIL® fumed silica adsorbs onto the surface of active ingredient particles, forming a protective silica network around them.

This physical barrier keeps particles separated, preventing them from coming back into contact and re-agglomerating.



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How to disperse AEROSIL® fumed silica in liquid formulations

Procedure

Addition of 1 - 3% AEROSIL® fumed silica

Prewetting step 500 rpm/5min

Dispersion time/speed
2000 – 10000 rpm/
1.5 – 15 min



Dispersion equipment



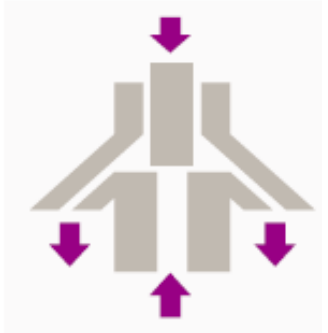
Dissolver



Ultra-Turax



Bead mill



High Pressor homogenizer



kJ/m³	150	200	300	2000

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Tips when selection the right type of AEROSIL fumed silica

Depend on the 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

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Tips when selection the right type of AEROSIL fumed silica

What we have learnt:

• 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.

- A **higher surface area** of the incorporated fumed silica type generally results in a higher viscosity (same % AEROSIL 380 provide higher viscosity than AEROSIL 200)
- **Polarity of the oil**:
  - None-polar oils, such as mineral or paraffin oil the hydrophilicthe hydrophilic grades create a higher viscosity level
  - Oils low polarity, silica grades with a higher degree of hydrophobicity, such as AEROSILR R 816, AEROSILR R 972 have better performance
- **Stabilizing solid actives in polar oils**, such as triglycerides, the most hydrophobic silica types

like AEROSILR R 805, AEROSILR R 812, AEROSILR R 812 S and AEROSILR R 202 are recommended to obtain a high viscosity level.

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Tips when selection the right type of AEROSIL fumed silica

What we have learnt:

• For **high loaded water-based** formulations the stabilization at elevated temperatures is a challenge. The incorporation of AEROXIDE ALU C (modified Aluminum) stabilizing high-active ingredient systems, improves the suspension's resistance to separation, ensuring consistent particle size of the active and performance even under challenging conditions.

• Dispersion tips: Shear intensity during the dispersing process, therefore equipment

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Examples of formulations

Nicosulfuron 4% OD Formulation

wt%	Ingredient	Function
4	Nicosulfuron	Active Ingredient
72	Methylated soybean oil	Solvent
3	Break Thru DA 646	Dispersant
12	Break Thru EM V 20	Emulsifier
3	Break Thru EM O 5	Co-emulsifier
4	Break Thru OE 440	Oil enhancer
2	Aerosil R 816	Thickener

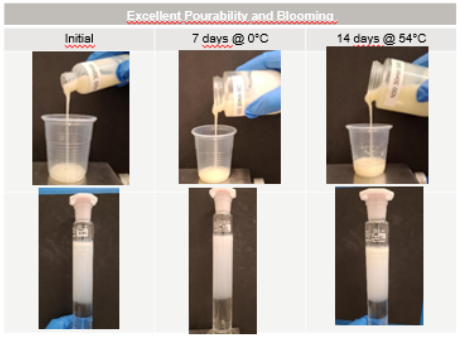
Evonik Products (% active content)
BREAK-THRU® DA 646: Non-ionic modified polyether
BREAK-THRU® EM V 20: PEG (20) glyceryl oleoricinoleate
Break Thru EM O 5: Polyglycerol Oleate
BREAK-THRU® OE 440: Organo modified siloxane
Aerosil® R 816: Hydrophobic fumed silica

Equipment
Milling: MiniZeta Bead mill, zirconium balls 0.6-0.8 mm.

Methodology

- **Addition of componentes:** the liquids are mixed before, followed by solid ones.
- **Dispersion step:** full formulation under mechanical stiring during 30 minutes at 1500 rpm, using Cowles rod.
- **Milling process:** after dispersion, the formulation is milled during 30 minutes at 2500 rpm.

Results
Stability according FAO guideline



Methodology	Initial	7d@0C	14d@54C
Cake	-	no	no
Syneresis	-	0	2,33
pH (1%)	4.15	4.14	3.87
Particle Size (D50, µm)	2.18	--	2.00
Particle Size (D90, µm)	5.6	--	4.56
Persistent foam (mL after 1min) (MT 47.1) 1,5L/ 100L water 20ppm	6	6	5,5
Dispersion Stability (MT 180)			
Initial determination (after standing for 30min) (1,5L/100L water 20 ppm - from label)	good blooming	good blooming	good blooming
Sediment volume (mL)	-	-	-
Top cream or oil (mL)	1.2c	0.6c	2.2c
Re-dispersibility (after standing for 24h) (1,5L/100L water 20 ppm - from label)	good blooming	good blooming	good blooming
Sediment volume (mL)	-	-	-
Top cream or oil (mL)	1.3c	0.6c	2c
Wet Sieve test - triplicate average (MT 185 - 45um)	0.53	0.76	0.83
AI quantification (%)			

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Examples of formulations

High loaded AI formulation

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
Total	**100.00**

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

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Take aways
Key benefits working with fumed silica for liquid formulations

- **Prevents Settling:** Maintains uniform suspension of active ingredients, preventing separation and ensuring optimal tank-side addition

- **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.

- **Broad 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.

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Equipo IMCD COLOMBIA



Jeronimo Parra

Inside Sales

Jeronimo.parra@imcdcolombia.com

+57 315 7831248



Aixa Satizabal

Business Unit Manager

Aixa.satizabal@imcdcolombia.com

+57 315 7831248



Andrea Duarte

Account Manager

Andrea.duarte@imcdcolombia.com

+57 318 3401296



Alvaro Castro

Account manager

Alvaro.castro@imcdcolombia.com

+51 912 524 073

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