ULTRASIL®

Solutions for the Tire & Rubber Industry

Reinforcing Silica and More

Industry Brochure 306

EVONIK
Leading Beyond Chemistry

Evonik – The leading global silica supplier

The World of Silica

Synthetic amorphous silica, or SAS, is now indispensable in tire manufacture and the production of industrial rubber goods. It is an essential component in the treads of what are known as Green Tires, which are distinguished from conventional tires particularly by low rolling resistance and significantly improved grip (roadholding). The roughly 30 percent reduction in rolling resistance can reduce fuel consumption by up to 8 percent; this saves money and, even more important, protects the environment by reducing CO_2 emissions. The superior grip of Green Tires also improves safety because braking distances are lower (by about 18 m at 80 km/h) than with conventional tires.

In industrial rubber goods silica is used, for example, to reduce rolling resistance in conveyor belts or as an active filler in colored rubber articles or in products with food contact. The applications of silica described above use precipitated silica, which Evonik markets as ULTRASIL®; the company also produces fumed silica under the AEROSIL® brand name. Fumed silica are used mainly as reinforcing fillers in silicone rubbers and also in transparent rubber compounds, such as for the soles of sports shoes, and other elastomers.

From Innovation to Market Leadership

Both of these silica types were developed at Evonik and its predecessor company Degussa. As long ago as the 1940s chemist Harry Klöpfer discovered the fumed silica AEROSIL® in Rheinfelden (Germany); the development of the precipitated silica ULTRASIL® followed less than ten years later. ULTRASIL® VN 3 production started in Wesseling (Germany), between Cologne and Bonn, in what is now one of the largest silica production plants in the world. In the decades between its invention and initial production to the present time, the product has undergone continuous development. Today a wide range of conventional and highly dispersible ULTRASIL® grades are available for the most diverse applications, from sports shoes to high-tech tires. As in the past, further development of the product is driven

by customers working in close collaboration with our R&D team and our global Technical Service. At the same time our production capacities have been steadily expanding to meet growing demand from our customers: Evonik now has 16 global production sites for precipitated silica and eight for fumed silica. Thanks to a global production network covering all the important industrial regions, regional storage facilities, and our local sales teams, we are able to service our customers locally all over the world. Our Technical Service with laboratories in Europe, Asia, and the US offers customers local consulting services and develops innovative solutions in collaboration with them.

Silica and More

The spectacular success of precipitated silica in tire applications would not have been possible without sulfur silanes. Hydrophilic silica does not easily mix with hydrophobic rubber; a sulfur silane must therefore be added to bind them chemically. This was achieved for the first time by means of Evonik's Silica/Silane technology – and ULTRASIL® VN 3 and Si 69® are the result of this development. Further, it was only through the sulfur silanes that the development of the Green Tire and a host of other applications became at all possible.

The desire of tire and MRG manufacturers for improved processability of rubber compounds has resulted in a continuous expansion of Evonik's product range: For example, elastomers and additives can be more easily, and above all more efficiently, mixed through the addition of the special process additive VESTENAMER®. POLYVEST® liquid polybutadienes reduce rolling resistance further; in this case it is even possible to dispense with mineral oil as plasticizer.

With its wide product portfolio, production sites worldwide, local service, and application technology expertise accumulated over decades, Evonik is a strong partner to the tire and rubber industries.

Rubber Silica

Synthetic amorphous silica, a class of its own.

Silica has been an active high-performance ingredient for rubber compounds since the 1990s. It is well known that only homogeneously and well dispersed silica particles are able to provide the maximum reinforcement in rubber compounds. Highly dispersible silica (HDS) has been developed in response to this requirement and to meet market demand.

The reinforcement of rubber by addition of an active filler produces pronounced improvements in mechanical properties such as tensile strength, tear resistance, abrasion resistance, and modulus. These improvements can be attributed to the inclusion of a solid dispersed phase, resulting in an internal stress that is higher than the external stress applied to the sample. This strain amplification is caused by the addition of the undeformable filler to the viscoelastic rubber matrix (hydrodynamic effect) and the partial immobilization of rubber on the filler surface and in the structure of the active filler. Without this reinforcement, most rubber products would be inconceivable. Reinforcing fillers are generally classified according to their specific surface area.

The high-purity precipitated silica and silicates offered by Evonik and used as reinforcing fillers in the rubber industry are sold globally under the ULTRASIL® trade name. The ULTRASIL® line offers a broad range of particle sizes and performance benefits to suit the specific needs of our customers. Evonik is the only supplier worldwide to develop and offer Silica/Silane systems to the rubber industry. This reinforcing filler system is used predominantly in low rolling resistance tires with excellent wet grip, and also in mechanical rubber goods and shoe soles that require enhanced performance.

Suitability by Application

		TIRES				MRG				SHOE SOLES		
PRODUCT	SPEC. SURFACE AREA BET/ (m^2/g)	PROCESSING	REINFORCEMENT	DISPERSION	HYSTERESIS	PROCESSING	REINFORCEMENT	DISPERSION	COMPRESSION SET	PROCESSING	ABRASION RESISTANCE	TRANSPARENCY
ULTRASIL® 880* white powder	35					+++	+	++	+++			
ULTRASIL® 360 white powder	55					+++	+	++	+++			
ULTRASIL® AS 7** white powder	65					+++	+	++	+++			
ULTRASIL® 4000 GR white granules	85	+++	++	+++	+++	+++	++	+++	+++			
ULTRASIL® 5000 GR white granules	115	+++	+	+++	+++	++	++	+++	++	+++	+	+
ULTRASIL® 5500 GR white granules	125	++	++	++	+++	++	+++	++	++			
ULTRASIL® VN 2 white powder	130					++	++	++	++	++	+	+
ULTRASIL® VN 2 GR white granules	130	++	+	++	+++	++	++	++	++	++	+	+
ULTRASIL® 6100 GR white granules	160	+	++	+++	++							
ULTRASIL® 7000 GR white granules	175	++	++	+++	++	+	+++	+++	+	++	++	++
ULTRASIL® VN 3 white powder	180					+	+++	++	+	+	++	++
ULTRASIL® VN 3 GR white granules	180	+	++	+	++	+	+++	+	+	+	++	++
ULTRASIL® 7800 GR white granules	195	+	+++	+++	++	+	+++	+++	+	+	+++	++
ULTRASIL® 7500 GR white granules	205	+	++	+++	++	+	+++	+++	+			
ULTRASIL® 9500 GR white granules	225	+	+++	+++	++	+	+++	++	+			
ULTRASIL® 9100 GR white granules	235	+	+++	+++	++	+	+++	+++	+	+	+++	++

*with Ca-Silicate **Sodium Aluminum Silicate + good ++ very good +++ excellent

Precipitated Silica for use as a Reinforcement Filler in the Rubber Industry

The increasing performance demands on passenger car tires require novel tread compounds, which grant low rolling resistance, long service life and excellent handling properties on wet and dry roads in the winter and summer season.

HDS (Highly Dispersible Silica) developed by Evonik meet these requirements in combination with a bifunctional silane as coupling agent. Especially with regard to highly efficient mixing cycles and in particular in order to achieve an excellent abrasion resistance level, today HDS is essential for many compounders. Nevertheless, the well-known types like ULTRASIL® VN 2 or ULTRASIL® VN 3 still do a great reinforcing job.

ULTRASIL® 360

ULTRASIL® 360 is a semi-active precipitated silica with a very low N_2 surface area of approximately 55 m^2/g, suited in particular for extrusion, injection molding and calandering mixtures as well as for soft roll processes. Easy processing is also given for high filler loadings. The product results in lower residual deformation and excellent dynamic characteristics in vulcanized rubber goods

ULTRASIL® 4000 GR

ULTRASIL® 4000 GR is a highly dispersible silica with a low specific CTAB surface area of approximately 85 m^2/g. It combines excellent hysteresis performance and high reinforcement in both – tires and mechanical rubber goods.

In tires ULTRASIL® 4000 GR can be used in tread and tire body. In tire tread compounds high silica loadings are possible with excellent processing behavior. The results are distinctive and balanced wet and winter tire properties.

In the tire body, e. g., sidewall or other non-tread compounds ULTRASIL® 4000 GR provides significantly better hysteresis at the same dynamic stiffness level compared to typical carbon blacks.

In mechanical rubber goods ULTRASIL® 4000 GR enables excellent processing and extrusion at high filler loadings. Compounds with ULTRASIL® 4000 GR are also characterized by low residual deformation (compression set) and excellent dynamic properties.

ULTRASIL® 5000 GR

ULTRASIL® 5000 GR with its low specific BET surface area of approximately 115 m^2/g combines optimal dispersion, excellent hysteresis performance and high reinforcement with improved processing behavior in passenger car tire tread compounds. This silica is especially suited to high filler loadings for the optimization of wet and winter properties. ULTRASIL® 5000 GR is currently produced in Asia.

ULTRASIL® VN 2/ULTRASIL® VN 2 GR

Due to the relatively low specific N_2 surface area of approximately 130 m^2/g ULTRASIL® VN 2 is mainly used at high filler loadings without losses in the processing behavior in PCT (Passenger Car Tires) tread compounds. This silica is especially suited in combination with bifunctional organosilanes for the optimization of wet and winter properties. Additionally high static moduli are observed with and without additional organosilanes. This is why ULTRASIL® VN 2 is also widely used in other mechanical rubber goods. It is offered as powder and as granulated silica.

ULTRASIL® 6100 GR

ULTRASIL® 6100 GR is a highly dispersible silica with a specific surface range of approximately 160 m^2/g especially for high performance passenger car tread compounds. ULTRASIL® 6100 GR is characterized by a specifically tailored particle size distribution to optimize dynamic stiffness at elevated temperatures. As a result, ULTRASIL® 6100 GR provides excellent tire handling for high- and ultra-high-performance tires (HP/UHP). The well-established high abrasion resistance and first-class fuel efficiency of tires with ULTRASIL® silica are maintained.

ULTRASIL® 7000 GR

ULTRASIL® 7000 GR is developed as highly reinforcing silica for applications in low rolling resistant passenger car tire tread compounds, so called "Green Tire". This silica with specific BET surface area of approximately 175 m^2/g and with excellent incorporation and dispersion behavior imparts to tire tread compounds high abrasion resistance combined with excellent rolling resistance and improved wet traction. ULTRASIL® 7000 GR is produced globally.

ULTRASIL® VN 3/ULTRASIL® VN 3 GR

The well-known silica ULTRASIL® VN 3 with a specific N_2 surface area of approximately 180 m^2/g is used in nearly all areas of the rubber industry. It is offered as powder and as granulated version. The main application is passenger car tire treads where in combination with bifunctional organosilanes a very low rolling resistance and a high wet grip are achieved. In other applications ULTRASIL® VN 3 offers a high reinforcing potential in combination with a high transparency of the finished rubber good, e. g. in shoe soles. ULTRASIL® VN 3 is also widely used in different bonding systems.

ULTRASIL® 7800 GR

ULTRASIL® 7800 GR is a highly dispersible silica (HDS) with a high specific surface area of approximately 195 m^2/g. Due to its outstanding dispersion behavior and the high reinforcing potential, ULTRASIL® 7800 GR is best suited in car tire treads with demanding requirement on high dynamic stiffness, high abrasion resistance and hysteresis characteristics at moderate compound viscosities. Additionally this silica is also used in truck tire tread compounds with superior cut & chip resistance as well as MRG and shoe soles compounds.

ULTRASIL® 9500 GR

ULTRASIL® 9500 GR is a highly dispersible (HD) silica. It is strongly reinforcing with a specific surface area (SSA) of approximately 225 m^2/g. Due to its outstanding dispersion behavior compared to other high SSA range silica and the very high reinforcing potential, ULTRASIL® 9500 GR is best suited for high performance and ultra high performance OTR tire. In this application it combines a high dynamic stiffness with excellent abrasion and hysteresis characteristics at moderate green compound viscosities. Additionally this silica is also used in truck tire tread compounds with superior cut & chip resistance.

Bifunctional organosilanes like Si 69®, Si 75®, Si 266® or Si 363® are required for the use of precipitated silica in tire tread compounds. The use of diethylene glycol, triethanolamine or other alkaline accelerators might be necessary in order to achieve optimum in-rubber data.

ULTRASIL® 9100 GR

ULTRASIL® 9100 GR is a highly dispersible high surface area silica with approximately 235 m^2/g BET surface area. The combination of high dispersibility and high surface area results in an excellent reinforcement potential. The high reinforcement level is achieved in combination with an increased silane dosage to further improve, e. g. abrasion resistance in high performance tires.

Performance of a selection of high reinforcement fillers
(ULTRASIL® + bifunctional organosilane Si 69®, *silane content adjusted)

REF.: ULTRASIL® VN 3 GR	ULTRASIL® 5000 GR white granules	ULTRASIL® 4000 GR white granules	ULTRASIL® 6100 GR white granules	ULTRASIL® 7000 GR white granules	ULTRASIL® 7800 GR white granules	ULTRASIL® 9100 GR* white granules
Dispersion	↑	↑	↑	↑	↑	↑
Mixing time	↓	↓	↓	↓	↓	↘
Mooney- Viscosity	↓	↓	↘	↘	↘	→
Curing Time	↘	→	→	→	→	→
Shore-A-Hardness	→	↓	→	→	→	→
Tensile Strength	↘	↗	↗	↗	↗	↑
Stress @ 300 % Elongation	↑	↘	↗	↗	↗	↗
Abrasion Resistance	↘	↘	↗	↗	↑	↑
Resilience	↑	↑	↗	↗	↘	→
Heat Build-up	↘	↓	↘	↘	↘	→

Increased	Decreased	No Change	Slightly Increased	Slightly Decreased
↑	↓	→	↗	↘

Silicates

Metal Silicates are obtained by replacing a part of the acid used during the precipitation by metallic salts. In rubber mixtures these silicates offer processing and product properties which could only hardly be achieved by pure silica.

ULTRASIL® 880

ULTRASIL® 880 is a precipitated silica with a Calcium admixture and a very low specific N_2 surface area of approximately 35 m^2/g. It gives rubber mixtures excellent residual deformation and extrusion characteristics. ULTRASIL® 880 allows profiles with virtually no swelling and a very smooth surface. Even EPDM mixtures with extremely high filling grades (up to 200 parts per hundred rubber) can still be easily processed. In white mixtures, ULTRASIL® 880 can partially be substituted for titanium dioxide. The effect of sulfur adsorption is negligible.

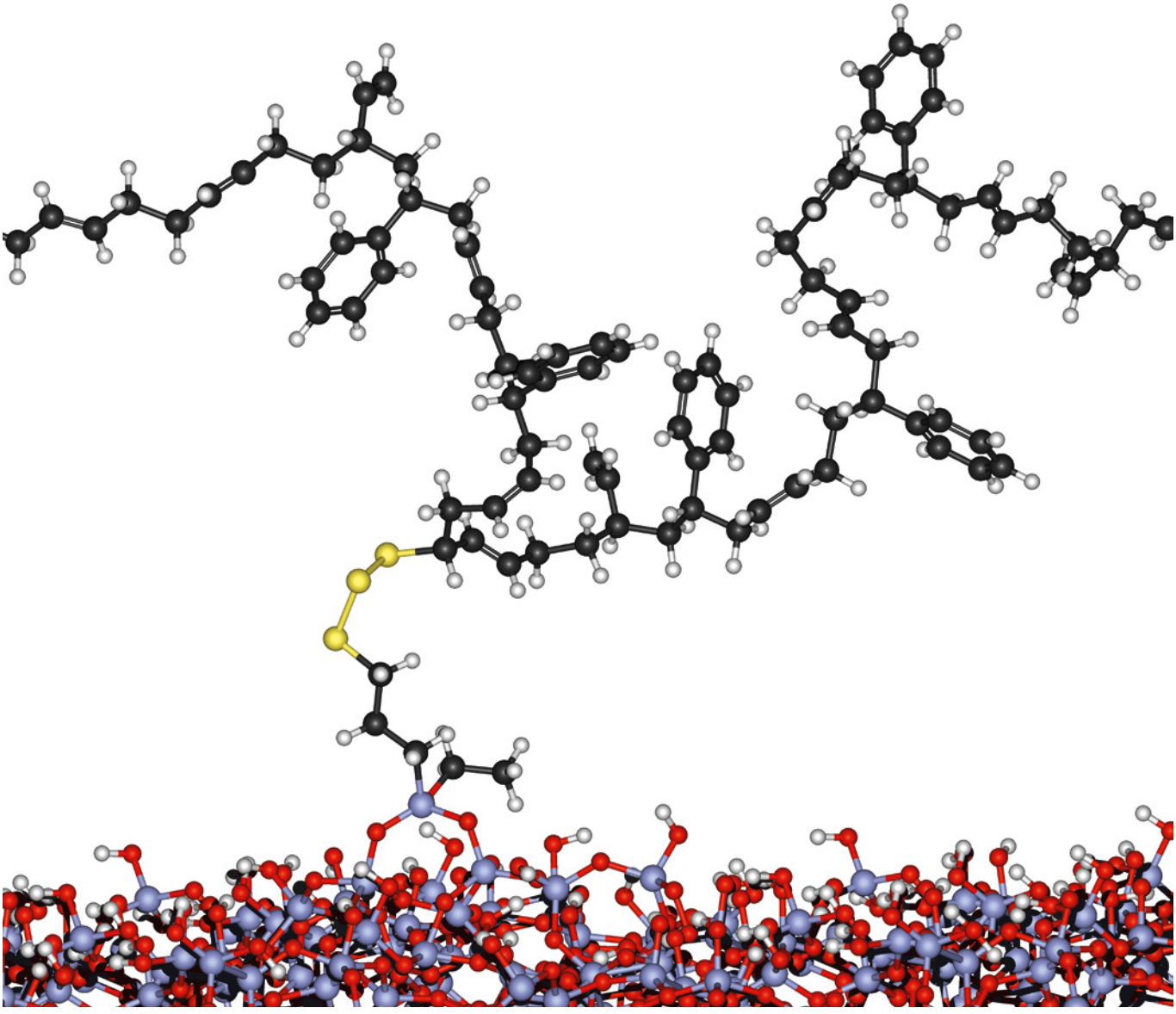
ULTRASIL® AS 7

ULTRASIL® AS 7 is a precipitated aluminum silicate with a low specific N_2 surface area of approximately 65 m^2/g. It combines medium reinforcement properties with particularly trouble-free handling and processing. The latter allows for higher concentrations than would be possible with highly active precipitated silica. Blending with ULTRASIL® VN 3 or inactive fillers makes it possible to adjust the reinforcement effect within a wide range.

The Silica / Silane Reinforcement System

The technology of Silica / Silane coupling.

In classical elastomers, precipitated and fumed silica fillers only provided a limited reinforcement to the compound. This is predominantly due to the different nature of the non-polar elastomer matrix and the hydrophilic filler forming a strong silica filler network and providing a low interaction with the polymer. With the use of bifunctional organosilanes as coupling agent, it is now possible to improve reinforcement with silica in such nonpolar polymer compounds considerably. Bifunctional organosilanes react with the silica surface and the polymer during the mixing and vulcanization process, forming chemical cross-links between two otherwise non-reacting materials. This chemical bond is responsible for the excellent reinforcement of the Silica / Silane filler system. Depending on the elastomer type and the vulcanization system applied, the choice of right silane functionality is crucial. For example, in classical diene rubbers with sufur vulcanization a sulfur-functionalized silane such as Si 69® is an excellent choice. The benefit of silica to effectively improve the dynamic properties of the rubber, is now fully recognized thanks to these permanent chemical bonds. Nowadays the Silica / Silane system is the benchmark for passenger car tire tread performance, i. e. to reduce the rolling resistance and improve the wet traction behavior.



Rubber Silanes

From past to future with Evonik rubber silanes.

The first and still most important of these products, Si 69®, was developed as far back as 1971. It was first used in adhesive mixtures for steel-reinforced conveyor belts and soon proved to be eminently suitable for a range of other applications.

In particular, the introduction of the Silica/Silane technology revolutionized the manufacture of passenger car tires. The most important tire properties such as rolling resistance, wet grip and abrasion resistance, which in conventional systems of the past could not be optimized individually without affecting other properties, can now be considerably improved.

In the meantime disulfides (Si 75® and Si 266®) have been successfully introduced into the market. These silanes offer higher thermal stability during mixing and downstream processing compared to the polysulfide silane Si 69®. Si 466™ EXT is a silatrane silane with superior sustainability features. Is does not release any volatile organic compounds during processing and can be used at higher mixing and processing temperatures. A real jump in tire performance can be obtained with the latest rubber silane of Evonik. Tires made using Si 363® provide a reduced rolling resistance and lower fuel consumption of up to 8 % over conventional tires.

For easier handling or processing, some silanes are also available as dry blend with carbon black or as a pre-reacted silica compound (COUPSIL®). The brand Dynasylan® represents the functional silanes of Evonik which are used in a multitude of industries. For the rubber industry hydrophobizing alkyl silanes as well as vinyl silanes for peroxide-cured rubber formulations are of highest interest.

But also other functional silanes are available from Evonik completing the portfolio of coupling agents for nearly all curing systems. Today Evonik produces rubber silanes at five locations in Europe, USA and China.

The Liquids

These silanes can be added to the mixer either in pre-weighed quantities or via direct dosing.

PRODUCT	STRUCTURE	TIRES	MRG	SHOE SOLES
Si 69®	$(C_2H_5O)_3Si(CH_2)_3S_4(CH_2)_3Si(OC_2H_5)_3$ Bis(triethoxysilylpropyl)tetrasulfide	+	+	+
Si 75®	$(C_2H_5O)_3Si(CH_2)_3S_2(CH_2)_3Si(OC_2H_5)_3$ Bis(triethoxysilylpropyl)disulfide	+	+	
Si 266®	$(C_2H_5O)_3Si(CH_2)_3S_2(CH_2)_3Si(OC_2H_5)_3$ Bis(triethoxysilylpropyl)disulfide	+	+	
Si 264™	$(C_2H_5O)_3Si(CH_2)_3SCN$ 3-Thiocyanatopropyltriethoxysilane		+	+
Si 363®	Proprietary mercaptosilane	+	+	

The Sustainability Booster

Si 466™ EXT is a solid silatrane silane with a disulfane function. It does not release any VOC during processing at can be processed at higher mixing an processing temperatures.

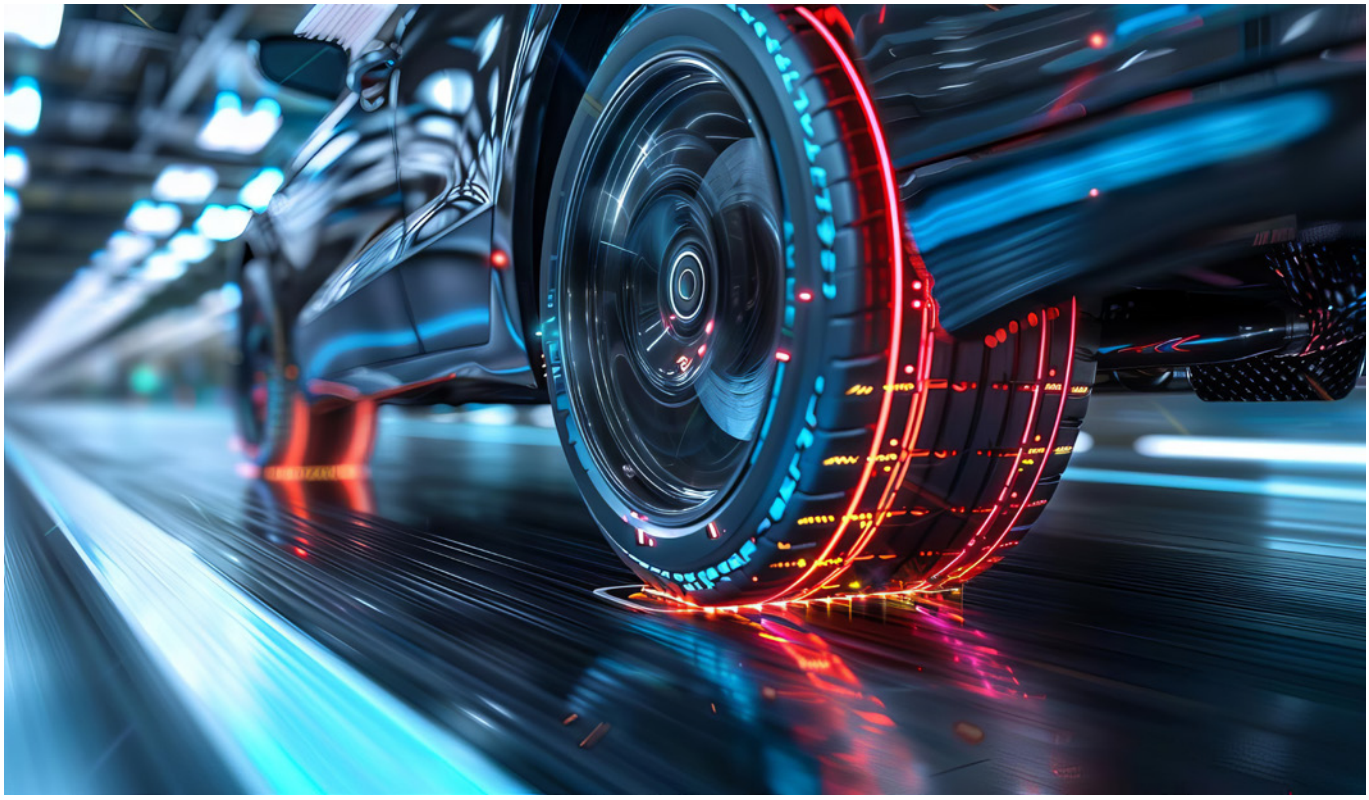
PRODUCT	FORM	TIRES	MRG	SHOE SOLES
Si 466™ EXT	Solid silatrane silane; co-extrudate in SBR matrix	+	+	+

The Black Solids
These 1:1 silane/carbon black blends can easily be added into the mixer.

PRODUCT	SILANE/CARBON BLACK	TIRES	MRG	SHOE SOLES
X 50-S®	Si 69®/ Carbon Black	+	+	
X 266-S®	Si 266®/ Carbon Black	+	+	

The White Solids
The COUPSIL® types, as an additional solid product type, are pre-reacted precipitated silica available in powder or granule form for easy handling and processing.

PRODUCT	PRECIP. SILICA/SILANE	TIRES	MRG	SHOE SOLES
COUPSIL® 8113	ULTRASIL® VN 3/Si 69®	+	+	+
COUPSIL® 8113 GR	ULTRASIL® VN 3/Si 69®	+	+	
COUPSIL® 6109	ULTRASIL® VN 2/Si 69®	+	+	
COUPSIL® VP 6411	ULTRASIL® VN 2/ Si 264™		+	+
COUPSIL® VP 6508	ULTRASIL® VN 2/Dynasylan® VTEO	+	+	



POLYVEST® Liquid Rubber

Designed Polymers.

With our POLYVEST® grades, we offer a range of stereospecific and low-viscous liquid polybutadienes of different chemical composition.

POLYVEST® ST - Silane Terminated Liquid Rubber

POLYVEST® ST is a new generation of silane-modified liquid rubber additives. It combines the advantages of liquid rubbers and functional silanes.

Its silane functionalities allow the surface modification of hydrophilic silica fillers and therefore improve the dispersibility of silica in rubber compounds.

Due to its rubber-based nature POLYVEST® ST exhibits a natural fit and excellent compatibility to the rubber matrix of tire compounds.

During the vulcanization process it incorporates chemically, which exhibits a reinforcement of the rubber matrix and efficiently prevents migration.

POLYVEST® ST enables to improve the overall performance of silica-reinforced tire tread compounds used in combination with sulfur silanes like Si 69® or Si 266®. It allows to further significantly reduce the rolling resistance, which is indicated by reduced Payne effect and tan δ at 60 °C in Green Tire and truck tire tread compounds.

Key features and benefits POLYVEST® ST

- Reduced compound viscosity
- No migration
- Improved micro-dispersion of silica
- Reduced tan δ at 60 °C
- Reduced Payne effect

LOOKING FOR SUSTAINABLE **POLYVEST®** SOLUTIONS? ASK FOR OUR **POLYVEST® eCO** SERIES.

POLYVEST® 130 S - Unmodified Liquid Rubber

POLYVEST® 130 S is a liquid rubber designed for the needs of the tire and rubber industry. It exhibits an excellent compatibility with different rubbers and allows the complete or partial replacement of oil while keeping the compound viscosity low. POLYVEST® 130 S is reactively incorporated during the vulcanization process, which prevents migration.
POLYVEST® MA 75 is a maleic anhydride functionalized grade that allow to significantly improve the adhesion to metal surfaces.

Key features and benefits POLYVEST® 130 S

- Low glass transition temperature (–99 °C) and low product viscosity
- Reduced compound viscosity
- Strongly reduced migration and therefore reduced hardness changes over time
- Excellent grip and breaking performance on ice and snow and at same time on wet and dry roads
- Increased wear resistance

POLYVEST® – liquid polybutadienes for tire and rubber applications

PRODUCT		SUPPLY FORM	VISCOSITY / mPa s	T_g / °C	MEAN MOLECULAR WEIGHT* M_n / g/mol
Silane-terminated	POLYVEST® ST-E 60	Clear colorless liquid	4,000-7,500 @ 30 °C	approx. –1	≈ 3,200
Unmodified	POLYVEST® 130 S	Viscous liquid	2,700-3,300 @ 20 °C	–99	≈ 4,600
Maleic anhydride modified	POLYVEST® MA 75	Viscous liquid	6,000-9,000 @ 20 °C	–95	≈ 3,000

* Determination via GPC calibrated with polybutadiene standard for POLYVEST® ST-E 60 and polystyrene standard for POLYVEST® 130 S and POLYVEST® MA 75.

VESTENAMER® a unique Rubber Additive

Synthetic rubber additive for rubber compounding, processing, and recycling.

Leading rubber industry customers have been relying on VESTENAMER® for more than 25 years. This versatile polyoctenamer is a perfect fit for rubber manufacturing due to its unusual and unique property profile.

- Low-melting range at 54 °C
- Low viscosity above the melting point: <10 Mooney units at 100 °C
- Higher molecular weight than common plasticizers: 120,000-150,000 g/mol
- Semi-crystalline properties: 30 % crystallinity at 23 °C
- Reactive, rubber-like material

By virtue of its properties, VESTENAMER® can solve a variety of challenges in rubber compounding and processing. The full spectrum of advantages of using VESTENAMER® includes the following:

Benefits of VESTENAMER® process additive

MIXING	SHAPING	PERFORMANCE
▪ Increases compatibility between non-polar and polar rubber types and filling components ▪ Improves & stabilizes dispersions due to interphase activity & wetting effect ▪ Reduces mixing time by maintaining dispersion quality in NR/SBR compounds, etc. ▪ Reduces energy intake, saving energy and allowing for more gentle polymer processing ▪ Can be used as a replacement material for rubber thanks to its rubber-like properties	▪ Improves dimensional stability and green strength, reducing shrinkage and die/calender swelling effects ▪ Improves quality and increases throughput due to its reduced viscosity and greater flowability ▪ Improves storage stability of the green compound and reduces stickiness ▪ Improves bonding to reinforcement materials	▪ Does not migrate, since the additive is readily crosslinked into the rubber matrix ▪ Reduces heat build-up of the rubber product under stress ▪ Can increase abrasion resistance and product hardness ▪ Can reduce compression set ▪ Gives surfaces a smoother finish ▪ Additive is colorless

VESTENAMER® – THE WORLD's MOST VERSATILE RUBBER ADDITIVE.

VESTENAMER® ON YOUTUBE

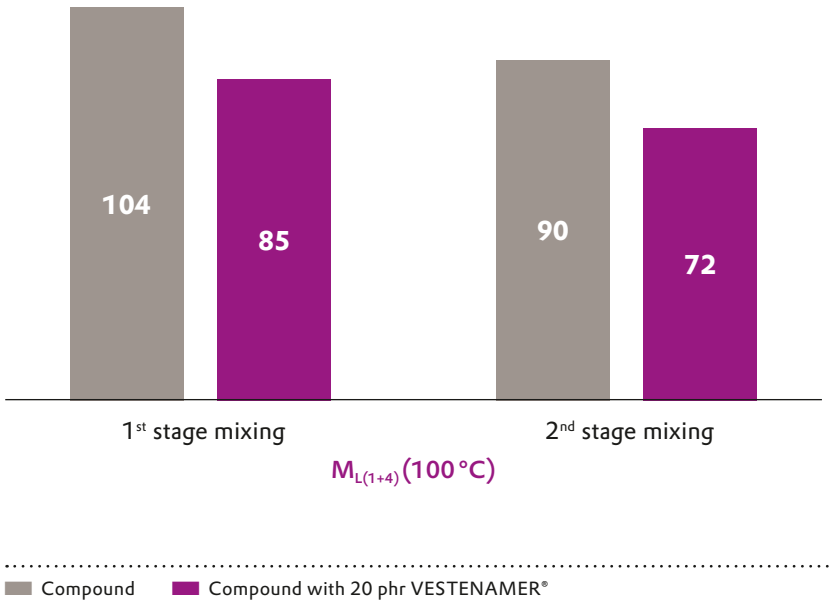
The world's most versatile rubber additive explained in less than 3 minutes!

www.vestenamer.com
www.plastics-database.com

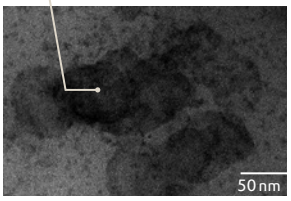
VESTENAMER® in Tire Manufacturing

Adding only a small amount of VESTENAMER® pellets makes various tire compounds significantly easier to mix and process. VESTENAMER® enhances processability, especially in highly filled compounds, and shows a wetting effect with carbon black. VESTENAMER® also improves dispersion of difficult polymer blends as it reduces the viscosity of the compound and can act as a compatibilizer between rubber types for which compatibility is low to non-existant. At the same time, it has no negative effect on the dynamic properties of the cured rubber. Abrasion resistance and aging properties can even be improved. VESTENAMER® also reduces the tendency of NR rubber grades to revert at high vulcanization temperatures.

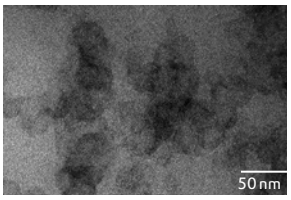
MIXING (apex compound)



FILLER DISPERSION
(Carbon black)



w/o VESTENAMER®



with VESTENAMER®

Compound Compound with 20 phr VESTENAMER®

The Science behind VESTENAMER®

VESTENAMER® is a semi-crystalline material with a high macrocycle content. Based on our C8 monomer portfolio, we specifically developed this high performance polymer for the requirements of the tire industry. The double bond of the cyclooctene monomer is preserved upon metathesis polymerization, allowing the resulting trans-polyoctenamer rubber (TOR) to vulcanize with all crosslinking agents commonly used in rubber curing, such as sulfur, sulfur donors, peroxides, and curing resins. Its broad molecular weight distribution and comparatively low molecular weight are responsible for its unusually low viscosity at higher temperatures. At lower temperatures, its high trans-double bond content leads to crystallinity in the material, for a unique property package that gives VESTENAMER® its many benefits in the compounding and shaping steps of rubber processing.

Fumed Silica

More than just a powder.

AEROSIL® fumed silica is different in several aspects from precipitated silica, which is widely used in the rubber industry. Precipitated silica originates from an aqueous solution and therefore has a higher water content (3 % to 7 %). The starting materials for precipitated silica are sodium silicate solution and sulfuric acid, so the finished products contain relatively large quantities of sulfate ions and alkali or alkaline earth metal ions. AEROSIL® fumed silica contains far fewer impurities. It is made in a flame synthesis from silicon tetrachloride, air, and hydrogen. The synthesis produces as a by-product hydrogen chloride, which is retained in the final product to the extent of <0.025 %. There are some large overlaps in physical properties, but particularly clear differences in specific surface area (BET), aggregate and agglomerate size, tamped density, loss on drying, and aggregate structure. Precipitated silica consists of aggregates and agglomerates that form a relatively dense sponge-like structure. To bring the particles into their final form they are usually spray-dried, granulated, or milled. This greatly alters the size and structure of the aggregates or agglomerates. Silica types produced by the fumed process form branched aggregates that are only loosely agglomerated, resulting in a fluffy powder. These can be used without any further shaping step like grinding or granulation; however, granulated versions of AEROSIL® are available under the brand name AEROPERL®. AEROSIL® fumed silica is initially hydrophilic, but can be turned into a hydrophobic material by chemical treatment. Hydrophobic fumed silica are available as AEROSIL® grades.

Thanks to these special properties fumed silica is used successfully in a large number of applications. In the rubber industry it is used mainly in silicone rubber and clear rubber but there are also highly interesting application fields in classical elastomers.

Due to different raw materials and production technology, AEROSIL® fumed silica has unique properties allowing manufacture of rubber compounds with outstanding transparency and the special mechanical properties necessary in high-performance mechanical rubber goods.

Shoe Sole Industry

In the shoe sole industry, AEROSIL® 200 V is widely used for highly sophisticated applications, especially for sports shoes. AEROSIL® 200 V provides excellent transparency as well as less yellowing and better abrasion resistance than precipitated silica in clear rubber applications. AEROSIL® 300 V, which typically has a specific surface area of 300 m^2 / g, gives excellent transparency similar to that of AEROSIL® 200 V in thin clear rubber and is more transparent than AEROSIL® 200 V in thick clear rubber. SIPERNAT® 238 precipitated silica also has fairly good transparency but spectrophotometric measurement shows that the transparency of clear rubber with AEROSIL® 200 V is better than that of clear rubber with SIPERNAT® 238 by about 3 %. Therefore we recommend to use SIPERNAT® 238 in clear rubber where transparency is not a critical property.

PRODUCT	PROCESSING	ABRASION RESISTANCE	TRANSPARENCY	YELLOWNESS INDEX
AEROSIL® 300 V	++	+++	+++	+++
AEROSIL® 200 V	++	+++	+++	+++
SIPERNAT® 238	++	++	++	++

++ very good +++ excellent

Silicone Rubber Industry

AEROSIL® fumed silica imparts the necessary rheological, mechanical, and optical properties to silicone rubber.

In general, hydrophilic AEROSIL® products of moderate active surface area such as AEROSIL® 150 (or the hydrophobic grade AEROSIL® R 972 for moisture sensitive formulations) are used for RTV one – component silicone sealants. The effect that AEROSIL® fumed silica provides is known as thixotropy.

The use of AEROSIL® fumed silica as a reinforcing filler allows significant improvement of the mechanical properties of, for example, various sports goods made of HCR silicone rubber. Hydrophobic products like AEROSIL® R 106 with a high active surface area are excellently suited for highly transparent systems. The high degree of hydrophobicity allows easy processing to HCR (high consistency rubber). In addition, SIPERNAT® 160 precipitated silica provides good reinforcement and significantly decreases compression set.

PRODUCT	MECHANICAL PROPERTIES	TRANSPARENCY	COMPRESSION SET
AEROSIL® 200	++	++	+
AEROSIL® 300	+++	+++	+
AEROSIL® R 106	+++	+++	++
SIPERNAT® 160	+	+	+++

+ good ++ very good +++ excellent

Hydrogenated Nitrile Butadiene Rubber (HNBR)

Depending on filler selection and loading, the water-swelling and mechanical behavior of HNBR compounds can be improved by replacing the black filler with precipitated or fumed silica.

PRODUCT	MECHANICAL PROPERTIES	WATER SWELLING	HOT AIR AGING
ULTRASIL® VN 2 GR	+	+	+
AEROSIL® 130 V	+++	++	+++
AEROSIL® R 972 V	++	+++	+++

+ good ++ very good +++ excellent

The advantage of a Global Enterprise – Local Proximity


Taavetti, Finland
Hamina, Finland
Wesseling, Germany
Qingdao, China
Ako, Japan
Adapazari, Turkey
Taoyuan, Taiwan
Jhagadia, India
Nanping, China
Map Ta Phut, Thailand
Production Precipitated Silica
Production Sodium Silicate

EUROPE/MIDDLE-EAST/AFRICA
Evonik Operations GmbH
Smart Effects business line
Rodenbacher Chaussee 4
63457 Hanau
Germany
ask-se@evonik.com
www.evonik.com
www.evonik.com/smarteffects

AMERICAS
Evonik Corporation
Smart Effects business line
2 Turner Place
Piscataway, NJ 08804
USA
ask-se-americas@evonik.com

ASIA/PACIFIC
Evonik Specialty Chemicals
(Shanghai) Co., Ltd.
Smart Effects business line
55 Chundong Road
Shanghai
China
ask-se-asia@evonik.com

IB-306-EN-04-2025/02-L+L

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

EVONIK
Leading Beyond Chemistry