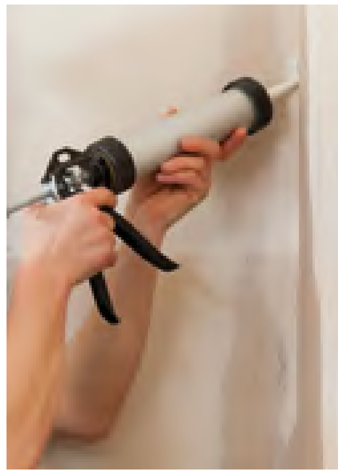
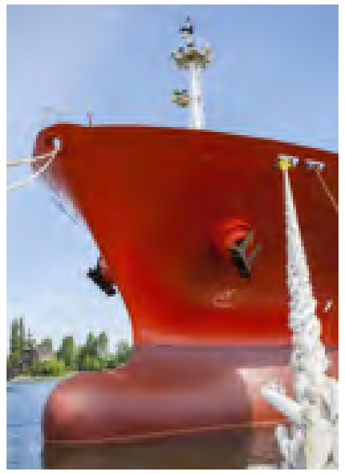
BRB

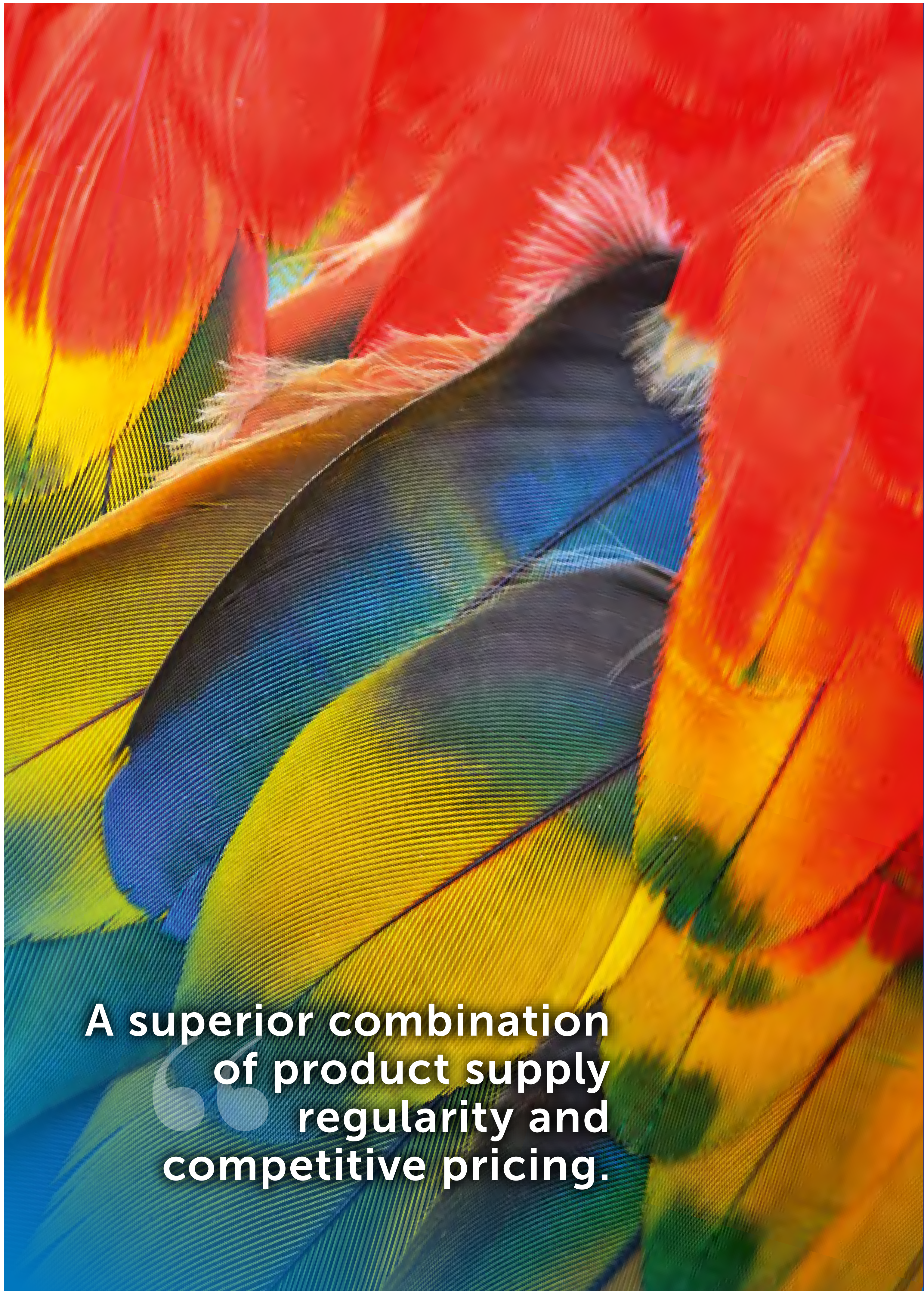
A Subsidiary of PETRONAS Chemicals Group

Sticking to reliability

Silanes







BRB Silanil® range

It's all about silanes

BRB International B.V. is a global producer of specialty silicones, core intermediates and silanes. We offer a comprehensive range of silicone based products, serving many different applications, with the aim to enhance everyday life. BRB is committed to delivering a customer driven service and consistently high quality products at a market-conscious price level.

With an extensive experience in silicones, BRB is the largest independent producer in the world able to challenge the silane market leaders.

- We offer the most popular silane block busters at a competitive price
- We ensure premium quality and reliability
- We give you the possibility to eliminate your main single sourcing issues
- We have demonstrated the ability to supply in all situations over the years
- We can customized special blends like no other silane major

Being used in many industries, silanes are particularly valuable as adhesion promoters, cross-linkers, coupling agents, surface modifiers and water scavengers.

Typical applications and industries include: fiberglass, glass and rock wool, mineral reinforcement, foundry resins, rubbers, coupling agents, filler coating, sealants and adhesives, paints and coatings.

As a subsidiary of PETRONAS Chemicals Group Berhad, BRB now has even greater global presence and innovation resources.

Organofunctional silanes

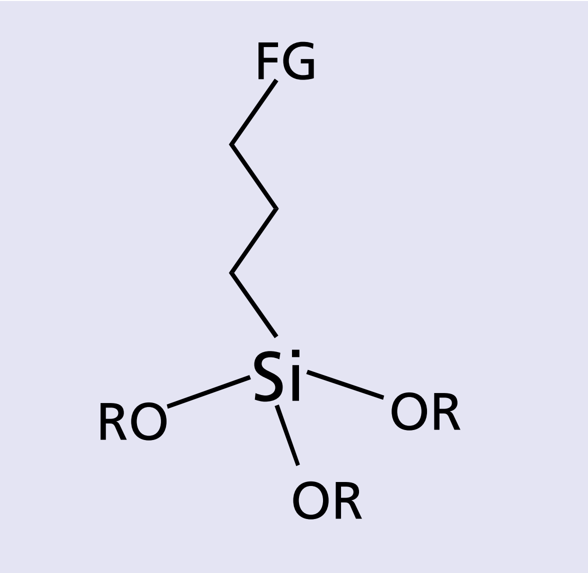
Building basics

Two groups: Silane is a reactive chemical typically containing a functional group and alkoxy groups. The functional group is useful for bonding with resins, improving compatibility with organic materials, and enhancing hydrophobicity – depending on characteristics of each functional group.

Alkoxy

The alkoxy groups, which bond with a silicon atom, associate with hydrolysis reaction, are so-called hydrolyzable silyl groups. These groups form chemical bonds with inorganic materials;

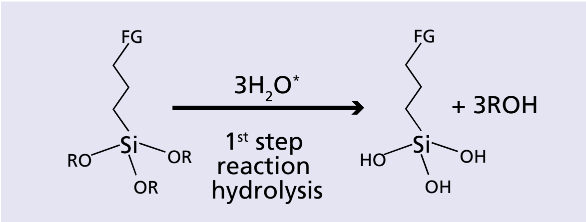
- The methoxy group hydrolyzes faster than the ethoxy group.
- The ethoxy group provides better stability during hydrolysis reaction and releases ethyl alcohol (by-product) which is eco-friendly substance.



FG Functional groups (organic types), e.g. Vinyl, Glycidoxy (Epoxy), Amino, Methacryloxy, Mercapto, Alkyl, etc.
OR Alkoxy groups, e.g. Methoxy (-OCH$_3$), Ethoxy (-OCH$_2$CH$_3$), etc.

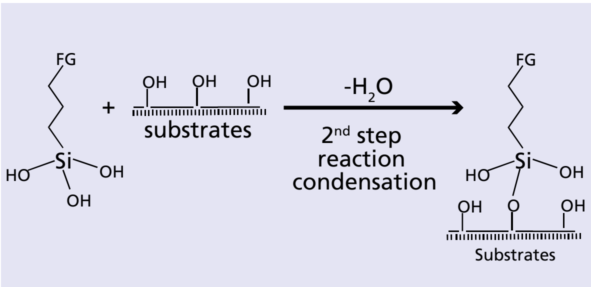
Mechanism

When storing under nitrogen gas, silane is a non-reactive chemical in form of FG-Si-OR. Once a container of silane is unsealed, silane hydrolyzes with moisture where -Si–OR changes to -Si-OH (silanol group). This is the first step of reaction so-called hydrolysis.



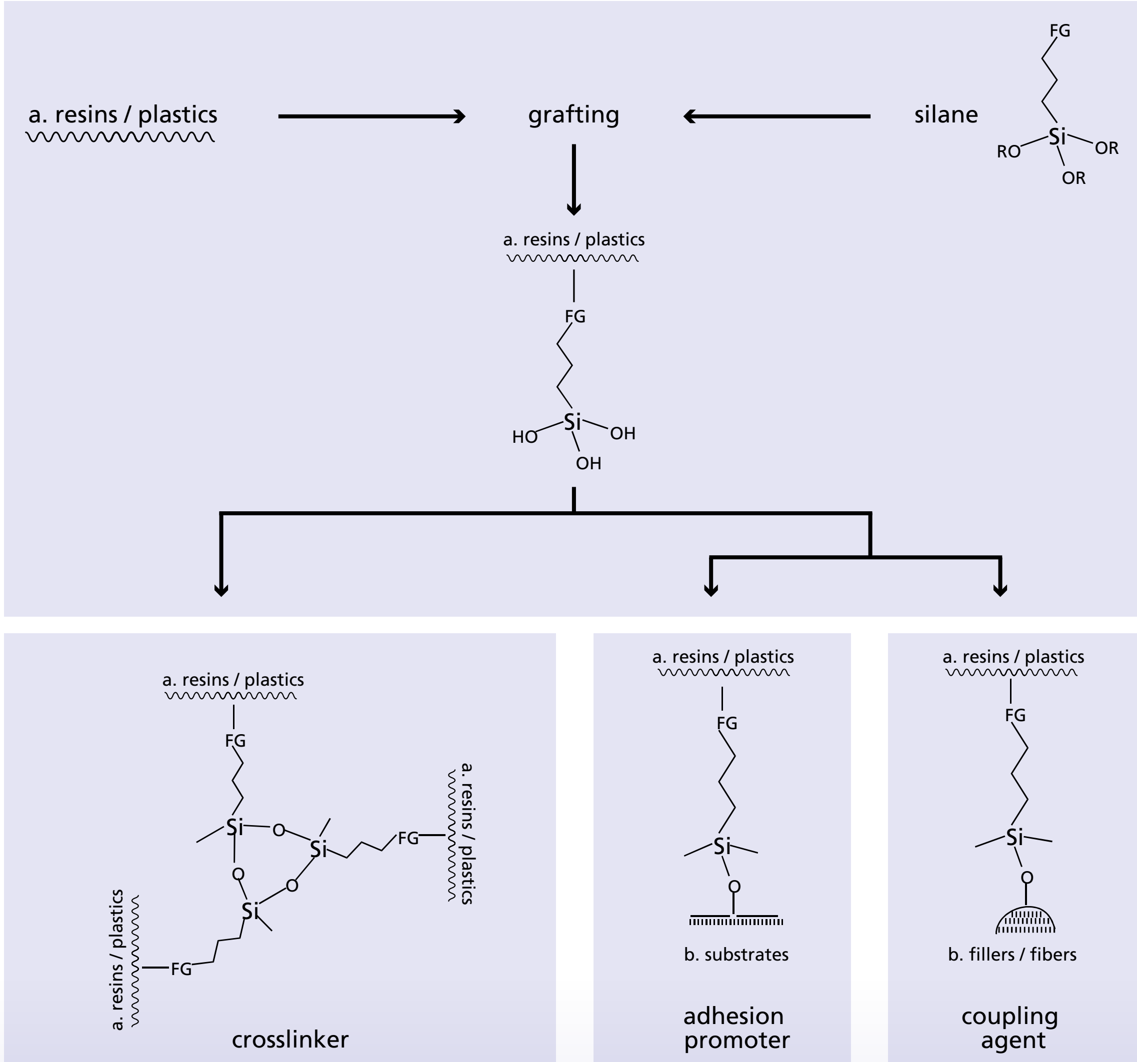
* H_2O can be from atmosphere

The second step of the reaction is condensation where the silanol groups readily bond with substrates or fillers containing hydroxyl groups or other reactive groups; in this case silane acts as an adhesion promoter or a coupling agent.



In addition, silanol groups also bond each other and create crosslink network among resins; silane herein acts as a crosslinker.

Basic functions



Key benefits

Crosslinker

- Create network structure in Polymers
- Increase strength and hardness
- Provide longer service life of products
- Give higher temperature resistance
- Enhance ability of scrub resistance

Adhesion promoter coupling agent

- Improve adhesion between resins and substrates
- Enhance corrosion resistance
- Provide compatibility between resins and fillers
- Increase mechanical strengths of composites
- Provide higher filler loading for composites

Silanes connect

Silanil® product range

Silanil®	Chemical name	Formula	Cas no.	Purity	Refractive index	Flash point (°c)	Boiling point (°c) @ mmhg	Adhesion promoter	Crosslinker	Coupling agent	Surface modifier	Water scavenger	REACh registration
								Functionality					
Amino													
138	3-aminopropyltrimethoxysilane	$(CH_3O)_3Si\text{-}(CH_2)_3NH_2$	13822-56-5	≥ 97%	1,424	90	194	•	•	•	•		•
176	N-(2-aminoethyl)-3-aminopropyl-trimethoxysilane	$(CH_3O)_3Si\text{-}(CH_2)_3NH(CH_2)_2NH_2$	1760-24-3	≥ 97%	1,442	128	261	•	•	•	•		•
307	N-(2-aminoethyl)-3-aminopropyl-methyldimethoxysilane	$CH_3(CH_3O)_2Si\text{-}(CH_2)_3NH(CH_2)_2NH_2$	3069-29-2	≥ 97%	1,445	> 100	265	•	•	•	•		•
505	N-(2-aminoethyl)-3-aminopropyl-triethoxysilane	$(CH_3CH_2O)_3Si\text{-}(CH_2)_3NH(CH_2)_2NH_2$	5089-72-5	≥ 95%	1,430	123	156 @ 15	•	•	•	•		•
581	3-aminopropyltriethoxysilane aqueous solution	oligomer	58160-99-9	N.A.	1,370	> 95	> 100	•		•	•		E
919	3-aminopropyltriethoxysilane	$(CH_3CH_2O)_3Si\text{-}(CH_2)_3NH_2$	919-30-2	≥ 98.5%	1,419	96	217	•	•	•	•		•
919 HP	3-aminopropyltriethoxysilane high purity	$(CH_3CH_2O)_3Si\text{-}(CH_2)_3NH_2$	919-30-2	≥ 99%	1,419	96	217	•	•	•	•		•
Epoxy													
258	3-glycidoxypropyltrimethoxysilane	$(CH_3O)_3Si\text{-}(CH_2)_3OCH_2\text{-}C_2H_3O$	2530-83-8	≥ 98.5%	1,428	> 101	> 250	•	•	•	•		•
260	3-glycidoxypropyltriethoxysilane	$(CH_3CH_2O)_3Si\text{-}(CH_2)_3OCH_2\text{-}C_2H_3O$	2602-34-8	≥ 98%	1,425	110	124 @ 3	•	•	•	•		
289	3-glycidoxypropylmethyldiethoxysilane	$CH_3(CH_3CH_2O)_2Si\text{-}(CH_2)_3OCH_2\text{-}C_2H_3O$	2897-60-1	≥ 97%	1,423	128	122 @ 5	•	•	•			•
Vinyl													
106	vinyltris(2-methoxyethoxy)silane	$(CH_3OCH_2CH_2O)_3Si\text{-}CH{=}CH_2$	1067-53-4	≥ 97%	1,433	> 80	285	•	•	•		•	
276	vinyltrimethoxysilane	$(CH_3O)_3Si\text{-}CH{=}CH_2$	2768-02-7	≥ 99%	1,392	25	123	•	•	•		•	•
780	vinyltriethoxysilane	$(CH_3CH_2O)_3Si\text{-}CH{=}CH_2$	78-08-0	≥ 98%	1,398	34	160	•	•	•		•	•
Methacryloxy and mercapto													
250	3-methacryloxypropyltrimethoxysilane	$(CH_3O)_3Si\text{-}(CH_2)_3O\text{-}(C{=}O)\text{-}C(CH_3){=}CH_2$	2530-85-0	≥ 98%	1,428	108	225	•	•	•			•
442	3-mercaptopropyltrimethoxysilane	$(CH_3O)_3Si\text{-}(CH_2)_3SH$	4420-74-0	≥ 98%	1,442	88	212	•	•	•			•
Oxime													
MOS	methyltris(methylethylketoxime)silane	$(CH_3CH_2C(CH_3){=}N\text{-}O)_3Si\text{-}CH_3$	22984-54-9	≥ 95%	1,455	> 95	≥ 200		•				•
VOS	vinyltris(methylethylketoxime)silane	$(CH_3CH_2C(CH_3){=}N\text{-}O)_3Si\text{-}CH{=}CH_2$	2224-33-1	≥ 95%	1,465	> 95	113 @ 0.1		•				•
Acetoxy													
MTAS	methyltriacetoxysilane	$(CH_3\text{-}(C{=}O)\text{-}O)_3Si\text{-}CH_3$	4253-34-3	≥ 90%	1,454	82	87 @ 3		•				
ETAS	ethyltriacetoxysilane	$(CH_3\text{-}(C{=}O)\text{-}O)_3Si\text{-}CH_2CH_3$	17689-77-9	≥ 95%	1,412	> 106	180		•				•
PTAS/MTAS 70:30	propyltriacetoxysilane / methyltriacetoxysilane 70:30	$(CH_3\text{-}(C{=}O)\text{-}O)_3Si\text{-}CH_2CH_2CH_3$ and $(CH_3\text{-}(C{=}O)\text{-}O)_3Si\text{-}CH_3$	17865-07-5 (PTAS), 4253-34-3 (MTAS)		1.521	85			•				•
Alkyl and alkoxy													
294	N-octyltriethoxysilane	$(CH_3CH_2O)_3Si\text{-}(CH_2)_7CH_3$	2943-75-1	≥ 95%	1,416	> 65	98 @ 2				•		•
118	methyltrimethoxysilane	$(CH_3O)_3Si\text{-}CH_3$	1185-55-3	≥ 98%	1,370	8	100		•		•		•
150	propyltrimethoxysilane	$(CH_3O)_3Si\text{-}CH_2CH_2CH_3$	1067-25-0	≥ 97%	1,391	35	137		•		•		•
203	methyltriethoxysilane	$(CH_3CH_2O)_3Si\text{-}CH_3$	2031-67-6	≥ 98%	1,383	> 23	142				•		
Si 28	Tetraethoxysilane	$(CH_3CH_2O)_4Si$	78-10-4	≥ 99%	1,384	45	167		•		•		•
Si 40	Tetraethoxysilane oligomer	oligomer	68412-27-3	N.A.	1,4	≥ 62	160		•		•		E

E = Exempted

Product selector

Compatibility guideline: polymers and functional groups of silanes

polymers	Amino	Epoxy	Vinyl	Methacryloxy	Mercapto	Alkyl
	Functional group of silanes					
Rubber						
EPDM	•		•	•	•	
Butyl rubber	•	•		•	•	•
Neoprene rubber	•				•	
Nitrile rubber	•	•			•	
SBR	•	•			•	
Polysulfide	•	•			•	
Polybutadiene rubber					•	
Polyisoprene rubber					•	
NBR	•	•			•	
Silicone	•	•	•	•		•
Epichlorohydrin rubber		•			•	
Urethane rubber	•	•			•	
Thermoset resins						
PU	•	•	•		•	
Phenolic	•	•			•	
Unsaturated polyester		•	•	•		
Epoxy	•	•			•	
Melamine	•	•				
Furan	•	•				
Polyimide	•	•				
Diallyl phthalate		•	•	•		
Thermoplastic resins						
PET	•	•				
PBT	•	•				
PVC	•	•			•	
PE			•	•		•
PP			•	•		•
PS	•	•		•	•	
ABS	•	•		•	•	
PC	•	•		•		
PU	•	•		•	•	
Acrylic	•	•		•		•
Nylon	•	•				

Constructing attraction

Selection guideline: products and silanes

products	Amino							Epoxy			Vinyl			Methacryloxy	Mercapto	Oxime		Acetoxy			Alkyl	Alkoxy				
Silanil®	138	176	307	505	581	919	919 HP	258	260	289	106	276	780	250	442	MOS	VOS	MTAS	ETAS	PTAS/MTAS 70:30	294	118	150	203	Si 28	Si 40
Crosslinked polyolefins												•														
Treated mineral fillers/glass fibers	•	•			•	•	•	•	•					•	•						•	•	•	•	•	•
Fiber-reinforced unsat. polyester											•	•	•	•												
Phenolic for foundry molds	•	•				•	•	•																		
Epoxy molding compounds	•	•	•			•	•	•	•						•											
Mineral wool for insulation	•					•	•	•						•												
Artificial marble														•												
Paints and coatings	•	•			•	•	•	•	•	•	•	•	•	•							•	•	•	•	•	•
Sealants and adhesives	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•
Copper clad laminates	•	•				•	•	•																		
Copper foil	•					•	•								•											
Peroxide-cured rubber compounds						•	•				•		•	•												
Sulfur-cured rubber compounds						•	•								•											
Ziegler-Natta catalyst																						•	•		•	

Application guideline for silanes

Filler treatment

A silane solution is prepared by dissolving 10 wt% of silane into a solvent mixture of alcohols:water at 90:10 by wt. Isopropanol, ethanol, and methanol can be used.

A few drops of diluted acetic acid may be added into the silane solution to adjust pH; pH in the range of 4-5 is recommended. The purpose of pH adjustment is to accelerate hydrolysis reaction. Nevertheless, the pH adjustment is not required for the amino silane solution.

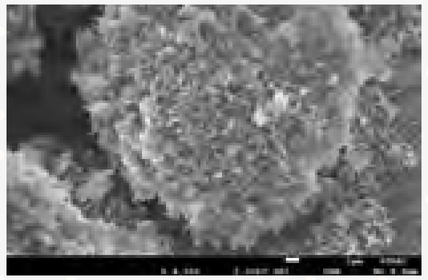
The silane solution will be aged for overnight, then applied to fillers by using mixing instruments, for example, Twin Shell mixer, Henschel mixer, or Littleford Lodige mixer.

Amount of silane in the solution may be estimated from size of filler particles.

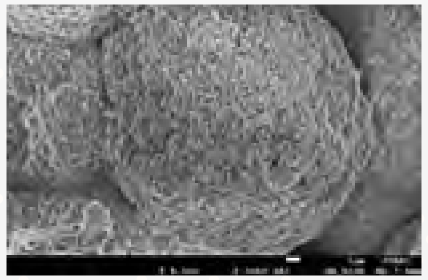
Size of filler particles	Amount of silane*
> 20 microns	< 0.5 wt%
10 - 20 microns	0.5 - 1 wt%
1 - 10 microns	1 - 1.5 wt%
<1 micron	1.5 - > 2 wt%

* which is sufficient for filler surface coverage (% based on weight of fillers)

Silanil® 138 Treated Silica Nanopowder



before



after

Polymer modification by grafting

Emulsion polymerization

- Silane, e.g. Silanil® 276 or Silanil® 250, is used to graft onto polymer backbone during polymerization. It is recommended to add silaneinto monomer mixture tank after the monomer mixture is discharged approx. 80-90% of total monomers into polymerization kettle. In addition, silane is advised to add in pre-emulsion stage.
- Core-shell emulsion polymerization is also recommended; it consists of seed, core, and shell stages. Silane is added in the shell stage.
- Recommended dosage of silane in emulsion is 0.2-2 wt% based on total weight of monomers.

Crosslinked polyethylene (XLPE)

- For Soaking process, silane is mixed with dicumyl peroxide (initiator) and tin catalyst, then the mixture is discharged into PE pellets and other solid additives. Later, all ingredients are soaked at least overnight in a closed container, in which Aluminium foil bag and desiccant vent dryer are recommended for moisture prevention.
- For Siloplas process, silane is mixed with dicumyl peroxide. A side feeder is recommended for injecting the silane blend into a barrel. A twin screw extruder with L/D ratio >35 is necessary to be later a conventional single screw can be used to compound part A and used for grafting process (part A), part B (tin catalyst masterbatch).
- Recommended dosage of silane is 1-2 wt% based on weight of PE.

Polymer modification by integral blending

Silane, e.g. Silanil® 258, can be directly blended into resin, without fillers, additives, or pigments. Dosage of silane is typically used from 0.2 wt% up to 2 wt% based on solid content of resin. Ladder test is recommended to find an optimum dosage.

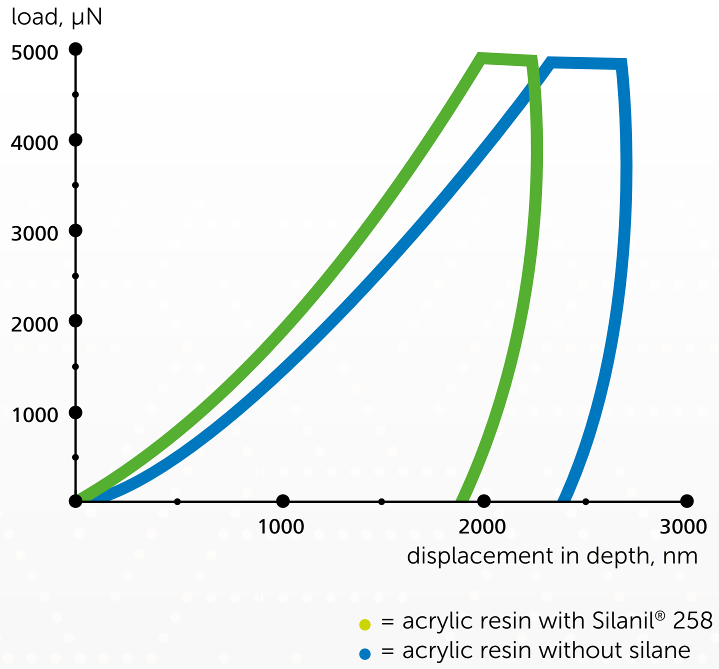
In case of waterborne resin, pH of resin should be near to neutral or less than pH 8.5 prior to addition of silane. The neutral pH can minimize hydrolysis rate of alkoxy groups, that the accelerated hydrolysis may cause self-crosslinking of silanes by silanol groups.

Induction time is required for the mixture of silane and resin; it implies the minimum aging time required for the mixture before the significant properties of the mixture is developed. At least overnight until a few days is recommended. For waterborne resin, the proper induction time can be studied by plotting curve of pH evolution against time. The induction time will be at the onset point where the pH value is started to dramatically increase. Typical induction time is 5-48 hours.

High shear and agitation can accelerate the induction time. Other additives and fillers are recommended to add after the induction time as well as application tests. If pH adjustment is required for the end product, it is also advised to adjust the pH value after the induction time.

Silanil® 258 could significantly increase hardness and elastic modulus of a waterborne acrylic resin by integral blending

Viscoelastic graph*
Silanil® 258 modified acrylic resin



Waterborne acrylic resin	Hardness (MPa)	Elastic modulus** (MPa)
acrylic without silane	29 ± 1	1,837 ± 52
acrylic with Silanil® 258	40 ± 3	1,917 ± 79

* by nano-indentation test using Berkovich indentor and 5 mN load
** reduced modulus

Recommendation for storage and handling

N_2 gas is required to purge into a container to get rid of moisture before and after filling silane liquid.

In case of sample packing without N_2 gas, the minimum air space in a sample container is recommended. Inner and outer caps must be tightly closed. More air space left in the container may cause self-crosslinking of silanes.

Equipment should be cleaned with ethanol or methylated spirits and dried completely before use.

Stainless steel, glass, and Teflon® are recommended for contact with silanes.

Some silanes such as Silanil® 250 are recommended to keep in an amber container to avoid the sun light.

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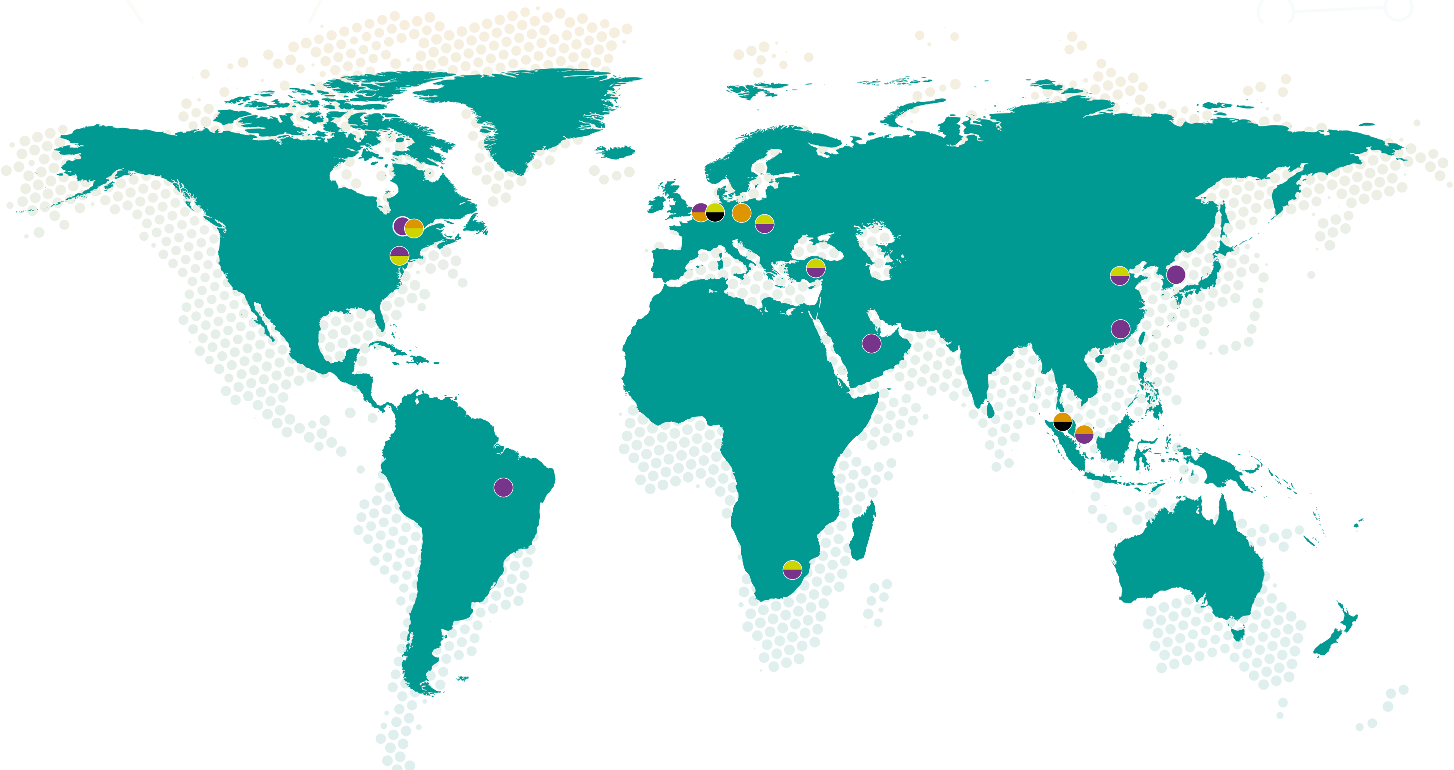

Sales office **Production** **Warehouse** **R&D center**