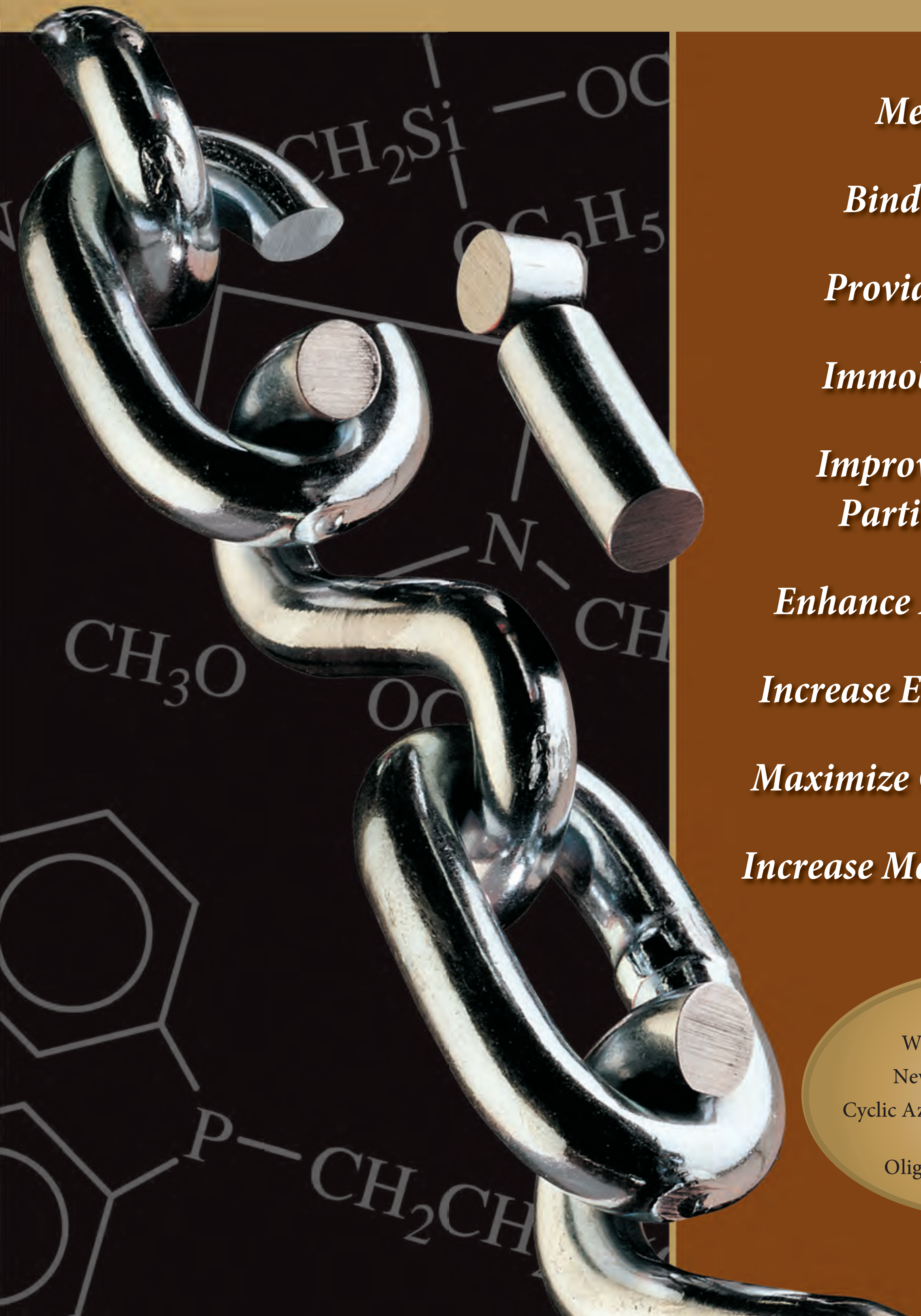
Gelest

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

Version3 .0:

Water-borne Silanes

New Coupling Agents:

Cyclic Aza-Silanes, Azido-Silanes, Dipodal Silanes

Oligomeric Hydrolysates

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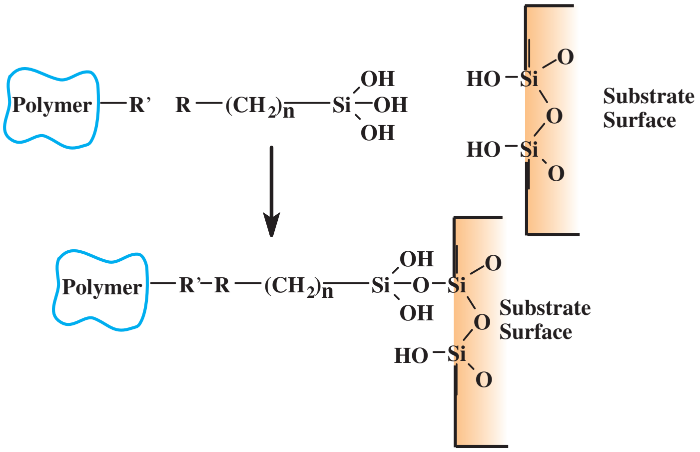
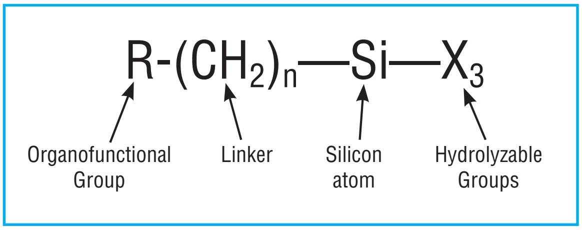
Silane Coupling Agents: Connecting Across Boundaries (3rd Edition)
by Barry Arkles
with selected updates
by Annalese Maddox, Mani Singh, Joel Zazyczny, and Janis Matisons

Silane Coupling Agents

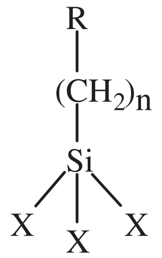
Silane coupling agents have the ability to form a durable bond between organic and inorganic materials. Encounters between dissimilar materials often involve at least one member that's siliceous or has surface chemistry with siliceous properties; silicates, aluminates, borates, etc., are the principal 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.



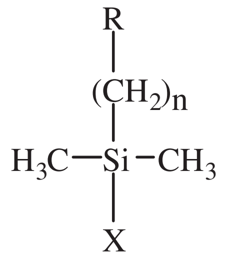


The general formula for a silane coupling agent typically shows the two classes of functionality. X is a hydrolyzable group typically alkoxy, acyloxy, halogen or amine. Following hydrolysis, a reactive silanol group is formed, which can condense with other silanol groups, for example, those on the surface 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 posses a functionality that imparts desired characteristics.

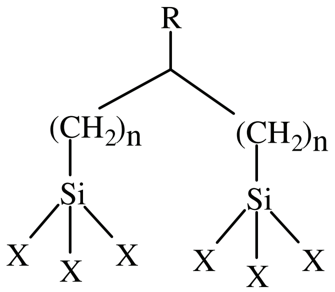
The final result of reacting an organosilane with a substrate ranges from altering the wetting or adhesion characteristics of the substrate, utilizing the substrate to catalyze chemical transformations at the heterogeneous interface, ordering the interfacial region, and modifying its partition characteristics.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



Trialkoxysilane



Monoalkoxysilane



Dipodal Silane

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 alkoxysilanes, only methoxysilanes are effective without catalysis for vapor deposition. The most effective silanes for vapor phase deposition are cyclic azasilanes.

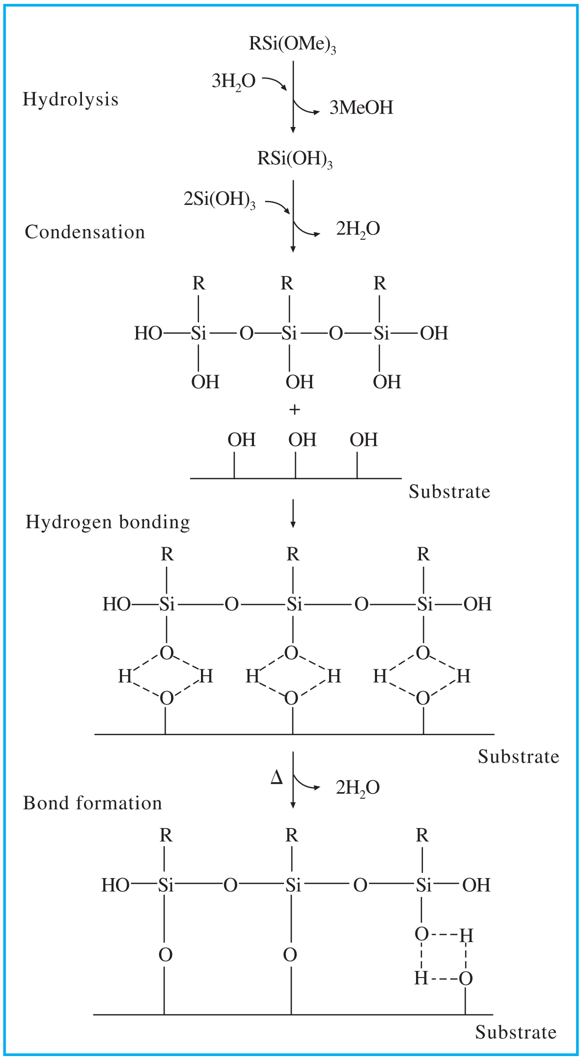
Hydrolysis Considerations

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.

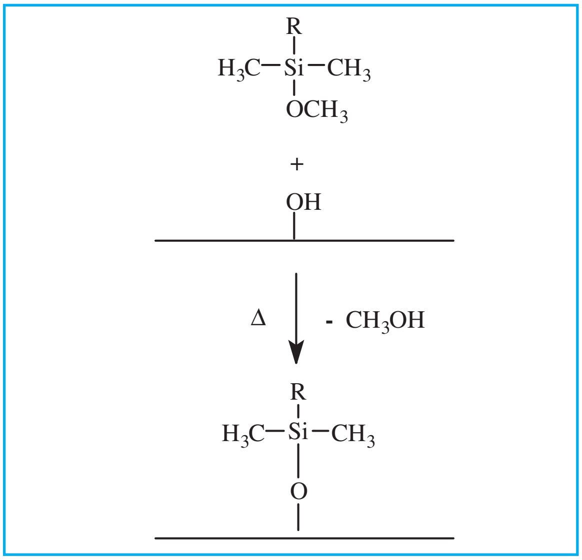
The formation of covalent bonds to the surface proceeds with a certain amount of reversibility. As water is removed, generally by heating to 120°C for 30 to 90 minutes or evacuation for 2 to 6 hours, bonds may form, break, and reform to relieve internal stress. The same mechanism can permit a positional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

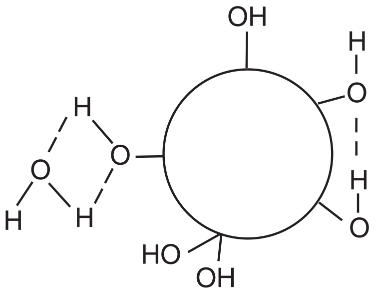
Physical dimensions of the substrate or substrate features

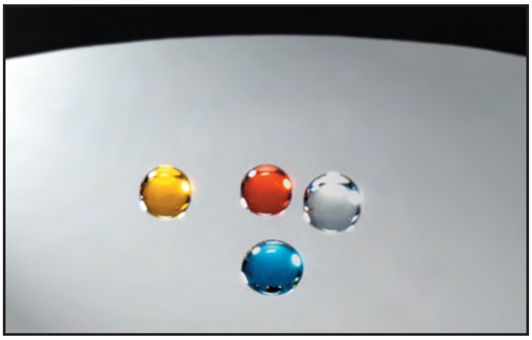
Surface modification is maximized when silanes react with the substrate surface and present the maximum number of accessible sites with appropriate surface energies. An additional consideration is the physical and chemical properties of the interphase region. The interphase can promote or detract from 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 alkoxysilanes can also interfere in activity. Monoalkoxy-silanes provide a frequently used alternative for nano-featured substrates since deposition is limited to a monolayer.

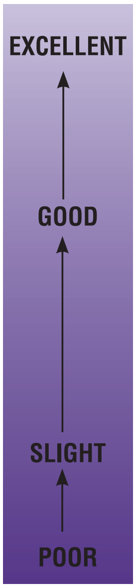
If the hydrolytic stability of the oxane bond between the silane and the substrate is poor or the application is in an aggressive aqueous environment, dipodal silanes often exhibit substantial performance improvements. These materials form tighter networks and may offer up to 10^5x greater hydrolysis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

Silica
Quartz
Glass
Aluminum (AlO(OH))
Alumino-silicates (e.g. clays)
Silicon
Copper
Tin (SnO)
Talc
Inorganic Oxides (e.g. Fe_2O_3, TiO_2, Cr_2O_3)
Steel, Iron
Asbestos
Nickel
Zinc
Lead
Marble, Chalk ($CaCO_3$)
Gypsum ($CaSO_4$)
Barytes ($BaSO_4$)
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:

$$\gamma sv - \gamma sl = \gamma lv \bullet \cos\theta_e$$

where γsl = interfacial surface tension, γlv = 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 (γc) 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

	γ_c mN/m
heneicosafluorododecyltrichlorosilane	6-7
heptadecafluorodecyltrichlorosilane	12.0
poly(tetrafluoroethylene)	18.5
octadecyltrichlorosilane	20-24
methyltrimethoxysilane	22.5
nonafluorohexyltrimethoxysilane	23.0
vinyltriethoxysilane	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
acetoxypropyltrimethoxylsilane	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.

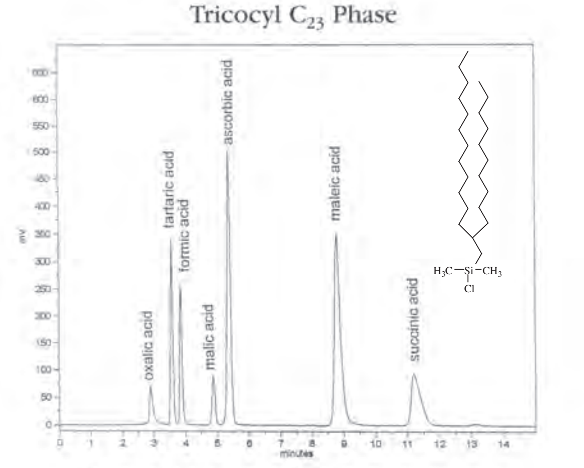
Self-Assembled Monolayers (SAMs)

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 alkoxysilanes 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.

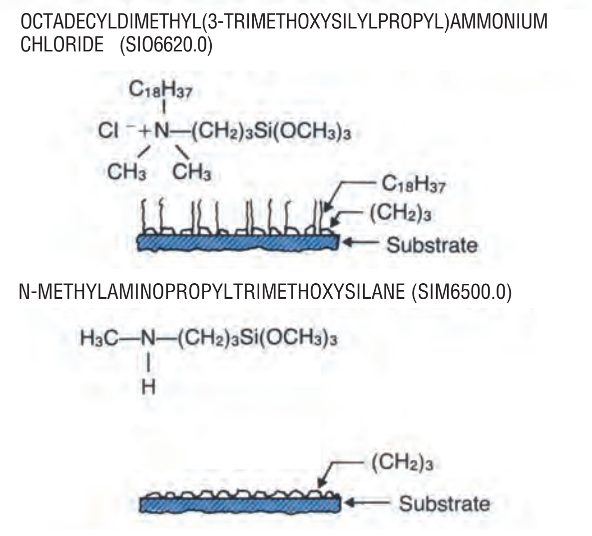
The perpendicular orientation of silanes with C_{10} or greater length can be utilized in micro-contact printing and other soft lithography methods. Here the silane may effect a simple differential adsorption, or if functionalized have a direct sensor effect.

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



Column-C23, 60-5, 250x4.66mm; Mobile Phase-0.1% H_3PO_4, 1mL/min; Temperature 30°C; Detector-210 nm

Orientation effects of silanes for passive LCDs

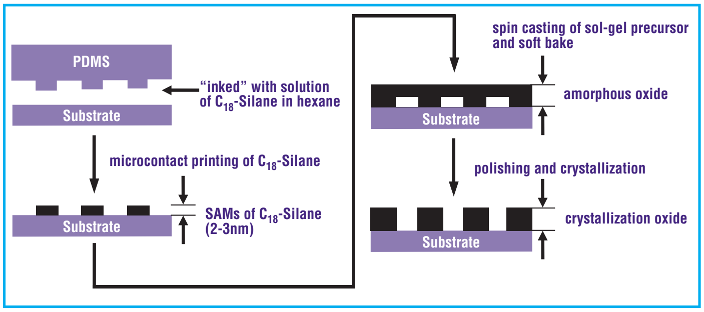


OCTADECYLDIMETHYL(3-TRIMETHOXYSILYLPROPYL)AMMONIUM CHLORIDE (SIO6620.0)

N-METHYLAMINOPROPYLTRIMETHOXYSILANE (SIM6500.0)

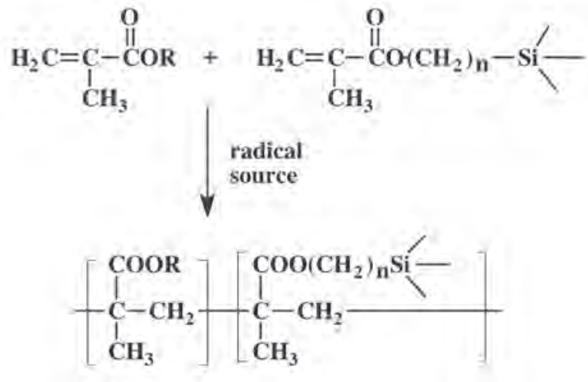
F. Kahn., Appl. Phys. Lett. *22*, 386, 1973

Micro-Contact Printing Using SAMs



Selecting a Silane Coupling Agent:
Polymer Applications

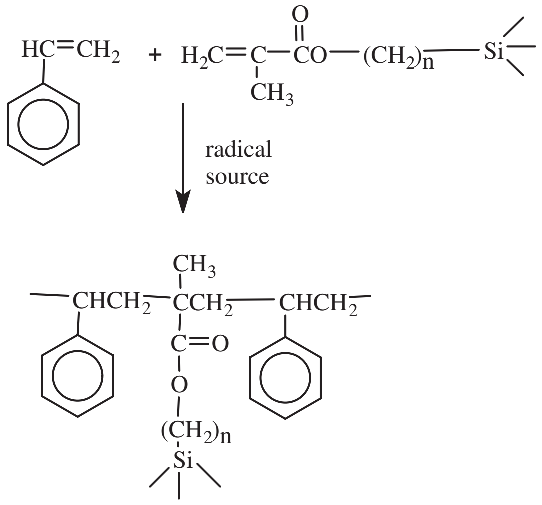
Coupling agents find their largest application in the area of polymers. Since any silane that enhances the adhesion of a polymer is often termed a coupling agent, regardless of whether or not a covalent bond is formed, the definition becomes vague. In this discussion, the parochial outlook will be adopted, 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 mμ^2.



Acrylate Coupling Reaction

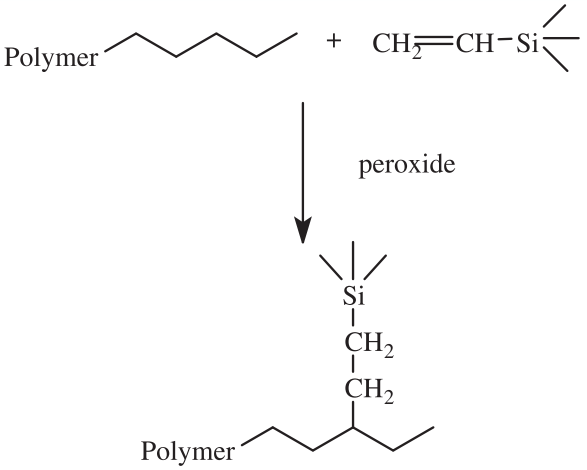
Thermosets

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.



Unsaturated Polyester (Styrene) Coupling Reaction

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.



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

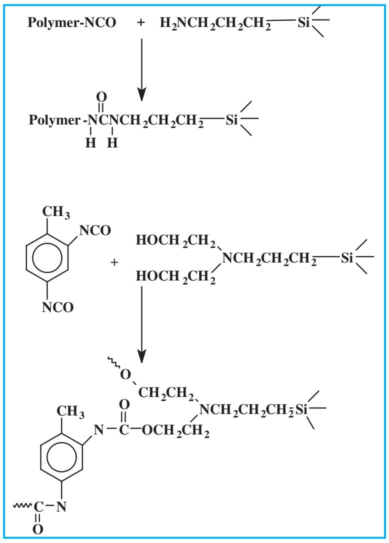
Secondary aminosilanes have the general ability to convert isocyanate functional urethane prepolymers to systems that crosslink in the presence of water and a tin catalyst. The preferred aminosilanes are secondary containing methyl, ethyl or butyl substitutions on nitrogen.

Epoxies

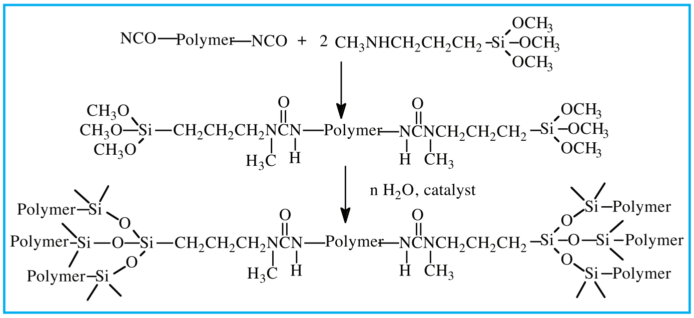
Epoxycyclohexyl and glycidoxy functional silanes are used to pretreat the filler or to blend with the glycidylbisphenol-A ether. Amine functional silanes can likewise be used to pretreat the filler or to blend with the hardener portion. Treatment of fillers in epoxy adhesives improves their dispersibility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

Phenolics

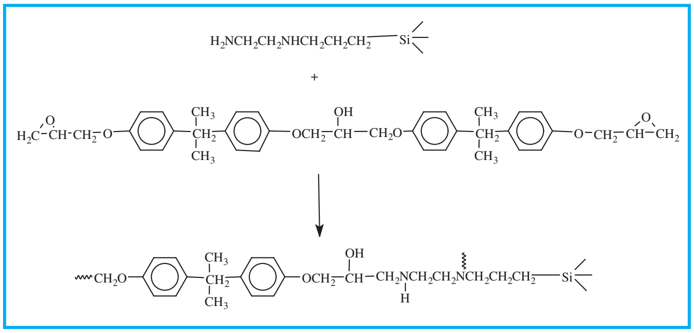
Phenolic resins are divided into base catalyzed single-step resins called resols or better known acid catalyzed two-step systems called novolaks. Although foundry and molds are formulated with resols such as aminopropylmethyldialkoxysilanes, the commercial utilization of silanes in phenolic resins is 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.



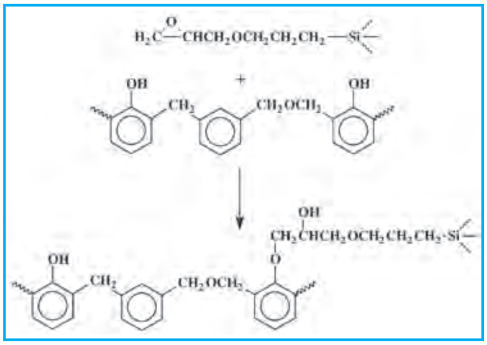
Polyurethane Coupling Reactions



Moisture-Cure Silicone Polyurethane (SPUR)



Epoxy Coupling Reaction



Phenolic Coupling Reaction

Thermoplastics

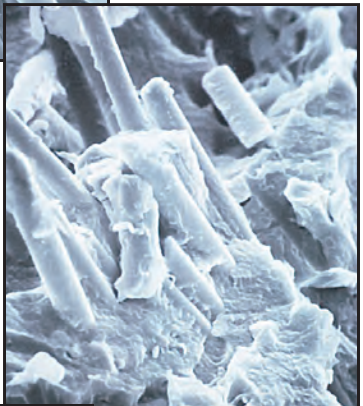
Thermoplastics provide a greater challenge in promoting adhesion through silane coupling agents than thermosets. The silanes must react with the polymer and not the monomeric precursors, which not only limits avenues for coupling, but also presents additional problems in rheology and thermal properties 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

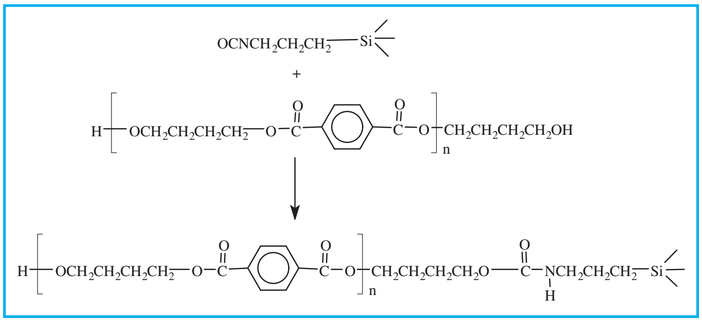
The group of polymers that most closely approaches theoretical limits of composite strength does not appear to contain regular opportunities for covalent bond formation to substrate. Most of the condensation polymers including polyamides, polyesters, polycarbonates, and polysulfones are in this group. 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

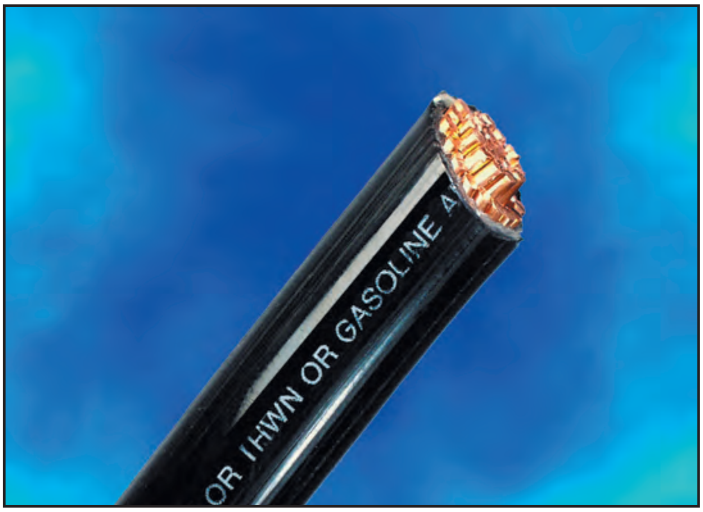
Polyolefins

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.

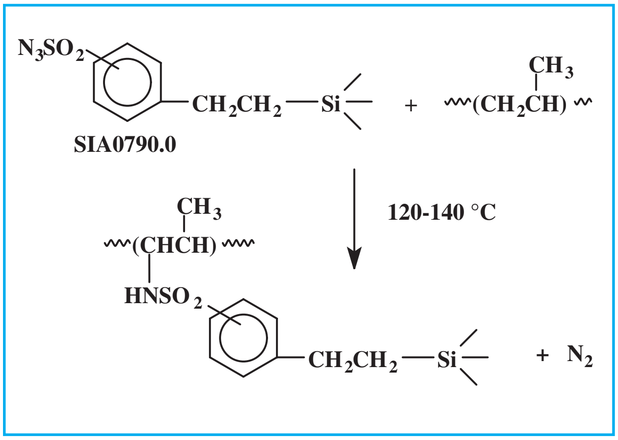
Another approach for coupling polypropylene and polyethylene is through silylsulfonylazides. Unlike azide bound to silicon, sulfonyl azides decompose above 150°C to form a molecule of nitrogen and a reactive nitrene that is capable of insertion into carbon-hydrogen bonds, forming sulfonamides, into carbon-carbon 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.

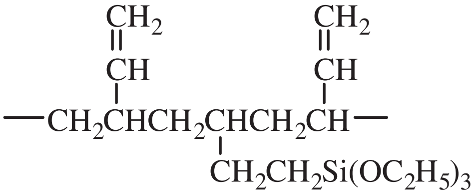
Finally, an oxygen plasma treatment prior to applying silane coupling agents produces hydroxyl radicals on a polyolefin surface. These hydroxyl radicals provide good linkage sites for any silane coupling agent to link onto the polyolefin surface, and this opens a larger range of applicable silanes.



Vinylsilanes are used in PE and EPDM insulated wire and cable

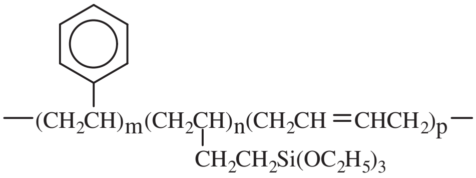


Polypropylene Coupling Reaction



$$-CH_2\overset{\substack{CH_2\\ \| \\ CH\\ |}}{C}HCH_2\underset{\substack{|\\ CH_2CH_2Si(OC_2H_5)_3}}{C}HCH_2\overset{\substack{CH_2\\ \| \\ CH\\ |}}{C}H-$$

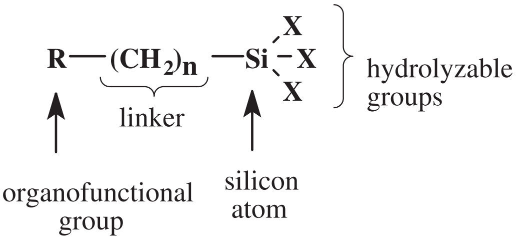
SSP-055



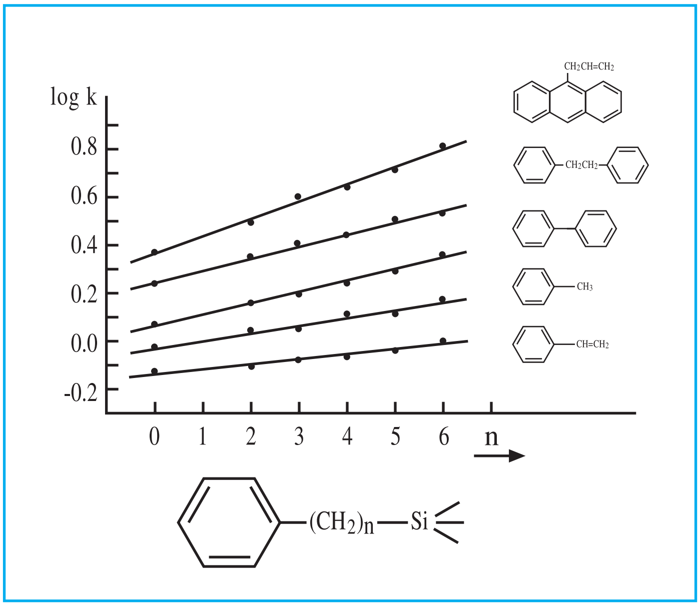
SSP-255

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.

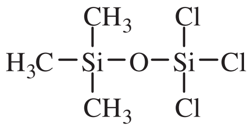


Effect of linker length on the separation of aromatic hydrocarbons



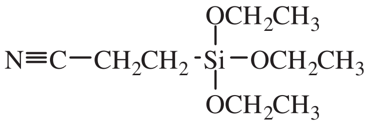
T. Den et al, in "Silanes, Surfaces, Interfaces" D. Leyden ed., 1986 p403.

Silanes with short linker length



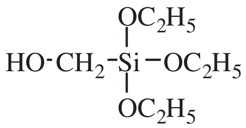
$$H_3C-\underset{CH_3}{\overset{CH_3}{Si}}-O-\underset{Cl}{\overset{Cl}{Si}}-Cl$$

SIT8572.6



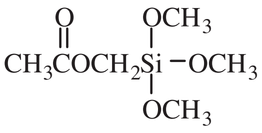
$$N{\equiv}C-CH_2CH_2-\underset{OCH_2CH_3}{\overset{OCH_2CH_3}{Si}}-OCH_2CH_3$$

SIC2445.0



$$HO-CH_2-\underset{OC_2H_5}{\overset{OC_2H_5}{Si}}-OC_2H_5$$

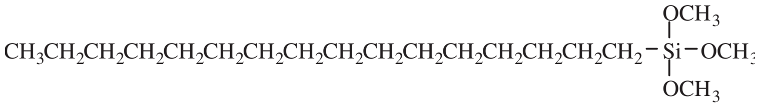
SIH6175.0



$$CH_3\overset{O}{\overset{\|}{C}}OCH_2\underset{OCH_3}{\overset{OCH_3}{Si}}-OCH_3$$

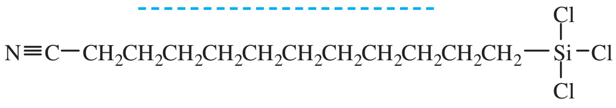
SIA0055.0

Silanes with extended linker length



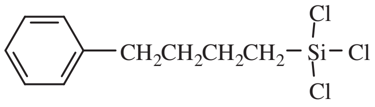
$$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2-\underset{OCH_3}{\overset{OCH_3}{Si}}-OCH_3$$

SIH5925.0

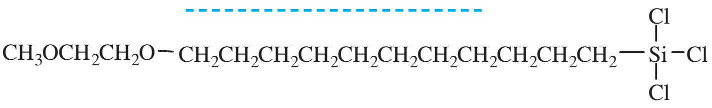


$$N{\equiv}C-CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2-\underset{Cl}{\overset{Cl}{Si}}-Cl$$

SIC2456.3



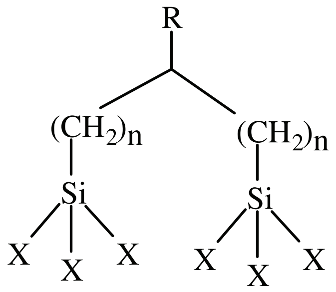
SIP6724.9



$$CH_3OCH_2CH_2O-CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2-\underset{Cl}{\overset{Cl}{Si}}-Cl$$

SIM6491.5

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.

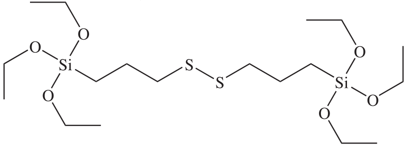
Functional dipodal silanes and combinations of non-functional dipodal silanes with functional conventional silanes have significant impact on substrate bonding and possess enabling activity in many adhesive systems, particularly primer and aqueous immersion applications. The fundamental step by which 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 $\equiv\text{Si-O-Si}\equiv + H_2O \rightleftharpoons \equiv\text{Si-OH} + \equiv\text{Si-OH}$ 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 ~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 ~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:

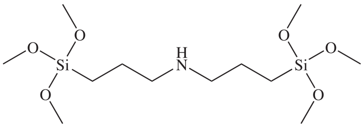
1. Improved wet adhesion
2. Improved chemical resistance
3. Improved processing
4. Improved coating performance
   (such as improved corrosion protection)

Functional Dipodal Silanes

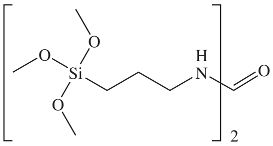
SIB1824.6



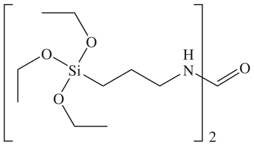
SIB1833.0



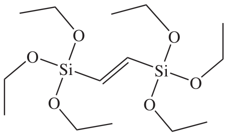
SIB1835.5



SIB1828.0

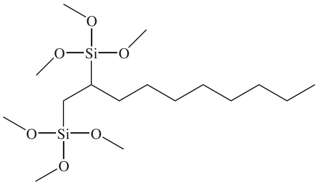


SIB1820.0

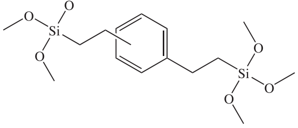


Non-functional Dipodal Silanes

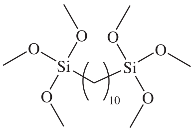
SIB1829.0



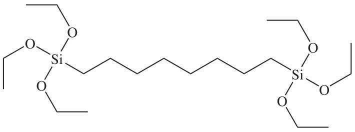
SIB1831.0



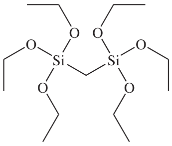
SIB1829.2



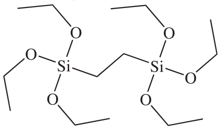
SIB1824.0



SIB1821.0



SIB1817.0



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 $-\mathrm{SiCH_2CH_2Si}-$ on the bond strength of a crosslinkable eythlene-vinyl acetate primer formulation

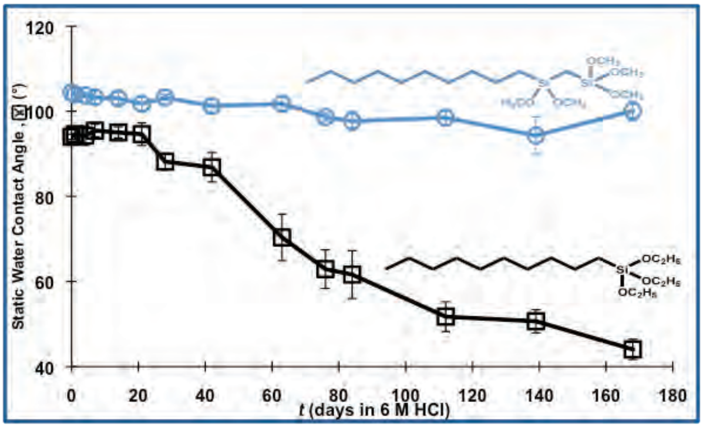
Primer on metal 10% in i-PrOH	Wet adhesion to metals (N/cm)	
	Titanium	Cold-rolled Steel
No silane	Nil	Nil
Methacryloxypropylsilane	0.35	7.0
Methacryloxypropylsilane + 10% dipodal	10.75	28.0 (cohesive failure)
90° peel strength after 2 h in 80°C water		

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 Hydrolutic 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 organofuntional 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.

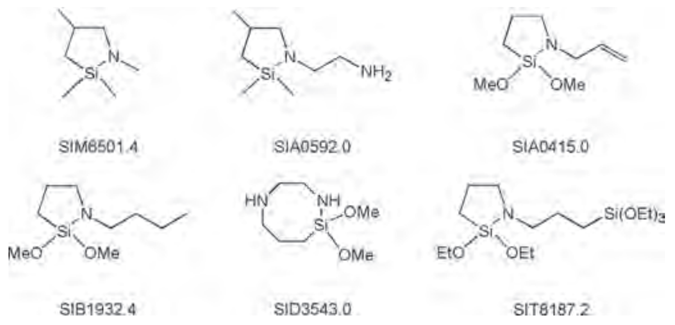
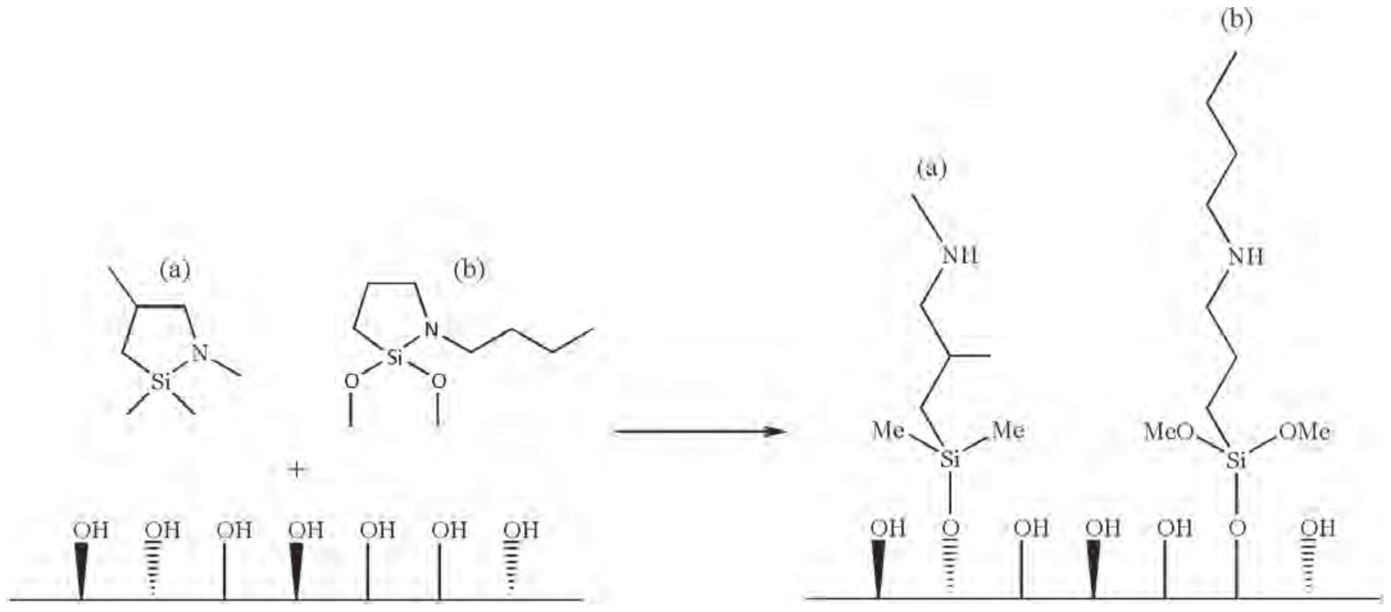


Figure 1: Examples of Cyclic azasilanes



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 cm^{-1}) occurs within 58 seconds of addition of the cyclic azasilane solution, while the C-H stretching vibrations of the $Si(OMe)_2$ remain at 2864 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

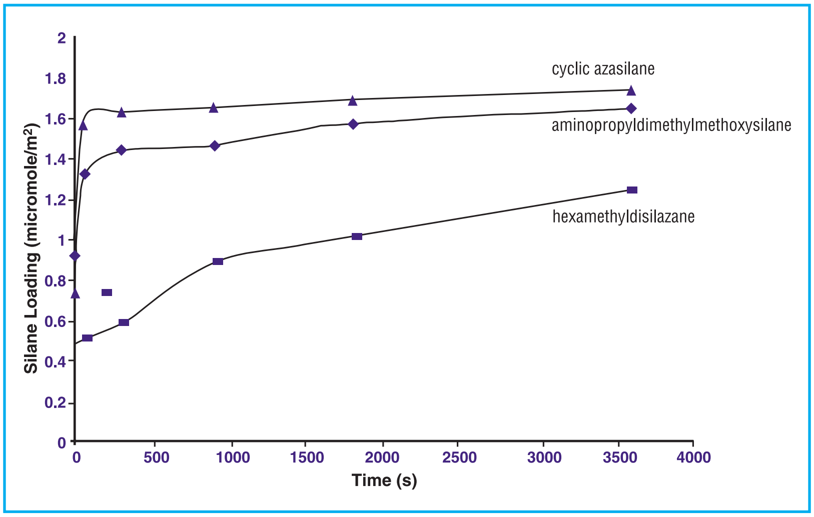


Figure 2: Extent of reaction of organosilanes with fumed silica.

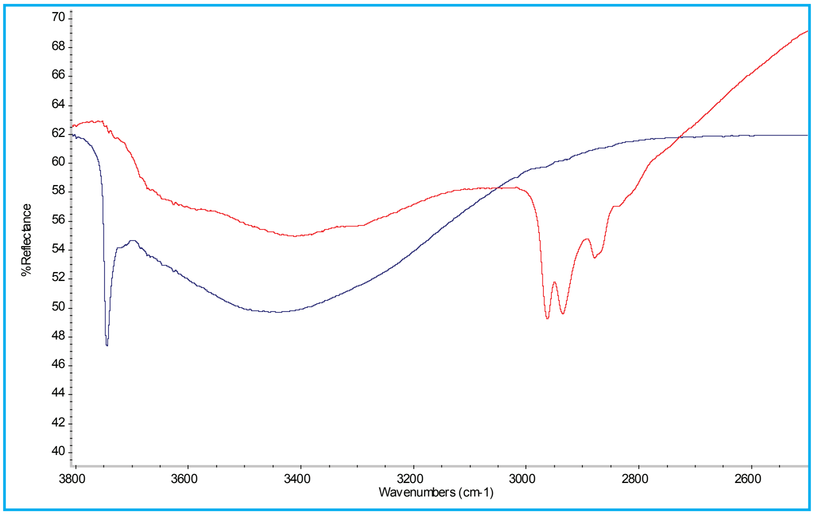
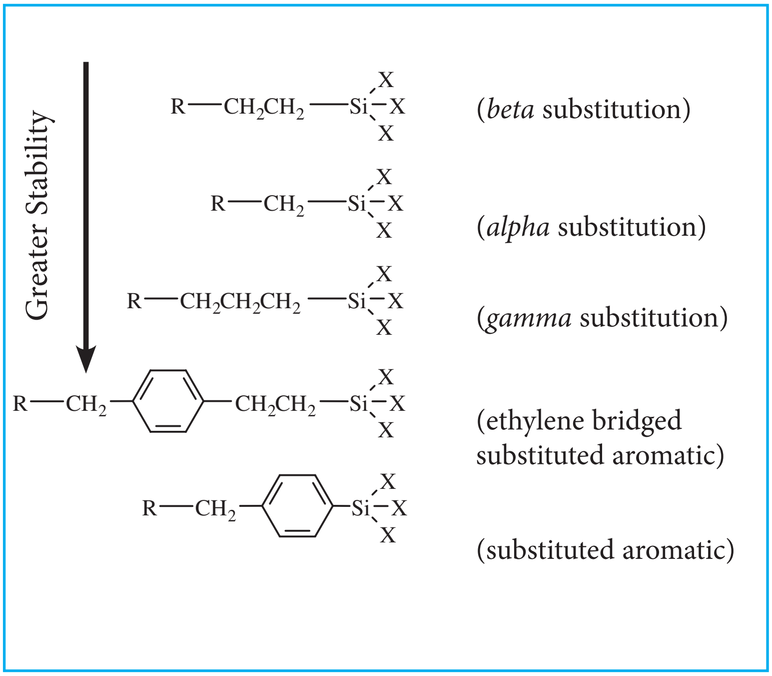


Figure 3: DRIFT of untreated silica (blue) and SIB1932.4 treated silica (red) after 56 sec.

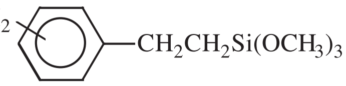
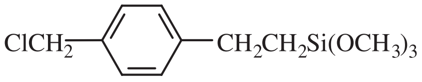
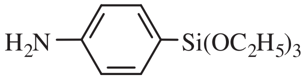
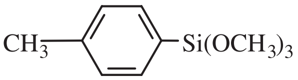
Thermal Stability of Silane Coupling Agents

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.

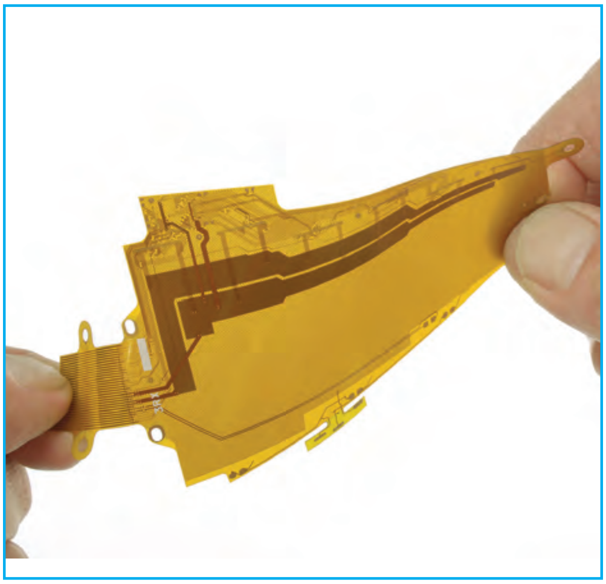
Relative Thermal Stability of Silanes



Thermal Stability of Silanes

SIA0025.0	 $CH_3\overset{\overset{O}{\|}}{C}OCH_2CH_2Si(OC_2H_5)_3$	220°
SIC2271.0	$ClCH_2CH_2CH_2Si(OCH_3)_3$	360°
SIM6487.4	 $H_2C{=}\underset{\underset{CH_3}{\vert}}{C}\overset{\overset{O}{\|}}{C}OCH_2CH_2CH_2Si(OCH_3)_3$	395°
SIA0591.0	 $H_2NCH_2CH_2\overset{\overset{H}{\vert}}{N}CH_2CH_2CH_2Si(OCH_3)_3$	390°
SIA0588.0		435°
SIC2295.5		495°
SIA0599.1		485°
SIT8042.0		530°

25% weight loss of dried hydrolysates as determined by TGA



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

Aqueous Systems & Water-borne Silanes

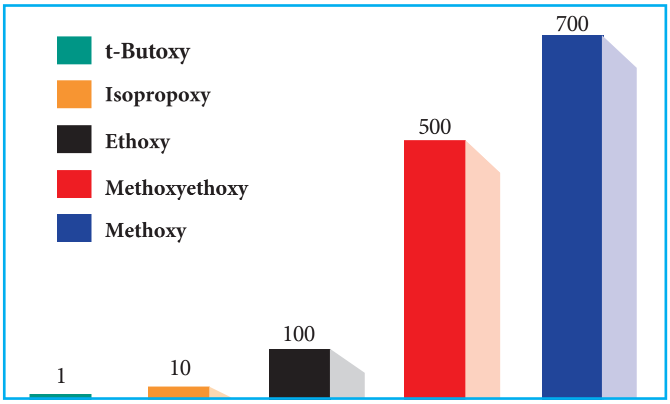
Before most surface modification processes, alkoxysilanes are hydrolyzed forming silanol-containing species. The silanol-containing species are highly reactive intermediates which are responsible for bond formation with the substrate. In principal, if silanol species were stable, they would be preferred for surface treatments. Silanols condense with other silanols or with alkoxysilanes to form siloxanes. This can be observed when preparing aqueous treatment solutions. Initially, since most alkoxysilanes 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.[1]

Hydrolysis and condensation of alkoxysilanes 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.

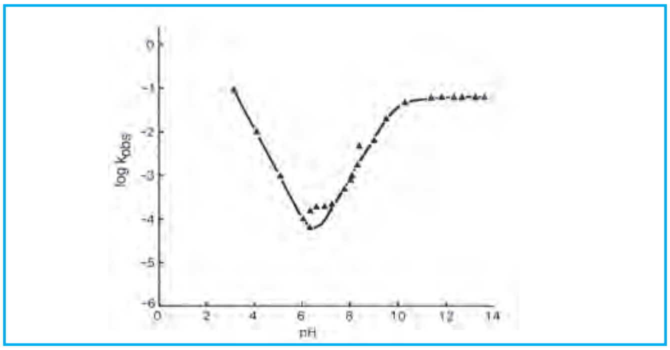
Stable aqueous solutions of silanes are more readily prepared if byproduct or additional alcohol is present in the solution since they contribute to an equilibrium condition favoring monomeric species.

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.

Relative Hydrolysis Rates of Hydrolyzable Groups

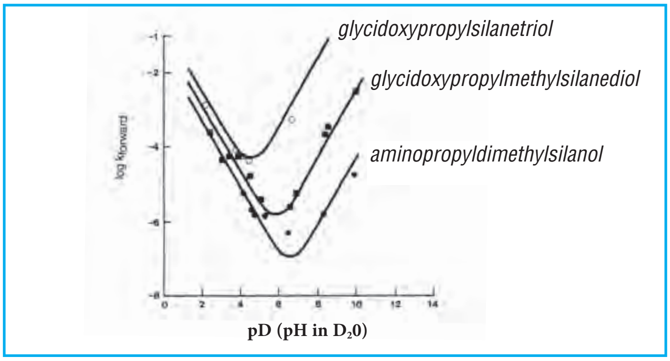


Hydrolysis Profile of Phenylbis(2-methoxyethoxy)silanol

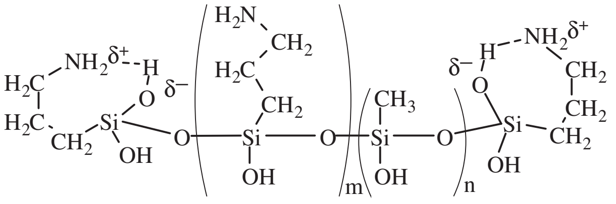


F. Osterholtz et al in Silanes and Other Coupling Agents ed K. Mittal, VSP, 1992, p119

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

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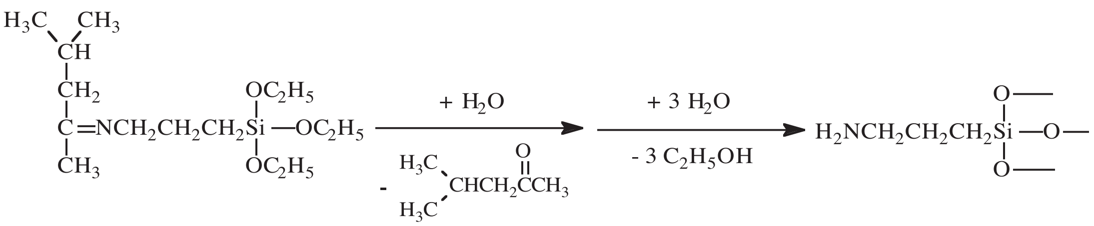
1. B. Arkles et al, "Factors contributing to the stability of alkoxysilanes in aqueous solutions", *J. Adhesion Science Technology*, **1992**, 6(1), 193.

Masked Silanes - Latent Functionality

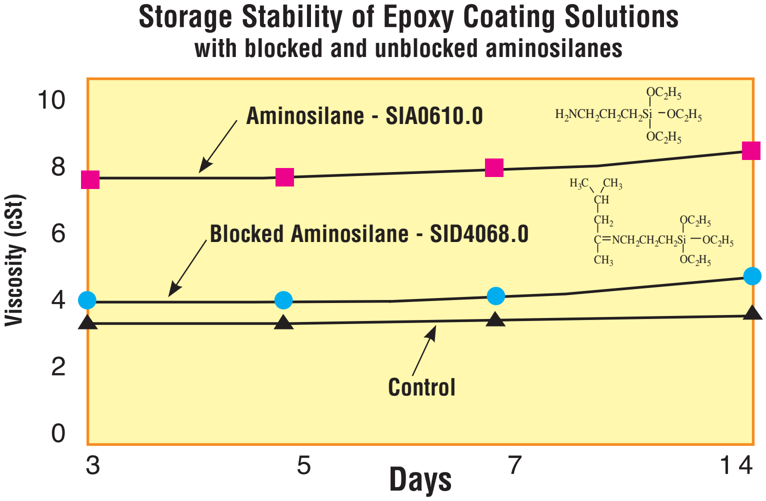
Maximum bond strength in some adhesion and bonding systems requires that the organic functionality of a silane coupling agent becomes available during a discrete time period of substrate - matrix contact. Examples are epoxy adhesives in which reaction of the silane with the resin increases viscosity 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

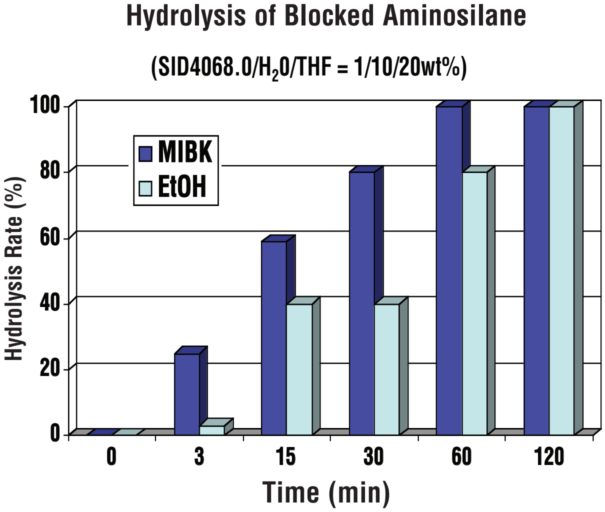
Single-component liquid-cure epoxy adhesives and coatings employ dimethylbutylidene blocked amino silanes. These materials show excellent storage stability in resin systems, but are activated by moisture provided by water adsorbed on substrate surfaces or from humidity. Deblocking begins in minutes and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



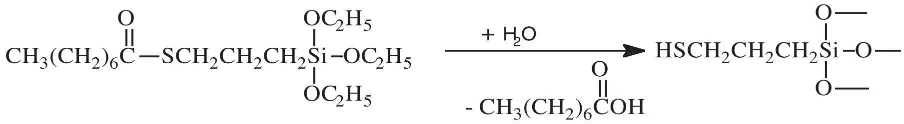
$$(H_3C)_2CHCH_2C(CH_3){=}NCH_2CH_2CH_2Si(OC_2H_5)_3 \xrightarrow[-\ (H_3C)_2CHCH_2\overset{O}{\overset{\|}{C}}CH_3]{+\ H_2O} \xrightarrow[-\ 3\ C_2H_5OH]{+\ 3\ H_2O} H_2NCH_2CH_2CH_2Si(O-)_3$$



Epoxy Resin Solution: 50 parts bisphenol A epoxide, 5 parts SID4068.0 or SIA0610.0, 50 parts toluene.



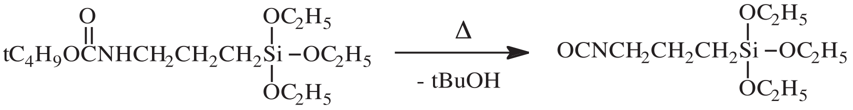
An alternative is to use the moisture adsorbed onto fillers to liberate alcohol which, in turn, demasks the organic functionality.



$$CH_3(CH_2)_6\overset{O}{\overset{\|}{C}}{-}SCH_2CH_2CH_2Si(OC_2H_5)_3 \xrightarrow[-\ CH_3(CH_2)_6\overset{O}{\overset{\|}{C}}OH]{+\ H_2O} HSCH_2CH_2CH_2Si(O-)_3$$

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.



$$tC_4H_9O\overset{O}{\overset{\|}{C}}NHCH_2CH_2CH_2Si(OC_2H_5)_3 \xrightarrow[-\ tBuOH]{\Delta} OCNCH_2CH_2CH_2Si(OC_2H_5)_3$$

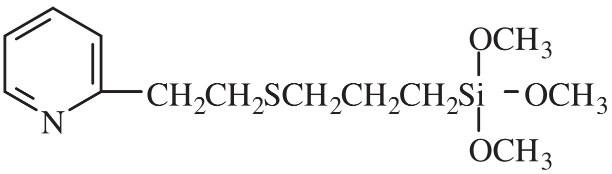
Modification of Metal Substrates

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.

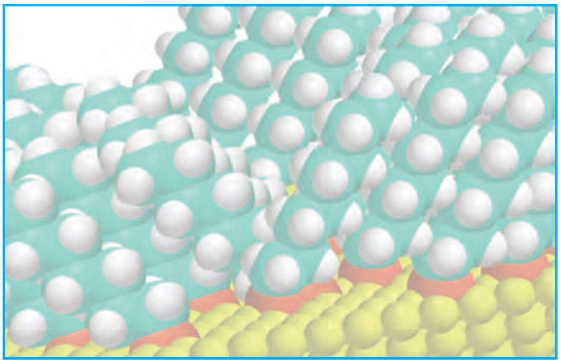
Metals that form hydrolytically stable surface oxides, e.g. aluminum, tin, titanium. These oxidized surfaces tend to have sufficient hydroxyl functionality to allow coupling under the same conditions applied to the siliceous substrates discussed earlier.

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.



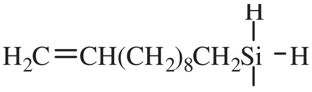
SIP6926.2



Octysilane 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.[1] 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.



$$H_2C{=}CH(CH_2)_8CH_2\overset{H}{\underset{H}{Si}}-H$$

SIU9048.0

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.

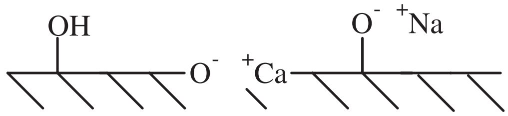
Difficult Substrates

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[1].

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 dibutyldiacetoxytin 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[1].

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_2O/O_2 in high energy environments including steam at 1050°C and water plasma[1].

1. N. Alcanter 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 alkoxysilane 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

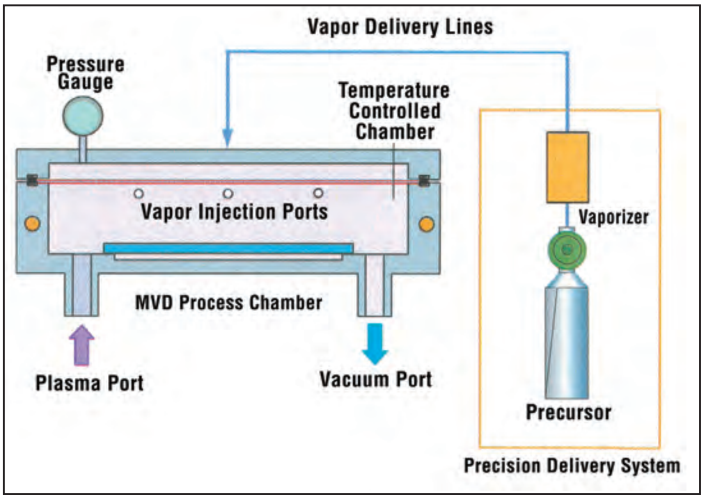
Integral blend methods are used in composite formulations. In this method the silane is used as a simple additive. Composites can be prepared by the addition of alkoxysilanes to dry-blends of polymer and filler prior to compounding. Generally 0.2 to 1.0 weight percent of silane (of the total mix) is 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 devolatization 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 benzyldimethylamine 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

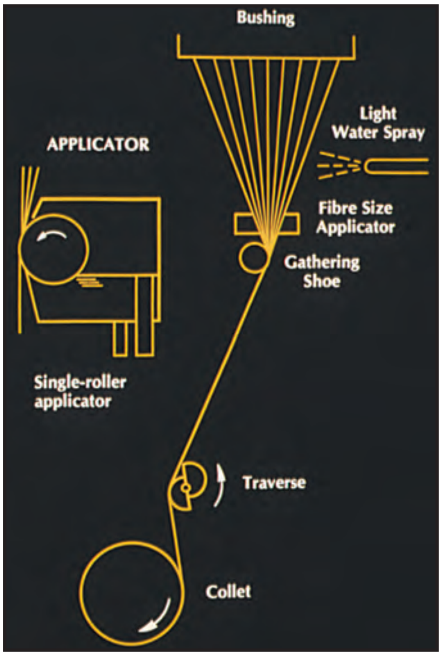
Spin-On Spin-On applications can be made under hydrolytic conditions which favor maximum functionalization and polylayer deposition or dry conditions which favor monolayer deposition. For hydrolytic deposition 2-5% solutions are prepared (see deposition from aqueous alcohol). Spin speed is low, typically 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.

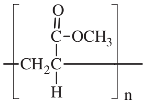
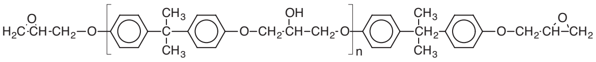
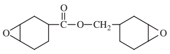
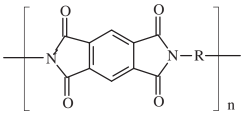
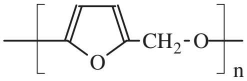
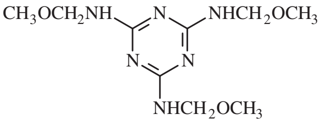
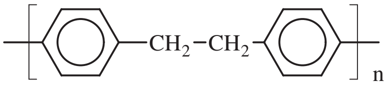
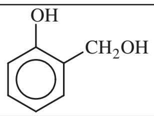
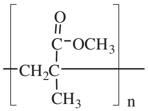
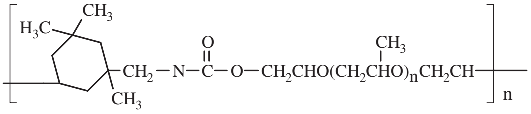
Figure 7: Spray & contact roller application of silanes on fiberglass.



Acrylate-silanes in dental restorative composites.

Silane Coupling Agents for Thermosets

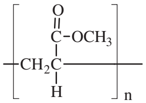
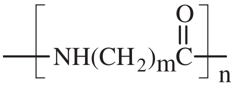
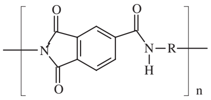
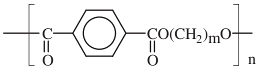
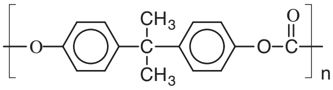
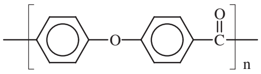
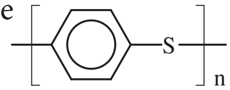
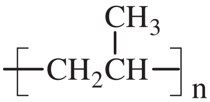
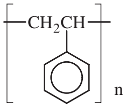
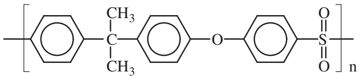
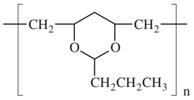
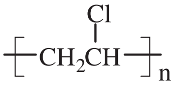
Selection Chart

		Coupling Agent Class	Suggestions for Primary Screening	
Acrylate, UV cure		Acrylate	SIA0200.0	SIM6487.4
		Vinyl/Olefin	SIS6964.0	
Diallylphthalate		Amine	SIA0591.0	SIA0610.0
		Vinyl/Olefin	SIS6964.0	
		Dipodal	SIB1824.5	
Epoxy		Amine	SIA0591.0	SIT8398.0
		Anhydride	SIT8192.6	
		Epoxy	SIG5840.0	
		Dipodal	SIB1834.0	
Epoxy, UV Cure		Amine	SIA0591.0	SIT8398.0
		Epoxy	SIE4668.0	SIE4670.0
Polyimide		Amine	SIA0599.2	SIA0591.0
		Halogen	SIC2295.5	SIC2296.2
		Dipodal	SIB1833.0	
Furan		Amine	SIA0611.0	SIA0599.0
		Epoxy	SIG5840.0	
Melamine		Amine	SIA0611.0	SIA0599.0
		Hydroxyl	SIB1140.0	
		Dipodal	SIB1833.0	SIT8717.0
Parylene		Halogen	SIC2295.5	
		Vinyl/Olefinic	SIS6990.0	SIM6487.4
		Dipodal	SIB1832.0	VMM-010
Phenol-formaldehyde		Amine	SIA0611.0	SIT8187.5
		Epoxy	SIE4670.0	SIG5840.0
Methylmethacrylate, cast		Acrylate	SIM6487.4	SIA0200.0
		Amine	SIB1828.0	
Polyester, unsaturated	 $[\text{COCH=CH}\overset{\overset{O}{\|}}{C}\text{OCH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\text{O}]_n$	Acrylate	SIM6487.4	
		Vinyl/Olefin	SIS6994.0	SIV9112.0
Urea-formaldehyde	 $\text{HOCH}_2\text{NH}\overset{\overset{O}{\|}}{C}\text{NHCH}_2\text{NH}\overset{\overset{O}{\|}}{C}\text{NHCH}_2\text{OH}$	Amine	SIA0610.0	SIU9055.0
		Hydroxyl	SIB1140.0	
Urethane		Amine	SIA0610.0	SIM6500.0
		Isocyanate	SII6455.0	
		Sulfur	SIM6476.0	

Diamine-silanes couple polycarbonate in CDs

Silane Coupling Agents for Thermoplastics

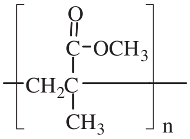
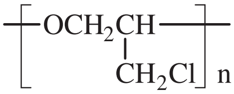
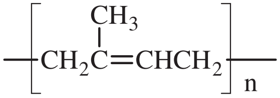
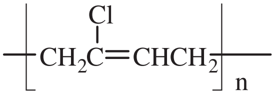
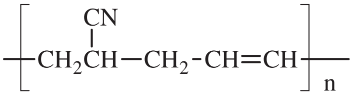
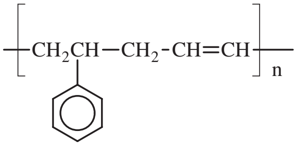
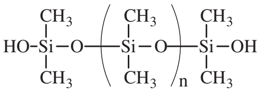
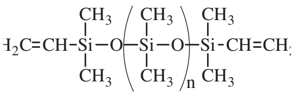
Selection Chart

		Coupling Agent Class	Suggestions for Primary Screening	
Polyacetal	$\left[CH_2O\right]_n$	Vinyl/Olefin	SIS6994.0	
Polyacrylate	 $\left[CH_2CH(C(=O)OCH_3)\right]_n$	Amine	SIU9058.0	SIA0610.0
Polyamide	 $\left[NH(CH_2)_mC(=O)\right]_n$	Amine Dipodal Water-borne	SIA0610.0 SIB1834.1 WSA-7011	SIA0614.0 SSP-060
Polyamide-imide		Amine Halogen	SIA0610.0 SIC2295.5	
Polybutylene terephthalate		Amine Isocyanate	SIA0610.0 SII6455.0	
Polycarbonate		Amine	SIA0591.0	SIA0610.0
Polyether ketone		Amine Dipodal	SIA0591.0 SIT8717.0	
Polyethylene	$\left[CH_2CH_2\right]_n$	Amine Vinyl/Olefin	SIA0591.0 SSP-055	SIT8398.0 SIV9112.0
Polyphenylene sulfide		Amine Halogen Sulfur	SIA0605.0 SIC2295.5 SIM6476.0	
Polypropylene	 $\left[CH_2CH(CH_3)\right]_n$	Acrylate Azide Vinyl/Olefin	SIM6487.4 SIA0780.0 VEE-005	 SSP-055
Polystyrene		Acrylate Dipodal	SIM6487.4 SIB1831.0	
Polysulfone		Amine	SIA0591.0	SIU9055.0
Polyvinyl butyral		Amine	SIA0611.0	SIU9058.0
Polyvinyl chloride	 $\left[CH_2CH(Cl)\right]_n$	Amine Sulfur	SIA0605.0 SIM6474.0	 SIB1825.0

Water-borne aminosilanes increase bonding of acrylic latex sealants

Silane Coupling Agents for Sealants & Elastomers

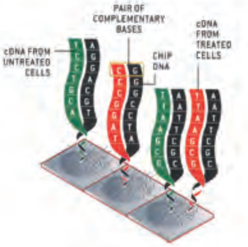
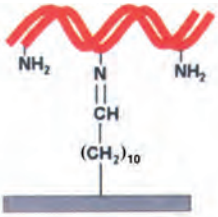
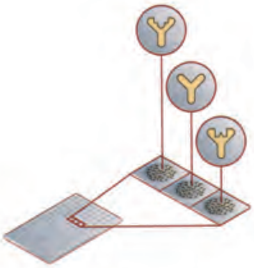
Selection Chart

		Coupling Agent Class	Suggestions for Primary Screening	
Acrylic latex	 $\left[-CH_2-\underset{CH_3}{\overset{\overset{O}{\|}C-OCH_3}{C}}-\right]_n$	Acrylate	SIM6487.4	
		Vinyl/Olefin	SIV9210.0	SIV9218.0
		Water-borne	WSA-7021	WSA-6511
Butyl	$-\!\!\left[CH_2CH{=}CHCH_2\right]\!\!-_n$	Acrylate	SIM6487.4	
		Sulfur	SIB1825.0	SIM6476.0
		Vinyl/Olefin	SSP-055	VEE-005
Epichlorohydrin	 $\left[-OCH_2\underset{CH_2Cl}{CH}-\right]_n$	Amine	SIA0605.0	
		Sulfur	SIM6474.0	
Fluorocarbon	$-(CF_2CF_2)_m(CH_2CF_2)_n-$	Amine	SIB1834.1	
		Dipodal	SIT8717.0	
Isoprene	 $\left[-CH_2\overset{CH_3}{C}{=}CHCH_2-\right]_n$	Sulfur	SIM6474.0	SIM6476.0
		Vinyl/Olefin	SSP-055	VEE-005
Neoprene	 $\left[-CH_2\overset{Cl}{C}{=}CHCH_2-\right]_n$	Sulfur	SIM6474.0	SIM6476.0
		Vinyl/Olefin	SSP-055	VEE-005
Nitrile	 $\left[-CH_2\overset{CN}{CH}-CH_2-CH{=}CH-\right]_n$	Epoxy	SIG5840.0	
		Sulfur	SIB1825.0	
Polysulfide	$-\!\!\left[CH_2CH_2S\right]\!\!-_n$	Epoxy	SIG5840.0	
		Sulfur	SIB1825.0	SIM6476.0
SBR		Amine	SIA0605.0	
		Sulfur	SIB1825.0	SIM6486.0
Silicone (hydroxyl terminated)	 $HO-\underset{CH_3}{\overset{CH_3}{Si}}-O\left(\underset{CH_3}{\overset{CH_3}{Si}}-O\right)_n\underset{CH_3}{\overset{CH_3}{Si}}-OH$	Amine	SIA0605.0	SIA0589.0
		Vinyl/Olefin	SIV9098.0	VMM-010
		Dipodal	SIB1824.0	
Silicone (vinyl terminated)	 $H_2C{=}CH-\underset{CH_3}{\overset{CH_3}{Si}}-O\left(\underset{CH_3}{\overset{CH_3}{Si}}-O\right)_n\underset{CH_3}{\overset{CH_3}{Si}}-CH{=}CH$	Acrylate	SIM6487.4	
		Vinyl/Olefin	SIA0540.0	VMM-010

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

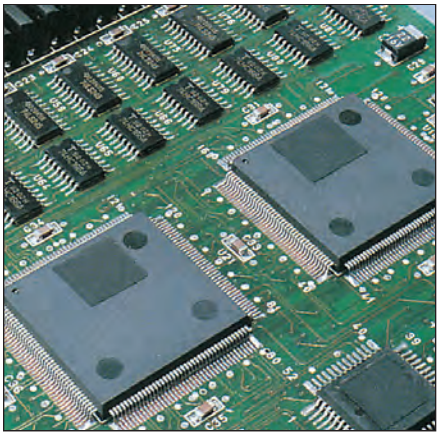
Silane Coupling Agents for Biomaterials

Selection Chart

	Site/Type	*Coupling Class*	*Co-reactant*	*Suggestions for Screening*	
Oligonucleotides		*hydroxyl*		*SIB1140.0*	
		diamine	*cobalt ethylenediamine*	*SIA0591.0*	
		semicarbazide		*SIS6944.0*	
 		**G. McGall** et al, J. Am. Chem. Soc., *119*, 5081, 1997. **F. Chow**, in “Silylated Surfaces” D. Leyden ed., Gordon & Breach, 1978, p.301. **M. Podyminogin** et al, Nucleic Acid Res., 2001, 29, 5090.			
DNA	*terminal favored*	*vinyl/olefin*		*SIO6708.0*	*SIU9049.0*
	pendant amine	*aldehyde*		*SIT8194.0*	
	pendant amine	*diamine*		*SIA0594.0*	*SID3543.0*
	pendant amine	*epoxy*		*SIE4675.0*	*SIG5838.0*
 		**A. Bensimon**, Science, *265*, 2096, 1994. **J. Grobe** et al, J. Chem. Soc. Chem. Commun, 2323, 1995. **C. Kneuer** et al, Int’l J. Pharmaceutics, *196(2)*, 257, 2000.			
Protein	*lysine*	*aldehyde*		*SIT8194.0*	
	lysine	*amine*	*glutaraldehyde*	*SIA0611.0*	*SIA0595.0*
	lysine	*amine*	*thiophosgene*	*SIA0611.0*	
	cysteine	*sulfur*	*dithionite*	*SIM6476.0*	
	tyrosine	*nitrobenzamide*	*NaNO2/HCl*	*SIT8191.0*	*SIA0599.0*
	heparinated	*amine/quat*		*SSP-060*	*SIT8415.0*
	immunoglobin	*pyridyl-thio*		*SIP6926.4*	
	antibody	*cyano*		*SIC2456.0*	
	**J. Grobe** et al, J. Chem. Soc. Chem. Commun, 2323, 1995. **H. Weetall**, US Pat. 3,652,761. **G. Royer**, CHEMTECH, *4*, 699, 1974. **S. Bhatia** et al, Anal. Biochem., *178*, 408, 1989. **J. Venter** et al, Proc. Nat. Acad. Soc., *69(5)*, 1141, 1972. **R. Merker** et al, Proc. Artificial Heart Prog. Conf., June 9-13, 1969 HEWNIH, p29. **S. Falipou**, Fundamental & Applied Aspects of Chemically Modified Surfaces, p389, 1999.				
Cell-Organelle					
 mitochondria on silica bead	*chloroplast*	*alkyl*		*SIO6645.0*	
	mitochondria	*alkyl*		*SIO6645.0*	
		B. Arkles et al, in “Silylated Surfaces” D. Leyden ed., Gordon & Breach, 1978, p363. **B. Arkles** et al, J. Biol. Chem., *250*, 8856, 1975.			
Whole Cell					
 erythrocytes on glass wall	*erythrocytes*	*short alkyl*		*SIE4901.4*	
		B. Arkles et al, in “Silylated Surfaces” D. Leyden ed., Gordon & Breach, 1978, p363.			
Whole Cell (causing lysis)	*procaryotic*	*alkyl-quat* **W. White** et al in “Silanes, Surfaces & Interfaces” ed. D. Leyden, Gordon & Breach, 1986, p. 107.		*SIO6620.0* *SID3392.0*	
Tissue	*histological samples*			*SIA0611.0*	*SIA0610.0*

Silane Coupling Agent Properties

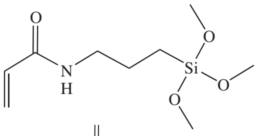

Adhesion promoter for structural polysulfide glass sealants


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

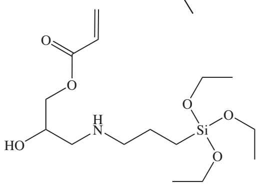
Commercial Status—produced on a regular basis for inventory
Developmental Status—available to support development and commercialization
New Products—available to support development and commercialization

Acrylate and Methacrylate Functional Silanes

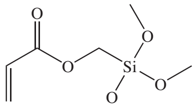
Acrylate and Methacrylate Functional Silanes - Trialkoxy



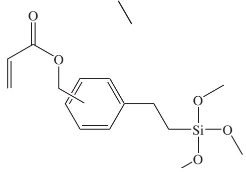
SIA0146.0
3-ACRYLAMIDOPROPYLTRIMETHOXYSILANE, tech-95
$C_9H_{19}NO_4Si$ 233.34 1.062 1.465
Inhibited with MEHQ
[57577-96-5] HMIS: 3-2-1-X store <5°C 10g
NEW



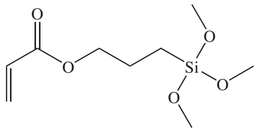
SIA0180.0
N-(3-ACRYLOXY-2-HYDROXYPROPYL)-3-AMINOPROPYLTRIETHOXYSILANE, 50% in ethanol
$C_{15}H_{31}NO_6Si$ 349.50 0.931 1.4084
Inhibited with MEHQ Flashpoint: 15°C (59°F)
Used to stabilize Stober silica suspensions.[1]
1. Park, B. et al. *J. Mater. Sci.* **1992**, *27*, 5692.
[123198-57-2] HMIS: 3-4-1-X store <5°C 25g



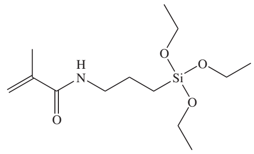
SIA0182.0
ACRYLOXYMETHYLTRIMETHOXYSILANE
$C_7H_{14}O_5Si$ 206.27 42-6° / 0.15 1.060
Coupling agent, comonomer for ormosils
[21134-38-3] TSCA-L HMIS: 3-3-1-X store <5°C 25g
NEW



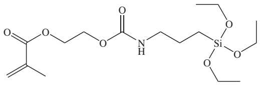
SIA0184.0
(ACRYLOXYMETHYL)PHENETHYLTRIMETHOXYSILANE, tech-95
$C_{15}H_{22}O_5Si$ 310.42
Inhibited with MEHQ; mixed m-, p-; α-, β- isomers
Coupling agent for UV cure systems with less oxygen sensitivity
[141813-19-6](m-)/[141813-20-9](p-) HMIS: 3-3-1-X store <5°C 10g
NEW



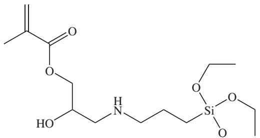
SIA0200.0
(3-ACRYLOXYPROPYL)TRIMETHOXYSILANE, 96%
$C_9H_{18}O_5Si$ 234.32 68° / 0.4 (<-20°) 1.06 1.4155
Inhibited with BHT Flashpoint: 123°C (253°F)
Coupling agent for epoxies, UV cure coatings
Employed in optical fiber coatings.[1]
In combination with dipodal silane, SIB1833.0, increases strength and hydrolytic stability of dental composites.[2]
1. Yokoshima, M. et al. *Chem. Abstr.* 113, 15746d; Jap. Pat. 02133338, 1990.
2. Matinlinna, J. et al. *Acta Odontol. Scand.* **2012***, 70*, 405.
[4369-14-6] TSCA HMIS: 3-1-1-X store <5°C 25g 100g 2kg
COMMERCIAL



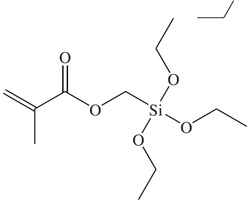
SIM6480.73
(3-METHACRYLAMIDOPROPYL)TRIETHOXYSILANE, tech-95
$C_{13}H_{27}NO_4Si$ 289.44 1.017 1.454
Contains 3-methacrylamidopropyldiethoxymethoxysilane Flashpoint: >110°C (>230°F)
Hydrophilic coupling agent
Intermediate for contact lens monomers
[109213-85-6] HMIS: 2-2-1-X store <5°C 25g
NEW



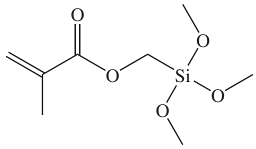
SIM6480.8
O-(METHACRYLOXYETHYL)-N-(TRIETHOXYSILYLPROPYL)CARBAMATE, 90%
$C_{16}H_{31}NO_7Si$ 377.51 1.051^{25} 1.446^{25}
Inhibited with MEHQ
Hydrophilic monomer
[115396-93-5] HMIS: 3-2-1-X store <5°C 25g 100g



SIM6481.1
N-(3-METHACRYLOXY-2-HYDROXYPROPYL)-3-AMINOPROPYLTRIETHOXYSILANE, 50% in ethanol
$C_{16}H_{33}NO_6Si$ 363.53 0.910 1.4084
Inhibited with MEHQ Flashpoint: 11°C (52°F)
Employed in conservation/consolidation of stone.[1]
1. Wheeler, G. In *Ninth Int'l Cong. On Deterioration and Conservation of Stone;* Fassina, Ed.; Elsevier: 2000; Vol. 2, 541.
[96132-98-8] HMIS: 3-4-1-X store <5°C 25g 100g

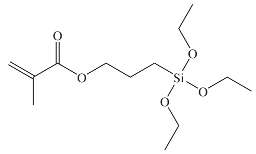


SIM6482.0
METHACRYLOXYMETHYLTRIETHOXYSILANE
$C_{11}H_{22}O_5Si$ 262.38 65-8° / 2 1.000 1.4225
Inhibited with MEHQ Flashpoint: 100°C (212°F)
Treatment of fumed silica in acrylic casting compositions accelerates polymerization.[1]
1. Morozova, E. et al. *Chem. Abstr.* 95,98753g; *Plast. Massy* **1981,** 7.
[5577-72-0] TSCA HMIS: 3-2-1-X store <5°C 10g 50g

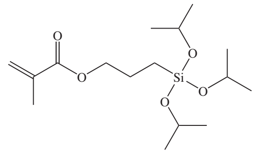


SIM6483.0
METHACRYLOXYMETHYLTRIMETHOXYSILANE
$C_8H_{16}O_5Si$ 220.30 48-50° / 2 (-44°) 1.070 1.4271
Inhibited with MEHQ Flashpoint: 92°C (198°F)
Viscosity: 1.5 cSt TOXICITY: oral rat, LD50: >2,000 mg/kg
Autoignition temperature: 285°C
Hydrolysis rate > 10 X SIM6487.4
Modification of novolac resin affords bilevel resists having attributes of trilevel resists.[1]
1. Reichmanis, E.; Smolinsky, G. U.S. Patent 4,481,049, 1984.
[54586-78-6] TSCA HMIS: 3-2-1-X store <5°C 10g 50g 2kg

Name | Mw | bp °C/mm | (mp °C) | D_4^{20} | n_D^{20}

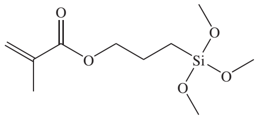


SIM6487.3
METHACRYLOXYPROPYLTRIETHOXYSILANE
$C_{13}H_{26}O_5Si$ 290.43 130° / 4 0.985 1.4277
Inhibited with MEHQ Flashpoint: 128°C (262°F)
[21142-29-0] TSCA EC 244-239-0 HMIS: 3-1-1-X store <5°C 10g 50g 2kg



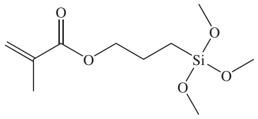
SIM6487.35
METHACRYLOXYPROPYLTRIISOPROPOXYSILANE
$C_{16}H_{32}O_5Si$ 332.51 0.942 1.4234
Inhibited with MEHQ, HQ TOXICITY: oral rat, LD50: >5,000 mg/kg
[80750-05-6] TSCA EC 279-538-5 HMIS: 2-2-1-X store <5°C 25g 100g

NEW



SIM6487.4
METHACRYLOXYPROPYLTRIMETHOXYSILANE
$C_{10}H_{20}O_5Si$ 248.35 78-81° / 1 (-48°) 1.045 1.4310
Inhibited with MEHQ, HQ Flashpoint: 108°C (226°F)
Viscosity: 2 cSt TOXICITY: oral rat, LD50: 3,000 mg/kg
Copolymerization parameters-e,Q: 0.07, 2.7 Primary irritation index: 1.19
Specific wetting surface: 314m²/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.[1]
Copolymerized with styrene in formation of sol-gel composites.[2]
Employed in dental polymer composites.[3]
1. Arkles, B. *Chemtech* **1977,** *7*, 713.
2. Wei, Y. et al. *J. Mater. Res.* **1993,** *8*, 1143.
3. Matinlinna, J. et al. *Int. J. Prosthodontics* **2004**, *17*, 157.
[2530-85-0] TSCA EC 219-785-8 HMIS: 3-1-1-X store <5°C 100g 2kg 18kg

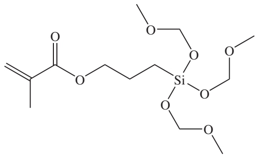
COMMERCIAL



SIM6487.4LI
METHACRYLOXYPROPYLTRIMETHOXYSILANE, low inhibitor grade
$C_{10}H_{20}O_5Si$ 248.35 78-81° / 1 1.045 1.4310
Contains <10 ppm BHT, hydroquinones
Employed in dental restorative composites

[2530-85-0] TSCA EC 219-785-8 HMIS: 3-1-1-X store <5°C 25g

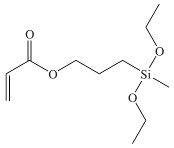
NEW



SIM6487.5
METHACRYLOXYPROPYLTRIS(METHOXYETHOXY)SILANE, tech-80
$C_{16}H_{32}O_8Si$ 380.51 128° / 10 1.06
Inhibited with MEHQ Flashpoint: 195°C (383°F)
Contains methacryloxypropylbis(methoxyethoxy)methoxysilane and methacryloxypropyl(methoxyethoxy)dimethoxysilane
[57069-48-4] TSCA EC 260-537-3 HMIS: 3-1-1-X store <5°C 50g

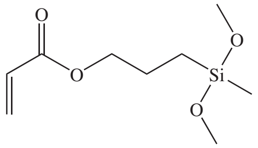
NEW

Acrylate and Methacrylate Functional Silanes - Dialkoxy



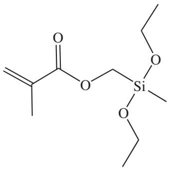
SIA0197.0
(3-ACRYLOXYPROPYL)METHYLDIETHOXYSILANE, 95%
$C_{11}H_{22}O_4Si$ 246.38 40° / 1 0.947 1.4139
Inhibited with MEHQ Flashpoint: >110°C (>230°F)
[146666-71-9] HMIS: 3-2-1-X store <5°C 25g

NEW

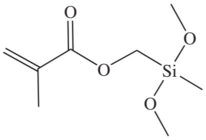


SIA0198.0
(3-ACRYLOXYPROPYL)METHYLDIMETHOXYSILANE, 95%
$C_9H_{18}O_4Si$ 218.33 65° / 0.35 1.01 1.431
Inhibited with MEHQ
Employed in fabrication of photoimageable, low shrinkage multimode waveguides.[1]
1. Xu, C. et al. *Chem. Mater.* **1996,** *8*, 2701.
[13732-00-8] TSCA-L HMIS: 3-2-1-X store <5°C 50g 250g

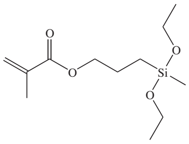
Name **Mw** **bp °C/mm** **(mp °C)** **D_4^{20}** **n_D^{20}**



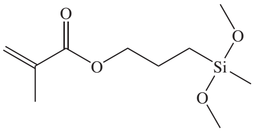
SIM6481.43
(METHACRYLOXYMETHYL)METHYLDIETHOXYSILANE
$C_{10}H_{20}O_4Si$ 232.35 221° 0.977
Inhibited with MEHQ
Flashpoint: 88°C (190°F)
TOXICITY: oral rat, LD50: >2,000 mg/kg
[121177-93-3] TSCA HMIS: 2-2-1-X store <5°C 25g



SIM6481.46
(METHACRYLOXYMETHYL)METHYLDIMETHOXYSILANE
$C_8H_{16}O_4Si$ 204.30 205° 1.020 1.4274
Inhibited with MEHQ
Flashpoint: 82°C (180°F)
TOXICITY: oral rat, LD50: >2,000 mg/kg
Autoignition temperature: 300°C
[3978-58-3] HMIS: 3-2-1-X store <5°C 25g 100g

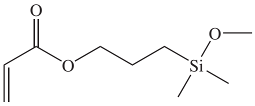


SIM6486.8
METHACRYLOXYPROPYLMETHYLDIETHOXYSILANE, 95%
$C_{12}H_{24}O_4Si$ 260.40 95° / 1 0.965 1.4330
Inhibited with MEHQ
Flashpoint: 136°C (277°F)
[65100-04-1] HMIS: 3-1-1-X store <5°C 10g 50g

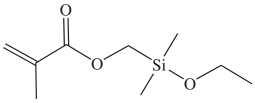


SIM6486.9
METHACRYLOXYPROPYLMETHYLDIMETHOXYSILANE, 95%
$C_{10}H_{20}O_4Si$ 235.69 65° / 0.35 1.000 1.4355
Flashpoint: 115°C (239°F)
Monomer for hybrid inorganic-organic composites.[1]
1. Taylor-Smith, R. *Polym. Mater. Sci. Eng., Preprints* **1997,** *77*, 503.
[14513-34-9] TSCA-L EC 238-518-6 HMIS: 3-1-1-X store <5°C 25g 100g 2kg
COMMERCIAL

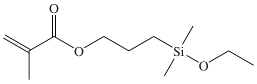
Acrylate and Methacrylate Functional Silanes - Monoalkoxy



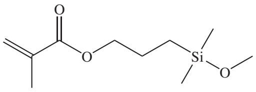
SIA0190.0
(3-ACRYLOXYPROPYL)DIMETHYLMETHOXYSILANE, 95%
$C_9H_{18}O_3Si$ 202.32 54-5° / 0.1
Inhibited with MEHQ
Flashpoint: 85°C (185°F)
[111918-90-2] HMIS: 3-2-1-X store <5°C 5g 25g
NEW



SIM6481.3
(METHACRYLOXYMETHYL)DIMETHYLETHOXYSILANE
$C_9H_{18}O_3Si$ 202.32 62-3° / 0.3 0.9447 1.4282^{25}
Inhibited with MEHQ
[5577-70-8] HMIS: 3-2-1-X store <5°C 10g 50g
NEW

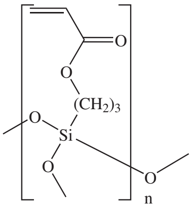


SIM6486.4
METHACRYLOXYPROPYLDIMETHYLETHOXYSILANE, 95%
$C_{11}H_{22}O_3Si$ 230.38 75-6° / 0.4 0.926 1.4371
Inhibited with MEHQ
[13731-98-1] HMIS: 3-2-1-X store <5°C 10g

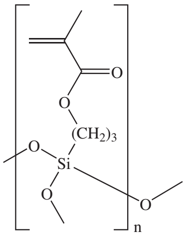


SIM6486.5
METHACRYLOXYPROPYLDIMETHYLMETHOXYSILANE, 95%
$C_{10}H_{20}O_3Si$ 216.35 70-2° / 0.5 0.944 1.4381
Inhibited with MEHQ
Component in positive tone 157 nm resist.[1]
1. Tegou, E. et al. *Chem. Mater.* **2004,** *16*, 2567.
[66753-64-8] EC 266-472-7 HMIS: 3-2-1-X store <5°C 10g 50g

Acrylate and Methacrylate Functional Silanes - Polymeric



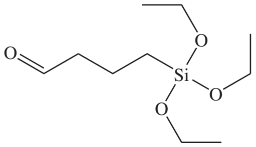
SIA0200.2
(3-ACRYLOXYPROPYL)TRIMETHOXYSILANE, oligomeric hydrolysate
1.2
Viscosity: 8-12 cSt
Employed in rapid prototyping
HMIS: 2-2-1-X store <5°C 25g 100g
NEW



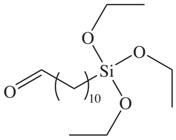
SIM6487.42
METHACRYLOXYPROPYLTRIMETHOXYSILANE, oligomeric hydrolysate
1200-2500 1.20 1.46
Viscosity: 1,000-3,000 cSt
Soluble: acetone, ethanol, THF
[160185-24-0] TSCA HMIS: 2-1-0-X store <5°C 25g 100g
NEW

Aldehyde Functional Silanes

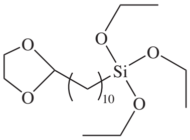
Aldehyde Functional Silanes - Trialkoxy



SIT8185.3
TRIETHOXYSILYLBUTYRALDEHYDE, tech-90
$C_{10}H_{22}O_4Si$ 234.37 85-71° / 1 0.96 1.414
Contains 3-TRIETHOXYSILYL-2-METHYLPROPANAL isomer and
cyclic siloxy acetal, 2,2,6-TRIETHOXY-1-OXA-2-SILACYCLOHEXANE
Coupling agent for chitosan to titanium.[1]
1. Martin, H. et al. *Appl. Surf. Sci. 2008,* **254**, 4599.
[917773-12-7]/[88276-92-0] TSCA-L HMIS: 3-3-1-X 10g



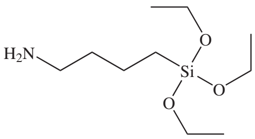
SIT8194.0
TRIETHOXYSILYLUNDECANAL, tech-95
$C_{17}H_{36}O_4Si$ 332.56 150-5° / 0.5 0.930 1.4343
Treated surface contact angle, water: 70°
Long chain coupling agent for DNA
Provides greater stability for coupled proteins than shorter alkyl homologs.[1]
1. Seitz, O. et al. *J. Mater. Chem.* **2011***, 21*, 4384.
[116047-42-8] HMIS: 2-2-1-X 5g



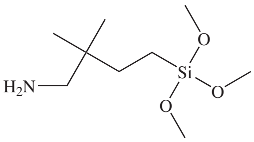
SIT8194.5
TRIETHOXYSILYLUNDECANAL, ETHYLENE GLYCOL ACETAL
$C_{19}H_{40}O_5Si$ 366.61 160-5° / 0.25
[866935-66-2] HMIS: 2-2-1-X 5g

Amino Functional Silanes

Monoamine Functional Silanes - Trialkoxy

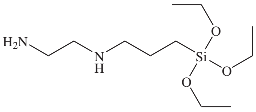


SIA0587.0
4-AMINOBUTYLTRIETHOXYSILANE, 95%
$C_{10}H_{25}NO_3Si$ 235.40 114-6° / 14 0.941^{25} 1.4270^{25}
Flashpoint: 109°C (228°F)
TOXICITY: oral rat, LD50: 1,620 mg/kg
Amino-functional coupling agent
[3069-30-5] HMIS: 2-1-1-X 10g 50g

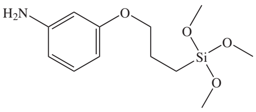


SIA0587.07
4-AMINO-3,3-DIMETHYLBUTYLTRIMETHOXYSILANE
AMINONEOHEXYLTRIMETHOXYSILANE
$C_9H_{23}NO_3Si$ 221.37 230° 0.977 1.4302
Flashpoint: 97°C (207°F)
Sterically hindered primary amine coupling agent
Non-yellowing aminosilane coupling agent for flexible adhesives and sealants
[157923-74-5] TSCA HMIS: 3-1-1-X 25g 100g 2kg

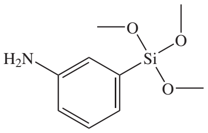
COMMERCIAL



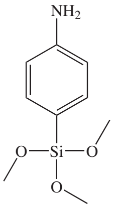
SIA0590.5
N-(2-AMINOETHYL)-3-AMINOPROPYLTRIETHOXYSILANE, 95%
$C_{11}H_{28}N_2O_3Si$ 264.55 156° / 15 0.994 1.4367^{25}
Flashpoint: 148°C (298°F)
Coupling agent with slower hydrolysis than SIA0591.0, SAI0592.6
[5089-72-5] TSCA EC 225-806-1 HMIS: 3-1-1-X 25g



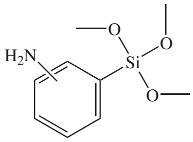
SIA0598.0
3-(m-AMINOPHENOXY)PROPYLTRIMETHOXYSILANE, tech-95
$C_{12}H_{21}NO_4Si$ 271.39 125-135° / 0.5 1.02 1.495
Amber liquid
High temperature coupling agent
[55648-29-8] TSCA HMIS: 3-1-1-X 10g 50g



SIA0599.0
m-AMINOPHENYLTRIMETHOXYSILANE, 95%
$C_9H_{15}NO_3Si$ 213.31 110-4° / 0.6 1.19 1.5187
Contains other isomers
Flashpoint: 180°C (356°F)
Coupling agent for polyimides used in electronics
[70411-42-6] TSCA-L HMIS: 3-1-1-X 5g

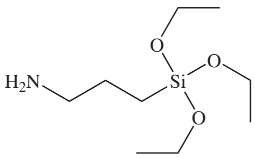


SIA0599.1
p-AMINOPHENYLTRIMETHOXYSILANE, 95%
$C_9H_{15}NO_3Si$ 213.31 110-4° / 0.6 (60-62°)
Contains other isomers
Flashpoint: 180°C (356°F)
Coupler for silica-poly(phenyleneterephthalamide) composite films.[1]
Together with phenyltrimethoxysilane, SIP6822.0, can be used to increase the dispersibility of mesoporous silica.[2]
1. Mark, J. et al. *J. Mater. Chem.* **1997,** *7*, 259.
2. Banet, P. et al. *Langmuir* **2008**, *24*, 9030.
[33976-43-1] EC 251-772-2 HMIS: 3-1-1-X 5g

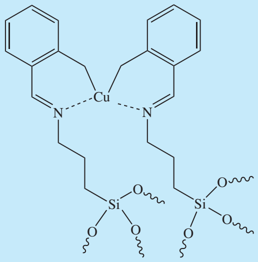


SIA0599.2
AMINOPHENYLTRIMETHOXYSILANE
$C_9H_{15}NO_3Si$ 213.31 110-4° / 0.6 (60-62°) 1.19
Mixed isomers, typically 60-70% para,30-40% meta
Flashpoint: 180°C (356°F)
Coupling agent for polyimides used in electronics
[33976-43-1] HMIS: 3-1-1-X 25g

NEW



SIA0610.0
3-AMINOPROPYLTRIETHOXYSILANE
GAPS, AMEO, A-1100
$C_9H_{23}NO_3Si$ 221.37 122-3° / 30 0.951 1.4225
Viscosity: 1.6 cSt
Flashpoint: 104°C (219°F)
ΔHvap: 11.8 kcal/mole
TOXICITY: oral rat, LD50: 1,780 mg/kg
Treated surface contact angle, water: 59°
Primary irritation index: 6.50
γc of treated surfaces: 37.5 mN/m
Vapor pressure, 100°: 10 mm
Specific wetting surface: 353 m²/g
Widely used coupling agent for phenolic, epoxy, polyamide and polycarbonate resins
Effects imobilization of enzymes.[1]
Used to bind Cu(salicylaldimine) to silica.[2]

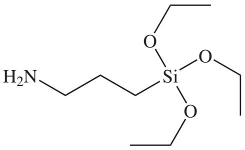


1. *Enzymes* **1976,** *84*, 55915.
2. Murphy, E. F. et al. *Inorg. Chem.* **2003,** *42*, 2559.
[919-30-2] TSCA EC 213-048-4 HMIS: 3-1-1-X 25g 2kg 16kg

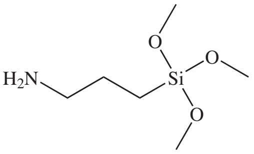
COMMERCIAL

Aminosilanes are widely used as coupling agents for fiberglass insulation and composites

Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}

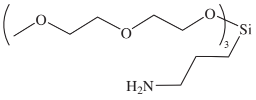


SIA0610.1
3-AMINOPROPYLTRIETHOXYSILANE 99+%
$C_9H_{23}NO_3Si$ 221.37 122-3° / 30 0.951 1.4225
Flashpoint: 104°C (219°F)
Low fluorescence grade for high throughput screening
[919-30-2] TSCA EC 213-048-4 HMIS: 3-1-1-X 25g
* in fluoropolymer bottle

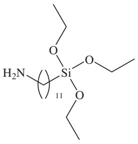


SIA0611.0
3-AMINOPROPYLTRIMETHOXYSILANE
$C_6H_{17}NO_3Si$ 179.29 80° / 8 1.027 1.4240
Flashpoint: 83°C (181°F)
TOXICITY: oral rat, LD50: >2,000 mg/kg
Autoignition temperature: 300˚C
Vapor pressure, 67˚: 5 mm
Coupling agent with superior reactivity in vapor phase and non-aqueous surface treatments
Hydrolysis rate vs SIA0610.0: 6:1
Used to immobilize Cu and Zn Schiff base precatalysts for formation of cyclic carbonates.[1]
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

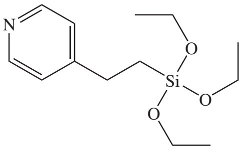
COMMERCIAL



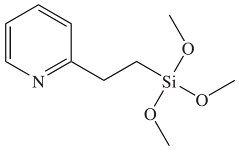
SIA0614.0
3-AMINOPROPYLTRIS(METHOXYETHOXYETHOXY)SILANE, 95%
$C_{18}H_{41}NO_9Si$ 443.61 1.066 1.448
Flashpoint: 68°C (154°F)
Coupling agent for melt compounding of polyamides and epoxides
[87994-64-7] EC 289-365-7 HMIS: 3-2-1-X 25g



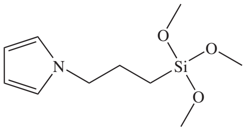
SIA0630.0
11-AMINOUNDECYLTRIETHOXYSILANE
$C_{17}H_{39}NO_3Si$ 333.59 128-32° / 1 0.895^{25} 1.4352^{25}
Contains ~ 5% isomers
[116821-45-5] HMIS: 2-2-1-X 1.0g



SIP6928.0
2-(4-PYRIDYLETHYL)TRIETHOXYSILANE
$C_{13}H_{23}NO_3Si$ 269.43 105° / 0.9 1.00 1.4624^{24}
Amber liquid
Forms self-assembled layers which can be "nano-shaved" by scanning AFM.[1]
1. Rosa, L. et al. *Mater. Lett.***2009**, *63*, 961.
[98299-74-2] HMIS: 3-2-1-X 10g

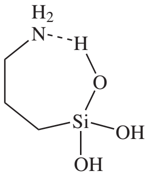


SIP6930.0
2-(2-PYRIDYLETHYL)TRIMETHOXYSILANE
2-(TRIMETHOXYSILYLETHYL)PYRIDINE
$C_{10}H_{17}NO_3Si$ 227.33 105° / 0.3 1.06 1.4755
Flashpoint: >110°C (>230°F)
[27326-65-4] HMIS: 3-1-1-X 10g 50g



SIT8410.0
N-(3-TRIMETHOXYSILYLPROPYL)PYRROLE
$C_{10}H_{19}NO_3Si$ 229.35 105-7° / 1 1.017 1.463
Flashpoint: >110°C (>230°F)
For electrode modification, polypyrrole adhesion.[1]
1. Simon, R. et al. *J. Am. Chem. Soc.* **1982,** *104*, 2031.
[80906-67-8] HMIS: 3-1-1-X 5g

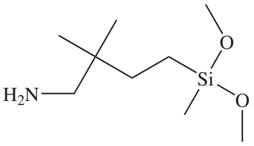
Monoamine Functional Silanes - Water-borne



SIA0608.0
3-AMINOPROPYLSILANETRIOL, 22-25% in water
$C_3H_{11}NO_3Si$ 137.21 1.06
Mainly oligomers; monomeric at concentrations <5% Flashpoint: >110°C (>230°F)
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 25g 2kg 18kg

COMMERCIAL

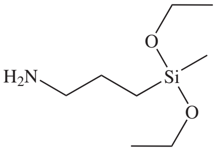
Monoamine Functional Silanes - Dialkoxy



SIA0587.05
4-AMINO-3,3-DIMETHYLBUTYLMETHYLDIMETHOXYSILANE
$C_9H_{23}NO_2Si$ 205.37 0.9248^{25} 1.4365
Flashpoint: 100°C (212°F)
TOXICITY: oral rat, LD50: 631 mg/kg
Comonomer for non-yellowing textile lubricants
[156849-43-3] TSCA HMIS: 3-2-1-X 25g 100g 2kg

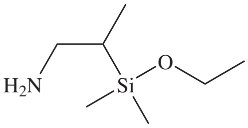
NEW

Name | Mw | bp °C/mm | (mp °C) | D_4^{20} | n_D^{20}

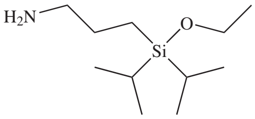


SIA0605.0
3-AMINOPROPYLMETHYLDIETHOXYSILANE, 95%
$C_8H_{21}NO_2Si$ 191.34 85-8° / 8 0.916 1.4272
Flashpoint: 85°C (185°F)
TOXICITY: oral rat, LD50: 4,760 mg/kg
Coupling agent for foundry resins, including phenolic novolaks and resols
Vapor phase deposition >150˚ on silica yields high density amine functionality.[1]
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
COMMERCIAL

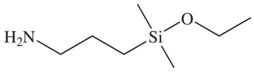
Monoamine Functional Silanes - Monoalkoxy



SIA0587.1
1-AMINO-2-(DIMETHYLETHOXYSILYL)PROPANE, 85%
$C_7H_{19}NOSi$ 161.32 101-7° / 100 0.85 1.431
Contains 3-aminopropyldimethylethoxysilane
HMIS: 3-2-1-X 5g
NEW

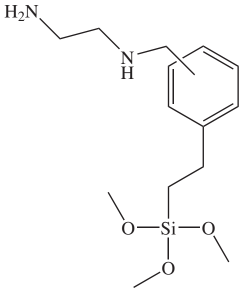


SIA0602.0
3-AMINOPROPYLDIISOPROPYLETHOXYSILANE
$C_{11}H_{27}NOSi$ 217.43 78-80° / 0.4 0.872^{25} 1.4489
Forms hydrolytically stable amino-functional bonded phases and monolayers
[117559-36-1] HMIS: 3-2-0-X 5g 25g

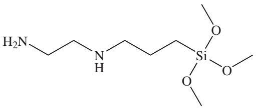


SIA0603.0
3-AMINOPROPYLDIMETHYLETHOXYSILANE
$C_7H_{19}NOSi$ 161.32 78-9° / 24 0.857^{25} 1.4276^{25}
ΔHform: 147.6 kcal/mole
Flashpoint: 73°C (163°F)
Coupling agent for DNA array technology
[18306-79-1] TSCA HMIS: 3-2-1-X 5g 25g

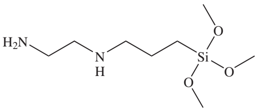
Diamine Functional Silanes - Trialkoxy



SIA0588.0
(AMINOETHYLAMINOMETHYL)PHENETHYLTRIMETHOXYSILANE, tech-90
$C_{14}H_{26}N_2O_3Si$ 298.46 126-30° / 0.2 1.02 1.5083
Mixed *m-,p-* isomers
Flashpoint: >110°C (>230°F)
Coupling agent for polyimides.[1]
Photochemically sensitive (194nm).[2]
Forms self assembled monolayers.[3]
Reagent for charge heterogeneity in micropatterning.[4]
1. Arkles, B. et al. *Modern Plastics* **1980**, *57*, 64.
2. Dressick, W. et al. *Thin Solid Films* **1996,** *284*, 568.
3. Harnett, C. et al. *Appl. Phys. Lett.* **2000,** *76*, 2466.
4. Chen, J. et al. *Nano Lett.* **2002,** *2*, 393.
[74113-77-2] TSCA HMIS: 3-1-1-X 25g 100g

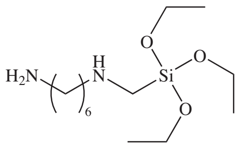


SIA0591.0
N-(2-AMINOETHYL)-3-AMINOPROPYLTRIMETHOXYSILANE, tech-95
N-[3-(TRIMETHOXYSILYL)PROPYL]ETHYLENEDIAMINE; DAMO
$C_8H_{22}N_2O_3Si$ 222.36 140° / 15 1.019^{25} 1.450^{25}
Contains 2-6% N,N'-BIS[(TRIMETHOXYSILYL)PROPYL]ETHYLENEDIAMINE
Viscosity: 6.5 cSt
Surface tension: 36.5 mN/m
Specific wetting surface: 358 m^2/g
Flashpoint: 150°C (302°F)
TOXICITY: oral rat, LD50: 7,460 mg/kg
Autoignition temperature: 300˚C
Coefficient of thermal expansion: 0.8 x 10^{-3}
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.[1]
Used together w/ SID3396.0 to anchor $PdCl_2$ catalyst to silica for acceleration of the Tsuji-Trost reaction.[2]
1. Wu, Q.; Wang, L. *Synthesis* **2008**, 2007.
2. Noda, H. et al. *Angew. Chem., Int. Ed. Engl.***2012**, *51*, 8017.
[1760-24-3] TSCA EC 217-164-6 HMIS: 3-1-1-X 25g 2kg 16kg
COMMERCIAL

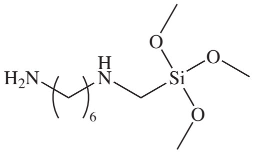


SIA0591.1
N-(2-AMINOETHYL)-3-AMINOPROPYLTRIMETHOXYSILANE, 98%
N-[3-(TRIMETHOXYSILYL)PROPYL]ETHYLENEDIAMINE; DAMO
$C_8H_{22}N_2O_3Si$ 222.36 140° / 15 1.019^{25} 1.450^{25}
Flashpoint: 150°C (302°F)
[1760-24-3] TSCA EC 217-164-6 HMIS: 3-1-1-X 25g 100g 2kg
COMMERCIAL

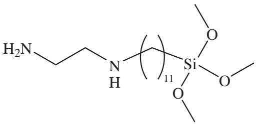
Name **Mw** **bp °C/mm** **(mp °C)** **D_4^{20}** **n_D^{20}**



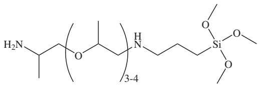
SIA0592.6
N-(6-AMINOHEXYL)AMINOMETHYLTRIETHOXYSILANE, 95%
$C_{13}H_{32}N_2O_3Si$ 292.49 160° / 0.1 0.928^{25} 1.4385^{25}
Flashpoint: >110°C (>230°F)
TOXICITY: oral rat, LD50: 500 mg/kg
Long-chain amino coupling agent
[15129-36-9] HMIS: 3-2-1-X 25g 100g



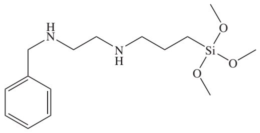
SIA0594.0
N-(6-AMINOHEXYL)AMINOPROPYLTRIMETHOXYSILANE, 95%
$C_{12}H_{30}N_2O_3Si$ 278.47 160-5° / 0.15 1.11 1.4501
Flashpoint: >110°C (>230°F)
Employed in immobilization of DNA.[1]
Employed for immobilization of PCR primers on beads.[2]
1. Kneuer, C. et al. *Int'l. J. Pharmaceutics* **2000,** *196*, 257.
2. Andreadis, J. et al. *Nuc. Acid Res.* **2000,** *28*, E-5.
[51895-58-0] HMIS: 3-1-1-X 10g 50g



SIA0595.0
N-(2-AMINOETHYL)-11-AMINOUNDECYLTRIMETHOXYSILANE
$C_{16}H_{38}N_2O_3Si$ 334.57 155-9° / 0.4 0.873^{25} 1.4515
Coupling agent with extended spacer-group for remote substrate binding
[121772-92-7] HMIS: 3-1-1-X 5g

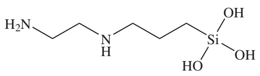


SIA0599.4
N-3-[(AMINO(POLYPROPYLENOXY)]AMINOPROPYLTRIMETHOXYSILANE, 60 - 65%
337-435 0.984 1.4508
Contains amine-terminated polypropylene oxide
3-4 propylenoxy units
Coupling agent with film-forming capability.
HMIS: 2-2-1-X 25g



SIB0956.0
N-(2-N-BENZYLAMINOETHYL)-3-AMINOPROPYLTRIMETHOXYSILANE, tech-90
$C_{15}H_{28}N_2O_3Si$ 312.48 1.035 1.4902
Contains aminoethylaminopropyltrimethoxysilane Flashpoint: 69°C (156°F)
[209866-89-7] TSCA HMIS: 3-2-1-X 25g 100g
NEW

Diamine Functional Silanes - Water-borne

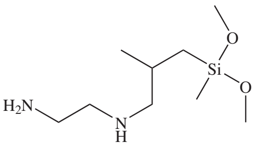


SIA0590.0
N-(2-AMINOETHYL)-3-AMINOPROPYLSILANETRIOL, 25% in water, mainly oligomers
$C_5H_{16}N_2O_3Si$ 180.28 1.00
pH: 10.0-10.5 Flashpoint: >110°C (>230°F)
Internal hydrogen bonding stabilizes solution
Additive for CMP slurries
Aqueous primer, adhesion promoter for resin-to-metal applications
See also WSA-7021 for greater hydrolytic stability
[68400-09-9] TSCA HMIS: 2-0-0-X 100g 2kg 18kg
COMMERCIAL

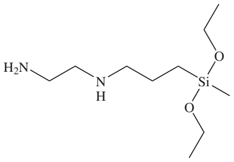
Diamine Functional Silanes - Polymeric

SIA0591.3
N-(2-AMINOETHYL)-3-AMINOPROPYLTRIMETHOXYSILANE-PROPYLTRIMETHOXYSILANE, oligomeric co-hydrolysate
$C_9H_{24}N_2OSi$ 1.09 1.442
Flashpoint: >110°C (>230°F)
TSCA HMIS: 3-2-1-X 25g 100g
NEW

Diamine Functional Silanes - Dialkoxy

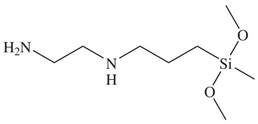


SIA0587.5
N-(2-AMINOETHYL)-3-AMINOISOBUTYLMETHYLDIMETHOXYSILANE, 95%
$C_9H_{24}N_2O_2Si$ 220.39 131° / 15 0.960 1.4518
Amino-functional coupling agent Flashpoint: 96°C (205°F)
[23410-40-4] TSCA EC 245-642-4 HMIS: 3-2-1-X 25g



SIA0588.8
N-(2-AMINOETHYL)-3-AMINOPROPYLMETHYLDIETHOXYSILANE
$C_{10}H_{26}N_2O_2Si$ 234.41 108-110° / 1.5 0.923 1.445
Flashpoint: >110°C (>230°F)
Adhesion promoter for silanol-functional silicones on metal substrates
[70240-34-5] EC 274-494-3 HMIS: 3-2-1-X 25g
NEW

Name **Mw** **bp °C/mm** **(mp °C)** **D_4^{20}** **n_D^{20}**

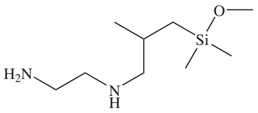


SIA0589.0
N-(2-AMINOETHYL)-3-AMINOPROPYLMETHYLDIMETHOXYSILANE, tech-95
$C_8H_{22}N_2O_2Si$ 206.36 265° 0.975^{25} 1.4447^{25}
Specific wetting surface: 380 m²/g
Flashpoint: 90°C (194°F)
TOXICITY: oral rat, LD50: >2,000 mg/kg
Autoignition temperature: 280˚C

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

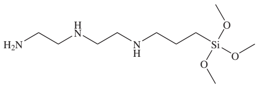
Diamine Functional Silanes - Monoalkoxy



SIA0587.2
N-(2-AMINOETHYL)-3-AMINOISOBUTYLDIMETHYLMETHOXYSILANE, 95%
$C_9H_{24}N_2OSi$ 204.39 85-9° / 2 0.900^{25} 1.4513^{25}
Flashpoint: 88°C (190°F)

Amino-functional coupling agent
[31024-49-4] HMIS: 3-2-1-X 25g

Triamine Functional Silanes

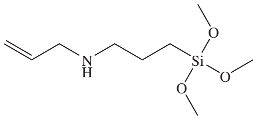


SIT8398.0
(3-TRIMETHOXYSILYLPROPYL)DIETHYLENETRIAMINE, tech-95
$C_{10}H_{27}N_3O_3Si$ 265.43 114-8° / 2 1.030 1.4590
γc of treated surface: 37.5 mN/m
Flashpoint: 137°C (279°F)
TOXICITY: oral rat, LD50: >2,000 mg/kg

Hardener, coupling agent for epoxies
[35141-30-1] TSCA EC 252-390-9 HMIS: 3-1-1-X 100g 2kg 18kg

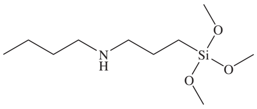
COMMERCIAL

Secondary Amine Functional Silanes



SIA0400.0
3-(N-ALLYLAMINO)PROPYLTRIMETHOXYSILANE, 95%
$C_9H_{21}NO_3Si$ 219.36 106-9° / 25 0.989^{25} 1.4990^{25}
Flashpoint: 88°C (190°F)

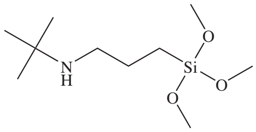
Coupling agent for polyesters
Coupling agent for acrylic coatings for glass containers.[1]
1. Hashimoto. Y. et al. Eur. Pat. Appl. EP 289,325, 1988.
[31024-46-1] TSCA EC 250-435-7 HMIS: 3-2-1-X 10g 50g



SIB1932.2
n-BUTYLAMINOPROPYLTRIMETHOXYSILANE
$C_{10}H_{25}NO_3Si$ 235.40 102° / 3.5 0.947 1.4246^{25}
Flashpoint: 110°C (230°F)

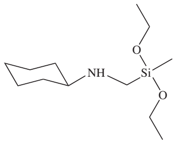
Reacts with isocyanate resins (urethanes) to form moisture cureable systems
[31024-56-3] TSCA EC 250-437-8 HMIS: 2-1-1-X 25g 2kg 17kg

COMMERCIAL



SIB1932.3
t-BUTYLAMINOPROPYLTRIMETHOXYSILANE
$C_{10}H_{25}NO_3Si$ 235.40 98-9° / 3 0.924 1.4208
[174219-86-4] HMIS: 2-2-1-X 5g

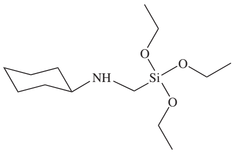
NEW



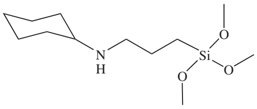
SIC2464.16
(N-CYCLOHEXYLAMINOMETHYL)METHYLDIETHOXYSILANE, 95%
$C_{12}H_{27}NO_2Si$ 245.40 235° 0.93
Flashpoint: 89°C (192°F)

End-cap modifier for moisture-cure urethane systems (SPUR)
[27445-54-1] HMIS: 2-2-1-X 25g

NEW

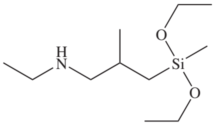


SIC2464.2
(N-CYCLOHEXYLAMINOMETHYL)TRIETHOXYSILANE, 95%
$C_{13}H_{29}NO_3Si$ 275.46 236° 0.950 1.4377
Flashpoint: 119°C (246°F)
[26495-91-0] TSCA EC 247-744-4 HMIS: 2-1-1-X 25g 100g

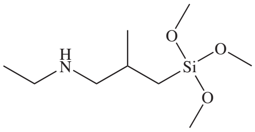


SIC2464.4
(N-CYCLOHEXYLAMINOPROPYL)TRIMETHOXYSILANE
$C_{12}H_{27}NO_3Si$ 261.43 114° / 3 0.99 1.486^{25}
Viscosity: 5-7 cSt
Flashpoint: >110°C (>230°F)
Autoignition temperature: 260°C
[3068-78-8] TSCA EC 221-329-8 HMIS: 3-2-1-X 25g 2kg

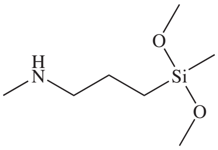
Name **Mw** **bp °C/mm** **(mp °C)** **D_4^{20}** **n_D^{20}**



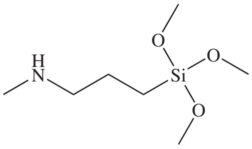
SIE4885.8
(3-(N-ETHYLAMINO)ISOBUTYL)METHYLDIETHOXYSILANE
$C_{11}H_{27}NO_2Si$ 233.43 89° / 27
[275378-62-6] HMIS: 3-2-1-X 25g



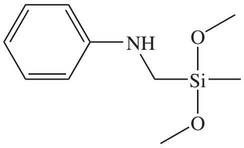
SIE4886.0
(3-(N-ETHYLAMINO)ISOBUTYL)TRIMETHOXYSILANE
$C_9H_{23}NO_3Si$ 221.37 95° / 10 0.952^{25} 1.4234
Flashpoint: 91°C (196°F)
Reacts with isocyanate resins (urethanes) to form moisture cureable systems
[227085-51-0] TSCA HMIS: 3-2-1-X 25g 100g 2kg
COMMERCIAL



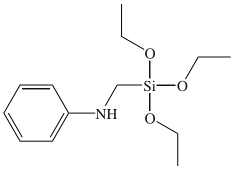
SIM6498.0
N-METHYLAMINOPROPYLMETHYLDIMETHOXYSILANE
$C_7H_{19}NO_2Si$ 177.32 93° / 25 0.9173^{25} 1.4224^{25}
Flashpoint: 80°C (176°F)
[31024-35-8] EC 250-434-1 HMIS: 3-2-1-X 25g 100g



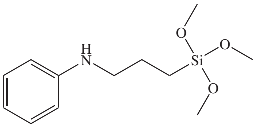
SIM6500.0
N-METHYLAMINOPROPYLTRIMETHOXYSILANE
$C_7H_{19}NO_3Si$ 193.32 106° / 30 0.978^{25} 1.4194
γc of treated surfaces: 31 mN/m Flashpoint: 82°C (180°F)
pKb^{25}, H_2O: 5.18
Orients liquid crystals
Reacts with urethane prepolymers to form moisture-curable resins
[3069-25-8] TSCA EC 221-334-5 HMIS: 3-2-1-X 25g 2kg 15kg
COMMERCIAL



SIP6723.67
(PHENYLAMINOMETHYL)METHYLDIMETHOXYSILANE, 95%
$C_{10}H_{17}NO_2Si$ 211.34 255° 1.04 1.5147
Flashpoint: 106°C (223°F)
[17890-10-7] HMIS: 3-2-1-X 25g 100g

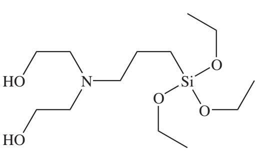


SIP6723.7
N-PHENYLAMINOMETHYLTRIETHOXYSILANE
$C_{13}H_{23}NO_3Si$ 269.42 135-7° / 4 1.004^{25} 1.485^{25}
Flashpoint: >110°C (>230°F)
Converts isocyanate-terminated polyurethanes to moisture curable resins
[3473-76-5] HMIS: 3-2-1-X 25g 100g 2kg
COMMERCIAL

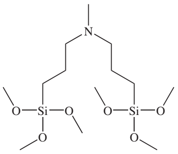


SIP6724.0
N-PHENYLAMINOPROPYLTRIMETHOXYSILANE
$C_{12}H_{21}NO_3Si$ 255.38 132-5° / 0.3 1.07 1.504
Specific wetting surface: 307 m^2/g Flashpoint: 165°C (329°F)
Oxidatively stable coupling agent for polyimides, phenolics, epoxies
[3068-76-6] TSCA EC 221-328-2 HMIS: 3-1-1-X 25g 2kg 18kg
COMMERCIAL

Tertiary Amine Functional Silanes

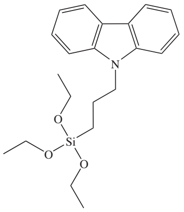


SIB1140.0
N,N-BIS(2-HYDROXYETHYL)-3-AMINOPROPYLTRIETHOXYSILANE, 62% in ethanol
$C_{13}H_{31}NO_5Si$ 309.48 0.92 1.4090^{25}
Contains 2-3% hydroxyethylaminopropyltriethoxysilane Flashpoint: 24°C (75°F)
Specific wetting surface: 252 m^2/g
Urethane polymer coupling agent
Employed in surface modification for preparation of oligonucleotide arrays.[1]
1. McGall, G. et al. *Proc. Natl. Acad. Sci.* **1996,** *93*, 1355.
[7538-44-5] TSCA EC 231-408-9 HMIS: 3-4-0-X 25g 100g

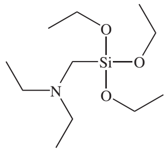


SIB1835.0
BIS(3-TRIMETHOXYSILYLPROPYL)-N-METHYLAMINE
$C_{13}H_{33}NO_6Si_2$ 355.58 175° / 10 1.023 1.430
Flashpoint: 106°C (223°F)
[31024-70-1] HMIS: 2-1-0-X 25g 100g
NEW

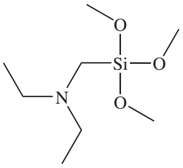
Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}



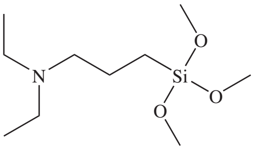
SIC2058.2
3-CARBAZOLYLPROPYLTRIETHOXYSILANE
$C_{21}H_{29}NO_3Si$ 371.55 185-195° / 0.3 1.072 1.5527^{25}
For non-linear optic materials
Employed in OLED fabrication.[1]
1. DeMais, T. et al. *SPIE Proc.* **1998**, *3476*, 338
[221105-38-0] HMIS: 2-2-1-X 2.5g
NEW



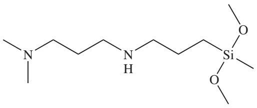
SID3395.4
(N,N-DIETHYLAMINOMETHYL)TRIETHOXYSILANE
$C_{11}H_{27}NO_3Si$ 249.43 74-6° / 3 0.9336^{25} 1.4142^{25}
TOXICITY: oral rat, LD50: >3,000 mg/kg
Catalyst for neutral cure 1-part RTVs
[15180-47-9] TSCA-L HMIS: 2-2-1-X 25g 100g 2kg
COMMERCIAL



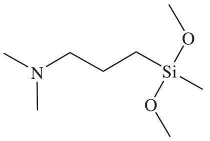
SID3395.6
(N,N-DIETHYLAMINOMETHYL)TRIMETHOXYSILANE, 95%
$C_8H_{21}NO_3Si$ 207.40 0.95 1.415
Charge control agent for toner particles
Crosslinker for moisture-cure silicone RTVs
[67475-66-5] TSCA-L HMIS: 3-2-1-X 25g
NEW



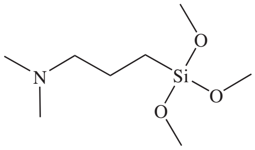
SID3396.0
(N,N-DIETHYL-3-AMINOPROPYL)TRIMETHOXYSILANE
$C_{10}H_{25}NO_3Si$ 235.40 120° / 20 0.934 1.4245
Flashpoint: 100°C (212°F)
Provides silica-supported catalyst for 1,4-addition reactions.[1]
Used together w/ SIA0591.0 to anchor $PdCl_2$ catalyst to silica for acceleration of the Tsuji-Trost reaction.[2]
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] TSCA EC 255-192-0 HMIS: 2-1-1-X 25g 100g 2kg
COMMERCIAL



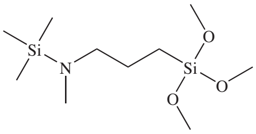
SID3546.92
3-(N,N-DIMETHYLAMINOPROPYL)AMINOPROPYLMETHYLDIMETHOXYSILANE
$C_{11}H_{28}N_2O_2Si$ 284.44 92-4° / 0.7 0.915 1.442
Combines secondary and tertiary amine functionality
Comonomer for silicone textile finishes
[224638-27-1] HMIS: 3-2-1-X 25g 100g
NEW



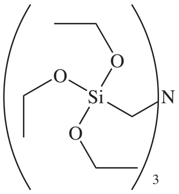
SID3546.94
N,N-DIMETHYL-3-AMINOPROPYLMETHYLDIMETHOXYSILANE
$C_8H_{21}NO_2Si$ 191.36 92° / 25 0.894 1.4203
[67353-42-8] HMIS: 2-2-1-X 10g
NEW



SID3547.0
(N,N-DIMETHYL-3-AMINOPROPYL)TRIMETHOXYSILANE
$C_8H_{21}NO_3Si$ 207.34 106° / 30 0.948^{25} 1.4150
Flashpoint: 99°C (210°F)
Derivatized silica catalyzes Michael reactions.[1]
1. Mode, J. et al. *Synlett* 1998, 625.
[2530-86-1] TSCA EC 219-786-3 HMIS: 2-2-1-X 10g 50g 2kg

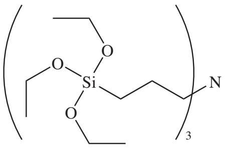


SIM6572.0
N-METHYL-N-TRIMETHYLSILYL-3-AMINOPROPYLTRIMETHOXYSILANE, 95%
$C_{10}H_{27}NO_3Si_2$ 265.50
Contains N-methylaminopropyltrimethoxysilane
HMIS: 3-2-1-X 10g
NEW



SIT8716.2
TRIS(TRIETHOXYSILYLMETHYL)AMINE, tech-90
$C_{21}H_{51}NO_9Si_3$ 545.90 156° / 0.7 0.99 1.426
Contains ~5% bis(triethoxysilylmethyl)amine
Forms immobilized quaternary salts
[1250435-76-7] HMIS: 2-2-1-X 5g
NEW

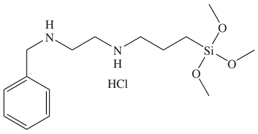
Name Mw bp °C/mm (mp °C) D_4^{20} n_D^{20}



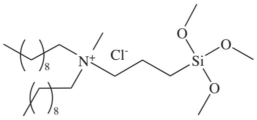
SIT8716.3
TRIS(TRIETHOXYSILYLPROPYL)AMINE, tech-95
$C_{27}H_{63}NO_9Si_3$ 630.06 200-5° / 1 1.4322^{25}
Coupling agent/primer for metal substrates
[18784-74-2] HMIS: 2-2-1-X 25g

NEW

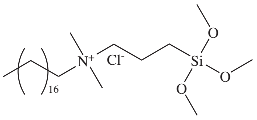
Quaternary Amine Functional Silanes



SIB0957.0
N-(2-N-BENZYLAMINOETHYL)-3-AMINOPROPYLTRIMETHOXYSILANE hydrochloride, 50% in methanol
$C_{15}H_{28}N_2O_3Si{\cdot}HCl$ 348.95 0.942 1.4104
Amber liquid Flashpoint: 9°C (48°F)
[623938-90-9] TSCA HMIS: 3-3-1-X 25g 100g

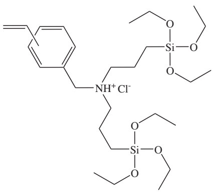


SID3392.0
N,N-DIDECYL-N-METHYL-N-(3-TRIMETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 40-42% in methanol
$C_{27}H_{60}ClNO_3Si$ 510.32 0.863 1.4085
Contains 3-5% $Cl(CH_2)_3Si(OMe)_3$ Flashpoint: 11°C (52°F)
In combination with TEOS forms high pore volume xerogels with adsorptive capacity.[1]
1. Markovitz, M. et al. *Langmuir* **2001,** *17*, 7085.
[68959-20-6] TSCA EC 273-403-4 HMIS: 3-4-0-X 25g

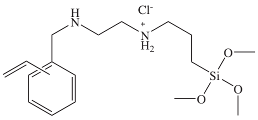


SIO6620.0
OCTADECYLDIMETHYL(3-TRIMETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 60% in methanol
$C_{26}H_{58}ClNO_3Si$ 496.29 0.89
Contains 3-5% $Cl(CH_2)_3Si(OMe)_3$ Flashpoint: 15°C (59°F)
Autoignition temperature: 230°C
Employed as a glass lubricant
Orients liquid crystals
Provides an antistatic surface coating
Dispersion/coupling agent for high density magnetic recording media.[1]
Application as immobilizable antimicrobial reported.[2]
1. Vincent, H. In *Chemically Modified Oxide Surfaces;* D. Leyden, D., Ed.; Gordon & Breach: 1990; p.305.
2. White, W. et al. In *Silanes, Surfaces & Interfaces;* Leyden, D., Ed.; Gordon & Breach: 1986; p.107.
[27668-52-6] TSCA EC 248-595-8 HMIS: 3-4-0-X 25g 2kg 16kg

COMMERCIAL

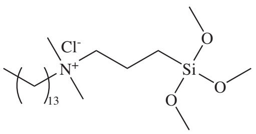


SIS6989.0
(STYRYLMETHYL)BIS(TRIETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 40% in ethanol
$C_{27}H_{52}ClNO_6Si_2$ 578.34 0.909
Inhibited with BHT, mixed *m*-, *p*-isomers Flashpoint: 15°C (59°F)
Dipodal quaternary coupling agent
HMIS: 3-4-1-X store <5°C 25g 100g

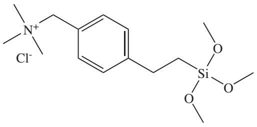


SIS6994.0
3-(N-STYRYLMETHYL-2-AMINOETHYLAMINO)PROPYLTRIMETHOXYSILANE HYDROCHLORIDE, 40% in methanol
$C_{17}H_{31}ClN_2O_3Si$ 374.98 0.91 1.395
Inhibited with BHT Flashpoint: 11°C (52°F)
Viscosity: 2.3 cSt
Specific wetting surface area: 208 m²/g
Coupling agent for phenolic and epoxy fiberglass laminates (printed circuit boards)
[34937-00-3] TSCA EC 252-297-3 HMIS: 3-4-1-X store <5°C 25g 2kg 15kg

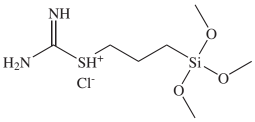
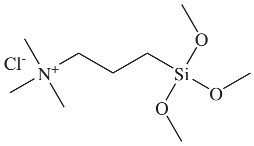
COMMERCIAL



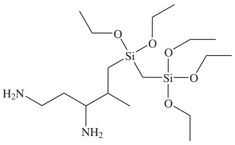
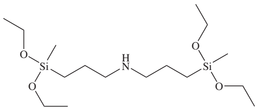
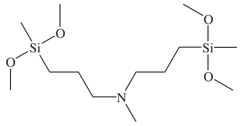
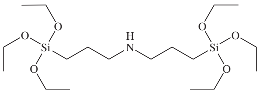
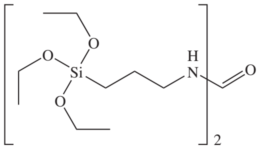
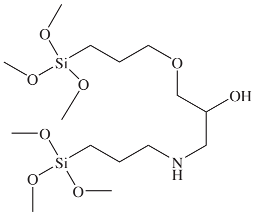
SIT7090.0
TETRADECYLDIMETHYL(3-TRIMETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 50% in methanol
$C_{22}H_{50}ClNO_3Si$ 440.18 0.878 1.3971
Contains 3-5% $Cl(CH_2)_3Si(OMe)_3$ Flashpoint: 11°C (52°F)
[41591-87-1] TSCA EC 255-451-8 HMIS: 3-4-0-X 25g



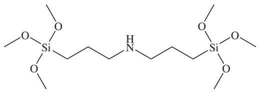
SIT8395.0
4-(TRIMETHOXYSILYLETHYL)BENZYLTRIMETHYLAMMONIUM CHLORIDE, 60% in methanol
$C_{15}H_{28}ClNO_3Si$ 333.93 0.966
Flashpoint: 11°C (52°F)
Candidate for exchange resins and extraction phases
HMIS: 3-3-1-X 25g

	Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}	
	**SIT8405.0**						
	S-(TRIMETHOXYSILYLPROPYL)ISOTHIOURONIUM CHLORIDE, 50% in water						
	TRIHYDROXYPROPYLCARBAMIDOTHIOIC ACID HYDROCHLORIDE						
	$C_7H_{19}ClN_2O_3SSi$	274.84			1.190	1.441	
	Essentially silanetriol						
	pH: 6						
	Antimicrobial activity reported						
	[84682-36-0] TSCA EC 283-599-3	HMIS: 2-0-0-X	25g				
	**SIT8415.0**						COMMERCIAL
	N-TRIMETHOXYSILYLPROPYL-N,N,N-TRIMETHYLAMMONIUM CHLORIDE, 50% in methanol						
	N,N,N-TRIMETHYL-3-(TRIMETHOXYSILYL)-1-PROPANAMINIUM CHLORIDE						
	$C_9H_{24}ClNO_3Si$	257.83			0.927	1.3966	
			Flashpoint: 11°C (52°F)				
	Employed for bonded chromatographic phases						
	Anti-static agent						
	Used to treat glass substrates employed in electroblotting						
	Prevents contact electrification.[1]						
	1. Thomas, S. et al. *J. Am. Chem. Soc.* **2009**, *131*, 8746.						
	[35141-36-7] TSCA EC 252-393-5	HMIS: 2-4-1-X	25g	2kg	15kg		

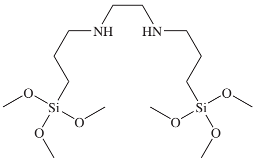
Dipodal Amine Functional Silanes

	Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}	
	**SIA0587.6**						NEW
	1-[3-(2-AMINOETHYL)-3-AMINOISOBUTYL]-1,1,3,3,3-PENTAETHOXY-1,3-DISILAPROPANE, 95%						
	$C_{17}H_{42}N_2O_5Si_2$	410.70	130-140° / 0.5		0.990		
	Pendant dipodal silane						
		HMIS: 3-1-1-X	10g				
	**SIB1620.0**						
	BIS(METHYLDIETHOXYSILYLPROPYL)AMINE, 95%						
	$C_{16}H_{39}NO_4Si_2$	365.66	155° / 0.6		0.937	1.4385	
	Dipodal coupling agent						
	[31020-47-0]	HMIS: 2-1-1-X	25g	100g			
	**SIB1645.0**						
	BIS(METHYLDIMETHOXYSILYLPROPYL)-N-METHYLAMINE, 95%						
	$C_{13}H_{33}NO_4Si_2$	323.58	140° / 2		0.951	1.4368	
	Viscosity: 6 - 7 cSt						
		HMIS: 3-2-1-X	25g				
	**SIB1824.5**						COMMERCIAL
	BIS(3-TRIETHOXYSILYLPROPYL)AMINE, 95%						
	$C_{18}H_{43}NO_6Si_2$	425.71	160° / 0.6		0.97	1.4265	
	Viscosity: 5.5 cSt		Flashpoint: 162°C (324°F)				
	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		
	**SIB1828.0**						
	N,N'-BIS[3-(TRIETHOXYSILYL)PROPYL]UREA, 60% in ethanol						
	$C_{19}H_{44}N_2O_7Si_2$	468.73			0.923		
			Flashpoint: 17°C (63°F)				
	[69465-84-5]	HMIS: 2-1-1-X	25g	100g			
	**SIB1832.8**						NEW
	1,11-BIS(TRIMETHOXYSILYL)-4-OXA-8-AZAUNDECAN-6-OL, 50% in methanol						
	3,3,15,15-TETRAMETHOXY-2,7,16-TRIOXA-11-AZA-3,15-DISILAHEPTADECAN-9-OL						
	$C_{15}H_{37}NO_8Si_2$	415.63			0.922	1.384^{25}	
			Flashpoint: 11°C (52°F)				
	Provides strong glass-to-glass bonds						
	[126552-46-3]	HMIS: 3-4-1-X	25g	100g			

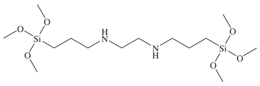
Name | Mw | bp °C/mm | (mp °C) | D_4^{20} | n_D^{20}



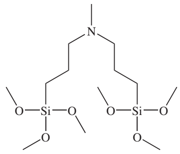
SIB1833.0
BIS(3-TRIMETHOXYSILYLPROPYL)AMINE, 96%
$C_{12}H_{31}NO_6Si_2$ 341.56 152° / 4 1.040 1.4320
Flashpoint: 113°C (235°F)
Dipodal coupling agent
Secondary amine allows more control of reactivity with isocyanates
Low level incorporation with acryloxypropyltrimethoxysilane, SIA0200, increases strength and hydrolytic stability of dental composites.[1]
1. Matinlinna, J. et al. *Acta Odontol. Scand.* **2012**, *70*, 405.
[82985-35-1] TSCA EC 280-084-5 HMIS: 3-1-1-X 25g 2kg 18kg
COMMERCIAL



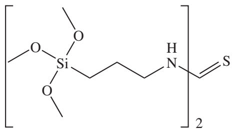
SIB1834.0
N,N'-BIS[(3-TRIMETHOXYSILYL)PROPYL]ETHYLENEDIAMINE, 62% in methanol
$C_{14}H_{36}N_2O_6Si_2$ 384.62 0.89
Contains N,N-isomer Flashpoint: 20°C (68°F)
Coupling agent for polyamides with enhanced hydrolytic stability
Provides improved solder resistance for printed circuit boards
[68845-16-9] TSCA EC 272-453-4 HMIS: 3-4-1-X 25g 2kg 16kg
COMMERCIAL



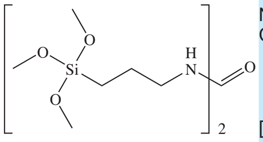
SIB1834.1
N,N'-BIS[(3-TRIMETHOXYSILYL)PROPYL]ETHYLENEDIAMINE, 95%
$C_{14}H_{36}N_2O_6Si_2$ 384.62 1.050 1.4428
Contains N,N-isomer Flashpoint: >110°C (>230°F)
Coupling agent for polyamides with enhanced hydrolytic stability
Forms thin film environments for metal ions.[1]
1. He, J. et al. *RIKEN Review* **2002,** *45*, 27.
[68845-16-9] TSCA EC 272-453-4 HMIS: 3-1-1-X 10g 50g



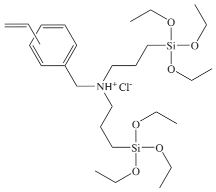
SIB1835.0
BIS(3-TRIMETHOXYSILYLPROPYL)-N-METHYLAMINE
$C_{13}H_{33}NO_6Si_2$ 355.58 175° / 10 1.023 1.430
Flashpoint: 106°C (223°F)
[31024-70-1] HMIS: 2-1-0-X 25g 100g
NEW



SIB1835.2
N,N'-BIS(3-TRIMETHOXYSILYLPROPYL)THIOUREA, tech-90
$C_{14}H_{36}N_2O_6Si_3$ 400.66 1.13 1.485
Viscosity: 160-200 cSt
Forms mesoporous silicas that chelate metals
HMIS: 3-2-1-X 10g
NEW

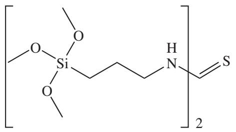


SIB1835.5
N,N'-BIS(3-TRIMETHOXYSILYLPROPYL)UREA, 95%
$C_{13}H_{32}N_2O_7Si_2$ 384.58 1.10 1.4488
Amber liquid Flashpoint: >110°C (>230°F)
Viscosity: 100 - 250 cSt
Adhesion promoter for 2-part condensation cure silicone RTVs
[18418-53-6] TSCA HMIS: 3-2-1-X 25g 100g 2kg
COMMERCIAL

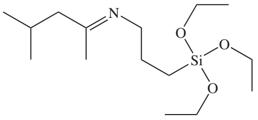


SIS6989.0
(STYRYLMETHYL)BIS(TRIETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 40% in ethanol
$C_{27}H_{52}ClNO_6Si_2$ 578.34 0.909
Inhibited with BHT, mixed *m*-, *p*-isomers Flashpoint: 15°C (59°F)
Dipodal quaternary coupling agent
HMIS: 3-4-1-X store <5°C 25g 100g

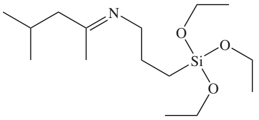
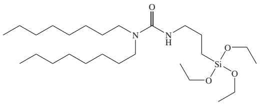
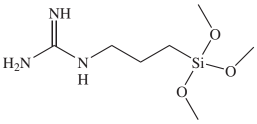
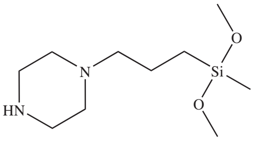
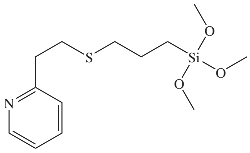
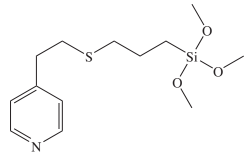
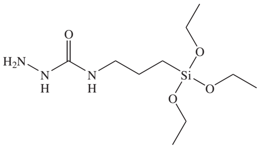
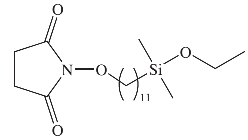
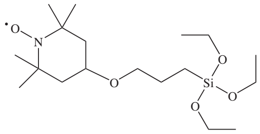
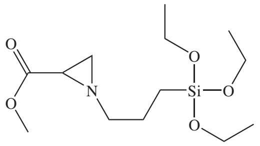
Specialty Amine Functional Silanes

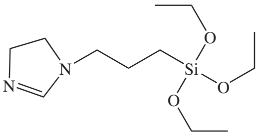


SIB1835.2
N,N'-BIS(3-TRIMETHOXYSILYLPROPYL)THIOUREA, tech-90
$C_{13}H_{32}N_2O_6SSi_2$ 400.66 1.13 1.485
Viscosity: 160-200 cSt
Forms mesoporous silicas that chelate metals
HMIS: 3-2-1-X 10g
NEW



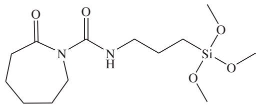
SID4068.0
3-(1,3-DIMETHYLBUTYLIDENE)AMINOPROPYLTRIETHOXYSILANE, tech-95
$C_{15}H_{33}NO_3Si$ 303.52 134° / 5 0.93 1.437^{25}
Contains oligomers Flashpoint: 131°C (268°F)
Coupling agent for epoxy coatings; blocked amine - moisture deblocked
Preferred adhesion promoter for low viscosity epoxy systems
[116229-43-7] TSCA HMIS: 2-1-1-X 25g 100g 2kg
COMMERCIAL

	Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}	
	**SID4068.1** 3-(1,3-DIMETHYLBUTYLIDENE)AMINOPROPYLTRIETHOXYSILANE, 98% $C_{15}H_{33}NO_3Si$ 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	303.52	134° / 5 Flashpoint: 131°C (268°F)		0.93	1.437^{25}	NEW
	**SID4465.0** N,N-DIOCTYL-N'-TRIETHOXYSILYLPROPYLUREA $C_{26}H_{56}N_2O_4Si$ Forms hydrophobic phases with embedded hydrophilicity Forms organic-inorganic vesicles (cerasomers).[1] 1. Hashizume, M. et al. *J. Thin Solid Films* **2003,** *438*, 20. [259727-10-1] HMIS: 2-2-1-X 25g	488.83			0.924^{25}	1.4521^{25}	
	**SIG5840.12** 3-(GUANIDINYL)PROPYLTRIMETHOXYSILANE $C_7H_{19}N_3O_3Si$ White powder Water-soluble coupling agent [128310-21-4] HMIS: 3-1-1-X 5g	221.35		(>200°)			NEW
	**SIP6828.4** [3-(1-PIPERAZINYL)PROPYL]METHYLDIMETHOXYSILANE, 95% $C_{10}H_{24}N_2O_2Si$ Adhesion promoter for metal substrates Comonomer for silicones [128996-12-3] HMIS: 3-2-1-X 25g	232.40	110-2° / 1 Flashpoint: 123°C (253°F)		0.986	1.4628^{25}	NEW
	**SIP6926.2** 3-(2-PYRIDYLETHYL)THIOPROPYLTRIMETHOXYSILANE $C_{13}H_{23}NO_3SSi$ [29098-72-4] HMIS: 3-2-1-X 10g	301.48	156-7° / 0.25		1.089	1.498	
	**SIP6926.4** 3-(4-PYRIDYLETHYL)THIOPROPYLTRIMETHOXYSILANE, 95% $C_{13}H_{23}NO_3SSi$ Immobilizable ligand for immunoglobulin IgG separation using hydrophobic charge induction chromatography (HCIC) [198567-47-4] HMIS: 3-2-1-X 10g	301.48	160-2° / 0.2		1.09	1.5037	
	**SIS6944.0** 3-(4-SEMICARBAZIDYL)PROPYLTRIETHOXYSILANE, tech-95 $C_{10}H_{25}N_3O_4Si$ Employed in immobilization of oligonucleotides.[1] 1. Podyminogin, M. et al. *Nucleic Acids Res.* **2001,** *29*, 5090. [106868-88-6] HMIS: 3-1-1-X 5g	279.41	Flashpoint: >110°C (>230°F)		1.08	1.4593	NEW
	**SIS6995.0** 11-(SUCCINIMIDYLOXY)UNDECYLDIMETHYLETHOXYSILANE, 95% $C_{19}H_{37}NO_4Si$ Reagent for immobilization of proteins via primary amines HMIS: 3-2-1-X 1.0g	371.59	195-200° / 0.6	(28°)			
	**SIT8186.45** 4-(TRIETHOXYSILYLPROPOXY)-2,2,6,6-TETRAMETHYLPIPERIDINE N-OXIDE, tech-85 *TEMPO-SILANE* $C_{18}H_{38}NO_5Si$ Employed in nitroxyl mediated grafting of vinylsilanes to polyolefins.[1] 1. Weaver, J. et al. *J. Polym. Sci., Part A: Polym. Chem.* **2008**, *46*, 4542. [913375-27-6] HMIS: 2-2-1-X 10g	376.58					NEW
	**SIT8186.7** N-[3-(TRIETHOXYSILYL)PROPYL]-2-CARBOMETHOXYAZIRIDINE, 95% $C_{13}H_{27}NO_5Si$ Reacts with fullerenes by 1,3-dipolar addition of azomethine ylide to yield pyrollidine adduct.[1] 1. Bianco, A. et al. *J. Am. Chem. Soc.* **1997,** *119*, 7550. [193417-26-4] HMIS: 3-2-1-X 2.5g	305.44			1.052^{25}	1.4197^{25}	NEW

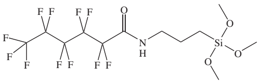


SIT8187.5
N-(3-TRIETHOXYSILYLPROPYL)-4,5-DIHYDROIMIDAZOLE
3-(2-IMIDAZOLIN-1-YL)PROPYLTRIETHOXYSILANE, IMEO
$C_{12}H_{26}N_2O_3Si$ 274.43 134° / 2 1.005 1.452
Viscosity: 5 cSt. Flashpoint: >110°C (>230°F)
Coupling agent for elevated temperature-cure epoxies
Utilized in HPLC of metal chelates.[1]
Forms proton vacancy conducting polymers with sulfonamides by sol-gel.[2]
Ligand for molecular imprinting of silica with chymotrypsin transition state analog.[3]
1. Suzuki, T. et al. *Chem. Lett.* **1994,** 881.
2. De Zea Bermudez, V. et al. *Sol-Gel Optics II, SPIE Proc.* **1992,** *1728*, 180.
3. Markowitz, M. et al. *Langmuir* **2000**, *16*, 1759.
[58068-97-6] TSCA EC 261-093-3 HMIS: 2-1-1-X 25g 100g 2kg

COMMERCIAL

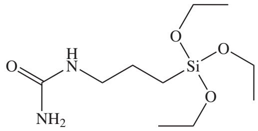


SIT8394.0
N-[5-(TRIMETHOXYSILYL)-2-AZA-1-OXOPENTYL]CAPROLACTAM, 95%
N-TRIMETHOXYSILYLPROPYLCARBAMOYLCAPROLACTAM
$C_{13}H_{26}N_2O_5Si$ 318.45 (-39°) 1.14 1.4739
Flashpoint: 136°C (277°F)
[106996-32-1] HMIS: 3-1-1-X 25g



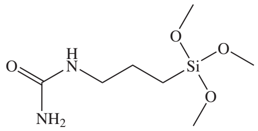
SIT8409.0
N-(3-TRIMETHOXYSILYLPROPYL)PERFLUOROHEXANAMIDE
$C_{12}H_{16}F_{11}NO_4Si$ 475.33 1.367 1.360
Surface tension: 20.6 mN/m
Contact angle, water on treated silica surface: 105-110˚
[154380-34-4] HMIS: 3-1-1-X 10g

NEW



SIU9055.0
UREIDOPROPYLTRIETHOXYSILANE, 50% in methanol
$C_{10}H_{24}N_2O_4Si$ 264.40 (-97°) 0.92 1.386
Contains ureidopropyltrimethoxysilane and related transesterification products Flashpoint: 11°C (52°F)
Coupling agent for polyamides and urea-formaldehyde resins
[23779-32-0] TSCA EC 245-876-7 HMIS: 2-4-1-X 25g 2kg 16kg

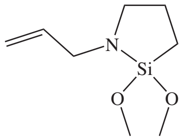
COMMERCIAL



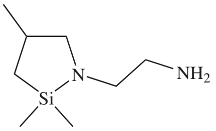
SIU9058.0
UREIDOPROPYLTRIMETHOXYSILANE
$C_7H_{18}N_2O_4Si$ 222.32 217-225° (-5°) 1.150 1.386^{25}
Flashpoint: 99°C (210°F)
TOXICITY: oral rat, LD50: >5,000 mg/kg
Autoignition temperature: 300˚C
Component in primers for tin alloys
Adhesion promoter for foundry resins
[23843-64-3] TSCA EC 245-904-8 HMIS: 2-2-1-X 25g 100g 2kg

COMMERCIAL

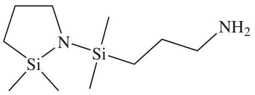
Cyclic Azasilanes



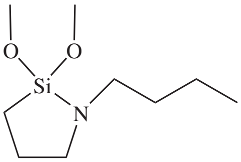
SIA0415.0
N-ALLYL-AZA-2,2-DIMETHOXYSILACYCLOPENTANE
$C_8H_{17}NO_2Si$ 187.31 52-4° / 3
Coupling agent for nanoparticles
[618914-49-1] HMIS: 3-3-1-X 10g



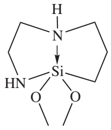
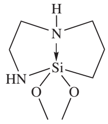
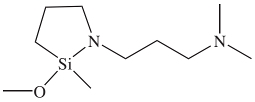
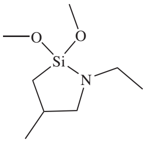
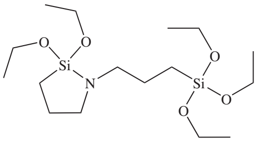
SIA0592.0
N-(2-AMINOETHYL)-2,2,4-TRIMETHYL-1-AZA-2-SILACYCLOPENTANE
$C_8H_{20}N_2Si$ 172.35 54-6° / 2 0.905 1.4769
Coupling agent for vapor phase modification of nanoparticles
[18246-33-8] HMIS: 3-2-1-X 10g



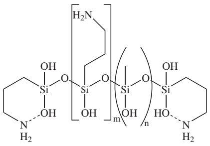
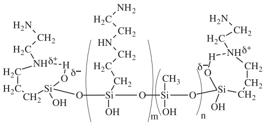
SIA0604.0
N-(3-AMINOPROPYLDIMETHYLSILYL)AZA-2,2-DIMETHYL-2-SILACYCLOPENTANE, 95%
3-[(2,2-DIMETHYL-1-AZA-2-SILACYCLOPENT-1-YL)DIMETHYLSILYL]-1-PROPANAMINE, 3-[(2,2-DIMETHYL-1,2-AZASILOLIDIN-1-YL)DIMETHYLSILYL]-1-PROPANAMINE
$C_{10}H_{26}N_2Si_2$ 230.50 158° 1.4705
Flashpoint: 72°C (162°F)
Employed in vapor phase derivatization of porous silica.[1]
1. Brandhuber, D. et al. *J. Mater. Chem.* **2005,** *15*, 3896.
[388606-32-4] HMIS: 3-2-1-X 10g



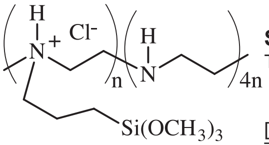
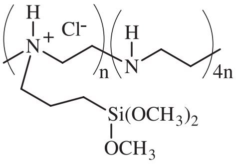
SIB1932.4
N-n-BUTYL-AZA-2,2-DIMETHOXYSILACYCLOPENTANE
$C_9H_{21}NO_2Si$ 203.36 63-71° / 3 0.941 1.438
Flashpoint: 85°C (185°F)
Coupling agent for nanoparticles.[1]
Interlayer bonding agent for anti-reflective lenses.[2]
1. Arkles, B. et al. In *Silanes and Other Coupling Agents;* Mittal, K., Ed.; 2004; 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

	Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}	
	**SID3543.0** 2,2-DIMETHOXY-1,6-DIAZA-2-SILACYCLOOCTANE $C_7H_{18}N_2O_2Si$ Volatile coupling agent [182008-07-7] HMIS: 3-2-1-X 25g	190.32	71-3° / 2.5	(61-2°)			
	**SID3543.1** 2,2-DIMETHOXY-1,6-DIAZA-2-SILACYCLOOCTANE, 10% in cyclohexane $C_7H_{18}N_2O_2Si$ [182008-07-7] 25g	190.32			0.79		NEW
	**SID3546.93** (N,N-DIMETHYLAMINOPROPYL)-AZA-2-METHYL-2-METHOXYSILACYCLOPENTANE, 95% $C_{10}H_{24}N_2OSi$ Cyclic azasilane - acts as coupling agent for metals HMIS: 3-3-1-X 10g	216.39	65-7° / 0.5		0.919^{25}		NEW
	**SIE4891.0** 1-ETHYL-2,2-DIMETHOXY-4-METHYL-1-AZA-2-SILACYCLOPENTANE $C_8H_{19}NO_2Si$ Cyclic azasilane utilized for vapor-phase surface treatment of nano-featured substrates HMIS: 3-3-1-X 25g	189.33					NEW
	**SIT8187.2** (1-(3-TRIETHOXYSILYL)PROPYL)-2,2-DIETHOXY-1-AZA-2-SILACYCLOPENTANE, tech-90 $C_{16}H_{37}NO_5Si_2$ Contains bis(triethoxysilylpropyl)amine Cyclic azasilane that acts as coupling agent for metal-oxide films [1184179-50-7] HMIS: 3-2-1-X 25g	379.64	136-8° / 1		0.974	1.4322^{25}	NEW

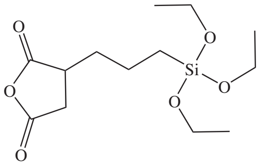
Water-borne Aminoalkyl Silsesquioxane Oligomers

	**WSA-7011** AMINOPROPYLSILSESQUIOXANE IN AQUEOUS SOLUTION Viscosity: 5-15 cSt Mole % functional group: 65-75 pH: 10-10.5 [1411854-75-5] TSCA 100g 3kg 18kg	250-500			1.10		COMMERCIAL
	WSA-9911 AMINOPROPYLSILSESQUIOXANE IN AQUEOUS SOLUTION Viscosity: 5-15 cSt Mole % functional group: 100 pH: 10-10.5 [29159-37-3] TSCA 100g 3kg 18kg	270-550			1.06		COMMERCIAL
	**WSA-7021** AMINOETHYLAMINOPROPYLSILSESQUIOXANE IN AQUEOUS SOLUTION Viscosity: 5-10 cSt Mole % functional group: 65-75 pH: 10-11 TSCA 100g 3kg 18kg	370-650			1.10		COMMERCIAL
	WSAV-6511 AMINOETHYLAMINOPROPYL/VINYL/SILSESQUIOXANE IN AQUEOUS SOLUTION Viscosity: 3-10 cSt Mole % functional group: 60-65 pH: 10-11 [207308-27-8] TSCA 100g 3kg	250-500			1.11		COMMERCIAL

Polyamine

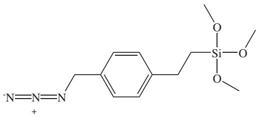
	**SSP-060** TRIMETHOXYSILYLPROPYL MODIFIED (POLYETHYLENIMINE), 50% in isopropanol Flashpoint: 12°C (54°F) [136856-91-2] / [37251-86-8] TSCA HMIS: 2-4-1-X 100g 2kg 16kg	1,500-1,800			0.92		
	**SSP-065** DIMETHOXYSILYLMETHYLPROPYL MODIFIED (POLYETHYLENIMINE), 50% in isopropanol Flashpoint: 12°C (54°F) [125441-88-5] TSCA HMIS: 2-4-1-X 100g 3kg 16kg	1,500-1,800			0.92		

Anhydride Functional Silanes

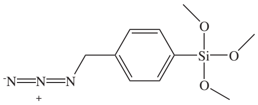


SIT8192.6
(3-TRIETHOXYSILYL)PROPYLSUCCINIC ANHYDRIDE, 95%
$C_{13}H_{24}O_6Si$ 304.41 135° / 0.2 1.070 1.4405
Viscosity: 20 cSt
Flashpoint: >100°C (>212°F)
TOXICITY: oral rat, LD50: >2,000 mg/kg
Autoignition temperature: 250˚C
Coupling agent for dibasic surfaces
Acetic acid-catalyzed hydrolysis yields succinic acid derivatives
[93642-68-3] TSCA EC 297-566-6 HMIS: 2-1-1-X 25g 100g 2kg
COMMERCIAL

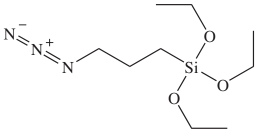
Azide Functional Silanes



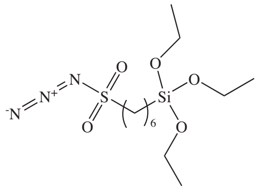
SIA0770.0
(AZIDOMETHYL)PHENETHYLTRIMETHOXYSILANE, tech-90
$C_{12}H_{19}N_3O_3Si$ 281.39 1.11 1.497^{25}
CAUTION: CAN FORM EXPLOSIVE COMPOUNDS IN CONTACT WITH COPPER AND SILVER COMPOUNDS
Mixed isomers
Reagent for "click" chemistry
[1245946-78-4] HMIS: 4-2-1-X 5g
NEW



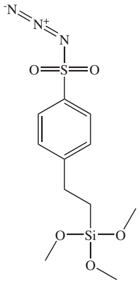
SIA0774.0
p-AZIDOMETHYLPHENYLTRIMETHOXYSILANE, 90%
$C_{10}H_{15}N_3O_3Si$ 253.33 1.14 1.497^{25}
AVOID CONTACT WITH METALS
[83315-74-6] HMIS: 4-2-1-X 2.5g
NEW



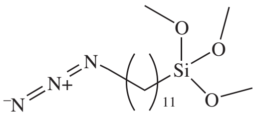
SIA0777.0
3-AZIDOPROPYLTRIETHOXYSILANE
$C_9H_{21}N_3O_3Si$ 247.37 72-5° / 0.5 0.981 1.4257
AVOID CONTACT WITH METALS
Used with click chemistry to introduce and immobilize discrete complexes onto the SBA-15 surface.[1]
Used in the preparation of poly-L-lysine to silica nanoparticles.[2]
1. Nakazawa, J. et al. *J. Am. Chem. Soc.* **2012**, *134*, 2750.
2. Kar, M. et al. *Langmuir*, **2010**, *26*, 5772.
[83315-69-9] HMIS: 4-1-1-X 1.0g
NEW



SIA0780.0
6-AZIDOSULFONYLHEXYLTRIETHOXYSILANE, tech-95
1-TRIETHOXYSILYL-6-SULFONAZIDE-n-HEXANE
$C_{12}H_{27}N_3O_5SSi$ 353.51 1.147 1.4634
AVOID CONTACT WITH METALS
Amber-brown liquid
Flashpoint: 114°C (237°F)
Inserts nitrenes into aliphatics and aromatics at temperatures >110°C
[96550-26-4] HMIS: 3-1-1-X 25g



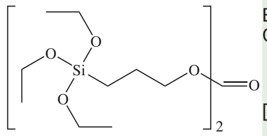
SIA0790.0
4-(AZIDOSULFONYL)PHENETHYLTRIMETHOXYSILANE, 22-25% in methanol/toluene
4-[2-(TRIMETHOXYSILYL)ETHYL]-1-BENZENESULFONYL AZIDE
$C_{11}H_{17}N_3O_5SSi$ 331.42 0.90 1.550
AVOID CONTACT WITH METALS
Contains hydrolysis oligomers
Flashpoint: 29°C (4°F)
Extremely reactive coupling agent
Inserts nitrenes into aliphatics and aromatics at temperatures >110°C
[68479-60-7] TSCA EC 270-862-2 HMIS: 3-4-1-X 25g
NEW



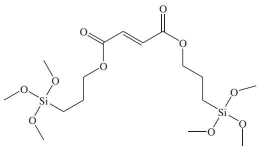
SIA0795.0
11-AZIDOUNDECYLTRIMETHOXYSILANE, 95%
$C_{14}H_{31}N_3O_3Si$ 317.50 111° / 0.05
AVOID CONTACT WITH METALS
Forms "click" functionalized surfaces
[334521-23-2] HMIS: 3-1-1-X 2.5g
NEW

Name **Mw** **bp °C/mm** **(mp °C)** D_4^{20} n_D^{20}

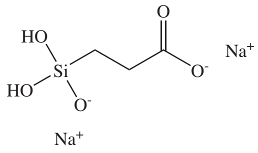
Carboxylate, Phosphonate and Sulfonate Functional Silanes



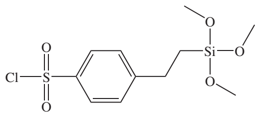
SIB1824.56
BIS(3-TRIETHOXYSILYLPROPYL)CARBONATE
$C_{19}H_{42}O_9Si_2$ 470.71 1.020
Forms thermally labile bridged silsesquioxanes.[1]
1. Loy, D.A. et al. *Chem. Mater.* **1999,** *11*, 3333.
[88321-11-3] HMIS: 2-2-1-X 10g
NEW



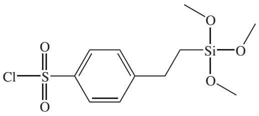
SIB1834.5
BIS(3-TRIMETHOXYSILYLPROPYL) FUMARATE, 96%
$C_{16}H_{32}O_{10}Si_2$ 440.59 1.118 1.443
Flashpoint: >110°C (>230°F)
Dipodal silane
Adhesion promoter for Pt-cure silicone RTVs
[3371-62-8] TSCA HMIS: 3-1-1-X 25g
NEW



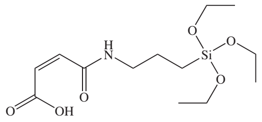
SIC2263.0
CARBOXYETHYLSILANETRIOL, DISODIUM SALT, 25% in water
$C_3H_6Na_2O_5Si$ 196.14 1.170^{25}
pH: 12 - 12.5
In combination with aminofunctional silanes forms amphoteric silicas.[1]
1. Han, L. et al. *Chem. Mater*. **2007**, *19*, 2860.
[18191-40-7] HMIS: 2-0-0-X 25g 100g



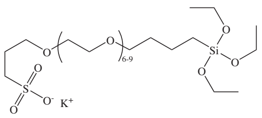
SIC2417.0
2-(4-CHLOROSULFONYLPHENYL)ETHYLTRIMETHOXYSILANE, 50% in methylene chloride
$C_{11}H_{17}ClO_5SSi$ 324.85 1.30^{25}
Amber color
Contains free sulfonic acid
Treated silica acts as etherification catalyst.[1]
Reagent for surface initiated ATRP.[2]
Employed in mesostructured fuel-cell membranes.[3]
1. Sow, B. et al. *Microporous and Mesoporous Mat'ls.* **2005,** *79*, 129.
2. Fukuda, J. et al. *Macromolecules* **2000**, *33*, 2870.
3. Pereira, F. et al. *Chem. Mater*. **2008**, *20,* 1710.
[126519-89-9] HMIS: 3-2-1-X 25g 100g



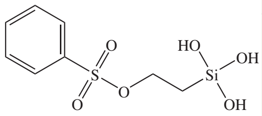
SIC2417.4
2-(4-CHLOROSULFONYLPHENYL)ETHYLTRIMETHOXYSILANE, 50% in toluene
$C_{11}H_{17}ClO_5SSi$ 324.85
Flashpoint: 4°C (39°F)
[126519-89-9] 25g
NEW



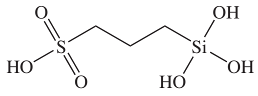
SIT8189.8
TRIETHOXYSILYLPROPYLMALEAMIC ACID, tech-90
$C_{13}H_{25}NO_6Si$ 319.43 1.11 1.472
Contains condensation products and 10% ethanol
Viscosity: 600-900 cSt
Reagent for immobilization of anti-bodies on silicon nitride sensor chips.[1]
1. Kurihara, Y, et al. *Langmuir* **2012***,* *28*, 13609.
[33525-68-7] TSCA EC 251-564-1 HMIS: 3-2-1-X 25g



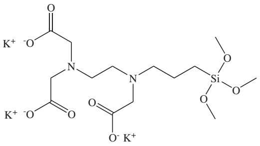
SIT8192.2
TRIETHOXYSILYLPROPYL(POLYETHYLENEOXY)PROPYLPOTASSIUM SULFATE, 45-50% in ethanol
$C_{25}H_{53}KO_{13}SSi$ - $C_{31}H_{65}KO_{16}SSi$ 661 - 793 0.95
Flashpoint: 15°C (59°F)
HMIS: 2-3-0-X 2.5g
NEW



SIT8378.1
TRIHYDROXYSILYLETHYL PHENYLSULPHONIC ACID, 25% in water
$C_8H_{12}O_6SSi$ 264.33
Mixed isomers
Forms hybrid organic-inorganic ionic membranes
[143282-00-2]/[876338-08-8] HMIS: 3-0-0-X 25g
NEW

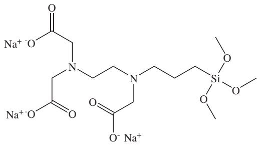


SIT8378.3
3-(TRIHYDROXYSILYL)-1-PROPANESULFONIC ACID, 30-35% in water
$C_3H_{10}O_6SSi$ 202.26 1.12
pH: <1
Employed in preparation of nanoscale ionic silicas.[1]
Forms sulfonated fuel cell electrodes.[2]
1. Giannelis, E. et al. *Appl. Organomet. Chem.* **2010**, *24*, 581.
2. Eastcott, J. et al. *J. Power Sources* **2012***,197*,102.
[70942-24-4] TSCA HMIS: 3-0-0-X 25g 100g



SIT8401.0
N-(TRIMETHOXYSILYLPROPYL)ETHYLENEDIAMINETRIACETATE, TRIPOTASSIUM SALT, 30% in water
$C_{14}H_{25}K_3N_2O_9Si$ 510.75 1.22
Essentially silanetriol, contains KCl
Chelates metal ions
[1309595-29-6] HMIS: 2-0-0-X 25g

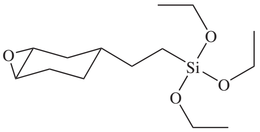
NEW



SIT8402.0
N-(TRIMETHOXYSILYLPROPYL)ETHYLENEDIAMINETRIACETATE, TRISODIUM SALT, 35% in water
$C_{14}H_{25}N_2Na_3O_9Si$ 462.42 1.26
Essentially silanetriol, contains NaCl
Chelates metal ions
[128850-89-5]/[1138444-28-6] TSCA-L HMIS: 2-0-0-X 25g 100g

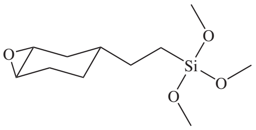
Epoxy Functional Silanes

Epoxy Functional Silanes - Trialkoxy



SIE4668.0
2-(3,4-EPOXYCYCLOHEXYL)ETHYLTRIETHOXYSILANE
$C_{14}H_{28}O_4Si$ 288.46 114-7° / 0.4 1.015 1.4455
Flashpoint: 104°C (219°F)
Adhesion promoter for water-borne coatings on alkaline substrates
[10217-34-2] TSCA HMIS: 2-1-1-X 25g 100g 2kg

COMMERCIAL

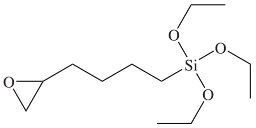


SIE4670.0
2-(3,4-EPOXYCYCLOHEXYL)ETHYLTRIMETHOXYSILANE
$C_{11}H_{22}O_4Si$ 246.38 95-7° / 0.25 1.065 1.4490
Viscosity: 5.2 cSt
Flashpoint: 146°C (295°F)
γc of treated surfaces: 39.5 mN/m
TOXICITY: oral rat, LD50: 12,300 mg/kg
Coefficient of thermal expansion: 0.8 x 10^{-3}
Vapor pressure, 152˚: 10 mm
Specific wetting surface: 317 m^2/g

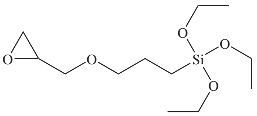
Ring epoxide more reactive than glycidoxypropyl systems
UV initiated polymerization of epoxy group with weak acid donors
Forms UV-curable coating resins by controlled hydrolysis.[1]
Used to make epoxy-organosilica particles w/ high positive Zeta potential.[2]
1. Crivello, J.; Mao. Z. *Chem. Mater.* **1997**, *9*, 1554.
2. Nakamura, M.; Ishimura, K. *Langmuir* **2008**, *24*, 12228.
[3388-04-3] TSCA EC 222-217-1 HMIS: 3-1-1-X 100g 2kg 18kg

COMMERCIAL

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

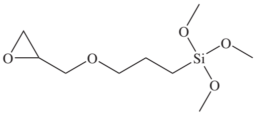


SIE4675.0
5,6-EPOXYHEXYLTRIETHOXYSILANE
$C_{12}H_{26}O_4Si$ 262.42 115-9° / 1.5 0.960^{25} 1.4254^{25}
Flashpoint: 99°C (210°F)
[86138-01-4] HMIS: 3-2-1-X 10g



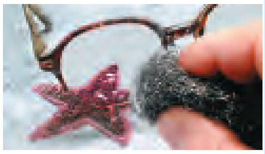
SIG5839.0
(3-GLYCIDOXYPROPYL)TRIETHOXYSILANE
$C_{12}H_{26}O_5Si$ 278.42 124° / 3 1.00 1.425
Viscosity: 3 cSt
Flashpoint: 144°C (291°F)
Autoignition temperature: 225°C
Coupling agent for latex polymers
Primer for aluminum and glass to epoxy coatings and adhesives when applied as a 1-2% solution in solvent
[2602-34-8] TSCA EC 220-011-6 HMIS: 3-1-1-X 25g 100g 2kg

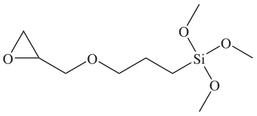
COMMERCIAL



SIG5840.0
(3- GLYCIDOXYPROPYL)TRIMETHOXYSILANE
3-(2,3-EPOXYPROPOXY)PROPYLTRIMETHOXYSILANE
$C_9H_{20}O_5Si$ 236.34 120° / 2 (<-70°) 1.070 1.4290
Viscosity: 3.2 cSt
Flashpoint: 135°C (276°F)
Surface tension: 38.5 mN/m
TOXICITY: oral rat, LD50: 8,400 mg/kg
Specific wetting surface area: 331 m^2/g
Autoignition temperature: 231°C
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.[1]
1. Innocenzi, P. et al. *Chem. Mater.* **1999,** *11*, 1672.
[2530-83-8] TSCA EC 219-784-2 HMIS: 3-1-1-X 100g 2kg 18kg

COMMERCIAL

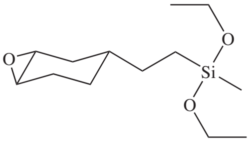




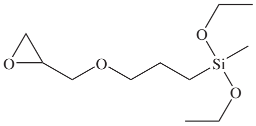
SIG5840.1
(3- GLYCIDOXYPROPYL)TRIMETHOXYSILANE, 99+%
$C_9H_{20}O_5Si$ 236.34 120° / 2 (<-70°) 1.070 1.4290
Flashpoint: 135°C (276°F)
Low fluorescence grade for high-throughput screening
[2530-83-8] TSCA EC 219-784-2 HMIS: 3-1-1-X 25g
* in fluoropolymer bottle

Name **Mw** **bp °C/mm** **(mp °C)** **D_4^{20}** **n_D^{20}**

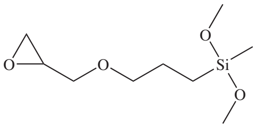
Epoxy Functional Silanes - Dialkoxy



SIE4666.0
2-(3,4-EPOXYCYCLOHEXYL)ETHYLMETHYLDIETHOXYSILANE
$C_{13}H_{26}O_3Si$ 258.43 114-7° / 1 0.976^{25} 1.4248^{25}
UV polymerizeable monomer
[14857-35-3] HMIS: 2-2-1-X 25g
NEW

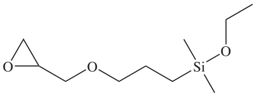


SIG5832.0
(3-GLYCIDOXYPROPYL)METHYLDIETHOXYSILANE
$C_{11}H_{24}O_4Si$ 248.39 122-6° / 5 0.978^{25} 1.431
Flashpoint: 122°C (252°F)
TOXICITY: oral rat, LD50: >2,000 mg/kg
Employed in scratch resistant coatings for eye glasses
Coupling agent for latex systems with reduced tendancy to gel compared to SIG5840.0
[2897-60-1] TSCA EC 220-780-8 HMIS: 2-1-1-X 25g 100g 2kg
COMMERCIAL



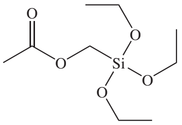
SIG5836.0
(3-GLYCIDOXYPROPYL)METHYLDIMETHOXYSILANE
$C_9H_{20}O_4Si$ 220.34 100° / 4 1.02 1.431^{25}
Flashpoint: 105°C (221°F)
Relative hydrolysis rate vs. SIG5840.0: 7.5:1
[65799-47-5] TSCA EC 265-929-8 HMIS: 3-1-1-X 25g 100g

Epoxy Functional Silanes - Monoalkoxy

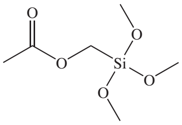


SIG5825.0
(3-GLYCIDOXYPROPYL)DIMETHYLETHOXYSILANE
$C_{10}H_{22}O_3Si$ 218.37 100° / 3 0.950 1.4337^{25}
Flashpoint: 87°C (189°F)
[17963-04-1] TSCA EC 241-889-7 HMIS: 3-2-1-X 10g 50g

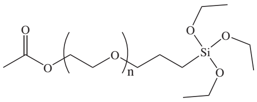
Ester Functional Silanes



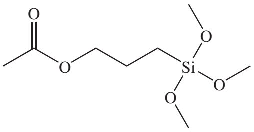
SIA0050.0
ACETOXYMETHYLTRIETHOXYSILANE
$C_9H_{20}O_5Si$ 236.34 106° / 15 1.042^{25} 1.4092
Hydrolyzes to form stable silanol solutions in neutral water
[5630-83-1] TSCA-L HMIS: 2-2-1-X 25g 100g



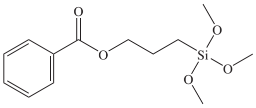
SIA0055.0
ACETOXYMETHYLTRIMETHOXYSILANE, 95%
$C_6H_{14}O_5Si$ 194.26 190-1° 1.085 1.4031
Flashpoint: 56°C (133°F)
[65625-39-0] TSCA-L HMIS: 3-2-1-X 10g 50g



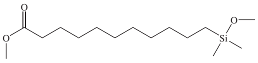
SIA0078.0
2-[(ACETOXY(POLYETHYLENEOXY)PROPYL]TRIETHOXYSILANE, 95%
500 - 700 1.071 1.4527
Viscosity: 30 cSt
HMIS: 2-1-1-X 25g



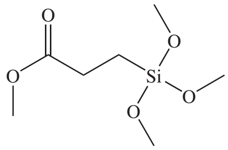
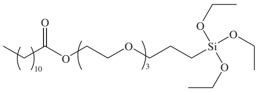
SIA0100.0
3-ACETOXYPROPYLTRIMETHOXYSILANE
$C_8H_{18}O_5Si$ 222.31 92° / 2 1.062 1.4146
γc of treated surfaces: 37.5 mN/m Flashpoint: 93°C (199°F)
Forms sol-gel derived epoxidation catalyst in combination with titanium diisopropoxide bispentanedionate.[1]
1. Müller, C. et al. *Catal. Lett.* **2000**, *64(1), 9-14*, DOI 10.1023/A:109074617565
[59004-18-1] EC 261-552-8 HMIS: 3-1-1-X 25g 100g 2kg
COMMERCIAL



SIB0959.0
BENZOYLOXYPROPYLTRIMETHOXYSILANE
$C_{13}H_{20}O_5Si$ 284.38 145° / 0.2 1.104 1.4806
[76241-02-6] TSCA HMIS: 3-2-1-X 25g

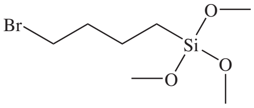
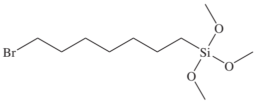
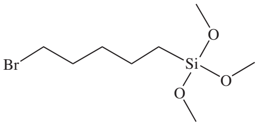
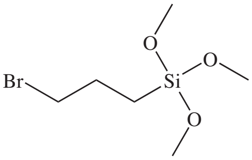
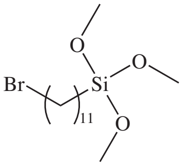
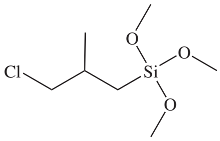
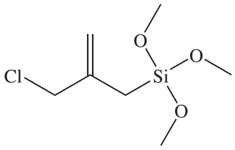


SIC2067.0
10-(CARBOMETHOXY)DECYLDIMETHYLMETHOXYSILANE
$C_{15}H_{32}O_3Si$ 288.50 130° / 0.3 0.903 1.4399
Long chain organofunctional silane
[1211488-83-3] HMIS: 2-1-1-X 10g 50g

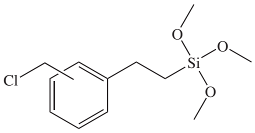
	Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}	
	**SIC2072.0** 2-(CARBOMETHOXY)ETHYLTRIMETHOXYSILANE *METHYL (3-TRIMETHOXYSILYLPROPIONATE)* $C_7H_{16}O_5Si$ Contains ~ 20% 1-(carbomethoxy)ethyltrimethoxysilane isomer [76301-00-3] HMIS: 3-3-1-X 10g	208.29	75° / 1.5 Flashpoint: >43°C (>110°F)		1.069	1.410	
 	**SIT8186.3** TRIETHOXYSILYLPROPOXY(POLYETHYLENEOXY)DODECANOATE, tech-95 $C_{27}H_{56}O_8Si$ 2-4 EO Units Contact angle (treated surface), water: 61-2° Contact angle (treated surface), 2-ethylhexyl palmitate: <15° Provides embedded hydrophilicity with oleophilic compatibility Surface treatments stabilize particle dispersions.[1] 1. Arkles, B. et al. in *Silanes and Other Coupling Agents;* Mittal, K., Ed.; VSP (Brill), 2009, Vol. 5, p. 51. [1041420-54-5] TSCA-L HMIS: 2-1-1-X 25g 100g	536.82			0.977	1.4479^{25}	NEW

Halogen Functional Silanes

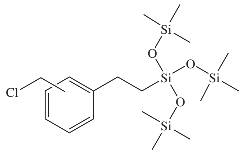
Halogen Functional Silanes - Trialkoxy

	Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}	
	**SIB1879.7** 4-BROMOBUTYLTRIMETHOXYSILANE $C_7H_{17}BrO_3Si$ [226558-82-3] HMIS: 3-2-1-X 10g	257.20	68-9° / 1		1.259	1.4437	NEW
	**SIB1886.0** 7-BROMOHEPTYLTRIMETHOXYSILANE $C_{10}H_{23}BrO_3Si$ HMIS: 3-2-1-X 10g	299.28	83-5° / 1		1.1695^{25}	1.4493^{25}	
	**SIB1894.2** 5-BROMOPENTYLTRIMETHOXYSILANE $C_8H_{19}BrO_3Si$ [773893-02-0] HMIS: 3-2-1-X 10g	271.22	110° / 1		1.222^{25}	1.446	NEW
	**SIB1906.0** 3-BROMOPROPYLTRIMETHOXYSILANE $C_6H_{15}BrO_3Si$ Forms self-assembled monolayers which can be modified with pyridine ligands.[1] 1. Paulson, S. et al. *J. Chem. Soc., Chem. Commun.* **1992,** *21*, 1615. [51826-90-5] EC 257-453-4 HMIS: 2-2-1-X 10g 2.5kg	243.17	130° / 45 Flashpoint: 82°C (180°F)		1.293	1.4400	
	**SIB1909.0** 11-BROMOUNDECYLTRIMETHOXYSILANE, 95% $C_{14}H_{31}BrO_3Si$ Contains undecyltrimethoxysilane [17947-99-8] TSCA-L HMIS: 2-1-0-X 10g	355.39	158° / 0.8		1.119	1.4559	
	**SIC2280.4** 3-CHLOROISOBUTYLTRIMETHOXYSILANE $C_7H_{17}ClO_3Si$ [17256-27-8] HMIS: 3-2-1-X 25g	212.75	59-60° / 2		1.054^{25}	1.4277^{25}	NEW
	**SIC2282.0** 2-(CHLOROMETHYL)ALLYLTRIMETHOXYSILANE $C_7H_{15}ClO_3Si$ Versatile coupling agent [39197-94-9] HMIS: 3-2-1-X 2.5g	210.73	128° / 70 Flashpoint: 89°C (192°F)		1.09		NEW

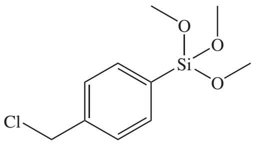
Name — **Mw** — **bp °C/mm** — **(mp °C)** — **D_4^{20}** — **n_D^{20}**



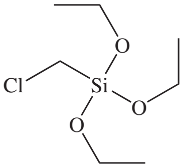
SIC2295.5
((CHLOROMETHYL)PHENYLETHYL)TRIMETHOXYSILANE
$C_{12}H_{19}ClO_3Si$ 274.82 115° / 1.5 1.09^{25} 1.4930^{25}
Mixed *m*-, *p*-isomers Flashpoint: 130°C (266°F)
Adhesion promoter for polyphenylenesulfide and polyimide coatings
Employed as a high temperature coupling agent.[1]
1. Arkles, B. et al. *Modern Plastics* **1980**, *57*, 64.
[68128-25-6] TSCA EC 268-575-2 HMIS: 3-1-1-X 25g 100g 2kg
COMMERCIAL



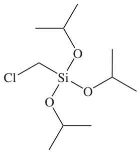
SIC2295.7
CHLOROMETHYLPHENETHYLTRIS(TRIMETHYLSILOXY)SILANE, mixed m,p; α,β isomers
$C_{18}H_{37}ClO_3Si_4$ 449.28 1.007 1.469
Mixed *m*-, *p*-isomers
[167426-89-3] HMIS: 3-2-0-X 25g
NEW



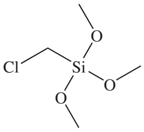
SIC2296.2
(p-CHLOROMETHYL)PHENYLTRIMETHOXYSILANE, 95%
$C_{10}H_{15}ClO_3Si$ 246.77 134-43° / 10 1.14 1.4965
Flashpoint: 183°C (361°F)
Coupling agent for polyimides, e.g in printed circuit boards
Modifies silica for high-throughput peptide synthesis.[1]
1. Houghten, R. et al. *J. Am. Chem. Soc.* **2005,** *127*, 8582.
[24413-04-5] TSCA EC 246-235-4 HMIS: 3-1-1-X 25g 100g 2kg
COMMERCIAL



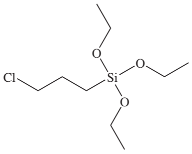
SIC2298.4
CHLOROMETHYLTRIETHOXYSILANE
$C_7H_{17}ClO_3Si$ 212.75 90-1° / 25 1.048 1.4069^{25}
Flashpoint: 47°C (117°F)
TOXICITY: oral rat, LD50: 2,400 mg/kg
Grignard reacts with chlorosilanes or intermolecularly to form carbosilanes.[1]
1. Brondani, D. et al. *Tetrahedron Lett.* **1993,** *34*, 2111.
[15267-95-5] TSCA EC 239-311-3 HMIS: 2-2-1-X 25g 100g 2kg
COMMERCIAL



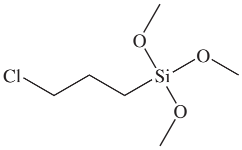
SIC2298.5
CHLOROMETHYLTRIISOPROPOXYSILANE
$C_{10}H_{23}ClO_3Si$ 254.82 195-8° 0.9836 1.4145
Forms Grignard reagents
[18162-82-8] TSCA-L HMIS: 2-2-1-X 25g
NEW



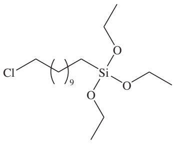
SIC2298.6
CHLOROMETHYLTRIMETHOXYSILANE
$C_4H_{11}ClO_3Si$ 170.67 156° 1.125 1.4070
Flashpoint: 26°C (79°F)
[5926-26-1] TSCA-L HMIS: 3-4-1-X 10g 50g



SIC2407.0
3-CHLOROPROPYLTRIETHOXYSILANE
$C_9H_{21}ClO_3Si$ 240.80 100-2° / 10 1.009 1.420
Flashpoint: 78°C (172°F)
Adhesion promoter for polyamine and epoxy resins
[5089-70-3] TSCA EC 225-805-6 HMIS: 2-2-0-X 25g 2kg 18kg
COMMERCIAL

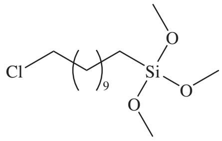


SIC2410.0
3-CHLOROPROPYLTRIMETHOXYSILANE
$C_6H_{15}ClO_3Si$ 198.72 100° / 40 1.077^{25} 1.4183^{25}
Viscosity, 20°: 0.56 cSt Flashpoint: 78°C (172°F)
γc of treated surface: 40.5 mN/m TOXICITY: oral rat, LD50: 5,628 mg/kg
Specific wetting surface: 394 m^2/g Vapor pressure, 100°: 40 mm
Adhesion promoter 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

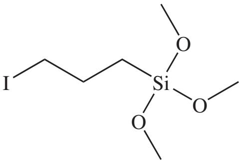


SIC2428.0
11-CHLOROUNDECYLTRIETHOXYSILANE
$C_{17}H_{37}ClO_3Si$ 353.01 112° / 0.01 0.944 1.4390
[120876-31-5] HMIS: 2-1-1-X 10g
NEW

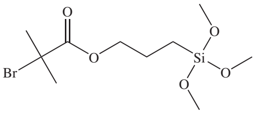
Name | **Mw** | **bp °C/mm** | **(mp °C)** | D_4^{20} | n_D^{20}



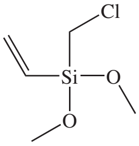
SIC2429.0
11-CHLOROUNDECYLTRIMETHOXYSILANE
$C_{14}H_{31}ClO_3Si$ 310.93 156-8° / 2 0.9855 1.4226
Flashpoint: >110°C (>230°F)
[17948-05-9] HMIS: 2-1-1-X 10g
NEW



SII6452.0
3-IODOPROPYLTRIMETHOXYSILANE
$C_6H_{15}IO_3Si$ 290.17 79-80° / 2 1.475 1.4714
Flashpoint: 78°C (172°F)
Couples zeolite monolayers to glass.[1]
1. Ha, K. et al. *Adv. Mater.* **2002,** *12(15)*, 1114.
[14867-28-8] TSCA-L HMIS: 3-2-1-X 10g 50g

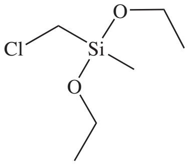


SIT8397.0
(3-TRIMETHOXYSILYL)PROPYL 2-BROMO-2-METHYLPROPIONATE
$C_{10}H_{21}BrO_5Si$ 329.27 90-5° / 0.5 1.243^{25}
For surface initiated ATRP polymerization.[1,2]
1. Mulvihill, M. et al. *J. Am. Chem. Soc.* **2005**, *127*, 16040.
2. Huck, J. et al. *J. Mater. Chem.* **2004**, *14*, 730.
[314021-97-1] HMIS: 2-2-1-X 5g

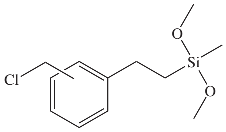


SIV9064.0
VINYL(CHLOROMETHYL)DIMETHOXYSILANE
$C_5H_{11}ClO_2Si$ 166.68
Multi-functional coupling agent
[1314981-48-0] HMIS: 3-3-1-X 10g
NEW

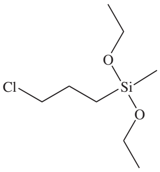
Halogen Functional Silanes - Dialkoxy



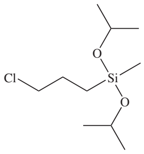
SIC2292.0
CHLOROMETHYLMETHYLDIETHOXYSILANE
$C_6H_{15}ClO_2Si$ 182.72 160-1° 1.000^{25} 1.407
Flashpoint: 38°C (100°F)
TOXICITY: oral rat, LD50: 1,300 mg/kg
Vapor pressure, 70°: 20 mm
[2212-10-4] TSCA EC 218-657-9 HMIS: 3-3-1-X 25g 100g



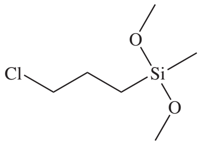
SIC2295.2
((CHLOROMETHYL)PHENYLETHYL)METHYLDIMETHOXYSILANE
$C_{12}H_{19}ClO_2Si$ 258.82 120-5° / 0.5
Mixed *m*-, *p*-isomers
Intermediate for silicone analog of Merrifield resins
[160676-60-8]/[160676-58-4] HMIS: 2-1-1-X 25g



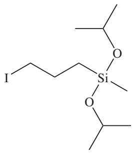
SIC2352.0
3-CHLOROPROPYLMETHYLDIETHOXYSILANE
$C_8H_{19}ClO_2Si$ 210.77 81-3° / 8 0.9744 1.4260
Flashpoint: 80°C (176°F)
Intermediate for functional silicone polymers
[13501-76-3] HMIS: 2-2-1-X 100g
NEW



SIC2353.0
3-CHLOROPROPYLMETHYLDIISOPROPOXYSILANE
$C_{10}H_{23}ClO_2Si$ 238.84 92-4° / 10 0.93
HMIS: 2-2-1-X 25g
NEW



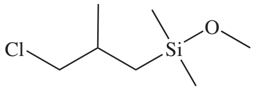
SIC2355.0
3-CHLOROPROPYLMETHYLDIMETHOXYSILANE
$C_6H_{15}ClO_2Si$ 182.72 70-2° / 11 1.0250 1.4253
Specific wetting surface: 428 m^2/g Flashpoint: 80°C (176°F)
[18171-19-2] TSCA EC 242-056-0 HMIS: 3-2-1-X 100g 2kg 18kg
COMMERCIAL



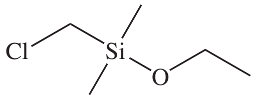
SII6451.2
(3-IODOPROPYL)METHYLDIISOPROPOXYSILANE
$C_{10}H_{23}IO_2Si$ 330.27 50-3° / 0.3 1.257 1.4623
HMIS: 3-2-1-X 10g
NEW

Name **Mw** **bp °C/mm** **(mp °C)** **D_4^{20}** **n_D^{20}**

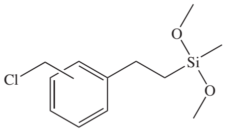
Halogen Functional Silanes - Monoalkoxy



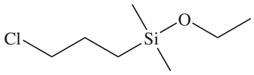
SIC2278.0
3-CHLOROISOBUTYLDIMETHYLMETHOXYSILANE
$C_7H_{17}ClOSi$ 180.75 182° 0.950 1.4331^{25}
[18244-08-1] TSCA HMIS: 3-3-1-X 25g



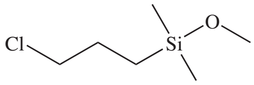
SIC2286.0
CHLOROMETHYLDIMETHYLETHOXYSILANE
$C_5H_{13}ClOSi$ 152.70 132-3° 0.944^{25} 1.412^{25}
Dipole moment: 2.14 debye
Flashpoint: 26°C (79°F)
TOXICITY: oral rat, LD50: 1,550 mg/kg
[13508-53-7] TSCA EC 236-835-4 HMIS: 3-3-1-X 25g



SIC2295.2
((CHLOROMETHYL)PHENYLETHYL)METHYLDIMETHOXYSILANE
$C_{12}H_{19}ClO_2Si$ 258.82 120-5° / 0.5
Mixed *m*-, *p*-isomers
Intermediate for silicone analog of Merrifield resins
[160676-60-8]/[160676-58-4] HMIS: 2-1-1-X 25g

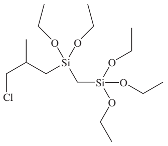


SIC2337.0
3-CHLOROPROPYLDIMETHYLETHOXYSILANE
$C_7H_{17}ClOSi$ 180.75 87° / 30 0.932^{25} 1.427^{25}
Flashpoint: 46°C (115°F)
[13508-63-9] EC 236-837-5 HMIS: 2-3-1-X 25g



SIC2338.0
3-CHLOROPROPYLDIMETHYLMETHOXYSILANE, 95%
$C_6H_{15}ClOSi$ 166.73 170-1° 0.941 1.4278
Flashpoint: 39°C (102°F)
[18171-14-7] EC 242-055-5 HMIS: 3-2-1-X 10g

Halogen Functional Silanes - Dipodal

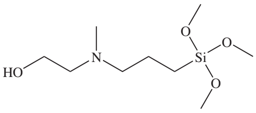


SIC2279.3
1-(3-CHLOROISOBUTYL)-1,1,3,3,3-PENTAETHOXY-1,3-DISILAPROPANE, 95%
$C_{15}H_{35}ClO_5Si_2$ 387.06 115-7° / 0.5 1.020
Pendant dipolar silane
HMIS: 3-1-1-X 10g

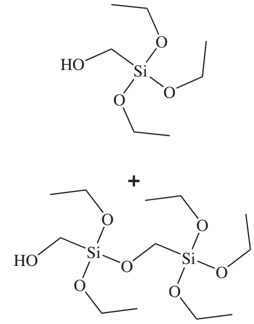
NEW

Hydroxyl Functional Silanes

Hydroxyl Functional Silanes - Trialkoxy



SIH6172.0
N-(HYDROXYETHYL)-N-METHYLAMINOPROPYLTRIMETHOXYSILANE, 75% in methanol
$C_9H_{23}NO_4Si$ 237.37 0.99 1.417
Flashpoint: 11°C (52°F)
[330457-46-0] HMIS: 3-4-1-X 25g 100g

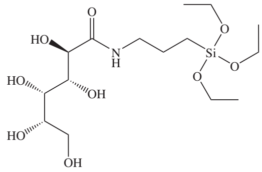


SIH6175.0
HYDROXYMETHYLTRIETHOXYSILANE, 50% in ethanol
TRIETHOXYSILYLMETHANOL
$C_7H_{18}O_4Si$ 194.31 0.866
Flashpoint: 15°C (59°F)

Contains equilibrium condensation oligomers
Hydrolysis yields analogs of silica-hydroxymethylsilanetriol polymers.[1]
Cohydrolysates form highly water dispersible nanoparticles.[2]
Functionalizes magnetic particles utilized in nucleic acid separation.[3]
Functionalizes nanoparticles for "stealth therapeutic" biomedical applications.[4]

1. Arkles, B. et al. *Silicon* **2013**, *5*, 187; DOI 10.1007/s12633-013-9146-2.
2. Du, H. et al. *J. Colloid Interface Sci.* **2009**, *340*, 202.
3. Templer, D. Eur Pat App. EP 1748 072 A1, 2007.
4. Neoh, K. G. et al. *Polymer Chemistry* **2011**, *2*, 747.

[162781-70-6] TSCA-L HMIS: 2-4-0-X 25g



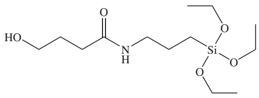
SIT8189.0
N-(3-TRIETHOXYSILYLPROPYL)GLUCONAMIDE, 50% in ethanol
GLUCONAMIDOPROPYLTRIETHOXYSILANE
$C_{15}H_{33}NO_9Si$ 399.51 0.951
Flashpoint: 15°C (59°F)

Water soluble, hydrophilic silane
Modifies silica micro-capillaries to enhance flow of aqueous media.[1]

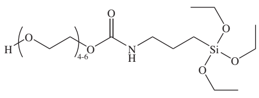
1. Constable, H. et al. *Colloids Surf., A* **2011**, *380*, 128.

[104275-58-3] HMIS: 2-4-1-X 25g 100g 2kg

Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}

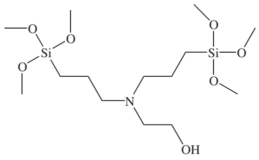


SIT8189.5
N-(3-TRIETHOXYSILYLPROPYL)-4-HYDROXYBUTYRAMIDE
$C_{13}H_{29}NO_5Si$ 307.47 1.02 1.4533
Anchoring reagent for light directed synthesis of DNA on glass.[1]
1. McGall, G. et al. *J. Am. Chem. Soc.* **1997**, *119*, 5081.
[156214-80-1] HMIS: 2-2-1-X 10g 50g



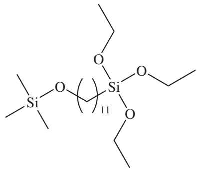
SIT8192.0
N-(TRIETHOXYSILYLPROPYL)-O-POLYETHYLENE OXIDE URETHANE, 95%
$C_{10}H_{22}NO_4SiO(CH_2CH_2O)_{4-6}H$ 400-500 1.09 1.4540^{25}
Contains some bis(urethane) analog
Viscosity: 75-125 cSt
Hydrophilic surface modifier
Forms PEGylated glass surfaces suitable for capillary electrophoresis.[1]
1. Razunguzwa, T. et al. *Anal. Chem.* **2006**, *78*, 4326.
[74695-91-3] TSCA HMIS: 2-1-1-X 25g 100g 2kg
COMMERCIAL

Dipodal Hydroxyl Functional Silanes



SIH6171.5
N-(HYDROXYETHYL)-N,N-BIS(TRIMETHOXYSILYLPROPYL)AMINE, 65% in methanol
$C_{14}H_{35}NO_7Si_2$ 385.61 0.97
Flashpoint: 15°C (59°F)
Dipodal silane with hydroxyl functionality
[264128-94-1] TSCA HMIS: 3-4-1-X 10g
NEW

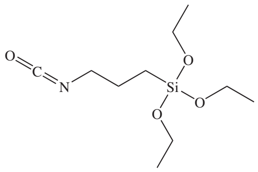
Masked Hydroxyl Functional Silanes



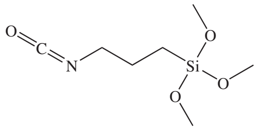
SIT8572.8
11-(TRIMETHYLSILOXY)UNDECYLTRIETHOXYSILANE
$C_{20}H_{46}O_4Si_2$ 406.75 145° / 0.3 0.887^{25} 1.4264^{25}
Masked hydroxyl - deprotected after deposition with acidic aqueous ethanol
[75389-03-6] HMIS: 2-1-1-X 5g

Isocyanate and Masked Isocyanate Functional Silanes

Isocyanate Functional Silanes - Trialkoxy

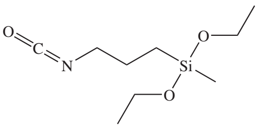


SII6455.0
3-ISOCYANATOPROPYLTRIETHOXYSILANE, 95%
$C_{10}H_{21}NO_4Si$ 247.37 130° / 20 0.990 1.4190
Flashpoint: 80°C (176°F)
TOXICITY: oral rat, LD50: 710 mg/kg
Component in hybrid organic/inorganic urethanes.[1]
1. Cuney, S. et al. *Better Ceramics Through Chemistry VII (MRS. Symp. Proc.)* **1996,** *435*, 143.
[24801-88-5] TSCA EC 246-467-6 HMIS: 3-2-1-X 25g 100g 2kg
COMMERCIAL

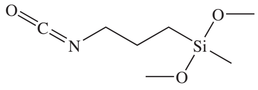


SII6456.0
3-ISOCYANOTOPROPYLTRIMETHOXYSILANE, 95%
$C_7H_{15}NO_4Si$ 205.29 95-8° / 10 1.073 1.4219
Viscosity: 1.4 cSt
Flashpoint: 108°C (226°F)
TOXICITY: oral rat, LD50: 878 mg/kg
Autoignition temperature: 265˚C
[15396-00-6] TSCA EC 239-415-9 HMIS: 3-2-1-X 25g 100g 2kg
COMMERCIAL

Isocyanate Functional Silanes - Dialkoxy



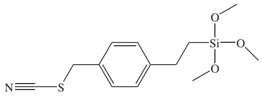
SII6454.45
3-ISOCYANATOPROPYLMETHYLDIETHOXYSILANE, 95%
$C_9H_{19}NO_3Si$ 217.34 110-5° / 10
Reacts rapidly with amine and hydroxyl functional species that can hydrolyze to form siloxane polymers
[33491-28-0] HMIS: 3-2-1-X 10g
NEW



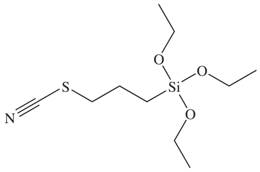
SII6454.5
3-ISOCYANATOPROPYLMETHYLDIMETHOXYSILANE, tech-95
$C_7H_{15}NO_3Si$ 189.29 61° / 1 1.03
Contains isomers
[26115-72-0] HMIS: 3-2-1-X 10g
NEW

Name Mw bp °C/mm (mp °C) D_4^{20} n_D^{20}

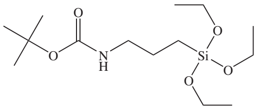
Masked Isocyanate Functional Silanes



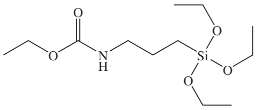
SIT7907.7
(THIOCYANATOMETHYL)PHENETHYLTRIMETHOXYSILANE, tech-95
$C_{13}H_{19}NO_3SSi$ 297.44 100-5° / 0.5
Contains isomers Flashpoint: >110°C (>230°F)
On exposure to UV light of 254 nm undergoes conversion to isothiocyanate which reacts w/ amines, etc.
HMIS: 3-2-1-X 10g
NEW



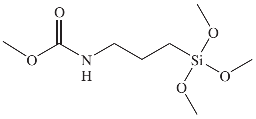
SIT7908.0
3-THIOCYANATOPROPYLTRIETHOXYSILANE, 96%
$C_{10}H_{21}NO_3SSi$ 263.43 95° / 0.1 1.03 1.4460
Flashpoint: 112°C (234°F)
TOXICITY: oral rat, LD50: 1,423 mg/kg
Complexing agent for Ag, Au, Pd, Pt.[1]
Potential adhesion promoter for gold.[2]
1. Schilling, T. et al. *Mikrochemica Acta* **1996,** *124*, 235.
2. Ciszek, J. W. et al. *J. Am. Chem. Soc.* **2004,** *126*, 13172.
[34708-08-2] TSCA EC 252-161-3 HMIS: 3-1-1-X 50g 250g 2kg
COMMERCIAL



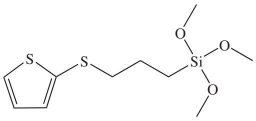
SIT8186.5
N-(3-TRIETHOXYSILYLPROPYL)-O-t-BUTYLCARBAMATE
$C_{14}H_{31}NO_5Si$ 321.49 110-5° / 0.2 0.990 1.4334
Flashpoint: >65°C (>150°F)
Masked isocyanate
[137376-38-6] HMIS: 2-1-1-X 25g 100g 2kg



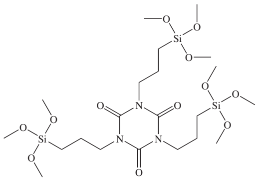
SIT8188.0
TRIETHOXYSILYLPROPYL ETHYLCARBAMATE
$C_{12}H_{27}NO_5Si$ 293.44 124-6° / 0.5 1.015 1.4321
Flashpoint: 95°C (203°F)
Masked isocyanate
[17945-05-0] TSCA EC 241-872-4 HMIS: 2-1-1-X 25g 100g 2kg
COMMERCIAL



SIT8407.0
N-TRIMETHOXYSILYLPROPYLMETHYLCARBAMATE
METHYL [3-(TRIMETHOXYSILYL)PROPYL]CARBAMATE
$C_8H_{19}NO_5Si$ 237.32 102° / 0.75 1.1087
Viscosity: 12 cSt Flashpoint: 99°C (210°F)
Autoignition temperature: 385˚C
[23432-62-4] HMIS: 3-2-1-X 25g
NEW

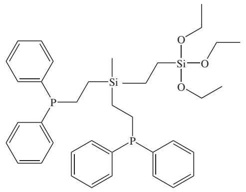


SIT8411.0
2-(3-TRIMETHOXYSILYLPROPYLTHIO)THIOPHENE
$C_{10}H_{18}O_3S_2Si$ 278.46 125-7° / 0.4 1.136^{25} 1.5123^{25}
Contact angle, water on treated silica surface: 76˚
[1364140-50-0] HMIS: 3-2-1-X 10g
NEW



SIT8717.0
TRIS(3-TRIMETHOXYSILYLPROPYL)ISOCYANURATE, tech-95
$C_{21}H_{45}N_3O_{12}Si_3$ 615.86 1.170 1.4610
Viscosity: 325-350 cSt. Flashpoint: 102°C (216°F)
Coupling agent for polyimides to silicon metal
Adhesion promoter for hotmelt adhesives
Forms periodic mesoporous silicas.[1]
1. Zhang, W. et al. *Chem. Mater.* **2007**, *19*, 2663.
[26115-70-8] TSCA EC 247-465-8 HMIS: 2-1-1-X 25g 100g 2kg
COMMERCIAL

Phosphine and Phosphate Functional Silanes



SIB1091.0

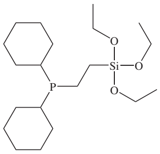
BIS(2-DIPHENYLPHOSPHINOETHYL)METHYLSILYLETHYLTRIETHOXYSILANE, mixed isomers

$C_{37}H_{50}O_3P_2Si_2$ 660.92 1.07 1.5746

Analogous structures form ruthenium(II) complexes with high selectivity for hydrogenation and non-leachable binding to solid supports.[1]

1. Wu, D. et al. *Chem. Mater.* **2005,** *17*, 3951.

HMIS: 2-2-1-X 1.0g



SID3385.0

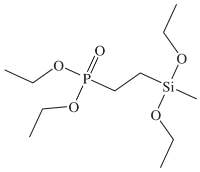
(2-DICYCLOHEXYLPHOSPHINOETHYL)TRIETHOXYSILANE

$C_{20}H_{41}O_3PSi$ 388.60 140° / 0.03 0.979^{25} 1.4811^{25}

Ligand for immobilization of precious metal catalytic complexes

[55289-47-9] HMIS: 3-1-0-X 5g

NEW



SID3411.0

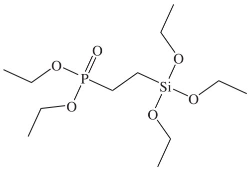
(2-DIETHYLPHOSPHATOETHYL)METHYLDIETHOXYSILANE, tech-95

$C_{11}H_{27}O_5PSi$ 298.39 124° / 2 1.020 1.4270^{25}

Comonomer for hydrophilic coatings

[18048-06-1] HMIS: 3-2-1-X 10g

NEW



SID3412.0

(2-DIETHYLPHOSPHATOETHYL)TRIETHOXYSILANE, tech-95

DIETHYLPHOSPHONATOETHYLTRIETHOXYSILANE

$C_{12}H_{29}O_6PSi$ 328.41 141° / 2 1.031^{25} 1.4216

Flashpoint: 70°C (158°F)

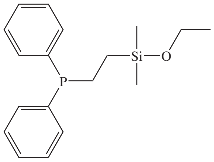
Water-soluble silane; anti-pilling agent for textiles.

Hydrolysis product catalytically hydrates olefins, forming alcohols.[1]

Forms corrosion resistant films for magnesium alloys.[2]

1. Young, F. et al. U.S. Patent 3,816,550, 1974.
2. Kramov, A. et al. *Thin Solid Films* **2006**, *174*, 514.

[757-44-8] TSCA EC 212-056-5 HMIS: 3-2-1-X 25g 100g

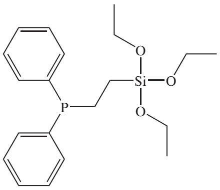


SID4557.5

(2-DIPHENYLPHOSPHINO)ETHYLDIMETHYLETHOXYSILANE

$C_{18}H_{25}OPSi$ 316.46 160° / 1 1.004 1.5630

[359859-29-3] HMIS: 2-2-1-X 10g



SID4558.0

2-(DIPHENYLPHOSPHINO)ETHYLTRIETHOXYSILANE

$C_{20}H_{29}O_3PSi$ 376.50 182° / 1.3 1.05 1.5384

Flashpoint: 134°C (273°F)

Immobilizing ligand for precious metals

Adhesion promoter for gold substrates in microelectronic applications.[1]

Forms stable bonds to silica and basic alumina suitable for catalyst immobilization.[2]

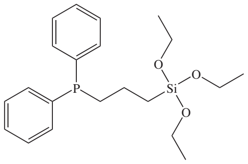
Forms luminescent gels on hydrolysis with $(EtO)_4Si$ and $Eu(NO_3)_3$.[3]

Used to immobilize an iridium catalyst for the enantioselective hydrogenation of aryl ketones.[4]

Used in the preparation of solid-phase Pd catalyst for Suzuki-Miyaura cross-coupling.[5]

1. Helbert, J. U.S. Patent 4,497,890, 1985.
2. Merchle, C. H. et al. *Chem. Mater.* **2001,** *13*, 3617.
3. Corriu, R. et al. *J. Chem. Soc., Chem. Commun.* **2001**, 1116.
4. Liu, G. et al. *Adv. Synth. Catal.* **2008**, *350,* 1464.
5. Zhang, X. et al. *Synthesis*, **2011**, 2975.

[18586-39-5] TSCA EC 242-427-7 HMIS: 3-1-1-X 5g 25g



SID4558.2

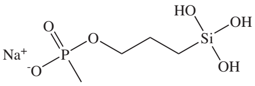
3-(DIPHENYLPHOSPHINO)PROPYLTRIETHOXYSILANE

$C_{21}H_{31}O_3PSi$ 390.53 190° / 1

Flashpoint: >110°C (>230°F)

[52090-23-0] HMIS: 3-1-1-X 1.0g

NEW



SIT8378.5

3-(TRIHYDROXYSILYL)PROPYL METHYLPHOSPHONATE, MONOSODIUM SALT, 42% in water

$C_4H_{12}NaO_6PSi$ 238.18 1.25

Contains 4-5% methanol, sodium methylphosphonate Flashpoint: 79°C (174°F)

Forms functionalized silica nanoparticles employed in amperometric glucose sensor.[1]

1. Zhao, W. et al. *Electrochim. Acta* **2013**, *89*, 278.

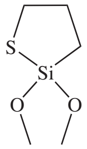
[84962-98-1] TSCA EC 284-799-3 HMIS: 1-2-0-X 100g 500g 2.5kg

COMMERCIAL

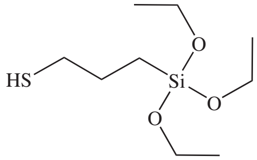
Name Mw bp °C/mm (mp °C) D_4^{20} n_D^{20}

Sulfur Functional Silanes

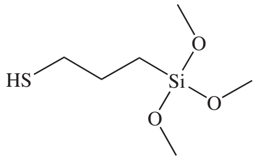
Sulfur Functional Silanes - Trialkoxy



SID3545.0
2,2-DIMETHOXY-1-THIA-2-SILACYCLOPENTANE
$C_5H_{12}O_2SSi$ 164.29 57-8° / 7 1.094
Reagent for modification of silver and gold surfaces
Coupling agent for rubber
[26903-85-5] HMIS: 3-3-1-X 25g



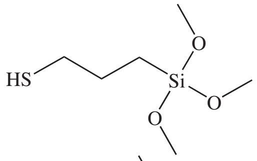
SIM6475.0
3-MERCAPTOPROPYLTRIETHOXYSILANE, 95%
$C_9H_{22}O_3SSi$ 238.42 210° 0.9325 1.4331
Flashpoint: 88°C (190°F)
TOXICITY: oral rat, LD50: >2,000 mg/kg
For blocked version see SIO6704.0
Used to make thiol-organosilica nanoparticles.[1]
1. Nakamura, M.; Ishimura, K. *Langmuir* **2008**, *24*, 5099.
[14814-09-6] TSCA EC 238-883-1 HMIS: 2-2-1-X 25g 100g 2kg



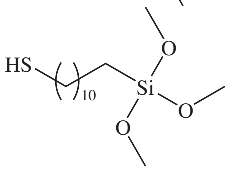
SIM6476.0
3-MERCAPTOPROPYLTRIMETHOXYSILANE
$C_6H_{16}O_3SSi$ 196.34 93° / 40 1.051^{25} 1.4502^{25}
Viscosity: 2 cSt
γc of treated surfaces: 41 mN/m
Specific wetting surface: 348 m^2/g
Flashpoint: 96°C (205°F)
TOXICITY: oral rat, LD50: 2,380 mg/kg
Primary irritation index: 0.19
Coupling agent for EPDM and mechanical rubber applications
Adhesion promoter for polysulfide adhesives
For enzyme immobilization.[1]
Treatment of mesoporous silica yields highly efficient heavy metal scavenger.[2]
Couples fluorescent biological tags to semiconductor CdS nanoparticles.[3]
Modified mesoporous silica supports Pd in coupling reactions.[4]
Used to make thiol-organosilica nanoparticles.[5]
Forms modified glass and silica surfaces suitable for SILAR fabrication of CdS thin films.[6]
1. Stjernlöf, P. et al. *Tetrahedron Lett.* **1990,** *31*, 5773.
2. Liu, J. et al. *Science* **1997,** *276*, 923.
3. Bruchez, M. et al. *Science* **1998,** *281*, 2013.
4. Crudden, C. et al. *J. Am. Chem. Soc.* **2005,** *127*, 10045.
5. Nakamura, M.; Ishimura, K. *Langmuir* **2008**, *24*, 5099.
6. Sun, H. et al. *J. Dispersion Sci. Technol.* **2005,** *26*, 719.
[4420-74-0] TSCA EC 224-588-5 HMIS: 3-2-1-X 100g 2kg 18kg

COMMERCIAL

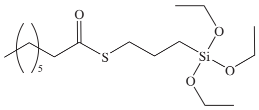
Adhesion promoter for structural polysulfide glass sealants



SIM6476.1
3-MERCAPTOPROPYLTRIMETHOXYSILANE, 99+%
$C_6H_{16}O_3SSi$ 196.34 93° / 40 1.051^{25} 1.4502^{25}
Flashpoint: 96°C (205°F)
Low fluorescence grade for high-throughput screening
[4420-74-0] TSCA EC 224-588-5 HMIS: 3-2-1-X 25g
* in fluoropolymer bottle

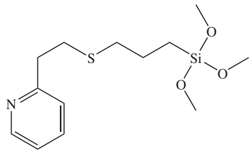


SIM6480.0
11-MERCAPTOUNDECYLTRIMETHOXYSILANE, 95%
$C_{14}H_{32}O_3SSi$ 308.55 150° / 0.5 0.955
Stabilizes ionic liquid drop micro-reactors.[1]
1. Zhang, X. et al. *J. Nanotechnol.* **2012**, *3*, 33.
[877593-17-4] HMIS: 3-2-1-X 2.5g

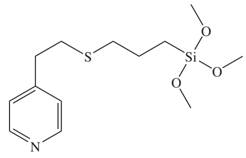


SIO6704.0
S-(OCTANOYL)MERCAPTOPROPYLTRIETHOXYSILANE
$C_{17}H_{36}O_4SSi$ 364.62 0.9686 1.4515
Flashpoint: 176°C (349°F)
TOXICITY: oral rat, LD50: >2,000 mg/kg
Masked mercaptan - deblocked with alcohols
Latent coupling agent for butadiene rubber
[220727-26-4] TSCA HMIS: 2-1-1-X 25g 100g 18kg

COMMERCIAL

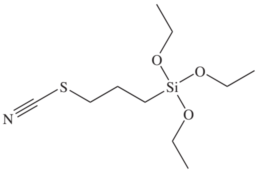


SIP6926.2
3-(2-PYRIDYLETHYL)THIOPROPYLTRIMETHOXYSILANE
$C_{13}H_{23}NO_3SSi$ 301.48 156-7° / 0.25 1.089 1.498
[29098-72-4] HMIS: 3-2-1-X 10g



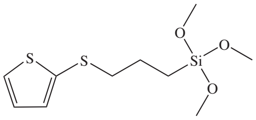
SIP6926.4
3-(4-PYRIDYLETHYL)THIOPROPYLTRIMETHOXYSILANE, 95%
$C_{13}H_{23}NO_3SSi$ 301.48 160-2° / 0.2 1.09 1.5037
pKa: 4.8
Immobilizable ligand for immunoglobulin IgG separation using hydrophobic charge induction chromatography (HCIC)
[198567-47-4] HMIS: 3-2-1-X 10g

Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}



SIT7908.0
3-THIOCYANATOPROPYLTRIETHOXYSILANE, 96%
$C_{10}H_{21}NO_3SSi$ 263.43 95° / 0.1 1.03 1.4460
Flashpoint: 112°C (234°F)
TOXICITY: oral rat, LD50: 1,423 mg/kg
Complexing agent for Ag, Au, Pd, Pt.[1]
Potential adhesion promoter for gold.[2]
1. Schilling, T. et al. *Mikrochemica Acta* **1996,** *124*, 235.
2. Ciszek, J. W. et al. *J. Am. Chem. Soc.* **2004,** *126*, 13172.
[34708-08-2] TSCA EC 252-161-3 HMIS: 3-1-1-X 50g 250g 2kg

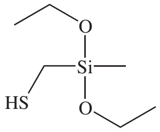
COMMERCIAL



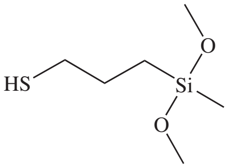
SIT8411.0
2-(3-TRIMETHOXYSILYLPROPYLTHIO)THIOPHENE
$C_{10}H_{18}O_3S_2Si$ 278.46 125-7° / 0.4 1.136^{25} 1.5123^{25}
Contact angle, water on treated silica surface: 76˚
[1364140-50-0] HMIS: 3-2-1-X 10g

NEW

Sulfur Functional Silanes - Dialkoxy



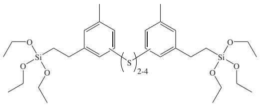
SIM6473.0
(MERCAPTOMETHYL)METHYLDIETHOXYSILANE, 95%
$C_6H_{16}O_2SSi$ 180.34 60° / 10 0.975 1.4446
Flashpoint: 58°C (136°F)
[55161-63-2] HMIS: 3-2-1-X 10g



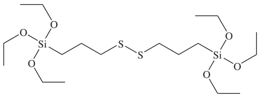
SIM6474.0
3-MERCAPTOPROPYLMETHYLDIMETHOXYSILANE, 96%
$C_6H_{16}O_2SSi$ 180.34 96° / 30 1.000 1.4502
Flashpoint: 93°C (199°F)
Intermediate for silicones in thiol-ene UV-cure systems
Adhesion promoter for polysulfide sealants
Used to make thiol-organosilica nanoparticles.[1]
1. Nakamura, M.; Ishimura, K. *Langmuir* **2008**, *24*, 5099.
[31001-77-1] TSCA EC 250-426-8 HMIS: 3-2-1-X 100g 2kg 18kg

COMMERCIAL

Sulfur Functional Silanes - Dipodal

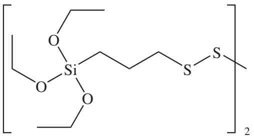


SIB1820.5
BIS[m-(2-TRIETHOXYSILYLETHYL)TOLYL]POLYSULFIDE, tech-90
$C_{30}H_{50}O_6S_{(2-4)}Si_2$ 627-691 1.10 1.533
Dark, viscous liquid
Flashpoint: 55°C (131°F)
Coupling agent for SBR rubber
[198087-81-9]/[85912-75-0]/[67873-85-2] TSCA HMIS: 2-2-1-X 25g 2kg



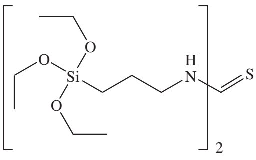
SIB1824.6
BIS[3-(TRIETHOXYSILYL)PROPYL]DISULFIDE, 90%
BIS(TRIETHOXYSILYL)-4,5-DITHIOOCTANE
$C_{18}H_{42}O_6S_2Si_2$ 474.82 1.025 1.457
Contains sulfide and tetrasulfide
Flashpoint: 75°C (167°F)
Dipodal coupling agent/vulcanizing agent for rubbers
Intermediate for mesoporous silicas with acidic pores.[1]
1. Alauzun, J. et al. *J. Am. Chem. Soc.* **2006**, *128*, 8718.
[56706-10-6] TSCA EC 260-350-7 HMIS: 2-2-1-X 25g 100g 2kg

COMMERCIAL



SIB1825.0
BIS[3-(TRIETHOXYSILYL)PROPYL]TETRASULFIDE, tech-95
TESPT
$C_{18}H_{42}O_6S_4Si_2$ 538.94 250° dec 1.095 1.49
Contains distribution of S2 - S10 species; average 3.8
Flashpoint: 91°C (196°F)
Viscosity: 11 cSt
TOXICITY: oral rat, LD50: 16,400 mg/kg
Adhesion promoter for precious metals
Coupling agent/vulcanizing agent for "green" tires
Adhesion promoter for PVD copper on parylene.[1]
1. Pimanpang, S. et al. *J. Vac. Sci. Technol. A* **2006**, *24*, 1884.
[40372-72-3] TSCA EC 254-896-5 HMIS: 2-2-1-X 100g 2kg 18kg

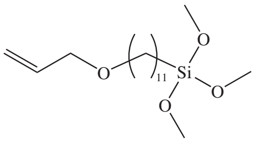
COMMERCIAL



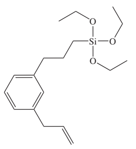
SIB1827.0
N,N'-BIS[3-(TRIETHOXYSILYL)PROPYL]THIOUREA, 90%
$C_{19}H_{44}N_2O_6SSi_2$ 484.73 1.047 1.4696
Flashpoint: >110°C (>230°F)
Forms films on electrodes for determination of mercury.[1]
1. Guo, Y. et al. *J. Pharm. Biol. Anal.* **1999**, *19* 175.
[69952-89-2] HMIS: 2-1-1-X 25g

Vinyl and Olefin Functional Silanes

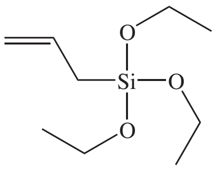
Vinyl and Olefin Functional Silanes - Trialkoxy



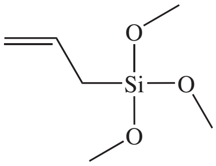
SIA0482.0
11-ALLYLOXYUNDECYLTRIMETHOXYSILANE
$C_{17}H_{36}O_4Si$ 332.56 140° / 0.5 0.914 1.4415
ω-olefin for functional self-assembled monolayers (SAMs)
[1196453-35-6] HMIS: 2-1-0-X 5g



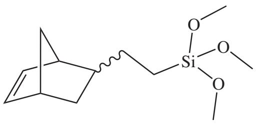
SIA0489.0
m-ALLYLPHENYLPROPYLTRIETHOXYSILANE
$C_{18}H_{30}O_3Si$ 322.52
Coupling agent for amine functional aromatic optical coatings
HMIS: 2-2-1-X 5g
NEW



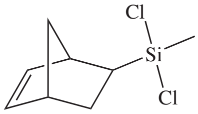
SIA0525.0
ALLYLTRIETHOXYSILANE
3-(TRIETHOXYSILYL)-1-PROPENE
$C_9H_{20}O_3Si$ 204.34 176° 0.9030 1.4074
Dipole moment: 1.79 debye
Flashpoint: 47°C (117°F)
Vapor pressure, 100˚: 50 mm
Extensive review on the use in silicon-based cross-coupling reactions.[1]
1. Denmark, S. E. et al. *Organic Reactions,* Vol. 75, Denmark, S. E. Ed., John Wiley and Sons, 233, **2011**.
[2550-04-1] TSCA EC 219-843-2 HMIS: 2-2-1-X 10g 50g



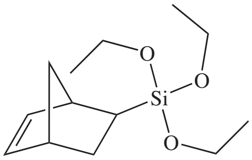
SIA0540.0
ALLYLTRIMETHOXYSILANE
$C_6H_{14}O_3Si$ 162.26 146-8° 0.963^{25} 1.4036^{25}
Flashpoint: 46°C (115°F)
Adhesion promoter for vinyl-addition silicones
Allylation of ketones, aldehydes and imines with dual activation of a Lewis Acid and fluoride ion.[1]
Used in the regioselective generation of the thermodynamically more stable enol trimethoxysilyl ethers, which in turn are used in the asymmetric generation of quaternary carbon centers.[2]
Converts arylselenyl bromides to arylallylselenides.[3]
Allylates aryl iodides.[4]
1. Yamasaki, S. et al. *J. Am. Chem. Soc.* **2002,** *124*, 6536.
2. Ichibakase, T. et al. *Tetrahedron Lett.* **2008**, *49*, 4427.
3. Bhadra, S. et al. *J. Org. Chem.* **2010**, *75*, 4864.
4. Mowery, M. E.; DeShong, P. *J. Org. Chem.* **1999***, 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 HMIS: 3-2-1-X 10g 50g 2kg
COMMERCIAL



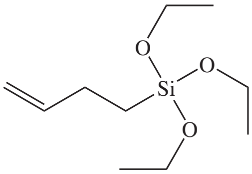
SIB0988.0
[(5-BICYCLO[2.2.1]HEPT-2-ENYL)ETHYL]TRIMETHOXYSILANE, tech-95, endo/exo isomers
$C_{12}H_{22}O_3Si$ 242.39 65° / 10 1.02 1.458
[68323-30-8] HMIS: 2-1-1-X 25g 2kg



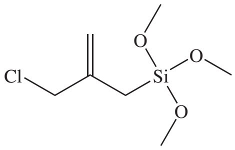
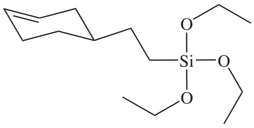
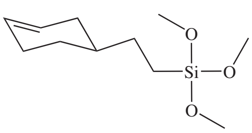
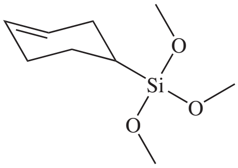
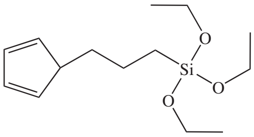
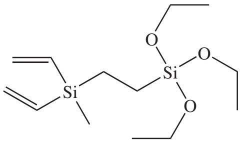
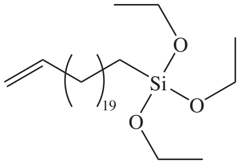
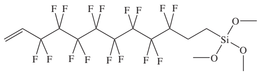
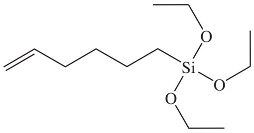
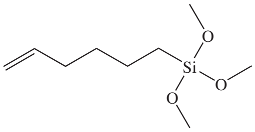
SIB0990.0
(5-BICYCLO[2.2.1]HEPT-2-ENYL)METHYLDICHLOROSILANE, 95%
$C_8H_{12}Cl_2Si$ 207.17 74-5° / 10 1.151 1.4938
Flashpoint: 86°C (187°F)
[18245-94-8] TSCA EC 242-122-9 HMIS: 3-2-1-X 10g
NEW



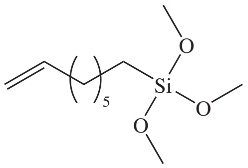
SIB0992.0
(5-BICYCLO[2.2.1]HEPT-2-ENYL)TRIETHOXYSILANE
NORBORNENYLTRIETHOXYSILANE
$C_{13}H_{24}O_3Si$ 256.42 106-8° / 8 0.960 1.4486
Flashpoint: 98°C (208°F)
Coupling agent for norbornadiene rubbers
Component in low dielectric constant films
Undergoes ring-opening metathetic polymerization (ROMP) with $RuCl_2(P(C_6H_5)_3)_3$.[1]
1. Finkelstein, E. *10th Int'l Organosilicon Symp. Proc.* **1993,** P-120.
[18401-43-9] TSCA EC 242-278-8 HMIS: 2-2-1-X 10g 50g



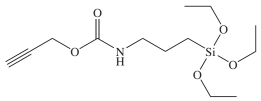
SIB1928.0
3-BUTENYLTRIETHOXYSILANE, 95%
$C_{10}H_{22}O_3Si$ 218.37 64° / 6 (-80°) 0.90
Mixed isomers (mainly 3-butenyl)
Flashpoint: 73°C (163°F)
TOXICITY: oral rat, LD50: >5,000 mg/kg
[57813-67-9] HMIS: 2-2-1-X 25g

	Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}
	**SIC2282.0**					
	2-(CHLOROMETHYL)ALLYLTRIMETHOXYSILANE					
	$C_7H_{15}ClO_3Si$	210.73	128° / 70		1.09	
			Flashpoint: 89°C (192°F)			NEW
	Versatile coupling agent					
	[39197-94-9]	HMIS: 3-2-1-X	2.5g			
	**SIC2459.5**					
	[2-(3-CYCLOHEXENYL)ETHYL]TRIETHOXYSILANE					
	$C_{14}H_{28}O_3Si$	272.46			0.948	1.444
	Contains isomers		Flashpoint: 120°C (248°F)			
	[77756-79-7]	HMIS: 2-1-1-X	10g	50g		
	**SIC2460.0**					
	[2-(3-CYCLOHEXENYL)ETHYL]TRIMETHOXYSILANE					
	$C_{11}H_{22}O_3Si$	230.38	109° / 6		1.02	1.4476
	Contains isomers		Flashpoint: 80°C (176°F)			
	Orients liquid crystals in display devices.[1]					
	Coupling agent for aramid fiber reinforced epoxy.[2]					
	1. Sharp, *Chem. Abstr.* 101,81758g; Jap. Patent JP 58122517, 1983.					
	2. Lechner, U. *Chem. Abstr.* 112, 218118x; Germ. Offen. DE 3820971, 1989.					
	[67592-36-3] TSCA EC 266-749-2	HMIS: 3-2-1-X	10g	50g		
	**SIC2464.1**					
	3-CYCLOHEXENYLTRIMETHOXYSILANE					
	$C_9H_{18}O_3Si$	202.32	78-9° / 6		1.039	
			Flashpoint: 60°C (140°F)			NEW
	[21619-76-1]	HMIS: 3-2-1-X	5g			
	**SIC2520.0**					
	(3-CYCLOPENTADIENYLPROPYL)TRIETHOXYSILANE					
	$C_{14}H_{26}O_3Si$	270.44	115° / 0.5		0.99	1.4513
			Flashpoint: 100°C (212°F)			
	Dimer; may be cracked to monomer at ~ 190° at 100mm					
	Employed in silica-supported purification of fullerenes.[1]					
	1. Nie, B. et al. *J. Org. Chem.* **1996**, *61*, 1870.					
	[102056-64-4]	HMIS: 2-1-1-X	10g			
	**SID4610.3**					
	2-(DIVINYLMETHYLSILYL)ETHYLTRIETHOXYSILANE					
	$C_{13}H_{28}O_3Si_2$	288.54	79-81° / 0.15		0.895	
		HMIS: 2-1-1-X	5g			
	**SID4618.0**					
	DOCOSENYLTRIETHOXYSILANE, 95%					
	$C_{28}H_{58}O_3Si$	470.88	187-195° / 0.05			
	Contains isomers					
	Forms self-assembled monolayers that can be modified to hydroxyls.[1]					
	1. Penansky, J. et al. *Langmuir* **1995,** 11, 953.					
	[330457-44-8]	HMIS: 1-1-0-X	1.0g			
	**SIH5919.0**					
	HEXADECAFLUORODODEC-11-EN-1-YLTRIMETHOXYSILANE					
	$C_{15}H_{16}F_{16}O_3Si$	576.35	90° / 0.5		1.4145^{25}	1.3526^{25}
	Forms self-assembled monolayers; reagent for immobilization of DNA					
		HMIS: 3-1-1-X	1.0g			
	**SIH6164.2**					
	5-HEXENYLTRIETHOXYSILANE, 95%					
	$C_{12}H_{26}O_3Si$	246.43	97° / 1		0.883	1.4185
	Primarily α-olefin		Flashpoint: 86°C (187°F)			
	[52034-14-7]	HMIS: 2-1-1-X	10g			
	**SIH6164.3**					
	5-HEXENYLTRIMETHOXYSILANE, 95%					
	$C_9H_{20}O_3Si$	204.34	193-4°		0.927	
	Adhesion promoter for Pt-cure silicones					NEW
	[58751-56-7]	HMIS: 3-1-1-X	10g			

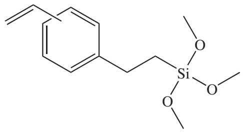
Name **Mw** **bp °C/mm** **(mp °C)** **D_4^{20}** **n_D^{20}**



SIO6709.0
7-OCTENYLTRIMETHOXYSILANE, tech-95
$C_{11}H_{24}O_3Si$ 232.39 48-9° / 0.1 0.94 1.4305
Contains 10-15% internal olefin isomers Flashpoint: 95°C (203°F)
Coupling agent for "in situ" polymerization of acrylamide for capillary electrophoresis.[1]
Employed in stretched DNA fibers for FISH (fluorescent in situ hybridization) mapping.[2]
Surface treatment for FISH and replication mapping on DNA fibers.[3]
1. Cifuentes, A. et al. *J. Chromatogr., A* **1999,** *830(2)*, 423.
2. Labit, H. et al. *BioTechniques* **2008**, *45*, 649.
3. Labit, H. et al. *Biotechniques Protocol Guide* **2010** (48) DOI 10.2144/000113255.
[52217-57-9] TSCA HMIS: 3-1-1-X 5g 25g



SIP6902.6
O-(PROPARGYL)-N-(TRIETHOXYSILYLPROPYL) CARBAMATE, 90%
$C_{13}H_{25}NO_5Si$ 303.43 110-20° / 0.2 0.990 1.4461^{25}
Inhibited with MEHQ Flashpoint: 95°C (203°F)
Surface derivatization reagent enabling “click” chemistry of nanoparticles.[1]
1. Achatz, D. et al. *Sensors and Actuators B* **2010***, 150*, 211.
[870987-68-1] HMIS: 2-2-1-X 25g



SIS6990.0
STYRYLETHYLTRIMETHOXYSILANE, tech-90
$C_{13}H_{20}O_3Si$ 252.38 98° / 0.1 1.02 1.505
Inhibited with t-butyl catechol Flashpoint: 97°C (207°F)
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

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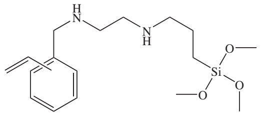

SIS6993.0
3-(N-STYRYLMETHYL-2-AMINOETHYLAMINO)PROPYLTRIMETHOXYSILANE, 40% in methanol
$C_{17}H_{30}N_2O_3Si$ 338.52 0.871 1.3900
Inhibited with BHT Flashpoint: 11°C (52°F)
Coupling agent for unsaturated polyesters
[34937-00-3] TSCA EC 252-297-3 HMIS: 3-4-1-X store <5°C 25g 100g 2kg

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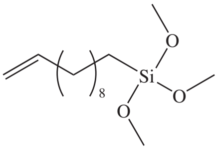
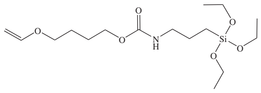
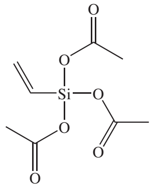


SIU9049.0
10-UNDECENYLTRIMETHOXYSILANE
$C_{14}H_{30}O_3Si$ 274.48 102-5° / 1 0.908 1.4334
When treated on glass provides a contact angle of 100°
[872575-06-9] HMIS: 2-1-1-X 5g

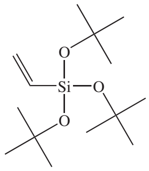


SIV9088.4
O-(VINYLOXYBUTYL)-N-TRIETHOXYSILYLPROPYL CARBAMATE, tech-95
$C_{16}H_{33}NO_6Si$ 363.53 1.015 1.4454
Inhibited with MEHQ
UV reactive coupling agent
[159856-61-8] HMIS: 3-2-1-X 10g

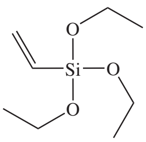


SIV9098.0
VINYLTRIACETOXYSILANE
$C_8H_{12}O_6Si$ 232.26 112-3° / 1 (10-13°) 1.167 1.423
Flashpoint: 88°C (190°F)
Crosslinker for moisture-cure silicone RTVs with greater liquid range for formulation, faster moisture-cure rate and better substrate adhesion properties than methyltriacetoxysilane
[4130-08-9] TSCA EC 223-943-1 HMIS: 3-2-1-X store <5°C 100g 2kg 18kg

COMMERCIAL

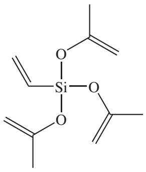


SIV9099.0
VINYLTRI-t-BUTOXYSILANE
$C_{14}H_{30}O_3Si$ 274.47 54° / 2 0.869
Flashpoint: 79°C (174°F)
[5356-88-7] EC 226-343-8 HMIS: 2-2-1-X 10g 50g



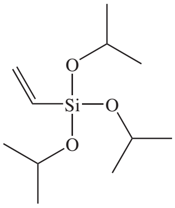
SIV9112.0
VINYLTRIETHOXYSILANE
$C_8H_{18}O_3Si$ 190.31 160-1° 0.903 1.3960
ΔHform: -463.5 kcal/mole Flashpoint: 44°C (111°F)
ΔHvap: 6.8 kcal/mole TOXICITY: oral rat, LD50: 22,500 mg/kg
Dipole moment: 1.69 debye Autoignition temperature: 268°C
Specific wetting surface area: 412 m^2/g Vapor pressure, 20°: 5 mm
Copolymerization parameters- e,Q: -0.42, 0.028 Specific heat: 0.25 cal/g/°
γc 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.[1]
Extensive review on the use in silicon-based cross-coupling reactions.[2]
1. Marciniec, B. et al. *J. Org. Chem.* **2005**, *70*, 8550.
2. Denmark, S. E. et al. *Organic Reactions,* Vol. 75, Denmark, S. E. ed., John Wiley and Sons, 233, **2011**.
[78-08-0] TSCA EC 201-081-7 HMIS: 1-2-1-X 25g 2kg 16kg

COMMERCIAL



SIV9209.0
VINYLTRIISOPROPENOXYSILANE, tech-95
$C_{11}H_{18}O_3Si$ 226.35 73-5° / 12 0.926 1.4373
Employed as a cross-linker and in vapor phase derivatization; byproduct is acetone
[15332-99-7] TSCA EC 239-362-1 HMIS: 1-3-1-X 25g 100g 2kg

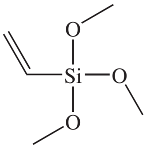
COMMERCIAL



SIV9210.0
VINYLTRIISOPROPOXYSILANE
$C_{11}H_{24}O_3Si$ 232.39 179-81° 0.8659 1.3961^{25}
Copolymerization parameters- e,Q: -0.36, 0.031
Flashpoint: 51°C (124°F)
Vapor pressure, 60°: 4 mm

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] TSCA EC 241-931-4 HMIS: 1-2-1-X 25g 100g 2kg

COMMERCIAL

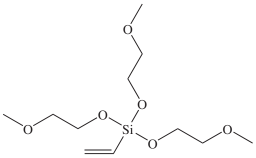


SIV9220.0
VINYLTRIMETHOXYSILANE
$C_5H_{12}O_3Si$ 148.23 123° 0.970 1.3930
Viscosity: 0.6 cSt
Copolymerization parameters- e,Q: -0.38, 0.031
Specific wetting surface area: 528 m^2/g
Flashpoint: 28°C (82°F)
TOXICITY: oral rat, LD50: 8,000 mg/kg
Autoignition temperature: 235°C
Vapor pressure, 20°: 9 mm

Employed in two-stage[1] and one-stage[2] graft polymerization/crosslinking for PE
Copolymerizes with ethylene to form moisture crosslinkable polymers.[3]
Converts arylselenyl bromides to arylvinylselenides.[4]
Reacts with anhydrides to transfer both vinyl and methoxy and thus form the mixed diester.[5]
Cross-couples w/ α-bromo esters to give α-vinyl esters in high ee.[6]
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. *J. Org. Chem.* **2010**, *75*, 4864.
5. Luo, F. et al. *J. Org. Chem.* **2010**, *75*, 5379.
6. Strotman, N. A.; Sommer, S.; Fu, G. C. *Angew. Chem., Int. Ed. Engl.* **2007**, *46*, 3556.
[2768-02-7] TSCA EC 220-449-8 HMIS: 3-3-1-X 25g 2kg 16kg

Vinylsilanes are used in PE and EPDM insulated wire and cable

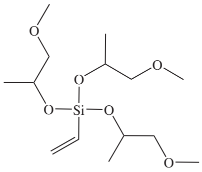
COMMERCIAL



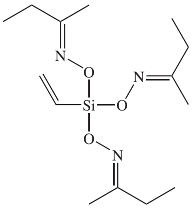
SIV9275.0
VINYLTRIS(2-METHOXYETHOXY)SILANE
$C_{11}H_{24}O_6Si$ 280.39 284-6° 1.0336^{25} 1.4271^{25}
Flashpoint: 115°C (239°F)
TOXICITY: oral rat, LD50: 2,960mg/kg
Autoignition temperature: 210°C
Vapor pressure, 108°: 2 mm

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.[1]
1. Arkles, B. et al. *Modern Plastics* **1987**, *64*, 138.
[1067-53-4] TSCA EC 213-934-0 HMIS: 3-1-1-X 50g 2kg 18kg

COMMERCIAL



SIV9277.0
VINYLTRIS(1-METHOXY-2-PROPOXY)SILANE
$C_{14}H_{30}O_6Si$ 322.47 0.981 1.424
Flashpoint: 122°C (252°F)
[303746-21-6] HMIS: 2-1-1-X 25g 100g

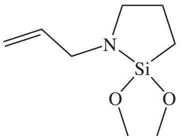


SIV9280.0
VINYLTRIS(METHYLETHYLKETOXIMINO)SILANE, tech-95
$C_{14}H_{27}N_3O_3Si$ 313.47 113° / 0.1 (-22°) 0.982^{25} 1.465
Neutral cross-linker/coupling agent for condensation cure silicones
Byproduct: methylethylketoxime
[2224-33-1] TSCA EC 218-747-8 HMIS: 3-3-1-X 50g 2kg 16kg

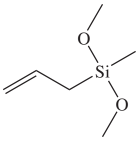
COMMERCIAL

Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}

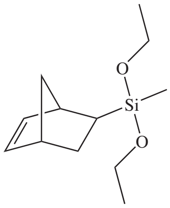
Vinyl and Olefin Functional Silanes - Dialkoxy



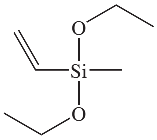
SIA0415.0
N-ALLYL-AZA-2,2-DIMETHOXYSILACYCLOPENTANE
$C_8H_{17}NO_2Si$ 187.31 52-4° / 3
Coupling agent for nanoparticles
[618914-49-1] HMIS: 3-3-1-X 10g
NEW



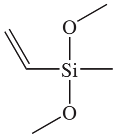
SIA0485.0
ALLYLMETHYLDIMETHOXYSILANE, tech-95
$C_6H_{14}O_2Si$ 146.26 127-8° 0.871^{25} 1.4055^{25}
Contains β-methylvinyl isomer
[67681-66-7] EC 266-901-8 HMIS: 3-3-1-X 5g
NEW



SIB0990.3
(5-BICYCLO[2.2.1]HEPT-2-ENYL)METHYLDIETHOXYSILANE
$C_{12}H_{22}O_2Si$ 226.39 65-7° / 1 0.959 1.4525^{25}
Comonomer for ROMP reactive resins
[113276-73-6] HMIS: 2-2-1-X 25g
NEW

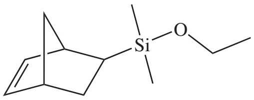


SIV9085.0
VINYLMETHYLDIETHOXYSILANE
$C_7H_{16}O_2Si$ 160.29 133-4° 0.858 1.3998
Dipole moment: 1.27 debye Flashpoint: 16°C (61°F)
Copolymerization parameters- e,Q; -0.86, 0.020
Chain extender, crosslinker for silicone RTVs and hydroxy-functional resins
[5507-44-8] TSCA EC 226-850-4 HMIS: 2-4-1-X 25g 2kg 15kg
COMMERCIAL

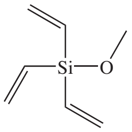


SIV9086.0
VINYLMETHYLDIMETHOXYSILANE
$C_5H_{12}O_2Si$ 132.23 103° 0.889 1.395
Viscosity: 0.7 cSt Flashpoint: 15°C (59°F)
Autoignition temperature: 245˚C
Vapor pressure, 20°: 38 mm
Additive to moisture-cure silane modified polyurethanes as a water scavenger to prevent premature cure
[16753-62-1] TSCA EC 240-816-6 HMIS: 3-4-1-X 25g 100g 2kg
COMMERCIAL

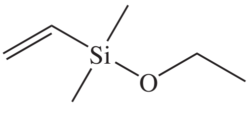
Vinyl and Olefin Functional Silanes - Monoalkoxy



SIB0981.0
(5-BICYCLO[2.2.1]HEPT-2-ENYL)DIMETHYLETHOXYSILANE
$C_{11}H_{20}OSi$ 196.36 67° / 3.5 0.926^{25} 1.4604^{25}
Undergoes ROMP reactions
[899823-76-8] HMIS: 2-2-1-X 25g
NEW

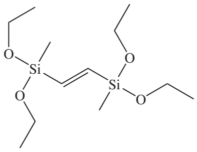
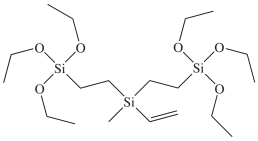
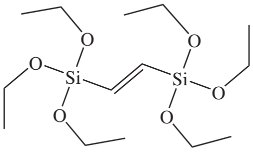
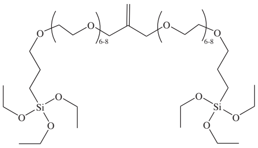
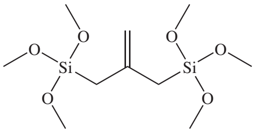
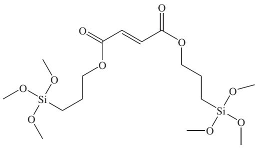


SIT8732.0
TRIVINYLMETHOXYSILANE, 95%
$C_7H_{12}OSi$ 140.25 131-3° 1.4400
Flashpoint: 26°C (79°F)
[193828-96-5] HMIS: 3-4-1-X 2.5g 10g

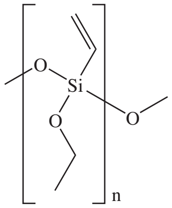
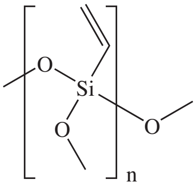


SIV9072.0
VINYLDIMETHYLETHOXYSILANE
$C_6H_{14}OSi$ 130.26 99-100° 0.790 1.3983
Dipole moment: 1.23 debye Flashpoint: 4°C (39°F)
Vinylates aryl halides.[1]
1. Denmark, S. E.; Butler, C. R. *J. Am. Chem. Soc.* **2008**, *130*, 3690.
[5356-83-2] TSCA EC 226-341-7 HMIS: 2-4-1-X 10g 50g

Vinyl and Olefin Functional Silanes - Dipodal

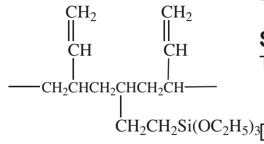
	Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}	
	**SIB1618.0** 1,2-BIS(METHYLDIETHOXYSILYL)ETHYLENE $C_{12}H_{28}O_4Si_2$ Mixed cis/trans isomers - primarily trans	292.52	80° / 2		0.918	1.4214	NEW
	[124279-15-8]	HMIS: 2-3-1-X	25g				
	**SIB1818.0** BIS(TRIETHOXYSILYLETHYL)VINYLMETHYLSILANE $C_{19}H_{44}O_6Si_3$	452.82	141° / 0.15		0.943		
		HMIS: 2-1-1-X	5g				
	**SIB1820.0** 1,2-BIS(TRIETHOXYSILYL)ETHYLENE, 95% *4,4,7,7-TETRAETHOXY-3,8-DIOXA-4,7-DISILADEC-5-ENE* $C_{14}H_{32}O_6Si_2$ ~80% trans isomer Forms ethylene-bridged mesoporous silicas.[1] 1. Vercaemst, C. et al. *Chem. Mater.* **2009**, *21*, 5792.	352.57	122-5° / 4		0.958	1.4168	
	[87061-56-1]	HMIS: 2-2-1-X	5g	25g			
	**SIB1824.9** 1,3-[BIS(3-TRIETHOXYSILYLPROPYL)POLYETHYLENOXY]-2-METHYLENEPROPANE $C_{50}H_{104}O_{20}Si_2$ (av) Vinyl functional hydrophilic dipodal coupling agent for protein immobilization	1113.5					
		HMIS: 2-2-1-X	1.0g				
	**SIB1832.5** 1,1-BIS(TRIMETHOXYSILYLMETHYL)ETHYLENE, tech-95 $C_{10}H_{24}O_6Si_2$ Contains ~ 10% cyclic siloxane condensation products Dipodal coupling agent	296.47	230-3°		1.05	1.429^{25}	
	[143727-20-2]	HMIS: 3-3-1-X	5g				
	**SIB1834.5** BIS(3-TRIMETHOXYSILYLPROPYL) FUMARATE, 96% $C_{16}H_{32}O_{10}Si_2$ Dipodal silane Adhesion promoter for Pt-cure silicone RTVs	440.59	Flashpoint: >110°C (>230°F)		1.118	1.443	NEW
	[3371-62-8] TSCA	HMIS: 3-1-1-X	25g				

Vinyl and Olefin Functional Silanes - Polymeric

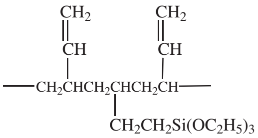
	Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}	
	**SIV9112.2** VINYLTRIETHOXYSILANE, oligomeric hydrolysate Viscosity: 4-7 cSt				1.02		NEW
	[29434-25-1] TSCA	HMIS: 2-2-1-X	100g	1kg			
	SIV9112.3 VINYLTRIETHOXYSILANE-PROPYLTRIETHOXYSILANE, oligomeric co-hydrolysate Viscosity: 3-7 cSt 9-11 wgt% vinyl	600-1,000	Flashpoint: 116°C (241°F)		1.02		NEW
	[201615-10-3] TSCA	HMIS: 2-1-1-X	100g	1kg			
	**SIV9220.2** VINYLTRIMETHOXYSILANE, oligomeric hydrolysate Viscosity: 8-10 cSt Graft-coupling agent for grafted polyethylene composites.[1] 1. Arkles, B. et al, *Modern Plastics* **1987**, *64, 38.*				1.10	1.428	NEW
	[131298-48-1] TSCA	HMIS: 2-2-1-X	100g	2kg			

Multi-Functional and Polymeric Silanes

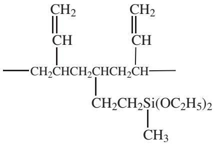
Polybutadiene



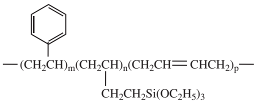
SSP-055
TRIETHOXYSILYL MODIFIED POLY-1,2-BUTADIENE, 50% in toluene
3,500-4,500 0.90
Flashpoint: 4°C (39°F)
[72905-90-9] TSCA HMIS: 2-4-1-X store <5°C 100g 2kg



SSP-056
TRIETHOXYSILYL MODIFIED POLY-1,2-BUTADIENE, 50% in volatile silicone
3,500-4,500 0.93
[72905-90-9] TSCA HMIS: 2-3-1-X store <5°C 100g 2kg



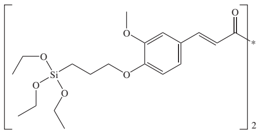
SSP-058
DIETHOXYMETHYLSILYL MODIFIED POLY-1,2-BUTADIENE, 50% in toluene
3,500-4,500 0.90
Flashpoint: 4°C (39°F)
HMIS: 2-4-1-X store <5°C 100g 3kg

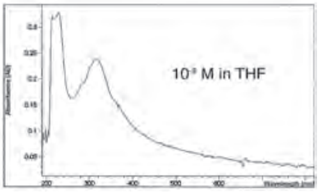


SSP-255
(30-35% TRIETHOXYSILYLETHYL)ETHYLENE-(35-40% 1,4-BUTADIENE)-(25-30% STYRENE) terpolymer, 50% in toluene
4,500-5,500
Flashpoint: 4°C (39°F)
HMIS: 2-3-1-X 100g

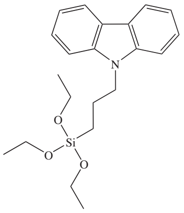
UV Active and Fluorescent Silanes

SIB1824.8
1,7-BIS(4-TRIETHOXYSILYLPROPOXY-3-METHOXYPHENYL)-1,6-HEPTADIENE-3,5-DIONE, tech-90
$C_{39}H_{60}O_{12}Si_2$ 777.07
UV max: 220, 232(vs), 354(broad)
Metal chelating chromophore





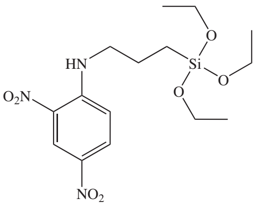
[947329-82-0] HMIS: 2-1-1-X 0.5g

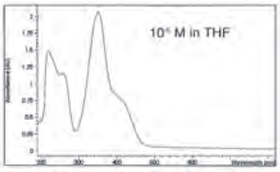


SIC2058.2
3-CARBAZOLYLPROPYLTRIETHOXYSILANE
$C_{21}H_{29}NO_3Si$ 371.55 185-195° / 0.3 1.072 1.5527^{25}
For non-linear optic materials
Employed in OLED fabrication.[1]
1. DeMais, T. et al. *SPIE Proc.* **1998**, *3476*, 338
[221105-38-0] HMIS: 2-2-1-X 2.5g

NEW

SID4352.0
3-(2,4-DINITROPHENYLAMINO)PROPYLTRIETHOXYSILANE, 95%
N-[3-(TRIETHOXYSILYL)PROPYL]-2,4-DINITROPHENYLAMINE
$C_{15}H_{25}N_3O_7Si$ 387.46 (27-30°) 1.5665
Viscous liquid or solid Flashpoint: >110°C (>230°F)
UV max: 222, 258, 350(s), 410
Forms χ2 non-linear optical sol-gel materials by corona poling.[1,2]

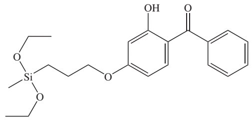




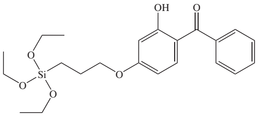
1. Toussaere, E. et al. *Non-Linear Optics* **1992,** *2*, 37.
2. Lebeau, J. et al. *J. Mater. Chem.* **1994,** *4*, 1855.

[71783-41-0] HMIS: 2-1-0-X 25g

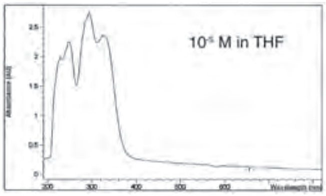
Name **Mw** **bp °C/mm** **(mp °C)** **D_4^{20}** **n_D^{20}**



SIH6198.0
2-HYDROXY-4-(3-METHYLDIETHOXYSILYLPROPOXY)DIPHENYLKETONE, tech-90
$C_{21}H_{28}O_5Si$ 388.54 1.116^{25} 1.5601^{25}
Amber liquid
Viscosity: 100-125 cSt
HMIS: 2-1-1-X 25g

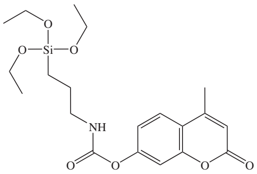


SIH6200.0
2-HYDROXY-4-(3-TRIETHOXYSILYLPROPOXY)DIPHENYLKETONE, tech-90
$C_{22}H_{30}O_6Si$ 418.56 1.120^{25} 1.545^{25}
Amber liquid
Viscosity, 25°: 125-150 cSt
UV max: 230, 248, 296(s), 336
Strong UV blocking agent for optically clear coatings, absorbs from 210-420 nm
UV blocking agent.[1]

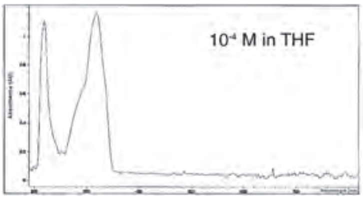


1. Anthony, B. U.S. Patent 4,495,360, 1985.

[79876-59-8] TSCA HMIS: 2-1-1-X 25g 100g 2kg

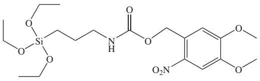


SIM6502.0
O-4-METHYLCOUMARINYL-N-[3-(TRIETHOXYSILYL)PROPYL]CARBAMATE
$C_{20}H_{29}NO_7Si$ 423.54 (88-90°)
UV max: 223, 281, 319.5 (vs)
Soluble: THF
Immobilizeable fluorescent compound.[1]



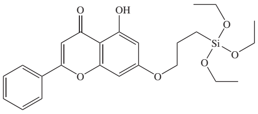
1. Arkles, B. U.S. Patent 4,918,200, 1990.

[129119-78-4] HMIS: 2-2-1-X 10g

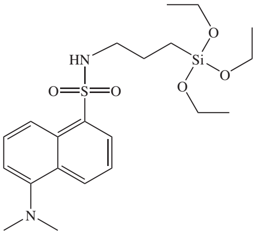


SIN6597.25
NITROVERATRYLOXYCARBONYLAMIDOPROPYLTRIETHOXYSILANE, 10% in tetrahydrofuran
N-TRIETHOXYSILYLPROPYL-O-4,5-DIMETHOXY-2-NITROBENZYLCARBAMATE
$C_{19}H_{32}N_2O_9Si$ 460.56
UV max: 365 nm Flashpoint: -14°C (7°F)
Photosensitive silane for lithography.[1]
1. del Campo, A. et al. *Angew. Chem.* **2005**, *44*, 4707
[188541-09-5] HMIS: 3-4-1-X 1.0g

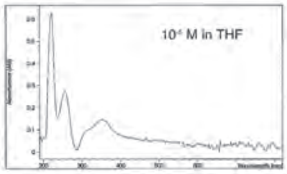
NEW



SIT8186.2
7-TRIETHOXYSILYLPROPOXY-5-HYDROXYFLAVONE, 50% in xylene
$C_{24}H_{30}O_7Si$ 458.58
Contains non-reactive dyestuffs Flashpoint: 30°C (86°F)
UV max: 350 nm
[945761-08-0] HMIS: 2-3-1-X 1.0g 5g



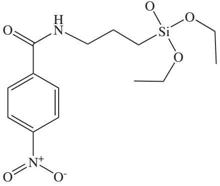
SIT8187.0
N-(TRIETHOXYSILYLPROPYL)DANSYLAMIDE
5-DIMETHYLAMINO-N-(3-TRIETHOXYSILYLPROPYL)NAPTHALENE-1-SULFONAMIDE
$C_{21}H_{34}N_2O_5SSi$ 454.66 115-9° / 0.1 1.12 1.5421
Viscous liquid
UV max: 222(s), 256, 354
Fluorescent - employed as a tracer in UV cure composites
Soluble in toluene, tetrahydrofuran
Fluorescence probe for crosslinking in silicones.[1]
Employed in a chemically modified logic gate.[2]



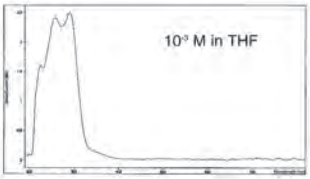
1. Leezenberg, P. et al. *Chem. Mater.* **1995,** *7*, 1784.
2. Mu, L. et al. *Angew. Chem., Int. Ed. Engl.* **2009**, *48*, 3469.

[70880-05-6] TSCA EC 274-980-5 HMIS: 2-1-1-X 1.0g

Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}



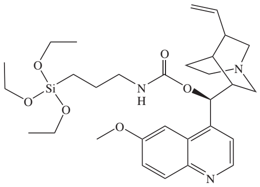
SIT8191.0
3-(TRIETHOXYSILYLPROPYL)-p-NITROBENZAMIDE
$C_{16}H_{26}N_2O_6Si$ 370.48 (54-5°) 1.5127
UV max: 224, 260, 292(s)
Used to prepare diazotizable supports for enzyme immobilization.[1]

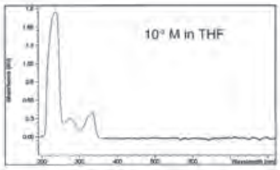


1. Weetall, H. U.S. Patent 3,652,761, 1972.

[60871-86-5] TSCA EC 262-508-0 HMIS: 2-1-1-X 25g

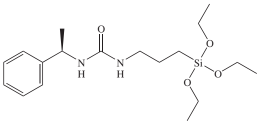
SIT8192.4
(R)-N-TRIETHOXYSILYLPROPYL-O-QUININEURETHANE, 95%
$C_{30}H_{45}N_3O_6Si$ 571.79 (82-4°)
UV max: 236(s), 274, 324, 334
Fluorescent, optically active silane
Soluble: warm toluene



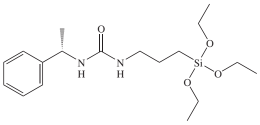


[200946-85-6] HMIS: 2-1-1-X 5g

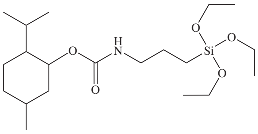
Chiral Silanes



SIP6731.5
(R)-N-1-PHENYLETHYL-N'-TRIETHOXYSILYLPROPYLUREA
$C_{18}H_{32}N_2O_4Si$ 368.55 1.05^{25}
Viscous liquid or solid Flashpoint: >110°C (>230°F)
Optically active silane; treated surfaces resolve enantiomers
[131206-15-0] HMIS: 2-1-0-X 25g

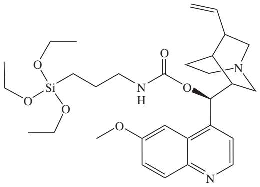


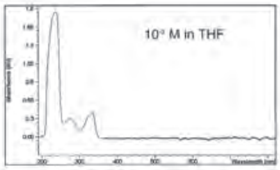
SIP6731.6
(S)-N-1-PHENYLETHYL-N'-TRIETHOXYSILYLPROPYLUREA
$C_{18}H_{32}N_2O_4Si$ 368.55 1.05^{25}
Viscous liquid or solid Flashpoint: >110°C (>230°F)
Optically active silane; treated surfaces resolve enantiomers
[67240-22-2] HMIS: 2-1-0-X 25g



SIT8190.0
(S)-N-TRIETHOXYSILYLPROPYL-O-MENTHOCARBAMATE
$C_{20}H_{41}NO_5Si$ 406.63 0.985^{25} 1.4526
Flashpoint: >110°C (>230°F)
Optically active
[68479-61-8] TSCA EC 270-863-8 HMIS: 2-1-1-X 10g

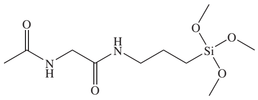
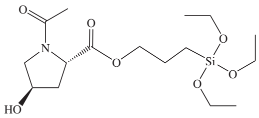
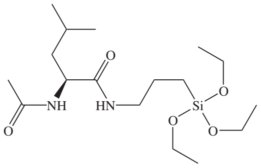
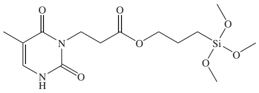
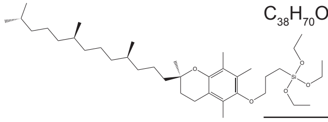
SIT8192.4
(R)-N-TRIETHOXYSILYLPROPYL-O-QUININEURETHANE, 95%
$C_{30}H_{45}N_3O_6Si$ 571.79 (82-4°)
UV max: 236(s), 274, 324, 334
Fluorescent, optically active silane
Soluble: warm toluene





[200946-85-6] HMIS: 2-1-1-X 5g

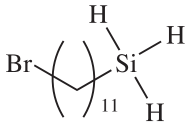
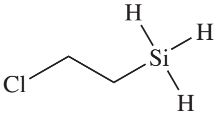
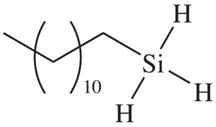
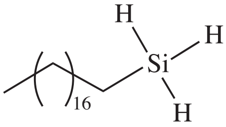
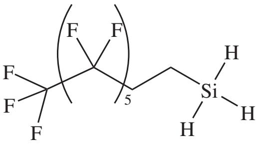
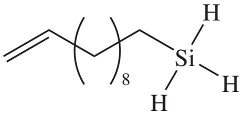
Biomolecular Probes

	Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}	
	**SIA0120.2** N-(ACETYLGLYCYL)-3-AMINOPROPYLTRIMETHOXYSILANE, 5% in methanol $C_{10}H_{22}N_2O_5Si$ Amino acid-tipped silane [1274903-53-5]	278.38 HMIS: 3-4-1-X	Flashpoint: 11°C (52°F) 25g	(171-3°)	0.80		*NEW*
	**SIA0126.0** 3-(N-ACETYL-4-HYDROXYPROLYLOXY)PROPYLTRIETHOXYSILANE, 25% in ethanol $C_{16}H_{31}NO_7Si$ Amino acid-tipped silane Hydrophilic reagent for biomimetic surface modification [1300591-79-0]	377.51 HMIS: 2-3-0-X	Flashpoint: 15°C (59°F) 5g		0.872		*NEW*
	**SIA0127.0** N-(N-ACETYLLEUCYL)-3-AMINOPROPYLTRIETHOXYSILANE, 12-15% in ethanol $C_{17}H_{36}N_2O_5Si$ Hydrophobic amino acid-tipped silane [1367348-25-1]	376.58 HMIS: 2-3-1-X	Flashpoint: 15°C (59°F) 2.5g		0.816		*NEW*
	**SIT7909.7** (3-(3-THYMINYL)PROPIONOXY)PROPYLTRIMETHOXYSILANE $C_{14}H_{24}N_2O_7Si$ Derivatized surfaces bind adenine modified polymers.[1] 1. Viswanathan, K. et al. *Polymer Preprints* **2005**, *4602*, 1133. [879197-67-8]	360.44 HMIS: 2-2-1-X	1.0g				
	**SIT8012.0** O-DL-a-TOCOPHEROLYLPROPYLTRIETHOXYSILANE, tech-90 $C_{38}H_{70}O_5Si$	635.04 HMIS: 2-2-1-X	10g		0.956	1.485	

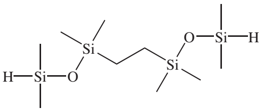
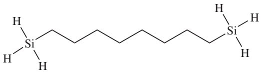
Trihydrosilanes

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 hydroxylic surfaces under both non-catalyzed and catalyzed conditions by a dehydrogenative coupling mechanism[1,2]. Trihydridosilanes react with a variety of pure metal surfaces including gold, titanium, zirconium and amorphous silicon, by a dissociative adsorption mechanism.[3] 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.

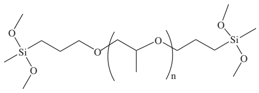
1. Fadeev, A. et al. *J. Am. Chem. Soc.* **1999***, 121*, 12184.
2. N. Morita, N. et al. *J. Am. Chem. Soc.* 2014, *136*, 11370.
3. B. Arkles, B. et al. *J. Adhesion Sci. Technol.* **2012***, 26*, 141.

	Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}	
	**SIB1907.8** 11-BROMOUNDECYLSILANE $C_{11}H_{25}BrSi$ Forms SAMs on titanium, gold and silicon surfaces.[1] 1. Arkles, B. et al. *J. Adhes. Sci. Technol.* **2012***, 26*, 41. [469904-33-4] HMIS: 2-3-1-X 5g	265.31	100-2° / 0.5		1.02		NEW
	**SIC2268.5** 2-CHLOROETHYLSILANE C_2H_7ClSi Intermediate for H_3SiCl; employed in CVD of SiN.[1] 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
	**SID4629.6** DODECYLSILANE $C_{12}H_{28}Si$ Forms SAMs on gold and titanium surfaces [872-19-5] HMIS: 2-2-1-X 10g	200.44	80° / 7		0.7753	1.438^{25}	
	**SIO6635.0** n-OCTADECYLSILANE $C_{18}H_{40}Si$ Contains 4-6% C_{18} isomers Flashpoint: >110°C (>230°F) Forms self-assembled monolayers on titanium.[1] Reacts onto a gold surface to form monolayers of long alkyl chains.[2] Forms SAMs on titanium, gold and silicon surfaces.[3] 1. Fadea, A. et al. *J. Am. Chem. Soc.* **1989**, *121*, 12184. 2. Owens, T. M. et al. *J. Am. Chem. Soc.* **2002**, *124*, 6800. 3. Arkles, B. et al. *J. Adhes. Sci. Technol.* **2012**, *26*, 41. [18623-11-5] TSCA EC 242-453-9 HMIS: 2-1-1-X 25g 100g 2kg	284.60	195° / 15	(29°)	0.794		
	**SIT8173.0** (TRIDECAFLUORO-1,1,2,2-TETRAHYDROOCTYL)SILANE $C_8H_7F_{13}Si$ 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	
	**SIU9048.0** 10-UNDECENYLSILANE $C_{11}H_{24}Si$ Forms self-assembled monolayers on gold HMIS: 2-3-1-X 2.5g	184.40			0.768^{25}	1.4415^{25}	

Dipodal Silyl Hydrides

	**SIB1770.0** 1,2-BIS(TETRAMETHYLDISILOXANYL)ETHANE, 95% $C_{10}H_{30}O_2Si_4$ [229621-70-9] HMIS: 2-2-1-X 25g	294.69	90-5° / 20		0.845	1.41
	**SID4593.5** 1,10-DISILADECANE $C_8H_{22}Si_2$ [4364-10-7] HMIS: 2-3-1-X 10g	174.44	35° / 0.3		0.772	1.4461

Dipodal Silanes - Non-Functional



SIB1660.0

BIS[(3-METHYLDIMETHOXYSILYL)PROPYL]POLYPROPYLENE OXIDE

600-800 1.00 1.452^{25}

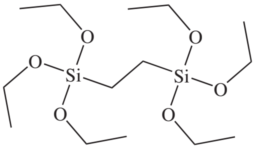
Viscosity: 6,000-10,000 cSt. Flashpoint: >110°C (>230°F)

Hydrophilic dipodal silane

With tin catalyst forms moisture-cross-linkable resins

[75009-88-0] TSCA HMIS: 3-1-1-X 100g 2kg 18kg

COMMERCIAL



SIB1817.0

1,2-BIS(TRIETHOXYSILYL)ETHANE

HEXAETHOXYDISILETHYLENE, BSE

$C_{14}H_{34}O_6Si_2$ 354.59 96° / 0.3 (-33°) 0.957 1.4052

ΔHvap: 101.5 kJ/mole

Flashpoint: 107°C (225°F)

TOXICITY: oral rat, LD50: 161 mg/kg

Vapor pressure, 150°: 10 mm

Additive to silane coupling agents formulations that enhances hydrolytic stability

Employed in corrosion resistant coatings/primers for steel and aluminum.[1,2]

Sol-gels of α,ω-bis(trimethoxysilyl)alkanes reported.[3]

Component in evaporation-induced self-assembly of mesoporous structures.[4]

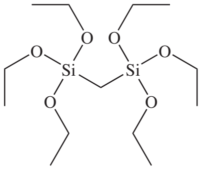
Forms mesoporous, derivatizeable molecular sieves.[5,6]

Hydrolysis kinetics studied.[7]

1. Van Ooij, W. et al. *J. Adhes. Sci. Technol.* **1997,** *11*, 29.
2. Van Ooij, W. et al. *Chemtech* **1999,** *28*, 3302.
3. Loy, D. A. et al. *J. Am. Chem. Soc.* **1999,** *121*, 5413.
4. Lu, Y. et al. *J. Am. Chem. Soc.* **2000,** *122*, 5258.
5. Molde, B. et al. *Chem. Mater.* **1999,** *11*, 3302.
6. Cho, E. et al. *Chem. Mater.* **2004,** *16*, 270.
7. Diaz-Benito, B. *Colloids and Surfaces A: Physicochemical Aspects* **2010**, *369*, 53.

[16068-37-4] TSCA EC 240-212-2 HMIS: 3-1-1-X 25g 100g 2kg

COMMERCIAL



SIB1821.0

BIS(TRIETHOXYSILYL)METHANE

4,4,6,6-TETRAETHOXY-3,7-DIOXA-4,6-DISILANONANE

$C_{13}H_{32}O_6Si_2$ 340.56 114-5° / 3.5 0.9741 1.4098

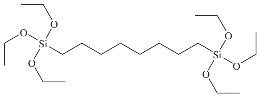
Intermediate for sol-gel coatings, hybrid inorganic-organic polymers

Forms methylene-bridged mesoporous structures.[1]

Forms modified silica membranes that separate propylene/propane mixtures.[2]

1. Zhang, W. et al. *Chem. Mater.* **2005,** *17*, 6407.
2. Kanezashi, M. et al. *J. Membr. Sci.* **2012**, *415-416*, 478.

[18418-72-9] TSCA-L HMIS: 3-2-1-X 5g 25g 100g



SIB1824.0

1,8-BIS(TRIETHOXYSILYL)OCTANE

$C_{20}H_{46}O_6Si_2$ 438.76 172-5° / 0.75 0.926 1.4240

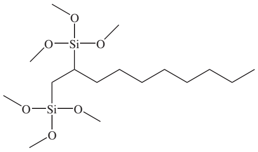
Employed in sol-gel synthesis of mesoporous structures

Crosslinker for moisture-cure silicone RTVs with improved environmental resistance

Sol-gels of α,ω-bis(trialkoxysilyl)alkanes reported.[1]

1. Loy, D.A. et al. *J. Am. Chem. Soc.* **1999**, *121*, 5413.

[52217-60-4] TSCA HMIS: 2-1-1-X 25g 100g 2kg



SIB1829.0

1,2-BIS(TRIMETHOXYSILYL)DECANE

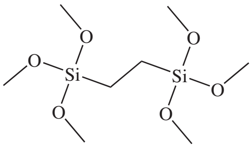
$C_{16}H_{38}O_6Si_2$ 382.65 130-2° / 0.4 0.984 1.4303

Pendant dipodal silane; employed in high pH HPLC

Employed in the fabrication of luminescent molecular thermometers.[1]

1. Brites, C. et al. *New J. Chem.* **2011**, *35*, 1173.

[832079-33-1] TSCA-L HMIS: 3-2-1-X 25g 100g



SIB1830.0

1,2-BIS(TRIMETHOXYSILYL)ETHANE

$C_8H_{22}O_6Si_2$ 270.43 103-4° / 5 1.068 1.4091

CAUTION: INHALATION HAZARD

AIR TRANSPORT FORBIDDEN

Flashpoint: 65°C (149°F)

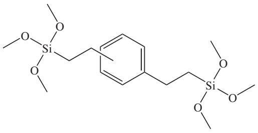
TOXICITY: ihl rat, LC50: 2.4 ppm

Vapor pressure, 20°: 0.08 mm

Employed in fabrication of multilayer printed circuit boards.[1]

1. Palladino, J. U.S. Patent 5,073,456, 1991.

[18406-41-2] TSCA EC 242-285-6 HMIS: 4-2-1-X 25g 100g 2kg



SIB1831.0

BIS(TRIMETHOXYSILYLETHYL)BENZENE, tech-95

$C_{16}H_{30}O_6Si_2$ 374.58 148-50° / 0.1 1.08 1.4734

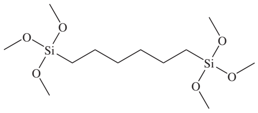
Mixed isomers Flashpoint: 193°C (379°F)

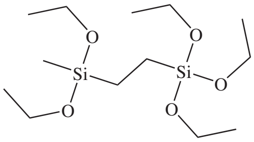
Forms high refractive index coatings

Forms resins that absorb organics from aqueous media.[1]

1. Edmiston, P. et al. *Sep. Purif. Technol.* **2009**, *66*, 532.

[266317-71-9] TSCA HMIS: 2-1-0-X 10g 50g 2kg

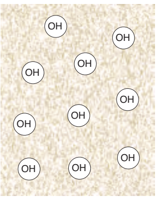


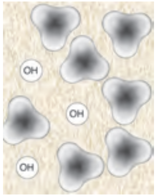


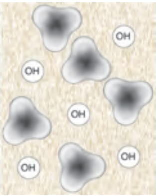
Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}
SIB1832.0 1,6-BIS(TRIMETHOXYSILYL)HEXANE $C_{12}H_{30}O_6Si_2$	326.54	161° / 2 Flashpoint: 95°C (203°F)		1.014	1.4213
Sol-Gels of α,ω-bis(trimethoxysilyl)alkanes reported.[1] 1. Loy, D.A. et al. *J. Am. Chem. Soc.* **1999,** *121*, 5413.					
[87135-01-1] HMIS: 3-2-1-X		10g	50g	2kg	
SIT8185.8 1-(TRIETHOXYSILYL)-2-(DIETHOXYMETHYLSILYL)ETHANE $C_{13}H_{32}O_5Si$ 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(triethoxysilyl)ethane Improves hydrolytic stability of silane adhesion promotion systems					
[18418-54-7] TSCA HMIS: 2-1-1-X		25g	100g	2kg	COMMERCIAL

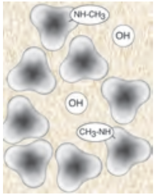
Organosilane-Modified Silica Nanoparticles

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.









Name	Mw	bp °C/mm	(mp °C)	D_4^{20}	n_D^{20}
SIS6960.0 SILICON DIOXIDE, amorphous *Fumed silica* SiO_2 Ultimate particle size: 12 - 20 nm Surface area, 200 m²/g Isoelectric point: 2.2	60.09	TOXICITY: oral rat, LD50: 8,160 mg/kg γc: 44 mN/m Bulk density: ~50 g/l pH, (4% aqueous slurry): 3.5-4.5	(>1,600°)	2.2	1.46
[112945-52-5] TSCA HMIS: 2-0-0-X		500g	2kg		COMMERCIAL
SIS6962.0 SILICON DIOXIDE, amorphous, HEXAMETHYLDISILAZANE TREATED *Fumed silica, HMDZ treated* SiO_2 Surface area, 150-200 m²/g	60.09	Carbon content: 3% Calculated ratio: $(CH_3)_3Si/HO-Si$: 2/1 ● *= $(CH_3)_3Si$- = trimethylsilyl group*	(>1,600°)	2.2	1.45
[68909-20-6]/[7631-86-9] TSCA EC 272-697-1 HMIS: 2-0-0-X		500g	2kg		COMMERCIAL
SIS6962.1M30 SILICON DIOXIDE, amorphous, HEXAMETHYLDISILAZANE TREATED *Fumed silica, HMDZ treated* SiO_2 Surface area, 150-200 m²/g	60.09	Carbon content: 2-3% Calculated ratio: $(CH_3)_3Si/HO-Si$: 1/1 ● *= $(CH_3)_3Si$- = trimethylsilyl group*	(>1,600°)	2.2	1.45
[68909-20-6]/[7631-86-9] TSCA EC 272-697-1 HMIS: 2-0-0-X		500g	2kg		COMMERCIAL
SIS6962.1N30 SILICON DIOXIDE, amorphous, CYCLIC AZASILANE/HEXAMETHYLDISILAZANE TREATED SiO_2 Surface area, 150-200 m²/g	60.09	Carbon content: 4-7% Calculated ratio: $CH_3NHCH_2CH_2CH_2Si/(CH_3)_3Si/HO-Si$: 1/2/1 ● NH-$CH_3$ *= $CH_3NHCH_2CH_2CH_2Si(CH_3)_2$*	(>1,600°)	2.2	1.45
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 reative 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

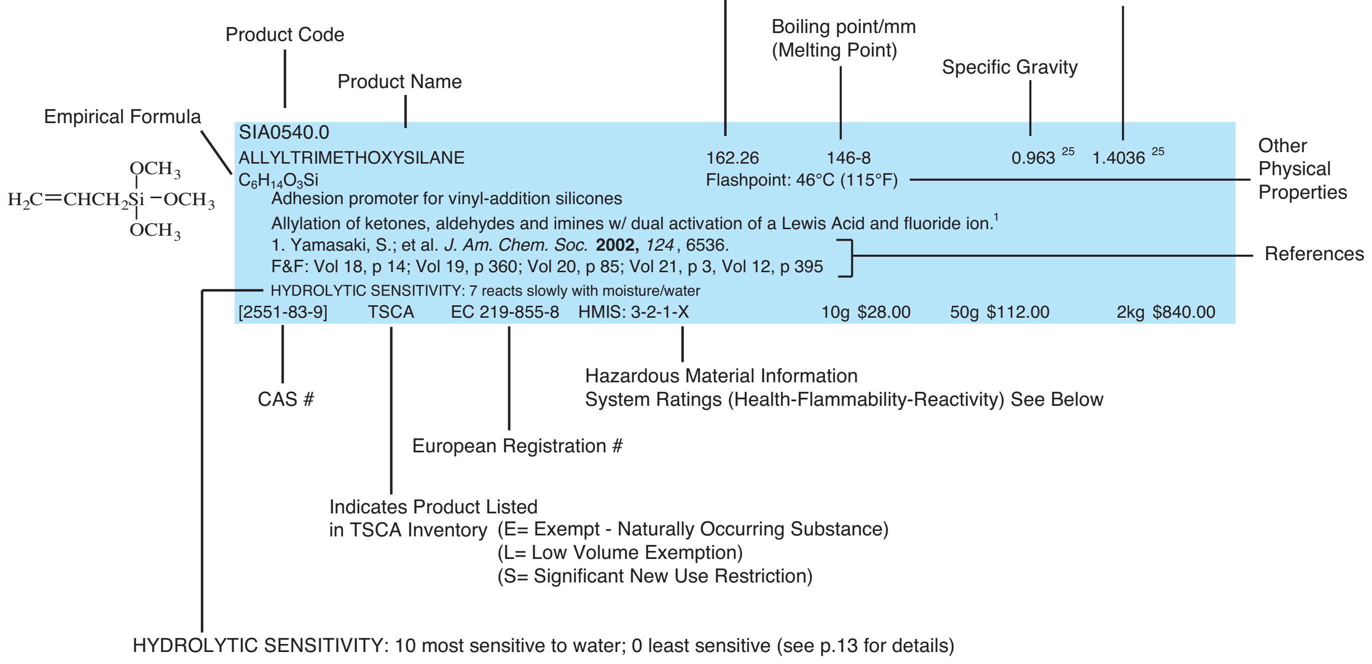
Silane Coupling Agents - General References and Proceedings

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_2 and Its Interfaces," MRS Proc. 105, 1988.

Product Information



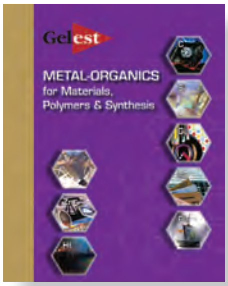
SIA0540.0
ALLYLTRIMETHOXYSILANE 162.26 146-8 0.963^{25} 1.4036^{25}
$C_6H_{14}O_3Si$ Flashpoint: 46°C (115°F)
Adhesion promoter for vinyl-addition silicones
Allylation of ketones, aldehydes and imines w/ dual activation of a Lewis Acid and fluoride ion.[1]
1. Yamasaki, S.; et al. *J. Am. Chem. Soc.* **2002,** *124*, 6536.
F&F: Vol 18, p 14; Vol 19, p 360; Vol 20, p 85; Vol 21, p 3, Vol 12, p 395
HYDROLYTIC SENSITIVITY: 7 reacts slowly with moisture/water
[2551-83-9] TSCA EC 219-855-8 HMIS: 3-2-1-X 10g $28.00 50g $112.00 2kg $840.00

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.

Gelest
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