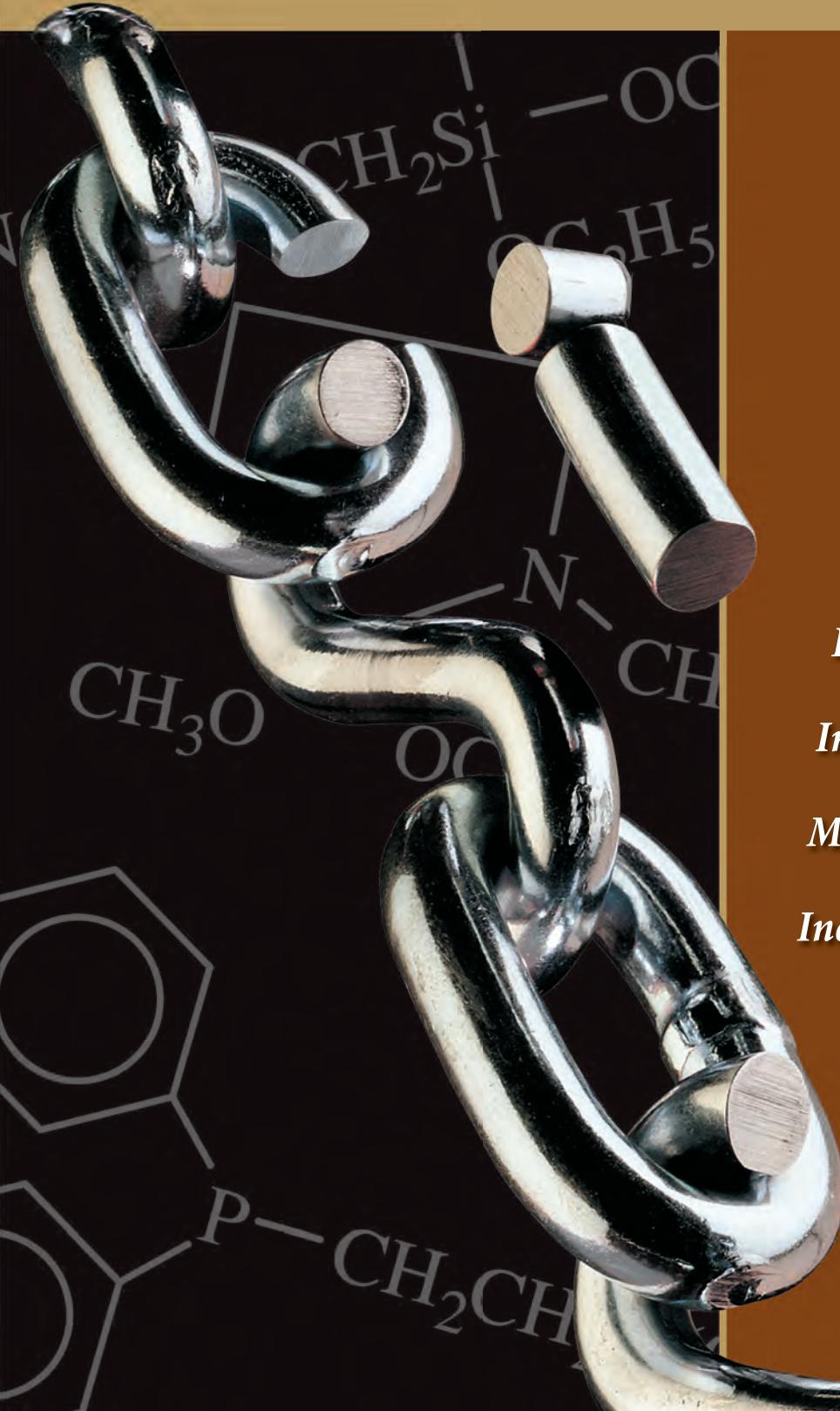


# Gelest

## Silane Coupling Agents

*Connecting Across Boundaries*



*Metal Primers*

*Bind Biomaterials*

*Provide Crosslinking*

*Immobilize Catalysts*

*Improve Polymer and  
Particle Dispersion*

*Enhance Adhesive Bonding*

*Increase Electrical Properties*

*Maximize Composite Strength*

*Increase Mechanical Properties*

*Version 3.0:*

Water-borne Silanes

New Coupling Agents:

Cyclic Aza-Silanes, Azido-Silanes,  
Dipodal Silanes

Oligomeric Hydrolysates



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Silane Coupling Agents: Connecting Across Boundaries (3rd Edition)

by Barry Arkles

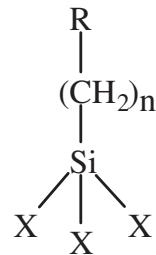
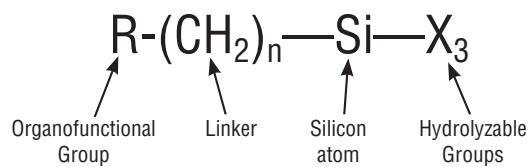
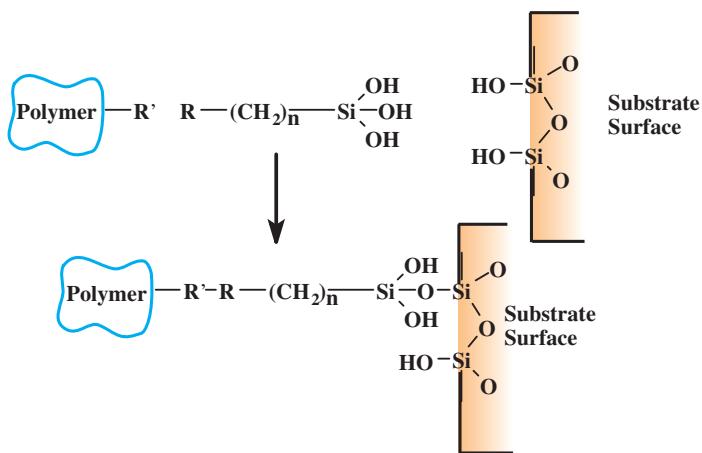
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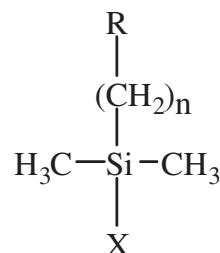
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## Silane Coupling Agents

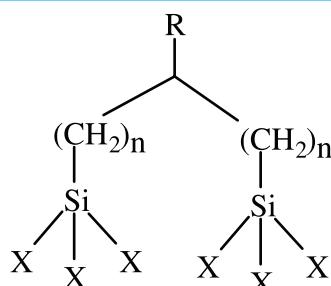
Silane coupling agents have the ability to form a durable bond between organic and inorganic materials. Encounters between dissimilar materials often involve at least one member that's siliceous or has surface chemistry with siliceous properties; silicates, aluminates, borates, etc., are the principal components of the earth's crust. Interfaces involving such materials have become a dynamic area of chemistry in which surfaces have been modified in order to generate desired heterogeneous environments or to incorporate the bulk properties of different phases into a uniform composite structure.



Trialkoxysilane



Monoalkoxysilane



Dipodal Silane

The general formula for a silane coupling agent typically shows the two classes of functionality. X is a hydrolyzable group typically alkoxy, acyloxy, halogen or amine. Following hydrolysis, a reactive silanol group is formed, which can condense with other silanol groups, for example, those on the surface of siliceous fillers, to form siloxane linkages. Stable condensation products are also formed with other oxides such as those of aluminum, zirconium, tin, titanium, and nickel. Less stable bonds are formed with oxides of boron, iron, and carbon. Alkali metal oxides and carbonates do not form stable bonds with Si-O-. The R group is a nonhydrolyzable organic radical that may possess a functionality that imparts desired characteristics.

The final result of reacting an organosilane with a substrate ranges from altering the wetting or adhesion characteristics of the substrate, utilizing the substrate to catalyze chemical transformations at the heterogeneous interface, ordering the interfacial region, and modifying its partition characteristics. Significantly, it includes the ability to effect a covalent bond between organic and inorganic materials.

## How Does a Silane Modify a Surface?

Most of the widely used organosilanes have one organic substituent and three hydrolyzable substituents. In the vast majority of surface treatment applications, the alkoxy groups of the trialkoxysilanes are hydrolyzed to form silanol-containing species. Reaction of these silanes involves four steps. Initially, hydrolysis of the three labile groups occurs. Condensation to oligomers follows. The oligomers then hydrogen bond with OH groups of the substrate. Finally, during drying or curing, a covalent linkage is formed with the substrate with concomitant loss of water. Although described sequentially, these reactions can occur simultaneously after the initial hydrolysis step. At the interface, there is usually only one bond from each silicon of the organosilane to the substrate surface. The two remaining silanol groups are present either in condensed or free form. The R group remains available for covalent reaction or physical interaction with other phases.

Silanes can modify surfaces under anhydrous conditions consistent with monolayer and vapor phase deposition requirements. Extended reaction times (4-12 hours) at elevated temperatures (50°-120°C) are typical. Of the alkoxy silanes, only methoxysilanes are effective without catalysis for vapor deposition. The most effective silanes for vapor phase deposition are cyclic azasilanes.

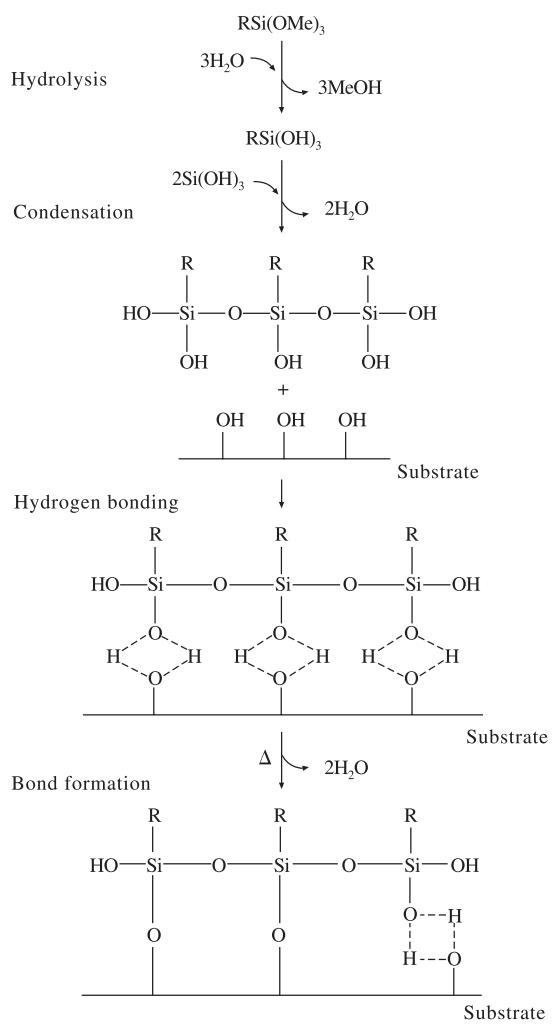
## Hydrolysis Considerations

Water for hydrolysis may come from several sources. It may be added, it may be present on the substrate surface, or it may come from the atmosphere. The degree of polymerization of the silane is determined by the amount of water available and the organic substituent. If the silane is added to water and has low solubility, a high degree of polymerization is favored. Multiple organic substitution, particularly if phenyl or tertiary butyl groups are involved, favors formation of stable monomeric silanols.

The thickness of a polysiloxane layer is also determined by the concentration of the siloxane solution. Although a monolayer is generally desired, multilayer adsorption results from solutions customarily used. It has been calculated that deposition from a 0.25% silane solution onto glass could result in three to eight molecular layers. These multilayers could be either inter-connected through a loose network structure, or intermixed, or both, and are, in fact, formed by most deposition techniques. The orientation of functional groups is generally horizontal, but not necessarily planar, on the surface of the substrate.

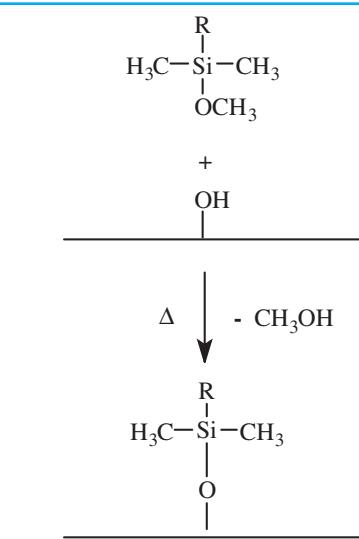
The formation of covalent bonds to the surface proceeds with a certain amount of reversibility. As water is removed, generally by heating to 120°C for 30 to 90 minutes or evacuation for 2 to 6 hours, bonds may form, break, and reform to relieve internal stress. The same mechanism can permit a positional displacement of interface components.

## Hydrolytic Deposition of Silanes



B. Arkles, CHEMTECH, 7, 766, 1977

## Anhydrous Deposition of Silanes



# Selecting a Silane for Surface Modification

## Inorganic Substrate Perspective

Factors influencing silane surface modification selection include:

*Concentration of surface hydroxyl groups*

*Type of surface hydroxyl groups*

*Hydrolytic Stability of the bond formed*

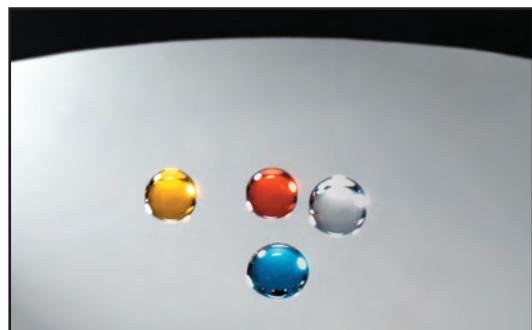
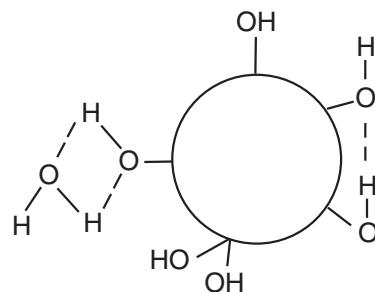
*Physical dimensions of the substrate or substrate features*

Surface modification is maximized when silanes react with the substrate surface and present the maximum number of accessible sites with appropriate surface energies. An additional consideration is the physical and chemical properties of the interphase region. The interphase can promote or detract from total system properties depending on its physical properties such as modulus or chemical properties such as water/hydroxyl content.

Hydroxyl-containing substrates vary widely in concentration and type of hydroxyl groups present. Freshly fused substrates stored under neutral conditions have a minimum number of hydroxyls. Hydrolytically derived oxides aged in moist air have significant amounts of physically adsorbed water which can interfere with coupling. Hydrogen bonded vicinal silanols react more readily with silane coupling agents, while isolated or free hydroxyls react reluctantly.

Silanes with three alkoxy groups are the usual starting point for substrate modification. These materials tend to deposit as polymeric films, effecting total coverage and maximizing the introduction of organic functionality. They are the primary materials utilized in composites, adhesives, sealants, and coatings. Limitations intrinsic in the utilization of a polylayer deposition are significant for nano-particles or nano-composites where the interphase dimensions generated by polylayer deposition may approach those of the substrate. Residual (non-condensed) hydroxyl groups from alkoxy-silanes can also interfere in activity. Monoalkoxy-silanes provide a frequently used alternative for nano-featured substrates since deposition is limited to a monolayer.

If the hydrolytic stability of the oxane bond between the silane and the substrate is poor or the application is in an aggressive aqueous environment, dipodal silanes often exhibit substantial performance improvements. These materials form tighter networks and may offer up to  $10^5$ x greater hydrolysis resistance making them particularly appropriate for primer applications.



Water droplets on a (heptadecafluoro-1,1,2,2-tetrahydrodecyl)trimethoxysilane-treated silicon wafer exhibit high contact angles, indicative of the low surface energy. Surfaces are both hydrophobic and resist wetting by hydrocarbon oils. (water droplets contain dye for photographic purposes).

### Silane Effectiveness on Inorganics

SUBSTRATES	
EXCELLENT	Silica
GOOD	Quartz
SLIGHT	Glass
Poor	Aluminum ( $\text{Al}(\text{OH})$ )
	Alumino-silicates (e.g. clays)
	Silicon
	Copper
	Tin ( $\text{SnO}$ )
	Talc
	Inorganic Oxides (e.g. $\text{Fe}_2\text{O}_3$ , $\text{TiO}_2$ , $\text{Cr}_2\text{O}_3$ )
	Steel, Iron
	Asbestos
	Nickel
	Zinc
	Lead
	Marble, Chalk ( $\text{CaCO}_3$ )
	Gypsum ( $\text{CaSO}_4$ )
	Barytes ( $\text{BaSO}_4$ )
	Graphite
	Carbon Black

### Estimates for Silane Loading on Siliceous Fillers

Average Particle Size	Amount of Silane (minimum of monolayer coverage)
<1 micron	1.5% or greater
1-10 microns	1.0%
10-20 microns	0.75%
>100 microns	0.1% or less

## Critical Surface Tension and Adhesion

While the contact angle of water on a substrate is a good indicator of the relative hydrophobicity or hydrophilicity of a substrate, it is not a good indicator for the wettability of the substrate by other liquids. The contact angle is given by Young's equation:

$$\gamma_{sv} - \gamma_{sl} = \gamma_{lv} \cdot \cos\theta_e$$

where  $\gamma_{sl}$  = interfacial surface tension,  $\gamma_{lv}$  = surface tension of liquid.

Critical surface tension is associated with the wettability or release properties of a solid. It serves as a better predictor of the behavior of a solid with a range of liquids.

Liquids with a surface tension below the critical surface tension ( $\gamma_c$ ) of a substrate will wet the surface, i.e., show a contact angle of 0 ( $\cos\theta_e = 1$ ). The critical surface tension is unique for any solid and is determined by plotting the cosine of the contact angles of liquids of different surface tensions and extrapolating to 1.

Hydrophilic behavior is generally observed by surfaces with critical surface tensions greater than 45 dynes/cm. As the critical surface tension increases, the expected decrease in contact angle is accompanied with stronger adsorptive behavior and with increased exotherms.

Hydrophobic behavior is generally observed by surfaces with critical surface tensions less than 35 dynes/cm. At first, the decrease in critical surface tension is associated with oleophilic behavior, i.e. the wetting of the surfaces by hydrocarbon oils. As the critical surface tensions decrease below 20 dynes/cm, the surfaces resist wetting by hydrocarbon oils and are considered oleophobic as well as hydrophobic.

In the reinforcement of thermosets and thermoplastics with glass fibers, one approach for optimizing reinforcement is to match the critical surface tension of the silylated glass surface to the surface tension of the polymer in its melt or uncured condition. This has been most helpful in resins with no obvious functionality such as polyethylene and polystyrene. Silane treatment has allowed control of thixotropic activity of silica and clays in paint and coating applications. Immobilization of cellular organelles, including mitochondria, chloroplasts, and microsomes, has been effected by treating silica with alkylsilanes of C8 or greater substitution.

### Critical surface tensions

	$\gamma_c$	mN/m
heneicosfluorododecyltrichlorosilane	6-7	
heptadecafluorododecyltrichlorosilane	12.0	
poly(tetrafluoroethylene)	18.5	
octadecyltrichlorosilane	20-24	
methyltrimethoxysilane	22.5	
nonafluorohexyltrimethoxysilane	23.0	
vinyltrimethoxysilane	25	
paraffin wax	25.5	
ethyltrimethoxysilane	27.0	
propyltrimethoxysilane	28.5	
glass, soda-lime (wet)	30.0	
poly(chlorotrifluoroethylene)	31.0	
poly(propylene)	31.0	
poly(propylene oxide)	32	
Polyethylene	33.0	
trifluoropropyltrimethoxysilane	33.5	
3-(2-aminoethyl)-aminopropyltrimethoxysilane	33.5	
poly(styrene)	34	
p-tolyltrimethoxysilane	34	
cyanoethyltrimethoxysilane	34	
aminopropyltriethoxysilane	35	
acetoxypropyltrimethoxysilane	37.5	
polymethylmethacrylate	39	
polyvinylchloride	39	
phenyltrimethoxysilane	40.0	
chloropropyltrimethoxysilane	40.5	
mercaptopropyltrimethoxysilane	41	
glycidoxypropyltrimethoxysilane	42.5	
poly(ethyleneterephthalate)	43	
poly(ethylene oxide)	43-45	
copper (dry)	44	
aluminum (dry)	45	
iron (dry)	46	
nylon 6/6	45-6	
glass, soda-lime (dry)	47	
silica, fused	78	
titanium dioxide (anatase)	91	
ferric oxide	107	
tin oxide	111	

**Note:** Critical surface tensions for silanes refer to smooth treated surfaces.

# Partition, Orientation and Self-Assembly in Bonded Phases

## Chromatography

Octadecyl, cyanopropyl and branched tricocyl silanes provide bonded phases for liquid chromatography. Reverse-phase thin-layer chromatography can be accomplished by treating plates with dodecyltrichlorosilane.

## Liquid Crystal Displays

The interphase can also impose orientation of the bulk phase. In liquid crystal displays, clarity and permanence of image are enhanced if the display can be oriented parallel or perpendicular to the substrate. The use of surfaces treated with octadecyl(3-(trimethoxysilyl)propyl) ammonium chloride (perpendicular) or methylaminopropyl-trimethoxysilane (parallel) has eliminated micromachining operations. The oriented crystalline domains often observed in reinforced nylons have also been attributed to orientation effects of the silane in the interphase.

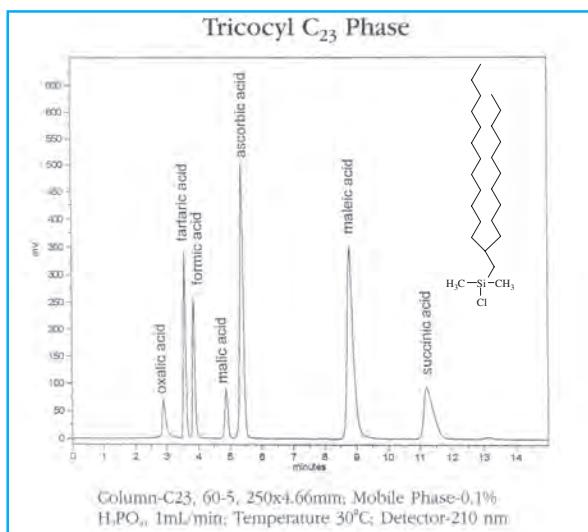
## Self-Assembled Monolayers (SAMs)

A Self-Assembled Monolayer (SAM) is a one molecule thick layer of material that bonds to a surface in an ordered way as a result of physical or chemical forces during a deposition process. Silanes can form SAMs by solution or vapor phase deposition processes. Most commonly, chlorosilanes or alkoxy silanes are used and once deposition occurs a chemical (oxane) bond forms with the surface rendering a permanent modification of the substrate. Applications for SAMs include micro-contact printing, soft lithography, dip-pen nanolithography, anti-stiction coatings and orientation layers involved in nanofabrication of MEMs, fluidic microassemblies, semiconductor sensors and memory devices.

Common long chain alkyl silanes used in the formation of SAMs are simple hydrocarbon, fluoroalkyl and end-group substituted silanes. Silanes with one hydrolyzeable group maintain interphase structure after deposition by forming a single oxane bond with the substrate. Silanes with three hydrolyzeable groups form siloxane (silsesquioxane) polymers after deposition, bonding both with each other as well as the substrate. For non-oxide metal substrates, silyl hydrides may be used, reacting with the substrate by a dehydrogenative coupling.

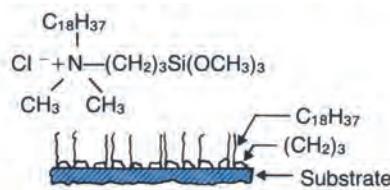
The perpendicular orientation of silanes with  $C_{10}$  or greater length can be utilized in micro-contact printing and other soft lithography methods. Here the silane may effect a simple differential adsorption, or if functionalized have a direct sensor effect.

Normal Phase HPLC of Carboxylic Acids with a  $C_{23}$ -Silane Bonded Phase

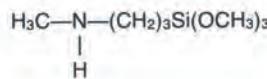


## Orientation effects of silanes for passive LCDs

OCTADECYLDIMETHYL(3-TRIMETHOXYSILYLPROPYL)AMMONIUM CHLORIDE (SIO6620.0)

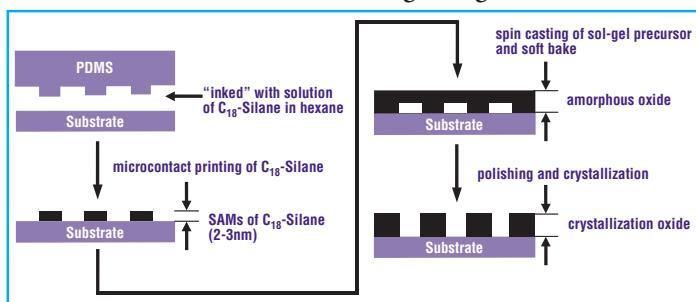


N-METHYLAMINOPROPYLTRIMETHOXYSILANE (SIM6500.0)



F. Kahn., Appl. Phys. Lett. 22, 386, 1973

## Micro-Contact Printing Using SAMs



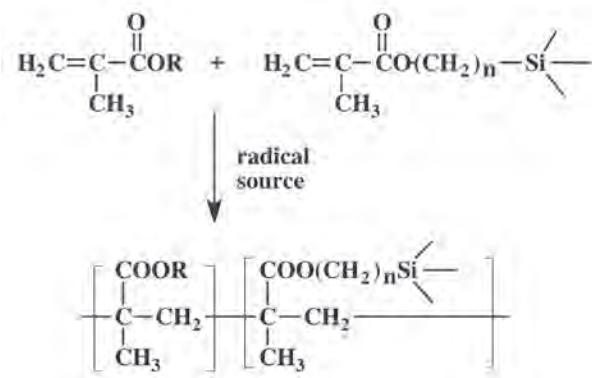
## Selecting a Silane Coupling Agent: Polymer Applications

Coupling agents find their largest application in the area of polymers. Since any silane that enhances the adhesion of a polymer is often termed a coupling agent, regardless of whether or not a covalent bond is formed, the definition becomes vague. In this discussion, the parochial outlook will be adopted, and only silanes that form covalent bonds directly to the polymer will be considered. The covalent bond may be formed by reaction with the finished polymer or copolymerized with the monomer. Thermoplastic bonding is achieved through both routes, although principally the former. Thermosets are almost entirely limited to the latter. The mechanism and performance of silane coupling agents is best discussed with reference to specific systems. The most important substrate is E-type fiberglass, which has 6-15 silanol groups per  $\text{m}\mu^2$ .

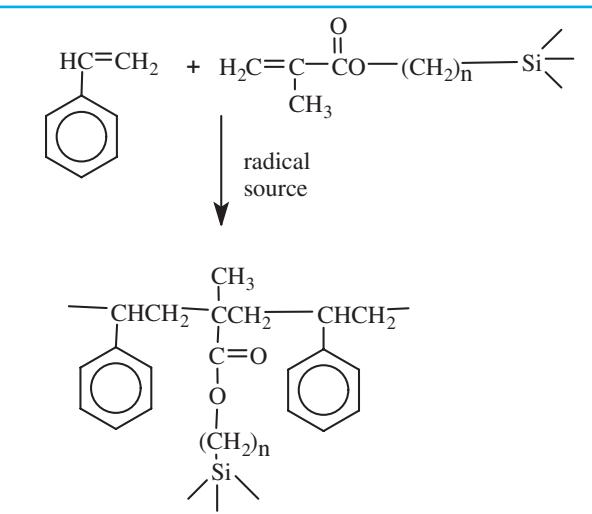
### Thermosets

**Acrylates, methacrylates and Unsaturated Polyesters,** owing to their facility for undergoing free-radical polymerization, can be modified by copolymerization with silanes that have unsaturated organic substitution. The usual coupling agents for thermoset polyesters undergo radical copolymerization in such systems. These resins, usually of loosely defined structure, often have had their viscosity reduced by addition of a second monomer, typically styrene. In general, better reinforcement is obtained when the silane monomer matches the reactivity of the styrene rather than the maleate portion of the polyester.

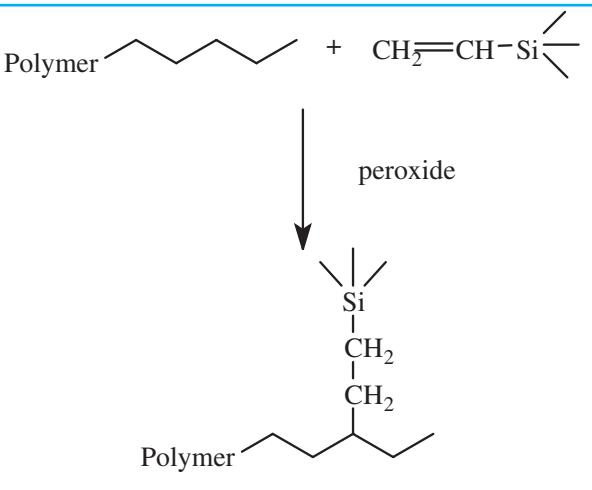
Methacrylyl and styryl functional silanes undergo addition much more readily than vinylsilanes. A direct approach to selecting the optimum silane uses the  $e$  and  $Q$  parameters of the Alfrey-Price treatment of polymerization. Here  $e$  indicates the polarity of the monomer radical that forms at the end of a growing chain, while  $Q$  represents the resonance stabilization of a radical by adjacent groups. Optimum random copolymerization is obtained from monomers with similar orders of reactivity. Vinyl functional silanes mismatch the reactionary parameters of most unsaturated polyesters. However, they can be used in direct high pressure polymerization with olefins such as ethylene, propylene and dienes.



Acrylate Coupling Reaction



Unsaturated Polyester (Styrene) Coupling Reaction



Polyethylene Graft Coupling Reaction

## Urethanes

Thermoset urethane can be effectively coupled with two types of silanes. The first type, including isocyanate functional silanes, may be used to treat the filler directly or integrally blended with the diisocyanate (TDI, MDI, etc.) prior to cure. Amine and alkanolamine functional silanes, on the other hand, are blended with the polyol rather than the diisocyanate. Isocyanate functional silanes couple with the polyol. Alkanolamine functional silanes react with the isocyanate to form urethane linkages, while amine silanes react with the isocyanates to yield urea linkages. A typical application for coupled urethane system is improving bond strength with sand in abrasion-resistant, sand-filled flooring resins.

## Moisture-Cureable Urethanes

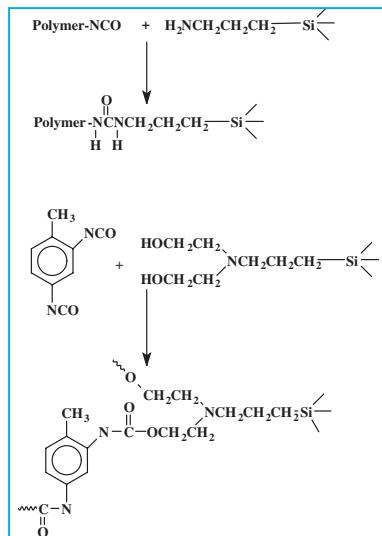
Secondary aminosilanes have the general ability to convert isocyanate functional urethane prepolymers to systems that crosslink in the presence of water and a tin catalyst. The preferred aminosilanes are secondary containing methyl, ethyl or butyl substitutions on nitrogen.

# Epoxies

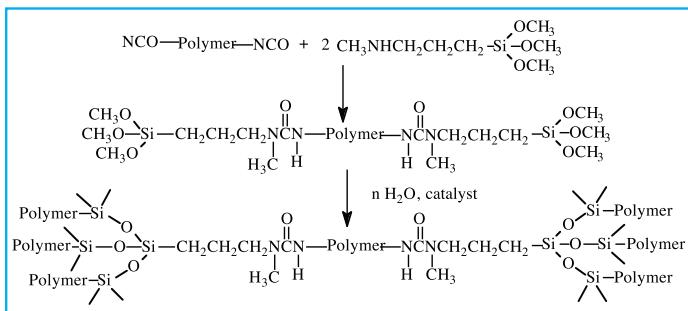
Epoxy cyclohexyl and glycidoxyl functional silanes are used to pretreat the filler or to blend with the glycidyl bisphenol-A ether. Amine functional silanes can likewise be used to pretreat the filler or to blend with the hardener portion. Treatment of fillers in epoxy adhesives improves their dispersibility and increases the mechanical properties of the cured resin. A large application area is glass cloth-reinforced epoxy laminates and prepgs in aerospace and electrical printed circuit board applications.

## Phenolics

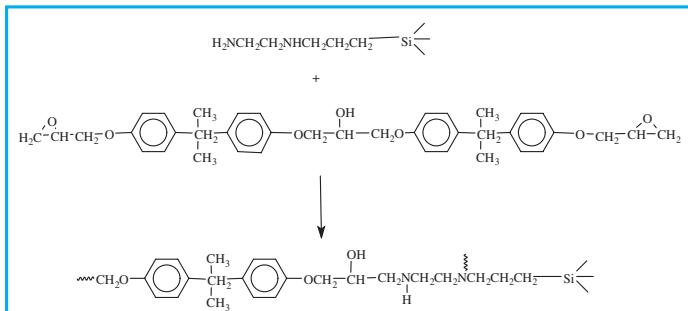
Phenolic resins are divided into base catalyzed single-step resins called resols or better known acid catalyzed two-step systems called novolaks. Although foundry and molds are formulated with resols such as aminopropyl-methyldialkoxysilanes, the commercial utilization of silanes in phenolic resins is largely limited to novolak/glass fabric laminates and molding compounds. The phenolic hydroxyl group of the resins readily react with the oxirane ring of epoxy silanes to form phenyl ether linkages. When phenolic resins are compounded with rubbers, as in the case with nitrile/phenolic or vinyl butyral/phenolic adhesives, or impact-resistant molding compounds, additional silanes, particularly mercapto-functional silanes, have been found to impart greater bond strength than silanes that couple to the phenolic portion.



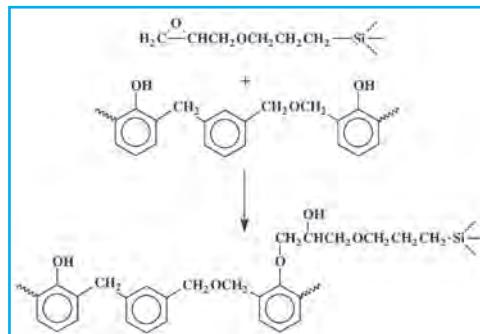
## Polyurethane Coupling Reactions



## **Moisture-Cure Silicone Polyurethane (SPUR)**



## Epoxy Coupling Reaction



## Phenolic Coupling Reaction

## Thermoplastics

Thermoplastics provide a greater challenge in promoting adhesion through silane coupling agents than thermosets. The silanes must react with the polymer and not the monomeric precursors, which not only limits avenues for coupling, but also presents additional problems in rheology and thermal properties during composite formulation. Moreover mechanical requirements here are stringently determined. Polymers that contain regular sites for covalent reactivity either in the backbone or in a pendant group include polydienes, polyvinylchloride, polyphenylene sulfide, acrylic homopolymers, maleic anhydride, acrylic, vinyl acetate, diene-containing copolymers, and halogen or chlorosulfonyl-modified homopolymers. A surprising number of these are coupled by aminoalkylsilanes. Chlorinated polymers readily form quaternary compounds while the carboxylate and sulfonate groups form amides and sulfonamides under process conditions. At elevated temperatures, the amines add across many double bonds although mercaptoalkylsilanes are the preferred coupling agents.

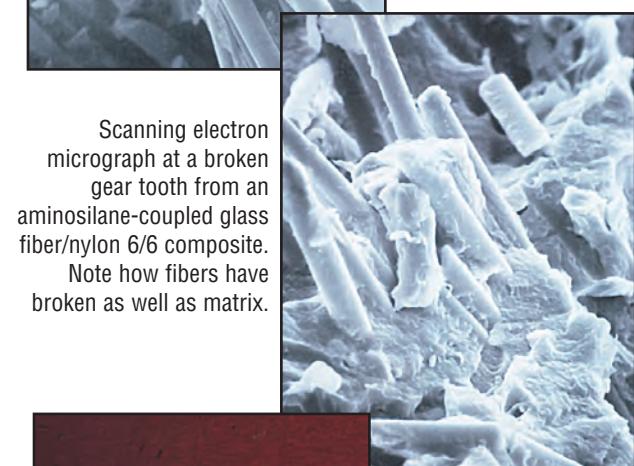
The most widely used coupling agents, the aminoalkylsilanes are the most economical, but are not necessarily the best. Epoxysilanes, for example, are successfully used with acrylic acid and maleic acid copolymers.

## Thermoplastic Condensation Polymers

The group of polymers that most closely approaches theoretical limits of composite strength does not appear to contain regular opportunities for covalent bond formation to substrate. Most of the condensation polymers including polyamides, polyesters, polycarbonates, and polysulfones are in this group. Adhesion is promoted by introducing high energy groups and hydrogen bond potential in the interphase area or by taking advantage of the relatively low molecular weight of these polymers, which results in a significant opportunity for end-group reactions. Aminoalkylsilanes, chloroalkylsilanes, and isocyanatosilanes are the usual candidates for coupling to these resins. This group has the greatest mechanical strength of the thermoplastics, allowing them to replace the cast metals in such typical uses as gears, connectors and bobbins.



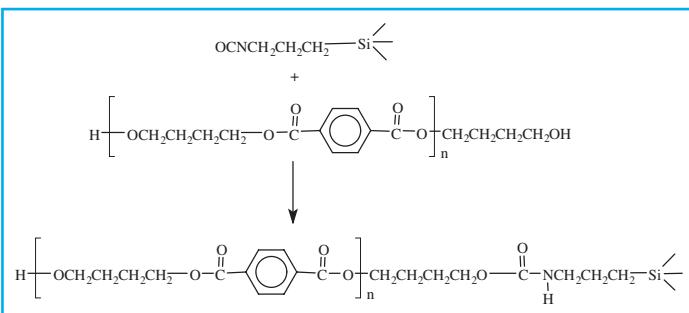
Scanning electron micrograph at a broken gear tooth from a non-coupled glass fiber/acetal composite. Note that cleavage occurred between fibers.



Scanning electron micrograph at a broken gear tooth from an aminosilane-coupled glass fiber/nylon 6/6 composite. Note how fibers have broken as well as matrix.



Chopped fiberglass strand sized with aminosilanes is a commonly used reinforcement for high temperature thermoplastics.



Thermoplastic Polyester Coupling Reaction

## Polyolefins

The polyolefins and polyethers present no direct opportunity for covalent coupling. Until recently, the principal approach for composite formulation was to match the surface energy of the filler surface, by treating it with an alkylsubstituted silane, with that of the polymer. For optimum reinforcement, preferred resins should be of high molecular weight, linear, and have low melt viscosity. Approaches to improved composite strength have been through compatibility with long-chain alkylsilanes or aminosilanes. Far more effective is coupling with vinyl or methacryloxy groups, particularly if additional coupling sites are created in the resin by addition of peroxides. Dicumyl peroxide and bis(*t*-butylperoxy) compounds at levels of 0.15% to 0.25% have been introduced into polyethylene compounded with vinylsilane-treated glass fibers for structural composites or vinylsilane-treated clay for wire insulation. Increases of 50% in tensile and flexural properties have been observed in both cases when compared to the same silane systems without peroxides.

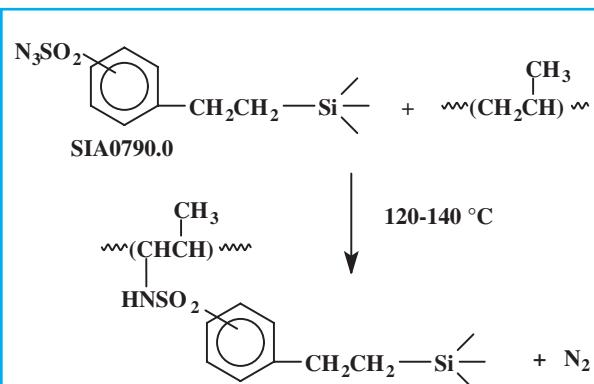
Another approach for coupling polypropylene and polyethylene is through silylsulfonylazides. Unlike azide bound to silicon, sulfonyl azides decompose above 150°C to form a molecule of nitrogen and a reactive nitrene that is capable of insertion into carbon-hydrogen bonds, forming sulfonamides, into carbon-carbon double bonds, forming triazoles, and into aromatic bonds, forming sulfonamides. Fillers are treated first with the silane and then the treated filler is fluxed rapidly with polymer melt.

One of the more innovative ways of modifying the surfaces of polyolefins is to apply a multipodal oligomeric coupling agent, such as SSP-055, SSP-056, SSP-058 and SSP-255. Such oligomers provide better adhesion to polyolefins and still have the linking effect of silane dipodal chemistry in attaching to surfaces. The olefin based backbones provide great compatibility with all hydrophobic olefins as well as elastomers of various types.

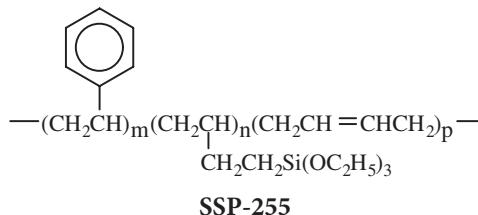
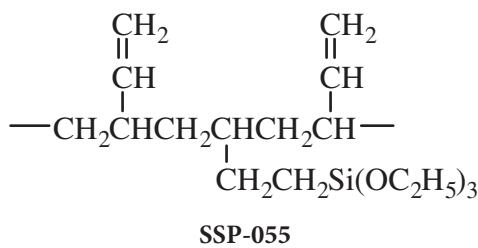
Finally, an oxygen plasma treatment prior to applying silane coupling agents produces hydroxyl radicals on a polyolefin surface. These hydroxyl radicals provide good linkage sites for any silane coupling agent to link onto the polyolefin surface, and this opens a larger range of applicable silanes.



Vinylsilanes are used in PE and EPDM insulated wire and cable

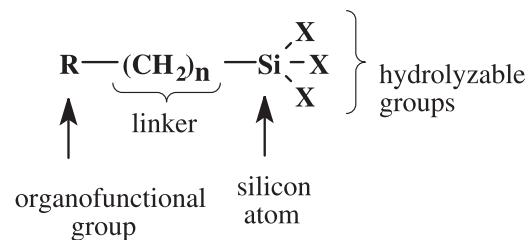


## Polypropylene Coupling Reaction

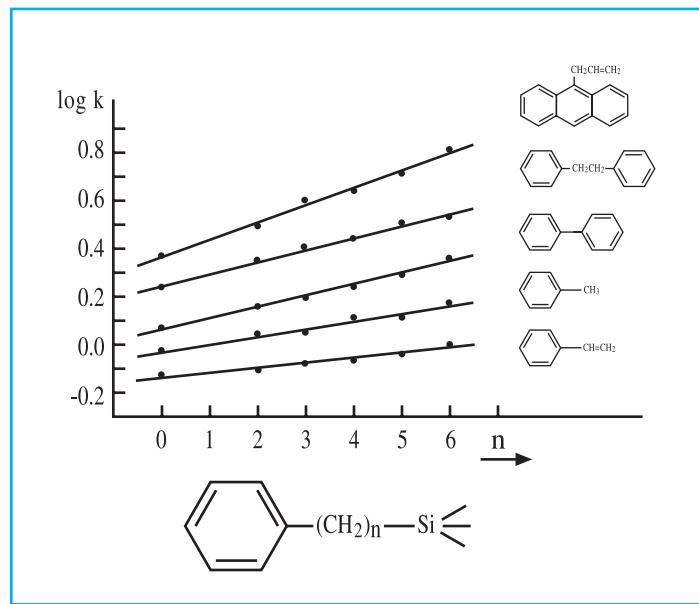


## Linker Length

An important factor in controlling the effectiveness and properties of a coupled system is the linker between the organic functionality and the silicon atom. The linker length imposes a number of physical property and reactivity limitations. The desirability of maintaining the reactive centers close to the substrate are most important in sensor applications, in heterogeneous catalysis, fluorescent materials and composite systems in which the interfacing components are closely matched in modulus and coefficient of thermal expansion. On the other hand, inorganic surfaces can impose enormous steric constraints on the accessibility of organic functional groups in close proximity. If the linker length is long the functional group has greater mobility and can extend further from the inorganic substrate. This has important consequences if the functional group is expected to react with a single component in a multi-component organic or aqueous phases found in homogeneous and phase transfer catalysis, biological diagnostics or liquid chromatography. Extended linker length is also important in oriented applications such as self-assembled monolayers (SAMs). The typical linker length is three carbon atoms, a consequence of the fact that the propyl group is synthetically accessible and has good thermal stability.

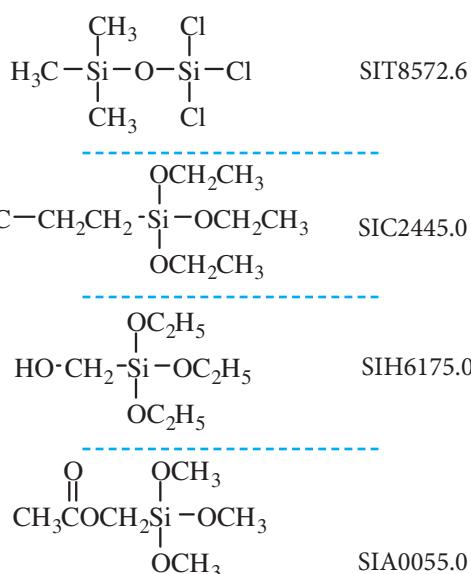


**Effect of linker length on the separation of aromatic hydrocarbons**

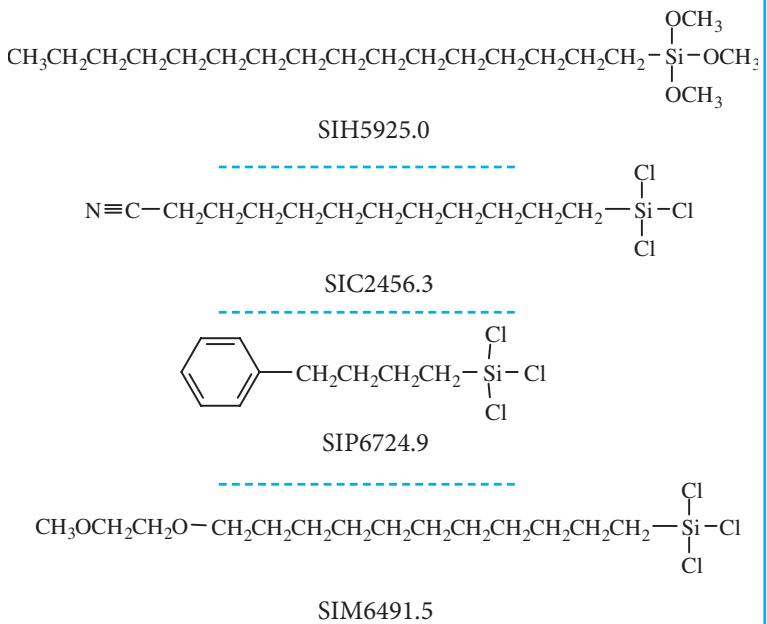


T. Den et al, in "Silanes, Surfaces, Interfaces" D. Leyden ed., 1986 p403.

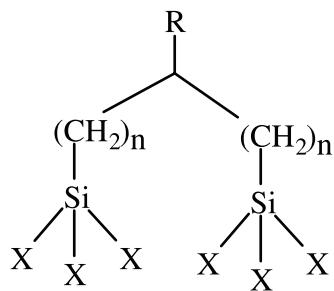
### Silanes with short linker length



### Silanes with extended linker length



## Dipodal Silanes



Dipodal silanes are a new series of adhesion promoters that have intrinsic hydrolytic stabilities up to ~10,000 times greater than conventional silanes. These products have a significant impact on substrate bonding and mechanical strength of many composite systems to include epoxy, urethane, epoxy/urethane hybrids, polysulfide, cyanoacrylate and silicone and may be utilized in water-borne, high solids and photo-active chemistries. Dipodal silanes are promising materials that have already achieved commercial success in applications as diverse as plastic optics, multilayer printed circuit boards and as adhesive primers for ferrous and nonferrous metals.

Due to the nature of the silicon molecules the silane coupling agent is a material used to resist deterioration by the intrusion of water between the polymer and the substrate. Through the modification of the interface, silane coupling agents not only provide water resistance, they are responsible for other important changes associated with composite systems. The interface region may exhibit increased strength because of the modification which forms interpenetrating polymer networks of resin and silane.

In silane surface treatment or ‘in situ’ applications, it has been the practice to hydrolyze the alkoxy groups to form silanol containing species, which are highly reactive and are responsible for hydrogen bonding with the substrate. However, it would be ideal to supply silanes with enhanced hydrolytic stability.

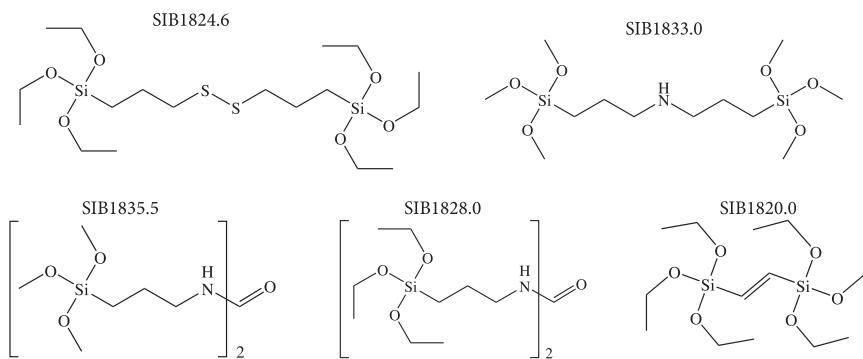
The problem with conventional silanes is that silanols self condense to form siloxanes resulting in phase separation or gelation. Through the addition of dipodal silanes, the enhanced hydrolytic stability will have significant impact on shelf life, substrate bonding and improved mechanical strength of many composite systems.

Functional dipodal silanes and combinations of non-functional dipodal silanes with functional conventional silanes have significant impact on substrate bonding and possess enabling activity in many adhesive systems, particularly primer and aqueous immersion applications. The fundamental step by which silanes provide adhesion is forming a —Si-O-X bond with the substrate. If the substrate is siliceous, the bond durability is dictated by bond dissociation of Si-O-Si. According to the equation  $\equiv\text{Si}-\text{O}-\text{Si}\equiv + \text{H}_2\text{O} \rightleftharpoons \equiv\text{Si}-\text{OH} + \equiv\text{Si}-\text{OH}$  the equilibrium for bond dissociation is  $\sim 10^{-4}$ . Recognizing that substrate hydroxyls are not subject to diffusion, the factor is closer to  $10^{-2}$ . By increasing the number of bonds by three, the equilibrium for dissociation is increased to  $\sim 10^{-6}$ . Theoretically this means that dissociative bond line failure that typically occurs in 1 month is increased to  $\sim 10,000$  months. Practically other factors influence the failure, but dipodal silanes clearly have the potential to eliminate failure of adhesive bonds during lifetime requirements of many devices. The effect is thought to be a result of both the increased crosslink density of the interphase and the resistance to hydrolysis of dipodal silanes, which is estimated at  $\sim 10,000$  times greater than conventional coupling agents. Dipodal silanes have the ability to form six bonds to a substrate compared to conventional silanes with the ability to form only three bonds to a substrate.

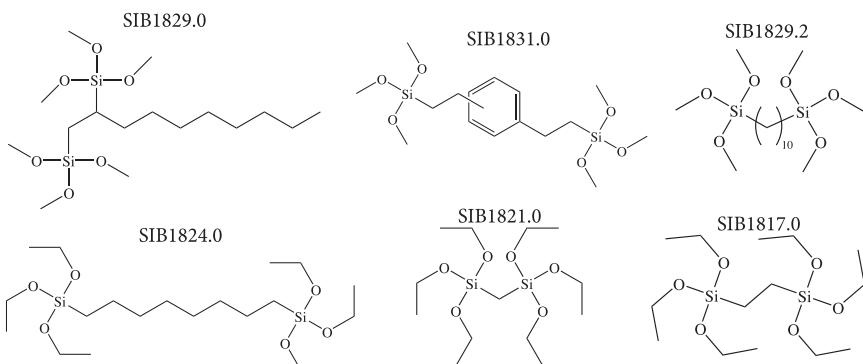
Different substrates, different conditions, varying silane combinations and finally the different applications all have an effect on dipodal silane selection. The key factors determining silane-dipodal silane mixtures are:

1. Improved wet adhesion
2. Improved chemical resistance
3. Improved processing
4. Improved coating performance  
(such as improved corrosion protection)

### Functional Dipodal Silanes



### Non-functional Dipodal Silanes



Many conventional coupling agents are frequently used in combination with 10-40% of a non-functional dipodal silane, where the conventional coupling agent provides the appropriate functionality for the application, and the non-functional dipodal silane provides increased durability. In a typical application a dipodal material such as bis(triethoxysilyl)ethane (SIB1817.0) is combined at a 1:5 to 1:10 ratio with a traditional coupling agent. It is then processed in the same way as the traditional silane coupling agent. With the addition of the non-functional dipodal silane the durability of coatings was extended when compared to the conventional silane alone.

#### Effect of dipodal $-\text{SiCH}_2\text{CH}_2\text{Si}-$ on the bond strength of a crosslinkable ethylene-vinyl acetate primer formulation

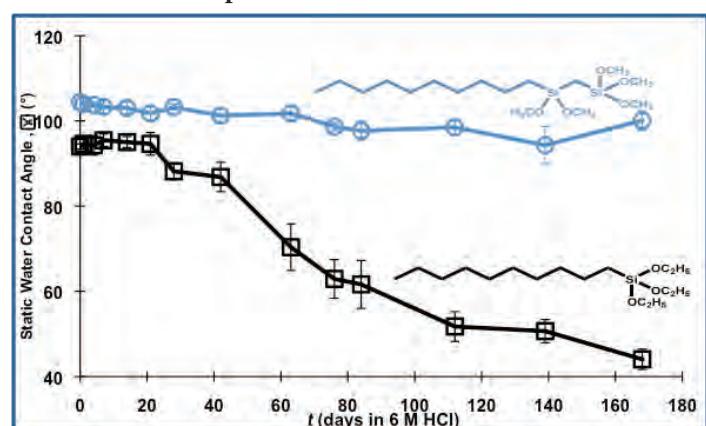
Primer on metal 10% in i-PrOH	Wet adhesion to metals (N/cm)	
	Titanium	Cold-rolled Steel
No silane	Nil	Nil
Methacryloxypropylsilane	0.35	7.0
Methacryloxypropylsilane + 10% dipodal	10.75	28.0 (cohesive failure)
90° peel strength after 2 h in 80°C water		

P. Pape et al, in Silanes and Other Coupling Agents, ed. K. Mittal, 1992, VSP, p105

Dipodal silanes are now commonly used in a wide variety of ways and in many diverse applications. Adding such dipodal silanes enhances hydrolytic stability, which impacts on increased product shelf life, ensures better substrate bonding and also leads to improved mechanical properties in coatings as well as composite applications.

1. Zazyczny et al in Adhesives & Sealants Industry, November 2008.

#### Dipodal Silane Hydrolytic Stability compared to conventional silane



B. Arkles, et al. Chemistry - A European Journal, 2014, 20, 9442.

## Cyclic Azasilanes

Efficient and high yielding, economical reactions are desired throughout chemistry. The rapid reaction of cyclic azasilanes with any and all surface hydroxyl groups is therefore of unique interest for surface modification. Volatile cyclic azasilanes afford high functional density monolayers on inorganic surfaces such as nanoparticles and other nano-featured substrates without a hydrolysis step. Furthermore, byproducts such as alcohol, HCl, and cage-like condensation products typical with the use of conventional silane coupling agents are eliminated by surface modification using cyclic azasilanes. This recently new class of silane coupling agents affords a smooth monolayer and reduces the overall waste stream as there are no longer any hazardous byproducts.

Cyclic azasilanes exploit the Si–N and Si–O bond energy differences affording a thermodynamically favorable ring-opening reaction with surface hydroxyls at ambient temperature, shown below.

Sometimes referred to as “click-chemistry on surfaces,” the ring opening occurs through the cleavage of the inherent Si–N bond in these structures, and promotes a strong covalent attachment to surface hydroxyl groups. This affords an organofunctional amine for further reactivity, depicted below, to link the inorganic surface to an organic moiety. This reaction proceeds to completion in less than a minute,

much faster compared to any conventional silane coupling agent. Importantly, the ring opening reaction depicted below also shows that the Si–OMe groups associated with traditional coupling agents remain unreacted thereby remaining available for hydrolysis and condensation reactions with other conventional silane coupling agents, should this be desired.

Cyclic azasilane coupling agents react with a wide variety of hydroxyl rich surfaces generating a range of organofunctional groups for further surface modification. Common examples of cyclic azasilanes are depicted in Figure 1. Physical properties are tabulated on page 45-46.

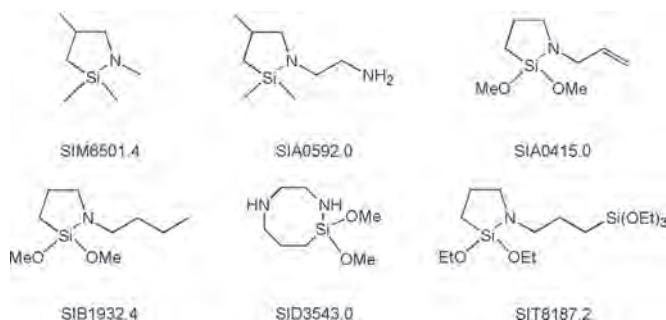
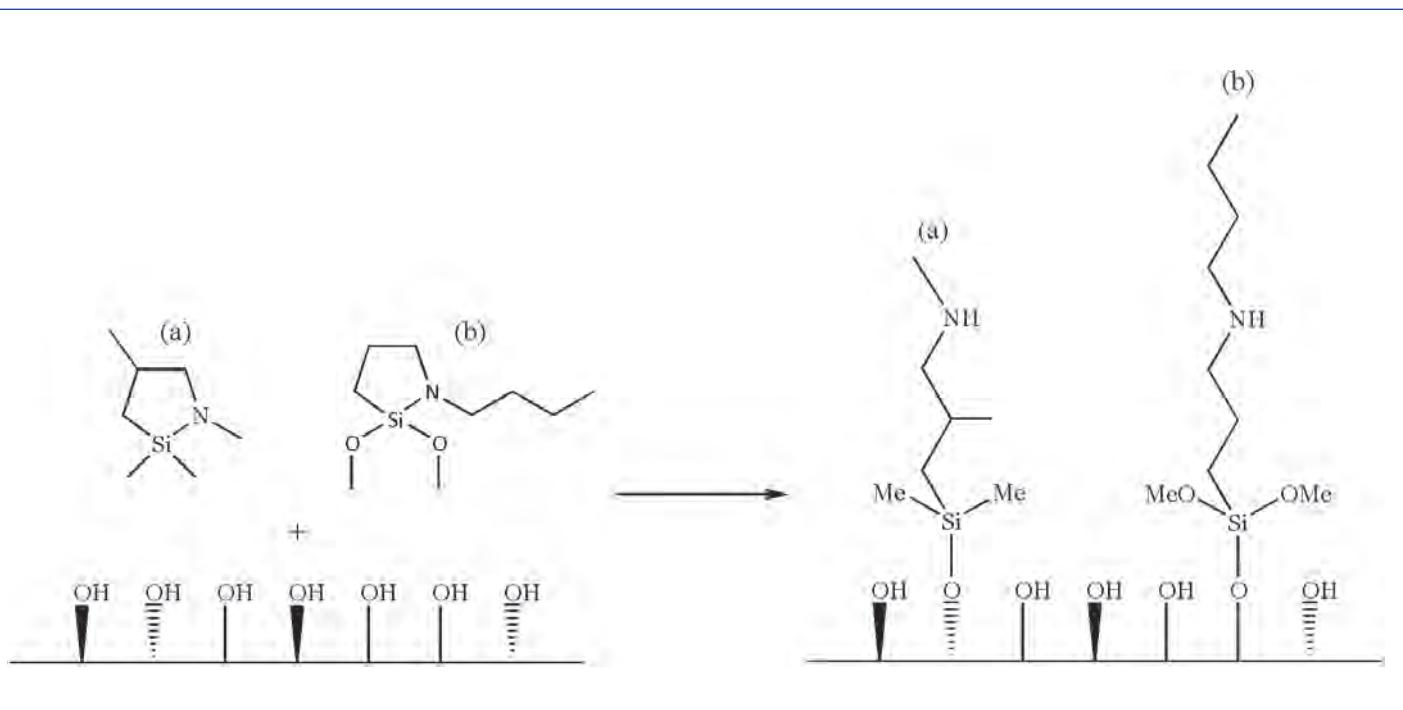


Figure 1: Examples of Cyclic azasilanes



Scheme 1: Reaction of one equivalent of a cyclic azasilane, SIM6501.4 (a), and a moisture cross-linking cyclic azasilane, SIB1932.4 (b), with a hydroxyl rich surface.

Cyclic azasilanes react with hydroxyl surfaces to afford a monolayer with amine functionality. The monolayers ranging from 2 to 5 nm, as measured by ellipsometry, and have an average roughness of 0.3 nm as measured by atomic force microscopy. Amine-modified surfaces are traditionally hydrophilic, and the characteristics of cyclic azasilane treated surfaces are consistently hydrophilic. The extent of the reaction is superior to the conventional counterparts as presented in Figure 2.

The rate of reaction with fumed silica can be monitored by diffuse reflectance FTIR as shown in Figure 3.

Consumption of the terminal hydroxyls ( $3745\text{ cm}^{-1}$ ) occurs within 58 seconds of addition of the cyclic azasilane solution, while the C-H stretching vibrations of the  $\text{Si(OMe)}_2$  remain at  $2864\text{ cm}^{-1}$ , indicating the hydrolysis of these groups, typical of conventional silane coupling agents, remain unaffected in this case, where the initial reaction is solely the breaking of the Si-N bond of the ring by the terminal surface hydroxyl groups. Additional information regarding this class of silane coupling agents can be found in the references below.

1. B. Arkles et al in "Silanes and Other Coupling Agents, Vol. 3," K. Mittal (Ed.) VSP-Brill, 2004, p 179.
2. M. Vedamuthu et al, J. Undergrad. Chem. Res., 1, 5, 2002
3. D. Brandhuber et al, J. Mater. Chem., 2005
4. Su, K. et al. U.S. Patent Appl. 2012 2672,790, 2012

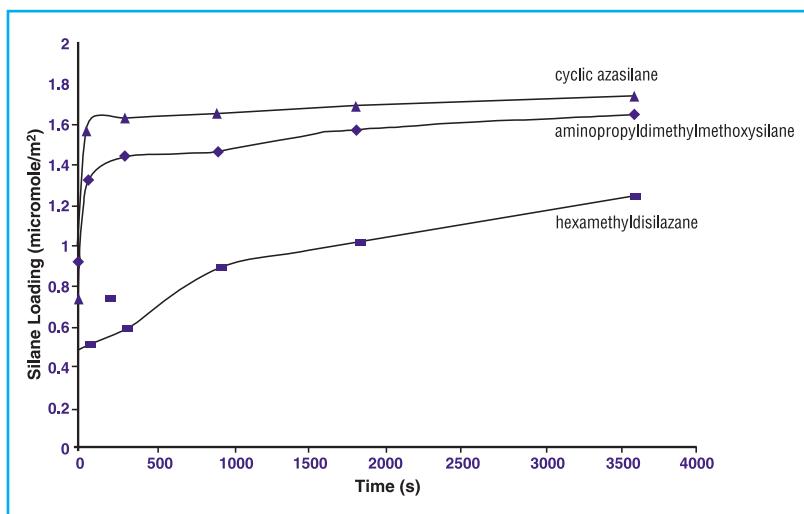


Figure 2: Extent of reaction of organosilanes with fumed silica.

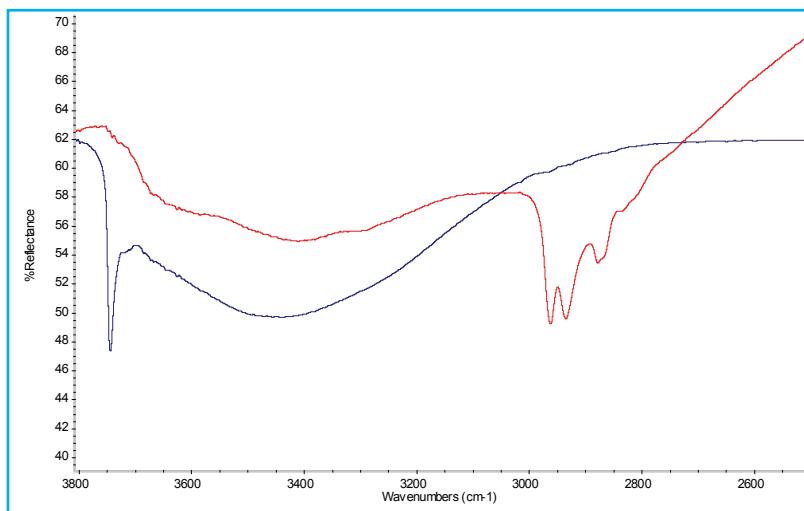
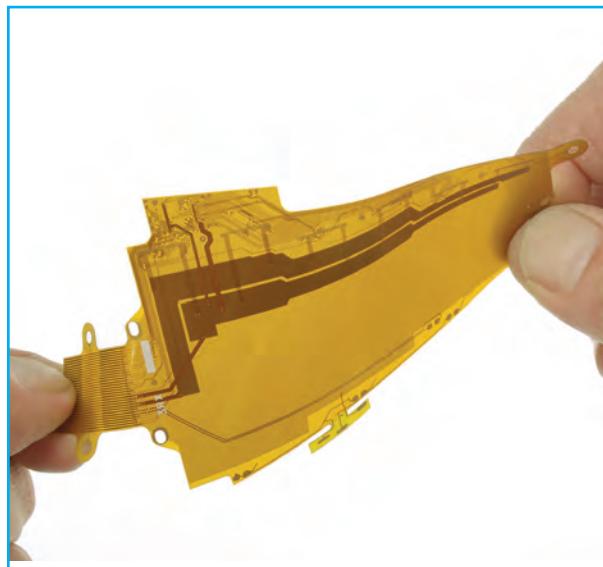
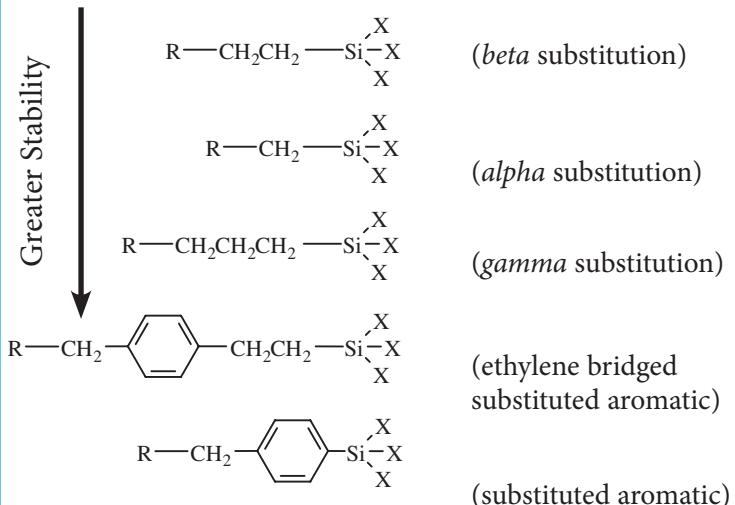


Figure 3: DRIFT of untreated silica (blue) and SIB1932.4 treated silica (red) after 56 sec.

## Thermal Stability of Silane Coupling Agents

The general order of thermal stability for silane coupling agents is depicted. Most commercial silane coupling agents have organic functionality separated from the silicon atom by three carbon atoms and are referred to as gamma-substituted silanes. The gamma-substituted silanes have sufficient thermal stability to withstand short-term process conditions of 350°C and long-term continuous exposure of 160°C. In some applications gamma-substituted silanes have insufficient thermal stability or other system requirements that can eliminate them from consideration. In this context, some comparative guidelines are provided for the thermal stability of silanes. Thermogravimetric Analysis (TGA) data for hydrolysates may be used for bench-marking. The specific substitution also plays a significant role in thermal stability. Electron withdrawing substitution reduces thermal stability, while electropositive groups enhance thermal stability.

### Relative Thermal Stability of Silanes



Flexible multi-layer circuit boards for cell phones utilize polyimide films coupled w/chloromethylaromatic silanes.

### Thermal Stability of Silanes

SIA0025.0	$\text{CH}_3\text{COCH}_2\text{CH}_2\text{Si}(\text{OC}_2\text{H}_5)_3$	220°
SIC2271.0	$\text{ClCH}_2\text{CH}_2\text{CH}_2\text{Si}(\text{OCH}_3)_3$	360°
SIM6487.4	$\text{H}_2\text{C}=\overset{\text{O}}{\underset{\text{CH}_3}{\text{C}}} \text{COCH}_2\text{CH}_2\text{CH}_2\text{Si}(\text{OCH}_3)_3$	395°
SIA0591.0	$\text{H}_2\text{NCH}_2\text{CH}_2\text{NHCH}_2\text{CH}_2\text{CH}_2\text{Si}(\text{OCH}_3)_3$	390°
SIA0588.0	$\text{H}_2\text{NCH}_2\text{CH}_2\text{NHCH}_2\text{C}_6\text{H}_4-\text{CH}_2\text{CH}_2\text{Si}(\text{OCH}_3)_3$	435°
SIC2295.5	$\text{ClCH}_2-\text{C}_6\text{H}_4-\text{CH}_2\text{CH}_2\text{Si}(\text{OCH}_3)_3$	495°
SIA0599.1	$\text{H}_2\text{N}-\text{C}_6\text{H}_4-\text{Si}(\text{OC}_2\text{H}_5)_3$	485°
SIT8042.0	$\text{CH}_3-\text{C}_6\text{H}_4-\text{Si}(\text{OCH}_3)_3$	530°

25% weight loss of dried hydrolysates as determined by TGA

## Aqueous Systems & Water-borne Silanes

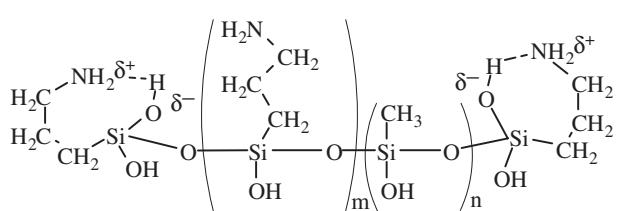
Before most surface modification processes, alkoxy silanes are hydrolyzed forming silanol-containing species. The silanol-containing species are highly reactive intermediates which are responsible for bond formation with the substrate. In principal, if silanol species were stable, they would be preferred for surface treatments. Silanols condense with other silanols or with alkoxy silanes to form siloxanes. This can be observed when preparing aqueous treatment solutions. Initially, since most alkoxy silanes have poor solubility in water, two phases are observed. As the hydrolysis proceeds, a single clear phase containing reactive silanols forms. With aging, the silanols condense forming siloxanes and the solution becomes cloudy. Eventually, as molecular weight of the siloxanes increases, precipitation occurs.<sup>1</sup>

Hydrolysis and condensation of alkoxy silanes is dependent on both pH and catalysts. The general objective in preparing aqueous solutions is to devise a system in which the rate of hydrolysis is substantially greater than the rate of condensation beyond the solubility limit of the siloxane oligomers. Other considerations are the work-time requirements for solutions and issues related to byproduct reactivity, toxicity or flammability.

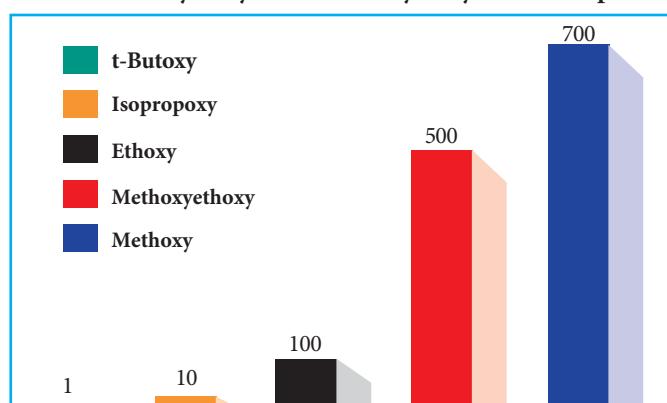
Stable aqueous solutions of silanes are more readily prepared if byproduct or additional alcohol is present in the solution since they contribute to an equilibrium condition favoring monomeric species.

Water-borne coupling agent solutions are usually free of VOCs and flammable alcohol byproducts. Most water-borne silanes can be described as hydroxyl-rich silsesquioxane copolymers. Apart from coupling, silane monomers are included to control water-solubility and extent of polymerization. Water-borne silanes act as primers for metals, additives for acrylic latex sealants and as coupling agents for siliceous surfaces.

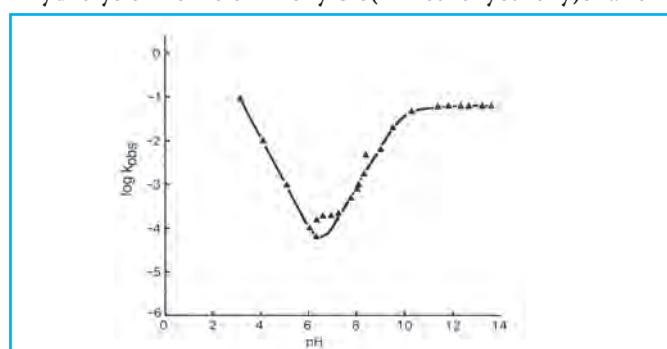
1. B. Arkles et al, "Factors contributing to the stability of alkoxy silanes in aqueous solutions", *J. Adhesion Science Technology*, 1992, 6(1), 193.



Relative Hydrolysis Rates of Hydrolyzable Groups

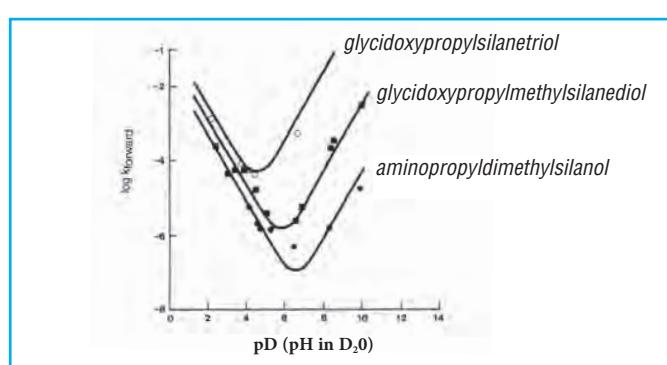


Hydrolysis Profile of Phenylbis(2-methoxyethoxy)silanol



F. Osterholtz et al in *Silanes and Other Coupling Agents* ed K. Mittal, VSP, 1992, p119

Profile for Condensation of Silanols to Disiloxanes



E. Pohl et al in *Silanes Surfaces and Interfaces* ed., D. Leyden, Gordon and Breach, 1985, p481.

Water-borne Silsesquioxane Oligomers

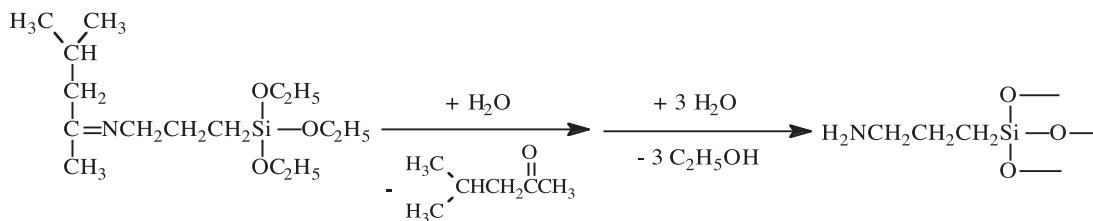
Code	Functional Group	Mole %	Molecular Weight	Weight % in solution
WSA-7011	Aminopropyl	65-75	250-500	25-28
WSA-9911	Aminopropyl	100	270-550	22-25
WSA-7021	Aminoethylaminopropyl	65-75	370-650	25-28
WSAV-6511	Aminopropyl, Vinyl	60-65	250-500	25-28
WSAF-1511	Aminopropyl, Fluoroalkyl	15-20	—	15-20

## Masked Silanes - Latent Functionality

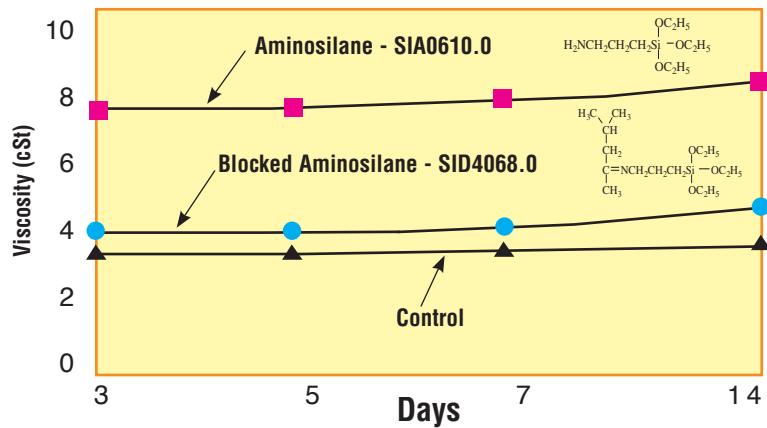
Maximum bond strength in some adhesion and bonding systems requires that the organic functionality of a silane coupling agent becomes available during a discrete time period of substrate - matrix contact. Examples are epoxy adhesives in which reaction of the silane with the resin increases viscosity of an adhesive to the extent that substrate wet-out is inhibited and pretreated fillers for composites which can react prematurely with moisture before melt compounding or vulcanization. A general approach is to mask the organic functionality of the silane which converts it to a storage-stable form and then to trigger the demasking with moisture, or heat concomitant with bonding or composite formation.

### Masked Silanes - Moisture Triggered

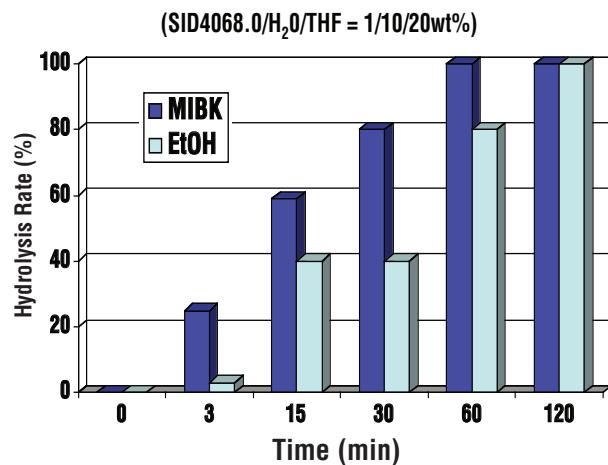
Single-component liquid-cure epoxy adhesives and coatings employ dimethylbutylidene blocked amino silanes. These materials show excellent storage stability in resin systems, but are activated by moisture provided by water adsorbed on substrate surfaces or from humidity. Deblocking begins in minutes and is generally complete within two hours in sections with a diffusional thickness of less than 1mm.



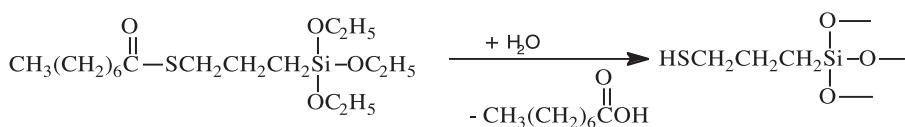
**Storage Stability of Epoxy Coating Solutions  
with blocked and unblocked aminosilanes**



**Hydrolysis of Blocked Aminosilane**

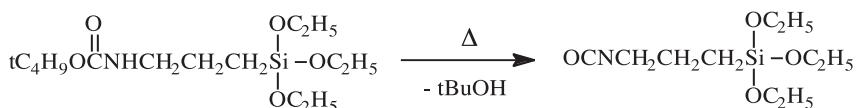


An alternative is to use the moisture adsorbed onto fillers to liberate alcohol which, in turn, demasks the organic functionality.



### Masked Silanes - Heat Triggered

Isocyanate functionality is frequently delivered to resin systems during elevated temperature bonding or melt processing steps. Demasking temperatures are typically 160-200°C.



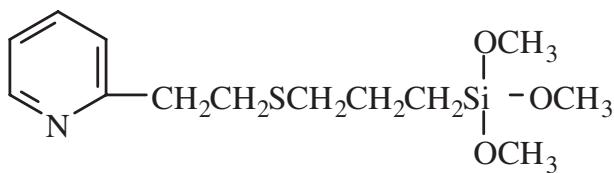
## Modification of Metal Substrates

The optimum performance of silanes is associated with siliceous substrates. While the use of silanes has been extended to metal substrates, both the effectiveness and strategies for bonding to these less-reactive substrates vary. Four approaches of bonding to metals have been used with differing degrees of success. In all cases, selecting a dipodal or polymeric silane is preferable to a conventional trialkoxy silane.

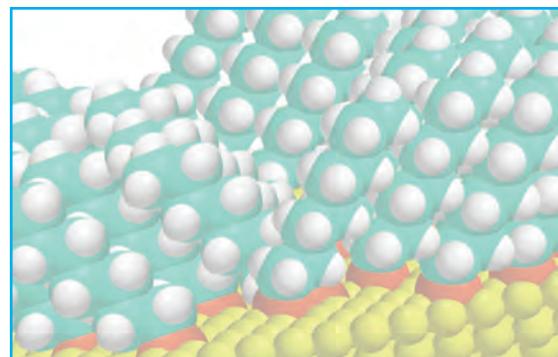
**Metals that form hydrolytically stable surface oxides, e.g. aluminum, tin, titanium.** These oxidized surfaces tend to have sufficient hydroxyl functionality to allow coupling under the same conditions applied to the siliceous substrates discussed earlier.

**Metals that form hydrolytically or mechanically unstable surface oxides, e.g. iron, copper, zinc.** These oxidized surfaces tend to dissolve in water leading to progressive corrosion of the substrate or form a passivating oxide layer without mechanical strength. The successful strategies for coupling to these substrates typically involves two or more silanes. One silane is a chelating agent such as a diamine, polyamine or polycarboxylic acid. A second silane is selected which has a reactivity with the organic component and reacts with the first silane by co-condensation. If a functional dipodal or polymeric silane is not selected, 10-20% of a non-functional dipodal silane typically improves bond strength.

**Metals that do not readily form oxides, e.g. nickel, gold and other precious metals.** Bonding to these substrates requires coordinative bonding, typically a phosphine, sulfur (mercapto), or amine functional silane. A second silane is selected which has a reactivity with the organic component. If a functional dipodal or polymeric silane is not selected, 10-20% of a non-functional dipodal silane typically improves bond strength.



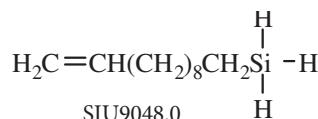
SIP6926.2



Octylsilane adsorbed on titanium

figure courtesy of  
M. Banaszak-Holl

**Metals that form stable hydrides, e.g. titanium, zirconium, nickel.** In a significant departure from traditional silane coupling agent chemistry, the ability of certain metals to form so-called amorphous alloys with hydrogen is exploited in an analogous chemistry in which hydride functional silanes adsorb and then react with the surface of the metal.<sup>1</sup> Most silanes of this class possess only simple hydrocarbon substitution such as octylsilane. However they do offer organic compatibility and serve to markedly change wet-out of the substrate. Both hydride functional silanes and treated metal substrates will liberate hydrogen in the presence of base or with certain precious metals such as platinum and associated precautions must be taken.



Coupling Agents for Metals*			
Metal	Class	Screening	Candidates
Copper	Amine	SSP-060	SIT8398.0
Gold	Sulfur	SIT7908.0	SIP6926.2
	Phosphorus	SID4558.0	SIB1091.0
Iron	Amine	SIB1834.0	WSA-7011
	Sulfur	SIB1824.6	SIM6476.0
Tin	Amine	SIB1835.5	
Titanium	Epoxy	SIG5840.0	SIE6668.0
	Hydride	SIU9048.0	
Zinc	Amine	SSP-060	SIT8398.0
	Carboxylate	SIT8402.0	SIT8192.6

\*These coupling agents are almost always used in conjunction with a second silane with organic reactivity or a dipodal silane.

1. B. Arkles et al J. Adhesion Science Technol, 2012, 26, 41.

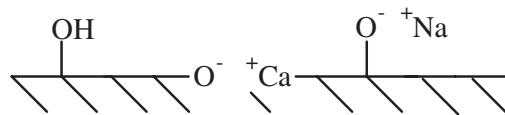
## Difficult Substrates

Silane coupling agents are generally recommended for applications in which an inorganic surface has hydroxyl groups and the hydroxyl groups can be converted to stable oxane bonds by reaction with the silane. Substrates such as calcium carbonate, copper and ferrous alloys, and high phosphate and sodium glasses are not recommended substrates for silane coupling agents. In cases where a more appropriate technology is not available a number of strategies have been devised which exploit the organic functionality, film-forming and crosslinking properties of silane coupling agents as the primary mechanism for substrate bonding in place of bonding through the silicon atom. These approaches frequently involve two or more coupling agents.

Calcium carbonate fillers and marble substrates do not form stable bonds with silane coupling agents. Applications of mixed silane systems containing a dipodal silane or tetraethoxysilane in combination with an organofunctional silane frequently increases adhesion. The adhesive mechanism is thought to be due to the low molecular weight and low surface energy of the silanes which allows them initially to spread to thin films and penetrate porous structures followed by the crosslinking which results in the formation of a silica-rich encapsulating network. The silica-rich encapsulating network is then susceptible to coupling chemistry comparable to siliceous substrates. Marble and calciferous substrates can also benefit from the inclusion of anhydride-functional silanes which, under reaction conditions, form dicarboxylates that can form salts with calcium ions.

Metals and many metal oxides can strongly adsorb silanes if a chelating functionality such as diamine or dicarboxylate is present. A second organofunctional silane with reactivity appropriate to the organic component must be present. Precious metals such as gold and rhodium form weak coordination bonds with phosphine and mercaptan functional silanes.

High phosphate and sodium content glasses are frequently the most frustrating substrates. The primary inorganic constituent is silica and would be expected to react readily with silane coupling agents. However alkali metals and phosphates not only do not form hydrolytically stable bonds with silicon, but, even worse, catalyze the rupture and redistribution of silicon-oxygen bonds. The first step in coupling with these substrates is the removal of ions from the surface by extraction with deionized water. Hydrophobic dipodal or multipodal silanes are usually used in combination with organofunctional silanes. In some cases polymeric silanes with multiple sites for interaction with the substrate are used. Some of these, such as the polyethylenimine functional silanes can couple to high sodium glasses in an aqueous environment.



Substrates with low concentrations of non-hydrogen bonded hydroxyl groups, high concentrations of calcium, alkali metals or phosphates pose challenges for silane coupling agents.

### Removing Surface Impurities

Eliminating non-bonding metal ions such as sodium, potassium and calcium from the surface of substrates can be critical for stable bonds. Substrate selection can be essential. Colloidal silicas derived from tetraethoxysilane or ammonia sols perform far better than those derived from sodium sols. Bulk glass tends to concentrate impurities on the surface during fabrication. Although sodium concentrations derived from bulk analysis may seem acceptable, the surface concentration is frequently orders of magnitude higher. Surface impurities may be reduced by immersion in 5% hydrochloric acid for 4 hours, followed by a deionized water rinse, and then immersion in deionized water overnight followed by drying.

Oxides with high isoelectric points can adsorb carbon dioxide, forming carbonates. These can usually be removed by a high temperature vacuum bake.

### Increasing Hydroxyl Concentration

Hydroxyl functionalization of bulk silica and glass may be increased by immersion in a 1:1 mixture of 50% aqueous sulfuric acid : 30% hydrogen peroxide for 30 minutes followed by rinses in D.I. water and methanol and then air drying. Alternately, if sodium ion contamination is not critical, boiling with 5% aqueous sodium peroxodisulfate followed by acetone rinse is recommended<sup>1</sup>.

1. K. Shirai et al, J. Biomed. Mater. Res. 53, 204, 2000.

### Catalyzing Reactions in Water-Free Environments

Hydroxyl groups without hydrogen bonding react slowly with methoxy silanes at room temperature. Ethoxy silanes are essentially non-reactive. The methods for enhancing reactivity include transesterification catalysts and agents which increase the acidity of hydroxyl groups on the substrate by hydrogen bonding. Transesterification catalysts include tin compounds such as dibutylacetoxytin and titanates such as titanium isopropoxide. Incorporation of transesterification catalysts at 2-3 weight % of the silane effectively promotes reaction and deposition in many instances. Alternatively, amines can be premixed with solvents at 0.01-0.5 weight % based on substrate prior or concurrent to silane addition. Volatile primary amines such as butylamine can be used, but are not as effective as tertiary amines such as benzyldimethylamine or diamines such as ethylenediamine. The more effective amines, however, are more difficult to remove after reaction<sup>1</sup>.

1. S. Kanan et al, Langmuir, 18, 6623, 2002.

### Hydroxylation by Water Plasma & Steam Oxidation

Various metals and metal oxides including silicon and silicon dioxide can achieve high surface concentrations of hydroxyl groups after exposure to H<sub>2</sub>O/O<sub>2</sub> in high energy environments including steam at 1050°C and water plasma<sup>1</sup>.

1. N. Alcantar et al, in "Fundamental & Applied Aspects of Chemically Modified Surfaces" ed. J. Blitz et al, 1999, Roy. Soc. Chem., p212.

## Applying Silanes

**Deposition from aqueous alcohol** solutions is the most facile method for preparing silylated surfaces. A 95% ethanol-5% water solution is adjusted to pH 4.5-5.5 with acetic acid. Silane is added with stirring to yield a 2% final concentration. Five minutes should be allowed for hydrolysis and silanol formation. Large objects, e.g. glass plates, are dipped into the solution, agitated gently, and removed after 1-2 minutes. They are rinsed free of excess materials by dipping briefly in ethanol. Particles, e.g. fillers and supports, are silylated by stirring them in solution for 2-3 minutes and then decanting the solution. The particles are usually rinsed twice briefly with ethanol. Cure of the silane layer is for 5-10 mins at 110°C or 24 hours at room temperature (<60% relative humidity).

**Deposition from aqueous solution** is employed for most commercial fiberglass systems. The alkoxy silane is dissolved at 0.5-2.0% concentration in water. For less soluble silanes, 0.1% of a non-ionic surfactant is added prior to the silane and an emulsion rather than a solution is prepared. The solution is adjusted to pH 5.5 with acetic acid. The solution is either sprayed onto the substrate or employed as a dip bath. Cure is at 110-120°C for 20-30 minutes. Stability of aqueous silane solutions varies from 2-12 hours for the simple alkyl silanes. Poor solubility parameters limit the use of long chain alkyl and aromatic silanes by this method. Distilled water is not necessary, but water containing fluoride ions must be avoided.

**Bulk deposition onto powders**, e.g. filler treatment, is usually accomplished by a spray-on method. It assumes that the total amount of silane necessary is known and that sufficient adsorbed moisture is present on the filler to cause hydrolysis of the silane. The silane is prepared as a 25% solution in alcohol. The powder is placed in a high intensity solid mixer, e.g. twin cone mixer with intensifier. The methods are most effective. If the filler is dried in trays, care must be taken to avoid wicking or skinning of the top layer of treated material by adjusting heat and air flow.

Figure 1: Vacuum tumble dryers can be used for slurry treatment of powders.



Figure 2: Lab-scale Reactor for slurry treatment of powders. Separate filtration and drying steps are required.



Figure 3: Twin-cone blenders with intensive mixing bars are used for bulk deposition of silanes onto powders.



## Applying Silanes

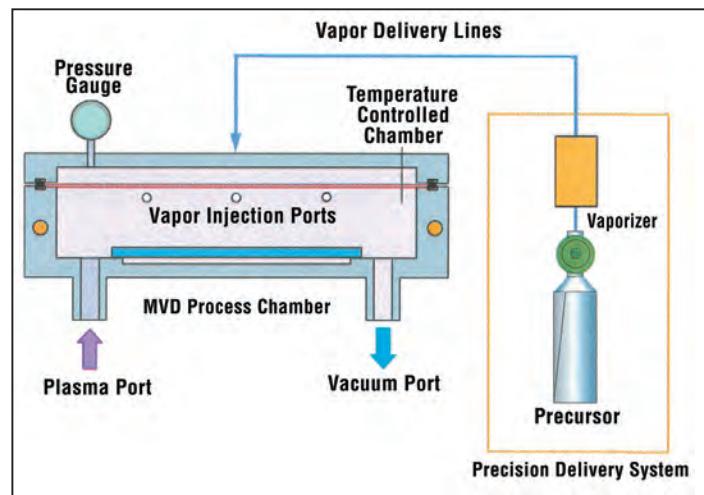
**Integral blend methods** are used in composite formulations. In this method the silane is used as a simple additive. Composites can be prepared by the addition of alkoxysilanes to dry-blends of polymer and filler prior to compounding. Generally 0.2 to 1.0 weight percent of silane (of the total mix) is dispersed by spraying the silane in an alcohol carrier onto a preblend. The addition of the silane to non-dispersed filler is not desirable in this technique since it can lead to agglomeration. The mix is dry-blended briefly and then melt compounded. Vacuum devolatilization of byproducts of silane reaction during melt compounding is necessary to achieve optimum properties. Properties are sometimes enhanced by adding 0.5-1.0% of tetrabutyl titanate or benzylidimethylamine to the silane prior to dispersal.

**Anhydrous liquid phase deposition** of chlorosilanes, methoxysilanes, aminosilanes and cyclic azasilanes is preferred for small particles and nano-featured substrates. Toluene, tetrahydrofuran or hydrocarbon solutions are prepared containing 5% silane. The mixture is refluxed for 12-24 hours with the substrate to be treated. It is washed with the solvent. The solvent is then removed by air or explosion-proof oven drying. No further cure is necessary. This reaction involves a direct nucleophilic displacement of the silane chlorines by the surface silanol. If monolayer deposition is desired, substrates should be predried at 150°C for 4 hours. Bulk deposition results if adsorbed water is present on the substrate. This method is cumbersome for large scale preparations and rigorous controls must be established to ensure reproducible results. More reproducible coverage is obtained with monochlorosilanes.

**Chlorosilanes** can also be deposited from alcohol solution. Anhydrous alcohols, particularly ethanol or isopropanol are preferred. The chlorosilane is added to the alcohol to yield a 2-5% solution. The chlorosilane reacts with the alcohol producing an alkoxysilane and HCl. Progress of the reaction is observed by halt of HCl evolution. Mild warming of the solution (30-40°C) promotes completion of the reaction. Part of the HCl reacts with the alcohol to produce small quantities of alkyl halide and water. The water causes formation of silanols from alkoxysilanes. The silanols condense on the substrate. Treated substrates are cured for 5-10 mins. at 110°C or allowed to stand 24 hours at room temperature.

**Vapor Phase Deposition** Silanes can be applied to substrates under dry aprotic conditions by chemical vapor deposition methods. These methods favor monolayer deposition. Although under proper conditions almost all silanes can be applied to substrates in the vapor phase, those with vapor pressures >5 torr at 100°C have achieved the greatest number of commercial applications. In closed chamber designs, substrates are supported above or adjacent to a silane reservoir and the reservoir is heated to sufficient temperature to achieve 5mm vapor pressure. Alternatively, vacuum can be applied until silane evaporation is observed. In still another variation the silane can be prepared as a solution in toluene, and the toluene brought to reflux allowing sufficient silane to enter the vapor phase through partial pressure contribution. In general, substrate temperature should be maintained above 50° and below 120° to promote reaction. Cyclic azasilanes deposit the quickest- usually less than 5 minutes. Amine functional silanes usually deposit rapidly (within 30 minutes) without a catalyst. The reaction of other silanes requires extended reaction times, usually 4-24 hours. The reaction can be promoted by addition of catalytic amounts of amines.

Figure 4: Apparatus for vapor phase silylation.



## Applying Silanes

**Spin-On** Spin-On applications can be made under hydrolytic conditions which favor maximum functionalization and polylayer deposition or dry conditions which favor monolayer deposition. For hydrolytic deposition 2-5% solutions are prepared (see deposition from aqueous alcohol). Spin speed is low, typically 500 rpm. Following spin-deposition a hold period of 3-15 minutes is required before rinse solvent. Dry deposition employs solvent solutions such as methoxypropanol or ethyleneglycol monoacetate (EGMA). Aprotic systems utilize toluene or THF. Silane solutions are applied at low speed under a nitrogen purge. If strict monolayer deposition is preferred, the substrate should be heated to 50°. In some protocols, limited polylayer formation is induced by spinning under an atmospheric ambient with 55% relative humidity.

**Spray Application** Formulations for spray applications vary widely depending on end-use. They involve alcohol solutions and continuously hydrolyzed aqueous solutions employed in architectural and masonry applications. The continuous hydrolysis is effected by feeding mixtures of silane containing an acid catalyst such as acetic acid into a water stream by means of a venturi (aspirator). Stable aqueous solutions (see water-borne silanes), mixtures of silanes with limited stability (4-8 hours) and emulsions are utilized in textile and fiberglass applications. Complex mixtures with polyvinyl acetates or polyesters enter into the latter applications as sizing formulations.

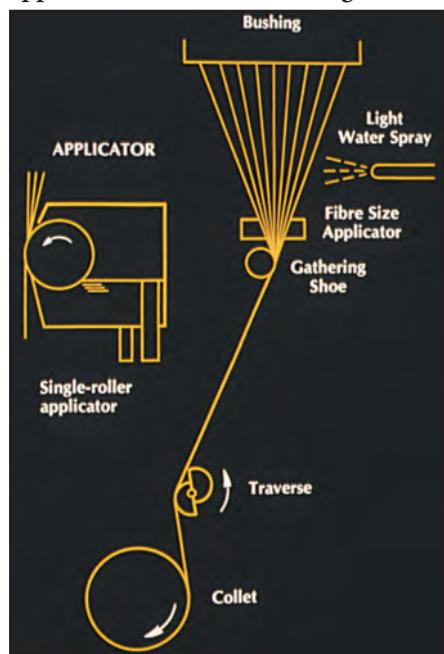
Figure 5: Spin-coater for deposition on wafers.



Figure 6:  
Spray application of silanes on large structures.



Figure 7: Spray & contact roller application of silanes on fiberglass.





## Acrylate-silanes in dental restorative composites.

# Silane Coupling Agents for Thermosets

## Selection Chart

		Coupling Agent Class	Suggestions for Primary Screening	
Acrylate, UV cure		Acrylate Vinyl/Olefin	SIA0200.0 SIS6964.0	SIM6487.4
Diallylphthalate		Amine Vinyl/Olefin Dipodal	SIA0591.0 SIS6964.0 SIB1824.5	SIA0610.0
Epoxy		Amine Anhydride Epoxy Dipodal	SIA0591.0 SIT8192.6 SIG5840.0 SIB1834.0	SIT8398.0
Epoxy, UV Cure		Amine Epoxy	SIA0591.0 SIE4668.0	SIT8398.0 SIE4670.0
Polyimide		Amine Halogen Dipodal	SIA0599.2 SIC2295.5 SIB1833.0	SIA0591.0 SIC2296.2
Furan		Amine Epoxy	SIA0611.0 SIG5840.0	SIA0599.0
Melamine		Amine Hydroxyl Dipodal	SIA0611.0 SIB1140.0 SIB1833.0	SIA0599.0 SIT8717.0
Parylene		Halogen Vinyl/Olefinic Dipodal	SIC2295.5 SIS6990.0 SIB1832.0	SIM6487.4 VMM-010
Phenol-formaldehyde		Amine Epoxy	SIA0611.0 SIE4670.0	SIT8187.5 SIG5840.0
Methylmethacrylate, cast		Acrylate Amine	SIM6487.4 SIB1828.0	SIA0200.0
Polyester, unsaturated		Acrylate Vinyl/Olefin	SIM6487.4 SIS6994.0	SIV9112.0
Urea-formaldehyde		Amine Hydroxyl	SIA0610.0 SIB1140.0	SIU9055.0
Urethane		Amine Isocyanate Sulfur	SIA0610.0 SII6455.0 SIM6476.0	SIM6500.0

Diamine-silanes  
couple  
polycar-  
bonate  
in CDs



## Silane Coupling Agents for Thermoplastics Selection Chart

	Coupling Agent Class	Suggestions for Primary Screening	
Polyacetal	$\left[ \text{CH}_2\text{O} \right]_n$	Vinyl/Olefin	SIS6994.0
Polyacrylate	$\left[ \begin{array}{c} \text{O} \\    \\ \text{C}-\text{OCH}_3 \\   \\ \text{CH}_2-\text{C} \\   \\ \text{H} \end{array} \right]_n$	Amine	SIU9058.0      SIA0610.0
Polyamide	$\left[ \begin{array}{c} \text{O} \\    \\ \text{NH}(\text{CH}_2)_m\text{C} \end{array} \right]_n$	Amine Dipodal Water-borne	SIA0610.0 SIB1834.1 WSA-7011      SIA0614.0 SSP-060
Polyamide-imide	$\left[ \begin{array}{c} \text{O} & \text{O} \\    &    \\ \text{N} & \text{C}_6\text{H}_4 & \text{N}-\text{R} \\    &   \\ \text{O} & \text{H} \end{array} \right]_n$	Amine Halogen	SIA0610.0 SIC2295.5
Polybutylene terephthalate	$\left[ \begin{array}{c} \text{C} & \text{O} \\    &    \\ \text{O} & \text{C}(\text{CH}_2)_m\text{O} \\    &    \\ \text{O} & \text{C} \end{array} \right]_n$	Amine Isocyanate	SIA0610.0 SII6455.0
Polycarbonate	$\left[ \begin{array}{c} \text{O} & \text{CH}_3 \\   &   \\ \text{O} & \text{C} & \text{O} \\   &   \\ \text{O} & \text{C} & \text{O} \\   &   \\ \text{O} & \text{C} & \text{O} \end{array} \right]_n$	Amine	SIA0591.0      SIA0610.0
Polyether ketone	$\left[ \begin{array}{c} \text{O} & \text{O} \\   &   \\ \text{O} & \text{C} \end{array} \right]_n$	Amine Dipodal	SIA0591.0 SIT8717.0
Polyethylene	$\left[ \text{CH}_2\text{CH}_2 \right]_n$	Amine Vinyl/Olefin	SIA0591.0 SSP-055      SIT8398.0 SIV9112.0
Polyphenylene sulfide	$\left[ \begin{array}{c} \text{O} & \text{S} \\   &   \\ \text{O} & \text{S} \end{array} \right]_n$	Amine Halogen Sulfur	SIA0605.0 SIC2295.5 SIM6476.0
Polypropylene	$\left[ \begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_2-\text{CH} \end{array} \right]_n$	Acrylate Azide Vinyl/Olefin	SIM6487.4 SIA0780.0 VEE-005      SSP-055
Polystyrene	$\left[ \begin{array}{c} \text{CH}_2\text{CH} \\   \\ \text{C}_6\text{H}_5 \end{array} \right]_n$	Acrylate Dipodal	SIM6487.4 SIB1831.0
Polysulfone	$\left[ \begin{array}{c} \text{CH}_3 & \text{O} & \text{S} \\   &   &    \\ \text{O} & \text{C} & \text{O} \\   &   &    \\ \text{O} & \text{C} & \text{O} \\   &   &    \\ \text{O} & \text{C} & \text{O} \end{array} \right]_n$	Amine	SIA0591.0      SIU9055.0
Polyvinyl butyral	$\left[ \begin{array}{c} \text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2 \\   \\ \text{O} & \text{O} \\   &   \\ \text{CH}_2-\text{CH}_2-\text{CH}_3 \end{array} \right]_n$	Amine	SIA0611.0      SIU9058.0
Polyvinyl chloride	$\left[ \begin{array}{c} \text{Cl} \\   \\ \text{CH}_2-\text{CH} \end{array} \right]_n$	Amine Sulfur	SIA0605.0 SIM6474.0      SIB1825.0

Water-borne aminosilanes  
increase bonding  
of acrylic  
latex  
sealants



## Silane Coupling Agents for Sealants & Elastomers Selection Chart

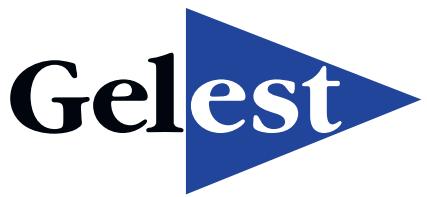
	Coupling Agent Class	Suggestions for Primary Screening	
Acrylic latex	$\left[ \text{CH}_2 \overset{\overset{\text{O}}{\parallel}}{\underset{\underset{\text{CH}_3}{\mid}}{\text{C}}} \text{OCH}_3 \right]_n$ Acrylate Vinyl/Olefin Water-borne	SIM6487.4 SIV9210.0 WSA-7021	SIV9218.0 WSA-6511
Butyl	$\left[ \text{CH}_2 \text{CH}=\text{CHCH}_2 \right]_n$ Acrylate Sulfur Vinyl/Olefin	SIM6487.4 SIB1825.0 SSP-055	SIM6476.0 VEE-005
Epichlorohydrin	$\left[ \text{OCH}_2 \overset{\overset{\text{CH}}{\mid}}{\underset{\underset{\text{CH}_2\text{Cl}}{\mid}}{\text{CH}}} \right]_n$ Amine Sulfur	SIA0605.0 SIM6474.0	
Fluorocarbon	$-(\text{CF}_2\text{CF}_2)_m(\text{CH}_2\text{CF}_2)_n-$ Amine Dipodal	SIB1834.1 SIT8717.0	
Isoprene	$\left[ \text{CH}_2 \overset{\overset{\text{CH}_3}{\mid}}{\underset{\underset{\text{CH}}{\mid}}{\text{C}}}=\text{CHCH}_2 \right]_n$ Sulfur Vinyl/Olefin	SIM6474.0 SSP-055	SIM6476.0 VEE-005
Neoprene	$\left[ \text{CH}_2 \overset{\overset{\text{Cl}}{\mid}}{\underset{\underset{\text{CH}}{\mid}}{\text{C}}}=\text{CHCH}_2 \right]_n$ Sulfur Vinyl/Olefin	SIM6474.0 SSP-055	SIM6476.0 VEE-005
Nitrile	$\left[ \text{CH}_2 \overset{\overset{\text{CN}}{\mid}}{\underset{\underset{\text{CH}_2-\text{CH}_2-\text{CH}}{\mid}}{\text{CH}}}=\text{CH} \right]_n$ Epoxy Sulfur	SIG5840.0 SIB1825.0	
Polysulfide	$\left[ \text{CH}_2\text{CH}_2\text{S} \right]_n$ Epoxy Sulfur	SIG5840.0 SIB1825.0	SIM6476.0
SBR	$\left[ \text{CH}_2 \overset{\overset{\text{CH}_2-\text{CH}_2-\text{CH}}{\mid}}{\underset{\underset{\text{C}_6\text{H}_5}{\mid}}{\text{CH}}}=\text{CH} \right]_n$ Amine Sulfur	SIA0605.0 SIB1825.0	SIM6486.0
Silicone (hydroxyl terminated)	$\text{HO}-\overset{\overset{\text{CH}_3}{\mid}}{\text{Si}}-\text{O}-\left( \begin{array}{c} \text{CH}_3 \\   \\ \text{Si}-\text{O} \\   \\ \text{CH}_3 \end{array} \right)_n \overset{\overset{\text{CH}_3}{\mid}}{\text{Si}}-\text{OH}$ Amine Vinyl/Olefin Dipodal	SIA0605.0 SIV9098.0 SIB1824.0	SIA0589.0 VMM-010
Silicone (vinyl terminated)	$\text{H}_2\text{C}=\text{CH}-\overset{\overset{\text{CH}_3}{\mid}}{\text{Si}}-\text{O}-\left( \begin{array}{c} \text{CH}_3 \\   \\ \text{Si}-\text{O} \\   \\ \text{CH}_3 \end{array} \right)_n \overset{\overset{\text{CH}_3}{\mid}}{\text{Si}}-\text{CH}=\text{CH}_2$ Acrylate Vinyl/Olefin	SIM6487.4 SIA0540.0	VMM-010



aldehyde-,  
amino-, and  
hydroxyl-  
silanes couple  
DNA in array  
technology

## Silane Coupling Agents for Biomaterials Selection Chart

<b>Site/Type</b>	<b>Coupling Class</b>	<b>Co-reactant</b>	<b>Suggestions for Screening</b>	
Oligonucleotides	hydroxyl diamine semicarbazide	cobalt ethylenediamine	SIB1140.0 SIA0591.0 SIS6944.0	
			<p><b>G. McGall</b> et al, J. Am. Chem. Soc., 119, 5081, 1997. <b>F. Chow</b>, in "Silylated Surfaces" D. Leyden ed., Gordon &amp; Breach, 1978, p.301. <b>M. Podyminogin</b> et al, Nucleic Acid Res., 2001, 29, 5090.</p>	
DNA	terminal favored pendant amine pendant amine pendant amine	vinyl/olefin aldehyde diamine epoxy	SIO6708.0 SIT8194.0 SIA0594.0 SIE4675.0	SIU9049.0 SID3543.0 SIG5838.0
			<p><b>A. Bensimon</b>, Science, 265, 2096, 1994. <b>J. Grobe</b> et al, J. Chem. Soc. Chem. Commun, 2323, 1995. <b>C. Kneuer</b> et al, Int'l J. Pharmaceutics, 196(2), 257, 2000.</p>	
Protein	lysine lysine lysine cysteine tyrosine heparinated immunoglobulin antibody	aldehyde amine amine sulfur nitrobenzamide amine/quat pyridyl-thio cyano	SIT8194.0 SIA0611.0 SIA0611.0 SIM6476.0 SIT8191.0 SSP-060 SIP6926.4 SIC2456.0	SIA0595.0 SIA0595.0 SIA0595.0 SIT8415.0
			<p><b>J. Grobe</b> et al, J. Chem. Soc. Chem. Commun, 2323, 1995. <b>H. Weetall</b>, US Pat. 3,652,761. <b>G. Royer</b>, CHEMTECH, 4, 699, 1974. <b>S. Bhatia</b> et al, Anal. Biochem., 178, 408, 1989. <b>J. Venter</b> et al, Proc. Nat. Acad. Soc., 69(5), 1141, 1972. <b>R. Merker</b> et al, Proc. Artificial Heart Prog. Conf., June 9-13, 1969 HEWNIH, p29. <b>S. Falipou</b>, Fundamental &amp; Applied Aspects of Chemically Modified Surfaces, p389, 1999.</p>	
Cell-Organelle	chloroplast mitochondria	alkyl alkyl	SIO6645.0 SIO6645.0	
mitochondria on silica bead			<p><b>B. Arkles</b> et al, in "Silylated Surfaces" D. Leyden ed., Gordon &amp; Breach, 1978, p363. <b>B. Arkles</b> et al, J. Biol. Chem., 250, 8856, 1975.</p>	
Whole Cell	erythrocytes	short alkyl	SIE4901.4	
erythrocytes on glass wall			<p><b>B. Arkles</b> et al, in "Silylated Surfaces" D. Leyden ed., Gordon &amp; Breach, 1978, p363.</p>	
Whole Cell (causing lysis)	procaryotic	alkyl-quat	SIO6620.0 SID3392.0	
Tissue	histological samples		SIA0611.0	SIA0610.0



## Silane Coupling Agent Properties



Adhesion promoter for structural polysulfide glass sealants



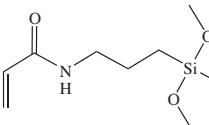
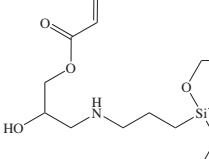
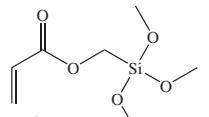
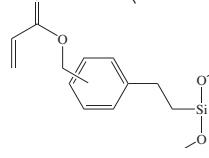
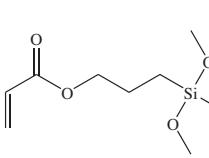
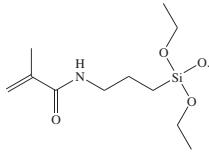
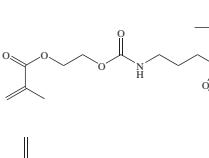
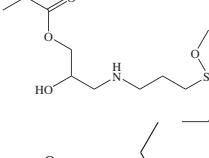
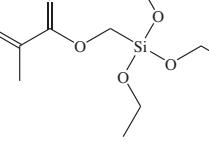
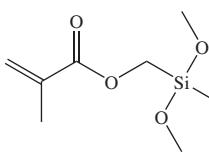
Epoxy-silanes are essential for performance of epoxy resin encapsulants for microchips.

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**Commercial Status**—produced on a regular basis for inventory

**Developmental Status**—available to support development and commercialization

**New Products**—available to support development and commercialization

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>Acrylate and Methacrylate Functional Silanes</b>					
<b>Acrylate and Methacrylate Functional Silanes - Trialkoxy</b>					
	<b>SIA0146.0</b> 3-ACRYLAMIDOPROPYLTRIMETHOXYSILANE, tech-95 C <sub>9</sub> H <sub>19</sub> NO <sub>4</sub> Si Inhibited with MEHQ [5757-96-5]	233.34		1.062	1.465
		HMIS: 3-2-1-X store <5°C	10g		NEW
	<b>SIA0180.0</b> N-(3-ACRYLOXY-2-HYDROXYPROPYL)-3-AMINOPROPYLTRIETHOXYSILANE, 50% in ethanol C <sub>15</sub> H <sub>31</sub> NO <sub>5</sub> Si Inhibited with MEHQ Used to stabilize Stober silica suspensions. <sup>1</sup> 1. Park, B. et al. <i>J. Mater. Sci.</i> <b>1992</b> , 27, 5692. [123198-57-2]	349.50	Flashpoint: 15°C (59°F)	0.931	1.4084
		HMIS: 3-4-1-X store <5°C	25g		
	<b>SIA0182.0</b> ACRYLOXYMETHYLTRIMETHOXYSILANE C <sub>7</sub> H <sub>14</sub> O <sub>5</sub> Si Coupling agent, comonomer for ormocils [21134-38-3]	206.27	42-6° / 0.15	1.060	
		TSCA-L	HMIS: 3-3-1-X store <5°C	25g	NEW
	<b>SIA0184.0</b> (ACRYLOXYMETHYL)PHENETHYLTRIMETHOXYSILANE, tech-95 C <sub>15</sub> H <sub>22</sub> O <sub>5</sub> Si Inhibited with MEHQ; mixed m-, p-, α-, β- isomers Coupling agent for UV cure systems with less oxygen sensitivity [141813-19-6](m-)[141813-20-9](p-)	310.42			NEW
		HMIS: 3-3-1-X store <5°C	10g		
	<b>SIA0200.0</b> (3-ACRYLOXYPROPYL)TRIMETHOXYSILANE, 96% C <sub>9</sub> H <sub>16</sub> O <sub>5</sub> Si Inhibited with BHT Coupling agent for epoxies, UV cure coatings Employed in optical fiber coatings. <sup>1</sup> In combination with dipodal silane, SIB1833.0, increases strength and hydrolytic stability of dental composites. <sup>2</sup> 1. Yokoshima, M. et al. <i>Chem. Abstr.</i> 113, 15746d; Jap. Pat. 02133338, 1990. 2. Matinlinna, J. et al. <i>Acta Odontol. Scand.</i> <b>2012</b> , 70, 405.	234.32	68° / 0.4 Flashpoint: 123°C (253°F)	1.06	1.4155
	[4369-14-6]	TSCA	HMIS: 3-1-1-X store <5°C	25g	100g
				2kg	COMMERCIAL
	<b>SIM6480.73</b> (3-METHACRYLAMIDOPROPYL)TRIETHOXYSILANE, tech-95 C <sub>13</sub> H <sub>27</sub> NO <sub>5</sub> Si Contains 3-methacrylamidopropylmethoxymethoxysilane Hydrophilic coupling agent Intermediate for contact lens monomers [109213-85-6]	289.44	Flashpoint: >110°C (>230°F)	1.017	1.454
		HMIS: 2-2-1-X store <5°C	25g		NEW
	<b>SIM6480.8</b> O-(METHACRYLOXYETHYL)-N-(TRIETHOXYSILYLPROPYL)CARBAMATE, 90% C <sub>16</sub> H <sub>31</sub> NO <sub>5</sub> Si Inhibited with MEHQ Hydrophilic monomer [115396-93-5]	377.51		1.051 <sup>25</sup>	1.446 <sup>25</sup>
		HMIS: 3-2-1-X store <5°C	25g	100g	
	<b>SIM6481.1</b> N-(3-METHACRYLOXY-2-HYDROXYPROPYL)-3-AMINOPROPYLTRIETHOXYSILANE, 50% in ethanol C <sub>16</sub> H <sub>33</sub> NO <sub>6</sub> Si Inhibited with MEHQ Employed in conservation/consolidation of stone. <sup>1</sup> 1. Wheeler, G. In <i>Ninth Int'l Cong. On Deterioration and Conservation of Stone</i> ; Fassina, Ed.; Elsevier: 2000; Vol. 2, 541. [96132-98-8]	363.53	Flashpoint: 11°C (52°F)	0.910	1.4084
		HMIS: 3-4-1-X store <5°C	25g	100g	
	<b>SIM6482.0</b> METHACRYLOXYMETHYLTRIMETHOXYSILANE C <sub>11</sub> H <sub>22</sub> O <sub>5</sub> Si Inhibited with MEHQ Treatment of fumed silica in acrylic casting compositions accelerates polymerization. <sup>1</sup> 1. Morozova, E. et al. <i>Chem. Abstr.</i> 95, 98753g; <i>Plast. Massy</i> <b>1981</b> , 7. [5577-72-0]	262.38	65-8° / 2 Flashpoint: 100°C (212°F)	1.000	1.4225
		TSCA	HMIS: 3-2-1-X store <5°C	10g	50g
	<b>SIM6483.0</b> METHACRYLOXYMETHYLTRIMETHOXYSILANE C <sub>8</sub> H <sub>16</sub> O <sub>5</sub> Si Inhibited with MEHQ Viscosity: 1.5 cSt  Hydrolysis rate > 10 X SIM6487.4 Modification of novolac resin affords bilevel resists having attributes of trilevel resists. <sup>1</sup> 1. Reichmanis, E.; Smolinsky, G. U.S. Patent 4,481,049, 1984. [54586-78-6]	220.30	48-50° / 2 Flashpoint: 92°C (198°F) TOXICITY: oral rat, LD <sub>50</sub> : >2,000 mg/kg Autoignition temperature: 285°C	1.070	1.4271
		TSCA	HMIS: 3-2-1-X store <5°C	10g	50g
				2kg	

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIM6487.3</b> METHACRYLOXYPROPYLTRIETHOXYSILANE C <sub>13</sub> H <sub>26</sub> O <sub>5</sub> Si Inhibited with MEHQ [21142-29-0]	290.43	130° / 4 Flashpoint: 128°C (262°F)		0.985	1.4277
TSCA EC 244-239-0 HMIS: 3-1-1-X store <5°C 10g 50g 2kg					
<b>SIM6487.35</b> METHACRYLOXYPROPYLTRIISOPROPOXYSILANE C <sub>16</sub> H <sub>32</sub> O <sub>5</sub> Si Inhibited with MEHQ, HQ [80750-05-6]	332.51		TOXICITY: oral rat, LD50: >5,000 mg/kg	0.942	1.4234
TSCA EC 279-538-5 HMIS: 2-2-1-X store <5°C 25g 100g					NEW
<b>SIM6487.4</b> METHACRYLOXYPROPYLTRIMETHOXYSILANE C <sub>10</sub> H <sub>20</sub> O <sub>5</sub> Si Inhibited with MEHQ, HQ Viscosity: 2 cSt Copolymerization parameters-e,Q: 0.07, 2.7 Specific wetting surface: 314m <sup>2</sup> /g Coupling agent for radical cure polymer systems See SIA0200.0 for acrylate-functional UV cureable analog Widely used coupling agent for unsaturated polyester-fiberglass composites. <sup>1</sup> Copolymerized with styrene in formation of sol-gel composites. <sup>2</sup> Employed in dental polymer composites. <sup>3</sup>	248.35	78-81° / 1 (-48°) Flashpoint: 108°C (226°F)	TOXICITY: oral rat, LD50: 3,000 mg/kg Primary irritation index: 1.19	1.045	1.4310
1. Arkles, B. <i>Chemtech</i> <b>1977</b> , 7, 713. 2. Wei, Y. et al. <i>J. Mater. Res.</i> <b>1993</b> , 8, 1143. 3. Matinlinna, J. et al. <i>Int. J. Prosthodontics</i> <b>2004</b> , 17, 157.	[2530-85-0]	TSCA EC 219-785-8 HMIS: 3-1-1-X store <5°C 100g	2kg	18kg	COMMERCIAL
<b>SIM6487.4LI</b> METHACRYLOXYPROPYLTRIMETHOXYSILANE, low inhibitor grade C <sub>10</sub> H <sub>20</sub> O <sub>5</sub> Si Contains <10 ppm BHT, hydroquinones Employed in dental restorative composites	248.35	78-81° / 1		1.045	1.4310
[2530-85-0]	TSCA EC 219-785-8 HMIS: 3-1-1-X store <5°C	25g			NEW
<b>SIM6487.5</b> METHACRYLOXYPROPYLTRIS(METHOXYETHOXY)SILANE, tech-80 C <sub>16</sub> H <sub>32</sub> O <sub>8</sub> Si Inhibited with MEHQ Contains methacryloxypropylbis(methoxyethoxy)methoxysilane and methacryloxypropyl(methoxyethoxy)dimethoxysilane	380.51	128° / 10 Flashpoint: 195°C (383°F)		1.06	NEW
[57069-48-4]	TSCA EC 260-537-3 HMIS: 3-1-1-X store <5°C 50g				
<b>Acrylate and Methacrylate Functional Silanes - Dialkoxy</b>					
<b>SIA0197.0</b> (3-ACRYLOXYPROPYL)METHYLDIETHOXYSILANE, 95% C <sub>11</sub> H <sub>22</sub> O <sub>4</sub> Si Inhibited with MEHQ [146666-71-9]	246.38	40° / 1 Flashpoint: >110°C (>230°F)		0.947	1.4139
	HMIS: 3-2-1-X store <5°C 25g				NEW
<b>SIA0198.0</b> (3-ACRYLOXYPROPYL)METHYLDIMETHOXYSILANE, 95% C <sub>9</sub> H <sub>18</sub> O <sub>3</sub> Si Inhibited with MEHQ Employed in fabrication of photoimageable, low shrinkage multimode waveguides. <sup>1</sup>	218.33	65° / 0.35		1.01	1.431
1. Xu, C. et al. <i>Chem. Mater.</i> <b>1996</b> , 8, 2701. [13732-00-8]	TSCA-L	HMIS: 3-2-1-X store <5°C 50g 250g			

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIM6481.43</b> (METHACRYLOXYMETHYL)METHYLDIETHOXYSILANE C <sub>10</sub> H <sub>20</sub> O <sub>4</sub> Si Inhibited with MEHQ [121177-93-3]	232.35	221° Flashpoint: 88°C (190°F) TOXICITY: oral rat, LD50: >2,000 mg/kg		0.977	
TSCA	HMIS: 2-2-1-X store <5°C 25g				
<b>SIM6481.46</b> (METHACRYLOXYMETHYL)METHYLDIMETHOXYSILANE C <sub>8</sub> H <sub>16</sub> O <sub>4</sub> Si Inhibited with MEHQ [3978-58-3]	204.30	205° Flashpoint: 82°C (180°F) TOXICITY: oral rat, LD50: >2,000 mg/kg Autoignition temperature: 300°C		1.020	1.4274
	HMIS: 3-2-1-X store <5°C 25g 100g				
<b>SIM6486.8</b> METHACRYLOXYPROPYLMETHYLDIETHOXYSILANE, 95% C <sub>12</sub> H <sub>24</sub> O <sub>4</sub> Si Inhibited with MEHQ [65100-04-1]	260.40	95° / 1 Flashpoint: 136°C (277°F)		0.965	1.4330
	HMIS: 3-1-1-X store <5°C 10g 50g				
<b>SIM6486.9</b> METHACRYLOXYPROPYLMETHYLDIMETHOXYSILANE, 95% C <sub>10</sub> H <sub>20</sub> O <sub>4</sub> Si Monomer for hybrid inorganic-organic composites. <sup>1</sup> 1. Taylor-Smith, R. <i>Polym. Mater. Sci. Eng., Preprints</i> <b>1997</b> , <i>77</i> , 503. [14513-34-9]	235.69	65° / 0.35 Flashpoint: 115°C (239°F)		1.000	1.4355
	TSCA-L EC 238-518-6 HMIS: 3-1-1-X store <5°C 25g 100g 2kg				

COMMERCIAL

NEW

NEW

NEW

NEW

## Acrylate and Methacrylate Functional Silanes - Monoalkoxy

<b>SIA0190.0</b> (3-ACRYLOXYPROPYL)DIMETHYLMETHOXYSILANE, 95% C <sub>9</sub> H <sub>18</sub> O <sub>3</sub> Si Inhibited with MEHQ [111918-90-2]	202.32	54-5° / 0.1 Flashpoint: 85°C (185°F)			
	HMIS: 3-2-1-X store <5°C 5g 25g				
<b>SIM6481.3</b> (METHACRYLOXYMETHYL)DIMETHYLETHOXYSILANE C <sub>9</sub> H <sub>18</sub> O <sub>3</sub> Si Inhibited with MEHQ [5577-70-8]	202.32	62-3° / 0.3		0.9447	1.4282 <sup>25</sup>
	HMIS: 3-2-1-X store <5°C 10g 50g				
<b>SIM6486.4</b> METHACRYLOXYPROPYLDIMETHYLETHOXYSILANE, 95% C <sub>11</sub> H <sub>22</sub> O <sub>3</sub> Si Inhibited with MEHQ [13731-98-1]	230.38	75-6° / 0.4		0.926	1.4371
	HMIS: 3-2-1-X store <5°C 10g				
<b>SIM6486.5</b> METHACRYLOXYPROPYLDIMETHYLMETHOXYSILANE, 95% C <sub>10</sub> H <sub>20</sub> O <sub>3</sub> Si Inhibited with MEHQ Component in positive tone 157 nm resist. <sup>1</sup> 1. Tegou, E. et al. <i>Chem. Mater.</i> <b>2004</b> , <i>16</i> , 2567. [66753-64-8]	216.35	70-2° / 0.5		0.944	1.4381
	EC 266-472-7 HMIS: 3-2-1-X store <5°C 10g 50g				

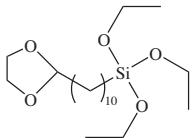
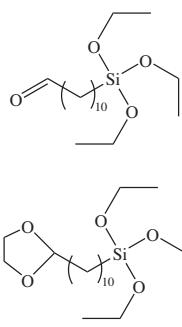
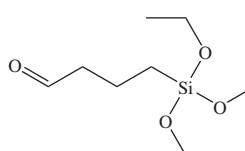
## Acrylate and Methacrylate Functional Silanes - Polymeric

<b>SIA0200.2</b> (3-ACRYLOXYPROPYL)TRIMETHOXYSILANE, oligomeric hydrolysate Viscosity: 8-12 cSt Employed in rapid prototyping [160185-24-0]				1.2	
	HMIS: 2-2-1-X store <5°C 25g 100g				
<b>SIM6487.42</b> METHACRYLOXYPROPYLTRIMETHOXYSILANE, oligomeric hydrolysate Viscosity: 1,000-3,000 cSt Soluble: acetone, ethanol, THF [160185-24-0]	1200-2500			1.20	1.46
	TSCA	HMIS: 2-1-0-X store <5°C 25g 100g			

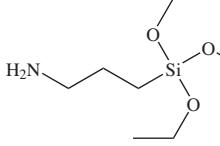
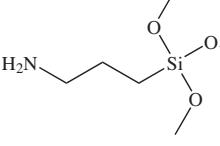
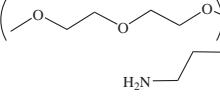
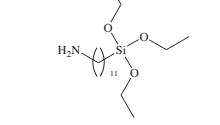
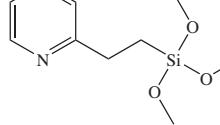
Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
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## Aldehyde Functional Silanes

### Aldehyde Functional Silanes - Trialkoxy



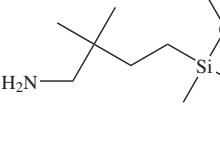


Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIA0610.1</b> 3-AMINOPROPYLTRIETHOXYSILANE 99+% C <sub>9</sub> H <sub>23</sub> NO <sub>3</sub> Si 	221.37	122-3° / 30 Flashpoint: 104°C (219°F)		0.951	1.4225
Low fluorescence grade for high throughput screening [919-30-2] TSCA EC 213-048-4 HMIS: 3-1-1-X 25g * in fluoropolymer bottle					
<b>SIA0611.0</b> 3-AMINOPROPYLTRIMETHOXYSILANE C <sub>6</sub> H <sub>17</sub> NO <sub>3</sub> Si 	179.29	80° / 8 Flashpoint: 83°C (181°F) TOXICITY: oral rat, LD50: >2,000 mg/kg Autoignition temperature: 300°C Vapor pressure, 67°: 5 mm		1.027	1.4240
Coupling agent with superior reactivity in vapor phase and non-aqueous surface treatments Hydrolysis rate vs SIA0610.0: 6:1 Used to immobilize Cu and Zn Schiff base precatalysts for formation of cyclic carbonates. <sup>1</sup> 1. Tasci, Z.; Ulusoy, M. J. Organomet. Chem. 2012, 713, 104. [13822-56-5] TSCA EC 237-511-5 HMIS: 3-2-1-X			25g	2kg	18kg
<b>SIA0614.0</b> 3-AMINOPROPYLTRIS(METHOXYETHOXYETHOXY)SILANE, 95% C <sub>18</sub> H <sub>41</sub> NO <sub>9</sub> Si 	443.61	Flashpoint: 68°C (154°F)		1.066	1.448
Coupling agent for melt compounding of polyamides and epoxides [87994-64-7] EC 289-365-7 HMIS: 3-2-1-X		25g			
<b>SIA0630.0</b> 11-AMINODECYLTRIETHOXYSILANE C <sub>17</sub> H <sub>39</sub> NO <sub>3</sub> Si Contains ~ 5% isomers [116821-45-5] 	333.59	128-32° / 1 HMIS: 2-2-1-X	1.0g	0.895 <sup>25</sup>	1.4352 <sup>25</sup>
<b>SIP6928.0</b> 2-(4-PYRIDYLETHYL)TRIETHOXYSILANE C <sub>13</sub> H <sub>23</sub> NO <sub>3</sub> Si Amber liquid Forms self-assembled layers which can be "nano-shaved" by scanning AFM. <sup>1</sup> 1. Rosa, L. et al. Mater. Lett. 2009, 63, 961. [98299-74-2] HMIS: 3-2-1-X	269.43	105° / 0.9	10g	1.00	1.4624 <sup>24</sup>
<b>SIP6930.0</b> 2-(2-PYRIDYLETHYL)TRIMETHOXYSILANE 2-(TRIMETHOXYSILYLETHYL)PYRIDINE C <sub>10</sub> H <sub>17</sub> NO <sub>3</sub> Si [27326-65-4] 	227.33	105° / 0.3 Flashpoint: >110°C (>230°F) 10g 50g HMIS: 3-1-1-X	1.06	1.4755	
<b>SIT8410.0</b> N-(3-TRIMETHOXYSILYLPROPYL)PYRROLE C <sub>10</sub> H <sub>19</sub> NO <sub>3</sub> Si For electrode modification, polypyrrole adhesion. <sup>1</sup> 1. Simon, R. et al. J. Am. Chem. Soc. 1982, 104, 2031. [80906-67-8] HMIS: 3-1-1-X	229.35	105-7° / 1 Flashpoint: >110°C (>230°F)	5g	1.017	1.463

## Monoamine Functional Silanes - Water-borne

<b>SIA0608.0</b> 3-AMINOPROPYLSILANETRIOL, 22-25% in water C <sub>3</sub> H <sub>11</sub> NO <sub>3</sub> Si Mainly oligomers; monomeric at concentrations <5% pH: 10.0-10.5 Water-borne, VOC-free coupling agent Internal hydrogen bonding stabilizes solution See also WSA-7011 for greater hydrolytic stability [58160-99-9] / [29159-37-3] TSCA EC 261-145-5 HMIS: 2-0-0-X	137.21	Flashpoint: >110°C (>230°F)	1.06	
		25g	2kg	18kg

## Monoamine Functional Silanes - Dialkoxy

<b>SIA0587.05</b> 4-AMINO-3,3-DIMETHYLBUTYL METHYL DIMETHOXYSILANE C <sub>9</sub> H <sub>23</sub> NO <sub>2</sub> Si 	205.37	Flashpoint: 100°C (212°F) TOXICITY: oral rat, LD50: 631 mg/kg	0.9248 <sup>25</sup>	1.4365
Comonomer for non-yellowing textile lubricants [156849-43-3] TSCA HMIS: 3-2-1-X		25g	100g	2kg

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIA0605.0</b> 3-AMINOPROPYL METHYLDIETHOXYSILANE, 95% C <sub>8</sub> H <sub>21</sub> NO <sub>2</sub> Si	191.34	85-8° / 8 Flashpoint: 85°C (185°F) TOXICITY: oral rat, LD50: 4,760 mg/kg		0.916	1.4272

Coupling agent for foundry resins, including phenolic novolaks and resols  
Vapor phase deposition >150° on silica yields high density amine functionality.<sup>1</sup>

1. Ek, S. et al. *Langmuir* **2003**, *19*, 3461.

[3179-76-8] TSCA EC 221-660-8 HMIS: 3-2-1-X 25g 2kg 15kg

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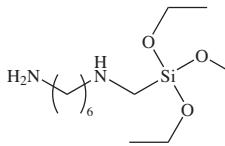
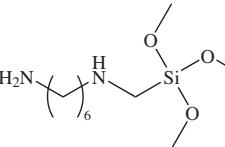
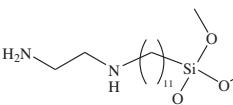
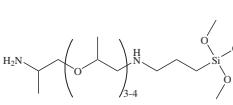
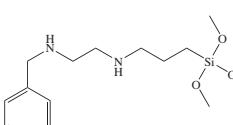
## Monoamine Functional Silanes - Monoalkoxy

<b>SIA0587.1</b> 1-AMINO-2-(DIMETHYLETHOXYSILYL)PROPANE, 85% C <sub>7</sub> H <sub>19</sub> NO <sub>3</sub> Si Contains 3-aminopropyl dimethyl ethoxysilane	161.32	101-7° / 100 HMIS: 3-2-1-X	0.85	1.431
<b>SIA0602.0</b> 3-AMINOPROPYLDIISOPROPYLETHOXYSILANE C <sub>11</sub> H <sub>27</sub> NO <sub>3</sub> Si Forms hydrolytically stable amino-functional bonded phases and monolayers [117559-36-1]	217.43	78-80° / 0.4 HMIS: 3-2-0-X	0.872 <sup>25</sup>	1.4489
<b>SIA0603.0</b> 3-AMINOPROPYLDIMETHYLETHOXYSILANE C <sub>7</sub> H <sub>19</sub> NO <sub>3</sub> Si ΔHform: 147.6 kcal/mole Coupling agent for DNA array technology [18306-79-1]	161.32	78-9° / 24 Flashpoint: 73°C (163°F) HMIS: 3-2-1-X	0.857 <sup>25</sup>	1.4276 <sup>25</sup>

## Diamine Functional Silanes - Trialkoxy

<b>SIA0588.0</b> (AMINOETHYLAMINOMETHYL)PHENETHYLTRIMETHOXYSILANE, tech-90 C <sub>14</sub> H <sub>26</sub> N <sub>2</sub> O <sub>3</sub> Si Mixed m-,p- isomers Coupling agent for polyimides. <sup>1</sup> Photochemically sensitive (194nm). <sup>2</sup> Forms self assembled monolayers. <sup>3</sup> Reagent for charge heterogeneity in micropatterning. <sup>4</sup> 1. Arkles, B. et al. <i>Modern Plastics</i> <b>1980</b> , <i>57</i> , 64. 2. Dressick, W. et al. <i>Thin Solid Films</i> <b>1996</b> , <i>284</i> , 568. 3. Harnett, C. et al. <i>Appl. Phys. Lett.</i> <b>2000</b> , <i>76</i> , 2466. 4. Chen, J. et al. <i>Nano Lett.</i> <b>2002</b> , <i>2</i> , 393. [74113-77-2]	298.46	126-30° / 0.2 Flashpoint: >110°C (>230°F) TSCA	1.02	1.5083
<b>SIA0591.0</b> N-(2-AMINOETHYL)-3-AMINOPROPYLTRIMETHOXYSILANE, tech-95 N-[3-(TRIMETHOXYSILYL)PROPYL]ETHYLENEDIAMINE; DAMO C <sub>8</sub> H <sub>22</sub> N <sub>2</sub> O <sub>3</sub> Si Contains 2-6% N,N'-BIS[(TRIMETHOXYSILYL)PROPYL]ETHYLENE- DIAMINE Viscosity: 6.5 cSt Surface tension: 36.5 mN/m Specific wetting surface: 358 m <sup>2</sup> /g Coupling agent for polyamides, polycarbonates (e.g. in CDs), polyesters and copper/brass adhesion Film-forming coupling agent/primer, fiberglass size component For cyclic version see SID3543.0, for pre-hydrolyzed version see SIA0590.0 Used in the immobilization of copper (II) catalyst on silica. <sup>1</sup> Used together w/ SID3396.0 to anchor PdCl <sub>2</sub> catalyst to silica for acceleration of the Tsuji-Trost reaction. <sup>2</sup> 1. Wu, Q.; Wang, L. <i>Synthesis</i> <b>2008</b> , 2007. 2. Noda, H. et al. <i>Angew. Chem., Int. Ed. Engl.</i> <b>2012</b> , <i>51</i> , 8017. [1760-24-3]	222.36	140° / 15 Flashpoint: 150°C (302°F) TSCA EC 217-164-6 HMIS: 3-1-1-X	1.019 <sup>25</sup>	1.450 <sup>25</sup>
<b>SIA0591.1</b> N-(2-AMINOETHYL)-3-AMINOPROPYLTRIMETHOXYSILANE, 98% N-[3-(TRIMETHOXYSILYL)PROPYL]ETHYLENEDIAMINE; DAMO C <sub>8</sub> H <sub>22</sub> N <sub>2</sub> O <sub>3</sub> Si [1760-24-3]	222.36	140° / 15 Flashpoint: 150°C (302°F) TSCA EC 217-164-6 HMIS: 3-1-1-X	1.019 <sup>25</sup>	1.450 <sup>25</sup>

COMMERCIAL

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIA0592.6</b> N-(6-AMINOHEXYL)AMINOMETHYLTRIETHOXYSILANE, 95% C <sub>13</sub> H <sub>32</sub> N <sub>2</sub> O <sub>3</sub> Si 	292.49	160° / 0.1 Flashpoint: >110°C (>230°F) TOXICITY: oral rat, LD50: 500 mg/kg		0.928 <sup>25</sup>	1.4385 <sup>25</sup>
Long-chain amino coupling agent [15129-36-9]	HMIS: 3-2-1-X	25g	100g		
<b>SIA0594.0</b> N-(6-AMINOHEXYL)AMINOPROPYLTRIMETHOXYSILANE, 95% C <sub>12</sub> H <sub>30</sub> N <sub>2</sub> O <sub>3</sub> Si 	278.47	160-5° / 0.15 Flashpoint: >110°C (>230°F)		1.11	1.4501
Employed in immobilization of DNA. <sup>1</sup> Employed for immobilization of PCR primers on beads. <sup>2</sup> 1. Kneuer, C. et al. <i>Int'l. J. Pharmaceutics</i> <b>2000</b> , 196, 257. 2. Andreadis, J. et al. <i>Nuc. Acid Res.</i> <b>2000</b> , 28, E-5. [51895-58-0]	HMIS: 3-1-1-X	10g	50g		
<b>SIA0595.0</b> N-(2-AMINOETHYL)-11-AMINOUNDECYLTRIMETHOXYSILANE C <sub>16</sub> H <sub>38</sub> N <sub>2</sub> O <sub>3</sub> Si 	334.57	155-9° / 0.4 HMIS: 3-1-1-X	5g	0.873 <sup>25</sup>	1.4515
Coupling agent with extended spacer-group for remote substrate binding [121772-92-7]					
<b>SIA0599.4</b> N-3-[(AMINO(POLYPROPYLENOXY)]AMINOPROPYLTRIMETHOXYSILANE, 60 - 65% 337-435 				0.984	1.4508
Contains amine-terminated polypropylene oxide 3-4 propylenoxy units Coupling agent with film-forming capability.	HMIS: 2-2-1-X	25g			
<b>SIB0956.0</b> N-(2-N-BENZYLAMINOETHYL)-3-AMINOPROPYLTRIMETHOXYSILANE, tech-90 C <sub>15</sub> H <sub>28</sub> N <sub>2</sub> O <sub>3</sub> Si 	312.48			1.035	1.4902
Contains aminoethylaminopropyltrimethoxysilane [209866-89-7]	TSCA	HMIS: 3-2-1-X	25g	100g	
		Flashpoint: 69°C (156°F)			
					NEW

## Diamine Functional Silanes - Water-borne

<b>SIA0590.0</b> N-(2-AMINOETHYL)-3-AMINOPROPYL SILANETRIOL, 25% in water, mainly oligomers C <sub>5</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub> Si pH: 10.0-10.5 Internal hydrogen bonding stabilizes solution Additive for CMP slurries Aqueous primer, adhesion promoter for resin-to-metal applications See also WSA-7021 for greater hydrolytic stability [68400-09-9]	180.28	Flashpoint: >110°C (>230°F)	1.00	
TSCA	HMIS: 2-0-0-X	100g	2kg	18kg

COMMERCIAL

## Diamine Functional Silanes - Polymeric

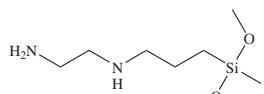
<b>SIA0591.3</b> N-(2-AMINOETHYL)-3-AMINOPROPYLTRIMETHOXYSILANE-PROPYLTRIMETHOXYSILANE, oligomeric co-hydrolysate C <sub>9</sub> H <sub>24</sub> N <sub>2</sub> O <sub>3</sub> Si TSCA	HMIS: 3-2-1-X	25g	1.09	1.442
		Flashpoint: >110°C (>230°F)		

## Diamine Functional Silanes - Dialkoxy

<b>SIA0587.5</b> N-(2-AMINOETHYL)-3-AMINOISOBUTYL METHYL DIMETHOXYSILANE, 95% C <sub>9</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub> Si Amino-functional coupling agent [23410-40-4]	220.39	131° / 15 Flashpoint: 96°C (205°F)	0.960	1.4518
TSCA	EC 245-642-4	HMIS: 3-2-1-X	25g	
<b>SIA0588.8</b> N-(2-AMINOETHYL)-3-AMINOPROPYL METHYL DIETHOXYSILANE C <sub>10</sub> H <sub>26</sub> N <sub>2</sub> O <sub>2</sub> Si Adhesion promoter for silanol-functional silicones on metal substrates [70240-34-5]	234.41	108-110° / 1.5 Flashpoint: >110°C (>230°F)	0.923	1.445
EC 274-494-3	HMIS: 3-2-1-X	25g		

NEW

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIA0589.0</b> N-(2-AMINOETHYL)-3-AMINOPROPYL METHYLDIMETHOXYSILANE, tech-95 <chem>C8H22N2O2Si</chem> Specific wetting surface: 380 m <sup>2</sup> /g	206.36	265° Flashpoint: 90°C (194°F) TOXICITY: oral rat, LD50: >2,000 mg/kg Autoignition temperature: 280°C		0.975 <sup>25</sup>	1.4447 <sup>25</sup>



Comonomer for silicones in textile softeners and hair care formulations  
Coupling agent for furan-quartz sand floor coating systems  
Adhesion promoter for urea-formaldehyde binders on flexible substrates  
[3069-29-2]

TSCA EC 221-336-6 HMIS: 3-1-1-X

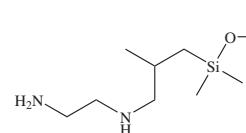
25g

2kg

16kg

COMMERCIAL

## Diamine Functional Silanes - Monoalkoxy



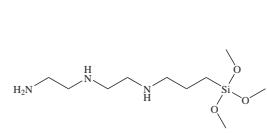
**SIA0587.2**  
N-(2-AMINOETHYL)-3-AMINOISOBUTYLDIMETHYL METHOXYSILANE, 95%  
C9H24N2OSi  
Amino-functional coupling agent  
[31024-49-4]

HMIS: 3-2-1-X

25g

0.900<sup>25</sup> 1.4513<sup>25</sup>

## Triamine Functional Silanes



**SIT8398.0**  
(3-TRIMETHOXYSIYLPROPYL)DIETHYLENETRIAMINE, tech-95  
C10H27N3O3Si  
γc of treated surface: 37.5 mN/m  
Hardener, coupling agent for epoxies  
[35141-30-1]

TSCA EC 252-390-9 HMIS: 3-1-1-X

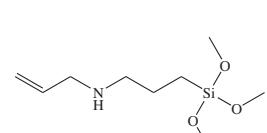
100g

2kg

18kg

COMMERCIAL

## Secondary Amine Functional Silanes



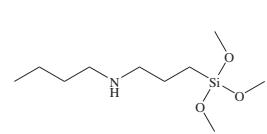
**SIA0400.0**  
3-(N-ALLYLAMINO)PROPYL TRIMETHOXYSILANE, 95%  
C9H21NO3Si  
Coupling agent for polyesters  
Coupling agent for acrylic coatings for glass containers.<sup>1</sup>  
1. Hashimoto, Y. et al. Eur. Pat. Appl. EP 289,325, 1988.  
[31024-46-1]

TSCA EC 250-435-7 HMIS: 3-2-1-X

10g

50g

0.989<sup>25</sup> 1.4990<sup>25</sup>



**SIB1932.2**  
n-BUTYLAMINOPROPYL TRIMETHOXYSILANE  
C10H25NO3Si  
Reacts with isocyanate resins (urethanes) to form moisture cureable systems  
[31024-56-3]

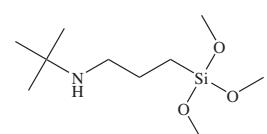
TSCA EC 250-437-8 HMIS: 2-1-1-X

25g

2kg

0.947 1.4246<sup>25</sup>

COMMERCIAL



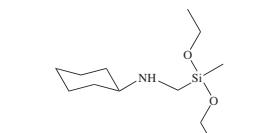
**SIB1932.3**  
t-BUTYLAMINOPROPYL TRIMETHOXYSILANE  
C10H25NO3Si  
[174219-86-4]

HMIS: 2-2-1-X

5g

0.924 1.4208

NEW



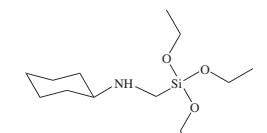
**SIC2464.16**  
(N-CYCLOHEXYLAMINOMETHYL)METHYLDIETHOXYSILANE, 95%  
C12H27NO2Si  
End-cap modifier for moisture-cure urethane systems (SPUR)  
[27445-54-1]

HMIS: 2-2-1-X

25g

0.93

NEW



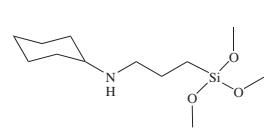
**SIC2464.2**  
(N-CYCLOHEXYLAMINOMETHYL)TRIETHOXYSILANE, 95%  
C13H29NO3Si  
[26495-91-0]

TSCA EC 247-744-4 HMIS: 2-1-1-X

25g

100g

0.950 1.4377



**SIC2464.4**  
(N-CYCLOHEXYLAMINOPROPYL)TRIMETHOXYSILANE  
C12H27NO3Si  
Viscosity: 5-7 cSt  
[3068-78-8]

TSCA EC 221-329-8 HMIS: 3-2-1-X

25g

2kg

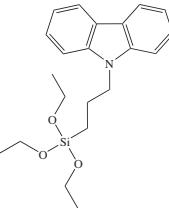
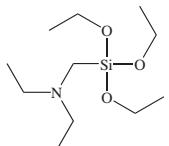
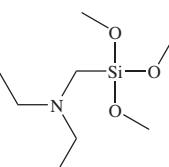
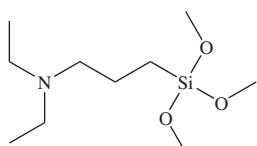
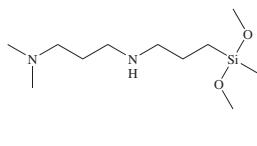
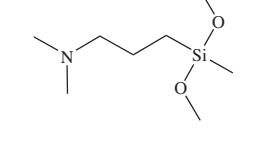
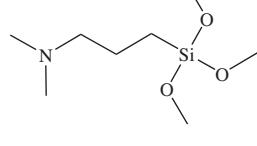
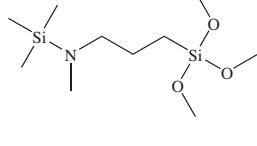
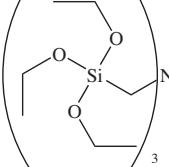
0.99 1.486<sup>25</sup>

COMMERCIAL

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIE4885.8</b> (3-(N-ETHYLAMINO)ISOBUTYL)METHYLDIETHOXYSILANE C <sub>11</sub> H <sub>27</sub> NO <sub>2</sub> Si [275378-62-6]	233.43	89° / 27 HMIS: 3-2-1-X	25g		
<b>SIE4886.0</b> (3-(N-ETHYLAMINO)ISOBUTYL)TRIMETHOXYSILANE C <sub>9</sub> H <sub>23</sub> NO <sub>3</sub> Si [227085-51-0]	221.37	95° / 10 Reacts with isocyanate resins (urethanes) to form moisture cureable systems TSCA HMIS: 3-2-1-X	25g	Flashpoint: 91°C (196°F) 100g	0.952 <sup>25</sup> 1.4234
<b>SIM6498.0</b> N-METHYLAMINOPROPYL METHYLDIMETHOXYSILANE C <sub>7</sub> H <sub>19</sub> NO <sub>2</sub> Si [31024-35-8]	177.32	93° / 25 EC 250-434-1 HMIS: 3-2-1-X	25g	Flashpoint: 80°C (176°F) 100g	0.9173 <sup>25</sup> 1.4224 <sup>25</sup>
<b>SIM6500.0</b> N-METHYLAMINOPROPYL TRIMETHOXYSILANE C <sub>7</sub> H <sub>19</sub> NO <sub>3</sub> Si yc of treated surfaces: 31 mN/m pK <sub>b</sub> <sup>25</sup> , H <sub>2</sub> O: 5.18 Orients liquid crystals Reacts with urethane prepolymers to form moisture-curable resins [3069-25-8]	193.32	106° / 30 TSCA EC 221-334-5 HMIS: 3-2-1-X	25g	Flashpoint: 82°C (180°F) 2kg	0.978 <sup>25</sup> 1.4194
<b>SIP6723.67</b> (PHENYLAMINOMETHYL)METHYLDIMETHOXYSILANE, 95% C <sub>10</sub> H <sub>17</sub> NO <sub>2</sub> Si [17890-10-7]	211.34	255° HMIS: 3-2-1-X	25g	Flashpoint: 106°C (223°F) 100g	1.04 1.5147
<b>SIP6723.7</b> N-PHENYLAMINOMETHYL TRIETHOXYSILANE C <sub>13</sub> H <sub>23</sub> NO <sub>3</sub> Si Converts isocyanate-terminated polyurethanes to moisture curable resins [3473-76-5]	269.42	135-7° / 4 HMIS: 3-2-1-X	25g	Flashpoint: >110°C (>230°F) 100g	1.004 <sup>25</sup> 1.485 <sup>25</sup>
<b>SIP6724.0</b> N-PHENYLAMINOPROPYL TRIMETHOXYSILANE C <sub>12</sub> H <sub>21</sub> NO <sub>3</sub> Si Specific wetting surface: 307 m <sup>2</sup> /g Oxidatively stable coupling agent for polyimides, phenolics, epoxies [3068-76-6]	255.38	132-5° / 0.3 TSCA EC 221-328-2 HMIS: 3-1-1-X	25g	Flashpoint: 165°C (329°F) 2kg	1.07 1.504

## Tertiary Amine Functional Silanes

<b>SIB1140.0</b> N,N-BIS(2-HYDROXYETHYL)-3-AMINOPROPYL TRIETHOXYSILANE, 62% in ethanol C <sub>13</sub> H <sub>31</sub> NO <sub>5</sub> Si Contains 2-3% hydroxyethylaminopropyltriethoxysilane Specific wetting surface: 252 m <sup>2</sup> /g Urethane polymer coupling agent Employed in surface modification for preparation of oligonucleotide arrays. <sup>1</sup> 1. McGall, G. et al. <i>Proc. Natl. Acad. Sci.</i> <b>1996</b> , 93, 1355. [7538-44-5]	309.48	Flashpoint: 24°C (75°F)	0.92	1.4090 <sup>25</sup>	
<b>SIB1835.0</b> BIS(3-TRIMETHOXYSILYLPROPYL)-N-METHYLAMINE C <sub>13</sub> H <sub>33</sub> NO <sub>6</sub> Si <sub>2</sub> [31024-70-1]	355.58	175° / 10 HMIS: 2-1-0-X	25g	Flashpoint: 106°C (223°F) 100g	1.023 1.430

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
 <b>SIC2058.2</b> 3-CARBAZOLYLPROPYLTRIETHOXYSILANE C <sub>21</sub> H <sub>29</sub> NO <sub>3</sub> Si For non-linear optic materials Employed in OLED fabrication. <sup>1</sup> 1. DeMais, T. et al. SPIE Proc. 1998, 3476, 338 [221105-38-0]	371.55	185-195° / 0.3		1.072	1.5527 <sup>25</sup>
		HMIS: 2-2-1-X	2.5g		NEW
 <b>SID3395.4</b> (N,N-DIETHYLAMINOMETHYL)TRIETHOXYSILANE C <sub>11</sub> H <sub>27</sub> NO <sub>3</sub> Si Catalyst for neutral cure 1-part RTVs [15180-47-9]	249.43	74-6° / 3		0.9336 <sup>25</sup>	1.4142 <sup>25</sup>
	TSCA-L	HMIS: 2-2-1-X	25g	100g	2kg
					COMMERCIAL
 <b>SID3395.6</b> (N,N-DIETHYLAMINOMETHYL)TRIMETHOXYSILANE, 95% C <sub>8</sub> H <sub>21</sub> NO <sub>3</sub> Si Charge control agent for toner particles Crosslinker for moisture-cure silicone RTVs [67475-66-5]	207.40			0.95	1.415
	TSCA-L	HMIS: 3-2-1-X	25g		NEW
 <b>SID3396.0</b> (N,N-DIETHYL-3-AMINOPROPYL)TRIMETHOXYSILANE C <sub>10</sub> H <sub>25</sub> NO <sub>3</sub> Si Provides silica-supported catalyst for 1,4-addition reactions. <sup>1</sup> Used together w/ SIA0591.0 to anchor PdCl <sub>2</sub> catalyst to silica for acceleration of the Tsuji-Trost reaction. <sup>2</sup> 1. Mutukura, K. et al. Chem.-Eur. J. 2009, 15, 10871. 2. Noda, H. et al. Angew. Chem., Int. Ed. Engl. 2012, 51, 8017. [41051-80-3]	235.40	120° / 20 Flashpoint: 100°C (212°F)		0.934	1.4245
	TSCA	EC 255-192-0	HMIS: 2-1-1-X	25g	100g
				2kg	COMMERCIAL
 <b>SID3546.92</b> 3-(N,N-DIMETHYLAMINOPROPYL)AMINOPROPYL METHYLDIMETHOXYSILANE C <sub>11</sub> H <sub>28</sub> N <sub>2</sub> O <sub>2</sub> Si Combines secondary and tertiary amine functionality Comonomer for silicone textile finishes [224638-27-1]	284.44	92-4° / 0.7		0.915	1.442
		HMIS: 3-2-1-X	25g	100g	NEW
 <b>SID3546.94</b> N,N-DIMETHYL-3-AMINOPROPYL METHYLDIMETHOXYSILANE C <sub>8</sub> H <sub>21</sub> NO <sub>2</sub> Si [67353-42-8]	191.36	92° / 25		0.894	1.4203
		HMIS: 2-2-1-X	10g		NEW
 <b>SID3547.0</b> (N,N-DIMETHYL-3-AMINOPROPYL)TRIMETHOXYSILANE C <sub>8</sub> H <sub>21</sub> NO <sub>3</sub> Si Derivatized silica catalyzes Michael reactions. <sup>1</sup> 1. Mode, J. et al. Synlett 1998, 625. [2530-86-1]	207.34	106° / 30 Flashpoint: 99°C (210°F)		0.948 <sup>25</sup>	1.4150
	TSCA	EC 219-786-3	HMIS: 2-2-1-X	10g	50g
				2kg	
 <b>SIM6572.0</b> N-METHYL-N-TRIMETHYLSILYL-3-AMINOPROPYLTRIMETHOXYSILANE, 95% C <sub>10</sub> H <sub>27</sub> NO <sub>3</sub> Si <sub>2</sub> Contains N-methylaminopropyltrimethoxysilane	265.50				NEW
		HMIS: 3-2-1-X	10g		
 <b>SIT8716.2</b> TRIS(TRIETHOXYSILYL METHYL)AMINE, tech-90 C <sub>21</sub> H <sub>51</sub> NO <sub>9</sub> Si <sub>3</sub> Contains ~5% bis(triethoxysilylmethyl)amine Forms immobilized quaternary salts [1250435-76-7]	545.90	156° / 0.7		0.99	1.426
		HMIS: 2-2-1-X	5g		NEW

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIT8716.3</b> TRIS(TRIETHOXYSILYLPROPYL)AMINE, tech-95 <chem>C27H63NO9Si3</chem> Coupling agent/primer for metal substrates [18784-74-2]	630.06	200-5° / 1		1.4322 <sup>25</sup>	NEW
<b>Quaternary Amine Functional Silanes</b>					
<b>SIB0957.0</b> N-(2-N-BENZYLAMINOETHYL)-3-AMINOPROPYLTRIMETHOXYSILANE hydrochloride, 50% in methanol <chem>C15H28N2O3Si·HCl</chem> Amber liquid [623938-90-9]	348.95	Flashpoint: 9°C (48°F)	HMIS: 2-2-1-X	25g	0.942 1.4104
<b>SID3392.0</b> N,N-DIDECYL-N-METHYL-N-(3-TRIMETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 40-42% in methanol <chem>C27H60ClNO3Si</chem> Contains 3-5% Cl(CH <sub>2</sub> ) <sub>3</sub> Si(OMe) <sub>3</sub> In combination with TEOS forms high pore volume xerogels with adsorptive capacity. <sup>1</sup> 1. Markovitz, M. et al. <i>Langmuir</i> 2001, 17, 7085. [68959-20-6]	510.32	Flashpoint: 11°C (52°F)	TSCA	100g	0.863 1.4085
<b>SIO6620.0</b> OCTADECYLDIMETHYL(3-TRIMETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 60% in methanol <chem>C28H56ClNO3Si</chem> Contains 3-5% Cl(CH <sub>2</sub> ) <sub>3</sub> Si(OMe) <sub>3</sub> Employed as a glass lubricant Orients liquid crystals Provides an antistatic surface coating Dispersion/coupling agent for high density magnetic recording media. <sup>1</sup> Application as immobilizable antimicrobial reported. <sup>2</sup> 1. Vincent, H. In <i>Chemically Modified Oxide Surfaces</i> ; D. Leyden, D., Ed.; Gordon & Breach: 1990; p.305. 2. White, W. et al. In <i>Silanes, Surfaces &amp; Interfaces</i> ; Leyden, D., Ed.; Gordon & Breach: 1986; p.107. [27668-52-6]	496.29	Flashpoint: 15°C (59°F) Autoignition temperature: 230°C	TSCA EC 273-403-4	25g	0.89
<b>SIS6989.0</b> (STYRYLMETHYL)BIS(TRIETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 40% in ethanol <chem>C27H52ClNO6Si2</chem> Inhibited with BHT, mixed <i>m</i> -, <i>p</i> -isomers Dipodal quaternary coupling agent	578.34	Flashpoint: 15°C (59°F)	HMIS: 3-4-1-X store <5°C	25g	0.909 100g
<b>SIS6994.0</b> 3-(N-STYRYLMETHYL-2-AMINOETHYLAMINO)PROPYLTRIMETHOXYSILANE HYDROCHLORIDE, 40% in methanol <chem>C17H31ClN2O3Si</chem> Inhibited with BHT Viscosity: 2.3 cSt Specific wetting surface area: 208 m <sup>2</sup> /g Coupling agent for phenolic and epoxy fiberglass laminates (printed circuit boards) [34937-00-3]	374.98	Flashpoint: 11°C (52°F)	TSCA EC 252-297-3	25g	0.91 1.395 2kg
<b>SIT7090.0</b> TETRADECYLDIMETHYL(3-TRIMETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 50% in methanol <chem>C22H50ClNO3Si</chem> Contains 3-5% Cl(CH <sub>2</sub> ) <sub>3</sub> Si(OMe) <sub>3</sub> [41591-87-1]	440.18	Flashpoint: 11°C (52°F)	TSCA EC 255-451-8	25g	0.878 1.3971
<b>SIT8395.0</b> 4-(TRIMETHOXYSILYLETHYL)BENZYLTRIMETHYLAMMONIUM CHLORIDE, 60% in methanol <chem>C15H28ClNO3Si</chem> Candidate for exchange resins and extraction phases	333.93	Flashpoint: 11°C (52°F)	HMIS: 3-3-1-X	25g	0.966

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIT8405.0</b> S-(TRIMETHOXYSILYLPROPYL)ISOTHIOURONIUM CHLORIDE, 50% in water <i>TRIHYDROXYPROPYLCARBAMIDOETHIOIC ACID HYDROCHLORIDE</i> C <sub>7</sub> H <sub>14</sub> ClN <sub>2</sub> O <sub>3</sub> SSi Essentially silanetriol pH: 6 Antimicrobial activity reported [84682-36-0] TSCA EC 283-599-3 HMIS: 2-0-0-X 25g 1.190 1.441	274.84				
<b>SIT8415.0</b> N-TRIMETHOXYSILYLPROPYL-N,N,N-TRIMETHYLMONIUM CHLORIDE, 50% in methanol <i>N,N,N-TRIMETHYL-3-(TRIMETHOXYSILYL)-1-PROPANAMINIUM CHLORIDE</i> C <sub>9</sub> H <sub>24</sub> CINO <sub>3</sub> Si Employed for bonded chromatographic phases Anti-static agent Used to treat glass substrates employed in electroblotting Prevents contact electrification. <sup>1</sup> 1. Thomas, S. et al. <i>J. Am. Chem. Soc.</i> <b>2009</b> , 131, 8746. [35141-36-7] TSCA EC 252-393-5 HMIS: 2-4-1-X 25g 2kg 15kg 0.927 1.3966 COMMERCIAL	257.83		Flashpoint: 11°C (52°F)		
<b>Dipodal Amine Functional Silanes</b>					
<b>SIA0587.6</b> 1-[3-(2-AMINOETHYL)-3-AMINOISOBUTYL]-1,1,3,3-PENTAETHOXY-1,3-DISILAPROPANE, 95% C <sub>17</sub> H <sub>42</sub> N <sub>2</sub> O <sub>5</sub> Si <sub>2</sub> Pendant dipodal silane HMIS: 3-1-1-X 10g 0.990 NEW	410.70	130-140° / 0.5			
<b>SIB1620.0</b> BIS(METHYLDIETHOXYSILYLPROPYL)AMINE, 95% C <sub>16</sub> H <sub>39</sub> NO <sub>2</sub> Si <sub>2</sub> Dipodal coupling agent [31020-47-0] HMIS: 2-1-1-X 25g 100g 0.937 1.4385	365.66	155° / 0.6			
<b>SIB1645.0</b> BIS(METHYLDIMETHOXYSILYLPROPYL)-N-METHYLAMINE, 95% C <sub>13</sub> H <sub>33</sub> NO <sub>2</sub> Si <sub>2</sub> Viscosity: 6 - 7 cSt HMIS: 3-2-1-X 25g 0.951 1.4368	323.58	140° / 2			
<b>SIB1824.5</b> BIS(3-TRIETHOXYSILYLPROPYL)AMINE, 95% C <sub>18</sub> H <sub>43</sub> NO <sub>6</sub> Si <sub>2</sub> Viscosity: 5.5 cSt Coupling agent for polyamides with improved hydrolytic stability Adhesion promoter, crosslinking agent for hot melt adhesives Adhesion promoter for aluminum-polyester multilayer laminates Adhesion promoter, crosslinker for 2-part condensation cure silicones [13497-18-2] TSCA EC 236-818-1 HMIS: 3-1-1-X 25g 100g 2kg 0.97 1.4265 COMMERCIAL	425.71	160° / 0.6 Flashpoint: 162°C (324°F)			
<b>SIB1828.0</b> N,N'-BIS[3-(TRIETHOXYSILYL)PROPYL]UREA, 60% in ethanol C <sub>19</sub> H <sub>44</sub> N <sub>2</sub> O <sub>2</sub> Si <sub>2</sub> [69465-84-5] HMIS: 2-1-1-X 25g 100g 0.923	468.73	Flashpoint: 17°C (63°F)			
<b>SIB1832.8</b> 1,11-BIS(TRIMETHOXYSILYL)-4-OXA-8-AZAUNDECAN-6-OL, 50% in methanol <i>3,3,15,15-TETRAMETHOXY-2,7,16-TRIOXA-11-AZA-3,15-DISILAHEPTADECAN-9-OL</i> C <sub>15</sub> H <sub>37</sub> NO <sub>8</sub> Si <sub>2</sub> Provides strong glass-to-glass bonds [126552-46-3] HMIS: 3-4-1-X 25g 100g 0.922 1.384 <sup>25</sup> NEW	415.63	Flashpoint: 11°C (52°F)			

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>		
<b>SIB1833.0</b> BIS(3-TRIMETHOXYSILYLPROPYL)AMINE, 96% <chem>C12H31NO6Si2</chem>	341.56	152° / 4 Flashpoint: 113°C (235°F)		1.040	1.4320		
Dipodal coupling agent Secondary amine allows more control of reactivity with isocyanates Low level incorporation with acryloxypropyltrimethoxysilane, SIA0200, increases strength and hydrolytic stability of dental composites. <sup>1</sup> 1. Matilinna, J. et al. <i>Acta Odontol. Scand.</i> <b>2012</b> , 70, 405. [82985-35-1] TSCA EC 280-084-5 HMIS: 3-1-1-X	25g	2kg	18kg		COMMERCIAL		
<b>SIB1834.0</b> N,N-BIS[(3-TRIMETHOXYSILYL)PROPYL]ETHYLENEDIAMINE, 62% in methanol <chem>C14H36N2O6Si2</chem> Contains N,N-isomer Coupling agent for polyamides with enhanced hydrolytic stability Provides improved solder resistance for printed circuit boards [68845-16-9] TSCA EC 272-453-4 HMIS: 3-4-1-X	384.62	Flashpoint: 20°C (68°F)		0.89	COMMERCIAL		
<b>SIB1834.1</b> N,N-BIS[(3-TRIMETHOXYSILYL)PROPYL]ETHYLENEDIAMINE, 95% <chem>C14H36N2O6Si2</chem> Contains N,N-isomer Coupling agent for polyamides with enhanced hydrolytic stability Forms thin film environments for metal ions. <sup>1</sup> 1. He, J. et al. <i>R/IKEN Review</i> <b>2002</b> , 45, 27. [68845-16-9] TSCA EC 272-453-4 HMIS: 3-1-1-X	384.62	Flashpoint: >110°C (>230°F)		1.050	1.4428		
<b>SIB1835.0</b> BIS(3-TRIMETHOXYSILYLPROPYL)-N-METHYLAMINE <chem>C13H33NO6Si2</chem> [31024-70-1]	355.58	175° / 10 Flashpoint: 106°C (223°F) HMIS: 2-1-0-X	25g	100g	1.023	1.430	NEW
<b>SIB1835.2</b> N,N-BIS(3-TRIMETHOXYSILYLPROPYL)THIOUREA, tech-90 <chem>C14H36N2O6Si3</chem> Viscosity: 160-200 cSt Forms mesoporous silicas that chelate metals	400.66				1.13	1.485	NEW
<b>SIB1835.5</b> N,N-BIS(3-TRIMETHOXYSILYLPROPYL)UREA, 95% <chem>C13H33NO6Si2</chem> Amber liquid Viscosity: 100 - 250 cSt Adhesion promoter for 2-part condensation cure silicone RTVs [18418-53-6] TSCA HMIS: 3-2-1-X	384.58	Flashpoint: >110°C (>230°F)	25g	100g	1.10	1.4488	COMMERCIAL
<b>SIS6989.0</b> (STYRYLMETHYL)BIS(TRIETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 40% in ethanol <chem>C27H52ClNO6Si2</chem> Inhibited with BHT, mixed <i>m</i> -, <i>p</i> -isomers Dipodal quaternary coupling agent	578.34	Flashpoint: 15°C (59°F) HMIS: 3-4-1-X store <5°C	25g	100g	0.909		
<b>Specialty Amine Functional Silanes</b>							
<b>SIB1835.2</b> N,N-BIS(3-TRIMETHOXYSILYLPROPYL)THIOUREA, tech-90 <chem>C13H33NO6SSi2</chem> Viscosity: 160-200 cSt Forms mesoporous silicas that chelate metals	400.66				1.13	1.485	NEW
<b>SID4068.0</b> 3-(1,3-DIMETHYLBUTYLIDENE)AMINOPROPYLTRIETHOXYSILANE, tech-95 <chem>C15H35NO3Si</chem> Contains oligomers Coupling agent for epoxy coatings; blocked amine - moisture deblocked Preferred adhesion promoter for low viscosity epoxy systems [116229-43-7] TSCA HMIS: 2-1-1-X	303.52	134° / 5 Flashpoint: 131°C (268°F)	25g	100g	0.93	1.437 <sup>25</sup>	COMMERCIAL

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SID4068.1</b> 3-(1,3-DIMETHYLBUTYLIDENE)AMINOPROPYLTRIETHOXYSILANE, 98% <chem>C15H33NO3Si</chem>	303.52	134° / 5 Flashpoint: 131°C (268°F)		0.93	1.437 <sup>25</sup> NEW
Coupling agent for epoxy coatings; blocked amine - moisture deblocked Preferred adhesion promoter for low viscosity epoxy systems [116229-43-7] TSCA HMIS: 2-1-1-X 25g					
<b>SID4465.0</b> N,N-DIOCTYL-N'-TRIETHOXYSILYLPROPYLUREA <chem>C26H56N2O4Si</chem>	488.83			0.924 <sup>25</sup>	1.4521 <sup>25</sup>
Forms hydrophobic phases with embedded hydrophilicity Forms organic-inorganic vesicles (cerasomers). <sup>1</sup> 1. Hashizume, M. et al. <i>J. Thin Solid Films</i> <b>2003</b> , 438, 20. [259727-10-1] HMIS: 2-2-1-X 25g					
<b>SIG5840.12</b> 3-(GUANIDINYLYL)PROPYLTRIMETHOXYSILANE <chem>C7H19N3O3Si</chem>	221.35		(>200°)		
White powder Water-soluble coupling agent [128310-21-4] HMIS: 3-1-1-X 5g					
<b>SIP6828.4</b> 3-(1-PIPERAZINYLYL)PROPYLMETHYLDIMETHOXYSILANE, 95% <chem>C10H24N2O2Si</chem>	232.40	110-2° / 1 Flashpoint: 123°C (253°F)		0.986	1.4628 <sup>25</sup> NEW
Adhesion promoter for metal substrates Comonomer for silicones [128996-12-3] HMIS: 3-2-1-X 25g					
<b>SIP6926.2</b> 3-(2-PYRIDYLETHYL)THIOPROPYLTRIMETHOXYSILANE <chem>C13H23NO3SSi</chem>	301.48	156-7° / 0.25 HMIS: 3-2-1-X 10g		1.089	1.498
[29098-72-4]					
<b>SIP6926.4</b> 3-(4-PYRIDYLETHYL)THIOPROPYLTRIMETHOXYSILANE, 95% <chem>C13H23NO3SSi</chem>	301.48	160-2° / 0.2 HMIS: 3-2-1-X 10g		1.09	1.5037
Immobilizable ligand for immunoglobulin IgG separation using hydrophobic charge induction chromatography (HCIC) [198567-47-4]					
<b>SIS6944.0</b> 3-(4-SEMICARBAZIDYL)PROPYLTRIETHOXYSILANE, tech-95 <chem>C10H25N3O3Si</chem>	279.41	Flashpoint: >110°C (>230°F)		1.08	1.4593 NEW
Employed in immobilization of oligonucleotides. <sup>1</sup> 1. Podyminogin, M. et al. <i>Nucleic Acids Res.</i> <b>2001</b> , 29, 5090. [106868-88-6] HMIS: 3-1-1-X 5g					
<b>SIS6995.0</b> 11-(SUCCINIMIDYOXY)UNDECYLDIMETHYLETHOXYSILANE, 95% <chem>C19H37NO5Si</chem>	371.59	195-200° / 0.6 (28°)			
Reagent for immobilization of proteins via primary amines HMIS: 3-2-1-X 1.0g					
<b>SIT8186.45</b> 4-(TRIETHOXYSILYLPOPOXY)-2,2,6,6-TETRAMETHYLPIPERIDINE N-OXIDE, tech-85 <i>TEMPO-SILANE</i> <chem>C18H38NO5Si</chem>	376.58				
Employed in nitroxyl mediated grafting of vinylsilanes to polyolefins. <sup>1</sup> 1. Weaver, J. et al. <i>J. Polym. Sci., Part A: Polym. Chem.</i> <b>2008</b> , 46, 4542. [913375-27-6] HMIS: 2-2-1-X 10g					
<b>SIT8186.7</b> N-[3-(TRIETHOXYSILYL)PROPYL]-2-CARBOMETHOXYAZIRIDINE, 95% <chem>C13H27NO5Si</chem>	305.44			1.052 <sup>25</sup>	1.4197 <sup>25</sup> NEW
Reacts with fullerenes by 1,3-dipolar addition of azomethine ylide to yield pyrrolidine adduct. <sup>1</sup> 1. Bianco, A. et al. <i>J. Am. Chem. Soc.</i> <b>1997</b> , 119, 7550. [193417-26-4] HMIS: 3-2-1-X 2.5g					

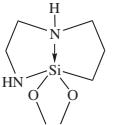
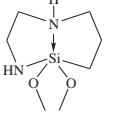
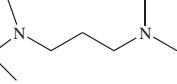
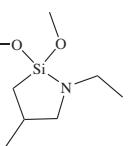
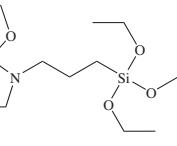
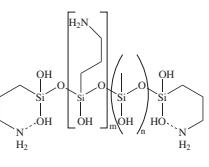
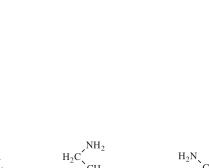
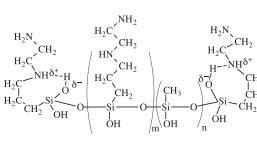
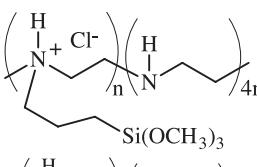
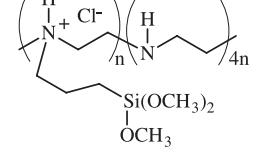
Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIT8187.5</b> N-(3-TRIETHOXYSILYLPROPYL)-4,5-DIHYDROIMIDAZOLE 3-(2-IMIDAZOLIN-1-YL)PROPYL TRIETHOXYSILANE, IMEO C <sub>12</sub> H <sub>26</sub> N <sub>2</sub> O <sub>3</sub> Si Viscosity: 5 cSt. Coupling agent for elevated temperature-cure epoxies Utilized in HPLC of metal chelates. <sup>1</sup> Forms proton vacancy conducting polymers with sulfonamides by sol-gel. <sup>2</sup> Ligand for molecular imprinting of silica with chymotrypsin transition state analog. <sup>3</sup> 1. Suzuki, T. et al. <i>Chem. Lett.</i> <b>1994</b> , 881. 2. De Zea Bermudez, V. et al. <i>Sol-Gel Optics II, SPIE Proc.</i> <b>1992</b> , 1728, 180. 3. Markowitz, M. et al. <i>Langmuir</i> <b>2000</b> , 16, 1759. [58068-97-6] TSCA EC 261-093-3 HMIS: 2-1-1-X 25g 100g 2kg	274.43	134° / 2 Flashpoint: >110°C (>230°F)		1.005	1.452
<b>SIT8394.0</b> N-[5-(TRIMETHOXYSILYL)-2-AZA-1-OXOPENTYL]CAPROLACTAM, 95% N-TRIMETHOXYSILYLPROPYLCARBAMOYL CAPROLACTAM C <sub>13</sub> H <sub>26</sub> N <sub>2</sub> O <sub>5</sub> Si [106996-32-1] HMIS: 3-1-1-X 25g (-39°) Flashpoint: 136°C (277°F)	318.45		(-39°)	1.14	1.4739
<b>SIT8409.0</b> N-(3-TRIMETHOXYSILYLPROPYL)PERFLUOROHEXANAMIDE C <sub>12</sub> H <sub>16</sub> F <sub>11</sub> NO <sub>4</sub> Si Surface tension: 20.6 mN/m Contact angle, water on treated silica surface: 105-110° [154380-34-4] HMIS: 3-1-1-X 10g	475.33			1.367	1.360
<b>SIU9055.0</b> UREIDOPROPYL TRIETHOXYSILANE, 50% in methanol C <sub>10</sub> H <sub>24</sub> N <sub>2</sub> O <sub>4</sub> Si Contains ureidopropyltrimethoxysilane and related transesterification products Coupling agent for polyamides and urea-formaldehyde resins [23779-32-0] TSCA EC 245-876-7 HMIS: 2-4-1-X 25g 2kg 16kg	264.40	Flashpoint: 11°C (52°F)	(-97°)	0.92	1.386
<b>SIU9058.0</b> UREIDOPROPYL TRIMETHOXYSILANE C <sub>7</sub> H <sub>18</sub> N <sub>2</sub> O <sub>4</sub> Si Component in primers for tin alloys Adhesion promoter for foundry resins [23843-64-3] TSCA EC 245-904-8 HMIS: 2-2-1-X 25g 100g 2kg	222.32	217-225° Flashpoint: 99°C (210°F) TOXICITY: oral rat, LD50: >5,000 mg/kg Autoignition temperature: 300°C	(-5°)	1.150	1.386 <sup>25</sup>
<b>Cyclic Azasilanes</b>					
<b>SIA0415.0</b> N-ALLYL-AZA-2,2-DIMETHOXYSILACYCLOPENTANE C <sub>8</sub> H <sub>17</sub> NO <sub>2</sub> Si Coupling agent for nanoparticles [618914-49-1]	187.31	52-4° / 3			
<b>SIA0592.0</b> N-(2-AMINOETHYL)-2,2,4-TRIMETHYL-1-AZA-2-SILACYCLOPENTANE C <sub>8</sub> H <sub>20</sub> N <sub>2</sub> Si Coupling agent for vapor phase modification of nanoparticles [18246-33-8] HMIS: 3-2-1-X 10g	172.35	54-6° / 2		0.905	1.4769
<b>SIA0604.0</b> N-(3-AMINOPROPYLDIMETHYLSILYL)AZA-2,2-DIMETHYL-2-SILACYCLOPENTANE, 95% 3-[(2,2-DIMETHYL-1-AZA-2-SILACYCLOPENT-1-YL)DIMETHYLSILYL]-1-PROPANAMINE, 3-[(2,2-DIMETHYL-1,2-AZASILOLIDIN-1-YL)DIMETHYLSILYL]-1-PROPANAMINE C <sub>10</sub> H <sub>26</sub> N <sub>2</sub> Si <sub>2</sub> Employed in vapor phase derivatization of porous silica. <sup>1</sup> 1. Brandhuber, D. et al. <i>J. Mater. Chem.</i> <b>2005</b> , 15, 3896. [388606-32-4] HMIS: 3-2-1-X 10g	230.50	158° Flashpoint: 72°C (162°F)		1.4705	
<b>SIB1932.4</b> N-n-BUTYL-AZA-2,2-DIMETHOXYSILACYCLOPENTANE C <sub>9</sub> H <sub>21</sub> NO <sub>2</sub> Si Coupling agent for nanoparticles. <sup>1</sup> Interlayer bonding agent for anti-reflective lenses. <sup>2</sup> 1. Arkles, B. et al. In <i>Silanes and Other Coupling Agents</i> ; Mittal, K., Ed.; 2004; Vol. 3, p.179. 2. Su, K. et al. U.S. Patent Appl. 2012 2672,790, 2012. [618914-44-6] TSCA HMIS: 3-2-1-X 25g	203.36	63-71° / 3 Flashpoint: 85°C (185°F)		0.941	1.438

COMMERCIAL

NEW

COMMERCIAL

COMMERCIAL

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>		
	<b>SID3543.0</b> 2,2-DIMETHOXY-1,6-DIAZA-2-SILACYCLOOCTANE C <sub>7</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub> Si Volatile coupling agent [182008-07-7]	190.32	71-3° / 2.5	(61-2°)			
	<b>SID3543.1</b> 2,2-DIMETHOXY-1,6-DIAZA-2-SILACYCLOOCTANE, 10% in cyclohexane C <sub>7</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub> Si [182008-07-7]	190.32	HMIS: 3-2-1-X	25g	0.79		
	<b>SID3546.93</b> (N,N-DIMETHYLAMINOPROPYL)-AZA-2-METHYL-2-METHOXYSILACYCLOPENTANE, 95% C <sub>10</sub> H <sub>24</sub> N <sub>2</sub> OSi Cyclic azasilane - acts as coupling agent for metals	216.39	65-7° / 0.5		0.919 <sup>25</sup>		
	<b>SIE4891.0</b> 1-ETHYL-2,2-DIMETHOXY-4-METHYL-1-AZA-2-SILACYCLOPENTANE C <sub>8</sub> H <sub>19</sub> NO <sub>2</sub> Si Cyclic azasilane utilized for vapor-phase surface treatment of nano-featured substrates	189.33	HMIS: 3-3-1-X	10g			
	<b>SIT8187.2</b> (1-(3-TRIETHOXYSILYL)PROPYL)-2,2-DIETHOXY-1-AZA-2-SILACYCLOPENTANE, tech-90 C <sub>16</sub> H <sub>37</sub> NO <sub>5</sub> Si <sub>2</sub> Contains bis(triethoxysilylpropyl)amine Cyclic azasilane that acts as coupling agent for metal-oxide films [1184179-50-7]	379.64	HMIS: 3-2-1-X	25g	0.974 1.4322 <sup>25</sup>		
<b>Water-borne Aminoalkyl Silsesquioxane Oligomers</b>							
	<b>WSA-7011</b> AMINOPROPYLSILSESQUIOXANE IN AQUEOUS SOLUTION Viscosity: 5-15 cSt Mole % functional group: 65-75 pH: 10-10.5 [1411854-75-5]	250-500	TSCA	100g	3kg	18kg	COMMERCIAL
	<b>WSA-9911</b> AMINOPROPYLSILSESQUIOXANE IN AQUEOUS SOLUTION Viscosity: 5-15 cSt Mole % functional group: 100 pH: 10-10.5 [29159-37-3]	270-550	TSCA	100g	3kg	18kg	COMMERCIAL
	<b>WSA-7021</b> AMINOETHYLAMINOPROPYLSILSESQUIOXANE IN AQUEOUS SOLUTION Viscosity: 5-10 cSt Mole % functional group: 65-75 pH: 10-11 [207308-27-8]	370-650	TSCA	100g	3kg	18kg	COMMERCIAL
	<b>WSAV-6511</b> AMINOETHYLAMINOPROPYL/VINYL/SILSESQUIOXANE IN AQUEOUS SOLUTION Viscosity: 3-10 cSt Mole % functional group: 60-65 pH: 10-11 [207308-27-8]	250-500	TSCA	100g	3kg	18kg	COMMERCIAL
<b>Polyamine</b>							
	<b>SSP-060</b> TRIMETHOXYSILYLPROPYL MODIFIED (POLYETHYLENIMINE), 50% in isopropanol 1,500-1,800 [136856-91-2] / [37251-86-8]	HMIS: 2-4-1-X	100g	2kg	0.92	16kg	
	<b>SSP-065</b> DIMETHOXYSILYL METHYLPROPYL MODIFIED (POLYETHYLENIMINE), 50% in isopropanol 1,500-1,800 [125441-88-5]	HMIS: 2-4-1-X	100g	3kg	0.92	16kg	

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>Anhydride Functional Silanes</b>					
<b>SIT8192.6</b> (3-TRIETHOXYSILYL)PROPYLSUCCINIC ANHYDRIDE, 95% C <sub>13</sub> H <sub>24</sub> O <sub>6</sub> Si Viscosity: 20 cSt	304.41	135° / 0.2 Flashpoint: >100°C (>212°F) TOXICITY: oral rat, LD50: >2,000 mg/kg Autoignition temperature: 250°C	1.070	1.4405	COMMERCIAL
Coupling agent for dibasic surfaces Acetic acid-catalyzed hydrolysis yields succinic acid derivatives [93642-68-3] TSCA EC 297-566-6 HMIS: 2-1-1-X	25g	100g	2kg		

## Azide Functional Silanes

<b>SIA0770.0</b> (AZIDOMETHYL)PHENETHYLTRIMETHOXYSILANE, tech-90 C <sub>12</sub> H <sub>15</sub> N <sub>3</sub> O <sub>3</sub> Si <b>CAUTION: CAN FORM EXPLOSIVE COMPOUNDS IN CONTACT WITH COPPER AND SILVER COMPOUNDS</b> Mixed isomers Reagent for "click" chemistry [1245946-78-4]	281.39	HMIS: 4-2-1-X	5g	1.11	1.497 <sup>25</sup>	NEW
<b>SIA0774.0</b> p-AZIDOMETHYLPHENYLTRIMETHOXYSILANE, 90% C <sub>10</sub> H <sub>15</sub> N <sub>3</sub> O <sub>3</sub> Si <b>AVOID CONTACT WITH METALS</b> [83315-74-6]	253.33	HMIS: 4-2-1-X	2.5g	1.14	1.497 <sup>25</sup>	NEW
<b>SIA0777.0</b> 3-AZIDOPROPYLTRIETHOXYSILANE C <sub>9</sub> H <sub>21</sub> N <sub>3</sub> O <sub>3</sub> Si <b>AVOID CONTACT WITH METALS</b> Used with click chemistry to introduce and immobilize discrete complexes onto the SBA-15 surface. <sup>1</sup> Used in the preparation of poly-L-lysine to silica nanoparticles. <sup>2</sup> 1. Nakazawa, J. et al. <i>J. Am. Chem. Soc.</i> <b>2012</b> , <i>134</i> , 2750. 2. Kar, M. et al. <i>Langmuir</i> , <b>2010</b> , <i>26</i> , 5772. [83315-69-9]	247.37	HMIS: 4-1-1-X	1.0g	0.981	1.4257	NEW
<b>SIA0780.0</b> 6-AZIDOSULFONYLHEXYLTRIETHOXYSILANE, tech-95 1-TRIETHOXYSILYL-6-SULFONAZIDE-n-HEXANE C <sub>12</sub> H <sub>21</sub> N <sub>3</sub> O <sub>5</sub> SSI <b>AVOID CONTACT WITH METALS</b> Amber-brown liquid Inserts nitrenes into aliphatics and aromatics at temperatures >110°C [96550-26-4]	353.51	HMIS: 3-1-1-X	25g	1.147	1.4634	
				Flashpoint: 114°C (237°F)		
<b>SIA0790.0</b> 4-(AZIDOSULFONYL)PHENETHYLTRIMETHOXYSILANE, 22-25% in methanol/toluene 4-[2-(TRIMETHOXYSILYL)ETHYL]-1-BENZENESULFONYL AZIDE C <sub>11</sub> H <sub>17</sub> N <sub>3</sub> O <sub>5</sub> SSI <b>AVOID CONTACT WITH METALS</b> Contains hydrolysis oligomers Extremely reactive coupling agent Inserts nitrenes into aliphatics and aromatics at temperatures >110°C [68479-60-7]	331.42	TSCA EC 270-862-2 HMIS: 3-4-1-X	25g	0.90	1.550	NEW
				Flashpoint: 29°C (4°F)		
<b>SIA0795.0</b> 11-AZIDOUNDECYLTRIMETHOXYSILANE, 95% C <sub>14</sub> H <sub>31</sub> N <sub>3</sub> O <sub>3</sub> Si <b>AVOID CONTACT WITH METALS</b> Forms "click" functionalized surfaces [334521-23-2]	317.50	HMIS: 3-1-1-X	2.5g			NEW

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>Carboxylate, Phosphonate and Sulfonate Functional Silanes</b>					
<b>SIB1824.56</b> BIS(3-TRIETHOXYSILYLPROPYL)CARBONATE  C <sub>19</sub> H <sub>42</sub> O <sub>9</sub> Si <sub>2</sub> Forms thermally labile bridged silsesquioxanes. <sup>1</sup> 1. Loy, D.A. et al. <i>Chem. Mater.</i> <b>1999</b> , <i>11</i> , 3333. [88321-11-3]	470.71			1.020	NEW
<b>SIB1834.5</b> BIS(3-TRIMETHOXYSILYLPROPYL) FUMARATE, 96%  C <sub>16</sub> H <sub>32</sub> O <sub>10</sub> Si <sub>2</sub> Dipodal silane Adhesion promoter for Pt-cure silicone RTVs [3371-62-8]	440.59	Flashpoint: >110°C (>230°F)		1.118	1.443
<b>SIC2263.0</b> CARBOXYETHYLSILANETRIOL, DISODIUM SALT, 25% in water  C <sub>3</sub> H <sub>6</sub> Na <sub>2</sub> O <sub>5</sub> Si pH: 12 - 12.5 In combination with aminofunctional silanes forms amphoteric silicas. <sup>1</sup> 1. Han, L. et al. <i>Chem. Mater.</i> <b>2007</b> , <i>19</i> , 2860. [18191-40-7]	196.14	HMIS: 2-0-0-X	25g	100g	1.170 <sup>25</sup>
<b>SIC2417.0</b> 2-(4-CHLOROSULFONYLPHENYL)ETHYLTRIMETHOXYSILANE, 50% in methylene chloride  C <sub>11</sub> H <sub>17</sub> ClO <sub>5</sub> SSi Amber color Contains free sulfonic acid Treated silica acts as etherification catalyst. <sup>1</sup> Reagent for surface initiated ATRP. <sup>2</sup> Employed in mesostructured fuel-cell membranes. <sup>3</sup> 1. Sow, B. et al. <i>Microporous and Mesoporous Mat'l's.</i> <b>2005</b> , <i>79</i> , 129. 2. Fukuda, J. et al. <i>Macromolecules</i> <b>2000</b> , <i>33</i> , 2870. 3. Pereira, F. et al. <i>Chem. Mater.</i> <b>2008</b> , <i>20</i> , 1710. [126519-89-9]	324.85	HMIS: 3-2-1-X	25g	100g	1.30 <sup>25</sup>
<b>SIC2417.4</b> 2-(4-CHLOROSULFONYLPHENYL)ETHYLTRIMETHOXYSILANE, 50% in toluene  C <sub>11</sub> H <sub>17</sub> ClO <sub>5</sub> SSi [126519-89-9]	324.85	Flashpoint: 4°C (39°F) 25g			NEW
<b>SIT8189.8</b> TRIETHOXYSILYLPROPYLMALEAMIC ACID, tech-90  C <sub>13</sub> H <sub>25</sub> NO <sub>5</sub> Si Contains condensation products and 10% ethanol Viscosity: 600-900 cSt Reagent for immobilization of anti-bodies on silicon nitride sensor chips. <sup>1</sup> 1. Kurihara, Y. et al. <i>Langmuir</i> <b>2012</b> , <i>28</i> , 13609. [33525-68-7]	319.43	TSCA EC 251-564-1 HMIS: 3-2-1-X	25g		1.11 1.472
<b>SIT8192.2</b> TRIETHOXYSILYLPROPYL(POLYETHYLENEOXY)PROPYLPOTASSIUM SULFATE, 45-50% in ethanol  C <sub>25</sub> H <sub>53</sub> KO <sub>13</sub> SSi - C <sub>31</sub> H <sub>65</sub> KO <sub>16</sub> SSi [143282-00-2]/[876338-08-8]	661 - 793	HMIS: 2-3-0-X	2.5g		0.95
<b>SIT8378.1</b> TRIHYDROXYSILYLETHYL PHENYLSULPHONIC ACID, 25% in water  C <sub>8</sub> H <sub>12</sub> O <sub>6</sub> SSi Mixed isomers Forms hybrid organic-inorganic ionic membranes	264.33	HMIS: 3-0-0-X	25g		NEW
<b>SIT8378.3</b> 3-(TRIHYDROXYSILYL)-1-PROPANESULFONIC ACID, 30-35% in water  C <sub>3</sub> H <sub>10</sub> O <sub>6</sub> SSi pH: <1 Employed in preparation of nanoscale ionic silicas. <sup>1</sup> Forms sulfonated fuel cell electrodes. <sup>2</sup> 1. Giannelis, E. et al. <i>Appl. Organomet. Chem.</i> <b>2010</b> , <i>24</i> , 581. 2. Eastcott, J. et al. <i>J. Power Sources</i> <b>2012</b> , <i>197</i> , 102. [70942-24-4]	202.26	TSCA HMIS: 3-0-0-X	25g	100g	1.12

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIT8401.0</b> N-(TRIMETHOXYSLYLPROPYL)ETHYLENEDIAMINETRIACETATE, TRIPOTASSIUM SALT, 30% in water <chem>C14H25K3N2O9Si</chem> Essentially silanetriol, contains KCl Chelates metal ions [1309595-29-6]	510.75			1.22	NEW
<b>SIT8402.0</b> N-(TRIMETHOXYSLYLPROPYL)ETHYLENEDIAMINETRIACETATE, TRISODIUM SALT, 35% in water <chem>C14H25Na2N2O9Si</chem> Essentially silanetriol, contains NaCl Chelates metal ions [128850-89-5]/[1138444-28-6]	462.42			1.26	
TSCA-L	HMIS: 2-0-0-X	25g	100g		

## Epoxy Functional Silanes

### Epoxy Functional Silanes - Trialkoxy

	<b>SIE4668.0</b> 2-(3,4-EPOXYCYCLOHEXYL)ETHYLTRIETHOXYSILANE <chem>C14H28O4Si</chem>	288.46	114-7° / 0.4 Flashpoint: 104°C (219°F)	1.015	1.4455	COMMERCIAL
	Adhesion promoter for water-borne coatings on alkaline substrates [10217-34-2]	TSCA	HMIS: 2-1-1-X	25g	100g	2kg
	<b>SIE4670.0</b> 2-(3,4-EPOXYCYCLOHEXYL)ETHYLTRIMETHOXYSILANE <chem>C11H22O4Si</chem>	246.38	95-7° / 0.25 Flashpoint: 146°C (295°F) TOXICITY: oral rat, LD50: 12,300 mg/kg Vapor pressure, 152°: 10 mm Specific wetting surface: 317 m <sup>2</sup> /g	1.065	1.4490	COMMERCIAL
	Viscosity: 5.2 cSt γc of treated surfaces: 39.5 mN/m Coefficient of thermal expansion: 0.8 x 10 <sup>-3</sup>					
	Ring epoxide more reactive than glycidoxypipyl systems UV initiated polymerization of epoxy group with weak acid donors Forms UV-curable coating resins by controlled hydrolysis. <sup>1</sup> Used to make epoxy-organosilica particles w/ high positive Zeta potential. <sup>2</sup>					
	1. Crivello, J.; Mao. Z. <i>Chem. Mater.</i> <b>1997</b> , 9, 1554. 2. Nakamura, M.; Ishimura, K. <i>Langmuir</i> <b>2008</b> , 24, 12228. [3388-04-3]	TSCA EC 222-217-1 HMIS: 3-1-1-X		100g	2kg	18kg
	<b>SIE4675.0</b> 5,6-EPOXYHEXYLTRIETHOXYSILANE <chem>C12H26O4Si</chem>	262.42	115-9° / 1.5 Flashpoint: 99°C (210°F) 10g	0.960 <sup>25</sup>	1.4254 <sup>25</sup>	COMMERCIAL
	[86138-01-4]	HMIS: 3-2-1-X				
	<b>SIG5839.0</b> (3-GLYCIDOXYPROPYL)TRIETHOXYSILANE <chem>C12H26O5Si</chem>	278.42	124° / 3 Flashpoint: 144°C (291°F) Autoignition temperature: 225°C	1.00	1.425	COMMERCIAL
	Viscosity: 3 cSt					
	Coupling agent for latex polymers Primer for aluminum and glass to epoxy coatings and adhesives when applied as a 1-2% solution in solvent [2602-34-8]	TSCA EC 220-011-6 HMIS: 3-1-1-X		25g	100g	2kg
	<b>SIG5840.0</b> (3- GLYCIDOXYPROPYL)TRIMETHOXYSILANE <chem>C9H20O5Si</chem>	236.34	120° / 2 (<-70°) Flashpoint: 135°C (276°F) TOXICITY: oral rat, LD50: 8,400 mg/kg Autoignition temperature: 231°C	1.070	1.4290	COMMERCIAL
	Viscosity: 3.2 cSt Surface tension: 38.5 mN/m Specific wetting surface area: 331 m <sup>2</sup> /g					
	Component in aluminum metal bonding adhesives Coupling agent for epoxy composites employed in electronic "chip" encapsulation Component in abrasion resistant coatings for plastic optics Used to prepare epoxy-containing hybrid organic-inorganic materials. <sup>1</sup>					
	1. Innocenzi, P. et al. <i>Chem. Mater.</i> <b>1999</b> , 11, 1672. [2530-83-8]	TSCA EC 219-784-2 HMIS: 3-1-1-X		100g	2kg	18kg
	<b>SIG5840.1</b> (3- GLYCIDOXYPROPYL)TRIMETHOXYSILANE, 99+%	236.34	120° / 2 (<-70°) Flashpoint: 135°C (276°F)	1.070	1.4290	COMMERCIAL
	<chem>C9H20O5Si</chem>					
	Low fluorescence grade for high-throughput screening [2530-83-8]	TSCA EC 219-784-2 HMIS: 3-1-1-X		25g		
					* in fluoropolymer bottle	

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>Epoxy Functional Silanes - Dialkoxy</b>					
<b>SIE4666.0</b> 2-(3,4-EPOXYCYCLOHEXYL)ETHYLMETHYLDIETHOXYSILANE C <sub>13</sub> H <sub>26</sub> O <sub>5</sub> Si UV polymerizable monomer [14857-35-3]	258.43	114-7° / 1		0.976 <sup>25</sup>	1.4248 <sup>25</sup>
		HMIS: 2-2-1-X	25g		NEW
<b>SIG5832.0</b> (3-GLYCIDEOXYPROPYL)METHYLDIETHOXYSILANE C <sub>11</sub> H <sub>24</sub> O <sub>4</sub> Si	248.39	122-6° / 5		0.978 <sup>25</sup>	1.431
		Flashpoint: 122°C (252°F) TOXICITY: oral rat, LD50: >2,000 mg/kg			COMMERCIAL
Employed in scratch resistant coatings for eye glasses Coupling agent for latex systems with reduced tendency to gel compared to SIG5840.0 [2897-60-1]	TSCA EC 220-780-8	HMIS: 2-1-1-X	25g	100g	2kg
<b>SIG5836.0</b> (3-GLYCIDEOXYPROPYL)METHYLDIMETHOXYSILANE C <sub>9</sub> H <sub>20</sub> O <sub>4</sub> Si	220.34	100° / 4		1.02	1.431 <sup>25</sup>
Relative hydrolysis rate vs. SIG5840.0: 7.5:1 [65799-47-5]	TSCA EC 265-929-8	HMIS: 3-1-1-X	25g	100g	
<b>Epoxy Functional Silanes - Monoalkoxy</b>					
<b>SIG5825.0</b> (3-GLYCIDEOXYPROPYL)DIMETHYLETHOXYSILANE C <sub>10</sub> H <sub>22</sub> O <sub>3</sub> Si [17963-04-1]	218.37	100° / 3		0.950	1.4337 <sup>25</sup>
	TSCA EC 241-889-7	HMIS: 3-2-1-X	10g	50g	
Flashpoint: 87°C (189°F)					
<b>Ester Functional Silanes</b>					
<b>SIA0050.0</b> ACETOXYMETHYLTRIETHOXYSILANE C <sub>9</sub> H <sub>20</sub> O <sub>5</sub> Si Hydrolyzes to form stable silanol solutions in neutral water [5630-83-1]	236.34	106° / 15		1.042 <sup>25</sup>	1.4092
	TSCA-L	HMIS: 2-2-1-X	25g	100g	
<b>SIA0055.0</b> ACETOXYMETHYLTRIMETHOXYSILANE, 95% C <sub>6</sub> H <sub>14</sub> O <sub>5</sub> Si [65625-39-0]	194.26	190-1°		1.085	1.4031
	TSCA-L	HMIS: 3-2-1-X	10g	50g	
Flashpoint: 56°C (133°F)					
<b>SIA0078.0</b> 2-[ACETOXY(POLYETHYLENEOXY)PROPYL]TRIETHOXYSILANE, 95% 500 - 700 Viscosity: 30 cSt [59004-18-1]				1.071	1.4527
		HMIS: 2-1-1-X	25g		
<b>SIA100.0</b> 3-ACETOXYPROPYLTRIMETHOXYSILANE C <sub>8</sub> H <sub>18</sub> O <sub>5</sub> Si μc of treated surfaces: 37.5 mN/m Forms sol-gel derived epoxidation catalyst in combination with titanium diisopropoxide bispentanediionate. <sup>1</sup> 1. Müller, C. et al. <i>Catal. Lett.</i> <b>2000</b> , 64(1), 9-14, DOI 10.1023/A:109074617565 [59004-18-1]	222.31	92° / 2		1.062	1.4146
		Flashpoint: 93°C (199°F)			COMMERCIAL
	EC 261-552-8	HMIS: 3-1-1-X	25g	100g	2kg
<b>SIB0959.0</b> BENZOYOXYPROPYLTRIMETHOXYSILANE C <sub>13</sub> H <sub>20</sub> O <sub>5</sub> Si [76241-02-6]	284.38	145° / 0.2		1.104	1.4806
	TSCA	HMIS: 3-2-1-X	25g		
<b>SIC2067.0</b> 10-(CARBOMETHOXY)DECYLDIMETHYL METHOXYSILANE C <sub>15</sub> H <sub>32</sub> O <sub>5</sub> Si Long chain organofunctional silane [1211488-83-3]	288.50	130° / 0.3		0.903	1.4399
		HMIS: 2-1-1-X	10g	50g	

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIC2072.0</b> 2-(CARBOMETHOXY)ETHYLTRIMETHOXYSILANE <i>METHYL (3-TRIMETHOXYSIYL)PROPIONATE</i> C <sub>7</sub> H <sub>16</sub> O <sub>5</sub> Si	208.29	75° / 1.5 Flashpoint: >43°C (>110°F)		1.069	1.410
Contains ~ 20% 1-(carbomethoxy)ethyltrimethoxysilane isomer [76301-00-3]		HMIS: 3-3-1-X	10g		



NEW

## Halogen Functional Silanes

### Halogen Functional Silanes - Trialkoxy

<b>SIB1879.7</b> 4-BROMOBUTYLTRIMETHOXYSILANE C <sub>7</sub> H <sub>17</sub> BrO <sub>3</sub> Si [226558-82-3]	257.20	68-9° / 1 HMIS: 3-2-1-X	10g	1.259	1.4437
<b>SIB1886.0</b> 7-BROMOHEPTYLTRIMETHOXYSILANE C <sub>10</sub> H <sub>23</sub> BrO <sub>3</sub> Si	299.28	83-5° / 1 HMIS: 3-2-1-X	10g	1.1695 <sup>25</sup>	1.4493 <sup>25</sup>
<b>SIB1894.2</b> 5-BROMOPENTYLTRIMETHOXYSILANE C <sub>8</sub> H <sub>19</sub> BrO <sub>3</sub> Si [773893-02-0]	271.22	110° / 1 HMIS: 3-2-1-X	10g	1.222 <sup>25</sup>	1.446
<b>SIB1906.0</b> 3-BROMOPROPYLTRIMETHOXYSILANE C <sub>6</sub> H <sub>15</sub> BrO <sub>3</sub> Si	243.17	130° / 45 Flashpoint: 82°C (180°F) Forms self-assembled monolayers which can be modified with pyridine ligands. <sup>1</sup> 1. Paulson, S. et al. <i>J. Chem. Soc., Chem. Commun.</i> <b>1992</b> , 21, 1615.	10g	1.293	1.4400
<b>SIB1909.0</b> 11-BROMOUNDECYLTRIMETHOXYSILANE, 95% C <sub>14</sub> H <sub>31</sub> BrO <sub>3</sub> Si Contains undecyltrimethoxysilane [17947-99-8]	355.39	158° / 0.8 TSCA-L HMIS: 2-1-0-X	10g	1.119	1.4559
<b>SIC2280.4</b> 3-CHLOROISOBUTYLTRIMETHOXYSILANE C <sub>7</sub> H <sub>17</sub> ClO <sub>3</sub> Si [17256-27-8]	212.75	59-60° / 2 HMIS: 3-2-1-X	25g	1.054 <sup>25</sup>	1.4277 <sup>25</sup>
<b>SIC2282.0</b> 2-(CHLOROMETHYL)ALLYLTRIMETHOXYSILANE C <sub>7</sub> H <sub>15</sub> ClO <sub>3</sub> Si Versatile coupling agent [39197-94-9]	210.73	128° / 70 Flashpoint: 89°C (192°F) HMIS: 3-2-1-X	2.5g	1.09	

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIC2295.5</b> ((CHLOROMETHYL)PHENYLETHYL)TRIMETHOXYSILANE <chem>C12H19ClO3Si</chem> Mixed m-, p-isomers Adhesion promoter for polyphenylenesulfide and polyimide coatings Employed as a high temperature coupling agent. <sup>1</sup> 1. Arkles, B. et al. <i>Modern Plastics</i> <b>1980</b> , 57, 64. [68128-25-6] TSCA EC 268-575-2 HMIS: 3-1-X 25g 100g 2kg COMMERCIAL	274.82	115° / 1.5 Flashpoint: 130°C (266°F)		1.09 <sup>25</sup>	1.4930 <sup>25</sup>
<b>SIC2295.7</b> CHLOROMETHYLPHENETHYLTRIS(TRIMETHYLSILOXY)SILANE, mixed m,p; α,β isomers <chem>C18H37ClO3Si3</chem> Mixed m-, p-isomers [167426-89-3] HMIS: 3-2-0-X 25g 1.007 1.469 NEW	449.28				
<b>SIC2296.2</b> (p-CHLOROMETHYL)PHENYLTRIMETHOXYSILANE, 95% <chem>C10H15ClO3Si</chem> Coupling agent for polyimides, e.g. in printed circuit boards Modifies silica for high-throughput peptide synthesis. <sup>1</sup> 1. Houghten, R. et al. <i>J. Am. Chem. Soc.</i> <b>2005</b> , 127, 8582. [24413-04-5] TSCA EC 246-235-4 HMIS: 3-1-X 25g 100g 2kg COMMERCIAL	246.77	134-43° / 10 Flashpoint: 183°C (361°F)		1.14	1.4965
<b>SIC2298.4</b> CHLOROMETHYLTRIETHOXYSILANE <chem>C7H17ClO3Si</chem> Grignard reacts with chlorosilanes or intermolecularly to form carbosilanes. <sup>1</sup> 1. Brondani, D. et al. <i>Tetrahedron Lett.</i> <b>1993</b> , 34, 2111. [15267-95-5] TSCA EC 239-311-3 HMIS: 2-2-1-X 25g 100g 2kg COMMERCIAL	212.75	90-1° / 25 Flashpoint: 47°C (117°F) TOXICITY: oral rat, LD50: 2,400 mg/kg		1.048	1.4069 <sup>25</sup>
<b>SIC2298.5</b> CHLOROMETHYLTRISOPROPOXYSILANE <chem>C10H23ClO3Si</chem> Forms Grignard reagents [18162-82-8] TSCA-L HMIS: 2-2-1-X 25g 0.9836 1.4145 NEW	254.82	195-8°			
<b>SIC2298.6</b> CHLOROMETHYLTRIMETHOXYSILANE <chem>C4H11ClO3Si</chem> [5926-26-1] TSCA-L HMIS: 3-4-1-X 10g 50g 1.125 1.4070	170.67	156° Flashpoint: 26°C (79°F)			
<b>SIC2407.0</b> 3-CHLOROPROPYLTRIETHOXYSILANE <chem>C9H21ClO3Si</chem> Adhesion promoter for polyamine and epoxy resins [5089-70-3] TSCA EC 225-805-6 HMIS: 2-2-0-X 25g 2kg 18kg COMMERCIAL	240.80	100-2° / 10 Flashpoint: 78°C (172°F)		1.009	1.420
<b>SIC2410.0</b> 3-CHLOROPROPYLTRIMETHOXYSILANE <chem>C6H15ClO3Si</chem> Viscosity, 20°: 0.56 cSt γc of treated surface: 40.5 mN/m Specific wetting surface: 394 m <sup>2</sup> /g Adhesion promoter for SBR hot-melt adhesives Powder flow control additive for dry powder fire extinguishing media [2530-87-2] TSCA EC 219-787-9 HMIS: 3-2-1-X 25g 2kg 18kg COMMERCIAL	198.72	100° / 40 Flashpoint: 78°C (172°F) TOXICITY: oral rat, LD50: 5,628 mg/kg Vapor pressure, 100°: 40 mm		1.077 <sup>25</sup>	1.4183 <sup>25</sup>
<b>SIC2428.0</b> 11-CHLOROUNDECYLTRIETHOXYSILANE <chem>C17H37ClO3Si</chem> [120876-31-5] HMIS: 2-1-1-X 10g 0.944 1.4390 NEW	353.01	112° / 0.01			

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIC2429.0</b> 11-CHLOROUNDECYLTRIMETHOXYSILANE C <sub>14</sub> H <sub>31</sub> ClO <sub>3</sub> Si [17948-05-9]	310.93	156-8° / 2 Flashpoint: >110°C (>230°F) 10g		0.9855	1.4226

<b>SII6452.0</b> 3-IODOPROPYLTRIMETHOXYSILANE C <sub>6</sub> H <sub>15</sub> ILO <sub>3</sub> Si Couples zeolite monolayers to glass. <sup>1</sup> 1. Ha, K. et al. <i>Adv. Mater.</i> <b>2002</b> , 12(15), 1114. [14867-28-8]	290.17	79-80° / 2 Flashpoint: 78°C (172°F)		1.475	1.4714
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<b>SIT8397.0</b> (3-TRIMETHOXYSILYL)PROPYL 2-BROMO-2-METHYLPROPIONATE C <sub>10</sub> H <sub>21</sub> BrO <sub>5</sub> Si For surface initiated ATRP polymerization. <sup>1,2</sup> 1. Mulvihill, M. et al. <i>J. Am. Chem. Soc.</i> <b>2005</b> , 127, 16040. 2. Huck, J. et al. <i>J. Mater. Chem.</i> <b>2004</b> , 14, 730. [314021-97-1]	329.27	90-5° / 0.5		1.243 <sup>25</sup>	
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<b>SIV9064.0</b> VINYL(CHLOROMETHYL)DIMETHOXYSILANE C <sub>5</sub> H <sub>11</sub> ClO <sub>2</sub> Si Multi-functional coupling agent [1314981-48-0]	166.68				
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## Halogen Functional Silanes - Dialkoxy

<b>SIC2292.0</b> CHLOROMETHYLMETHYLDIETHOXYSILANE C <sub>6</sub> H <sub>15</sub> ClO <sub>2</sub> Si [2212-10-4]	182.72	160-1° Flashpoint: 38°C (100°F) TOXICITY: oral rat, LD50: 1,300 mg/kg Vapor pressure, 70°: 20 mm		1.000 <sup>25</sup>	1.407
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<b>SIC2295.2</b> (CHLOROMETHYL)PHENYLETHYL)METHYLDIMETHOXYSILANE C <sub>12</sub> H <sub>19</sub> ClO <sub>2</sub> Si Mixed <i>m</i> -, <i>p</i> -isomers Intermediate for silicone analog of Merrifield resins [160676-60-8]/[160676-58-4]	258.82	120-5° / 0.5			
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<b>SIC2352.0</b> 3-CHLOROPROPYL METHYLDIETHOXYSILANE C <sub>8</sub> H <sub>19</sub> ClO <sub>2</sub> Si Intermediate for functional silicone polymers [13501-76-3]	210.77	81-3° / 8 Flashpoint: 80°C (176°F)		0.9744	1.4260
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<b>SIC2353.0</b> 3-CHLOROPROPYL METHYLDIISOPROPOXYSILANE C <sub>10</sub> H <sub>23</sub> ClO <sub>2</sub> Si [18171-19-2]	238.84	92-4° / 10		0.93	
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<b>SIC2355.0</b> 3-CHLOROPROPYL METHYLDIMETHOXYSILANE C <sub>6</sub> H <sub>15</sub> ClO <sub>2</sub> Si Specific wetting surface: 428 m <sup>2</sup> /g [18171-19-2]	182.72	70-2° / 11 Flashpoint: 80°C (176°F) 100g		1.0250	1.4253
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<b>SII6451.2</b> (3-IODOPROPYL)METHYLDIISOPROPOXYSILANE C <sub>10</sub> H <sub>23</sub> IO <sub>2</sub> Si [14867-28-8]	330.27	50-3° / 0.3 10g		1.257	1.4623
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Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>Halogen Functional Silanes - Monoalkoxy</b>					
<b>SIC2278.0</b> 3-CHLOROISOBUTYLDIMETHYL METHOXYSILANE C <sub>7</sub> H <sub>17</sub> ClOSi [18244-08-1]	180.75	182° 25g		0.950	1.4331 <sup>25</sup>
TSCA	HMIS: 3-3-1-X				
<b>SIC2286.0</b> CHLOROMETHYLDIMETHYLETHOXYSILANE C <sub>5</sub> H <sub>13</sub> ClOSi Dipole moment: 2.14 debye [13508-53-7]	152.70	132-3° Flashpoint: 26°C (79°F) TOXICITY: oral rat, LD50: 1,550 mg/kg 25g		0.944 <sup>25</sup>	1.412 <sup>25</sup>
TSCA	EC 236-835-4 HMIS: 3-3-1-X				
<b>SIC2295.2</b> ((CHLOROMETHYL)PHENYLETHYL)METHYLDIMETHOXYSILANE C <sub>12</sub> H <sub>19</sub> ClO <sub>2</sub> Si Mixed <i>m</i> -, <i>p</i> -isomers Intermediate for silicone analog of Merrifield resins [160676-60-8]/[160676-58-4]	258.82	120-5° / 0.5			
	HMIS: 2-1-1-X	25g			
<b>SIC2337.0</b> 3-CHLOROPROPYLDIMETHYLETHOXYSILANE C <sub>7</sub> H <sub>17</sub> ClOSi [13508-63-9]	180.75	87° / 30 Flashpoint: 46°C (115°F) 25g		0.932 <sup>25</sup>	1.427 <sup>25</sup>
	EC 236-837-5 HMIS: 2-3-1-X				
<b>SIC2338.0</b> 3-CHLOROPROPYLDIMETHYL METHOXYSILANE, 95% C <sub>6</sub> H <sub>15</sub> ClOSi [18171-14-7]	166.73	170-1° Flashpoint: 39°C (102°F) 10g		0.941	1.4278
	EC 242-055-5 HMIS: 3-2-1-X				
<b>Halogen Functional Silanes - Dipodal</b>					
<b>SIC2279.3</b> 1-(3-CHLOROISOBUTYL)-1,1,3,3,3-PENTAETHOXY-1,3-DISILAPROPANE, 95% C <sub>15</sub> H <sub>35</sub> ClO <sub>5</sub> Si <sub>2</sub> Pendant dipolar silane [330457-46-0]	387.06	115-7° / 0.5 HMIS: 3-1-1-X	10g	1.020	MEW
<b>Hydroxyl Functional Silanes</b>					
<b>Hydroxyl Functional Silanes - Trialkoxy</b>					
<b>SIH6172.0</b> N-(HYDROXYETHYL)-N-METHYLAMINOPROPYLTRIMETHOXYSILANE, 75% in methanol C <sub>9</sub> H <sub>23</sub> NO <sub>4</sub> Si [330457-46-0]	237.37	Flashpoint: 11°C (52°F) 25g	100g	0.99	1.417
	HMIS: 3-4-1-X				
<b>SIH6175.0</b> HYDROXYMETHYLTRIETHOXYSILANE, 50% in ethanol TRIETHOXYSILYL METHANOL C <sub>7</sub> H <sub>18</sub> O <sub>4</sub> Si [162781-70-6]	194.31	Flashpoint: 15°C (59°F)		0.866	
<p>Contains equilibrium condensation oligomers Hydrolysis yields analogs of silica-hydroxymethylsilanetriol polymers.<sup>1</sup> Cohydrolyses form highly water dispersible nanoparticles.<sup>2</sup> Functionalizes magnetic particles utilized in nucleic acid separation.<sup>3</sup> Functionalizes nanoparticles for “stealth therapeutic” biomedical applications.<sup>4</sup></p> <p>1. Arkles, B. et al. <i>Silicon</i> <b>2013</b>, 5, 187; DOI 10.1007/s12633-013-9146-2. 2. Du, H. et al. <i>J. Colloid Interface Sci.</i> <b>2009</b>, 340, 202. 3. Templer, D. Eur Pat App. EP 1748 072 A1, 2007. 4. Neoh, K. G. et al. <i>Polymer Chemistry</i> <b>2011</b>, 2, 747.</p>					
	TSCA-L	HMIS: 2-4-0-X	25g		
<b>SI8189.0</b> N-(3-TRIETHOXYSILYLPROPYL)GLUCONAMIDE, 50% in ethanol GLUCONAMIDOPROPYLTRIETHOXYSILANE C <sub>15</sub> H <sub>33</sub> NO <sub>9</sub> Si [104275-58-3]	399.51	Flashpoint: 15°C (59°F)		0.951	
<p>Water soluble, hydrophilic silane Modifies silica micro-capillaries to enhance flow of aqueous media.<sup>1</sup></p> <p>1. Constable, H. et al. <i>Colloids Surf., A</i> <b>2011</b>, 380, 128.</p>					
	HMIS: 2-4-1-X	25g	100g	2kg	

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>	
<b>SIT8189.5</b> N-(3-TRIETHOXYSILYLPROPYL)-4-HYDROXYBUTYRAMIDE C <sub>13</sub> H <sub>29</sub> NO <sub>5</sub> Si Anchoring reagent for light directed synthesis of DNA on glass. <sup>1</sup> 1. McGall, G. et al. <i>J. Am. Chem. Soc.</i> <b>1997</b> , <i>119</i> , 5081. [156214-80-1]	307.47			1.02	1.4533	
<b>SIT8192.0</b> N-(TRIETHOXYSILYLPROPYL)-O-POLYETHYLENE OXIDE URETHANE, 95% C <sub>10</sub> H <sub>22</sub> NO <sub>4</sub> SiO(CH <sub>2</sub> CH <sub>2</sub> O) <sub>4-6</sub> H Contains some bis(urethane) analog Viscosity: 75-125 cSt Hydrophilic surface modifier Forms PEGylated glass surfaces suitable for capillary electrophoresis. <sup>1</sup> 1. Razunguzwa, T. et al. <i>Anal. Chem.</i> <b>2006</b> , <i>78</i> , 4326. [74695-91-3]	400-500	HMIS: 2-2-1-X	10g	50g	1.09	1.4540 <sup>25</sup>

COMMERCIAL

## Dipodal Hydroxyl Functional Silanes

	<b>SIH6171.5</b> N-(HYDROXYETHYL)-N,N-BIS(TRIMETHOXYSILYLPROPYL)AMINE, 65% in methanol C <sub>14</sub> H <sub>35</sub> NO <sub>7</sub> Si <sub>2</sub> Dipodal silane with hydroxyl functionality [264128-94-1]	385.61	Flashpoint: 15°C (59°F)	0.97		NEW
	<b>SIT8572.8</b> 11-(TRIMETHYLSILOXY)UNDECYLTRIETHOXYSILANE C <sub>20</sub> H <sub>46</sub> O <sub>4</sub> Si <sub>2</sub> Masked hydroxyl - deprotected after deposition with acidic aqueous ethanol [75389-03-6]	406.75	145° / 0.3	0.887 <sup>25</sup>	1.4264 <sup>25</sup>	

## Masked Hydroxyl Functional Silanes

	<b>SIT8572.8</b> 11-(TRIMETHYLSILOXY)UNDECYLTRIETHOXYSILANE C <sub>20</sub> H <sub>46</sub> O <sub>4</sub> Si <sub>2</sub> Masked hydroxyl - deprotected after deposition with acidic aqueous ethanol [75389-03-6]	406.75	145° / 0.3	0.887 <sup>25</sup>	1.4264 <sup>25</sup>	
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## Isocyanate and Masked Isocyanate Functional Silanes

### Isocyanate Functional Silanes - Trialkoxy

	<b>SII6455.0</b> 3-ISOCYANATOPROPYLTRIETHOXYSILANE, 95% C <sub>10</sub> H <sub>21</sub> NO <sub>4</sub> Si Component in hybrid organic/inorganic urethanes. <sup>1</sup> 1. Cuney, S. et al. <i>Better Ceramics Through Chemistry VII (MRS. Symp. Proc.)</i> <b>1996</b> , <i>435</i> , 143. [24801-88-5]	247.37	130° / 20 Flashpoint: 80°C (176°F) TOXICITY: oral rat, LD50: 710 mg/kg	0.990	1.4190	COMMERCIAL
	<b>SII6456.0</b> 3-ISOCYANATOPROPYLTRIMETHOXYSILANE, 95% C <sub>7</sub> H <sub>15</sub> NO <sub>4</sub> Si Viscosity: 1.4 cSt [15396-00-6]	205.29	95-8° / 10 Flashpoint: 108°C (226°F) TOXICITY: oral rat, LD50: 878 mg/kg Autoignition temperature: 265°C	1.073	1.4219	COMMERCIAL

### Isocyanate Functional Silanes - Dialkoxy

	<b>SII6454.45</b> 3-ISOCYANATOPROPYL METHYLDIETHOXYSILANE, 95% C <sub>9</sub> H <sub>19</sub> NO <sub>5</sub> Si Reacts rapidly with amine and hydroxyl functional species that can hydrolyze to form siloxane polymers [33491-28-0]	217.34	110-5° / 10 HMIS: 3-2-1-X 10g			NEW
	<b>SII6454.5</b> 3-ISOCYANATOPROPYL METHYLDIMETHOXYSILANE, tech-95% C <sub>7</sub> H <sub>15</sub> NO <sub>3</sub> Si Contains isomers [26115-72-0]	189.29	61° / 1 HMIS: 3-2-1-X 10g	1.03		NEW

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>Masked Isocyanate Functional Silanes</b>					
<b>SIT7907.7</b> (THIOCYANATOMETHYL)PHENETHYLTRIMETHOXYSILANE, tech-95 C <sub>13</sub> H <sub>19</sub> NO <sub>3</sub> SSi Contains isomers On exposure to UV light of 254 nm undergoes conversion to isothiocyanate which reacts w/ amines, etc. HMIS: 3-2-1-X	297.44	100-5° / 0.5 Flashpoint: >110°C (>230°F)			NEW
		10g			
<b>SIT7908.0</b> 3-THIOCYANATOPROPYLTRIETHOXYSILANE, 96% C <sub>10</sub> H <sub>21</sub> NO <sub>3</sub> SSi Complexing agent for Ag, Au, Pd, Pt. <sup>1</sup> Potential adhesion promoter for gold. <sup>2</sup> 1. Schilling, T. et al. <i>Mikrochimica Acta</i> <b>1996</b> , 124, 235. 2. Ciszek, J. W. et al. <i>J. Am. Chem. Soc.</i> <b>2004</b> , 126, 13172. [34708-08-2]	263.43	95° / 0.1 Flashpoint: 112°C (234°F) TOXICITY: oral rat, LD50: 1,423 mg/kg	1.03	1.4460	COMMERCIAL
	50g	250g	2kg		
<b>SIT8186.5</b> N-(3-TRIETHOXYSILYLPROPYL)-O-t-BUTYLCARBAMATE C <sub>14</sub> H <sub>31</sub> NO <sub>5</sub> Si Masked isocyanate [137376-38-6]	321.49	110-5° / 0.2 Flashpoint: >65°C (>150°F)	0.990	1.4334	
	HMIS: 2-1-1-X	25g	100g	2kg	
<b>SIT8188.0</b> TRIETHOXYSILYLPROPYL ETHYLCARBAMATE C <sub>12</sub> H <sub>27</sub> NO <sub>5</sub> Si Masked isocyanate [17945-05-0]	293.44	124-6° / 0.5 Flashpoint: 95°C (203°F)	1.015	1.4321	COMMERCIAL
	TSCA EC 241-872-4 HMIS: 2-1-1-X	25g	100g	2kg	
<b>SIT8407.0</b> N-TRIMETHOXYSILYLPROPYLMETHYLCARBAMATE METHYL [β-(TRIMETHOXYSILYL)PROPYL]CARBAMATE C <sub>8</sub> H <sub>19</sub> NO <sub>5</sub> Si Viscosity: 12 cSt [23432-62-4]	237.32	102° / 0.75 Flashpoint: 99°C (210°F) Autoignition temperature: 385°C	1.1087		NEW
	HMIS: 3-2-1-X	25g			
<b>SIT8411.0</b> 2-(3-TRIMETHOXYSILYLPROPYLTHIO)THIOPHENE C <sub>10</sub> H <sub>18</sub> O <sub>3</sub> S <sub>2</sub> Si Contact angle, water on treated silica surface: 76° [1364140-50-0]	278.46	125-7° / 0.4	1.136 <sup>25</sup>	1.5123 <sup>25</sup>	NEW
	HMIS: 3-2-1-X	10g			
<b>SIT8717.0</b> TRIS(3-TRIMETHOXYSILYLPROPYL)ISOCYANURATE, tech-95 C <sub>21</sub> H <sub>45</sub> N <sub>3</sub> O <sub>12</sub> Si <sub>3</sub> Viscosity: 325-350 cSt. Coupling agent for polyimides to silicon metal Adhesion promoter for hotmelt adhesives Forms periodic mesoporous silicas. <sup>1</sup> 1. Zhang, W. et al. <i>Chem. Mater.</i> <b>2007</b> , 19, 2663. [26115-70-8]	615.86	Flashpoint: 102°C (216°F)	1.170	1.4610	COMMERCIAL
	TSCA EC 247-465-8 HMIS: 2-1-1-X	25g	100g	2kg	

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>Phosphine and Phosphate Functional Silanes</b>					
<b>SIB1091.0</b> BIS(2-DIPHENYLPHOSPHINOETHYL)METHYLSILYLETHYLTRIETHOXYSILANE, mixed isomers C <sub>37</sub> H <sub>50</sub> O <sub>3</sub> P <sub>2</sub> Si <sub>2</sub>  Analogous structures form ruthenium(II) complexes with high selectivity for hydrogenation and non-leachable binding to solid supports. <sup>1</sup> 1. Wu, D. et al. <i>Chem. Mater.</i> <b>2005</b> , <i>17</i> , 3951. HMIS: 2-2-1-X      1.0g	660.92		1.07	1.5746	
<b>SID3385.0</b> (2-DICYCLOHEXYLPHOSPHINOETHYL)TRIETHOXYSILANE C <sub>20</sub> H <sub>41</sub> O <sub>3</sub> PSi  Ligand for immobilization of precious metal catalytic complexes [55289-47-9] HMIS: 3-1-0-X      5g	388.60	140° / 0.03		0.979 <sup>25</sup>	1.4811 <sup>25</sup>
<b>SID3411.0</b> (2-DIETHYLPHOSPHATOETHYL)METHYLDIETHOXYSILANE, tech-95 C <sub>11</sub> H <sub>27</sub> O <sub>5</sub> PSi  Comonomer for hydrophilic coatings [18048-06-1] HMIS: 3-2-1-X      10g	298.39	124° / 2		1.020	1.4270 <sup>25</sup>
<b>SID3412.0</b> (2-DIETHYLPHOSPHATOETHYL)TRIETHOXYSILANE, tech-95 DIETHYLPHOSPHONATOETHYLTRIETHOXYSILANE C <sub>12</sub> H <sub>29</sub> O <sub>6</sub> PSi  Water-soluble silane; anti-pilling agent for textiles. Hydrolysis product catalytically hydrates olefins, forming alcohols. <sup>1</sup> Forms corrosion resistant films for magnesium alloys. <sup>2</sup> 1. Young, F. et al. U.S. Patent 3,816,550, 1974. 2. Kramov, A. et al. <i>Thin Solid Films</i> <b>2006</b> , <i>174</i> , 514. [757-44-8]      TSCA EC 212-056-5 HMIS: 3-2-1-X      25g      100g	328.41	141° / 2 Flashpoint: 70°C (158°F)		1.031 <sup>25</sup>	1.4216
<b>SID4557.5</b> (2-DIPHENYLPHOSPHINO)ETHYLDIMETHYLETHOXYSILANE C <sub>18</sub> H <sub>25</sub> O <sub>3</sub> PSi  [359859-29-3]	316.46	160° / 1 HMIS: 2-2-1-X      10g		1.004	1.5630
<b>SID4558.0</b> 2-(DIPHENYLPHOSPHINO)ETHYLTRIETHOXYSILANE C <sub>20</sub> H <sub>29</sub> O <sub>3</sub> PSi  Immobilizing ligand for precious metals Adhesion promoter for gold substrates in microelectronic applications. <sup>1</sup> Forms stable bonds to silica and basic alumina suitable for catalyst immobilization. <sup>2</sup> Forms luminescent gels on hydrolysis with (EtO) <sub>4</sub> Si and Eu(NO <sub>3</sub> ) <sub>3</sub> . <sup>3</sup> Used to immobilize an iridium catalyst for the enantioselective hydrogenation of aryl ketones. <sup>4</sup> Used in the preparation of solid-phase Pd catalyst for Suzuki-Miyaura cross-coupling. <sup>5</sup> 1. Helbert, J. U.S. Patent 4,497,890, 1985. 2. Mericle, C. H. et al. <i>Chem. Mater.</i> <b>2001</b> , <i>13</i> , 3617. 3. Corriu, R. et al. <i>J. Chem. Soc., Chem. Commun.</i> <b>2001</b> , 1116. 4. Liu, G. et al. <i>Adv. Synth. Catal.</i> <b>2008</b> , <i>350</i> , 1464. 5. Zhang, X. et al. <i>Synthesis</i> , <b>2011</b> , 2975. [18586-39-5]      TSCA EC 242-427-7 HMIS: 3-1-1-X      5g      25g	376.50	182° / 1.3 Flashpoint: 134°C (273°F)		1.05	1.5384
<b>SID4558.2</b> 3-(DIPHENYLPHOSPHINO)PROPYLTRIETHOXYSILANE C <sub>21</sub> H <sub>31</sub> O <sub>3</sub> PSi  [52090-23-0] HMIS: 3-1-1-X	390.53	190° / 1 Flashpoint: >110°C (>230°F) 1.0g			
<b>SIT8378.5</b> 3-(TRIHYDROXYSILYL)PROPYL METHYLPHOSPHONATE, MONOSODIUM SALT, 42% in water C <sub>4</sub> H <sub>12</sub> NaO <sub>6</sub> PSi  Contains 4-5% methanol, sodium methylphosphonate Forms functionalized silica nanoparticles employed in amperometric glucose sensor. <sup>1</sup> 1. Zhao, W. et al. <i>Electrochim. Acta</i> <b>2013</b> , <i>89</i> , 278. [84962-98-1]      TSCA EC 284-799-3 HMIS: 1-2-0-X      100g      500g      2.5kg	238.18	Flashpoint: 79°C (174°F)		1.25	

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>Sulfur Functional Silanes</b>					
<b>Sulfur Functional Silanes - Trialkoxy</b>					
<b>SID3545.0</b> 2,2-DIMETHOXY-1-THIA-2-SILACYCLOPENTANE <chem>C5H12O2SSi</chem> Reagent for modification of silver and gold surfaces Coupling agent for rubber [26903-85-5]	164.29	57-8° / 7		1.094	
		HMIS: 3-3-1-X	25g		
<b>SIM6475.0</b> 3-MERCAPTOPROPYLTRIETHOXYSILANE, 95% <chem>C9H22O3SSi</chem> For blocked version see SIO6704.0 Used to make thiol-organosilica nanoparticles. <sup>1</sup> 1. Nakamura, M.; Ishimura, K. <i>Langmuir</i> <b>2008</b> , <i>24</i> , 5099. [14814-09-6] TSCA EC 238-883-1 HMIS: 2-2-1-X	238.42	210° Flashpoint: 88°C (190°F) TOXICITY: oral rat, LD50: >2,000 mg/kg		0.9325	1.4331
			25g	100g	2kg
<b>SIM6476.0</b> 3-MERCAPTOPROPYLTRIMETHOXYSILANE <chem>C6H16O3SSi</chem> Viscosity: 2 cSt γc of treated surfaces: 41 mN/m Specific wetting surface: 348 m <sup>2</sup> /g Coupling agent for EPDM and mechanical rubber applications Adhesion promoter for polysulfide adhesives For enzyme immobilization. <sup>1</sup> Treatment of mesoporous silica yields highly efficient heavy metal scavenger. <sup>2</sup> Couples fluorescent biological tags to semiconductor CdS nanoparticles. <sup>3</sup> Modified mesoporous silica supports Pd in coupling reactions. <sup>4</sup> Used to make thiol-organosilica nanoparticles. <sup>5</sup> Forms modified glass and silica surfaces suitable for SILAR fabrication of CdS thin films. <sup>6</sup> 1. Stjernlöf, P. et al. <i>Tetrahedron Lett.</i> <b>1990</b> , <i>31</i> , 5773. 2. Liu, J. et al. <i>Science</i> <b>1997</b> , <i>276</i> , 923. 3. Bruchez, M. et al. <i>Science</i> <b>1998</b> , <i>281</i> , 2013. 4. Crudden, C. et al. <i>J. Am. Chem. Soc.</i> <b>2005</b> , <i>127</i> , 10045. 5. Nakamura, M.; Ishimura, K. <i>Langmuir</i> <b>2008</b> , <i>24</i> , 5099. 6. Sun, H. et al. <i>J. Dispersion Sci. Technol.</i> <b>2005</b> , <i>26</i> , 719. [4420-74-0] TSCA EC 224-588-5 HMIS: 3-2-1-X	196.34	93° / 40 Flashpoint: 96°C (205°F) TOXICITY: oral rat, LD50: 2,380 mg/kg Primary irritation index: 0.19		1.051 <sup>25</sup>	1.4502 <sup>25</sup>
 Adhesion promoter for structural polysulfide glass sealants			100g	2kg	18kg
<b>SIM6476.1</b> 3-MERCAPTOPROPYLTRIMETHOXYSILANE, 99% <chem>C6H16O3SSi</chem> Low fluorescence grade for high-throughput screening [4420-74-0] TSCA EC 224-588-5 HMIS: 3-2-1-X	196.34	93° / 40 Flashpoint: 96°C (205°F)	25g		1.051 <sup>25</sup> 1.4502 <sup>25</sup>
* in fluoropolymer bottle					
<b>SIM6480.0</b> 11-MERCAPTOUNDECYLTRIMETHOXYSILANE, 95% <chem>C14H32O3SSi</chem> Stabilizes ionic liquid drop micro-reactors. <sup>1</sup> 1. Zhang, X. et al. <i>J. Nanotechnol.</i> <b>2012</b> , <i>3</i> , 33. [877593-17-4] HMIS: 3-2-1-X	308.55	150° / 0.5		0.955	
			2.5g		
<b>SIO6704.0</b> S-(OCTANOYL)MERCAPTOPROPYLTRIETHOXYSILANE <chem>C17H36O4SSi</chem> Masked mercaptan - deblocked with alcohols Latent coupling agent for butadiene rubber [220727-26-4] TSCA HMIS: 2-1-1-X	364.62			0.9686	1.4515
			25g	100g	18kg
<b>SIP6926.2</b> 3-(2-PYRIDYLETHYL)THIOPROPYLTRIMETHOXYSILANE <chem>C13H23NO3SSi</chem> [29098-72-4] HMIS: 3-2-1-X	301.48	156-7° / 0.25 10g		1.089	1.498
<b>SIP6926.4</b> 3-(4-PYRIDYLETHYL)THIOPROPYLTRIMETHOXYSILANE, 95% <chem>C13H23NO3SSi</chem> pKa: 4.8 Immobilizable ligand for immunoglobulin IgG separation using hydrophobic charge induction chromatography (HCIC) [198567-47-4] HMIS: 3-2-1-X	301.48	160-2° / 0.2 10g		1.09	1.5037

COMMERCIAL

COMMERCIAL

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIT7908.0</b> 3-THIOCYANATOPROPYLTRIETHOXYSILANE, 96% <chem>C10H21NO3SSi</chem>	263.43	95° / 0.1 Flashpoint: 112°C (234°F) TOXICITY: oral rat, LD50: 1,423 mg/kg		1.03	1.4460
Complexing agent for Ag, Au, Pd, Pt. <sup>1</sup> Potential adhesion promoter for gold. <sup>2</sup> 1. Schilling, T. et al. <i>Mikrochimica Acta</i> <b>1996</b> , 124, 235. 2. Ciszek, J. W. et al. <i>J. Am. Chem. Soc.</i> <b>2004</b> , 126, 13172. [34708-08-2] TSCA EC 252-161-3 HMIS: 3-1-1-X	50g	250g	2kg		COMMERCIAL

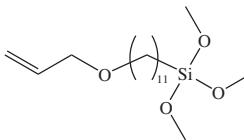
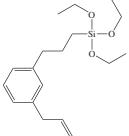
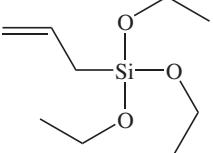
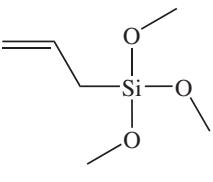
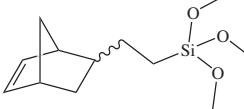
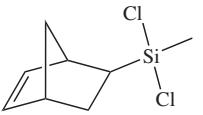
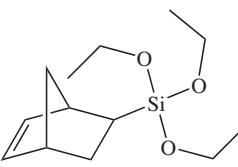
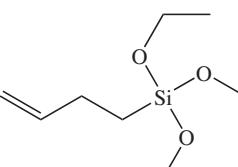
## Sulfur Functional Silanes - Dialkoxy

<b>SIM6473.0</b> (MERCAPTOETHYL)METHYLDIETHOXYSILANE, 95% <chem>C6H16O2SSi</chem>	180.34	60° / 10 Flashpoint: 58°C (136°F)	0.975	1.4446	
[55161-63-2] HMIS: 3-2-1-X		10g			
<b>SIM6474.0</b> 3-MERCAPTOPROPYL METHYLDIMETHOXYSILANE, 96% <chem>C6H16O2SSi</chem>	180.34	96° / 30 Flashpoint: 93°C (199°F)	1.000	1.4502	
Intermediate for silicones in thiol-ene UV-cure systems Adhesion promoter for polysulfide sealants Used to make thiol-organosilica nanoparticles. <sup>1</sup> 1. Nakamura, M.; Ishimura, K. <i>Langmuir</i> <b>2008</b> , 24, 5099. [31001-77-1] TSCA EC 250-426-8 HMIS: 3-2-1-X	100g	2kg	18kg		COMMERCIAL

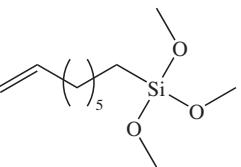
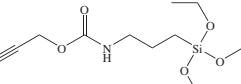
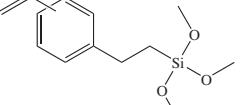
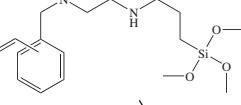
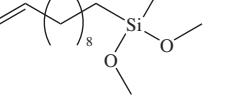
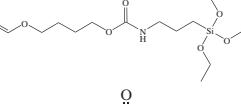
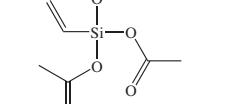
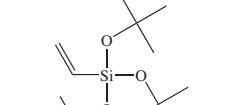
## Sulfur Functional Silanes - Dipodal

<b>SIB1820.5</b> BIS[m-(2-TRIETHOXYSILYLETHYL)TOLYL]POLYSULFIDE, tech-90 <chem>C30H50O6S(2-4)Si2</chem> Dark, viscous liquid Coupling agent for SBR rubber [198087-81-9]/[85912-75-0]/[67873-85-2] TSCA	627-691	Flashpoint: 55°C (131°F)	1.10	1.533	
<b>SIB1824.6</b> BIS[3-(TRIETHOXYSILYL)PROPYL]DISULFIDE, 90% BIS[TRIETHOXYSILYL]-4,5-DITHIOOCTANE <chem>C18H42O6S2Si2</chem> Contains sulfide and tetrasulfide Dipodal coupling agent/vulcanizing agent for rubbers Intermediate for mesoporous silicas with acidic pores. <sup>1</sup> 1. Alauzun, J. et al. <i>J. Am. Chem. Soc.</i> <b>2006</b> , 128, 8718. [56706-10-6] TSCA EC 260-350-7 HMIS: 2-2-1-X	474.82	Flashpoint: 75°C (167°F)	1.025	1.457	
<b>SIB1825.0</b> BIS[3-(TRIETHOXYSILYL)PROPYL]TETRASULFIDE, tech-95 TESPT <chem>C18H42O6S4Si2</chem> Contains distribution of S2 - S10 species; average 3.8 Viscosity: 11 cSt Adhesion promoter for precious metals Coupling agent/vulcanizing agent for "green" tires Adhesion promoter for PVD copper on parylene. <sup>1</sup> 1. Pimanpong, S. et al. <i>J. Vac. Sci. Technol. A</i> <b>2006</b> , 24, 1884. [40372-72-3] TSCA EC 254-896-5 HMIS: 2-2-1-X	538.94	250° dec Flashpoint: 91°C (196°F) TOXICITY: oral rat, LD50: 16,400 mg/kg	1.095	1.49	
		100g	2kg	18kg	COMMERCIAL

<b>SIB1827.0</b> N,N'-BIS[3-(TRIETHOXYSILYL)PROPYL]THIOUREA, 90% <chem>C19H44N2O6SSi2</chem>	484.73	Flashpoint: >110°C (>230°F)	1.047	1.4696	
Forms films on electrodes for determination of mercury. <sup>1</sup> 1. Guo, Y. et al. <i>J. Pharm. Biol. Anal.</i> <b>1999</b> , 19 175. [69952-89-2] HMIS: 2-1-1-X	25g				

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>	
<b>Vinyl and Olefin Functional Silanes</b>						
<b>Vinyl and Olefin Functional Silanes - Trialkoxy</b>						
	<b>SIA0482.0</b> 11-ALLYLOXYUNDECYLTRIMETHOXYSILANE <chem>C17H36O3Si</chem> ω-olefin for functional self-assembled monolayers (SAMs) [1196453-35-6]	332.56	140° / 0.5	0.914	1.4415	
	<b>SIA0489.0</b> m-ALLYLPHENYLPROPYLTRIETHOXYSILANE <chem>C18H30O3Si</chem> Coupling agent for amine functional aromatic optical coatings	322.52	HMS: 2-1-X	5g	NEW	
	<b>SIA0525.0</b> ALLYLTRIETHOXYSILANE 3-(TRIETHOXYSIYL)-1-PROPENE <chem>C9H20O3Si</chem> Dipole moment: 1.79 debye	204.34	176° Flashpoint: 47°C (117°F) Vapor pressure, 100°: 50 mm	0.9030	1.4074	
	Extensive review on the use in silicon-based cross-coupling reactions. <sup>1</sup> 1. Denmark, S. E. et al. <i>Organic Reactions</i> , Vol. 75, Denmark, S. E. Ed., John Wiley and Sons, 233, <b>2011</b> . [2550-04-1] TSCA EC 219-843-2 HMS: 2-2-X	10g	50g			
	<b>SIA0540.0</b> ALLYLTRIMETHOXYSILANE <chem>C6H14O3Si</chem>	162.26	146-8° Flashpoint: 46°C (115°F)	0.963 <sup>25</sup>	1.4036 <sup>25</sup>	
	Adhesion promoter for vinyl-addition silicones Allylation of ketones, aldehydes and imines with dual activation of a Lewis Acid and fluoride ion. <sup>1</sup> Used in the regioselective generation of the thermodynamically more stable enol trimethoxysilyl ethers, which in turn are used in the asymmetric generation of quaternary carbon centers. <sup>2</sup> Converts arylselenyl bromides to arylallylselenides. <sup>3</sup> Allylates aryl iodides. <sup>4</sup> 1. Yamasaki, S. et al. <i>J. Am. Chem. Soc.</i> <b>2002</b> , 124, 6536. 2. Ichibakase, T. et al. <i>Tetrahedron Lett.</i> <b>2008</b> , 49, 4427. 3. Bhadra, S. et al. <i>J. Org. Chem.</i> <b>2010</b> , 75, 4864. 4. Mowery, M. E.; DeShong, P. J. <i>Org. Chem.</i> <b>1999</b> , 64, 1684. F&F: Vol 18, p 14; Vol 19, p 360; Vol 20, p 85; Vol 21, p 3, Vol 12, p 395 [2551-83-9] TSCA EC 219-855-8 HMS: 3-2-X	10g	50g	2kg	COMMERCIAL	
	<b>SIB0988.0</b> [(5-BICYCLO[2.2.1]HEPT-2-ENYL)ETHYL]TRIMETHOXYSILANE, tech-95, endo/exo isomers <chem>C12H22O3Si</chem> [68323-30-8]	242.39	65° / 10 HMS: 2-1-X	25g	1.02	1.458
	<b>SIB0990.0</b> (5-BICYCLO[2.2.1]HEPT-2-ENYL)METHYLDICHLOROSILANE, 95% <chem>C8H12Cl2Si</chem> [18245-94-8]	207.17	74-5° / 10 TSCA EC 242-122-9 HMS: 3-2-X	10g	1.151	1.4938
	Flashpoint: 86°C (187°F)				NEW	
	<b>SIB0992.0</b> (5-BICYCLO[2.2.1]HEPT-2-ENYL)TRIETHOXYSILANE NORBORNENYLTRIETHOXYSILANE <chem>C13H24O3Si</chem> Coupling agent for norbornadiene rubbers Component in low dielectric constant films Undergoes ring-opening metathetic polymerization (ROMP) with RuCl <sub>2</sub> (P(C <sub>6</sub> H <sub>5</sub> ) <sub>3</sub> ) <sub>2</sub> . <sup>1</sup> 1. Finkelstein, E. <i>10th Int'l Organosilicon Symp. Proc.</i> <b>1993</b> , P-120. [18401-43-9] TSCA EC 242-278-8 HMS: 2-2-X	256.42	106-8° / 8 Flashpoint: 98°C (208°F)	10g	0.960	1.4486
		50g				
	<b>SIB1928.0</b> 3-BUTENYLTRIETHOXYSILANE, 95% <chem>C10H22O3Si</chem> Mixed isomers (mainly 3-butenyl) [57813-67-9]	218.37	64° / 6 Flashpoint: 73°C (163°F) TOXICITY: oral rat, LD50: >5,000 mg/kg HMS: 2-2-X	25g	0.90	

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIC2282.0</b> 2-(CHLOROMETHYL)ALLYLTRIMETHOXYSILANE <chem>C7H15ClO3Si</chem> Versatile coupling agent [39197-94-9]	210.73	128° / 70 Flashpoint: 89°C (192°F)		1.09	NEW
<b>SIC2459.5</b> [2-(3-CYCLOHEXENYL)ETHYL]TRIETHOXYSILANE <chem>C14H26O3Si</chem> Contains isomers [77756-79-7]	272.46	HMIS: 2-1-1-X Flashpoint: 120°C (248°F) 10g 50g		0.948	1.444
<b>SIC2460.0</b> [2-(3-CYCLOHEXENYL)ETHYL]TRIMETHOXYSILANE <chem>C11H22O3Si</chem> Contains isomers Orients liquid crystals in display devices. <sup>1</sup> Coupling agent for aramid fiber reinforced epoxy. <sup>2</sup> 1. Sharp, <i>Chem. Abstr.</i> 101,81758g; Jap. Patent JP 58122517, 1983. 2. Lechner, U. <i>Chem. Abstr.</i> 112, 218118x; Germ. Offen. DE 3820971, 1989. [67592-36-3]	230.38	TSCA EC 266-749-2 HMIS: 3-2-1-X 109° / 6 Flashpoint: 80°C (176°F)	10g 50g	1.02	1.4476
<b>SIC2464.1</b> 3-CYCLOHEXENYLTRIMETHOXYSILANE <chem>C9H18O3Si</chem> [21619-76-1]	202.32	HMIS: 3-2-1-X 78-9° / 6 Flashpoint: 60°C (140°F) 5g		1.039	NEW
<b>SIC2520.0</b> (3-CYCLOPENTADIENYLPROPYL)TRIETHOXYSILANE <chem>C14H26O3Si</chem> Dimer; may be cracked to monomer at ~ 190° at 100mm Employed in silica-supported purification of fullerenes. <sup>1</sup> 1. Nie, B. et al. <i>J. Org. Chem.</i> <b>1996</b> , 61, 1870. [102056-64-4]	270.44	HMIS: 2-1-1-X 115° / 0.5 Flashpoint: 100°C (212°F)	10g	0.99	1.4513
<b>SID4610.3</b> 2-(DIVINYLMETHYLSILYL)ETHYLTRIETHOXYSILANE <chem>C13H28O3Si2</chem>	288.54	HMIS: 2-1-1-X 79-81° / 0.15 5g		0.895	
<b>SID4618.0</b> DOCOSYNYLTRIETHOXYSILANE, 95% <chem>C28H58O3Si</chem> Contains isomers Forms self-assembled monolayers that can be modified to hydroxyls. <sup>1</sup> 1. Penansky, J. et al. <i>Langmuir</i> <b>1995</b> , 11, 953. [330457-44-8]	470.88	HMIS: 1-1-0-X 187-195° / 0.05 1.0g			
<b>SIH5919.0</b> HEXADECALUORODODEC-11-EN-1-YLTRIMETHOXYSILANE <chem>C15H16F16O3Si</chem> Forms self-assembled monolayers; reagent for immobilization of DNA	576.35	HMIS: 3-1-1-X 90° / 0.5 1.0g		1.4145 <sup>25</sup>	1.3526 <sup>25</sup>
<b>SIH6164.2</b> 5-HEXYNLTRIETHOXYSILANE, 95% <chem>C12H26O3Si</chem> Primarily α-olefin [52034-14-7]	246.43	HMIS: 2-1-1-X 97° / 1 Flashpoint: 86°C (187°F) 10g		0.883	1.4185
<b>SIH6164.3</b> 5-HEXYNLTRIMETHOXYSILANE, 95% <chem>C9H20O3Si</chem> Adhesion promoter for Pt-cure silicones [58751-56-7]	204.34	HMIS: 3-1-1-X 193-4° 10g		0.927	NEW

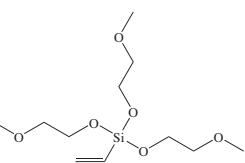
Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIO6709.0</b> 7-OCTENYLTRIMETHOXYSILANE, tech-95  C <sub>11</sub> H <sub>24</sub> O <sub>3</sub> Si Contains 10-15% internal olefin isomers Coupling agent for "in situ" polymerization of acrylamide for capillary electrophoresis. <sup>1</sup> Employed in stretched DNA fibers for FISH (fluorescent <i>in situ</i> hybridization) mapping. <sup>2</sup> Surface treatment for FISH and replication mapping on DNA fibers. <sup>3</sup> 1. Cifuentes, A. et al. <i>J. Chromatogr., A</i> <b>1999</b> , 830(2), 423. 2. Labit, H. et al. <i>BioTechniques</i> <b>2008</b> , 45, 649. 3. Labit, H. et al. <i>Biotechniques Protocol Guide</i> <b>2010</b> (48) DOI 10.2144/000113255. [52217-57-9] TSCA HMIS: 3-1-X 5g 25g	232.39	48-9° / 0.1 Flashpoint: 95°C (203°F)	0.94	1.4305	
<b>SIP6902.6</b> O-(PROPARGYL)-N-(TRIETHOXYSILYL)PROPYL CARBAMATE, 90%  C <sub>13</sub> H <sub>25</sub> NO <sub>5</sub> Si Inhibited with MEHQ Surface derivatization reagent enabling "click" chemistry of nanoparticles. <sup>1</sup> 1. Achatz, D. et al. <i>Sensors and Actuators B</i> <b>2010</b> , 150, 211. [870987-68-1] HMIS: 2-2-1-X 25g	303.43	110-20° / 0.2 Flashpoint: 95°C (203°F)	0.990	1.4461 <sup>25</sup>	
<b>SIS6990.0</b> STYREYLETHYLTRIMETHOXYSILANE, tech-90  C <sub>13</sub> H <sub>20</sub> O <sub>3</sub> Si Inhibited with t-butyl catechol Copolymerization parameter, e,Q: -0.880, 1.500 Mixed m-, p-isomers and α-, β-isomers Contains ethylphenethyltrimethoxysilane [119181-19-0]/[52783-38-7] TSCA-E HMIS: 2-1-1-X store <5°C 10g 50g	252.38	98° / 0.1 Flashpoint: 97°C (207°F)	1.02	1.505	
<b>SIS6993.0</b> 3-(N-STYRYLMETHYL-2-AMINOETHYLAMINO)PROPYLTRIMETHOXYSILANE, 40% in methanol  C <sub>17</sub> H <sub>30</sub> N <sub>2</sub> O <sub>3</sub> Si Inhibited with BHT Coupling agent for unsaturated polyesters [34937-00-3] TSCA EC 252-297-3 HMIS: 3-4-1-X store <5°C 25g 100g 2kg	338.52	Flashpoint: 11°C (52°F)	0.871	1.3900	
<b>SIU9049.0</b> 10-UNDECENYLTRIMETHOXYSILANE  C <sub>14</sub> H <sub>30</sub> O <sub>3</sub> Si When treated on glass provides a contact angle of 100° [872575-06-9] HMIS: 2-1-X 5g	274.48	102-5° / 1	0.908	1.4334	
<b>SIV9088.4</b> O-(VINYLOXYBUTYL)-N-TRIETHOXYSILYLPROPYL CARBAMATE, tech-95  C <sub>16</sub> H <sub>33</sub> NO <sub>5</sub> Si Inhibited with MEHQ UV reactive coupling agent [159856-61-8] HMIS: 3-2-1-X 10g	363.53		1.015	1.4454	
<b>SIV9098.0</b> VINYLTRIACETOXYL SILANE  C <sub>8</sub> H <sub>12</sub> O <sub>6</sub> Si Crosslinker for moisture-cure silicone RTVs with greater liquid range for formulation, faster moisture-cure rate and better substrate adhesion properties than methyltriacetoxysilane [4130-08-9] TSCA EC 223-943-1 HMIS: 3-2-1-X store <5°C 100g 2kg 18kg	232.26	112-3° / 1 Flashpoint: 88°C (190°F) (10-13°)	1.167	1.423	
<b>SIV9099.0</b> VINYLTRI-t-BUTOXYSILANE  C <sub>14</sub> H <sub>30</sub> O <sub>3</sub> Si [5356-88-7] EC 226-343-8 HMIS: 2-2-1-X 10g 50g	274.47	54° / 2 Flashpoint: 79°C (174°F)	0.869		
<b>SIV9112.0</b> VINYLTRIETHOXYSILANE  C <sub>8</sub> H <sub>18</sub> O <sub>3</sub> Si ΔHform: -463.5 kcal/mole ΔHvap: 6.8 kcal/mole Dipole moment: 1.69 debye Specific wetting surface area: 412 m <sup>2</sup> /g Copolymerization parameters- e,Q: -0.42, 0.028 yc of treated glass surface: 25 MN/m Relative hydrolysis rate versus SIV9220.0, vinyltrimethoxysilane; 0.05 Forms copolymers with ethylene Couples fillers or fiberglass to resins See VEE-005 for polymeric version Reacts with enamines to give (E)-β-silylenamines, which cross-couple w/ aryl iodides to give β-aryl enamines. <sup>1</sup> Extensive review on the use in silicon-based cross-coupling reactions. <sup>2</sup> 1. Marciniec, B. et al. <i>J. Org. Chem.</i> <b>2005</b> , 70, 8550. 2. Denmark, S. E. et al. <i>Organic Reactions</i> , Vol. 75, Denmark, S. E. ed., John Wiley and Sons, 233, <b>2011</b> . [78-08-0] TSCA EC 201-081-7 HMIS: 1-2-1-X 25g 2kg	190.31	160-1° Flashpoint: 44°C (111°F) TOXICITY: oral rat, LD50: 22,500 mg/kg Autoignition temperature: 268°C Vapor pressure, 20°: 5 mm Specific heat: 0.25 cal/g°	0.903	1.3960	

COMMERCIAL

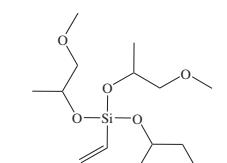
COMMERCIAL

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIV9209.0</b> VINYLTRIISOPROPOXENOSILANE, tech-95 C <sub>11</sub> H <sub>18</sub> O <sub>3</sub> Si Employed as a cross-linker and in vapor phase derivatization; byproduct is acetone [15332-99-7]	226.35	73-5° / 12 TSCA EC 239-362-1 HMIS: 1-3-1-X	25g	100g	0.926 1.4373
<b>SIV9210.0</b> VINYLTRIISOPROPOXYSILANE C <sub>11</sub> H <sub>24</sub> O <sub>3</sub> Si Copolymerization parameters- e,Q: -0.36, 0.031 Used for free-radical cure water-borne resin systems Adhesion promotor for vinyl acetate/ethylene latex Relative hydrolysis rate versus vinyltrimethoxysilane; 0.0015 [18023-33-1]	232.39	179-81° Flashpoint: 51°C (124°F) Vapor pressure, 60°: 4 mm TSCA EC 241-931-4 HMIS: 1-2-1-X	25g	100g	0.8659 1.3961 <sup>25</sup>
<b>SIV9220.0</b> VINYLTRIMETHOXYSILANE C <sub>5</sub> H <sub>12</sub> O <sub>3</sub> Si Viscosity: 0.6 cSt Copolymerization parameters- e,Q: -0.38, 0.031 Specific wetting surface area: 528 m <sup>2</sup> /g Employed in two-stage <sup>1</sup> and one-stage <sup>2</sup> graft polymerization/crosslinking for PE Copolymerizes with ethylene to form moisture crosslinkable polymers. <sup>3</sup> Converts arylselenyl bromides to arylvinylselenides. <sup>4</sup> Reacts with anhydrides to transfer both vinyl and methoxy and thus form the mixed diester. <sup>5</sup> Cross-couples w/ α-bromo esters to give α-vinyl esters in high ee. <sup>6</sup> 1. Scott, H. U.S. Patent 3,646,155, 1972. 2. Swarbrick, P. et al. U.S. Patent 4,117,195, 1978. 3. Isaka, T. et al. U.S. Patent 4,413,066, 1983. 4. Bhadra, S. et al. <i>J. Org. Chem.</i> <b>2010</b> , 75, 4864. 5. Luo, F. et al. <i>J. Org. Chem.</i> <b>2010</b> , 75, 5379. 6. Strotman, N. A.; Sommer, S.; Fu, G. C. <i>Angew. Chem., Int. Ed. Engl.</i> <b>2007</b> , 46, 3556. [2768-02-7]	148.23	123° Flashpoint: 28°C (82°F) TOXICITY: oral rat, LD50: 8,000 mg/kg Autoignition temperature: 235°C Vapor pressure, 20°: 9 mm	25g	100g	0.970 1.3930
<b>SIV9275.0</b> VINYLTRIS(2-METHOXYETHOXY)SILANE C <sub>11</sub> H <sub>24</sub> O <sub>6</sub> Si Employed in peroxide graft-moisture crosslinking of polyethylene Relative hydrolysis rate versus SIV9220.0, vinyltrimethoxysilane; 0.50 Coupling agent for kaolin in EPDM/PE cable formulations. <sup>1</sup> 1. Arkles, B. et al. <i>Modern Plastics</i> <b>1987</b> , 64, 138. [1067-53-4]	280.39	284-6° Flashpoint: 115°C (239°F) TOXICITY: oral rat, LD50: 2,960mg/kg Autoignition temperature: 210°C Vapor pressure, 108°: 2 mm	25g	100g	1.0336 <sup>25</sup> 1.4271 <sup>25</sup>
<b>SIV9277.0</b> VINYLTRIS(1-METHOXY-2-PROPOXY)SILANE C <sub>14</sub> H <sub>30</sub> O <sub>6</sub> Si [303746-21-6]	322.47	HMIS: 2-1-1-X Flashpoint: 122°C (252°F) 25g	100g	0.981	1.424
<b>SIV9280.0</b> VINYLTRIS(METHYLETHYLKETOIMINO)SILANE, tech-95 C <sub>14</sub> H <sub>27</sub> N <sub>3</sub> O <sub>3</sub> Si Neutral cross-linker/coupling agent for condensation cure silicones Byproduct: methylethylketoxime [2224-33-1]	313.47	113° / 0.1 TSCA EC 218-747-8 HMIS: 3-3-1-X	50g	2kg	0.982 <sup>25</sup> 1.465

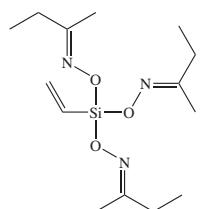
Vinylsilanes are used in PE and EPDM insulated wire and cable



Vinyltrimethoxysilane



Vinyltris(2-methoxyethoxy)silane



Vinyltris(1-methoxy-2-propoxy)silane

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>Vinyl and Olefin Functional Silanes - Dialkoxy</b>					
<b>SIA0415.0</b> N-ALLYL-AZA-2,2-DIMETHOXYSILACYCLOPENTANE C <sub>8</sub> H <sub>17</sub> NO <sub>2</sub> Si Coupling agent for nanoparticles [618914-49-1]	187.31	52-4° / 3			NEW
			HMIS: 3-3-1-X	10g	
<b>SIA0485.0</b> ALLYLMETHYLDIMETHOXYSILANE, tech-95 C <sub>6</sub> H <sub>14</sub> O <sub>2</sub> Si Contains β-methylvinyl isomer [67681-66-7]	146.26	127-8°		0.871 <sup>25</sup>	1.4055 <sup>25</sup>
		EC 266-901-8 HMIS: 3-3-1-X	5g		NEW
<b>SIB0990.3</b> (5-BICYCLO[2.2.1]HEPT-2-ENYL)METHYLDIETHOXYSILANE C <sub>12</sub> H <sub>22</sub> O <sub>2</sub> Si Comonomer for ROMP reactive resins [113276-73-6]	226.39	65-7° / 1		0.959	1.4525 <sup>25</sup>
		HMIS: 2-2-1-X	25g		NEW
<b>SIV9085.0</b> VINYL METHYLDIETHOXYSILANE C <sub>7</sub> H <sub>16</sub> O <sub>2</sub> Si Dipole moment: 1.27 debye Copolymerization parameters- e,Q; -0.86, 0.020 Chain extender, crosslinker for silicone RTVs and hydroxy-functional resins [5507-44-8]	160.29	133-4°	Flashpoint: 16°C (61°F)	0.858	1.3998
		TSCA EC 226-850-4 HMIS: 2-4-1-X	25g	2kg	COMMERCIAL
<b>SIV9086.0</b> VINYL METHYLDIMETHOXYSILANE C <sub>5</sub> H <sub>12</sub> O <sub>2</sub> Si Viscosity: 0.7 cSt Additive to moisture-cure silane modified polyurethanes as a water scavenger to prevent premature cure [16753-62-1]	132.23	103°	Flashpoint: 15°C (59°F) Autoignition temperature: 245°C Vapor pressure, 20°: 38 mm	0.889	1.395
		TSCA EC 240-816-6 HMIS: 3-4-1-X	25g	100g	COMMERCIAL
				2kg	
<b>Vinyl and Olefin Functional Silanes - Monoalkoxy</b>					
<b>SIB0981.0</b> (5-BICYCLO[2.2.1]HEPT-2-ENYL)DIMETHYLETHOXYSILANE C <sub>11</sub> H <sub>20</sub> OSi Undergoes ROMP reactions [899823-76-8]	196.36	67° / 3.5		0.926 <sup>25</sup>	1.4604 <sup>25</sup>
		HMIS: 2-2-1-X	25g		NEW
<b>SIT8732.0</b> TRIVINYLMETHOXYSILANE, 95% C <sub>7</sub> H <sub>12</sub> OSi [193828-96-5]	140.25	131-3°	Flashpoint: 26°C (79°F)		1.4400
		HMIS: 3-4-1-X	2.5g	10g	
<b>SIV9072.0</b> VINYLDIMETHYLETHOXYSILANE C <sub>6</sub> H <sub>14</sub> OSi Dipole moment: 1.23 debye Vinylates aryl halides. <sup>1</sup> 1. Denmark, S. E.; Butler, C. R. J. Am. Chem. Soc. 2008, 130, 3690. [5356-83-2]	130.26	99-100°	Flashpoint: 4°C (39°F)	0.790	1.3983
		TSCA EC 226-341-7 HMIS: 2-4-1-X	10g	50g	

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>Vinyl and Olefin Functional Silanes - Dipodal</b>					
<b>SIB1618.0</b> 1,2-BIS(METHYLDIETHOXYSILYL)ETHYLENE C <sub>12</sub> H <sub>28</sub> O <sub>4</sub> Si <sub>2</sub> Mixed cis/trans isomers - primarily trans [124279-15-8]	292.52	80° / 2		0.918	1.4214
		HMIS: 2-3-1-X	25g		NEW
<b>SIB1818.0</b> BIS(TRIETHOXYSILYLETHYL)VINYLMETHYLSILANE C <sub>19</sub> H <sub>44</sub> O <sub>6</sub> Si <sub>2</sub>	452.82	141° / 0.15		0.943	
		HMIS: 2-1-1-X	5g		
<b>SIB1820.0</b> 1,2-BIS(TRIETHOXYSILYL)ETHYLENE, 95% 4,4,7,7-TETRAETHOXY-3,8-DIOXA-4,7-DISILADEC-5-ENE C <sub>14</sub> H <sub>32</sub> O <sub>6</sub> Si <sub>2</sub> ~80% trans isomer Forms ethylene-bridged mesoporous silicas. <sup>1</sup> 1. Vercaemst, C. et al. <i>Chem. Mater.</i> <b>2009</b> , 21, 5792. [87061-56-1]	352.57	122-5° / 4		0.958	1.4168
		HMIS: 2-2-1-X	5g	25g	
<b>SIB1824.9</b> 1,3-[BIS(3-TRIETHOXYSILYLPROPYL)POLYETHYLENOXY]-2-METHYLENEPROPANE C <sub>50</sub> H <sub>104</sub> O <sub>20</sub> Si <sub>2</sub> (av) 1113.5 Vinyl functional hydrophilic dipodal coupling agent for protein immobilization			HMIS: 2-2-1-X	1.0g	
<b>SIB1832.5</b> 1,1-BIS(TRIMETHOXYSILYL)ETHYLENE, tech-95 C <sub>10</sub> H <sub>24</sub> O <sub>6</sub> Si <sub>2</sub> Contains ~ 10% cyclic siloxane condensation products Dipodal coupling agent [143727-20-2]	296.47	230-3°		1.05	1.429 <sup>25</sup>
		HMIS: 3-3-1-X	5g		
<b>SIB1834.5</b> BIS(3-TRIMETHOXYSILYLPROPYL) FUMARATE, 96% C <sub>16</sub> H <sub>32</sub> O <sub>10</sub> Si <sub>2</sub> Dipodal silane Adhesion promoter for Pt-cure silicone RTVs [3371-62-8]	440.59	Flashpoint: >110°C (>230°F)		1.118	1.443
		TSCA	HMIS: 3-1-1-X	25g	NEW
<b>Vinyl and Olefin Functional Silanes - Polymeric</b>					
<b>SIV9112.2</b> VINYLTRIETHOXYSILANE, oligomeric hydrolysate Viscosity: 4-7 cSt [29434-25-1]				1.02	
		TSCA	HMIS: 2-2-1-X	100g	1kg
					NEW
<b>SIV9112.3</b> VINYLTRIETHOXYSILANE-PROPYLTRIETHOXYSILANE, oligomeric co-hydrolysate Viscosity: 3-7 cSt 9-11 wt% vinyl [201615-10-3]	600-1,000	Flashpoint: 116°C (241°F)		1.02	
		TSCA	HMIS: 2-1-1-X	100g	1kg
					NEW
<b>SIV9220.2</b> VINYLTRIMETHOXYSILANE, oligomeric hydrolysate Viscosity: 8-10 cSt Graft-coupling agent for grafted polyethylene composites. <sup>1</sup> 1. Arkles, B. et al, <i>Modern Plastics</i> <b>1987</b> , 64, 38. [131298-48-1]				1.10	1.428
		TSCA	HMIS: 2-2-1-X	100g	2kg
					NEW

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
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## Multi-Functional and Polymeric Silanes

### Polybutadiene

<p><b>SSP-055</b> TRIETHOXYSILYL MODIFIED POLY-1,2-BUTADIENE, 50% in toluene [72905-90-9]</p>	3,500-4,500	Flashpoint: 4°C (39°F) HMIS: 2-4-1-X store <5°C 100g	0.90
<p><b>SSP-056</b> TRIETHOXYSILYL MODIFIED POLY-1,2-BUTADIENE, 50% in volatile silicone [72905-90-9]</p>	3,500-4,500	HMIS: 2-3-1-X store <5°C 100g	0.93
<p><b>SSP-058</b> DIETHOXYMETHYLSILYL MODIFIED POLY-1,2-BUTADIENE, 50% in toluene [72905-90-9]</p>	3,500-4,500	Flashpoint: 4°C (39°F) HMIS: 2-4-1-X store <5°C 100g	0.90
<p><b>SSP-255</b> (30-35% TRIETHOXYSILYLETHYL)ETHYLENE-(35-40% 1,4-BUTADIENE)-(25-30% STYRENE) terpolymer, 50% in toluene [72905-90-9]</p>	4,500-5,500	Flashpoint: 4°C (39°F) HMIS: 2-3-1-X 100g	

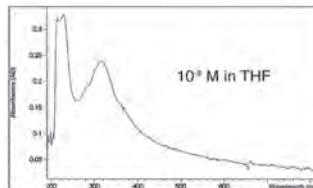
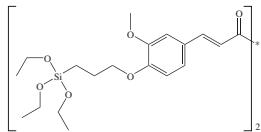
### UV Active and Fluorescent Silanes

#### SIB1824.8

1,7-BIS(4-TRIETHOXYSILYLPROPOXY-3-METHOXYPHENYL)-1,6-HEPTADIENE-3,5-DIONE, tech-90  
C<sub>39</sub>H<sub>60</sub>O<sub>12</sub>Si<sub>2</sub> 777.07

UV max: 220, 232(vs), 354(broad)

Metal chelating chromophore



[947329-82-0]

HMIS: 2-1-1-X 0.5g

#### SIC2058.2

3-CARBAZOLYLPROPYLTRIETHOXYSILANE  
C<sub>21</sub>H<sub>29</sub>NO<sub>3</sub>Si

For non-linear optic materials

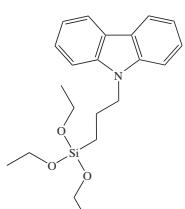
Employed in OLED fabrication.<sup>1</sup>

1. DeMais, T. et al. *SPIE Proc.* **1998**, 3476, 338  
[221105-38-0]

371.55 185-195° / 0.3

1.072 1.5527<sup>25</sup>

NFLW



HMIS: 2-2-1-X 2.5g

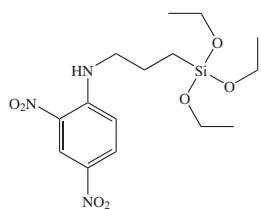
#### SID4352.0

3-(2,4-DINITROPHENYLAMINO)PROPYLTRIETHOXYSILANE, 95%  
N-[3-(TRIETHOXYSILYL)PROPYL]-2,4-DINITROPHENYLAMINE  
C<sub>15</sub>H<sub>25</sub>N<sub>3</sub>O<sub>7</sub>Si

Viscous liquid or solid

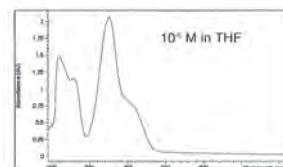
UV max: 222, 258, 350(s), 410

Forms  $\chi_2$  non-linear optical sol-gel materials by corona poling.<sup>1,2</sup>



387.46 (27-30°)  
Flashpoint: >110°C (>230°F)

1.5665



1. Toussaere, E. et al. *Non-Linear Optics* **1992**, 2, 37.

2. Lebeau, J. et al. *J. Mater. Chem.* **1994**, 4, 1855.

[71783-41-0]

HMIS: 2-1-0-X 25g

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIH6198.0</b> 2-HYDROXY-4-(3-METHYLDIETHOXYSILYLPROPOXY)DIPHENYLKETONE, tech-90 <chem>C21H28O5Si</chem> Amber liquid Viscosity: 100-125 cSt HMIS: 2-1-1-X 25g	388.54			1.116 <sup>25</sup>	1.5601 <sup>25</sup>
<b>SIH6200.0</b> 2-HYDROXY-4-(3-TRIETHOXYSILYLPROPOXY)DIPHENYLKETONE, tech-90 <chem>C22H30O6Si</chem> Amber liquid Viscosity, 25°: 125-150 cSt UV max: 230, 248, 296(s), 336 Strong UV blocking agent for optically clear coatings, absorbs from 210-420 nm UV blocking agent. <sup>1</sup>	418.56			1.120 <sup>25</sup>	1.545 <sup>25</sup>
1. Anthony, B. U.S. Patent 4,495,360, 1985. [79876-59-8] TSCA HMIS: 2-1-1-X 25g 100g 2kg					
<b>SIM6502.0</b> O-4-METHYLCOUMARINYL-N-[3-(TRIETHOXYSILYL)PROPYL]CARBAMATE <chem>C20H29NO7Si</chem> UV max: 223, 281, 319.5 (vs) Soluble: THF Immobilizable fluorescent compound. <sup>1</sup>	423.54		(88-90°)		
1. Arkles, B. U.S. Patent 4,918,200, 1990. [129119-78-4] HMIS: 2-2-1-X 10g					
<b>SIN6597.25</b> NITROVERATRYLOXYCARBONYLAMIDOPROPYLTRIETHOXYSILANE, 10% in tetrahydrofuran N-TRIETHOXYSILYLPROPYL-O-4,5-DIMETHOXY-2-NITROBENZYLCARBAMATE <chem>C19H32N2O9Si</chem> UV max: 365 nm Photosensitive silane for lithography. <sup>1</sup>	460.56		Flashpoint: -14°C (7°F)		
1. del Campo, A. et al. <i>Angew. Chem.</i> <b>2005</b> , 44, 4707 [188541-09-5] HMIS: 3-4-1-X 1.0g					
<b>SIT8186.2</b> 7-TRIETHOXYSILYLPROPOXY-5-HYDROXYFLAVONE, 50% in xylene <chem>C24H30O7Si</chem> Contains non-reactive dyestuffs UV max: 350 nm	458.58		Flashpoint: 30°C (86°F)		
[945761-08-0] HMIS: 2-3-1-X 1.0g 5g					
<b>SIT8187.0</b> N-(TRIETHOXYSILYLPROPYL)DANSYLAМИDE 5-DIMETHYLAMINO-N-(3-TRIETHOXYSILYLPROPYL)NAPHTHALENE-1-SULFONAMIDE <chem>C21H34N2O5SSi</chem> Viscous liquid UV max: 222(s), 256, 354 Fluorescent - employed as a tracer in UV cure composites Soluble in toluene, tetrahydrofuran Fluorescence probe for crosslinking in silicones. <sup>1</sup> Employed in a chemically modified logic gate. <sup>2</sup>	454.66	115-9° / 0.1		1.12	1.5421
1. Leezenberg, P. et al. <i>Chem. Mater.</i> <b>1995</b> , 7, 1784. 2. Mu, L. et al. <i>Angew. Chem., Int. Ed. Engl.</i> <b>2009</b> , 48, 3469. [70880-05-6] TSCA EC 274-980-5 HMIS: 2-1-1-X 1.0g					

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIT8191.0</b> 3-(TRIETHOXYSILYLPROPYL)-p-NITROBENZAMIDE C <sub>16</sub> H <sub>26</sub> N <sub>2</sub> O <sub>6</sub> Si UV max: 224, 260, 292(s) Used to prepare diazotizable supports for enzyme immobilization. <sup>1</sup>	370.48		(54-5°)		1.5127
1. Weetall, H. U.S. Patent 3,652,761, 1972. [60871-86-5] TSCA EC 262-508-0 HMIS: 2-1-1-X		25g			
<b>SIT8192.4</b> (R)-N-TRIETHOXYSILYLPROPYL-O-QUININEURETHANE, 95% C <sub>30</sub> H <sub>45</sub> N <sub>3</sub> O <sub>6</sub> Si UV max: 236(s), 274, 324, 334 Fluorescent, optically active silane Soluble: warm toluene	571.79		(82-4°)		
[200946-85-6]		HMIS: 2-1-1-X	5g		
<b>Chiral Silanes</b>					
<b>SIP6731.5</b> (R)-N-1-PHENYLETHYL-N'-TRIETHOXYSILYLPROPYLUREA C <sub>18</sub> H <sub>32</sub> N <sub>2</sub> O <sub>4</sub> Si Viscous liquid or solid Optically active silane; treated surfaces resolve enantiomers [131206-15-0]	368.55		Flashpoint: >110°C (>230°F)		1.05 <sup>25</sup>
		HMIS: 2-1-0-X	25g		
<b>SIP6731.6</b> (S)-N-1-PHENYLETHYL-N'-TRIETHOXYSILYLPROPYLUREA C <sub>18</sub> H <sub>32</sub> N <sub>2</sub> O <sub>4</sub> Si Viscous liquid or solid Optically active silane; treated surfaces resolve enantiomers [67240-22-2]	368.55		Flashpoint: >110°C (>230°F)		1.05 <sup>25</sup>
		HMIS: 2-1-0-X	25g		
<b>SIT8190.0</b> (S)-N-TRIETHOXYSILYLPROPYL-O-MENTHOCARBAMATE C <sub>20</sub> H <sub>41</sub> NO <sub>5</sub> Si Optically active [68479-61-8]	406.63		Flashpoint: >110°C (>230°F)	0.985 <sup>25</sup>	1.4526
		TSCA EC 270-863-8 HMIS: 2-1-1-X	10g		
<b>SIT8192.4</b> (R)-N-TRIETHOXYSILYLPROPYL-O-QUININEURETHANE, 95% C <sub>30</sub> H <sub>45</sub> N <sub>3</sub> O <sub>6</sub> Si UV max: 236(s), 274, 324, 334 Fluorescent, optically active silane Soluble: warm toluene	571.79		(82-4°)		
[200946-85-6]		HMIS: 2-1-1-X	5g		

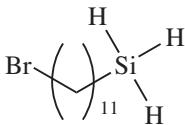
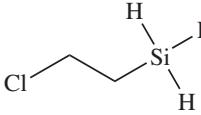
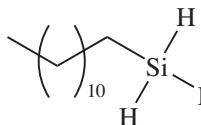
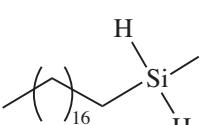
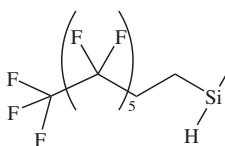
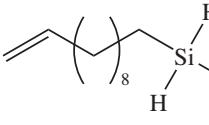
Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>Biomolecular Probes</b>					
<b>SIA0120.2</b> N-(ACETYLGLYCYL)-3-AMINOPROPYLTRIMETHOXYSILANE, 5% in methanol C <sub>10</sub> H <sub>22</sub> N <sub>2</sub> O <sub>5</sub> Si	278.38	(171-3°) Flashpoint: 11°C (52°F)		0.80	NEW
Amino acid-tipped silane [1274903-53-5]		HMIS: 3-4-1-X	25g		
<b>SIA0126.0</b> 3-(N-ACETYL-4-HYDROXYPROLYLOXY)PROPYLTRIETHOXYSILANE, 25% in ethanol C <sub>16</sub> H <sub>31</sub> NO <sub>7</sub> Si	377.51	Flashpoint: 15°C (59°F)		0.872	NEW
Amino acid-tipped silane Hydrophilic reagent for biomimetic surface modification [1300591-79-0]		HMIS: 2-3-0-X	5g		
<b>SIA0127.0</b> N-(N-ACETYLLEUCYL)-3-AMINOPROPYLTRIETHOXYSILANE, 12-15% in ethanol C <sub>17</sub> H <sub>36</sub> N <sub>2</sub> O <sub>5</sub> Si	376.58	Flashpoint: 15°C (59°F)		0.816	NEW
Hydrophobic amino acid-tipped silane [1367348-25-1]		HMIS: 2-3-1-X	2.5g		
<b>SIT7909.7</b> (3-(3-THYMINYL)PROPIONOXY)PROPYLTRIMETHOXYSILANE C <sub>14</sub> H <sub>24</sub> N <sub>2</sub> O <sub>7</sub> Si	360.44				
Derivatized surfaces bind adenine modified polymers. <sup>1</sup> 1. Viswanathan, K. et al. <i>Polymer Preprints</i> <b>2005</b> , <i>46</i> 02, 1133. [879197-67-8]		HMIS: 2-2-1-X	1.0g		
<b>SIT8012.0</b> O-DL- $\alpha$ -TOCOPHEROLYLPOLYTRIETHOXYSILANE, tech-90 C <sub>38</sub> H <sub>70</sub> O <sub>5</sub> Si	635.04			0.956	1.485
		HMIS: 2-2-1-X	10g		

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
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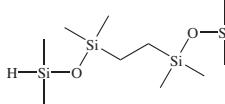
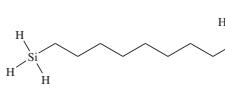
## Trihydrosilanes

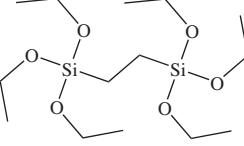
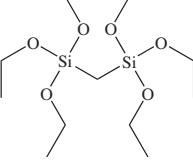
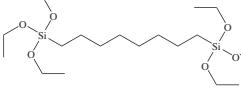
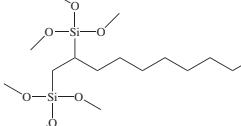
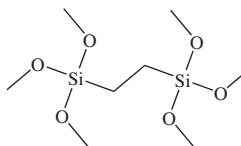
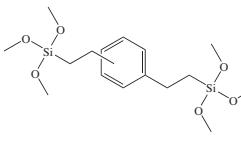
Silyl Hydrides are a distinct class of silanes that behave and react very differently than conventional silane coupling agents. They react with the liberation of byproduct hydrogen. Silyl hydrides can react with hydroxyl surfaces under both non-catalyzed and catalyzed conditions by a dehydrogenative coupling mechanism<sup>1,2</sup>. Trihydridosilanes react with a variety of pure metal surfaces including gold, titanium, zirconium and amorphous silicon, by a dissociative adsorption mechanism.<sup>3</sup> The reactions generally take place at room temperature and can be conducted in the vapor phase or with the pure silane or solutions of the silane in aprotic solvents. Deposition should not be conducted in water, alcohol or protic solvents.

1. Fadeev, A. et al. *J. Am. Chem. Soc.* **1999**, *121*, 12184.
2. N. Morita, N. et al. *J. Am. Chem. Soc.* **2014**, *136*, 11370.
3. B. Arkles, B. et al. *J. Adhesion Sci. Technol.* **2012**, *26*, 141.

<b>SIB1907.8</b> 11-BROMOUNDECYLSILANE <chem>C11H25BrSi</chem>  Forms SAMs on titanium, gold and silicon surfaces. <sup>1</sup> 1. Arkles, B. et al. <i>J. Adhes. Sci. Technol.</i> <b>2012</b> , <i>26</i> , 41. [469904-33-4] HMIS: 2-3-1-X 5g	265.31	100-2° / 0.5	1.02	NEW	
<b>SIC2268.5</b> 2-CHLOROETHYLSILANE <chem>C2H5ClSi</chem>  Intermediate for H <sub>3</sub> SiCl; employed in CVD of SiN. <sup>1</sup> 1. Arkles, B. et al. U.S. Patent 5,968,611, 1999. [18165-19-0] HMIS: 3-4-1-X store <5°C 10g	94.61	69-71°	0.904	1.4232	NEW
<b>SID4629.6</b> DODECYLSILANE <chem>C12H28Si</chem>  Forms SAMs on gold and titanium surfaces [872-19-5] HMIS: 2-2-1-X 10g	200.44	80° / 7	0.7753	1.438 <sup>25</sup>	
<b>SIO6635.0</b> n-OCTADECYLSILANE <chem>C18H40Si</chem>  Contains 4-6% C <sub>18</sub> isomers Forms self-assembled monolayers on titanium. <sup>1</sup> Reacts onto a gold surface to form monolayers of long alkyl chains. <sup>2</sup> Forms SAMs on titanium, gold and silicon surfaces. <sup>3</sup> 1. Fadea, A. et al. <i>J. Am. Chem. Soc.</i> <b>1989</b> , <i>121</i> , 12184. 2. Owens, T. M. et al. <i>J. Am. Chem. Soc.</i> <b>2002</b> , <i>124</i> , 6800. 3. Arkles, B. et al. <i>J. Adhes. Sci. Technol.</i> <b>2012</b> , <i>26</i> , 41. [18623-11-5] TSCA EC 242-453-9 HMIS: 2-1-1-X 25g 100g 2kg	284.60	195° / 15 (29°) Flashpoint: >110°C (>230°F)	0.794		
<b>SIT8173.0</b> (TRIDECAFLUORO-1,1,2,2-TETRAHYDROOCTYL)SILANE <chem>C8H7F13Si</chem>  Provides vapor-phase hydrophobic surfaces on titanium, gold, silicon [469904-32-3] HMIS: 3-3-1-X 10g	378.21	75° / 25	1.446	1.3184	
<b>SIU9048.0</b> 10-UNDECENYLSILANE <chem>C11H24Si</chem>  Forms self-assembled monolayers on gold	184.40	HMIS: 2-3-1-X 2.5g	0.768 <sup>25</sup>	1.4415 <sup>25</sup>	

## Dipodal Silyl Hydrides

<b>SIB1770.0</b> 1,2-BIS(TETRAMETHYLDILOXANYL)ETHANE, 95% <chem>C10H30O2Si4</chem> [229621-70-9] 	294.69	90-5° / 20 25g	0.845	1.41	
<b>SID4593.5</b> 1,10-DISILADECANE <chem>C8H22Si2</chem> [4364-10-7] 	174.44	35° / 0.3 10g	0.772	1.4461	

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>		
<b>Dipodal Silanes - Non-Functional</b>							
<b>SIB1660.0</b> BIS[(3-METHYLDIMETHOXYSILYL)PROPYL]POLYPROPYLENE OXIDE 600-800 Viscosity: 6,000-10,000 cSt. Hydrophilic dipodal silane With tin catalyst forms moisture-cross-linkable resins [75009-88-0]			Flashpoint: >110°C (>230°F)	1.00	1.452 <sup>25</sup>		
TSCA	HMIS: 3-1-1-X	100g	2kg	18kg	COMMERCIAL		
<b>SIB1817.0</b> 1,2-BIS(TRIETHOXYSILYL)ETHANE HEXAETHOXYSILYLETHYLENE, BSE <chem>C14H34O6Si2</chem> ΔH <sub>vap</sub> : 101.5 kJ/mole	354.59	96° / 0.3 Flashpoint: 107°C (225°F) TOXICITY: oral rat, LD <sub>50</sub> : 161 mg/kg Vapor pressure, 150°: 10 mm	(-33°)	0.957	1.4052		
	Additive to silane coupling agents formulations that enhances hydrolytic stability Employed in corrosion resistant coatings/primers for steel and aluminum. <sup>1,2</sup> Sol-gels of α,ω-bis(trimethoxysilyl)alkanes reported. <sup>3</sup> Component in evaporation-induced self-assembly of mesoporous structures. <sup>4</sup> Forms mesoporous, derivatizable molecular sieves. <sup>5,6</sup> Hydrolysis kinetics studied. <sup>7</sup>	[16068-37-4]	TSCA EC 240-212-2 HMIS: 3-1-1-X	25g	100g	2kg	COMMERCIAL
<b>SIB1821.0</b> BIS(TRIETHOXYSILYL)METHANE 4,4,6,6-TETRAETHOXYSILYL-3,7-DIOXO-4,6-DISILANONANE <chem>C13H32O6Si2</chem>	340.56	114.5° / 3.5		0.9741	1.4098		
	Intermediate for sol-gel coatings, hybrid inorganic-organic polymers Forms methylene-bridged mesoporous structures. <sup>1</sup> Forms modified silica membranes that separate propylene/propane mixtures. <sup>2</sup>	[18418-72-9]	TSCA-L HMIS: 3-2-1-X	5g	25g	100g	
<b>SIB1824.0</b> 1,8-BIS(TRIETHOXYSILYL)OCTANE <chem>C20H46O6Si2</chem>	438.76	172.5° / 0.75		0.926	1.4240		
	Employed in sol-gel synthesis of mesoporous structures Crosslinker for moisture-cure silicone RTVs with improved environmental resistance Sol-gels of α,ω-bis(triakoxysilyl)alkanes reported. <sup>1</sup>	[52217-60-4]	TSCA HMIS: 2-1-1-X	25g	100g	2kg	
<b>SIB1829.0</b> 1,2-BIS(TRIMETHOXYSILYL)DECANE <chem>C16H38O6Si2</chem>	382.65	130.2° / 0.4		0.984	1.4303		
	Pendant dipodal silane; employed in high pH HPLC Employed in the fabrication of luminescent molecular thermometers. <sup>1</sup>	[832079-33-1]	TSCA-L HMIS: 3-2-1-X	25g	100g		
<b>SIB1830.0</b> 1,2-BIS(TRIMETHOXYSILYL)ETHANE <chem>C8H22O6Si2</chem> CAUTION: INHALATION HAZARD AIR TRANSPORT FORBIDDEN	270.43	103.4° / 5 Flashpoint: 65°C (149°F) TOXICITY: ihl rat, LC <sub>50</sub> : 2.4 ppm Vapor pressure, 20°: 0.08 mm		1.068	1.4091		
	Employed in fabrication of multilayer printed circuit boards. <sup>1</sup>	[18406-41-2]	TSCA EC 242-285-6 HMIS: 4-2-1-X	25g	100g	2kg	
<b>SIB1831.0</b> BIS(TRIMETHOXYSILYLETHYL)BENZENE, tech-95 <chem>C16H30O6Si2</chem> Mixed isomers	374.58	148-50° / 0.1 Flashpoint: 193°C (379°F)		1.08	1.4734		
	Forms high refractive index coatings Forms resins that absorb organics from aqueous media. <sup>1</sup>	[266317-71-9]	TSCA HMIS: 2-1-0-X	10g	50g	2kg	

Name	Mw	bp °C/mm	(mp °C)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
<b>SIB1832.0</b> 1,6-BIS(TRIMETHOXYSILYL)HEXANE C <sub>12</sub> H <sub>30</sub> O <sub>6</sub> Si <sub>2</sub>	326.54	161° / 2 Flashpoint: 95°C (203°F)		1.014	1.4213
Sol-Gels of $\alpha,\omega$ -bis(trimethoxysilyl)alkanes reported. <sup>1</sup> 1. Loy, D.A. et al. <i>J. Am. Chem. Soc.</i> <b>1999</b> , 121, 5413. [87135-01-1]		HMIS: 3-2-1-X	10g 50g 2kg		
<b>SIT8185.8</b> 1-(TRIETHOXYSILYL)-2-(DIETHOXYMETHYLSILYL)ETHANE C <sub>13</sub> H <sub>32</sub> O <sub>5</sub> Si Dipodal silane	324.56	100° / 0.5 Flashpoint: 102°C (216°F) TOXICITY: oral rat, LD50: >500 mg/kg		0.946	1.4112
Lower toxicity, easier to handle than bis(trimethoxysilyl)ethane Improves hydrolytic stability of silane adhesion promotion systems [18418-54-7]	TSCA	HMIS: 2-1-1-X	25g 100g 2kg		

## Organosilane-Modified Silica Nanoparticles

A range of silica structures from 20 nm to 1 micron have been modified with silanes to reduce hydroxyl content allowing improved dispersion. Other versions have monolayers with isolated secondary amine functionality, providing controlled interactions with resins. Systems that maintain low levels of hydroxyls have improved electrical properties. Introduction of low levels of secondary amines impart improved mechanical properties particularly in high humidity environments.

<b>SIS6960.0</b> SILICON DIOXIDE, amorphous <i>Fumed silica</i> SiO <sub>2</sub>	60.09	(>1,600°) TOXICITY: oral rat, LD50: 8,160 mg/kg yc: 44 mN/m Bulk density: ~50 g/l pH, (4% aqueous slurry): 3.5-4.5 500g 2kg	2.2	1.46	COMMERCIAL
Ultimate particle size: 12 - 20 nm Surface area, 200 m <sup>2</sup> /g Isoelectric point: 2.2					
[112945-52-5]	TSCA	HMIS: 2-0-0-X			
<b>SIS6962.0</b> SILICON DIOXIDE, amorphous, HEXAMETHYLDISILAZANE TREATED <i>Fumed silica, HMDZ treated</i> SiO <sub>2</sub>	60.09	(>1,600°) Carbon content: 3% Calculated ratio: (CH <sub>3</sub> ) <sub>3</sub> Si/HO-Si: 2/1	2.2	1.45	COMMERCIAL
Surface area, 150-200 m <sup>2</sup> /g		= (CH <sub>3</sub> ) <sub>3</sub> Si- = trimethylsilyl group			
[68909-20-6]/[7631-86-9]	TSCA	EC 272-697-1	HMIS: 2-0-0-X 500g 2kg		
<b>SIS6962.1M30</b> SILICON DIOXIDE, amorphous, HEXAMETHYLDISILAZANE TREATED <i>Fumed silica, HMDZ treated</i> SiO <sub>2</sub>	60.09	(>1,600°) Carbon content: 2-3% Calculated ratio: (CH <sub>3</sub> ) <sub>3</sub> Si/HO-Si: 1/1	2.2	1.45	COMMERCIAL
Surface area, 150-200 m <sup>2</sup> /g		= (CH <sub>3</sub> ) <sub>3</sub> Si- = trimethylsilyl group			
[68909-20-6]/[7631-86-9]	TSCA	EC 272-697-1	HMIS: 2-0-0-X 500g 2kg		
<b>SIS6962.1N30</b> SILICON DIOXIDE, amorphous, CYCLIC AZASILANE/HEXAMETHYLDISILAZANE TREATED SiO <sub>2</sub>	60.09	(>1,600°) Carbon content: 4-7% Calculated ratio: CH <sub>3</sub> NHCH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> Si/(CH <sub>3</sub> ) <sub>3</sub> Si/HO-Si: 1/2/1	2.2	1.45	COMMERCIAL
Surface area, 150-200 m <sup>2</sup> /g		= CH <sub>3</sub> NHCH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> Si(CH <sub>3</sub> ) <sub>2</sub>			
	TSCA	HMIS: 2-0-0-X	500g		

**Gelest provides custom surface treatment services. We can handle a wide range of materials with special process considerations including: inert atmospheres, highly flammable and corrosive treatments, as well as thermal and vacuum drying.**

## Surface Modification with Silanes: What's not covered in "Silane Coupling Agents"?

**Chlorosilane, silazane and dialkylaminosilane** coupling agents are not discussed in this brochure. These materials can be found in the Gelest catalog entitled "Silicon Compounds: Silanes & Silicones." The use of these materials is limited commercially due to the difficulty in handling the corrosive, flammable or toxic byproducts associated with hydrolysis.

**Hydrophobic, Hydrophilic and Polar** silanes, although important in surface modification, do not have reactive organic functionality and are not discussed with coupling agents. Please see the Gelest brochure entitled "Hydrophobicity, Hydrophilicity and Silane Surface Modification" includes these materials.

## Further Reading

### Silane Coupling Agents - General References and Proceedings

1. B. Arkles, Tailoring Surfaces with Silanes, CHEMTECH, 7, 766-778, 1977
2. E. Plueddemann, "Silane Coupling Agents," Plenum, 1982.
3. K. Mittal, "Silanes and Other Coupling Agents," VSP, 1992.
4. D. Leyden and W. Collins, "Silylated Surfaces," Gordon & Breach, 1980.
5. D. E. Leyden, "Silanes, Surfaces and Interfaces," Gordon & Breach 1985.
6. J. Steinmetz and H. Mottola, "Chemically Modified Surfaces," Elsevier, 1992.
7. J. Blitz and C. Little, "Fundamental & Applied Aspects of Chemically Modified Surfaces," Royal Society of Chemistry, 1999.
8. B. Arkles, Y. Pan, G. Larson, M. Singh, Chemistry - A European Journal, 20, 9442-9450, 2014.

### Substrate Chemistry - General References and Proceedings

9. R. Iler, "The Chemistry of Silica," Wiley, 1979.
10. S. Pantelides, G. Lucovsky, "SiO<sub>2</sub> and Its Interfaces," MRS Proc. 105, 1988.

Product Information		Molecular Weight	Refractive Index		Other Physical Properties	References
Empirical Formula	Product Code		Boiling point/mm (Melting Point)	Specific Gravity		
$\begin{array}{c} \text{OCH}_3 \\   \\ \text{H}_2\text{C}=\text{CHCH}_2\text{Si}-\text{OCH}_3 \\   \\ \text{OCH}_3 \end{array}$	SIA0540.0 ALLYLTRIMETHOXYSILANE $\text{C}_6\text{H}_{14}\text{O}_3\text{Si}$	162.26 Flashpoint: 46°C (115°F)	146.8	0.963 <sup>25</sup>	1.4036 <sup>25</sup>	
	Adhesion promoter for vinyl-addition silicones Allylation of ketones, aldehydes and imines w/ dual activation of a Lewis Acid and fluoride ion. <sup>1</sup> 1. Yamasaki, S.; et al. <i>J. Am. Chem. Soc.</i> <b>2002</b> , 124, 6536. F&F: Vol 18, p 14; Vol 19, p 360; Vol 20, p 85; Vol 21, p 3, Vol 12, p 395					
[2551-83-9]	TSCA	EC 219-855-8	HMIS: 3-2-1-X	10g \$28.00	50g \$112.00	2kg \$840.00
CAS #			Hazardous Material Information System Ratings (Health-Flammability-Reactivity) See Below			
		European Registration #				
			Indicates Product Listed in TSCA Inventory (E= Exempt - Naturally Occurring Substance) (L= Low Volume Exemption) (S= Significant New Use Restriction)			
HYDROLYTIC SENSITIVITY: 10 most sensitive to water; 0 least sensitive (see p.13 for details)						

**Commercial Status**—produced on a regular basis for inventory

**Developmental Status**—available to support development and commercialization

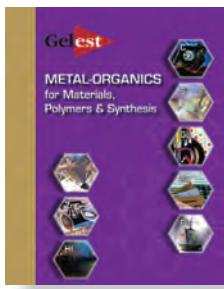
**New Products**—available to support development and commercialization

# Gelest Product Lines



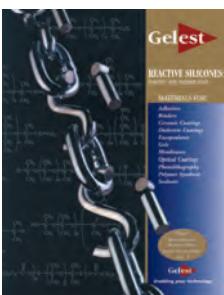
## Silicon Compounds: Silanes & Silicones

Detailed chemical properties and reference articles for over 3,000 compounds. The 608 page handbook of silane and silicone chemistry includes scholarly reviews as well as detailed application information.



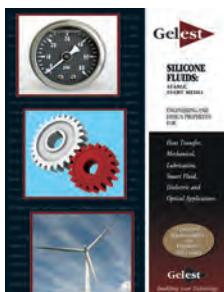
## Metal-Organics for Material & Polymer Technology

A reference manual for optical and electronic and nanotechnology applications. The literature provides information on metallization, electroceramic, and dielectric applications of silicon, germanium, aluminum, gallium, copper and other metal chemistries. Deposition techniques include ALD, CVD, spin coating and self-assembled monolayers (SAMs). Presents chemistry and physics in the context of device applications ranging from ULSI semiconductors to DNA array devices to flat-panel displays.



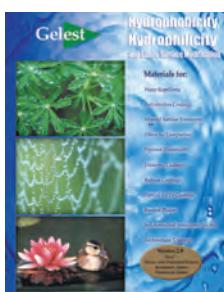
## Reactive Silicones - Forging New Polymer Links

The 64 page brochure describes reactive silicones that can be formulated into coatings, membranes, cured rubbers and adhesives for mechanical, optical, electronic and ceramic applications. Information on reactions and cures of silicones as well as physical property shortens product development time for chemists and engineers.



## Silicone Fluids - Stable, Inert Media

Design and Engineering properties for conventional silicone fluids as well as thermal, fluorosilicone, hydrophilic and low temperature grades are presented in a 30 page selection guide. The brochure provides data on thermal, rheological, electrical, mechanical and optical properties for silicones. Silicone fluids are available in viscosities ranging from 0.65 to 2,500,000 cSt.



## Hydrophobicity, Hydrophilicity and Silane Surface Modification

A description of non-functional silanes that are used to prepare hydrophobic and water repellent surfaces, as well as polar and hydroxylic silanes used to prepare wettable surfaces.



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