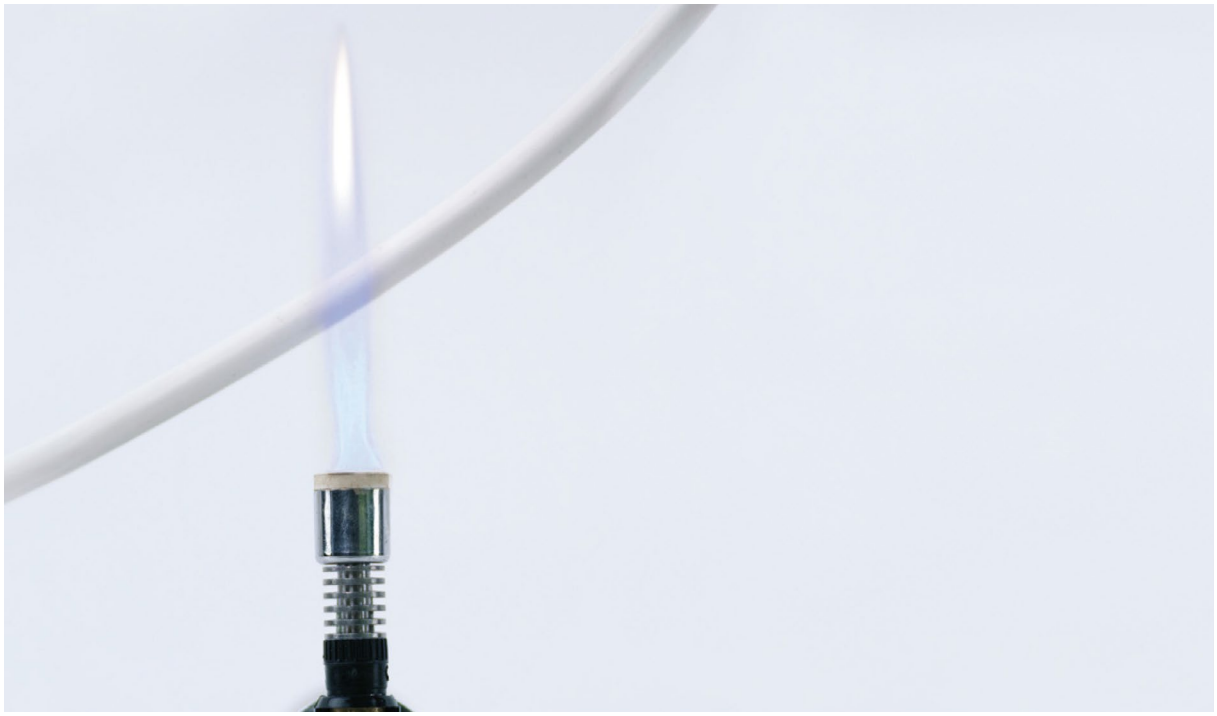
Dynasylan®
in Filled Plastic Compounds



Dynasylan®

EVONIK
POWER TO CREATE

Why fill plastics?

Today, most plastics are filled systems in which a mineral filler has been incorporated into the polymer matrix. The inclusion of such mineral fillers offers a number of advantages for the functionality of the final product.

For instance, flame retardants reduce flammability and smoke in fires. Furthermore, mechanical properties can be enhanced. In addition, using Dynasylan® treated fillers improves processing, for example, rheology, and reduces the cost of the final product.

Such improvements in properties can be achieved only when the filler and the polymer have excellent compatibility and adhesion. This is not an easy task, as organic and inorganic substances do not allow for optimal adhesion under normal circumstances.

Dynasylan® silanes are an ideal additive for producing filled plastic compounds. They are available for nearly any kind of polymer.

Typical fillers in plastics

- Aluminum trihydroxide
- Magnesium dihydroxide
- China clay
- Glass fibers
- Glass beads
- Quartz flour, silica, sand
- Cristobalite
- Wollastonite
- Mica
- Corundum
- Talc
- Iron oxides
- Titanium oxides

Applications

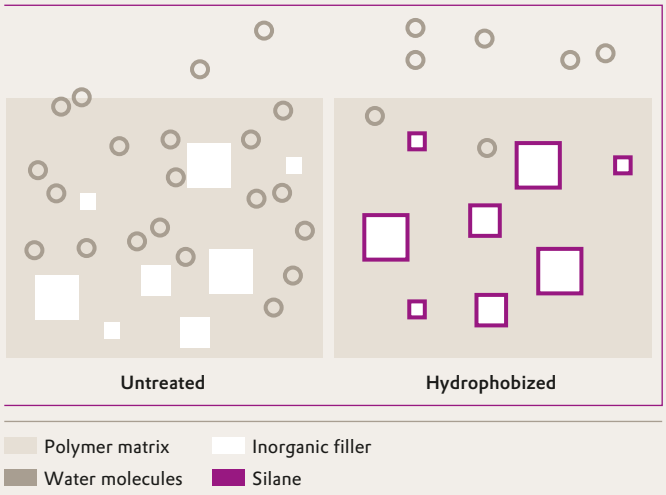
- HFFR cable insulation
- Rubber cables
- Glass fiber-reinforced composites
- Artificial stone
- Polymer concrete
- Foundry resins

Content

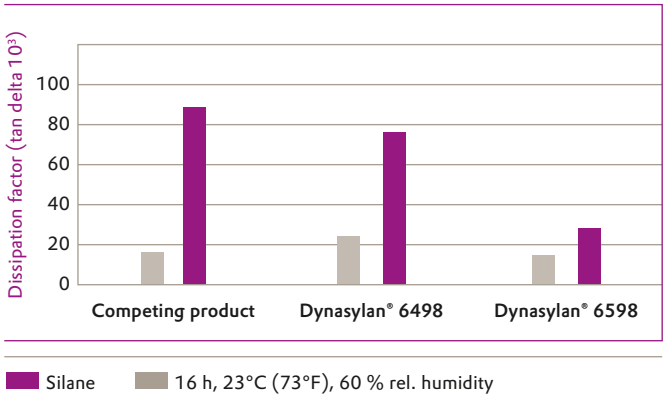
Dynasylan® significantly reduces water uptake

Silanes improve the hydrophobicity of filled plastics. Through the use of silanes, the absorption of water by the polymer is significantly reduced. Positive effects are, for example, an improvement of the electrical properties of rubber power cables. The following diagram shows the positive effect of Multifunctional Silane Systems™ on the dissipation factor of filled rubber cables, especially after exposure to water.

Silanes significantly reduce the water uptake in filled plastic



Electrical properties improve significantly with Dynasylan® 6598

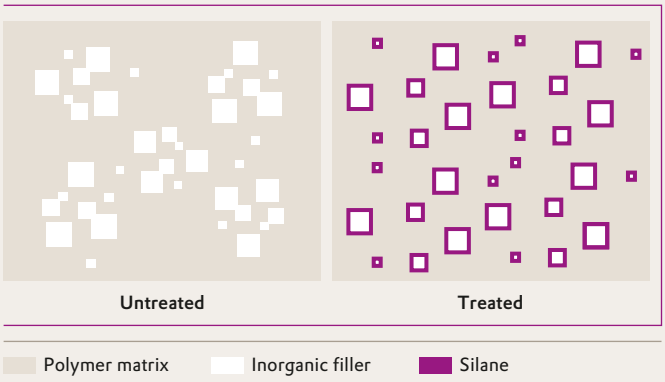


Melt-flow ratio can be improved by using Dynasylan® products

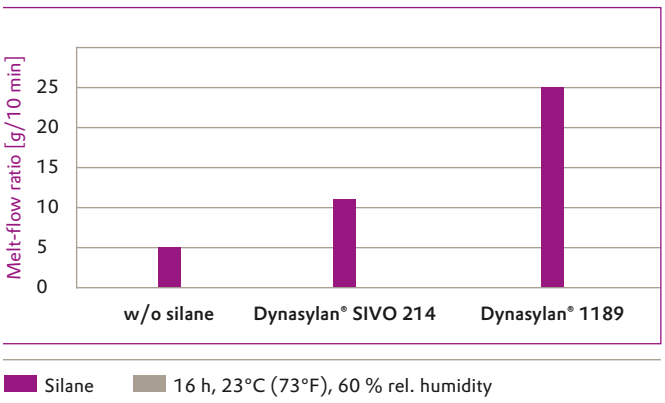
The dispersion of fillers in polymers is a significant technological challenge. Reason behind is the different polarity between the inorganic fillers and the organic polymer matrices. Silanes can act as excellent compatibilizers because of their dual character – the combination of organic and inorganic groups within one molecule. Some significantly improved characteristics:

- Reduced viscosity
- Improved processing
- Increased output
- Reduced agglomeration
- Higher filler loading
- Reduced total cost

Silanes improve dispersion of fillers in polymer matrices



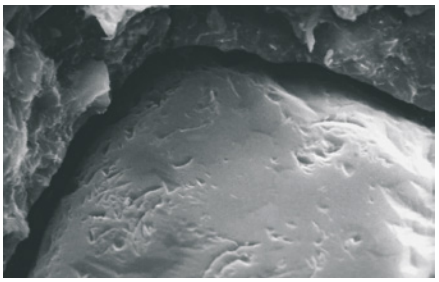
Melt-flow ratio depends on the type of silane used



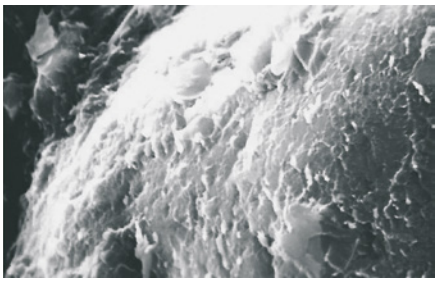
Dynasylan® couples fillers and polymers

An important characteristic of silanes is that they allow the coupling of inorganic mineral fillers and organic polymers through a chemical bond. As a consequence of the coupling, the mechanical properties of the filled compounds are significantly improved. Examples include the use of silane-treated glass fibers in polypropylene, quartz in unsaturated polyester, and aluminum trihydroxide in ethyl vinyl acetate.

Dynasylan® binds the resin to the filler



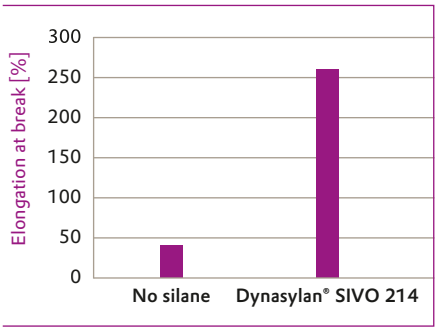
Untreated

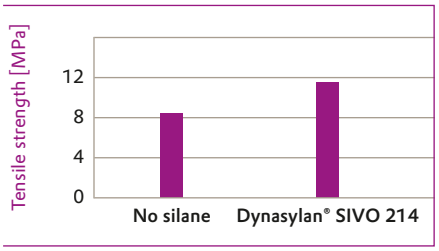


Treated with 1 % Dynasylan® MEMO

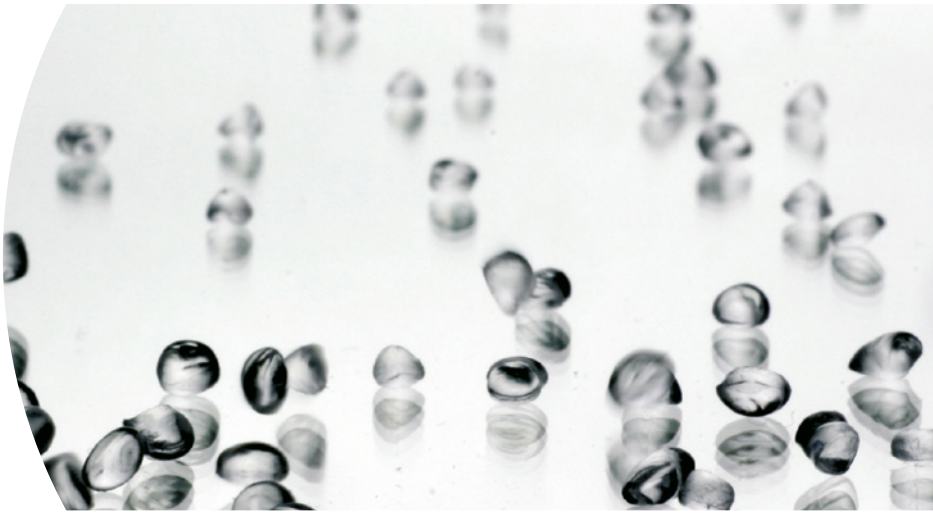
Scanning electron microscope (SEM) images of the broken edge of a quartz-filled unsaturated polyester. Silane coupling improves the adhesion of the filler to the polymer. The gap between the filler and the polymer is eliminated.

Mechanical properties can be improved by chemically coupling the polymer to the filler



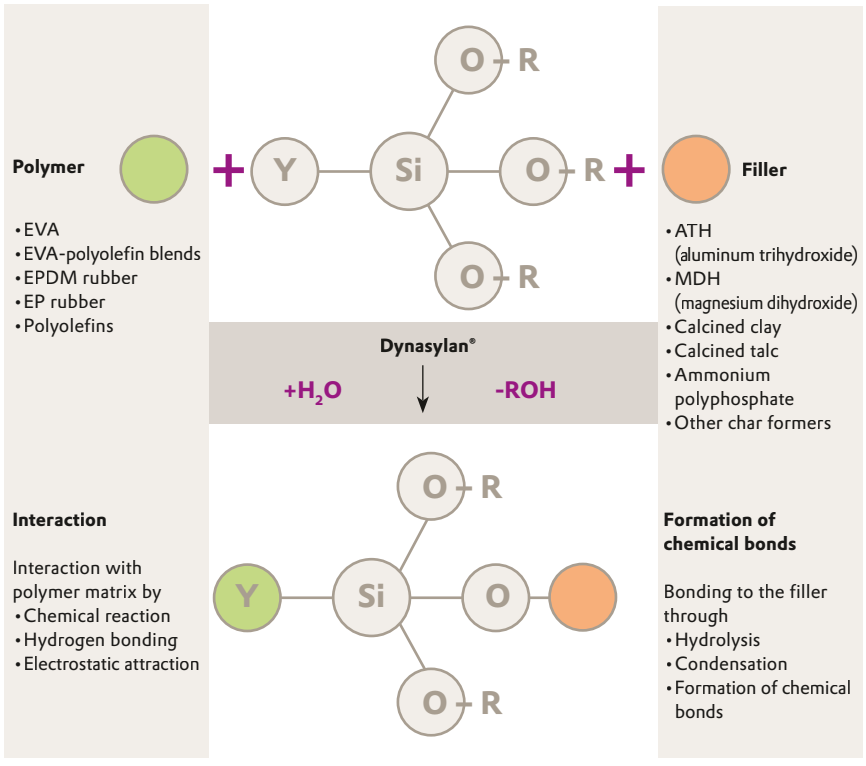


The mechanical properties of magnesium hydroxide-filled polypropylene (PP) compound, with additional maleic anhydride as a coupling agent.



How does it work?

Coupling mechanism between filler and polymer



The organofunctional Y-group of the silane links with the polymer. This group must be chosen to ensure maximum compatibility with the resin. A first possibility is to choose a silane that is compatible with the polymer. This ensures improved dispersion. For improved mechanical properties, a reaction needs to take place between the Y-group of the silane and the polymer.

The silane must also react with the filler. There are two steps to this reaction: first, hydrolysis of the alkoxy group, and then reaction of the resulting silanol with the surface hydroxyl groups of the inorganic filler.

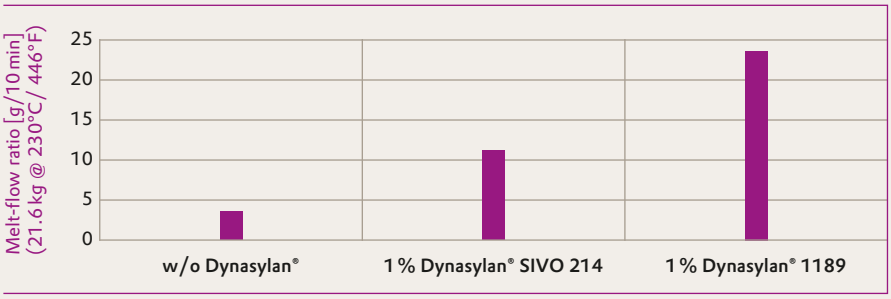
Halogen-free flame retardant cable compounds

The use of silanes in filled polypropylene HFFR compounds affords the same advantages as in other HFFR compounds:

- Increased loading levels
- Effective flame retardation
- Significantly reduced water uptake into the polymer
- Much improved electrical properties
- Improved processability of the highly filled polymers
- Increased throughput during cable production
- Improved mechanical properties

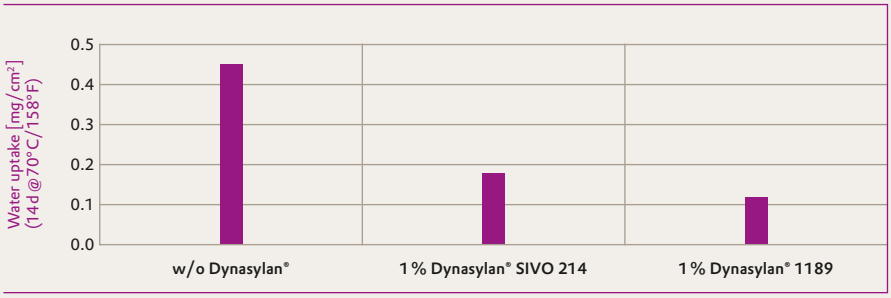
Special Multifunctional Silane Systems™ such as Dynasylan® SILFIN 70 and SILFIN 71 achieve a simultaneous crosslinking of the polyethylene and coupling between the filler and the resin.

Positive impact of Dynasylan® on Melt-Flow Ratio (MFR)

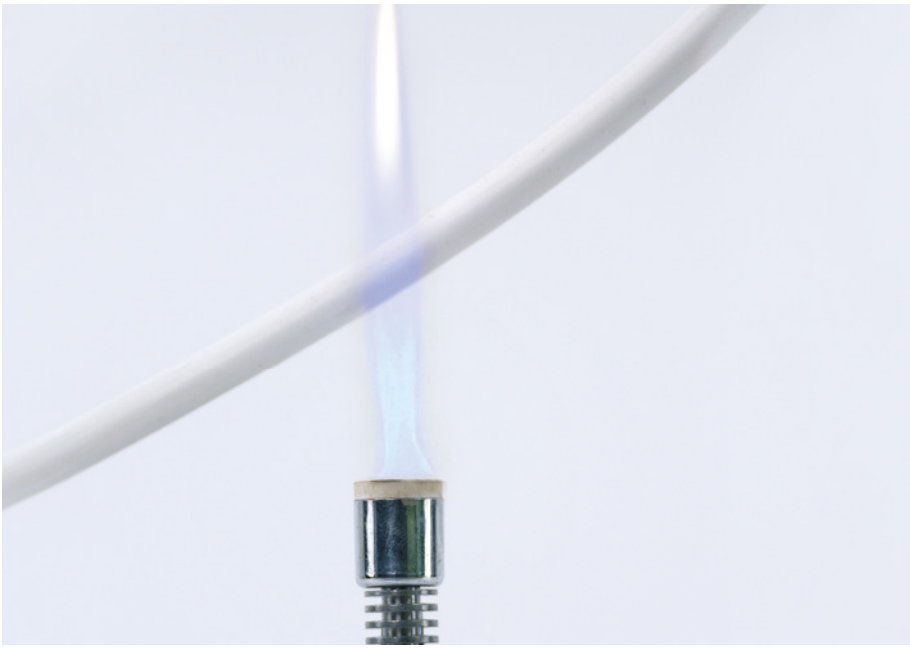


Melt-Flow Ratio (MFR) is increased by a factor of at least four through use of silanes.

Dynasylan® – Significant reduction of water-uptake



Water uptake is reduced by a factor of four through use of silanes.

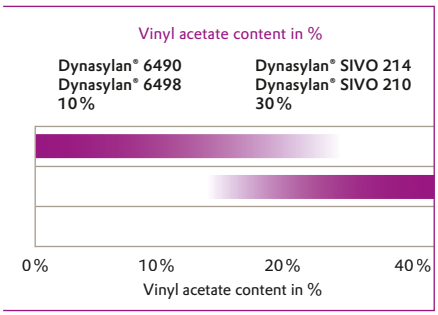


How to find a suitable Dynasylan® grade

For safety reasons, the use of low-flame and low-smoke cables is becoming more and more important. These cables are usually based on polymers, such as polyethylene and EVA, and are filled with mineral fillers that release water upon exposure to elevated temperatures.

The result is a cable that, in the case of a fire, produces significantly less smoke, chars instead of melts, and thus dramatically reduces fire propagation. Common fillers are aluminum trihydroxide and magnesium dihydroxide. Which is the right silane to choose depends on the polymer matrix.

The choice of Dynasylan® depends on the ratio of EVA to polyethylene in the polymer mix



Product Overview

Product name	Discription and use	Applications			Crosslinking		Coupling								
		Cables	Pipes	Filled plastics compounds	1-step (Monosil®)	2-step (Sioplas®)	Polyethylene	EVA / Polyethylene	Polypropylene	Rubber	Acrylics	Epoxy	Unsaturated polyester	Others
Multifunctional Silane Systems™														
Dynasylan® SILFIN 06	Standard product for cables	●			●									
Dynasylan® SILFIN 13	Standard product for cables	●				●								
Dynasylan® SILFIN 22	Standard product for cables	●			●									
Dynasylan® SILFIN 25	Multifunctional Silane System™, enables higher throughput	●	●		●	●								
Dynasylan® SILFIN 50	Multifunctional Silane System™ for pipes		●		●									
Dynasylan® SILFIN 53	Multifunctional Silane System™ for cables, LLDPE	●			●									
Dynasylan® SILFIN 63	Multifunctional Silane System™ for cables, ambient curing	●			●									
Dynasylan® SILFIN 70	High-performance Multifunctional Silane System™ for crosslinking of HFFR cables			●	●									
Dynasylan® SILFIN 71	High-performance Multifunctional Silane System™ for crosslinking of HFFR cables			●	●									
Dynasylan® SILFIN 75	High-performance Multifunctional Silane System™ for crosslinking of cables	●			●									
Dynasylan® SILFIN 80	All-in-one Multifunctional Silane System™ for cables	●			●									
Dynasylan® SILFIN 100	DBTDL-free alternative to Dynasylan® SILFIN 06	●			●									
VPS SILFIN 201	Tin-free Multifunctional Silane System™ for crosslinking of cables	●			●									
VPS SILFIN 202	Tin-free Multifunctional Silane System™ for crosslinking of cables	●			●									
Aminosilanes														
Dynasylan® AMEO	Coupling agent for polar compounds			●				●	●					
Dynasylan® SIVO 214	High-performance Multifunctional Silane System™ for polar compounds			●				●	●					
Dynasylan® SIVO 210	High-performance Multifunctional Silane System™ for polar compounds			●				●	●					
Dynasylan® 1189	High-performance silane for polar compounds			●				●	●					
Dynayslan® HYDROSIL 1151	Waterborne, VOC-free high-performance Multi-functional Silane System™ for polar compounds			●				●	●					
Dynayslan® HYDROSIL 2775	Waterborne, VOC-free high-performance Multi-functional Silane System™ for polar compounds			●				●	●					

Product Overview

		Applications			Crosslinking		Coupling							
Product name	Discription and use	Cables	Pipes	Filled plastics compounds	1-step (Monosil®)	2-step (Sioplas®)	Polyethylene	EVA / Polyethylene	Polypropylene	Rubber	Acrylics	Epoxy	Unsaturated polyester	Others
Vinylsilanes														
Dynasylan® VTMO	Vinylsilane	●	●	●	●	●								
Dynasylan® VTEO	Vinylsilane		●	●	●	●								
Dynasylan® HYDROSIL 2907	Waterborne, VOC-free high-performance Multi-functional Silane System™ for polar compounds			●		●	●	●		●				
Dynasylan® VTMOEO	Vinylsilane			●		●	●	●		●				
Dynasylan® 6490	High-performance Multifunctional Silane System™ for non-polar compounds			●		●	●	●		●				
Dynasylan® 6498	High-performance Multifunctional Silane System™ for non-polar compounds			●		●	●	●		●				
Dynasylan® 6598	High-performance Multifunctional Silane System™ for non-polar compounds			●		●	●	●		●				
Alkylsilanes														
Dynasylan® 9896	Hydrophobation agent			●										●
Dynasylan® OCTEO	Hydrophobation agent			●										●
Dynasylan® IBTEO	Hydrophobation agent			●										●
Dynayslan® HYDROSIL 2776	Waterborne, VOC-free hydrophobation agent			●										●
Dynayslan® HYDROSIL 2909	Waterborne, VOC-free hydrophobation agent			●										●
Phenylsilanes														
Dynasylan® 9165	High-performance silane for high temperature polymers			●										●
Dynasylan® 9265	High-performance silane for high temperature polymers			●										●
Fluorosilanes														
Dynasylan® F 8261	High-performance silane for fluorinated polymers			●				●	●					●
Dynayslan® HYDROSIL F8815	Waterborne, VOC-free hydrophobation agent			●										●
Other functional silanes														
Dynasylan® MEMO	Coupling agent for unsaturated compounds									●	●	●	●	●
Dynasylan® GLYMO	Coupling agent for polar compounds									●	●	●	●	
Dynasylan® 4144	High-performance silane for hydrophilic applications									●	●		●	●
Dynayslan® 4148	High-performance silane for hydrophilic applications									●	●		●	●
Dynayslan® HYDROSIL 2926	Waterborne, VOC-free high-performance Multi-functional Silane System™ for hydrophobation and oleophobation			●				●	●					●

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