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Connecting Across Boundaries

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Increase Mechanical Properties

Improve Dispersion

Provide Crosslinking

Immobilize Catalysts

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Version 2.0:

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Silane Coupling Agents

Connecting Across Boundaries

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Silane Coupling Agents: Connecting Across Boundaries v2.0

by Barry Arkles

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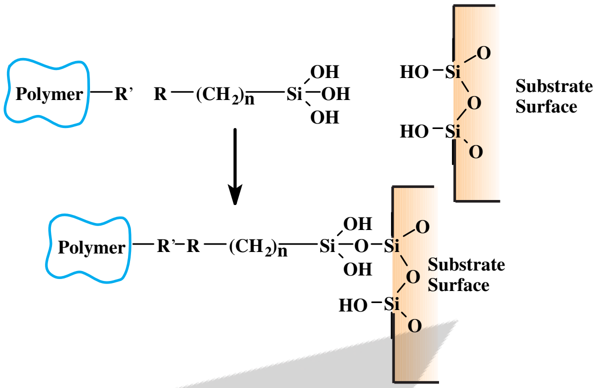
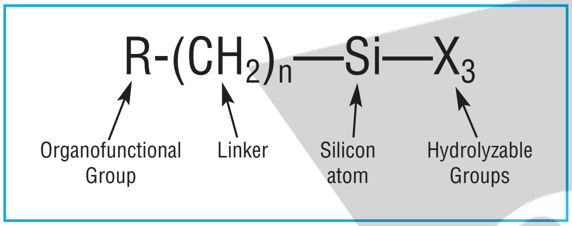
What is a Silane Coupling Agent?

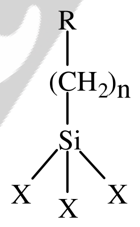
Silane coupling agents have the ability to form a durable bond between organic and inorganic materials. Encounters between dissimilar materials often involve at least one member that's siliceous or has surface chemistry with siliceous properties; silicates, aluminates, borates, etc., are the principal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



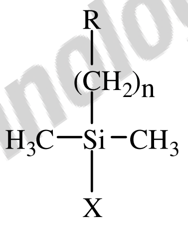


The general formula for a silane coupling agent typically shows the two classes of functionality. X is a hydrolyzable group typically alkoxy, acyloxy, halogen or amine. Following hydrolysis, a reactive silanol group is formed, which can condense with other silanol groups, for example, those on the surface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

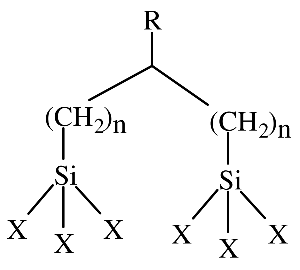
The final result of reacting an organosilane with a substrate ranges from altering the wetting or adhesion characteristics of the substrate, utilizing the substrate to catalyze chemical transformations at the heterogeneous interface, ordering the interfacial region, and modifying its partition characteristics.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



Trialkoxysilane



Monoalkoxysilane



Dipodal Silane

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How does a Silane Coupling Agent Work?

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. The most effective silanes for vapor phase deposition are cyclic azasilanes.

Hydrolysis Considerations

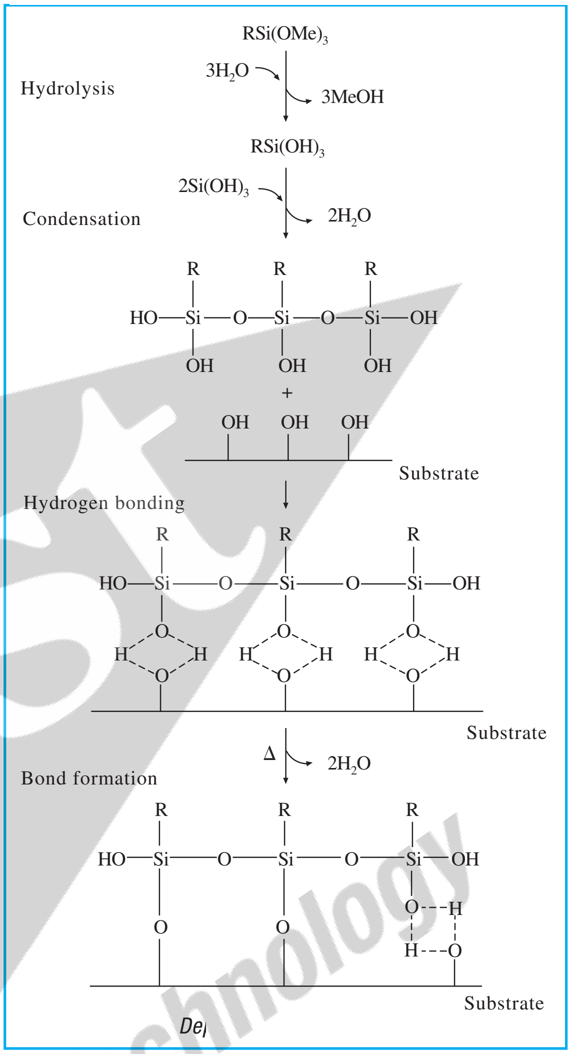
Water for hydrolysis may come from several sources. It may be added, it may be present on the substrate surface, or it may come from the atmosphere.

The degree of polymerization of the silanes 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 interconnected 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.

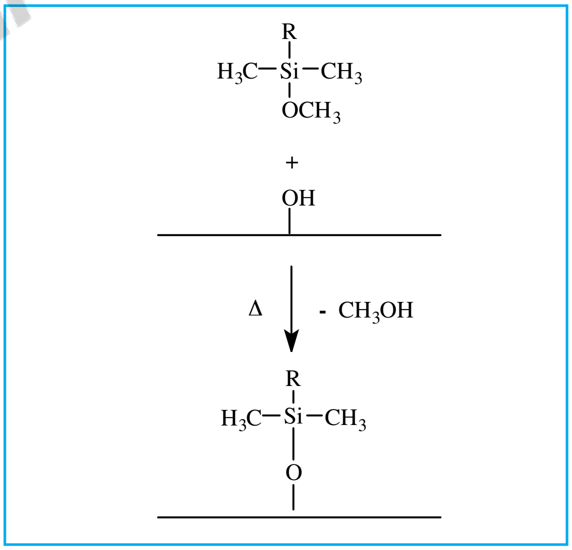
The formation of covalent bonds to the surface proceeds with a certain amount of reversibility. As water is removed generally by heating to 120°C for 30 to 90 minutes or evacuation for 2 to 6 hours, bonds may form, break, and reform to relieve internal stress. The same mechanism can permit a positional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

Hydrolytic Deposition of Silanes



B. Arkles, CHEMTECH, 7, 766, 1977

Anhydrous Deposition of Silanes



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Selecting A Silane Coupling Agent -

Inorganic Substrate Perspective

Factors influencing silane coupling agent selection include:

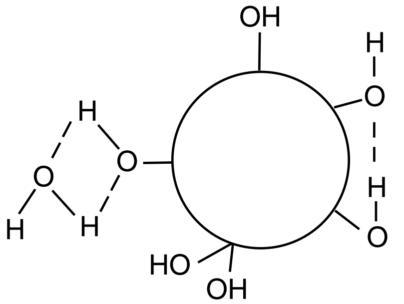
Concentration of surface hydroxyl groups
Type of surface hydroxyl groups
Hydrolytic Stability of the bond formed
Physical dimensions of the substrate or substrate features

Coupling is maximized when silanes react with the substrate surface and present the maximum number of sites with reactivity specific and accessible to the matrix phase. 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.

Silane coupling agents 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 presentation 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. Monoalkoxysilanes 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 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.



Amino-silanes couple fiberglass to phenolic or urea-formaldehyde resins

Silane Effectiveness on Inorganics

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

Estimates for Silane Loading on Siliceous Fillers

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

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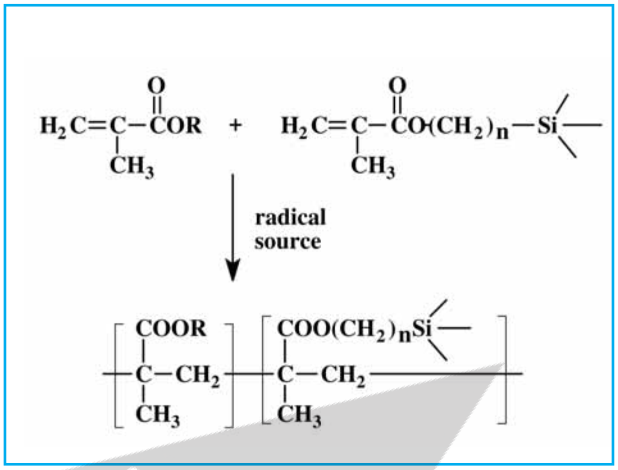
Selecting A Silane Coupling Agent -
Polymer Applications

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.

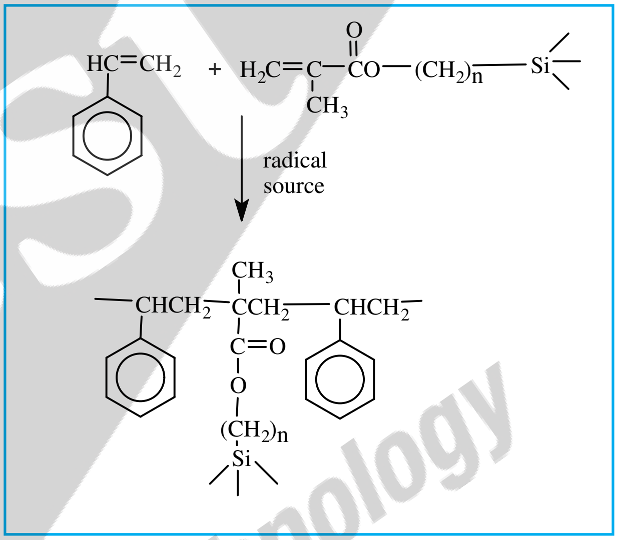
Thermosets

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

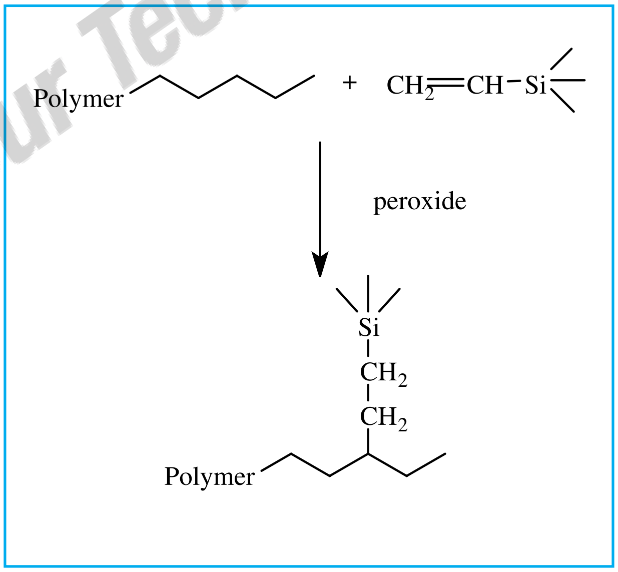
Methacrylyl and styryl functional silanes undergo addition much more readily than vinylsilanes A direct approach to selecting the optimum silane uses the e and Q parameters of the Alfrey-Price treatment of polymerization. Here e indicates the polarity of the monomer radical that forms at the end of a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



Acrylate Coupling Reaction



Unsaturated Polyester (Styrene) Coupling Reaction



Polyethylene Graft Coupling Reaction

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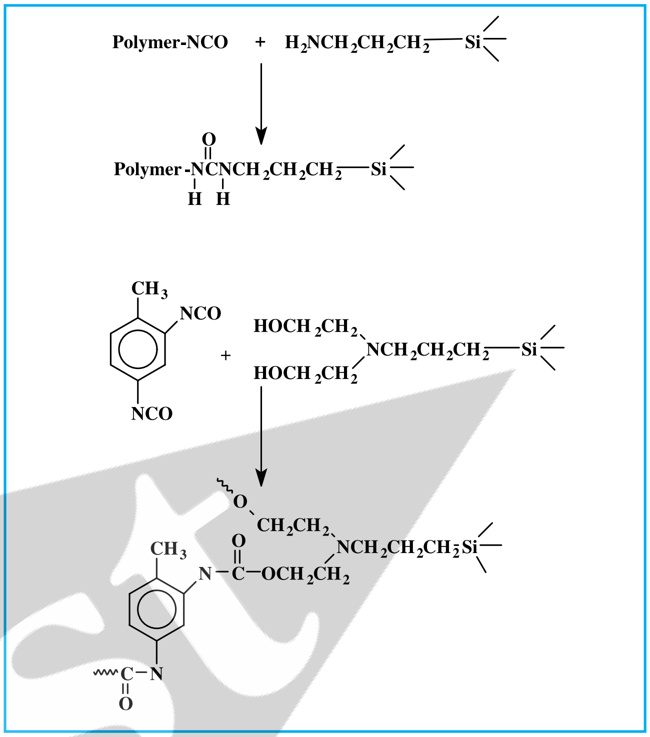
Urethanes

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.



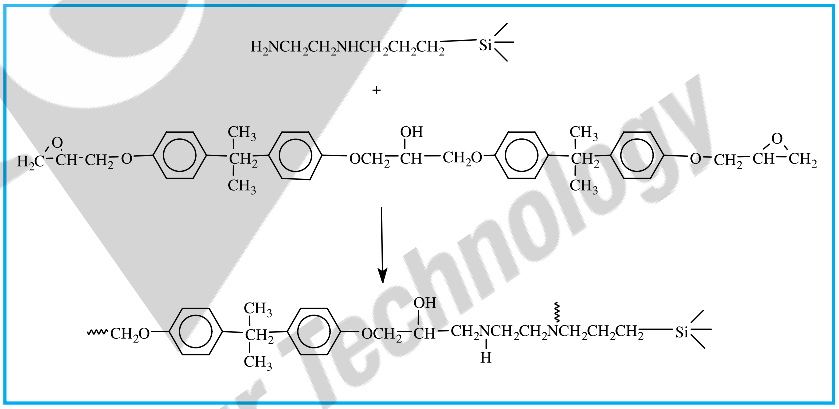
Polyurethane Coupling Reactions

Moisture-Cureable Urethanes

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

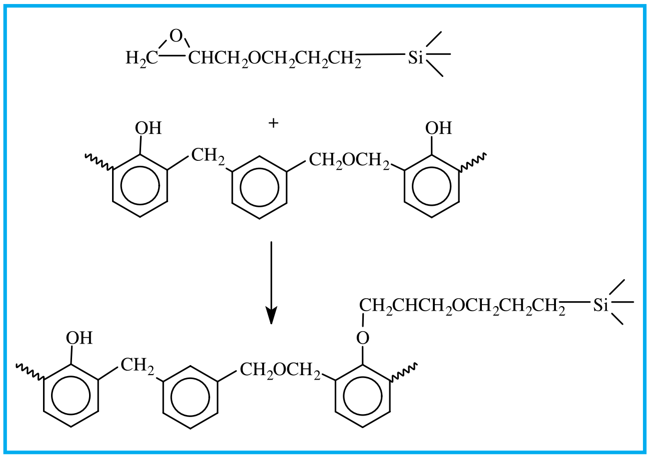
Epoxycyclohexyl and glycidoxy functional silanes are used to pretreat the filler or blended with the glycidylbisphenol-A ether. Amine functional silanes can likewise be used to pretreat the filler or blended with the hardener portion. Treatment of fillers in epoxy adhesives improves their dispersibility 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.



Epoxy Coupling Reaction

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.



Phenolic Coupling Reaction

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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 not necessarily the best. Epoxysilanes, for example, are successfully used with acrylic acid and maleic acid copolymers.

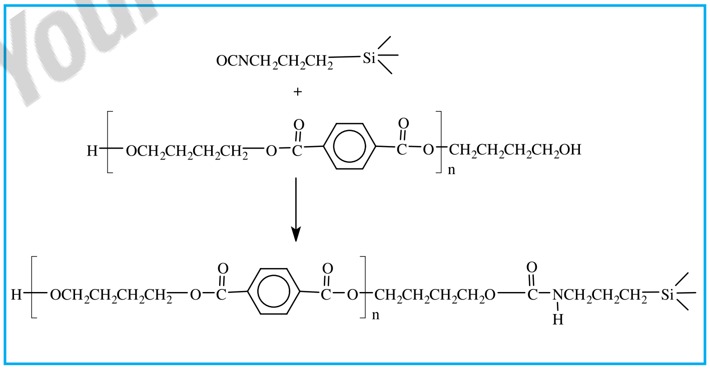

Scanning electron micrograph at a broken gear tooth from a non-coupled glass fiber/acetal composite. Note that cleavage occurred between fibers.


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 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 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.



Thermoplastic Polyester Coupling Reaction

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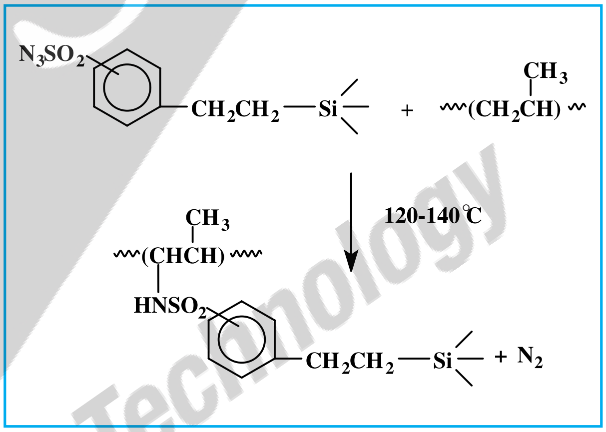
Polyolefins

The polyolefins and polyethers present no direct opportunity to 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 alkyl-substituted 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.

Vinylsilanes are used in PE and EPDM insulated wire and cable



Polypropylene Coupling Reaction

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Selecting a Silane Coupling Agent -

Interphase Considerations

The space between homogeneous phases is sometimes called the interphase. In this region there is a steep gradient in local properties of the system. By treating a substrate with silanes the interphase can acquire specific surface energy, partition characteristics, mechanical and chemical properties.

Hydrophobicity and Wetting

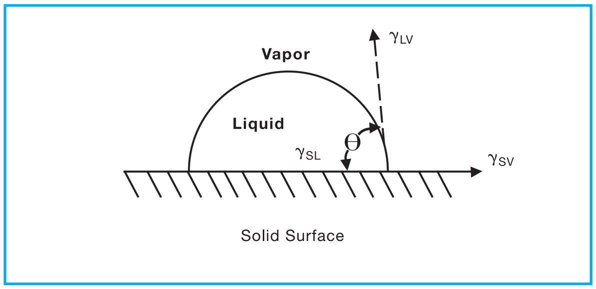
Alkyl- and arylsilanes are not considered coupling agents. Surface modification with these non-functional materials can have profound effects on the interphase. They are used to alter surface energy or wetting characteristics of the substrate. In the simplest cases, methyltrichlorosilane, dimethyldichlorosilane, trimethylchlorosilane, their alkoxy derivatives, and hexamethyldisilazane are used to render substrates water repellent. For example, glassware can be dipped into a 5% to 10% solution of dimethyldiethoxysilane and heated for ten minutes at 120° C to render the surface hydrophobic. Laboratory pipettes and graduated cylinders so treated exhibit a flat meniscus and completely transfer aqueous solutions. GC packing of diatomaceous earth or silica are often treated with dimethyldichlorosilane or trimethylchlorosilane to reduce tailing. Masonry can be treated with propyl-, isobutyl- or octyltrialkoxysilanes to render it water repellent while glass surfaces of metal-glass capacitors treated with alkylsilanes exhibit reduced electrical leakage in humid conditions.

Silanes can alter the critical surface tension of a substrate in a well-defined manner. Critical surface tension is associated with the wettability or release qualities of a substrate. Liquids with a surface tension below the critical surface tension (γ_c) of a substrate will wet the surface, i.e., show a contact angle of 0 ($\cos\theta_c = 1$). 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. The contact angle is given by Young's equation:

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

where γ_{sl} = interfacial surface tension, γ_{lv} = surface tension of liquid, and ($\gamma_{sv} = \gamma_l$ when $\gamma_{sl} = 0$ and $\cos\theta_e = 1$)

Contact Angle Defines Wettability



Critical surface tensions

	γ_c
Heptadecafluorodecyltrichlorosilane	12.0
Polytetrafluoroethylene	18.5
Methyltrimethoxysilane	22.5
Vinyltriethoxysilane	25
Paraffin wax	25.5
Ethyltrimethoxysilane	27.0
Propyltrimethoxysilane	28.5
Glass, soda-lime (wet)	30.0
Polychlorotrifluoroethylene	31.0
Polypropylene	31.0
Polyethylene	33.0
Trifluoropropyltrimethoxysilane	33.5
3-(2-aminoethyl)-aminopropyltrimethoxysilane	33.5
Polystyrene	34
Cyanoethyltrimethoxysilane	34
Aminopropyltriethoxysilane	35
Polyvinylchloride	39
Phenyltrimethoxysilane	40.0
Chloropropyltrimethoxysilane	40.5
Mercaptopropyltrimethoxysilane	41
Glycidoxypropyltrimethoxysilane	42.5
Polyethyleneterephthalate	43
Copper (dry)	44
Aluminum (dry)	45
Iron (dry)	46
Nylon 6/6	46
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 treated surfaces.

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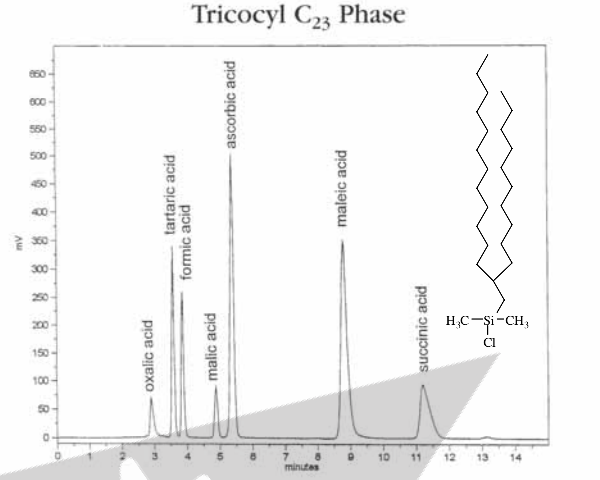
Silane treatment has allowed control of thixotropic activity of silica and clays in grease and oil applications. In the reinforcement of thermosets and thermoplastics with glass fibers, one approach for optimizing reinforcement is to match the critical surface tension of the silylated glass surface to 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. Immobilization of cellular organelles, including mitochondria, chloroplasts, and microsomes, has been effected by treating silica with alkylsilanes of C_8 or greater substitution.

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

Chromatography

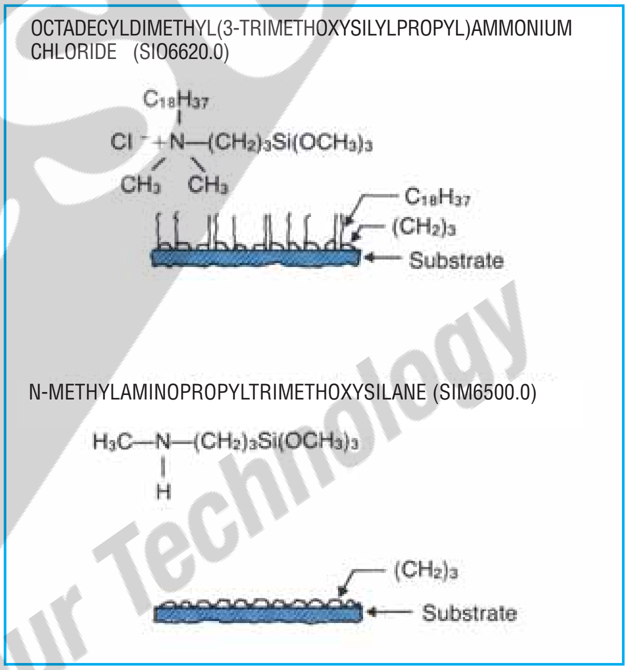
Octadecyl, cyanopropyl and branched tricocyl silanes provide bonded phases for liquid chromatography. Reverse-phase thin-layer chromatography can be accomplished by treating plates with dodecyltrichlorosilane.

By forming complexes of copper ions with aminoalkylsilylated surfaces, an interphase results that can selectively absorb ethylene, propylene and other gases.

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 methylaminopropyltrimethoxysilane (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.

Orientation effects of silanes for passive LCDs

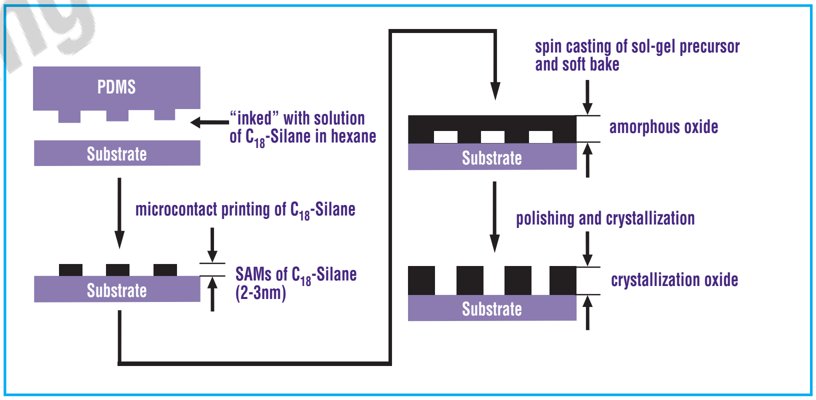


F. Kahn., Appl. Phys. Lett. *22*, 386, 1973

Self-Assembled Monolayers (SAMs)

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.

Micro-Contact Printing Using SAMs



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Special Topics

Dipodal Silanes

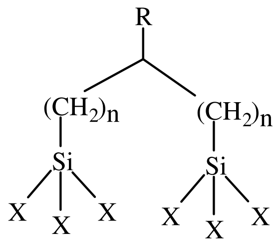
Functional dipodal silanes and combinations of non-functional dipodal silanes with functional silanes have significant impact on substrate bonding, hydrolytic stability and mechanical strength of many composites systems. They possess enabling activity in many coatings, particularly primer systems and aqueous immersion applications. The effect is thought to be a result of both the increased crosslink density of the interphase and a consequence of the fact that the resistance to hydrolysis of dipodal materials (with the ability to form six bonds to a substrate) is estimated at close to 100,000 times greater than conventional coupling agents (with the ability to form only three bonds to a substrate).

Both because dipodal silanes may not have functional groups identical to conventional coupling agents or because of economic considerations, conventional coupling agents are frequently used in combination with a non-functional dipodal silanes. 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.

Effect of dipodal -SiCH2CH2Si- on the bond strength of a crosslinkable ethylene-vinyl acetate primer formulation

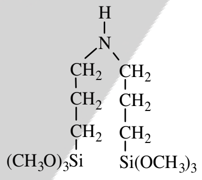
Primer on metal 10% in *i*-PrOH	Wet adhesion to metals (N/cm)	
	Titanium	Cold-rolled steel
No silane	Nil	Nil
Methacryloxypropylsilane	0.25	7.0
Methacryloxypropylsilane + 10% dipodal	10.75	28.0 (cohesive failure)
90º peel strength after 2 h in 80ºC water.		

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



Dipodal tetrasulfide silanes are used in "green" tires

Functional Dipodals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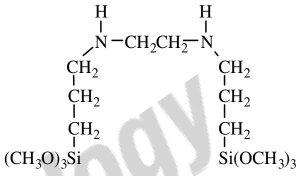
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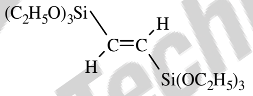
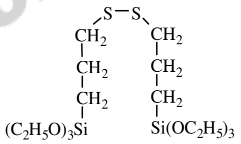

SB1820..0


SIB1824.6

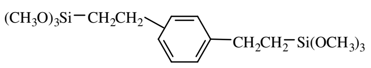
Non-Functional Dipodals

$(C_2H_5O)_3Si-CH_2CH_2-Si(OC_2H_5)_3$

SIB1817.0

$(C_2H_5O)_3Si-CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2-Si(OC_2H_5)_3$

SIB1824.0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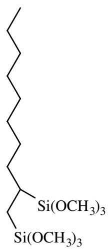
SIB1829.0

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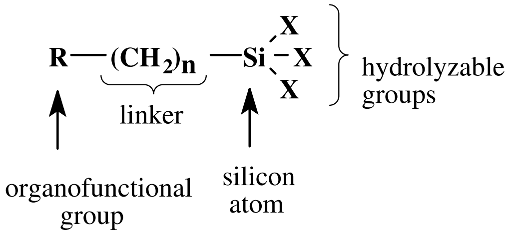
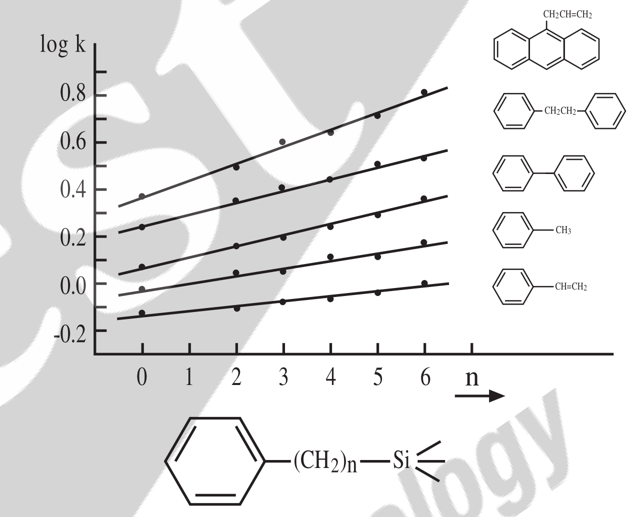
Linker Length

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.

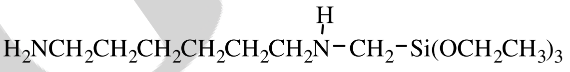


Effect of linker length on the separation of aromatic hydrocarbons



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

Silanes with short linker length


$H_2NCH_2CH_2CH_2CH_2CH_2CH_2\overset{H}{N}-CH_2-Si(OCH_2CH_3)_3$

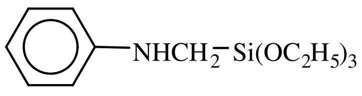
SIA0592.6

$Cl-CH_2-Si(OC_2H_5)_3$

SIC2298.4

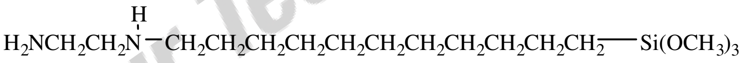
$OCN-CH_2-Si(OCH_3)_3$

SII6453.8

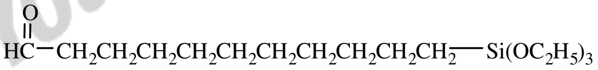


SIP6723.7

Silanes with extended linker length


$H_2NCH_2CH_2\overset{H}{N}-CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2-Si(OCH_3)_3$

SIA0595.0


$H\overset{O}{\overset{\|}{C}}-CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2-Si(OC_2H_5)_3$

SIT8194.0

$Br-CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2-Si(OCH_3)_3$

SIB1909.0

$HS-CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2-Si(OCH_3)_3$

SIM6480.0

$H_2C=CH-CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2-Si(OCH_3)_3$

SIU9049.0

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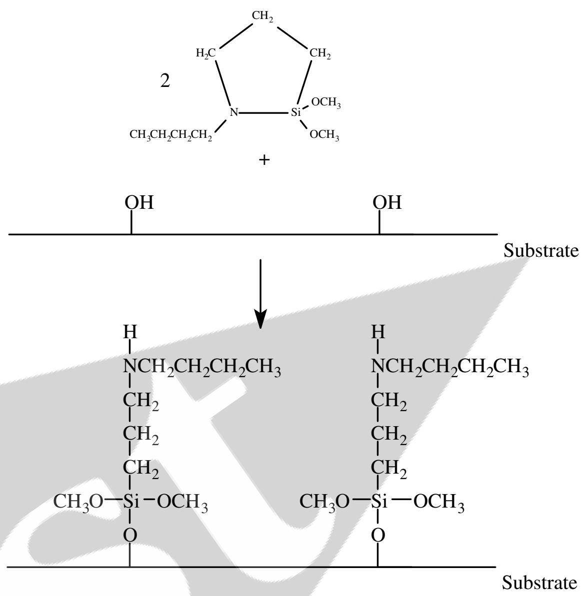
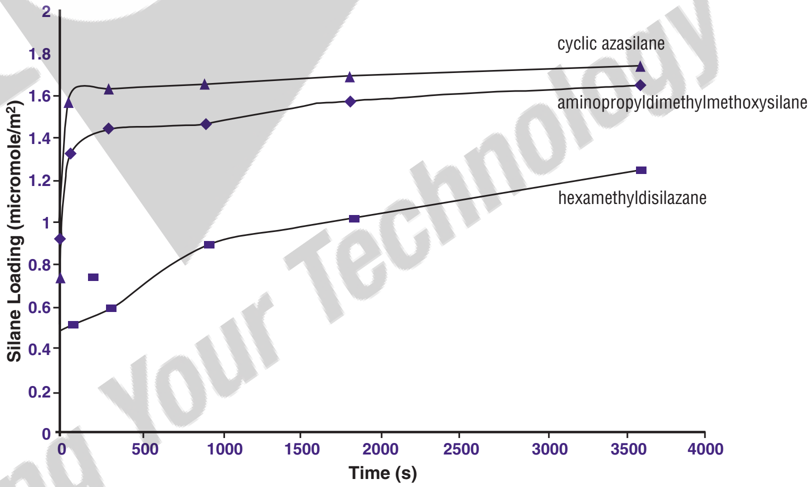
Cyclic Azasilanes

Volatile cyclic azasilanes are of particular interest in the surface modification of hydroxyl-containing surfaces, particularly inorganic surfaces such as nanoparticles and other nano-featured substrates. In these applications the formation of high functional density monolayers is critical. The cyclic azasilanes react with hydroxyl groups of a wide range of substrates at low temperatures by a ring-opening reaction that does not require water as a catalyst. Significantly, no byproducts of reaction form. The reactions of cyclic azasilanes are rapid at room temperature, even in the vapor phase. They also react rapidly at room temperature with isolated non-hydrogen bonded hydroxyls which do not undergo reaction with alkoxysilanes under similar conditions. The three most common cyclic azasilanes structures are depicted. (see p.35)

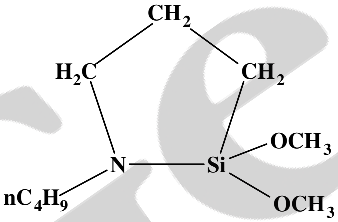
Anhydrous deposition with Cyclic Azasilanes



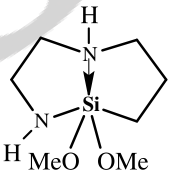
Extent of reaction of organosilanes with fumed silica



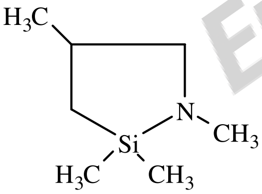
M. Vedamuthu et al, J. Undergrad., Chem. Res., *1*, 5, 2002



SIB1932.4



SID3543.0



SIM6501.4

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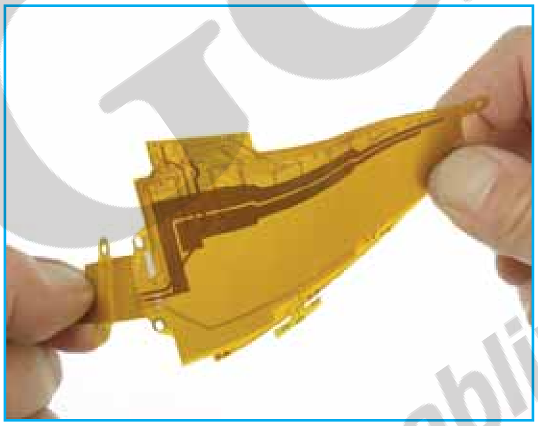
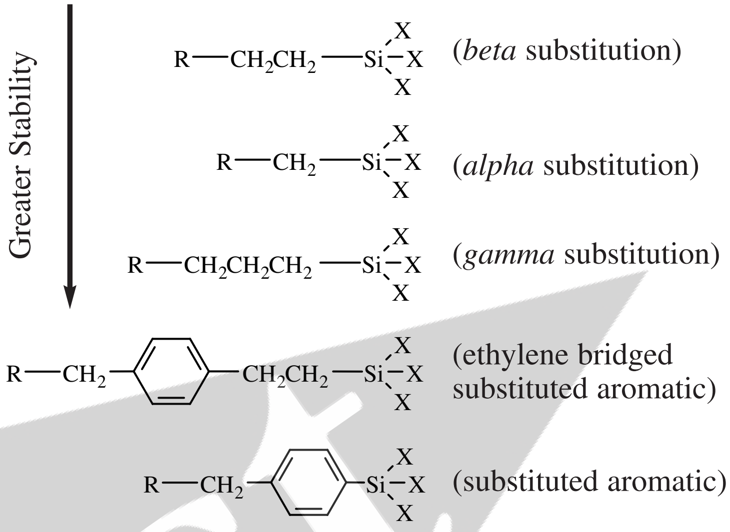
Thermal Stability of Silane Coupling Agents

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.

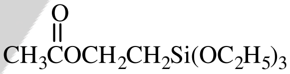
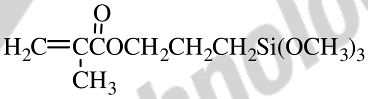
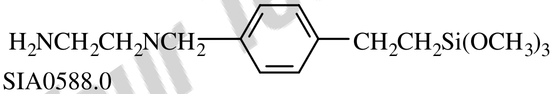
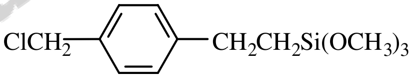
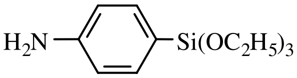
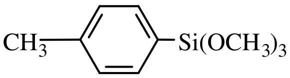


Flexible multi-layer circuit boards for cell-phones utilize polyimide films coupled w/chloromethylaromatic silanes.

Relative Thermal Stability of Silanes



Thermal Stability of Silanes

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

25% weight loss of dried hydrolysates as determined by TGA

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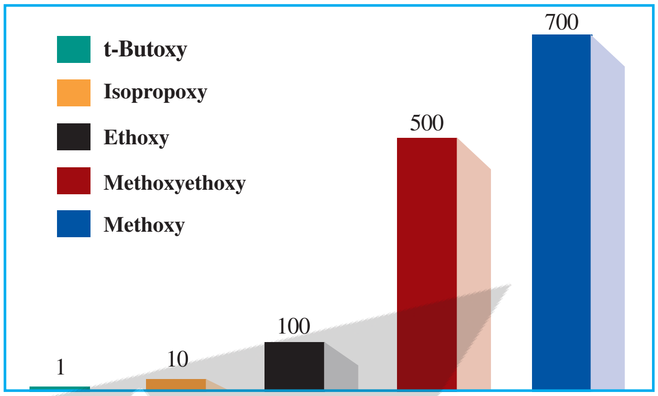
Aqueous Systems & Water-borne Silanes

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.

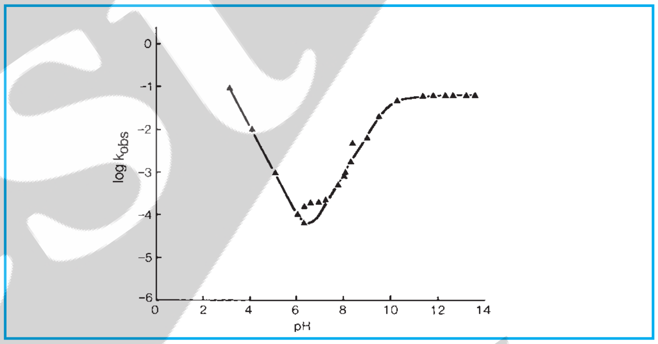
Hydrolysis and condensation of alkoxysilanes is dependent on both pH and catalysts. The general objective in preparing aqueous solutions is to devise a system in which the rate of hydrolysis is substantially greater than the rate of condensation beyond the solubility limit of the siloxane oligomers. 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

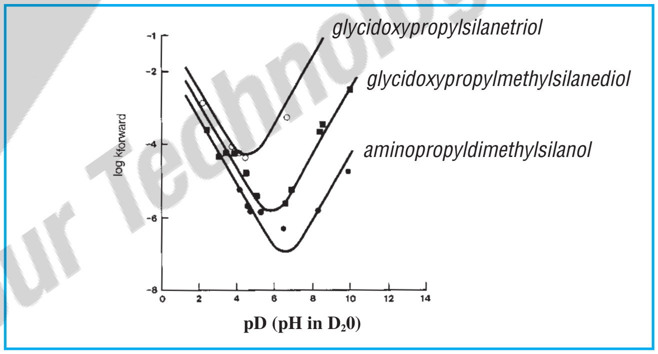


Hydrolysis Profile of Phenylbis(2-methoxyethoxy)silanol



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.

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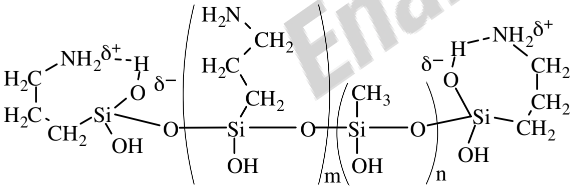

Water-borne Silsesquioxane Oligomers

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

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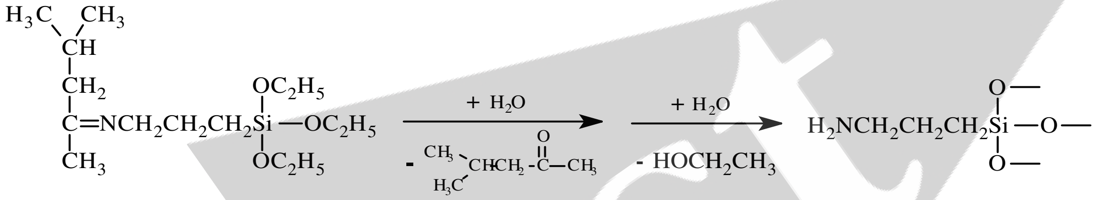
Masked Silanes - Latent Functionality

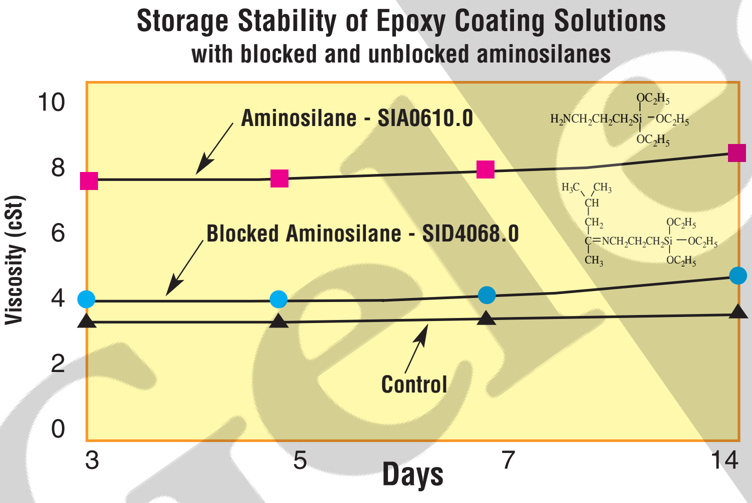
Maximum bond strength in some adhesion and bonding systems requires that the organic functionality of a silane coupling agent becomes available during a discrete time period of substrate - matrix contact. Examples are epoxy adhesives in which reaction of the silane with the resin increases viscosity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

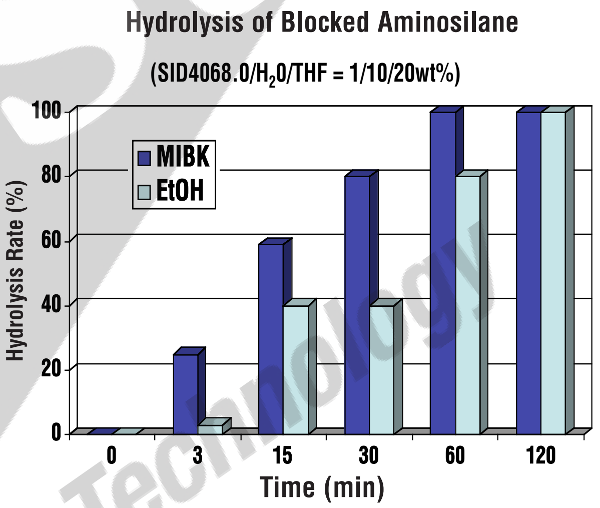
Single-component liquid-cure epoxy adhesives and coatings employ dimethylbutylidene blocked amino silanes. These materials show excellent storage stability in resin systems, but are activated by moisture provided by water adsorbed on substrate surfaces or from humidity. Deblocking begins in minutes and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



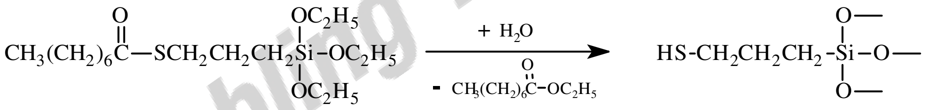
$$(\mathrm{H_3C})(\mathrm{CH_3})\mathrm{CH{-}CH_2{-}C(CH_3){=}NCH_2CH_2CH_2Si(OC_2H_5)_3} \xrightarrow[-\ \mathrm{CH_3CH(H_3C)CH_2\text{-}\overset{O}{\overset{\|}{C}}\text{—}CH_3}]{+\ \mathrm{H_2O}} \xrightarrow[-\ \mathrm{HOCH_2CH_3}]{+\ \mathrm{H_2O}} \mathrm{H_2NCH_2CH_2CH_2Si(O\text{—})_3}$$



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



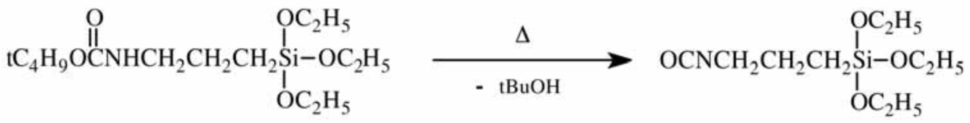
An alternative is to use the moisture adsorbed onto fillers to liberate alcohol which, in turn, demasks the organic functionality.



$$\mathrm{CH_3(CH_2)_6\overset{O}{\overset{\|}{C}}\text{—}SCH_2CH_2CH_2Si(OC_2H_5)_3} \xrightarrow[-\ \mathrm{CH_3(CH_2)_6\overset{O}{\overset{\|}{C}}\text{–}OC_2H_5}]{+\ \mathrm{H_2O}} \mathrm{HS\text{-}CH_2CH_2CH_2\text{-}Si(O\text{—})_3}$$

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.



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

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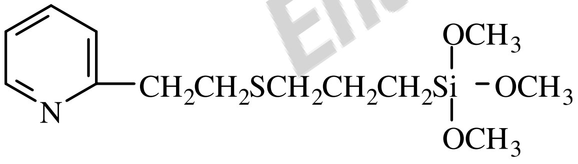
Coupling Agents for Metal Substrates

The optimum performance of silane coupling agents 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.

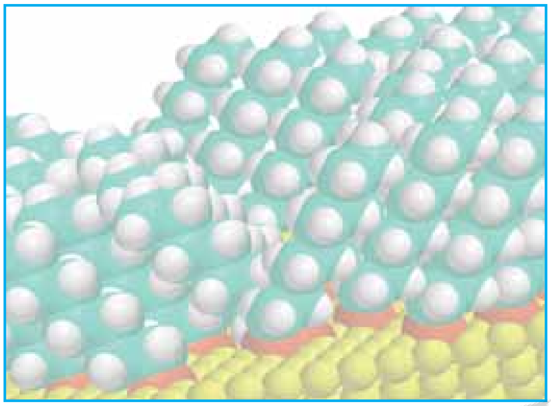
Metals that form hydrolytically stable surface oxides, e.g. aluminum, tin, titanium. These oxidized surfaces tend to have sufficient hydroxyl functionality to allow coupling under the same conditions applied to the siliceous substrates discussed earlier.

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.



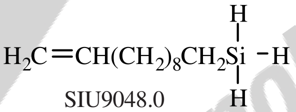
SIP6926.2



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 coordinate with the surface of the metal. 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. *(see p 53.)*



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

SIU9048.0

Coupling Agents for Metals*

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

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

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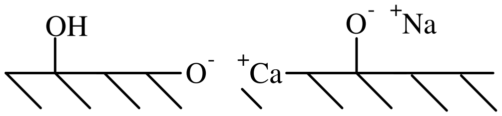
Difficult Substrates

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° 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.

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Applying Silanes

Fig. 1 Reactor for slurry treatment of powders. Separate filtration and drying steps are required.

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.

Fig. 2 Vacuum tumble dryers can be used for slurry treatment of powders.

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.

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 pre-blend. 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.

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

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.

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Applying Silanes

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.

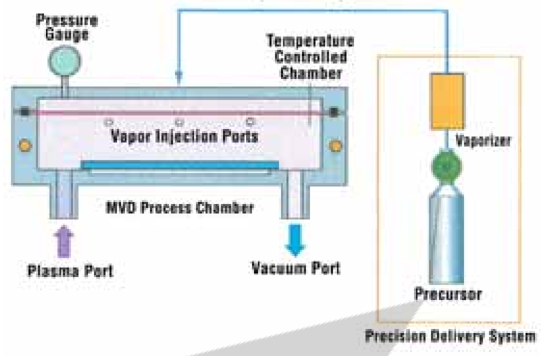


Figure 5. Spin-coater for deposition on wafers.

Spin-On

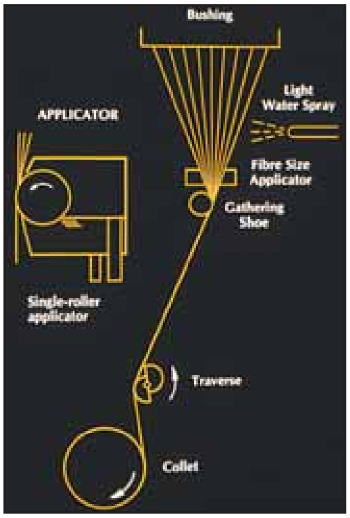
Spin-On applications can be made under hydrolytic conditions which favor maximum functionalization and polylayer deposition or dry conditions which favor monolayer deposition. For hydrolytic deposition 2-5% solutions are prepared (see deposition from aqueous alcohol). Spin speed is low, typically 500 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.

Figure 6. Spray application of silanes on large structures.

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



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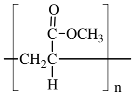
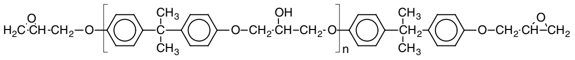
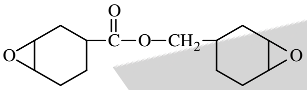
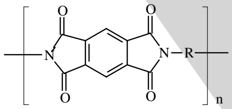
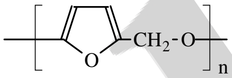
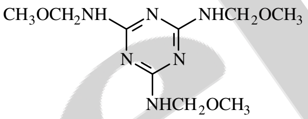
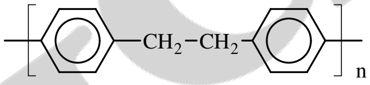
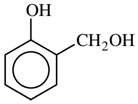
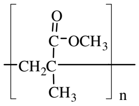
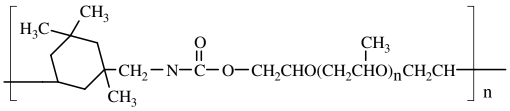
Acrylate-silanes in dental restorative composites.

Silane Coupling Agents for Thermosets

Selection Chart

		Coupling Agent Class	Suggestions for Primary Screening	
Acrylate, UV cure		Acrylate Vinyl/Olefin	SIA0200.0 SIS6964.0	SIM6487.4
Diallylphthalate		Amine Vinyl/Olefin	SIA0591.0 SIS6964.0	SIA0610.0
Epoxy		Amine Anhydride Epoxy	SIA0591.0 SIT8192.6 SIG5840.0	SIT8398.0
Epoxy, UV Cure		Amine Epoxy	SIA0591.0 SIE4668.0	SIT8398.0 SIE4670.0
Polyimide		Amine Halogen Dipodal	SIA0599.2 SIC2295.5 SIB1833.0	SIA0591.0 SIC2296.2
Furan		Amine Epoxy	SIA0611.0 SIG5840.0	SIA0599.0
Melamine		Amine Hydroxyl Dipodal	SIA0611.0 SIB1140.0 SIB1833.0	SIA0599.0 SIT8717.0
Parylene		Halogen Vinyl/Olefinic Dipodal	SIC2295.5 SIS6990.0 SIB1832.0	SIM6487.4 VMM-010
Phenol-formaldehyde		Amine Epoxy	SIA0611.0 SIE4670.0	SIT8187.5 SIG5840.0
Methylmethacrylate, cast		Acrylate Amine	SIM6487.4 SIB1828.0	SIA0200.0
Polyester, unsaturated	 $\left[-COCH{=}CH\overset{\overset{O}{\|}}{C}OCH_2CH_2OCH_2CH_2O-\right]_n$	Acrylate Vinyl/Olefin	SIM6487.4 SIS6994.0	SIV9112.0
Urea-formaldehyde	 $HOCH_2NH\overset{\overset{O}{\|}}{C}NHCH_2NH\overset{\overset{O}{\|}}{C}NHCH_2OH$	Amine Hydroxyl	SIA0610.0 SIB1140.0	SIU9055.0
Urethane		Amine Isocyanate Sulfur	SIA0610.0 SII6455.0 SIM6476.0	SIM6500.0

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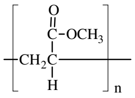
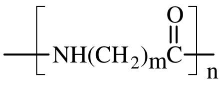
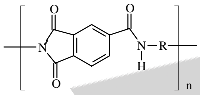
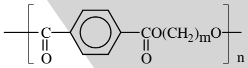
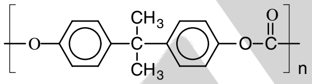
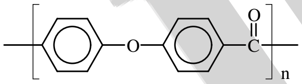
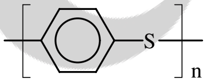
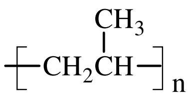
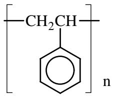
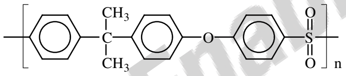
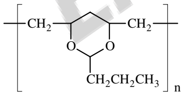
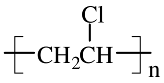
Diamine-silanes couple polycarbonate in CDs

Silane Coupling Agents for Thermoplastics

Selection Chart

		Coupling Agent Class	Suggestions for Primary Screening	
Polyacetal	$-[CH_2O]_n-$	Vinyl/Olefin	SIS6994.0	
Polyacrylate		Amine	SIU9058.0	SIA0610.0
Polyamide		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	$-[CH_2CH_2]_n-$	Amine Vinyl/Olefin	SIA0591.0 SSP-055	SIT8398.0 SIV9112.0
Polyphenylene sulfide		Amine Halogen Sulfur	SIA0605.0 SIC2295.5 SIM6476.0	
Polypropylene	 $-[CH_2CH(CH_3)]_n-$	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	 $-[CH_2CH(Cl)]_n-$	Amine Sulfur	SIA0605.0 SIM6474.0	 SIB1825.0

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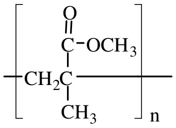
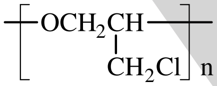
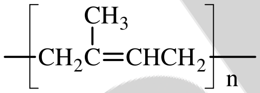
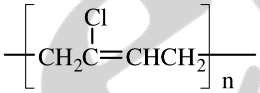
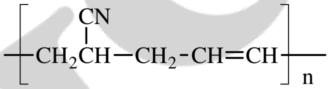
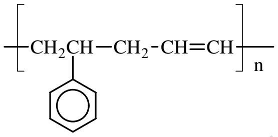
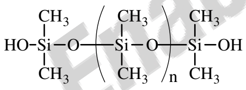
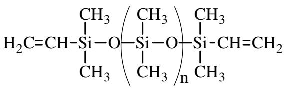
Silane Coupling Agents for Sealants & Elastomers

Selection Chart

Water-borne aminosilanes increase bonding of acrylic latex sealants

		Coupling Agent Class	Suggestions for Primary Screening	
Acrylic latex	 $\left[CH_2C(CH_3)(C(=O)OCH_3)\right]_n$	Acrylate Vinyl/Olefin Water-borne	SIM6487.4 SIV9210.0 WSA-7021	 SIV9218.0 WSA-6511
Butyl	$\left[CH_2CH=CHCH_2\right]_n$	Acrylate Sulfur Vinyl/Olefin	SIM6487.4 SIB1825.0 SSP-055	 SIM6476.0 VEE-005
Epichlorohydrin	 $\left[OCH_2CH(CH_2Cl)\right]_n$	Amine Sulfur	SIA0605.0 SIM6474.0	
Fluorocarbon	$-(CF_2CF_2)_m(CH_2CF_2)_n-$	Amine Dipodal	SIB1834.1 SIT8717.0	
Isoprene	 $\left[CH_2C(CH_3)=CHCH_2\right]_n$	Sulfur Vinyl/Olefin	SIM6474.0 SSP-055	SIM6476.0 VEE-005
Neoprene	 $\left[CH_2C(Cl)=CHCH_2\right]_n$	Sulfur Vinyl/Olefin	SIM6474.0 SSP-055	SIM6476.0 VEE-005
Nitrile	 $\left[CH_2CH(CN)-CH_2-CH=CH\right]_n$	Epoxy Sulfur	SIG5840.0 SIB1825.0	
Polysulfide	$\left[CH_2CH_2S\right]_n$	Epoxy Sulfur	SIG5840.0 SIB1825.0	 SIM6476.0
SBR		Amine Sulfur	SIA0605.0 SIB1825.0	 SIM6486.0
Silicone (hydroxyl terminated)	 $HO-Si(CH_3)_2-O-\left(Si(CH_3)_2-O\right)_n-Si(CH_3)_2-OH$	Amine Vinyl/Olefin Dipodal	SIA0605.0 SIV9098.0 SIB1824.0	SIA0589.0 VMM-010
Silicone (vinyl terminated)	 $H_2C=CH-Si(CH_3)_2-O-\left(Si(CH_3)_2-O\right)_n-Si(CH_3)_2-CH=CH_2$	Acrylate Vinyl/Olefin	SIM6487.4 SIA0540.0	 VMM-010

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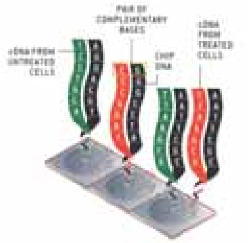
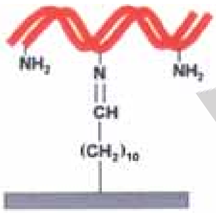
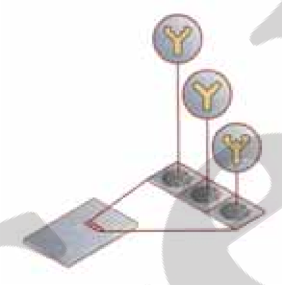
aldehyde-, amino-, and hydroxyl-silanes couple DNA in array technology

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*	
		G. McGall et al, J. Am. Chem. Soc., *119*, 5081, 1997. **F. Chow**, in "Silylated Surfaces" D. Leyden ed., Gordon & Breach, 1978, p.301.			
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*	*$NaNO_2$/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	*chloroplast*	*alkyl*		*SIO6645.0*	
 mitochondria on silica bead	*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*	*short alkyl*		*SIE4901.4*	
 erythrocytes on glass wall		**B. Arkles** et al, in "Silylated Surfaces" D. Leyden ed., Gordon & Breach, 1978, p363.			
Whole Cell (causing lysis)	*procaryotic*	*alkyl-quat*		*SIO6620.0*	
		W. White et al in "Silanes, Surfaces & Interfaces" ed. D. Leyden, Gordon & Breach, 1986, p. 107.		*SID3392.0*	
Tissue	*histological samples*			*SIA0611.0*	*SIA0610.0*

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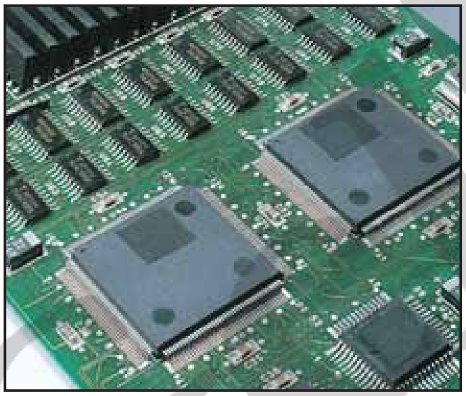
SILANE COUPLING AGENT PROPERTIES

Lactase is immobilized with aminosilanes and glutaraldehyde.



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

Methacrylate-silanes couple fiberglass to unsaturated polyester in corroson resistant rooftop ductwork at Gelest, Inc.

Commercial Status - produced on a regular basis for inventory

Developmental Status - available to support development and commercialization

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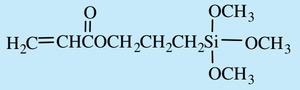
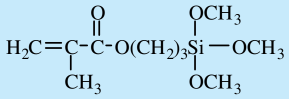
Methacrylate-silanes couple fiberglass to unsaturated polyester

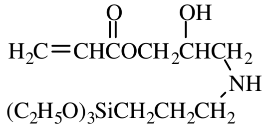
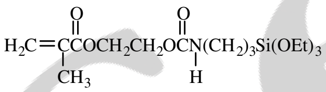
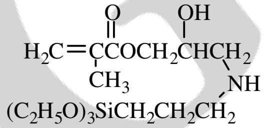
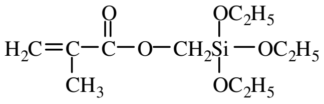
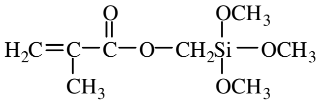
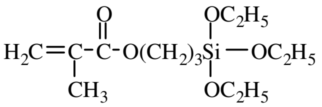
Acrylate & Methacrylate Functional Silanes

Acrylate & Methacrylate Functional Silanes - Trialkoxy

Commercial

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $H_2C=CH\overset{O}{\overset{\|}{C}}OCH_2CH_2CH_2Si(OCH_3)_3$	SIA0200.0 (3-ACRYLOXYPROPYL)TRIMETHOXYSILANE, 95% inhibited with MEHQ $C_9H_{18}O_5Si$ aqueous solutions more stable than methacrylate analog coupling agent for epoxies, UV cure coatings; employed in optical fiber coatings[1]. 1. M. Yokoshima et al, CA113, 15746d; Jap. Pat. 02133338, 1990 [4369-14-6] TSCA-S HMIS: 3-1-1-X store <5° 25g/$48.00 100g/$156.00 2.0kg/$580.00	234.32 flashpoint: 123°C (253°F)	68°/0.4	1.00	1.4155
 $H_2C=\underset{CH_3}{C}-\overset{O}{\overset{\|}{C}}-O(CH_2)_3Si(OCH_3)_3$	SIM6487.4 METHACRYLOXYPROPYLTRIMETHOXYSILANE *MEMO* inhibited with MEHQ, HQ $C_{10}H_{20}O_5Si$ viscosity: 2 cSt. copolymerization parameters-e,Q: 0.07, 2.7 widely used coupling agent for unsaturated polyester-fiberglass composites[1]. copolymerized with styrene in formation of sol-gel composites[2]. 1. B. Arkles, Chemtech, *7*, 713, 1977 2. Y. Wei et al, J. Mater. Res., *8*, 1143, 1993 [2530-85-0] TSCA HMIS: 3-2-1-X store <5° 100g/$10.00 2.0kg/$124.00 18kg/$630.00	248.35 TOXICITY- oral rat, LD50: 3,000mg/kg flashpoint: 108°C (226°F) Primary Irritation Index: 1.19 specific wetting surface: 314m²/g	78-81°/1 (-48°)mp	1.045	1.4310

Developmental

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $H_2C=CH\overset{O}{\overset{\|}{C}}OCH_2\overset{OH}{CH}CH_2NHCH_2CH_2CH_2Si(OC_2H_5)_3$	SIA0180.0 N-(3-ACRYLOXY-2-HYDROXYPROPYL)-3-AMINOPROPYLTRIETHOXYSILANE, 50% in ethanol $C_{15}H_{31}NO_6Si$ inhibited with MEHQ [123198-57-2] HMIS: 3-4-1-X store <5° 25g/$140.00	349.50 flashpoint: 8°C (48°F)		0.931	1.4084
 $H_2C=\underset{CH_3}{C}\overset{O}{\overset{\|}{C}}OCH_2CH_2O\overset{O}{\overset{\|}{C}}\underset{H}{N}(CH_2)_3Si(OEt)_3$	SIM6480.8 O-(METHACRYLOXYETHYL)-N-(TRIETHOXYSILYLPROPYL)URETHANE, 90% $C_{16}H_{31}NO_7Si$ [115396-93-5] HMIS: 3-2-1-X store <5° 25g/$42.00 100g/$136.00	377.51 inhibited with MEHQ		1.051^{25}	1.446^{25}
 $H_2C=\underset{CH_3}{C}\overset{O}{\overset{\|}{C}}OCH_2\overset{OH}{CH}CH_2NHCH_2CH_2CH_2Si(OC_2H_5)_3$	SIM6481.1 N-(3-METHACRYLOXY-2-HYDROXYPROPYL)-3-AMINOPROPYLTRIETHOXYSILANE, 50% in ethanol $C_{16}H_{33}NO_6Si$ inhibited with MEHQ employed in conservation/consolidation of stone[1]. 1. G. Wheeler, in "Ninth Int'l Cong. on Deteriorat'n and Conservat'n of Stone "ed. V Fassina, *2*, 541, Elsevier 2000. [96132-98-8] HMIS: 3-4-1-X store <5° 25g/$49.00 100g/$160.00	363.53 flashpoint: 8°C (48°F)		0.91	1.4084
 $H_2C=\underset{CH_3}{C}-\overset{O}{\overset{\|}{C}}-O-CH_2Si(OC_2H_5)_3$	SIM6482.0 METHACRYLOXYMETHYLTRIETHOXYSILANE $C_{11}H_{22}O_5Si$ inhibited with MEHQ treatment of fumed silica in acrylic casting compositions accelerates polymerization[1]. 1. E. Morozova et al, CA 95,98753g; Plast. Massy, 7, 1981 [5577-72-0] HMIS: 3-2-1-X store <5° 10g/$40.00 50g/$160.00	262.38	65-8°/2		
 $H_2C=\underset{CH_3}{C}-\overset{O}{\overset{\|}{C}}-O-CH_2Si(OCH_3)_3$	SIM6483.0 METHACRYLOXYMETHYLTRIMETHOXYSILANE $C_8H_{16}O_5Si$ inhibited with MEHQ modification of novolac resins afford bilevel resists having attributes of trilevel resists[1]. 1. E. Reichmanis et al, US Pat. 4,481,049,1984 [54586-78-6] HMIS: 3-2-1-X store <5° 10g/$32.00 50g/$128.00	220.30	48-50°/2	1.07	1.4271
 $H_2C=\underset{CH_3}{C}-\overset{O}{\overset{\|}{C}}-O(CH_2)_3Si(OC_2H_5)_3$	SIM6487.3 METHACRYLOXYPROPYLTRIETHOXYSILANE $C_{13}H_{26}O_5Si$ inhibited with MEHQ [21142-29-0] HMIS: 3-1-1-X store <5° 10g/$39.00 50g/$156.00	290.43 flashpoint: 128°C (262°F)	130°/4	0.985	1.4277

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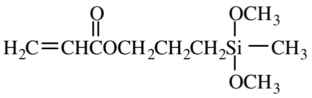
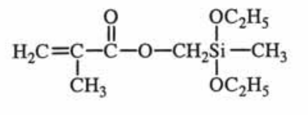
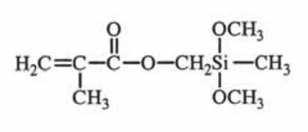
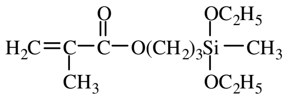
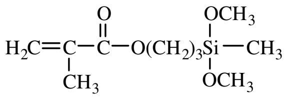
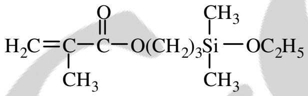
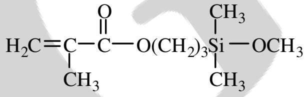
Acrylate & Methacrylate Functional Silanes - Dialkoxy

structure	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $H_2C{=}CH\overset{O}{\overset{\Vert}{C}}OCH_2CH_2CH_2\underset{OCH_3}{\overset{OCH_3}{Si}}-CH_3$	SIA0198.0 (3-ACRYLOXYPROPYL)METHYLDIMETHOXY SILANE, 95% inhibited w/ MEHQ $C_9H_{18}O_4Si$ employed in fabrication of photoimageable, low shrinkage multimode waveguides[1]. 1. C. Xu et al, Chem. Mater., *8*, 2701, 1996 [13732-00-8] HMIS: 3-2-1-X store <5°	218.33 50g/$46.00	65°/0.35	1.0 250g/$184.00	1.431
 $H_2C{=}\underset{CH_3}{C}-\overset{O}{\overset{\Vert}{C}}-O-CH_2\underset{OC_2H_5}{\overset{OC_2H_5}{Si}}-CH_3$	SIM6481.43 (METHACRYLOXYMETHYL)METHYL-DIETHOXYSILANE $C_{10}H_{20}O_4Si$ [121177-93-3] HMIS: 2-2-1-X store <5°	232.4 flashpoint: 88°C (190°F) TOXICITY oral-rat, LD50: >2000mg/kg 25g/$26.00	221°	0.977 100g/$84.00	
 $H_2C{=}\underset{CH_3}{C}-\overset{O}{\overset{\Vert}{C}}-O-CH_2\underset{OCH_3}{\overset{OCH_3}{Si}}-CH_3$	SIM6481.46 (METHACRYLOXYMETHYL)METHYL-DIMETHOXYSILANE $C_8H_{16}O_4Si$ viscosity: 1.4 cSt [3978-58-3] HMIS: 3-2-1-X store <5°	204.30 flashpoint: 82°C (180°F) autoignition temp: 300°C TOXICITY oral-rat, LD50: >2000mg/kg 25g/$22.00	205°	1.020 100g/$72.00	1.4274
 $H_2C{=}\underset{CH_3}{C}-\overset{O}{\overset{\Vert}{C}}-O(CH_2)_3\underset{OC_2H_5}{\overset{OC_2H_5}{Si}}-CH_3$	SIM6486.8 METHACRYLOXYPROPYLMETHYLDI-ETHOXYSILANE, 95% inhibited w/ MEHQ $C_{12}H_{24}O_4Si$ [65100-04-1] HMIS: 3-1-1-X store <5°	260.40 flashpoint 136°C (277°F) 10g/$39.00	95°/1	0.965 50g/$156.00	1.433
 $H_2C{=}\underset{CH_3}{C}-\overset{O}{\overset{\Vert}{C}}-O(CH_2)_3\underset{OCH_3}{\overset{OCH_3}{Si}}-CH_3$	SIM6486.9 METHACRYLOXYPROPYLMETHYLDI-METHOXYSILANE, 95% inhibited w/MEHQ $C_{10}H_{20}O_4Si$ monomer for hybrid inorganic-organic composites[1]. 1. R. Taylor-Smith, Polym. Mat. Sci. Eng., Preprints, *77*, 503, 1997 [14513-34-9] HMIS: 3-2-1-X store <5°	235.69 flashpoint: 115°C (190°F) 25g/$45.00	83°/3	1.00 100g/$146.00	1.4351

Acrylate & Methacrylate Functional Silanes - Monoalkoxy

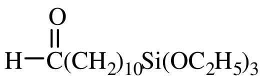
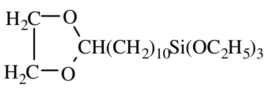
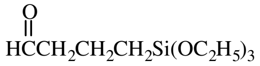
structure	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $H_2C{=}\underset{CH_3}{C}-\overset{O}{\overset{\Vert}{C}}-O(CH_2)_3\underset{CH_3}{\overset{CH_3}{Si}}-OC_2H_5$	SIM6486.4 METHACRYLOXYPROPYLDIMETHYLETHOXY-SILANE , 95% inhibited with MEHQ $C_{11}H_{22}O_3Si$ [13731-98-1] HMIS: 3-2-1-X store <5°	230.38	75-6°/0.4 10g/$78.00	0.926	1.4371
 $H_2C{=}\underset{CH_3}{C}-\overset{O}{\overset{\Vert}{C}}-O(CH_2)_3\underset{CH_3}{\overset{CH_3}{Si}}-OCH_3$	SIM6486.5 METHACRYLOXYPROPYLDIMETHYL-METHOXYSILANE, 95% inhibited with MEHQ $C_{10}H_{20}O_3Si$ [66753-64-8] HMIS: 3-2-1-X store <5°	216.35 10g/$48.00	70-2°/0.5	0.944 50g/$192.00	1.4381

Developmental

Developmental

Aldehyde Functional Silanes

Aldehyde Functional Silanes - Trialkoxy

structure	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $H-\overset{O}{\overset{\Vert}{C}}(CH_2)_{10}Si(OC_2H_5)_3$	SIT8194.0 TRIETHOXYSILYLUNDECANAL $C_{17}H_{36}O_4Si$ coupling agent for DNA HMIS: 2-2-1-X	332.56	150-5°/0.5 5.0g/$110.00		1.4343
	SIT8194.5 TRIETHOXYSILYLUNDECANAL, ETHYLENE GLYCOL ACETAL $C_{19}H_{40}O_5Si$ HMIS: 2-2-1-X	366.60	160-5°/0.25 5.0g/$110.00		
 $H\overset{O}{\overset{\Vert}{C}}CH_2CH_2CH_2Si(OC_2H_5)_3$	SIT8185.3 TRIETHOXSILYLBUTYRALDEHYDE, tech-90 $C_{10}H_{22}O_4Si$ contains 3-TRIETHOXYSILYL-2-METHYLPROPANAL isomer and cyclic siloxy acetal, 2,2,6-TRIETHOXY-1-OXA-2-SILACYCLOHEXANE [88276-92-0] HMIS: 3-3-1-X	234.37	85-7°/1 10g/$140.00	0.96	1.414

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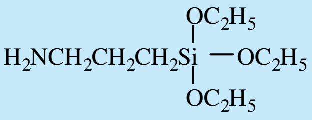
A variety of composite materials utilizing methacrylate and aminosilanes are used in laser-printers.

Amino Functional Silanes

name MW bp/mm (mp) D_4^{20} n_D^{20}

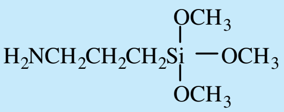
Monoamine Functional Silanes - Trialkoxy

Commercial



$H_2NCH_2CH_2CH_2Si(OC_2H_5)_3$

SIA0610.0
3-AMINOPROPYLTRIETHOXYSILANE 221.37 122-3°/30 0.951 1.4225
$C_9H_{23}NO_3Si$ *AMEO, GAPS* TOXICITY- oral rat, LD50: 1780mg/kg
flashpoint: 104°C (220°F) primary irritation index: 6.50
ΔHvap: 11.8 kcal/mole γc of treated surface: 37.5 dynes/cm
viscosity: 1.6 cSt. specific wetting surface: 353m²/g
versatile coupling agent vapor pressure, 100°: 10mm
effects immobilization of enzymes[1].
1. Enzymes, *84*, 55915, 1976
[919-30-2] TSCA HMIS: 3-1-1-X 25g/$10.00 2.0kg/$96.00 16kg/$488.00



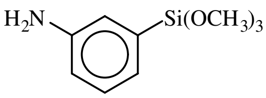
$H_2NCH_2CH_2CH_2Si(OCH_3)_3$

SIA0611.0
3-AMINOPROPYLTRIMETHOXYSILANE 179.29 80°/8 1.027 1.4240
$C_6H_{17}NO_3Si$ flashpoint: 83°C (182°F)
hydrolysis rate vs AMEO (SIA0610.0): 6:1 vapor pressure, 67°: 5mm
[13822-56-5] TSCA HMIS: 3-2-1-X 25g/$10.00 2.0kg/$160.00 18kg/$837.00

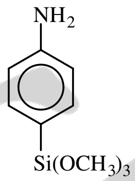
Developmental

$H_2NCH_2CH_2CH_2CH_2Si(OC_2H_5)_3$

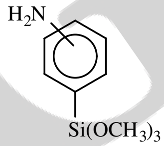
SIA0587.0
4-AMINOBUTYLTRIETHOXYSILANE, 95% 235.40 114-6°/14 0.941^{25} 1.4270^{25}
$C_{10}H_{25}NO_3Si$ flashpoint: 109°C (225°F)
TOXICITY- oral rat, LD50: 1620mg/kg
[3069-30-5] HMIS: 2-2-1-X 10g/$37.00 50g/$148.00



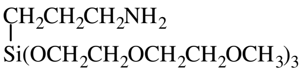
SIA0599.0
m-AMINOPHENYLTRIMETHOXYSILANE, 90% 213.31 110-4°/0.6 1.19 1.5187
$C_9H_{15}NO_3Si$ contains other isomers flashpoint: 180°C (356°F)
[70411-42-6] HMIS: 3-1-1-X 5.0g/$76.00



SIA0599.1
p-AMINOPHENYLTRIMETHOXYSILANE, 90% 213.31 110-4°/0.6
$C_9H_{15}NO_3Si$ contains other isomers (60-2°) mp
flashpoint: 180°C (356°F)
coupler for silica-poly(phenyleneterephthalamide) composite films.[1]
1. J. Mark et al, J. Mater. Chem. *7*, 259, 1997
[33976-43-1] HMIS: 3-1-1-X 5.0g/$82.00

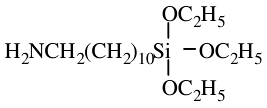


SIA0599.2
AMINOPHENYLTRIMETHOXYSILANE, 213.31 110-4°/0.6 1.19
mixed isomers typically 60-70% para, 30-40% meta
$C_9H_{15}NO_3Si$ flashpoint: 180°C (356°F)
for pure isomers, see SIA0559.0, SIA0559.1
[33976-43-1] HMIS: 3-1-1-X 5.0g/$64.00 25g/$256.00



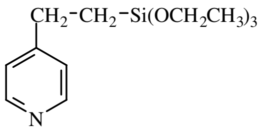
$H_2NCH_2CH_2CH_2Si(OCH_2CH_2OCH_2CH_2OCH_3)_3$

SIA0614.0
3-AMINOPROPYLTRIS(METHOXYETHOXYETHOXY)SILANE, 95% 443.61 1.066 1.448
flashpoint: 68°C (155°F)
$C_{18}H_{41}NO_9Si$
for melt compounding of polyamide composites
[87794-64-7] HMIS: 3-2-1-X 25g/$40.00



$H_2NCH_2(CH_2)_{10}Si(OC_2H_5)_3$

SIA0630.0
11-AMINOUNDECYLTRIETHOXYSILANE 333.59 130-2°/1 0.895^{25} 1.4352^{25}
$C_{17}H_{39}NO_3Si$ contains ~5% isomers
[116821-45-5] HMIS: 2-2-1-X 1.0g/$124.00



SIP6928.0
2-(4-PYRIDYLETHYL)TRIETHOXYSILANE 269.43 105°/0.9 1.00 1.4624^{24}
$C_{13}H_{23}NO_3Si$ amber liquid
see also SIT8396.0, SIP6926.4
HMIS: 3-2-1-X 10g/$112.00

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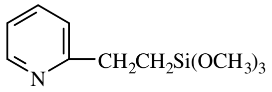
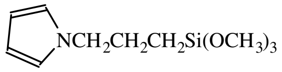
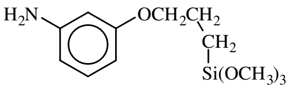
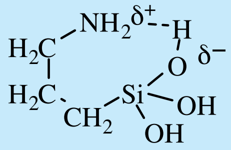
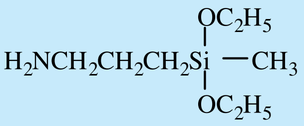
	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIT8396.0 2-(TRIMETHOXYSILYLETHYL)PYRIDINE $C_{10}H_{17}NO_3Si$ [27326-65-4] HMIS: 3-2-1-X	227.33 flashpoint: >110°C (>230°F) 10g/$39.00	105°/0.3	1.06 50g/$156.00	1.4755
	SIT8410.0 N-(3-TRIMETHOXYSILYLPROPYL)PYRROLE $C_{10}H_{19}NO_3Si$ for electrode modification, polypyrrole adhesion[1] 1. R. Simon et al. J. Am. Chem. Soc. *104*, 2031,1982. [80906-67-8] HMIS: 3-1-1-X	229.35 flashpoint: >110°C (>230°F)	105-7°/1 5.0g/$86.00	1.017	1.463
	SIA0598.0 3-(m-AMINOPHENOXY)PROPYLTRIMETHOXY-SILANE, 95% amber liquid $C_{12}H_{21}NO_4Si$ [55648-29-8] HMIS: 3-1-1-X	271.39 10g/$53.00		1.02 50g/$212.00	1.495

Developmental

Monoamine Functional Silanes - Water-borne

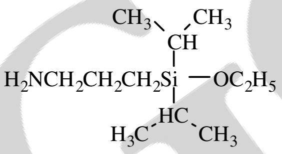
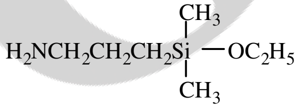
	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIA0608.0 AMINOPROPYLSILANETRIOL, 22-25% in water $C_3H_{11}NO_3Si$ mainly oligomers internal hydrogen bonding stabilizes solution [29159-37-3] TSCA HMIS: 2-0-0-X	137.21 flashpoint: >110°C (230°F) pH: 10.0-10.5 25g/$10.00	 2.0kg/$120.00	1.06 18kg/$495.00	

Monoamine Functional Silanes - Dialkoxy

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $H_2NCH_2CH_2CH_2\overset{OC_2H_5}{\underset{OC_2H_5}{Si}}-CH_3$	SIA0605.0 3-AMINOPROPYLMETHYLDIETHOXYSILANE $C_8H_{21}NO_2Si$ coupling agent for foundry resins [3179-76-8] TSCA HMIS: 3-2-1-X	191.34 TOXICITY- oral rat, LD50: 4760mg/kg flashpoint: 85°C (185°F) 25g/$10.00	85-8°/8	0.916 2.0kg/$172.00	1.4272

Commercial

Monoamine Functional Silanes - Monoalkoxy

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIA0602.0 3-AMINOPROPYLDIISOPROPYLETHOXY-SILANE $C_{11}H_{27}NOSi$ forms hydrolytically stable monlayers [17559-36-1] HMIS: 3-2-0-X	217.43 5.0g/$45.00	78-80°/0.4	0.872^{25} 25g/$180.00	1.4489
 $H_2NCH_2CH_2CH_2\overset{CH_3}{\underset{CH_3}{Si}}-OC_2H_5$	SIA0603.0 3-AMINOPROPYLDIMETHYLETHOXYSILANE $C_7H_{19}NOSi$ Δ Hform: 147.6 kcal/mole [18306-79-1] TSCA HMIS: 3-2-1-X	161.32 flashpoint: 73°C (163°F) 5.0g/$48.00	78-9°/24	0.857^{25} 25g/$192.00	1.427^{25}

Developmental

Diamine Functional Silanes - Trialkoxy

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
$H_2NCH_2CH_2NHCH_2CH_2CH_2Si(OCH_3)_3$	SIA0591.0 N-(2-AMINOETHYL)-3-AMINOPROPYLTRI-METHOXYSILANE *N-[3-(TRIMETHOXYSILYL)PROPYL]ETHYLENEDIAMINE DAMO* $C_8H_{22}N_2O_3Si$ visc: 6.5 cSt Ce: 0.8 γc, treated surface: 36.5 dynes/cm coupling agent for polyamides and polyesters with good film forming properties coupling agent for brass and copper substrates [1760-24-3] TSCA HMIS: 3-1-1-X	226.36 TOXICITY- oral rat, LD50: 7460mg/kg flashpoint: 150°C (302°F) specific wetting surface: 358 m^2/g 25g/$10.00	140°/15 2.0kg/$96.00	1.019^{25} 16kg/$576.00	1.450^{25}
$H_2NCH_2CH_2NHCH_2CH_2CH_2Si(OC_2H_5)_3$	SIA0590.5 N-(2-AMINOETHYL)-3-AMINOPROPYLTRI-ETHOXYSILANE, 95% $C_{11}H_{28}N_2O_3Si$ [5089-72-5] TSCA HMIS: 3-1-1-X	264.5 flashpoint: 148°C (298°F)	156°/15 25g/$60.00	0.994	1.4367^{25}

Commercial

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name **MW** **bp/mm (mp)** **D_4^{20}** **n_D^{20}**

Developmental

$H_2NCH_2CH_2CH_2CH_2CH_2CH_2NHCH_2Si(OC_2H_5)_3$

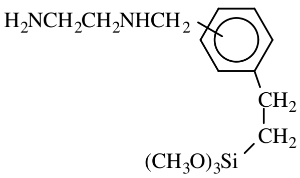
SIA0592.6
N-(6-AMINOHEXYL)AMINOMETHYL-TRIETHOXYSILANE, 95% 292.49 160°/0.1 0.928^{25} 1.4385^{25}
flashpoint: >110°C (>230°F)
$C_{13}H_{32}N_2O_3Si$
[15129-36-9] HMIS: 3-2-1-X 25g/$29.00 100g/$94.00

$H_2N(CH_2)_6NHCH_2CH_2CH_2Si(OCH_3)_3$

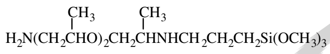
SIA0594.0
N-(6-AMINOHEXYL)AMINOPROPYL-TRIMETHOXYSILANE, 95% 278.47 160-5°/0.15 1.11 1.4501
flashpoint: >110°C (>230°F)
$C_{12}H_{30}N_2O_3Si$
employed in immobilization of DNA[1].
immobilizes PCR primers on glass beads[2].
1. C. Kneuer et al, Int'l J. Pharmaceutics, *196(2)*, 257, 2000.
2. J. Andreadis et al, Nuc. Acid Res., *28*, E-5, 2000.
[51895-58-0] HMIS: 3-2-1-X 10g/$31.00 50g/$124.00

$H_2NCH_2CH_2NH(CH_2)_{11}Si(OCH_3)_3$

SIA0595.0
N-(2-AMINOETHYL)-11-AMINOUNDECYL-TRIMETHOXYSILANE 334.57 155-9°/0.4 0.873^{25} 1.4515
$C_{16}H_{38}N_2O_3Si$
coupling agent with extended spacer-group for remote substrate binding
HMIS: 3-1-1-X 5.0g/$130.00



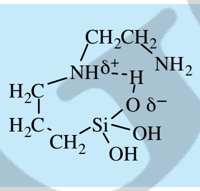
SIA0588.0
(AMINOETHYLAMINOMETHYL)PHENETHYL-TRIMETHOXYSILANE, 90% mixed m,p isomers 298.46 126-30°/0.2 1.02 1.5083
flashpoint: > 110°C (>230°F)
$C_{14}H_{26}N_2O_3Si$
coupling agent for polyimides
photochemically sensitive (194nm)[1] self-assembled monolayers[2].
1. W. Dressick et al, Thin Solid Films, *284*, 568, 1996
2. C. Harnett et al, Appl. Phys. Lett., *76*, 2466, 2000.
[74113-77-2] TSCA HMIS: 3-1-1-X 25g/$82.00 100g/$266.00


$H_2N(CH_2\overset{CH_3}{C}HO)_2CH_2\overset{CH_3}{C}HNHCH_2CH_2CH_2Si(OCH_3)_3$

SIA0599.4
N-3-[(AMINO(POLYPROPYLENOXY)]AMINO-PROPYLTRIMETHOXYSILANE 60-65% 337-435 0.984 1.4508
3-4 propyleneoxy units
contains 30-35% amine terminated polypropylene oxide
coupling agent with film-forming capability
HMIS: 2-2-1-X 25g/$72.00

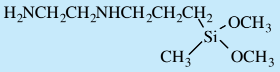
Commercial

Diamine Functional Silanes - Water-borne

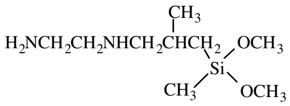


SIA0590.0
N-(2-AMINOETHYL)-3-AMINOPROPYL-SILANETRIOL, 25% in water mainly oligomers 180.28 1.00
flashpoint: >110°C (230°F)
$C_5H_{17}N_2O_3Si$ pH: 10.0-10.5
internal hydrogen bonding stabilizes solution
[68400-09-9] TSCA HMIS: 2-0-0-X 100g/$10.00 2.0kg/$130.00

Diamine Functional Silanes - Dialkoxy

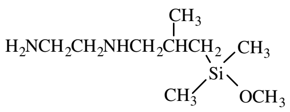


SIA0589.0
N-(2-AMINOETHYL)-3-AMINOPROPYLMETHYL-DIMETHOXYSILANE 206.36 265° 0.975^{25} 1.4447^{25}
flashpoint: 90°C (194°F)
autoignition temp: 280°C
specific wetting surface: 380 m^2/g
$C_8H_{22}N_2O_2Si$
comonomer for silicones in textile softeners and haircare formulations
[3069-29-2] TSCA HMIS: 3-1-1-X 25g/$10.00 2.0kg/$154.00 16kg/$954.00



SIA0587.5
N-(2-AMINOETHYL)-3-AMINOISOBUTYL-METHYLDIMETHOXYSILANE, 95% 220.39 131°/15 0.960 1.4518
flashpoint: 96°C (205°F)
$C_9H_{24}N_2O_2Si$
[23410-40-4] TSCA HMIS: 3-2-1-X 25g/$90.00

Diamine Functional Silanes - Monoalkoxy



SIA0587.2
(AMINOETHYLAMINO)-3-ISOBUTYLDI-METHYLMETHOXYSILANE, 95% 204.39 85-9°/2 0.900^{25} 1.4513^{25}
$C_9H_{24}N_2OSi$
[31024-49-4] HMIS: 3-2-1-X 25g/$84.00

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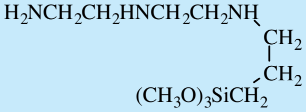
name MW bp/mm (mp) D_4^{20} n_D^{20}

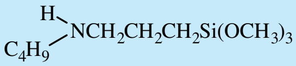
Triamine Functional


$H_2NCH_2CH_2HNCH_2CH_2NHCH_2CH_2CH_2Si(OCH_3)_3$

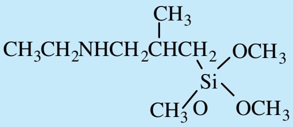
SIT8398.0
(3-TRIMETHOXYSILYLPROPYL)DIETHYLENETRIAMINE, 95% 265.43 114-8°/2 1.030 1.4590
flashpoint: 137°C (279°F)
$C_{10}H_{27}N_3O_3Si$
γc of treated surface: 37.5 dynes/cm
hardener, coupling agent for epoxies
[35141-30-1] TSCA HMIS: 3-1-1-X 100g/$19.00 2.0kg/$248.00

Secondary Amine Functional

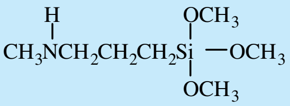
Commercial



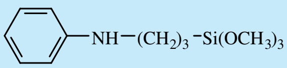
SIB1932.2
n-BUTYLAMINOPROPYLTRIMETHOXYSILANE 235.40 102°/3.5 0.947 1.4246^{25}
flashpoint: 110°C (230°F)
$C_{10}H_{25}NO_3Si$
coupling agent for urethane coatings
[31024-56-3] TSCA HMIS: 2-2-1-X 25g/$12.00 2.0kg/$240.00



SIE4886.0
N-ETHYLAMINOISOBUTYLTRIMETHOXYSILANE 221.37 95°/10 0.952^{25} 1.4234
flashpoint: 91°C (196°F)
$C_9H_{23}NO_3Si$
adhesion promoter for polyurethane coatings
[227085-51-0] TSCA HMIS: 3-2-1-X 25g/$18.00 2.0kg/$360.00


$CH_3N(H)CH_2CH_2CH_2Si(OCH_3)_3$

SIM6500.0
N-METHYLAMINOPROPYLTRIMETHOXYSILANE 193.32 106°/30 0.978^{25} 1.4194
flashpoint: 82°C (179°F)
$C_7H_{19}NO_3Si$
γc of treated surface: 31 dynes/cm
$pK_b{}^{25}H_2O$: 5.18
orients liquid crystals
[3069-25-8] TSCA HMIS: 3-2-1-X 25g/$21.00 2.0kg/$420.00

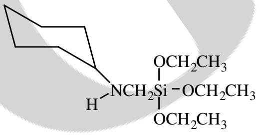


SIP6724.0
N-PHENYLAMINOPROPYLTRIMETHOXYSILANE, 95% 255.38 132-5°/0.3 1.07 1.504
flashpoint: 165°C (329°F)
$C_{12}H_{21}NO_3Si$
specific wetting surface: 307m^2/g
oxidatively stable coupling agent for polyimides, phenolics, epoxies
[3068-76-6] TSCA HMIS: 3-1-1-X 25g/$10.00 2.0kg/$180.00

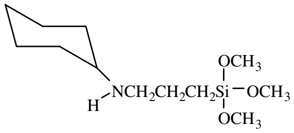
Developmental

$H_2C{=}CHCH_2NHCH_2CH_2CH_2Si(OCH_3)_3$

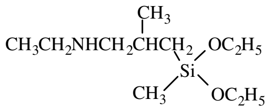
SIA0400.0
3-(N-ALLYLAMINO)PROPYLTRIMETHOXYSILANE, 95% 219.36 106-9°/25 0.989^{25} 1.4990^{25}
flashpoint: 88°C (190°F)
$C_9H_{21}NO_3Si$ coupling agent for polyesters
coupling agent for acrylic coatings for glass containers[1].
1. Y. Hashimoto et al, Eur. Pat. Appl. EP 289,325, 1988
[31024-46-1] HMIS: 3-2-1-X 10g/$40.00 50g/$160.00



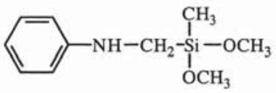
SIC2464.2
(CYCLOHEXYLAMINOMETHYL)TRIETHOXYSILANE, 95% 275.46 236° 0.95 1.4377
flashpoint: 119°C (246°F)
$C_{13}H_{29}NO_3Si$
[26495-91-0] HMIS: 2-1-1-X 25g/$28.00 100g/$91.00



SIC2464.4
N-CYCLOHEXYLAMINOPROPYLTRIMETHOXYSILANE 261.43 114°/3 0.99 1.486^{25}
$C_{12}H_{27}NO_3Si$
[3068-78-8] HMIS: 3-2-1-X 25g/$45.00



SIE4885.8
N-ETHYLAMINOISOBUTYLMETHYLDIETHOXYSILANE 233.43 89°/27
$C_{11}H_{27}NO_2Si$
HMIS: 3-2-1-X 25g/$72.00



SIP6723.67
(PHENYLAMINOMETHYL)METHYLDIMETHOXYSILANE, 95% 211.34 255° 1.04 1.5147
flashpoint: 106°C (223°F)
$C_{10}H_{17}NO_2Si$
converts isocyanate terminated polymers to moisture-cureable resins
[17890-10-7] HMIS: 3-2-1-X 25g/$29.00 100g/$94.00

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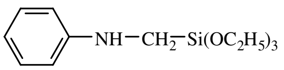
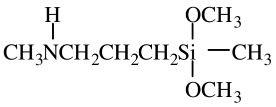
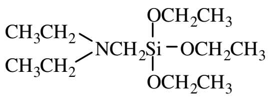
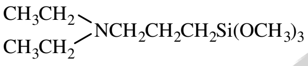
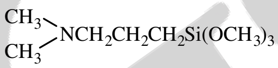
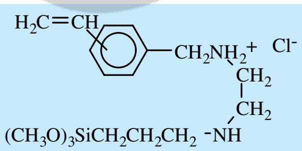
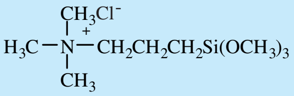
	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIP6723.7				
	N-PHENYLAMINOMETHYLTRIETHOXYSILANE	269.42	135-7°/4	1.004^{25}	1.485^{25}
	$C_{13}H_{23}NO_3Si$				
	[3473-76-5] HMIS: 3-2-1-X	25g/$29.00		100g/$94.00	
 $CH_3N(H)CH_2CH_2CH_2Si(OCH_3)_2CH_3$	SIM6498.0				
	N-METHYLAMINOPROPYLMETHYL-DIMETHOXYSILANE	177.32	93°/25	0.9173^{25}	1.4224^{25}
		flashpoint: 80°C (176°F)			
	$C_7H_{19}NO_2Si$				
	[31024-35-8] HMIS: 3-2-1-X	25g/$61.00		100g/$198.00	

Tertiary Amine Functional Silanes

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIB1140.0				
	BIS(2-HYDROXYETHYL)-3-AMINOPROPYL-TRIETHOXYSILANE, 62% in ethanol	309.48		0.92	1.409^{25}
		flashpoint: 24°C (75°F)			
	$C_{13}H_{31}NO_5Si$	specific wetting surface: $252m^2/g$			
	contains 2-3% hydroxyethylaminopropyltriethoxysilane urethane polymer coupling agent employed in surface modification for preparation of oligonucleotide arrays[1]. 1. G. McGall et al, Proc. Nat'l Acad. Sci., 93, 1355, 1996				
	[7538-44-5] TSCA HMIS: 3-4-0-X	25g/$30.00		100g/$98.00	
	SID3395.4				
	DIETHYLAMINOMETHYLTRIETHOXYSILANE	249.43	74-6°/3	0.9336^{25}	1.4142^{25}
	$C_{11}H_{27}NO_3Si$				
	catalyst for neutral cure 1-part RTV's				
	[15180-47-9] HMIS: 2-2-1-X		25g/$49.00		
	SID3396.0				
	(N,N-DIETHYL-3-AMINOPROPYL)TRI-METHOXYSILANE	235.40	120°/20	0.934	1.4245
		flashpoint: 100°C (212°F)			
	$C_{10}H_{25}NO_3Si$				
	[41051-80-3] TSCA HMIS: 2-2-1-X	25g/$58.00		100g/$188.00	
	SID3547.0				
	3-(N,N-DIMETHYLAMINOPROPYL)TRIMETHOXY-SILANE	207.34	106°/30	0.948^{25}	1.4150
		flashpoint: 99°C (210°F)			
	$C_8H_{21}NO_3Si$				
	derivatized silica catalyzes Michael reactions[1]. 1. J. Mdoe et al, Synlett., 625, 1998				
	[2530-86-1] TSCA HMIS: 2-2-1-X	10g/$30.00		50g/$120.00	

Quaternary Amine Functional Silanes

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIS6994.0				
	3-(N-STYRYLMETHYL-2-AMINOETHYLAMINO)-PROPYLTRIMETHOXYSILANE HYDROCHLORIDE, 40% in methanol, inhibited with BHT	374.98		0.91	1.395
		flashpoint: 13°C (55°F)			
	$C_{17}H_{31}ClN_2O_3Si$	viscosity: 2.3 cSt			
	see also SIS6993.0				
	[34937-00-3] TSCA HMIS: 3-4-1-X store <5°	25g/$10.00		2.0kg/$244.00	
 $(CH_3)_3N^+CH_2CH_2CH_2Si(OCH_3)_3\ Cl^-$	SIT8415.0				
	N-TRIMETHOXYSILYLPROPYL-N,N,N-TRI-METHYLAMMONIUM CHLORIDE (50% in methanol)	257.83		0.927	1.3966
	N,N,N-TRIMETHYL-3-(TRIMETHOXYSILYL)-1-PROPANAMINIUM CHLORIDE				
	$C_9H_{24}ClNO_3Si$	flashpoint: 16°C (61°F)			
	employed for bonded chromatographic phases anti-static agent used to treat glass substrates employed in electroblotting				
	[35141-36-7] TSCA HMIS: 2-4-1-X	25g/$17.00		2.0kg/$380.00	

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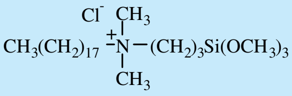
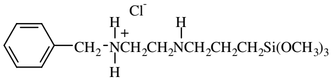
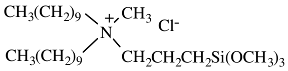
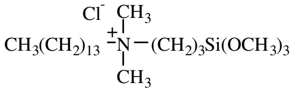
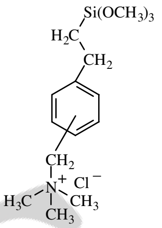
	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $CH_3(CH_2)_{17}\overset{+}{N}(CH_3)_2(CH_2)_3Si(OCH_3)_3\ Cl^-$	SIO6620.0 OCTADECYLDIMETHYL(3-TRIMETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 60% in methanol $C_{26}H_{58}ClNO_3Si$ contains 3-5% $Cl(CH_2)_3Si(OMe)_3$ flashpoint: 15°C (59°F) employed as lubricant/ anti-static surface treatment orients liquid crystals dispersion/coupling agent for high density magnetic recording media[1]. application as immobilizeable antimicrobial reported[2]. 1. H. Vincent in "Chemically Modified Oxide Surfaces," ed.D. Leyden, Gordon & Breach,1990, p.305 2. W. White et al in "Silanes, Surfaces & Interfaces" ed.D. Leyden, Gordon & Breach, 1986, p.107 [27668-52-6] TSCA HMIS: 3-4-0-X 25g/$24.00 2.0kg/$280.00	496.29		0.89	

Developmental

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIB0957.0 (2-N-BENZYLAMINOETHYL)-3-AMINOPROPYLTRIMETHOXYSILANE, hydrochloride 50% in methanol $C_{15}H_{28}N_2O_3Si.HCl$ amber liquid flashpoint: 9°C (48°F) [623938-90-9] TSCA HMIS: 3-3-1-X 25g/$16.00 100g/$52.00	348.25		0.942	1.4104
	SID3392.0 N,N-DIDECYL-N-METHYL-N-(3-TRIMETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 42% in methanol flashpoint: 13°C (55°F) $C_{27}H_{60}ClNO_3Si$ contains 3-5% $Cl(CH_2)_3Si(OMe)_3$ [68959-20-6] TSCA HMIS: 3-4-0-X 25g/$46.00	510.32		0.863	1.4085
 $CH_3(CH_2)_{13}\overset{+}{N}(CH_3)_2(CH_2)_3Si(OCH_3)_3\ Cl^-$	SIT7090.0 TETRADECYLDIMETHYL(3-TRIMETHOXYSILYLPROPYL)AMMONIUM CHLORIDE, 50% in methanol $C_{22}H_{50}ClNO_3Si$ contains 3-5% $Cl(CH_2)_3Si(OMe)_3$ flashpoint: 11°C (52°F) [41591-87-1] TSCA HMIS: 3-4-0-X 25g/$48.00	440.18		0.88	1.397
	SIT8395.0 N-(TRIMETHOXYSILYLETHYL)BENZYL-N,N,N-TRIMETHYLAMMONIUM CHLORIDE, 60% in methanol $C_{15}H_{28}ClNO_3Si$ flashpoint: 25°C (77°F) candidate for exchange resins and extraction phases HMIS: 3-3-1-X 25g/$80.00	333.93		0.966	
	SIT8405.0 N-(TRIMETHOXYSILYLPROPYL)ISOTHIOURONIUM CHLORIDE, 50% in water essentially silanetriol *TRIHYDROXYPROPYLCARBAMIDOTHIOIC ACID HYDROCHLORIDE* $C_7H_{19}ClN_2O_3SSi$ pH: 6 antimicrobial activity reported [84682-36-0] TSCA HMIS: 2-0-0-X 25g/$42.00	274.84		1.190	1.441

Dipodal Amine Functional Silanes

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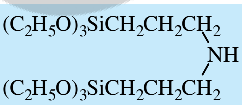
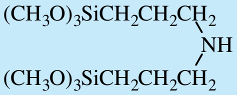
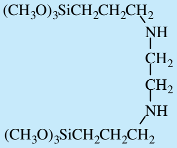
	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIB1824.5 BIS(TRIETHOXYSILYLPROPYL)AMINE, 95% $C_{18}H_{43}NO_6Si_2$ flashpoint: >162°C (328°F) [13497-18-2] TSCA HMIS: 3-1-1-X 25g/$16.00 100g/$52.00	425.71	160°/0.6	0.97	1.4265
	SIB1833.0 BIS(TRIMETHOXYSILYLPROPYL)AMINE, 95% $C_{12}H_{31}NO_6Si_2$ flashpoint: 113°C (235°) dipodal coupling agent [82985-35-1] TSCA HMIS: 3-1-1-X 25g/$12.00 2.0kg/$290.00 18kg/$1170.00	341.56	152°/4	1.040	1.4320
	SIB1834.0 BIS[(3-TRIMETHOXYSILYL)PROPYL]-ETHYLENEDIAMINE, 62% in methanol $C_{14}H_{36}N_2O_6Si_2$ flashpoint: 11°C (52°F) dipodal coupling agent for polyamides with enhanced hydrolytic stability provides improved solder resistance for printed circuit boards [68845-16-9] TSCA HMIS: 3-4-1-X 25g/$24.00 2.0kg/$410.00	384.62		0.89	

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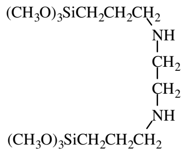
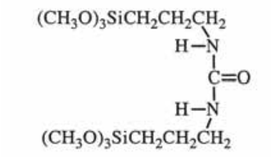
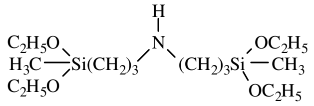
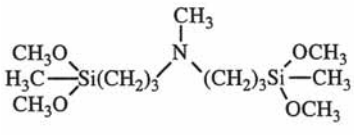
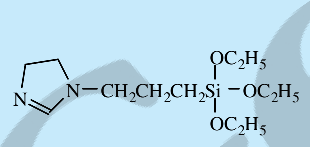
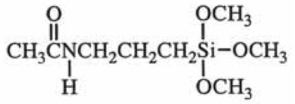
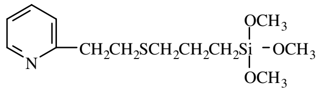
	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIB1834.1 BIS[(3-TRIMETHOXYSILYL)PROPYL]- ETHYLENEDIAMINE, 95% $C_{14}H_{36}N_2O_6Si_2$ coupling agent for polyamides with enhanced hydrolytic stability [68845-16-9] TSCA HMIS: 3-2-1-X	384.62 flashpoint: >110°C (>230°F) 10g/$36.00		1.050 50g/$144.00	1.443
	SIB1828.0 BIS[3-(TRIETHOXYSILYL)PROPYL]UREA, 60% in ethanol $C_{19}H_{44}N_2O_7Si_2$ [69465-84-5] HMIS: 2-4-1-X	468.73 flashpoint: 24°C (75°F) 25g/$32.00		0.923 100g/$104.00	
	SIB1835.5 BIS(TRIMETHOXYSILYLPROPYL)UREA, 95% $C_{13}H_{32}N_2O7Si_2$ *amber liquid* [18418-53-6] TSCA HMIS: 3-2-1-X	384.58 flashpoint: >110°C (>230°F) viscosity: 200-250 cSt. 25g/$19.00		100g/$62.00	
	SIB1620.0 BIS(METHYLDIETHOXYSILYLPROPYL)AMINE, 95% $C_{16}H_{39}NO_4Si_2$ dipodal coupling agent [31020-47-0] HMIS: 2-1-1-X	365.66 25g/$36.00	155°/0.6	0.937 100g/$117.00	1.4385
	SIB1645.0 BIS(METHYLDIMETHOXYSILYLPROPYL)- N-METHYLAMINE, 95% $C_{13}H_{33}NO_4Si_2$ HMIS: 3-2-1-X	323.58 viscosity: 6-7 cSt.	140°/2 25g/$48.00	0.951	1.4368

Developmental

Specialty Amine Functional Silanes

	SIT8187.5 N-(3-TRIETHOXYSILYLPROPYL)- 4,5-DIHYDROIMIDAZOLE *3-(2-IMIDAZOLIN-1-YL)PROPYLTRIETHOXYSILANE* $C_{12}H_{26}N_2O_3Si$ coupling agent for elevated temperature cure epoxies utilized in HPLC of metal chelates[1]. forms proton vacancy conducting polymers w/sulfonamides by sol-gel[2]. ligand for molecurlarly imprinting silica w/ chymotrypsin transition state analog[3]. 1. T. Suzuki et al, Chem. Lett, 881, 1994 2. V. De Zea Bermudez et al, Sol-Gel Optics II, SPIE Proc. *1728*, 180, 1992 3. M. Markowitz et al, Langmuir, 1989. [58068-97-6] TSCA HMIS: 2-1-1-X	274.43 flashpoint: >110°C (>230°F) viscosity: 5 cSt. 25g/$18.00	134°/2 100g/$62.00	1.005 2.0kg/680.00	1.452
	SIU9055.0 UREIDOPROPYLTRIETHOXYSILANE, 50% in methanol $C_{10}H_{24}N_2O_4Si$ contains ureidopropyltrimethoxysilane and related transesterification products coupling agent for polyamides, area-formaldehyde resins [23779-32-0] TSCA HMIS: 2-3-1-X	264.40 flashpoint:14°C (58°F) 25g/$10.00	(-97°)mp	0.92 2.0kg/$150.00	1.386
	SIA0006.0 ACETAMIDOPROPYLTRIMETHOXYSILANE $C_8H_{19}NO_4Si$ [57757-66-1] HMIS: 3-2-1-X	221.33	162-5°/2-3 10g/$120.00		1.4410
	SIP6926.2 2-(2-PYRIDYLETHYL)THIOPROPYLTRI- METHOXYSILANE $C_{13}H_{23}NO_3SSi$ chelates metal ions [29098-72-4] HMIS: 3-2-1-X	301.48	156-7°/0.25 10g/$118.00	1.089	1.498

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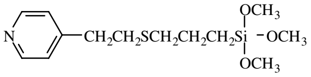
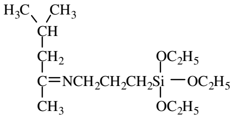
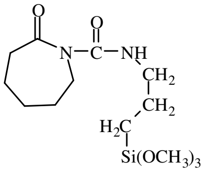
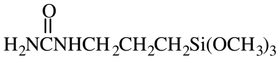
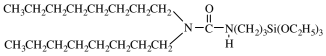
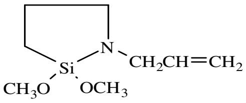
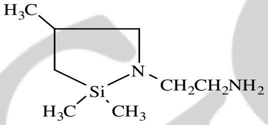
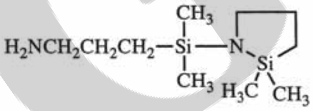
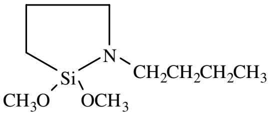
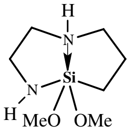
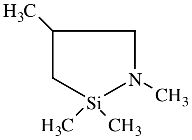
	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIP6926.4				
	2-(4-PYRIDYLETHYL)THIOPROPYLTRIMETHOXYSILANE	301.48	160-2°/0.2	1.09	1.5037
	$C_{13}H_{23}NO_3SSi$	pKa: 4.8			
	immobilizeable ligand for immunoglobulin IgG separation using hydrophobic charge induction chromatography (HCIC)				
	[198567-47-4] HMIS: 3-2-1-X		10g/$124.00		
	SID4068.0				
	3-(1,3-DIMETHYLBUTYLIDENE)AMINOPROPYLTRIETHOXYSILANE	303.52	134°/5	0.93	1.437^{25}
		flashpoint: 131°C (268°F)			
	$C_{15}H_{33}NO_3Si$	blocked amine - moisture deblocked			
	[116229-43-7] TSCA HMIS: 2-2-1-X	25g/$19.00		100g/$62.00	
	SIT8394.0				
	N-[5-(TRIMETHOXYSILYL)-2-AZA-1-OXOPENTYL]CAPROLACTAM, 95%	318.45	(-39°)mp	1.14	1.4739
		flashpoint: 136°C (276°F)			
	N-TRIMETHOXYSILYLPROPYLCARBAMOYLCAPROLACTAM				
	patterns in vitro growth of neurons[1]. 1. J. Hickman et al, J. Vac. Sci Tech., *12*, 607, 1994				
	$C_{13}H_{26}N_2O_5Si$				
	[106996-32-1] HMIS: 3-1-1-X	25g/$24.00		100g/$78.00	
 $H_2N\overset{O}{\overset{\Vert}{C}}NHCH_2CH_2CH_2Si(OCH_3)_3$	SIU9058.0				
	UREIDOPROPYLTRIMETHOXYSILANE	222.32	217-225°	1.150	1.386^{25}
	$C_7H_{18}N_2O_4Si$	flashpoint: 99°C (210°F)			
	[23843-64-3] TSCA HMIS: 2-3-1-X	25g/$10.00		100g/$32.00	
	SID4465.0				
	N,N-DIOCTYL-N'-TRIETHOXYSILYLPROPYLUREA	488.83		0.924^{25}	1.4521^{25}
	$C_{26}H_{56}N_2O_4Si$				
	[259727-10-1] HMIS: 2-2-1-X		25g/$82.00		

Cyclic Azasilanes

	SIA0380.0				
	N-ALLYL-AZA-2,2-DIMETHOXYSILACYCLOPENTANE	187.31	52-4°/3		
	$C_8H_{17}NO_2Si$				
	[618914-49-1] HMIS: 3-3-1-X		10g/$110.00		
	SIA0592.0				
	N-AMINOETHYL-AZA-2,2,4-TRIMETHYLSILACYCLOPENTANE	156.28	54-6°/2	0.905	1.4768
	$C_8H_{21}NSi$				
	[18246-33-8] HMIS: 3-2-1-X		10g/$60.00		
	SIA0604.0				
	N-(3-AMINOPROPYLDIMETHYLSILA)AZA-2,2-DIMETHYL-2-SILACYCLOPENTANE tech-90	230.50			1.4705
	$C_{10}H_{26}N_2Si_2$				
	employed in vapor-phase derivatization of porous sol-gel silica[1]. 1. D. Brandhuber et al, J. Mater. Chem., 2005				
	[388606-32-4] HMIS: 3-1-1-X		10g/$72.00		
	SIB1932.4				
	N-n-BUTYL-AZA-2,2-DIMETHOXYSILACYCLOPENTANE	203.36	69-71°/3	0.941	1.438
		flashpoint: 85°C (185°F)			
	$C_9H_{21}NO_2Si$				
	vapor phase deposition coupling agent for nanoparticles[1]. 1. B. Arkles et al in "Silanes and Other Coupling Agents, Vol. 3," K. Mittal (Ed.) VSP-Brill, 2004, p179.				
	[618914-44-6] HMIS: 3-2-1-X		25g/$64.00		
	SID3543.0				
	2,2-DIMETHOXY-1,6-DIAZA-2-SILACYCLOOCTANE	190.32	71-3°/2.5 (61-2°)mp		
	$C_7H_{18}N_2O_2Si$				
	[182008-07-7] HMIS: 3-2-1-X		25g/$80.00		
	SIM6501.4				
	N-METHYL-AZA-2,2,4-TRIMETHYLSILACYLCOPENTANE	143.30	137°	0.813	1.4308
	$C_7H_{17}NSi$				
	coupling agent for nanoparticles				
	[18387-19-4] TSCA HMIS: 3-3-1-X	25g/$48.00		100g/$156.00	

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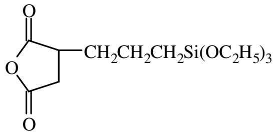
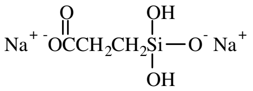
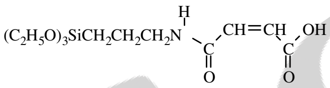
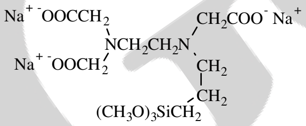
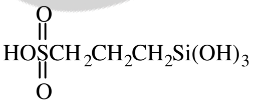
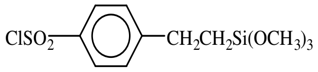
Anhydride Functional Silanes

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIT8192.6 3-(TRIETHOXYSILYL)PROPYLSUCCINIC ANHYDRIDE, 95% *3-(TRIETHOXYSILYLPROPYL)DIHYDRO-3,5-FURANDIONE* $C_{13}H_{24}O_6Si$ coupling agent for dibasic surfaces acetic acid-catalyzed hydrolysis yields succinic acid derivative. [93642-68-3] HMIS: 2-1-1-X	304.41 flashpoint: >100°C (>212°F) viscosity: 20 cSt. 25g/$45.00	135°/0.2	1.070 100g/$136.00	1.4405

Azide Functional Silanes

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
$N_3SO_2(CH_2)_6Si(OC_2H_5)_3$	SIA0780.0 6-AZIDOSULFONYLHEXYLTRIETHOXYSILANE, 95% *1-TRIETHOXYSILYL-6-SULFONAZIDE-n-HEXANE* $C_{12}H_{27}N_3O_5SSi$ inserts nitrenes into aliphatics and aromatics at temperatures >110°C [96550-26-4] HMIS: 3-2-1-X	353.51 flashpoint: 114°C (237°F)	25g/$120.00	1.147	1.4634

Carboxylate, Phosphonate and Sulfonate Functional Silanes

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $Na^+\,{}^-O\overset{O}{\overset{\Vert}{C}}CH_2CH_2\overset{OH}{\underset{OH}{Si}}-O^-\,Na^+$	SIC2263.0 CARBOXYETHYLSILANETRIOL, SODIUM SALT, 25% in water $C_3H_6O_5Na_2Si$ [18191-40-7] HMIS: 2-0-0-X	196.14 pH:12-12.5 25g/$42.00		1.17^{25} 100g/$136.00	
	SIT8189.8 TRIETHOXYSILYLPROPYLMALEAMIC ACID, tech 90 $C_{13}H_{25}NO_6Si$ viscosity: 600-900 cSt. may be imidized by heating after deposition [33525-68-7] TSCA HMIS: 3-2-1-X	319.43	25g/$48.00	1.11	1.472
	SIT8402.0 N-(TRIMETHOXYSILYLPROPYL)ETHYLENEDIAMINE TRIACETIC ACID, TRISODIUM SALT, 45% in water $C_{14}H_{25}N_2Na_3O_9Si$ essentially silanetriol, contains NaCl chelates metal ions [128850-89-5] TSCA HMIS: 2-0-0-X	462.42 25g/$40.00		1.26 100g/$130.00	
 $HO\overset{O}{\underset{O}{S}}CH_2CH_2CH_2Si(OH)_3$	SIT8378.3 3-(TRIHYDROXYSILYL)-1-PROPANESULFONIC ACID 30-35% in water $C_3H_{10}O_6SSi$ [70942-24-4] TSCA HMIS: 3-0-0-X	202.26 pH: <1	(-62°)mp 25g/$48.00	1.12	
	SIC2417.0 2-(4-CHLOROSULFONYLPHENYL)ETHYLTRIMETHOXYSILANE, 50% in methylene chloride $C_{11}H_{17}ClO_5SSi$ contains free sulfonic acid; amber color treated silica acts as etherification catalyst[1]. treatment of surface oxidized PMDSO supports electroosmotic flow[2]. 1. B. Sow et al, Microporous & Mesoporous Materials, *79*, 129, 2005 2. B. Wang et al, Micro Total Analysis Systems 2004 Vol 2., Roy Soc. Chem., 297, p109 [126519-89-9] HMIS: 3-2-1-X	324.85 25g/$68.00		1.30^{25} 100g/$221.00	

Masked Carboxylates - See Anhydride and Ester Functional Silanes

Developmental

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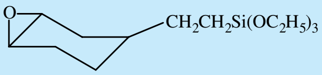
Epoxy Functional Silanes

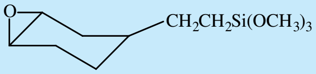
name **MW** **bp/mm (mp)** **D_4^{20}** **n_D^{20}**

Epoxy Functional Silanes - Trialkoxy

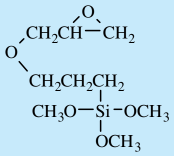
Commercial



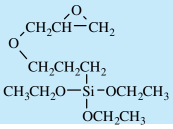
SIE4668.0
2-(3,4-EPOXYCYCLOHEXYL)ETHYLTRIETHOXYSILANE 288.46 114-7°/0.4 1.015 1.4455
flashpoint: 104°C (220°F)
$C_{14}H_{28}O_4Si$
[10217-34-2] TSCA HMIS: 2-1-1-X 25g/$14.00 100g/$46.00 2.0kg/$320.00



SIE4670.0
2-(3,4-EPOXYCYCLOHEXYL)ETHYLTRIMETHOXYSILANE 246.38 95-7°/0.25 1.065 1.449
TOXICITY- oral rat, LD50: 12,300mg/kg
$C_{11}H_{22}O_4Si$
flashpoint: 146°C (295°F)
viscosity: 5.2 cSt
γc of treated surface: 39.5 dynes/cm
coefficient of thermal expansion: 0.8 x 10^{-3}
specific wetting surface: 317 m^2/g
vapor pressure, 152°: 10mm
ring epoxide more reactive than glycidoxypropyl systems.
UV initiated polymerization of epoxy group with weak acid donors.
forms UV-cureable coating resins by controlled hydrolysis[1].
1. J. Crivello et al, Chem. Mater. *9*, 1554, 1997.
[3388-04-3] TSCA HMIS: 3-1-1-X 100g/$24.00 2.0kg/$270.00 18kg/$1044.00

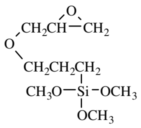


SIG5840.0
(3-GLYCIDOXYPROPYL)TRIMETHOXYSILANE 236.34 120°/2 (<-70°)mp 1.070 1.4290
3-(2,3-EPOXYPROPOXY)PROPYLTRIMETHOXYSILANE
$C_9H_{20}O_5Si$
TOXICITY- oral rat, LD50: 8,400 mg/kg
coupling agent for epoxy composites employed in electronic “chip” encapsulation.
[2530-83-8] TSCA HMIS: 3-1-1-X 100g/$16.00 2.0kg/$138.00 18kg/$693.00



SIG5839.0
(3-GLYCIDOXYPROPYL)TRIETHOXYSILANE 278.4 124°/3 1.00 1.425
$C_{12}H_{26}O_5Si$
flashpoint: 144°C (291°F)
[2602-34-8] TSCA HMIS:3-2-1-X 25g/$38.00 100g/$124.00 2.0kg/$580.00

Developmental



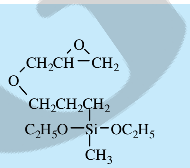
SIG5840.1
(3-GLYCIDOXYPROPYL)TRIMETHOXYSILANE 99+% 236.34 120°/2 (<-70°)mp 1.070 1.4290
3-(2,3-EPOXYPROPOXY)PROPYLTRIMETHOXYSILANE
$C_9H_{20}O_5Si$
TOXICITY- oral rat, LD50: 8,400 mg/kg
[2530-83-8] TSCA HMIS: 3-1-1-X
25g/$180.00 in fluoropolymer bottle

$H_2C(O)CHCH_2CH_2CH_2CH_2Si(OC_2H_5)_3$

SIE4675.0
5,6-EPOXYHEXYLTRIETHOXYSILANE 262.42 115-9°/1.5 0.960^{25} 1.4254^{25}
$C_{12}H_{26}O_4Si$
flashpoint: 99°C (210°F)
[86138-01-4] HMIS: 3-2-1-X 10g/$84.00

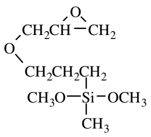
Epoxy Functional Silanes - Dialkoxy

Commercial



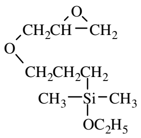
SIG5832.0
(3-GLYCIDOXYPROPYL)METHYLDIETHOXYSILANE 248.39 122-6°/5 0.978^{25} 1.431
TOXICITY- oral rat, LD50: >2000mg/kg
$C_{11}H_{24}O_4Si$
flashpoint: 122°C (252°F)
viscosity: 3.0 cSt
employed in scratch-resistant coatings for eyeglasses.
[2897-60-1] TSCA HMIS: 2-1-1-X 25g/$38.00 100g/$124.00 2.0kg/$580.00

Developmental



SIG5836.0
(3-GLYCIDOXYPROPYL)METHYLDIMETHOXYSILANE 220.34 100°/4 1.02 1.431^{25}
flashpoint: 105°C (221°F)
$C_9H_{20}O_4Si$
relative hydrolysis rate vs. SIG5840.0: 7.5:1
[65799-47-5] TSCA-L HMIS: 3-1-1-X 25g/$50.00 100g/$162.00

Epoxy Functional Silanes - Monoalkoxy



SIG5825.0
(3-GLYCIDOXYPROPYL)DIMETHYLETHOXYSILANE 218.37 100°/3 0.950 1.4337^{25}
flashpoint: 87°C (189°F)
$C_{10}H_{22}O_3Si$
[17963-04-1] TSCA HMIS: 3-2-1-X 10g/$38.00 50g/$152.00

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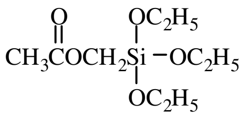
Ester Functional Silanes

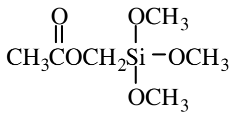
name | **MW** | **bp/mm (mp)** | **D_4^{20}** | **n_D^{20}**

Developmental



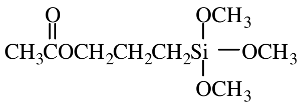
$CH_3\overset{O}{\overset{\|}{C}}OCH_2\overset{OC_2H_5}{\underset{OC_2H_5}{Si}}-OC_2H_5$

SIA0050.0
ACETOXYMETHYLTRIETHOXYSILANE 236.34 106°/15 1.042^{25} 1.4092
$C_9H_{20}O_5Si$ hydrolyzes to form stable silanol solutions in neutral water
[5630-83-1] HMIS: 2-2-1-X 25g/\$55.00 100g/\$179.00



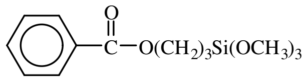
$CH_3\overset{O}{\overset{\|}{C}}OCH_2\overset{OCH_3}{\underset{OCH_3}{Si}}-OCH_3$

SIA0055.0
ACETOXYMETHYLTRIMETHOXYSILANE, 95% 194.26 190-1° 1.085 1.4031
$C_6H_{14}O_5Si$ flashpoint: 56°C (133°F)
[65625-39-0] TSCA-L HMIS: 3-3-1-X 10g/\$45.00 50g/\$180.00

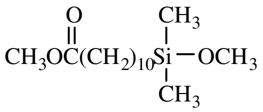


$CH_3\overset{O}{\overset{\|}{C}}OCH_2CH_2CH_2\overset{OCH_3}{\underset{OCH_3}{Si}}-OCH_3$

SIA0100.0
ACETOXYPROPYLTRIMETHOXYSILANE 222.31 92°/2 1.062 1.4146
$C_8H_{18}O_5Si$ flashpoint: 93°C (200°F)
γc of treated surface: 37.5 dynes/cm
[59004-18-1] HMIS: 3-1-1-X 25g/\$18.00 100g/\$58.00

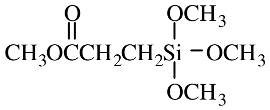


SIB0959.0
BENZOYLOXYPROPYLTRIMETHOXYSILANE 284.38 145°/0.2 1.104 1.4806
$C_{13}H_{20}O_5Si$
[76241-02-6] TSCA-L HMIS: 3-2-1-X 25g/\$64.00



$CH_3O\overset{O}{\overset{\|}{C}}(CH_2)_{10}\overset{CH_3}{\underset{CH_3}{Si}}-OCH_3$

SIC2067.0
10-(CARBOMETHOXY)DECYLDIMETHYL-METHOXYSILANE 288.50 130°/0.3 0.903 1.4399
$C_{15}H_{32}O_3Si$
HMIS: 2-1-1-X 10g/\$48.00 50g/\$192.00



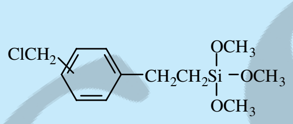
$CH_3O\overset{O}{\overset{\|}{C}}CH_2CH_2\overset{OCH_3}{\underset{OCH_3}{Si}}-OCH_3$

SIC2072.0
2-(CARBOMETHOXY)ETHYLTRIMETHOXY-SILANE, 95% 208.29
contains ~ 20% 1-(carbomethoxy)ethyltrimethoxysilane isomer
METHYL(3-TRIMETHOXYSILYLPROPIONATE) flashpoint: > 43°C (>110°F)
$C_7H_{16}O_5Si$
[76301-00-3] HMIS: 3-3-1-X 10g/\$88.00

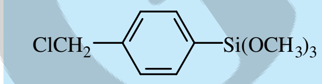
Halogen Functional Silanes

Halogen Functional Silanes - Trialkoxy

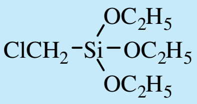
Commercial



SIC2295.5
((CHLOROMETHYL)PHENYLETHYL)-TRIMETHOXYSILANE, mixed m,p isomers 274.82 115°/1.5 1.09^{25} 1.4930^{25}
$C_{12}H_{19}ClO_3Si$ flashpoint: 130°C (282°F)
employed as a high temperature coupling agent[1].
1. B. Arkles et al, Modern Plastics, *57*(11), 64, 1980.
[68128-25-6] TSCA HMIS: 3-1-1-X 25g/\$39.00 100g/\$126.00

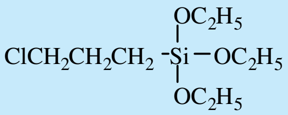


SIC2296.2
(p-CHLOROMETHYL)PHENYLTRIMETHOXY-SILANE 246.77 134-43°/10 1.14 1.4965
$C_{10}H_{15}ClO_3Si$ flashpoint: 183°C (361°F)
coupling agent for polyimides
[24413-04-5] TSCA HMIS: 3-2-1-X 25g/\$62.00 100g/\$202.00



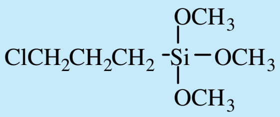
$ClCH_2-\overset{OC_2H_5}{\underset{OC_2H_5}{Si}}-OC_2H_5$

SIC2298.4
CHLOROMETHYLTRIETHOXYSILANE 212.75 90-1°/25 1.048 1.4069
$C_7H_{17}ClO_3Si$ TOXICITY- oral rat, LD50: 2400mg/kg
flashpoint: 47°C (117°F)
Grignard reacts with chlorosilanes or intramolecularly to form carbosilanes[1].
1. D. Brondani et al, Tet. Lett., *34*, 2111, 1993
[15267-95-5] TSCA HMIS: 2-3-1-X 25g/\$24.00 100g/\$78.00 2.0kg/\$692.00



$ClCH_2CH_2CH_2-\overset{OC_2H_5}{\underset{OC_2H_5}{Si}}-OC_2H_5$

SIC2407.0
3-CHLOROPROPYLTRIETHOXYSILANE 240.80 100-2°/10 1.009 1.420
$C_9H_{21}ClO_3Si$ flashpoint: 74°C (172°F)
[5089-70-3] TSCA HMIS: 2-2-0-X 25g/\$10.00 2.0kg/\$110.00



$ClCH_2CH_2CH_2-\overset{OCH_3}{\underset{OCH_3}{Si}}-OCH_3$

SIC2410.0
3-CHLOROPROPYLTRIMETHOXYSILANE 198.72 195-6° 1.077^{25} 1.4183^{25}
$C_6H_{15}ClO_3Si$ flashpoint: 78°C (172°F)
vapor pressure, 100°: 40mm TOXICITY- oral rat, LD50: 5628mg/kg
viscosity, 20°C: 0.56 cSt specific wetting surface: 394m²/g
γc of treated surface: 40.5 dynes/cm
[2530-87-2] TSCA HMIS: 3-2-1-X 25g/\$10.00 2.0kg/\$96.00 18kg/\$468.00

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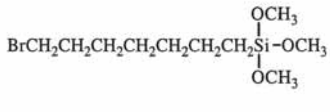
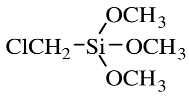
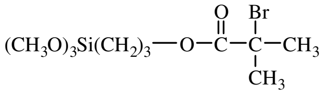
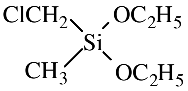
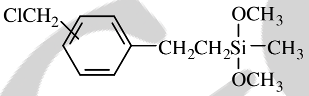
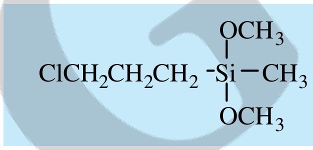
	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $BrCH_2CH_2CH_2CH_2CH_2CH_2CH_2\overset{OCH_3}{\underset{OCH_3}{Si}}-OCH_3$	SIB1886.0				
	7-BROMOHEPTYLTRIMETHOXYSILANE	299.28			
	$C_{10}H_{23}BrO_3Si$				
	HMIS: 3-2-1-X		10g$86.00		
$BrCH_2CH_2CH_2Si(OCH_3)_3$	SIB1906.0				
	3-BROMOPROPYLTRIMETHOXYSILANE	243.17	130°/45	1.293	1.440
	$C_6H_{15}BrO_3Si$	flashpoint: 82°C (180°F)			
	forms self-assembled monolayers which can be modified w/ pyridine ligands[1].				
	1. S. Paulson et al, J. Chem. Soc., Chem. Commun., 1615, 1992.				
	[51826-90-5] HMIS: 2-2-1-X		10g/$64.00		
$BrCH_2(CH_2)_{10}Si(OCH_3)_3$	SIB1909.0				
	11-BROMOUNDECYLTRIMETHOXYSILANE, 95%	355.39	158°/0.8	1.119	1.4559
	$C_{14}H_{31}BrO_3Si$ contains undecyltrimethoxysilane				
	[17947-99-8] HMIS: 2-1-0-X		10g/$80.00		
	SIC2298.6				
	CHLOROMETHYLTRIMETHOXYSILANE	170.67	156°	1.125	1.4070
	$C_4H_{11}ClO_3Si$	flashpoint: 26°C (79°F)			
	[5926-26-1] HMIS: 3-4-1-X	10g/$25.00		50g/$100.00	
$ICH_2CH_2CH_2Si(OCH_3)_3$	SII6452.0				
	3-IODOPROPYLTRIMETHOXYSILANE	290.17	79-80°/2	1.475	1.4714
	$C_6H_{15}IO_3Si$	flashpoint: 78°C (172°F)			
	couples zeolite monolayers to glass[1]				
	1. K. Ha et al, Adv. Mater., *12(15)*, 1114, 2002.				
	[14867-28-8] HMIS: 3-2-1-X	10g/$22.00		50g/$88.00	
 $(CH_3O)_3Si(CH_2)_3-O-\overset{O}{\overset{\|}{C}}-\overset{Br}{\underset{CH_3}{C}}-CH_3$	SIT8397.0				
	3-(TRIMETHOXYSILYPROPYL)-2-BROMO-	329.27	90-5°/0.5	1.243^{25}	
	2-METHYLPROPIONATE				
	$C_{10}H_{21}BrO_5Si$				
	for surface initiated ATRP polymerization[1].				
	1. M. Mulvihill et al, J. Am. Chem. Soc., *127*, 16040, 2005				
	[314021-97-1] HMIS: 2-2-1-X		5.0g/$180.00		

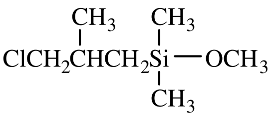
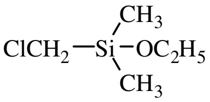
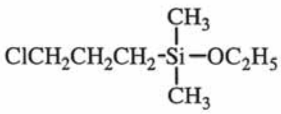
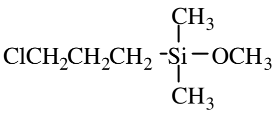
Developmental

Halogen Functional Silanes - Dialkoxy

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIC2292.0				
	CHLOROMETHYLMETHYLDIETHOXYSILANE	182.72	160-1°	1.000^{25}	1.407
	$C_6H_{15}ClO_2Si$	TOXICITY:oral rat, LD50: 1300mg/kg			
	vapor pressure, 70°: 20mm	flashpoint: 38°C (100°F)			
	[2212-10-4] TSCA HMIS: 3-3-1-X		100g/$110.00		
	SIC2295.2				
	((CHLOROMETHYL)PHENYLETHYL)-	258.82	120-5°/0.5		
	METHYLDIMETHOXYSILANE mixed m,p isomers				
	$C_{12}H_{19}ClO_2Si$				
	intermediate for silicone analog of Merrifield resins.				
	HMIS: 2-1-1-X		25g/$120.00		
 $ClCH_2CH_2CH_2-\overset{OCH_3}{\underset{OCH_3}{Si}}-CH_3$	SIC2355.0				
	3-CHLOROPROPYLMETHYLDIMETHOXY-	182.72	70-2°/11	1.0250	1.4253
	SILANE	flashpoint: 80°C (176°F)			
	$C_6H_{15}ClO_2Si$	specific wetting surface: 428m²/g			
	[18171-19-2] TSCA HMIS: 3-2-1-X	100g/$15.00		2.0kg/$184.00	

Commercial

Halogen Functional Silanes - Monoalkoxy

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $ClCH_2\overset{CH_3}{CH}CH_2\overset{CH_3}{\underset{CH_3}{Si}}-OCH_3$	SIC2278.0				
	3-CHLOROISOBUTYLDIMETHYLMETHOXY-	180.75	182°	0.950	1.4331^{25}
	SILANE	flashpoint: 52°C (125°F)			
	$C_7H_{17}ClOSi$				
	[18244-08-1] TSCA HMIS: 3-3-1-X		25g/$52.00		
	SIC2286.0				
	CHLOROMETHYLDIMETHYLETHOXYSILANE	152.70	132-3°	0.944^{25}	1.412^{25}
	$C_5H_{13}ClOSi$	TOXICITY- oral rat, LD50: 1550mg/kg			
	dipole moment: 2.14 debye	flashpoint: 26°C (79°F)			
	[13508-53-7] TSCA HMIS: 3-3-1-X		25g/$62.00		
 $ClCH_2CH_2CH_2-\overset{CH_3}{\underset{CH_3}{Si}}-OC_2H_5$	SIC2337.0				
	3-CHLOROPROPYLDIMETHYLETHOXYSILANE	180.75	87°/30	0.932^{25}	1.4270^{25}
	$C_7H_{17}ClOSi$	flashpoint: 46°C (115°F)			
	[13508-63-9] HMIS: 2-3-1-X		25g/$48.00		
 $ClCH_2CH_2CH_2-\overset{CH_3}{\underset{CH_3}{Si}}-OCH_3$	SIC2338.0				
	3-CHLOROPROPYLDIMETHYLMETHOXY-	166.73	170-1°	0.9413	1.4278
	SILANE, 95%	flashpoint: 39°C (102°F)			
	$C_6H_{15}ClOSi$ see also SIC2278.0				
	[18171-14-7] HMIS: 3-3-1-X		10g/$54.00		

Developmental

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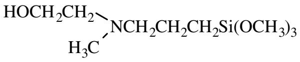
Hydroxyl Functional Silanes

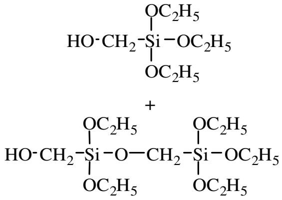
name — **MW** — **bp/mm (mp)** — **D_4^{20}** — **n_D^{20}**

Hydroxyl Functional Silanes - Trialkoxy

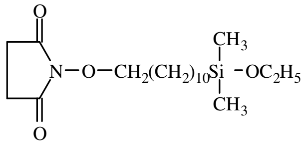
SIB1140.0
BIS(2-HYDROXYETHYL)-3-AMINOPROPYL-TRIETHOXYSILANE, 62% in ethanol — 309.48 — 0.92 — 1.409^{25}
$C_{13}H_{31}NO_5Si$
flashpoint: 24°C (75°F)
specific wetting surface: 252m^2/g
contains 2-3% hydroxyethylaminopropyltriethoxysilane
urethane polymer coupling agent
employed in surface modification for preparation of oligonucleotide arrays[1].
1. G. McGall et al, Proc. Nat'l Acad. Sci., 93, 1355, 1996
[7538-44-5] TSCA HMIS: 3-4-0-X — 25g/$30.00 — 100g/$98.00



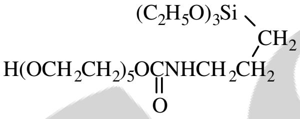
SIH6172.0
N-(HYDROXYETHYL)-N-METHYLAMINO-PROPYLTRIMETHOXYSILANE, 75% in methanol — 237.37 — 0.99 — 1.417
$C_9H_{23}NO_4Si$
flashpoint: 16°C (61°F)
HMIS: 3-3-1-X — 25g/$52.00 — 100g/$169.00



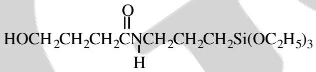
SIH6175.0
HYDROXYMETHYLTRIETHOXYSILANE, 50% in ethanol — 194.31 — 0.866
TRIETHOXYSILYLMETHANOL
$C_7H_{18}O_4Si$ — contains equilibrium condensation oligomers
hydrolysis yields analogs of silica- hydroxymethylsilanetriol polymers[1].
1. B. Arkles, US Pat. 5,371,262, 1994
[162781-73-9] HMIS: 2-4-0-X — 25g/$96.00



SIS6995.0
11-(SUCCINIMIDYLOXY)UNDECYL-DIMETHYLETHOXYSILANE, 95% — 385.58 — 195-200°/0.6 (28°)mp
$C_{19}H_{35}NO_5Si$
reagent for immobilization of proteins via primary amines
HMIS: 3-2-1-X — 1.0g/$210.00

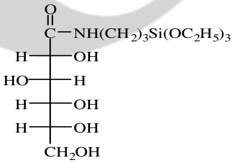


SIT8192.0
N-(TRIETHOXYSILYLPROPYL)-O-POLY-ETHYLENE OXIDE URETHANE, 95% — 400-500 — 1.09
viscosity: 75-125 cSt
$C_{10}H_{22}NO_4SiO(CH_2CH_2O)_{4\text{-}6}H$
contains some bis(urethane) analog
HMIS: 2-1-1-X — 25g/$24.00 — 100g/$78.00

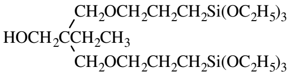


$HOCH_2CH_2CH_2C(=O)N(H)CH_2CH_2CH_2Si(OC_2H_5)_3$

SIT8189.5
N-(3-TRIETHOXYSILYLPROPYL)-4-HYDROXY-BUTYRAMIDE — 307.47
$C_{13}H_{29}NO_5Si$
anchoring reagent for light directed synthesis of DNA on glass[1].
1. G. McGall et al, J. Am. Chem. Soc., *119*, 5081, 1997
[186543-03-3] HMIS: 2-2-1-X — 10g/$29.00 — 50g/$116.00

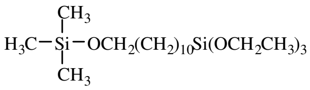


SIT8189.0
N-(3-TRIETHOXYSILYLPROPYL)GLUCONAMIDE 50% in ethanol — 399.51 — 0.951
flashpoint: 8°C (46°F)
$C_{15}H_{33}NO_9Si$
water soluble, hydrophilic silane
[104275-58-3] HMIS: 2-4-1-X — 25g/$26.00 — 100g/$84.00



SIB1824.4
2,2-BIS(3-TRIETHOXYSILYLPROPOXY-METHYL)BUTANOL, 50% in ethanol — 542.86 — 0.899
$C_{24}H_{54}O_9Si_2$
for solid state synthesis of oligonucleotides
HMIS: 2-4-1-X — 10g/$136.00

Masked Hydroxyl



$(CH_3)_3Si\text{-}OCH_2(CH_2)_{10}Si(OCH_2CH_3)_3$

SIT8572.8
11-(TRIMETHYLSILOXY)UNDECYLTRIETHOXY-SILANE — 406.75
$C_{20}H_{46}O_4Si_2$
masked hydroxyl- deprotected after deposition with acidic aqueous ethanol
[75389-03-6] HMIS: 2-1-1-X — 5.0g/$134.00

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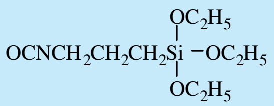
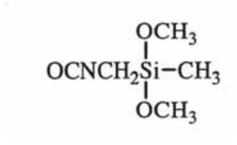
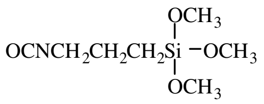
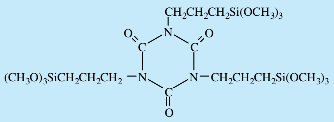
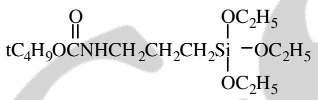
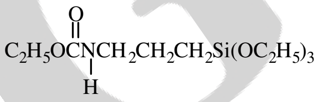
Isocyanate and Masked Isocyanate Functional Silanes

Isocyanate Functional Silanes - Trialkoxy

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}	
 $OCNCH_2CH_2CH_2\overset{OC_2H_5}{\underset{OC_2H_5}{Si}}-OC_2H_5$	SII6455.0 3-ISOCYANATOPROPYLTRIETHOXYSILANE, 95% $C_{10}H_{21}NO_4Si$	247.37 flashpoint: 80°C (176°F)	130°/20	0.99	1.419	Commercial
	component in hybrid organic/inorganic urethanes[1]. 1. S. Cuney et al, Better Ceramics Through Chemistry VII (MRS. Symp. Proc.), 435, 143, 1996					
	[24801-88-5] TSCA HMIS: 3-2-1-X	25g/$14.00	100g/$45.00	2.0kg/$220.00		
 $OCNCH_2\overset{OCH_3}{\underset{OCH_3}{Si}}-CH_3$	SII6453.8 (ISOCYANATOMETHYL)METHYLDIMETHOXYSILANE tech-85 $C_5H_{11}NO_3Si$	161.23 flashpoint: 66°C (151°F) autoignition temp.: 290°	157°	1.06	1.435	
	reacts w/polymeric diamines to form moisture-cureable polymers					
	[406679-89-8] HMIS: 3-4-1-X store <5°C		25g/$82.00			
 $OCNCH_2CH_2CH_2\overset{OCH_3}{\underset{OCH_3}{Si}}-OCH_3$	SII6456.0 3-ISOCYANATOPROPYLTRIMETHOXYSILANE, 95% $C_7H_{15}NO_4Si$	205.29 TOXICITY- oral rat, LD50: 878mg/kg viscosity: 1.4 cSt.	95-8°/10	1.073	1.4219	
	[15396-00-6] TSCA HMIS: 3-2-1-X	25g/$29.00		100g/$94.00		

Masked Isocyanate

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}	
	SIT8717.0 TRIS(3-TRIMETHOXYSILYLPROPYL)ISOCYANURATE, 95% $C_{21}H_{45}N_3O_{12}Si_3$	615.86 flashpoint: 102°C (216°F) viscosity: 325-350 cSt.		1.170	1.4610	Commercial
	coupling agent for polyimides to silicon metal					
	[26115-70-8] TSCA HMIS: 2-1-1-X	25g/$12.00	100g/$39.00	2.0kg/$380.00		
 $tC_4H_9O\overset{O}{\overset{\|}{C}}NHCH_2CH_2CH_2\overset{OC_2H_5}{\underset{OC_2H_5}{Si}}-OC_2H_5$	SIT8186.5 (3-TRIETHOXYSILYLPROPYL)-t-BUTYLCARBAMATE $C_{14}H_{31}NO_5Si$	321.49 flashpoint: >65°C (>150°F)		0.990	1.4334	Developmental
	[137376-38-6] HMIS: 2-1-1-X	25g/$36.00		100g/$117.00		
 $C_2H_5O\overset{O}{\overset{\|}{C}}\underset{H}{N}CH_2CH_2CH_2Si(OC_2H_5)_3$	SIT8188.0 TRIETHOXYSILYLPROPYLETHYLCARBAMATE $C_{12}H_{27}NO_5Si$	293.44 flashpoint: 95°C (203°F)	124-6°/0.5	1.015	1.4321	
	masked isocyanate					
	[17945-05-0] TSCA HMIS: 2-1-1-X	25g/$24.00		100g/$80.00		
$NCSCH_2CH_2CH_2Si(OC_2H_5)_3$	SIT7908.0 3-THIOCYANATOPROPYLTRIETHOXYSILANE $C_{10}H_{21}NO_3SSi$	263.43 flashpoint: 112°C (234°F)	95°/0.1	1.03	1.4460	
	TOXICITY- oral rat, LD50: 1423mg/kg					
	[34708-08-2] TSCA HMIS: 3-2-1-X	50g/$20.00		250g/$80.00		

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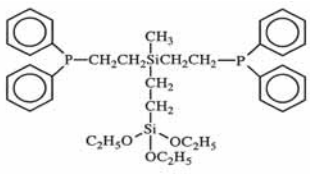
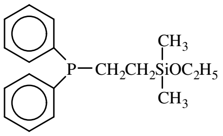
Phosphine and Phosphate Functional Silanes

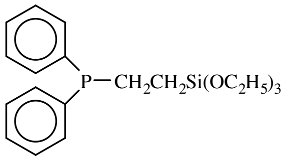
name | **MW** | **bp/mm (mp)** | **D_4^{20}** | **n_D^{20}**



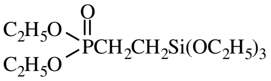
SIB1091.0
BIS(2-DIPHENYLPHOSPHINOETHYL)-METHYLSILYLETHYLTRIETHOXYSILANE, mixed isomers — 660.92 — 1.07 — 1.5746
$C_{37}H_{50}O_3P_2Si_2$
analogous structures form ruthenium II complexes w/ high selectivity for hydrogenation[1].
1. D. Wu et al, Chem. Mater., *17*, 3951, 2005
HMIS: 2-2-1 — 1.0g/$174.00



SID4557.5
DIPHENYLPHOSPHINOETHYLDIMETHYL-ETHOXYSILANE — 316.46 — 160°/1 — 1.004 — 1.5630
$C_{18}H_{25}OPSi$
[359859-29-3] HMIS: 2-2-1-X — 10g/$124.00

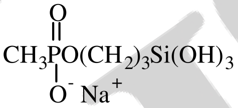


SID4558.0
2-(DIPHENYLPHOSPHINO)ETHYL-TRIETHOXYSILANE — 376.50 — 182°/1.3 — 1.05 — 1.5384
flashpoint: 134°C (273°F)
$C_{20}H_{29}O_3PSi$
immobilizing ligand for precious metals
adhesion promoter for gold substrates in microelectronic applications[1].
forms stable bonds to silica and basic alumina suitable for catalyst immobilization[2].
1. J. Helbert, US Pat. 4,497,890, 1985
2. C. H. Merchle et al, Chem. Mater. *13*, 3617, 2001.
[18586-39-5] TSCA HMIS: 3-1-0-X — 5.0g/$39.00 — 25g/$156.00



$(C_2H_5O)_2P(=O)CH_2CH_2Si(OC_2H_5)_3$

SID3412.0
DIETHYLPHOSPHATOETHYLTRIETHOXY-SILANE, 95% — 328.41 — 141°/2 — 1.031^{25} — 1.4216
flashpoint: 70°C (158°F)
DIETHOXYPHOSPHORYLETHYLTRIETHOXYSILANE
$C_{12}H_{29}O_6PSi$
water-soluble silane; anti-pilling agent for textiles
hydrolysis product catalytically hydrates olefins, forming alcohols[1].
1. F. Young et al, US Patent 3,816,550, 1974.
[757-44-8] TSCA HMIS: 3-2-1-X — 25g/$48.00 — 100g/$156.00



$CH_3P(=O)(O^- Na^+)O(CH_2)_3Si(OH)_3$

SIT8378.5
3-TRIHYDROXYSILYLPROPYLMETHYL-PHOSPHONATE, SODIUM SALT, 42% in water — 238.18 — 1.25
flashpoint: 79°C (174°F)
$C_4H_{12}O_6NaPSi$ contains 4-5% methanol, sodium methylphosphonate
[84962-98-1] TSCA HMIS: 1-2-0-X — 100g/$15.00 — 500g/$60.00

Developmental

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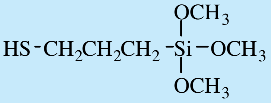
Sulfur Functional Silanes

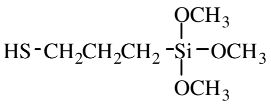
name MW bp/mm (mp) D_4^{20} n_D^{20}

Sulfur Functional Silanes - Trialkoxy

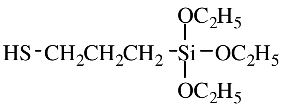
Commercial


$HS{-}CH_2CH_2CH_2{-}\overset{OCH_3}{\underset{OCH_3}{Si}}{-}OCH_3$

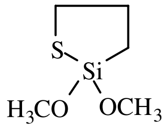
SIM6476.0
3-MERCAPTOPROPYLTRIMETHOXYSILANE 196.34 93°/40 1.051^{25} 1.4502^{25}
$C_6H_{16}O_3SSi$ TOXICITY- oral rat, LD50: 2380mg/kg
viscosity: 2 cSt flashpoint: 96°C (205°F)
γc of treated surface: 41 dynes/cm primary irritation index: 0.19
specific wetting surface: 348 m²/g
coupling agent for EPDM rubbers and polysulfide adhesives
for enzyme immobilization[1].
treatment of mesoporous silica yield highly efficient heavy metal scavenger[2].
employed in coupling of fluorescent biological tags to CdS nanocrystals[3].
1. Tet. Let., *31*, 5773, 1990
2. J. Liu et al, Science, *276*, 923, 1997
3. M. Bruohez et al, Science, *281*, 2013, 1998.
[4420-74-0] TSCA HMIS: 3-2-1-X 100g/$16.00 2.0kg/$164.00 18kg/$630.00


$HS{-}CH_2CH_2CH_2{-}\overset{OCH_3}{\underset{OCH_3}{Si}}{-}OCH_3$

SIM6476.1
3-MERCAPTOPROPYLTRIMETHOXYSILANE 99+% 196.34 93°/40 1.051^{25} 1.4502^{25}
$C_6H_{16}O_3SSi$
low fluorescence grade for high-throughput screening
[4420-74-0] TSCA HMIS: 3-2-1-X 25g/$180.00 in fluoropolymer bottle

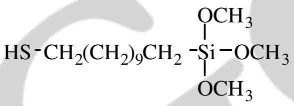

$HS{-}CH_2CH_2CH_2{-}\overset{OC_2H_5}{\underset{OC_2H_5}{Si}}{-}OC_2H_5$

SIM6475.0
3-MERCAPTOPROPYLTRIETHOXYSILANE, 95% 238.42 210° 0.9325 1.4331
$C_9H_{22}O_3SSi$ flashpoint: 88°C (190°F)
TOXICITY- oral rat, LD50: > 2000mg/kg
[14814-09-6] TSCA HMIS: 2-2-1-X 25g/$35.00 100g/$114.00

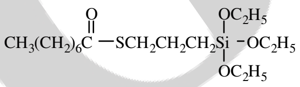


SID3545.0
2,2-DIMETHOXY-1-THIA-2-SILACYCLOPENTANE 164.29 57-8°/7 1.094
$C_5H_{12}O_2SSi$
reagent for modification of silver and gold surfaces; coupling agent for rubber
[26903-85-5] HMIS: 3-3-1-X 25g/$84.00

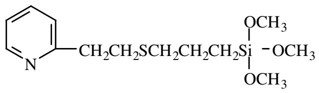
Developmental


$HS{-}CH_2(CH_2)_9CH_2{-}\overset{OCH_3}{\underset{OCH_3}{Si}}{-}OCH_3$

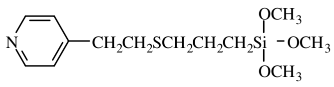
SIM6480.0
11-MERCAPTOUNDECYLTRIMETHOXYSILANE 308.55 150°/0.5 0.955 1.4523
$C_{14}H_{32}O_3SSi$
HMIS: 3-2-1-X 2.5g/$162.00


$CH_3(CH_2)_6\overset{O}{\overset{\|}{C}}{-}SCH_2CH_2CH_2\overset{OC_2H_5}{\underset{OC_2H_5}{Si}}{-}OC_2H_5$

SIO6704.0
S-(OCTANOYL)MERCAPTOPROPYLTRIETHOXYSILANE tech-95 364.62 0.9686 1.4514
TOXICITY- oral rat, LD50: >2000mg/kg
$C_{17}H_{36}O_4SSi$ flashpoint: 176°C (349°F)
masked mercaptan - deblocked w/alcohols
latent coupling agent for butadiene rubber
[220727-26-4] TSCA HMIS: 2-1-1-X 25g/$19.00 100g/$62.00



SIP6926.2
2-(2-PYRIDYLETHYL)THIOPROPYLTRIMETHOXYSILANE 301.48 156-7°/0.25 1.089 1.498
$C_{13}H_{23}NO_3SSi$
chelates metal ions
[29098-72-4] HMIS: 3-2-1-X 10g/$118.00



SIP6926.4
2-(4-PYRIDYLETHYL)THIOPROPYLTRIMETHOXYSILANE 301.48 160-2°/0.2 1.09 1.5037
pKa: 4.8
$C_{13}H_{23}NO_3SSi$
immobilizeable ligand for immunoglobulin IgG separation using hydrophobic charge induction chromatography (HCIC)
[198567-47-4] HMIS: 3-2-1-X 10g/$124.00

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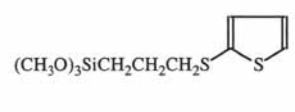
name **MW** **bp/mm (mp)** **D_4^{20}** **n_D^{20}**

$NCSCH_2CH_2CH_2Si(OC_2H_5)_3$

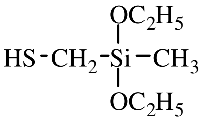
SIT7908.0
3-THIOCYANATOPROPYLTRIETHOXYSILANE 263.43 95°/0.1 1.03 1.4460
$C_{10}H_{21}NO_3SSi$ flashpoint: 112°C (234°F)
TOXICITY- oral rat, LD50: 1423mg/kg
coupling agent for butyl rubber in mechanical applications
complexing agent for Ag, Au, Pd, Pt[1].
1. T. Schilling et al, Mikrochemica Acta, *124*, 235, 1996.
[34708-08-2] TSCA HMIS: 3-2-1-X 50g/$20.00 250g/$80.00



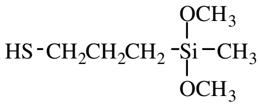
SIT8411.0
2-(3-TRIMETHOXYSILYLPROPYLTHIO)-THIOPHENE 278.46
$C_{10}H_{18}O_3S_2Si$
HMIS: 3-2-1-X 10g/$110.00

Developmental

Sulfur Functional Silanes - Dialkoxy


$HS-CH_2-Si(OC_2H_5)_2-CH_3$

SIM6473.0
MERCAPTOMETHYLMETHYLDIETHOXYSILANE, 95% 180.34 60°/10 0.975 1.4446
$C_6H_{16}O_2SSi$ flashpoint: 58°C (136°F)
HMIS: 3-2-1-X 10g/$90.00


$HS-CH_2CH_2CH_2-Si(OCH_3)_2-CH_3$

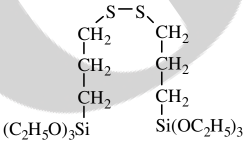
SIM6474.0
3-MERCAPTOPROPYLMETHYLDIMETHOXYSILANE 180.34 96°/30 1.00 1.4502
$C_6H_{16}O_2SSi$ flashpoint: 93°C (199°F)
intermediate for silicones in thiol-ene UV cure systems
[31001-77-1] TSCA HMIS: 3-2-1-X 100g/$23.00 500g/$92.00

Sulfur Functional Silanes - Dipodal

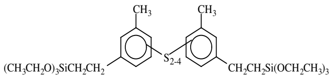
$[(C_2H_5O)_3SiCH_2CH_2CH_2-S-S]_2$

SIB1825.0
BIS[3-(TRIETHOXYSILYL)PROPYL]-TETRASULFIDE, tech-95 *TESPT* 538.94 250°d 1.095 1.49
$C_{18}H_{42}O_6S_4Si_2$ TOXICITY- oral rat, LD50: 16,400mg/kg
flashpoint: 91°C (196°F)
contains distribution of S_n species: n = 2-10, average 3.8
viscosity: 11.2 cSt
coupling agent for “green” tires
adhesion promoter for precious metals
dipodal coupling agent/ vulcanizing agent for rubbers
[40372-72-3] TSCA HMIS: 2-2-1-X 25g/$12.00 100g/$39.00 2.0kg/$180.00

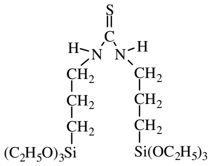
Commercial



SIB1824.6
BIS[3-(TRIETHOXYSILYL)PROPYL]-DISULFIDE, 90% 474.82 1.025 1.457
flashpoint: 75°C (167°F)
$C_{18}H_{42}O_6S_2Si_2$ contains sulfide and tetrasulfide
[56706-10-6] TSCA HMIS: 2-2-1-X 25g/$32.00 100g/$104.00



SIB1820.5
BIS-[m-(2-TRIETHOXYSILYLETHYL)TOLYL]-POLYSULFIDE tech-85 627-691 1.10 1.533
flashpoint: 55°C (132°F)
$C_{30}H_{50}O_6S_{(2-4)}Si_2$ dark viscous liquid
TSCA HMIS: 2-2-1-X 25g/$32.00



SIB1827.0
BIS[3-(TRIETHOXYSILYL)PROPYL]THIOUREA tech -90 484.40
$C_{19}H_{44}N_2O_6SSi_2$
forms films on electrodes for determination of mercury[1].
1. Y. Guo et al, J. Pharm. Biol. Anal., *19*, 175, 1999
[69952-89-2] HMIS: 2-1-1-X 25g/$134.00

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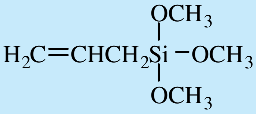
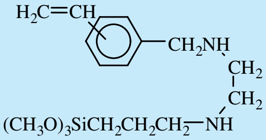
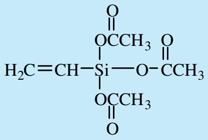
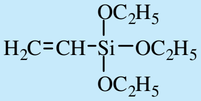
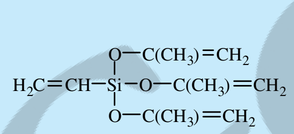
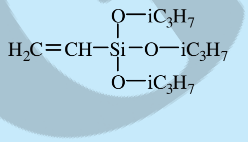
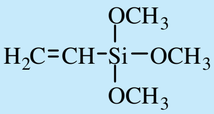
Vinyl and Olefin Functional Silanes

Vinyl and Olefin Functional Silanes - Trialkoxy

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	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				
	[2551-83-9] TSCA HMIS: 3-2-1-X	10g/$24.00	50g/$96.00	2.0kg/$720.00	
	SIS6993.0				
	3-(N-STYRYLMETHYL-2-AMINOETHYLAMINO)-PROPYLTRIMETHOXYSILANE, 40%	338.52		0.871	1.3900
	in methanol inhibited with BHT	flashpoint: 13°C (55°F)			
	$C_{17}H_{30}N_2O_3Si$				
	coupling agent for epoxy composites, primer for epoxy coatings				
	[34937-00-3] TSCA HMIS: 3-4-1-X store <5°	25g/$19.00	100g/$62.00	2.0kg/$292.00	
	SIV9098.0				
	VINYLTRIACETOXYSILANE	232.26	112-3°/1	1.167	1.423
	$C_8H_{12}O_6Si$	flashpoint: 88°C (190°F)			
	coefficient of thermal expansion: 1.6×10^{-3}				
	derivatization byproduct is acetic acid				
	[4130-08-9] TSCA HMIS: 3-2-1-X store <5°	100g/$16.00		2.0kg/$158.00	
	SIV9112.0				
	VINYLTRIETHOXYSILANE	190.31	160-1°	0.903	1.3960
	$C_8H_{18}O_3Si$	TOXICITY- oral rat, LD50: 22,500mg/kg			
	vapor pressure, 20°: 5mm	flashpoint: 44°C (111°F)			
	ΔHvap: 6.8 kcal/mole	autoignition temperature: 268°C (514°F)			
	specific heat: 0.25 cal/g/°	γc of treated surface: 25 dynes/cm			
	dipole moment: 1.69	ΔHform: -463.5 kcal/mole			
	copolymerization parameters- e,Q: -0.42, 0.028				
	relative rate of hydrolysis vs SIV9220.0: 0.05				
	[78-08-0] TSCA HMIS: 1-3-1-X	25g/$10.00	2.0kg/$110.00	16kg/$472.00	
	SIV9209.0				
	VINYLTRIISOPROPENOXYSILANE	226.35	73-5°/12	0.926	1.4373
	$C_{11}H_{18}O_3Si$				
	employed as a crosslinker and in vapor phase; derivatization byproduct is acetone				
	[15332-99-7] TSCA HMIS: 1-3-1-X	25g/$19.00		100g/$62.00	
	SIV9210.0				
	VINYLTRIISOPROPOXYSILANE	232.39	179-81°	0.8659	1.3961^{25}
	$C_{11}H_{24}O_3Si$	flashpoint: 51°C (124°F)			
	copolymerization parameters- e,Q: -0.36, 0.031	vapor pressure, 60°: 4mm			
	relative rate of hydrolysis vs SIV9220.0: 0.0015				
	[18023-33-1] TSCA HMIS: 1-3-1-X	25g/$16.00		100g/$52.00	
	SIV9220.0				
	VINYLTRIMETHOXYSILANE	148.23	123°	0.970	1.3930
	$C_5H_{12}O_3Si$	TOXICITY- oral rat, LD50: 8,000mg/kg			
	viscosity: 0.6 cSt	flashpoint: 28°C (82°F)			
	copolymerization parameters- e,Q: -0.38, 0.031	autoignition temp: 235°			
		vapor pressure, 20°: 9mm			
	employed in two-stage[1] and one-stage[2] graft polymerization/ cross-linking for PE.				
	copolymerizes with ethylene to form moisture cross-linkable polymers[3].				
	1. H. Scott US Pat. 3,646,155, 1972				
	2. P. Swarbrick et al, US Pat. 4,117,195, 1978				
	3. T. Isaka et al, U.S. Pat. 4,413,066, 1983				
	[2768-02-7] TSCA HMIS: 3-4-1-X	25g/$10.00	2.0kg/$96.00	16kg/$352.00	

Commercial

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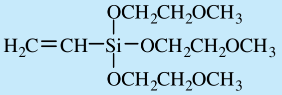
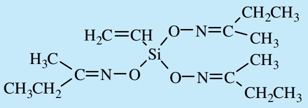
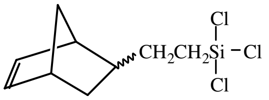
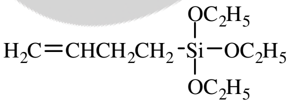
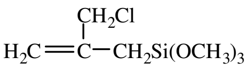
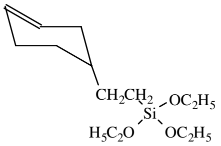
	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $H_2C{=}CH{-}\underset{OCH_2CH_2OCH_3}{\overset{OCH_2CH_2OCH_3}{Si}}{-}OCH_2CH_2OCH_3$	SIV9275.0				
	VINYLTRIS(2-METHOXYETHOXY)SILANE	280.39	284-6°	1.0336^{25}	1.4271^{25}
	$C_{11}H_{24}O_6Si$	TOXICITY- oral rat, LD50: 2960mg/kg			
	vapor pressure, 108°: 2mm	flashpoint: 115°C (239°F)			
	employed in peroxide graft-moisture crosslinking of polyethylene				
	relative rate of hydrolysis vs SIV9220.0: 0.50				
	[1067-53-4] TSCA HMIS: 3-2-1-X	50g/$10.00		2.0kg/$110.00	
	SIV9280.0				
	VINYLTRIS(METHYLETHYLKETOXIMINO)-SILANE, tech-95	313.47	113°/0.1 (-22°)mp	0.982^{25}	
	$C_{14}H_{27}N_3O_3Si$				
	neutral cross-linker/ coupling agent for condensation cure silicones; byproduct is methylethylketoxime				
	[2224-33-1] TSCA HMIS: 3-3-1-X	50g/$15.00		2.0kg/$180.00	
$H_2C{=}CHCH_2O(CH_2)_{11}Si(OCH_3)_3$	SIA0482.0				
	ALLYLOXYUNDECYLTRIMETHOXYSILANE	332.56	140°/0.5	0.914	1.4415
	$C_{17}H_{36}O_4Si$				
	ω-olefin for functional self-assembled monolayers				
	HMIS: 2-1-0-X		5.0g/$124.00		
$H_2C{=}CHCH_2Si(OC_2H_5)_3$	SIA0525.0				
	ALLYLTRIETHOXYSILANE	204.34	176°	0.9030	1.4074
	3-(TRIETHOXYSILYL)-1-PROPENE	flashpoint 47°C (117°F)			
	$C_9H_{20}O_3Si$ vapor pressure, 100°: 50mm	dipole moment: 1.79 debye			
	[2550-04-1] TSCA HMIS 2-3-1-X	10g/$29.00		50g/$128.00	
	SIB0988.0				
	[(BICYCLOHEPTENYL)ETHYL]TRIMETHOXY-SILANE, 95% endo/exo isomers	242.39	65°/10		
		flashpoint: >110°C (>230°F)			
	$C_{12}H_{22}O_3Si$				
	[68323-30-8] HMIS: 2-1-1-X		25g/$120.00		
	SIB0992.0				
	5-(BICYCLOHEPTENYL)TRIETHOXYSILANE	256.42	106-8°/8	0.960	1.4486
	NORBORNENYLTRIETHOXYSILANE	flashpoint: 98°C (208°F)			
	$C_{13}H_{24}O_3Si$				
	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. E. Finkelstein, 10th Int'l Organosilicon Symp. Proc. P-120, 1993				
	[18401-43-9] TSCA HMIS: 2-2-1-X	10g/$30.00		50g/$120.00	
 $H_2C{=}CHCH_2CH_2{-}\underset{OC_2H_5}{\overset{OC_2H_5}{Si}}{-}OC_2H_5$	SIB1928.0				
	BUTENYLTRIETHOXYSILANE, 95%	218.37	64°/6	0.90	
	$C_{10}H_{22}O_3Si$ mixed isomers (mainly 3-butenyl)		(-80°)mp		
		TOXICITY - oral rat, LD50: >5000mg/kg			
		flashpoint: 73°C (163°F)			
	[57813-67-9] HMIS: 2-2-1-X		25g/$88.00		
 $H_2C{=}\overset{CH_2Cl}{C}{-}CH_2Si(OCH_3)_3$	SIC2282.0				
	2-(CHLOROMETHYL)ALLYLTRIMETHOXY-SILANE	210.73	128°/70	1.09	
		flashpoint: 89°C (192°F)			
	$C_7H_{15}ClO_3Si$				
	versatile coupling agent				
	[39197-94-9] HMIS: 3-2-1-X		2.5g/$60.00		
	SIC2459.5				
	[2-(3-CYCLOHEXENYL)ETHYL]TRIETHOXY-SILANE	272.46		0.948	1.444
		flashpoint: 120°C (248°F)			
	$C_{14}H_{28}O_3Si$				
	[77756-79-7] HMIS:: 2-1-1-X	10g/$25.00		50g/$100.00	

Commercial

Developmental

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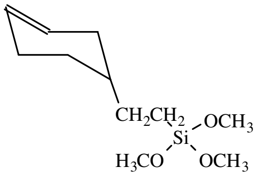
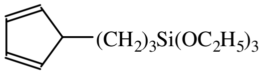
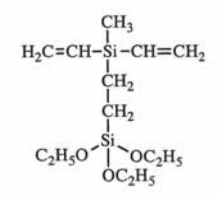
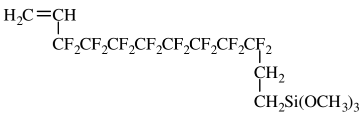
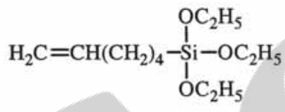
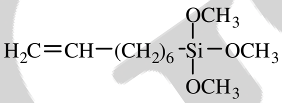
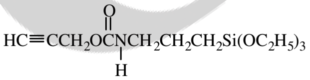
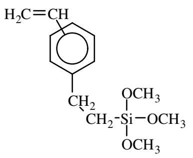
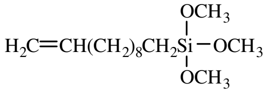
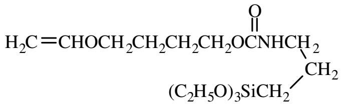
	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIC2460.0 [2-(3-CYCLOHEXENYL)ETHYL]TRIMETHOXY SILANE $C_{11}H_{22}O_3Si$ orients liquid crystals in display devices[1]. coupling agent for aramid fiber reinforced epoxy[2]. 1. Sharp, CA101,81758g; Jap. Pat. JP 58122517, 1983 2. U. Lechner, CA112, 218118x; Germ. Offen. DE 3820971, 1989 [67592-36-3] TSCA HMIS: 3-2-1-X	230.38 flashpoint: 80°C (176°F) 10g/$21.00	109°/6	1.02 50g/$84.00	1.4476
	SIC2520.0 (3-CYCLOPENTADIENYLPROPYL)TRI-ETHOXYSILANE - dimer $C_{14}H_{26}0_3Si$ may be cracked to monomer at ~190° at 100mm employed in silica-supported purification of fullerenes[1]. 1. B. Nie et al, J. Org. Chem., *61*, 1870, 1996 [102056-64-4] HMIS: 2-2-1-X	270.44 flashpoint: 100°C (212°F)	115°/0.5 10g/$60.00	0.99	
	SID4610.3 (DIVINYLMETHYLSILYLETHYL)TRIETHOXYSILANE $C_{13}H_{28}O_3Si_2$ HMIS: 2-1-1-X	288.54	79-81°/0.15 5.0g/$184.00	0.895	
$CH_2{=}CH(CH_2)_{20}Si(OC_2H_5)_3$	SID4618.0 DOCOSENYLTRIETHOXYSILANE, 95% $C_{28}H_{58}O_3Si$ contains internal isomers forms self-assembled monolayers that can be modified to hydroxyls[1]. 1. J. Peansky et al, Langmuir, *11*, 953, 1995 [330457-44-8] HMIS: 1-1-0-X	470.88	187-195°/0.05 1.0g/$110.00		
 $H_2C{=}CH\,CF_2CF_2CF_2CF_2CF_2CF_2CF_2CF_2\,CH_2\,CH_2Si(OCH_3)_3$	SIH5919.0 HEXADECAFLUORODODEC-11-ENYL-1-TRIMETHOXYSILANE $C_{15}H_{16}O_3F_{16}Si$ forms self-assembled monolayers/ reagent for immobilization of DNA HMIS: 3-1-1-X	576.35	90°/0.5 1.0g/$168.00		
 $H_2C{=}CH(CH_2)_4{-}Si(OC_2H_5)_3$	SIH6164.2 HEXENYLTRIETHOXYSILANE $C_{12}H_{26}O_3Si$ primarily α-olefin [52034-14-7] HMIS: 2-1-1-X	246.43 flashpoint: 86°C (187°F)	97°/1 10g/$48.00	0.883	1.4185
 $H_2C{=}CH{-}(CH_2)_6{-}Si(OCH_3)_3$	SIO6709.0 7-OCTENYLTRIMETHOXYSILANE, 95% $C_{11}H_{24}O_3Si$ contains 10-20% internal olefin isomers coupling agent for "in situ" polymerization of acrylamide for capillary elctrophoresis[1] 1. A. Cifuentes et al, J. Chromatog. A, *830(2)*, 423, 1999 [52217-57-9] TSCA HMIS: 3-1-1-X	232.39 flashpoint: 95°C (203°F) 5g/$36.00	48-9°/0.1	0.940 25g/$144.00	1.4305
 $HC{\equiv}CCH_2OC(O)NHCH_2CH_2CH_2Si(OC_2H_5)_3$	SIP6902.6 O-(PROPARGYLOXY)-N-(TRIETHOXY-SILYLPROPYL)URETHANE, 90% $C_{13}H_{25}NO_5Si$ HMIS: 2-2-1-X	303.43 inhibited with MEHQ flashpoint: 95°C (203°F)	110-20°/0.2 25g/$64.00	0.99	1.4461^{25}
	SIS6990.0 STYRYLETHYLTRIMETHOXYSILANE, 95% $C_{13}H_{20}O_3Si$ inhibited with t-butylcatechol mixed m,p isomers and α,β isomers copolymerization parameter, e,Q: -0.880, 1.500 [134000-44-5] HMIS: 2-1-1-X store <5°	252.38 flashpoint: 97°C (207°F) 10g/$60.00	98°/0.1	1.02 50g/$240.00	1.505
 $H_2C{=}CH(CH_2)_8CH_2Si(OCH_3)_3$	SIU9049.0 10-UNDECENYLTRIMETHOXYSILANE $C_{14}H_{30}O_3Si$ HMIS: 2-1-1-X	274.48	102-5°/1 5.0g/$160.00	0.908	
 $H_2C{=}CHOCH_2CH_2CH_2CH_2OC(O)NHCH_2CH_2CH_2Si(OC_2H_5)_3$	SIV9088.4 O-(VINYLOXYBUTYL)-N-(TRIETHOXYSILYL-PROPYL)URETHANE, 95% inhibited w/ MEHQ $C_{16}H_{23}NO_6Si$ UV reactive coupling agent HMIS: 3-2-1-X	363.53	10g/$82.00	1.015	1.4454

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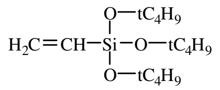
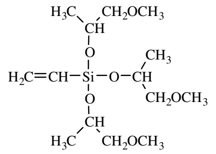
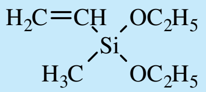
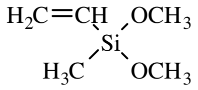
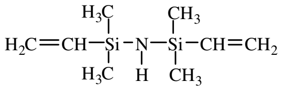
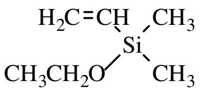
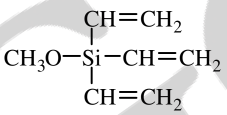
	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIV9099.0				
	VINYLTRI-t-BUTOXYSILANE	274.47	54°/2	0.869	
	$C_{14}H_{30}O_3Si$	flashpoint: 79°C (174°F)			
	[5356-88-7] HMIS: 2-2-1-X	10g/$48.00		50g/$192.00	
	SIV9277.0				
	VINYLTRIS(METHOXYPROPOXY)SILANE	322.47		0.981	1.424
	$C_{14}H_{30}O_6Si$	flashpoint: 122° (252°F)			
	[303746-21-6] HMIS: 2-1-1-X	25g/$24.00		100g/$78.00	

Vinyl and Olefin Functional - Dialkoxy

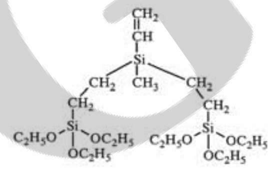
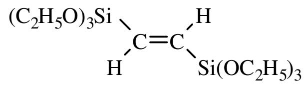
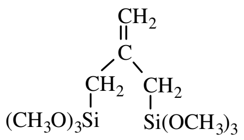
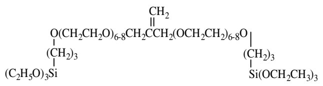
	SIV9085.0				
	VINYLMETHYLDIETHOXYSILANE	160.29	133-4°	0.858	1.4000
	$C_7H_{16}O_2Si$	flashpoint: 16°C (61°F)			
	copolymerization parameters- e,Q; -0.86, 0.020				
	dipole moment: 1.27				
	[5507-44-8] TSCA HMIS: 2-4-1-X	25g/$14.00		2.0kg/$320.00	
	SIV9086.0				
	VINYLMETHYLDIMETHOXYSILANE	132.23	104°	0.889	1.395
	$C_5H_{12}O_2Si$	flashpoint: 8°C (46°F)			
	viscosity, 20°: 0.51 cSt				
	[16753-62-1] TSCA HMIS: 3-4-1-X	25g/$18.00		100g/$58.00	

Commercial

Vinyl and Olefin Functional - Monoalkoxy

	SID4612.0				
	1,3-DIVINYLTETRAMETHYLDISILAZANE	185.42	160-1°	0.819	1.4405
	$C_8H_{19}NSi_2$	flashpoint: 34°C (93°F)			
	derivatization byproduct is ammonia				
	adhesion promoter for negative photoresists				
	for silylation of glass capillary columns[1]				
	1. M. Jaroniec et al, J. High Resol. Chromatog, *5*, 3, 1982				
	[7691-02-3] TSCA HMIS: 3-3-1-X	50g/$24.00		250g/$96.00	
	SIV9072.0				
	VINYLDIMETHYLETHOXYSILANE	130.26	99-100°	0.790	1.3983
	$C_6H_{14}OSi$	flashpoint: 4°C (39°F)			
	dipole moment: 1.23				
	[5356-83-2] TSCA HMIS: 2-4-1-X	10g/$22.00		50g/$88.00	
	SIT8732.0				
	TRIVINYLMETHOXYSILANE	140.25	131-3°		1.4400
	$C_7H_{12}OSi$				
	HMIS: 3-4-1-X	2.5g/$14.00		10g/$46.00	

Vinyl and Olefin Functional - Dipodal

	SIB1818.0				
	BIS(TRIETHOXYSILYLETHYL)VINYLMETHYLSILANE	452.82	141-3°/0.15	0.943	
	$C_{19}H_{44}O_6Si_3$				
	HMIS: 2-1-1-X		5.0g/$120.00		
	SIB1820.0				
	BIS(TRIETHOXYSILYL)ETHYLENE, 95%	352.57	122-5°/4	0.958	1.4168
	4,4,7,7-TETRAETHOXY-3,8-DIOXA-4,7-DISILADEC-5-ENE				
	$C_{14}H_{32}O_6Si_2$ ~80% trans isomer; contains 1,1-isomer				
	[87061-56-1] HMIS: 2-2-1-X	5.0g/$39.00		25g/$156.00	
	SIB1832.5				
	BIS(TRIMETHOXYSILYLMETHYL)ETHYLENE	296.47			
	$C_{10}H_{24}O_6Si_2$				
	[143727-20-2] HMIS: 3-3-1-X		5.0g/$170.00		
	SIB1824.9				
	1,3-[BIS(3-TRIETHOXYSILYLPROPYL)POLYETHYLENOXY]-2-METHYLENEPROPANE	1113.5			
	$C_{50}H_{104}O_{20}Si_2$ (average)				
	vinyl functional hydrophilic dipodal coupling agent for protein immobilization				
	HMIS: 2-2-1-X		1.0g/$275.00		

Developmental

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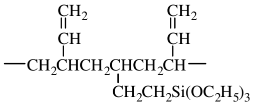
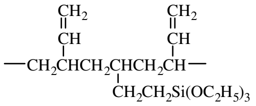
Multi-Functional and Polymeric Silanes

name **MW** **bp/mm (mp)** **D_4^{20}** **n_D^{20}**

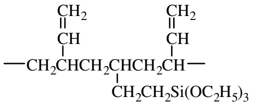
Polybutadiene



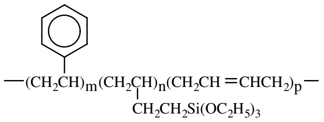
SSP-055
TRIETHOXYSILYL MODIFIED POLY-1,2-BUTADIENE, 50% in toluene 3500-4500 0.90
viscosity: 100-200 cSt.
coupling agent for EPDM resins
[72905-90-9] TSCA HMIS: 2-4-1-X store <5° 100g/$60.00 2.0kg/$780.00



SSP-056
TRIETHOXYSILYL MODIFIED POLY-1,2-BUTADIENE, 50% in volatile silicone 3500-4500 0.93
viscosity: 100-200 cSt.
primer coating for silicone rubbers
[72905-90-9] TSCA HMIS: 2-3-1-X store <5° 100g/$68.00

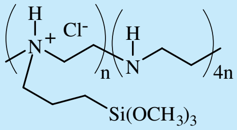


SSP-058
DIETHOXYMETHYLSILYL MODIFIED POLY-1,2-BUTADIENE, 50% in toluene 3500-4500 0.90
viscosity: 75-150 cSt.
water tree resistance additive for crosslinkable HDPE cable cladding
HMIS: 2-4-1-X store <5° 100g/$86.00

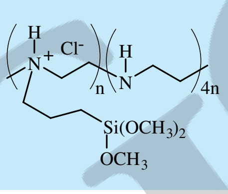


SSP-255
(30-35%TRIETHOXYSILYLETHYL)ETHYLENE- (35-40% 1,4-BUTADIENE) - (25-30% STYRENE) terpolymer, 50% in toluene 4500-5500
HMIS: 2-3-1-X viscosity: 20-30 cSt. 100g/$86.00

Polyamine



SSP-060
TRIMETHOXYSILYLPROPYL MODIFIED (POLYETHYLENIMINE) 50% in isopropanol 1500-1800 0.92
visc: 125-175 cSt ~20% of nitrogens substituted
employed as a coupling agent for polyamides[1].
in combination with glutaraldehyde immobilizes enzymes[2].
1. B. Arkles et al, SPI 42nd Composite Inst. Proc., 21-C, 1987
2. S. Cramer et al, Biotech. & Bioeng., *33(3)*, 344, 1989.
[136856-91-2] TSCA HMIS: 2-4-1-X 100g/$28.00 2.0kg/$364.00

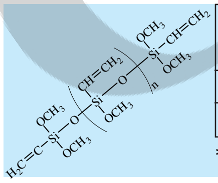


SSP-065
DIMETHOXYMETHYLSILYLPROPYL MODIFIED (POLYETHYLENIMINE) 50% in isopropanol 1500-1800 0.92
visc: 100-200 cSt ~20% of nitrogens substituted
primer for brass
[1255441-88-5] TSCA HMIS: 2-4-1-X 100g/$38.00 2.0kg/$494.00

Developmental

Vinylalkoxysiloxane Polymers

TSCA



Code	Description	wgt % vinyl	Viscosity, cSt	Density	Refractive Index	Price/100g	Price/1kg
VEE-005*	polyVinylethoxysiloxane	19 - 22	4 - 7	1.02		$36.00	$252.00
VMM-010**	polyVinylmethoxysiloxane	22 - 23	8 - 12	1.10	1.428	$28.00	$196.00

*CAS: [29434-25-1] **CAS: [131298-48-1]

Vinylethoxysiloxane-Propylethoxysiloxane Copolymer

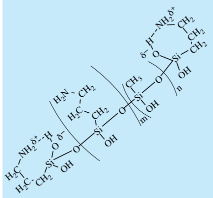
TSCA

Code	Description	Viscosity	Density	Price/100g	Price/1kg
VPE-005*	oligomer	3 - 7	1.02	$36.00	$252.00

*9-11 wgt% vinyl

Water-borne Aminoalkyl Silsesquioxane Oligomers

TSCA



Code	Functional Group	Mole %	Molecular Weight	Weight % in solution	Specific Gravity	Viscosity	pH	Price/100g	3kg
WSA-7011	Aminopropyl	65-75	250-500	25-28	1.10	5-15	10-10.5	$29.00	$435.00
WSA-9911*	Aminopropyl	100	270-550	22-25	1.06	5-15	10-10.5	$24.00	$360.00
WSA-7021	Aminoethylaminopropyl	65-75	370-650	25-28	1.10	5-10	10-11	$29.00	$435.00
WSAV-6511**	Aminopropyl, vinyl	60-65	250-500	25-28	1.11	3-10	10-11	$35.00	$480.00

*CAS [29159-37-3] **[207308-27-8]

Commercial

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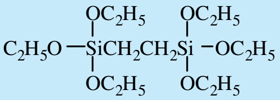
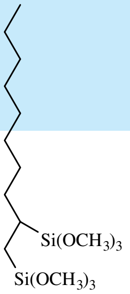
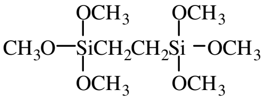
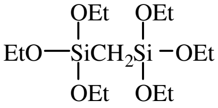
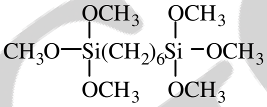
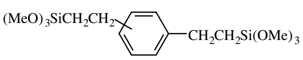
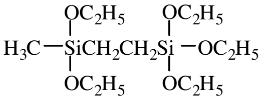
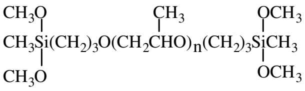
Non-Functional Dipodal Silanes

Commercial

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $C_2H_5O{-}\underset{OC_2H_5}{\overset{OC_2H_5}{Si}}CH_2CH_2\underset{OC_2H_5}{\overset{OC_2H_5}{Si}}{-}OC_2H_5$	SIB1817.0 BIS(TRIETHOXYSILYL)ETHANE *HEXAETHOXYDISILETHYLENE* $C_{14}H_{34}O_6Si_2$ ΔHvap: 101.5 kj/mole additive to silane coupling agent 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]. forms mesoporous, derivatizeable molecular sieves[4]. 1. W. Van Ooij et al, J. Adhes. Sci. Tech. *11*, 29, 1997 2. W. Van Ooij et al, Chemtech., *28*, 26, 1998. 3. D. A. Loy et al, J. Am. Chem. Soc., *121*, 5413, 1999. 4. B. Molde et al, Chem. Mat., *11*, 3302, 1999. [16068-37-4] TSCA-S HMIS: 3-1-1-X	354.59 flashpoint: 107°C (225°F) vapor pressure, 150°: 10mm TOXICITY - oral rat, LD50: 161mg/kg 25g/$15.00	96°/0.3 100g/$49.00	0.957 2.0kg/$420.00	1.4052
	SIB1829.0 1,2-BIS(TRIMETHOXYSILYL)DECANE $C_{16}H_{38}O_6Si_2$ pendant dipodal silane HMIS: 3-2-1-X	382.65 25g/$48.00	130-2°/0.4	0.984 100g/$156.00	1.4303
 $CH_3O{-}\underset{OCH_3}{\overset{OCH_3}{Si}}CH_2CH_2\underset{OCH_3}{\overset{OCH_3}{Si}}{-}OCH_3$	SIB1830.0 BIS(TRIMETHOXYSILYL)ETHANE $C_8H_{22}O_6Si_2$ **CAUTION: INHALATION HAZARD** employed in fabrication of multilayer printed circuit boards 1. J. Palladino, U.S. Pat. 5,073,456, 1991. [18406-41-2] TSCA HMIS: 4-2-1-X	270.43 flashpoint: 65° (149°F) vapor pressure, 20°: 0.08mm 25g/$69.00	103-4°/5	1.068 100g/$224.00	1.4091
 $EtO{-}\underset{OEt}{\overset{OEt}{Si}}CH_2\underset{OEt}{\overset{OEt}{Si}}{-}OEt$	SIB1821.0 BIS(TRIETHOXYSILYL)METHANE *4,4,6,6-TETRAETHOXY-3,7-DIOXA-4,6-DISILANONANE* $C_{13}H_{32}O_6Si_2$ intermediate for sol-gel coatings, hybrid inorganic-organic polymers [18418-72-9] HMIS: 2-3-0-X	340.56 5.0g/$37.00	114-5°/3.5	0.9741 25g/$148.00	1.4098
 $CH_3O{-}\underset{OCH_3}{\overset{OCH_3}{Si}}(CH_2)_6\underset{OCH_3}{\overset{OCH_3}{Si}}{-}OCH_3$	SIB1832.0 BIS(TRIMETHOXYSILYL)HEXANE $C_{12}H_{30}O_6Si_2$ sol-gels of α,ω-bis(trimethoxysilyl)alkanes reported[1]. 1. D. A. Loy et al, J. Am. Chem. Soc., *121*, 5413, 1999. [87135-01-1] HMIS: 3-2-1-X	326.54 flashpoint: 95°C (203°F) 10g/$36.00	161°/2	1.014 50g/$144.00	1.4213
$(C_2H_5O)_3Si(CH_2)_8Si(OC_2H_5)_3$	SIB1824.0 BIS(TRIETHOXYSILYL)OCTANE $C_{20}H_{46}O_6Si_2$ employed in sol-gel synthesis of mesoporous structures [52217-60-4] TSCA-L HMIS: 2-1-1-X	438.76 25g/$30.00	172-5°/0.75	0.926 100g/$98.00	1.4240
	SIB1831.0 BIS(TRIMETHOXYSILYLETHYL)BENZENE $C_{16}H_{30}O_6Si_2$ mixture of m,p isomers [58298-01-4] TSCA HMIS: 2-1-0-X	374.58 flashpoint: 193°C (380°F) 10g/$33.00	148-50°/.1	1.08 50g/$132.00	1.4734
 $H_3C{-}\underset{OC_2H_5}{\overset{OC_2H_5}{Si}}CH_2CH_2\underset{OC_2H_5}{\overset{OC_2H_5}{Si}}{-}OC_2H_5$	SIT8185.8 1-(TRIETHOXYSILYL)-2-(DIETHOXYMETHYLSILYL)ETHANE $C_{13}H_{32}O_5Si$ [18418-54-7] TSCA HMIS: 3-2-1-X	324.56 flashpoint: 102°C (215°F) 25g/$40.00	100°/0.5	0.946 100g/$130.00	1.4112
 $CH_3\underset{CH_3O}{\overset{CH_3O}{Si}}(CH_2)_3O(CH_2\overset{CH_3}{C}HO)_n(CH_2)_3\underset{OCH_3}{\overset{OCH_3}{Si}}CH_3$	SIB1660.0 BIS[(3-METHYLDIMETHOXYSILYL)PROPYL]-POLYPROPYLENE OXIDE viscosity: 6000-10,000 cSt. w/tin catalyst forms moisture-crosslinkable resins hydrophilic dipodal silane [75009-88-0] TSCA HMIS: 3-1-1-X	600-800 flashpoint: >110°C (>230°F) 100g/$24.00		1.00 2.0kg/$288.00	

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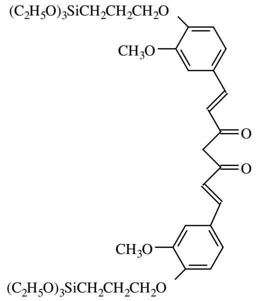
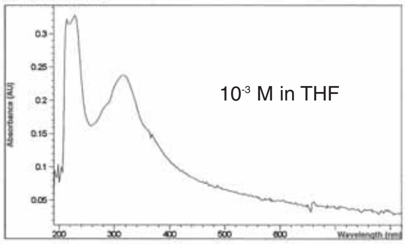
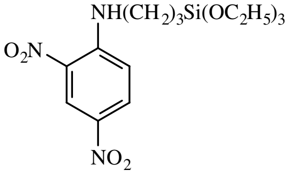
UV Active and Fluorescent Silanes

name | **MW** | **bp/mm (mp)** | n_D^{20}

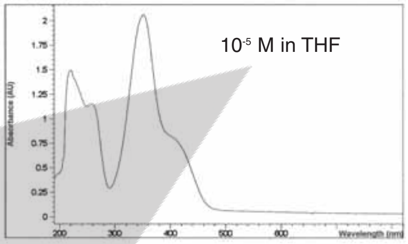


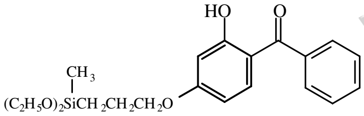
SIB1824.8
BIS(4-TRIETHOXYSILYLPROPOXY-3-METHOXY-PHENYL)-1,6-HEPTADIENE-3,5-DIONE tech-90 — 777.07
$C_{39}H_{60}O_{12}Si_2$
UV: 220, 232(max), 354(broad)
metal chelating chromophore
HMIS: 2-1-1-X — 500mg/$180.00



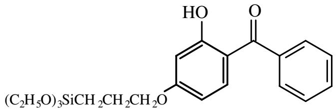


SID4352.0
3-(2,4-DINITROPHENYLAMINO)PROPYL-TRIETHOXYSILANE, 95% — 387.46 — (27-30°)mp — 1.5665
N-[3-(TRIETHOXYSILYL)PROPYL]-2,4-DINITROPHENYLAMINE
$C_{15}H_{25}N_3O_7Si$ viscous liquid or solid — flashpoint: >110°C (230°F)
UV: 222, 258, 350(max), 410
forms $\chi 2$ non-linear optical sol-gel materials by corona poling[1,2].
1. E. Toussaere et al, Non-Linear Optics, *2*, 37, 1992
2. B. Lebeau et al, J. Mater. Chem., *4*, 1855, 1994
[71783-41-0] HMIS: 2-1-0-X — 25g/$54.00 100g/$176.00

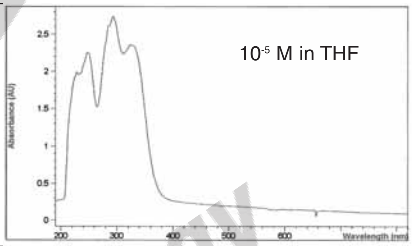


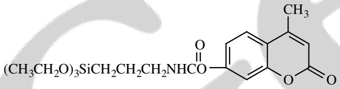


SIH6198.0
2-HYDROXY-4-(3-METHYLDIETHOXYSILYL-PROPOXY)DIPHENYLKETONE, 95% — 388.54 — viscosity, 25°: 100-125 cSt.
$C_{21}H_{28}O_5Si$ monomer for UV opaque fluids
HMIS: 2-1-1-X — 25g/$86.00

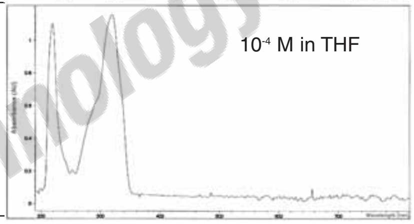


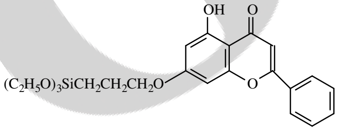
SIH6200.0
2-HYDROXY-4-(3-TRIETHOXYSILYLPROPOXY)-DIPHENYLKETONE, 95% — 418.56 — 1.545^{25}
viscosity, 25°: 125-150 cSt.
$C_{22}H_{30}O_6Si$ density: 1.12 — UV: 230, 248, 296(max), 336
strong UV blocking agent for optically clear coatings, absorbs from 210-420nm
UV blocking agent[1].
1. B. Anthony, US Pat. 4,495,360, 1985
[79876-59-8] TSCA HMIS: 2-1-1-X — 25g/$60.00 100g/$195.00



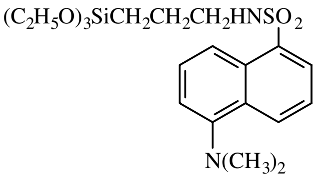


SIM6502.0
O-4-METHYLCOUMARINYL-N-[3-(TRIETHOXY-SILYL)PROPYL]CARBAMATE — 423.54 — (88-90°)mp
UV: 223, 281, 319.5(max)
$C_{20}H_{29}NO_7Si$ — soluble: THF
immobilizeable fluorescent compound[1].
1. B. Arkles, US Pat. 4,918,200, 1990
[129119-78-4] HMIS: 2-2-1-X — 10g/$120.00

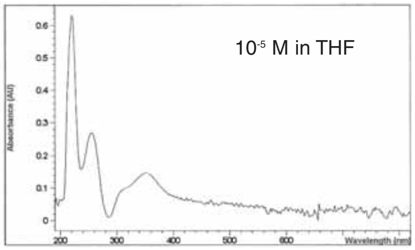


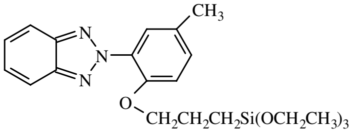


SIT8186.2
7-TRIETHOXYSILYLPROPOXY-5-HYDROXY-FLAVONE, 50% in xylene — 458.58 — UV: 350nm (max)
$C_{24}H_{30}O_7Si$ contains non-reactive dyestuffs
HMIS: 2-1-1-X — 1.0g/$48.00 5.0g/$192.00



SIT8187.0
N-(TRIETHOXYSILYLPROPYL)DANSYLAMIDE — 454.66 — 115-9°/0.1 — 1.5421
5-DIMETHYLAMINO-N-(3-TRIETHOXYSILYLPROPYL)-NAPTHALENE-1-SULFONAMIDE — viscous liquid - soluble in toluene THF
$C_{21}H_{34}N_2O_5SSi$ density: 1.12 — UV: 222(max), 256, 354
fluorescent- employed as a tracer in UV cure composites
fluorescence probe for crosslinking in silicones[1].
1. P. Leezenberg et al, Chem. Mat., *7*, 1784, 1995
[70880-05-6] TSCA HMIS: 2-1-1-X — 0.5g/$84.00 1.0g/$148.00





SIT8188.8
2-(2-TRIETHOXYSILYLPROPOXY-5-METHYL-PHENYL)BENZOTRIAZOLE — 429.59
$C_{22}H_{31}N_3O_4Si$ — UV: 300, 330(max)
UV blocking agent/stabilizer
HMIS: 2-1-1-X — 10g/$94.00

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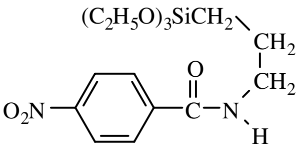
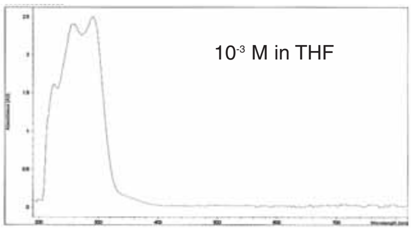
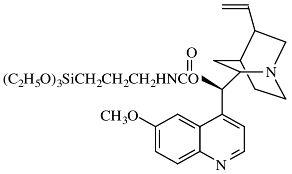
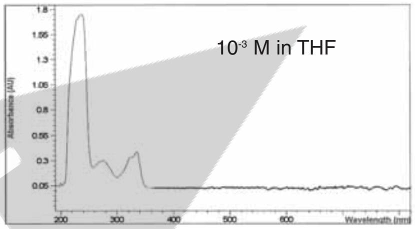
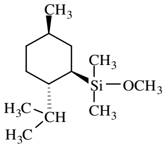
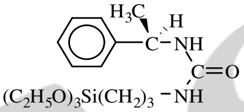
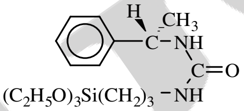
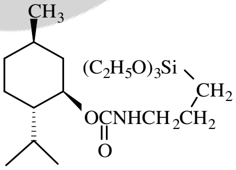
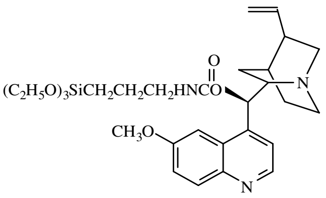
	name	MW	bp/mm (mp)	n_D^{20}	
	SIT8191.0 3-(TRIETHOXYSILYLPROPYL)-p-NITROBENZAMIDE $C_{16}H_{26}N_2O_6Si$ UV max: 224, 260, 292(s) used to prepare diazotizable supports for enzyme immobilization[1]. H. Weetall, US Pat., 3,652,761 [60871-86-5] TSCA HMIS: 2-1-1-X	370.48	(54-5°)mp 25g/$60.00		 10⁻³ M in THF
	SIT8192.4 (R)-N-TRIETHOXYSILYLPROPYL-O-QUININE-URETHANE, 95% $C_{30}H_{45}N_3O_6Si$ UV max: 236(s), 274, 324, 334 fluorescent, optically active silane [200946-85-6] HMIS: 2-1-1-X	571.79 soluble: warm toluene	(82-4°)mp 5.0g/$120.00		 10⁻³ M in THF

Chiral Silanes

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
	SIM6472.6 (-)-MENTHYLDIMETHYLMETHOXYSILANE $C_{13}H_{28}OSi$ reagent for chiral separations HMIS: 3-2-1-X	228.45	5.0g/$188.00		
	SIP6731.5 (R)-N-1-PHENYLETHYL-N'-TRIETHOXYSILYLPROPYLUREA $C_{18}H_{32}N_2O_4Si$ optically active silane; treated surfaces resolve enantiomers [68959-21-7] TSCA HMIS: 2-1-0-X	368.55 flashpoint: > 110°C (>230°F)	25g/$76.00	1.05^{25}	
	SIP6731.6 (S)-N-1-PHENYLETHYL-N'-TRIETHOXYSILYLPROPYLUREA $C_{18}H_{32}N_2O_4Si$ optically active silane; treated surfaces resolve enantiomers [68959-21-7] TSCA HMIS: 2-1-0-X	368.55 flashpoint: > 110°C (>230°F)	25g/$76.00	1.05^{25}	
	SIT8190.0 (S)-N-TRIETHOXYSILYLPROPYL-O-MENTHOCARBAMATE $C_{20}H_{41}NO_5Si$ optically active [68479-61-8] TSCA HMIS: 2-1-1-X	406.63 flashpoint: > 110°C (>230°F)	10g/$64.00	0.985^{25}	1.4526
	SIT8192.4 (R)-N-TRIETHOXYSILYLPROPYL-O-QUININE-URETHANE, 95% $C_{30}H_{45}N_3O_6Si$ fluorescent, optically active silane [200946-85-6] HMIS: 2-1-1-X	571.79 soluble: warm toluene	(82-4°)mp 5.0g/$120.00		

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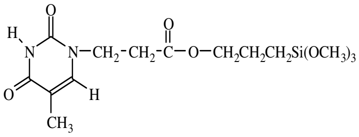
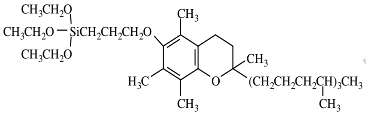
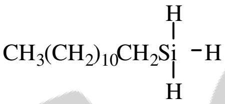
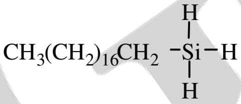
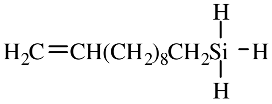
Biomolecular Probes

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $CH_3\overset{O}{\overset{\|}{C}}ONCH_2\overset{O}{\overset{\|}{C}}NHCH_2CH_2CH_2Si(OCH_3)_3$	SIA0120.0 (N-ACETYLGLYCYL)-3-AMINOPROPYLTRIMETHOXYSILANE $C_{10}H_{21}N_2O_7Si$ amino-acid tipped silane HMIS: 3-2-1-X	309.37	5.0g/$152.00		
	SIT7909.7 3-(N-THYMIDYL)PROPIONOXYPROPYLTRIMETHOXYSILANE $C_{14}H_{24}N_2O_7Si$ derivatized surfaces bind adenine modified polymers[1]. 1. K. Viswanathan et al, Polymer Preprints, *46(2)*, 1133, 2005 HMIS: 2-2-1-X	360.74	1.0g/$210.00		
	SIT8012.0 DL-α-TOCOPHEROLOXYPROPYLTRIETHOXYSILANE tech-90 $C_{36}H_{64}O_5Si$ HMIS: 2-2-1-X	604.99	10g/$120.00	0.956	1.485

Silyl Hydrides

Silyl Hydrides are a distinct class of silanes that behave and react very differently than conventional silane coupling agents. Their application is limited to deposition on metals (see discussion on p. 17). They liberate hydrogen on reaction and should be handled a with appropriate caution.

	name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}
 $CH_3(CH_2)_{10}CH_2\overset{H}{\underset{H}{Si}}-H$	SID4629.6 DODECYLSILANE $C_{12}H_{28}Si$ forms SAMS on gold surfaces 872-19-5 HMIS: 2-2-1-X	200.44	80°/7 10g/$78.00	0.7753	1.4380^{25}
 $CH_3(CH_2)_{16}CH_2-\overset{H}{\underset{H}{Si}}-H$	SIO6635.0 n-OCTADECYLSILANE $C_{18}H_{40}Si$ contains 4-6% C_{18} isomers forms self-assembled monolayers on titanium[1]. 1. A. Fadeau et al, J. Am. Chem. Soc., *121*, 12184, 1999 [18623-11-5] TSCA HMIS: 2-1-1-X	284.60 flashpoint: >110°C (>230°F) 25g/$46.00	195°/15 (29°)mp	0.794 100g/$150.00	
 $CF_3CF_2CF_2CF_2CF_2CF_2CH_2CH_2\overset{H}{\underset{H}{Si}}-H$	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	378.22	75°/251.446 10g/$190.00	1.3184	
 $H_2C{=}CH(CH_2)_8CH_2\overset{H}{\underset{H}{Si}}-H$	SIU9048.0 10-UNDECENYLSILANE $C_{11}H_{24}Si$ HMIS: 2-3-1-X	184.40	2.5g/$180.00	0.78	

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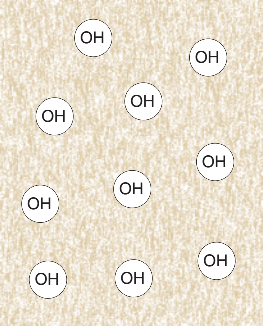
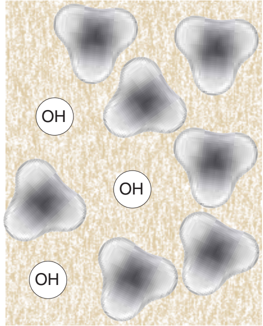
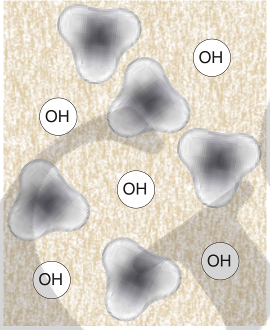
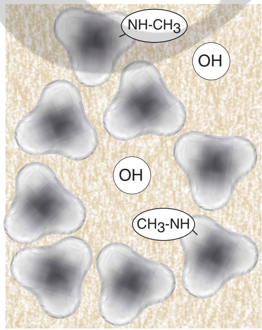
Organosilane-Modified Silica Nanoparticles

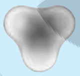
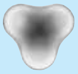
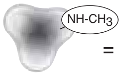
A range of silica structures from 20nm to 1 micron have been modified with silanes to reduce hydroxyl content allowing improved dispersion. Other versions have monolayers with isolated secondary amine functionality, providing controlled interactions with resins. Systems that maintain low levels of hydroxyls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









name	MW	bp/mm (mp)	D_4^{20}	n_D^{20}	
SIS6960.0					
SILICON DIOXIDE, amorphous	60.09	(>1600°)mp	2.2	1.46	
fumed silica	TOXICITY- oral rat, LD50: 8160mg/kg				
SiO_2	ultimate particle size: 0.02μ				
surface area, $200m^2/g$	γc: 44				
isoelectric point: 2.2	pH, (4% aqueous slurry): 3.5-4.5				
[112945-52-5] TSCA HMIS: 2-0-0-X	500g/$15.00		2kg/$45.00		
SIS6962.0					Commercial
SILICON DIOXIDE, amorphous	60.09	(>1600°)mp	2.2	1.45	
HEXAMETHYLDISILAZANE TREATED					
fumed silica, HMDZ TREATED	surface area, 150-200m^2/g				
SiO_2	ultimate particle size: 0.02μ				
carbon content: 3%					
approximate ratio: $(CH_3)_3Si/HO\text{-}Si$: 2/1					
[68909-20-6] TSCA HMIS: 2-0-0-X	500g/$40.00		2kg/$128.00		
 = $(CH_3)_3Si$ - = trimethylsilyl group					
SIS6962.1M30					
SILICON DIOXIDE, amorphous	60.09	(>1600°)mp	2.2	1.45	
HEXAMETHYLDISILAZANE TREATED					
fumed silica, HMDZ TREATED	surface area, 150-200m^2/g				
SiO_2	ultimate particle size: 0.02μ				
carbon content: 2-3%					
calculated ratio: $(CH_3)_3Si/HO\text{-}Si$: 1/1					
[68909-20-6] TSCA HMIS: 2-0-0-X	500g/$40.00		2kg/$128.00		
 = $(CH_3)_3Si$ - = trimethylsilyl group					
SIS6962.1N30					Developmental
SILICON DIOXIDE, amorphous	60.09	(>1600°)mp	2.2	1.45	
CYCLIC AZASILANE/HEXAMETHYLDISILAZANE TREATED					
fumed silica, N-Methylaminopropylfunctional	surface area, 150-200m^2/g				
SiO_2	ultimate particle size: 0.02μ				
carbon content: 4-7%					
calculated ratio: $CH_3NHCH_2CH_2CH_2Si/(CH_3)_3Si:HO\text{-}Si$:1/2/1					
[68909-20-6] TSCA HMIS: 2-0-0-X		500g/$84.00			
 = $CH_3NHCH_2CH_2CH_2(CH_3)_2Si$					

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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.

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

Polar, hydrophilic and water-dispersible silanes, although important in surface modification, do not have organic functionality and are not discussed with coupling agents. The Gelest brochure entitled "**Hydrophobicity, Hydrophilicity and Silane Surface Modification**" includes these materials.

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

Alkyl-silanes and **Aryl-silanes** including **Fluorinated Alkyl-silanes** are important in control of hydrophobicity and surface properties. These materials are discussed in the Gelest brochure "Alkyl-silanes and Aryl-silanes."

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.

Substrate Chemistry - General References and Proceedings

8. R. Iler, "The Chemistry of Silica," Wiley, 1979.
9. S. Pantelides, G. Lucovsky, "SiO_2 and Its Interfaces," MRS Proc. 105, 1988.

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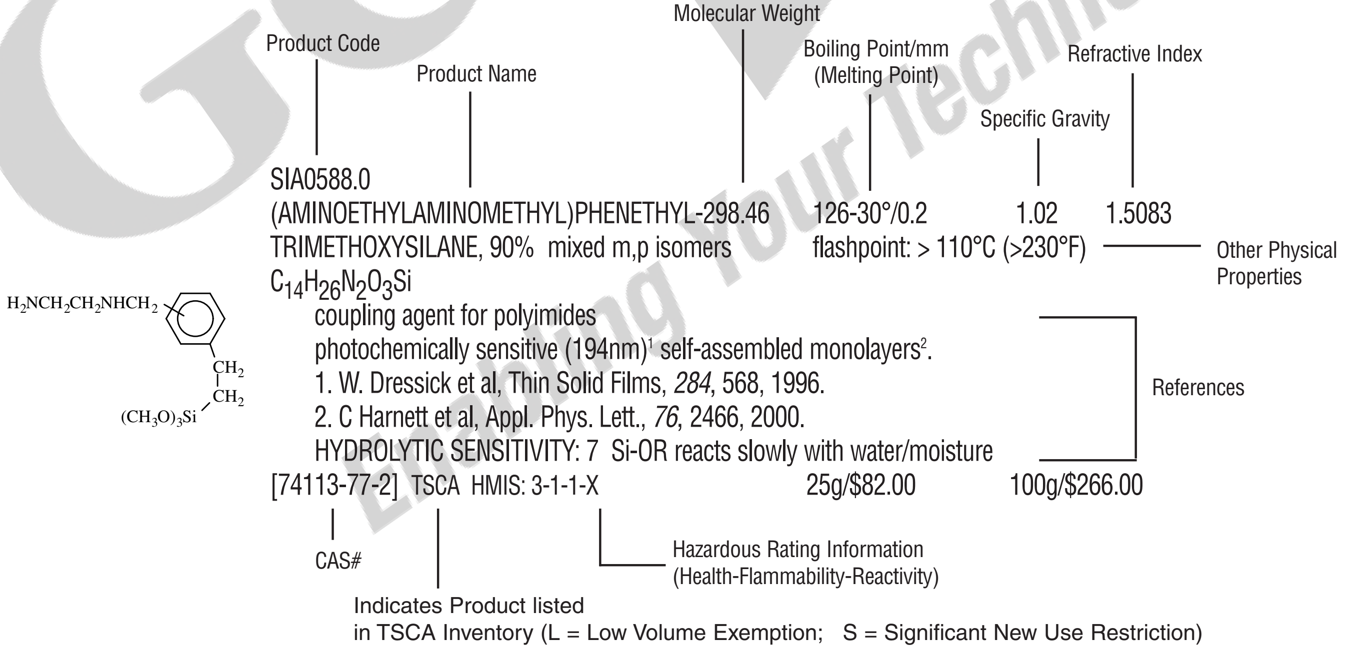
Product Information



SIA0588.0
(AMINOETHYLAMINOMETHYL)PHENETHYL- 298.46 126-30°/0.2 1.02 1.5083
TRIMETHOXYSILANE, 90% mixed m,p isomers flashpoint: > 110°C (>230°F)
$C_{14}H_{26}N_2O_3Si$
coupling agent for polyimides
photochemically sensitive (194nm)[1] self-assembled monolayers[2].
1. W. Dressick et al, Thin Solid Films, *284*, 568, 1996.
2. C Harnett et al, Appl. Phys. Lett., *76*, 2466, 2000.
HYDROLYTIC SENSITIVITY: 7 Si-OR reacts slowly with water/moisture
[74113-77-2] TSCA HMIS: 3-1-1-X 25g/$82.00 100g/$266.00

Indicates Product listed
in TSCA Inventory (L = Low Volume Exemption; S = Significant New Use Restriction)

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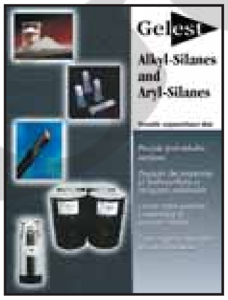
Gelest Product Lines

Silicon Compounds: Silanes & Silicones
Detailed chemical properties and reference articles for over 2000 compounds. The 560 page Gelest catalog of silicon and metal-organic chemistry includes scholarly reviews as well as detailed application information. Physical properties, references, structures, CAS numbers as well as HMIS (Hazardous Material Rating Information) of metal-organic and silicon compounds enable chemists to select materials to meet process and performance criteria.

Reactive Silicones - Forging New Polymer Links
The 48 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 properties shortens product development time for chemists and engineers. The detailed text provides starting-point formulations, references and application information. Vinyl, hydride, silanol and alkoxy functional silicones are provided for conventional silicone cure systems. Amine, epoxy, methacrylate, hydroxy and mercapto silicones are provided for hybrid organic-silicone cure systems.

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 24 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.



Alkyl-Silanes and Aryl-Silanes
A description of non-functional silanes that are used to prepare hydrophobic and water repellent surfaces, specialty resins and modified ceramics is given in an 8 page brochure. The emphasis is on distinguishing the features and benefits of the entire range of commercial alkyl-silanes and aryl-silanes, including fluorinated alkyl-silanes.

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.

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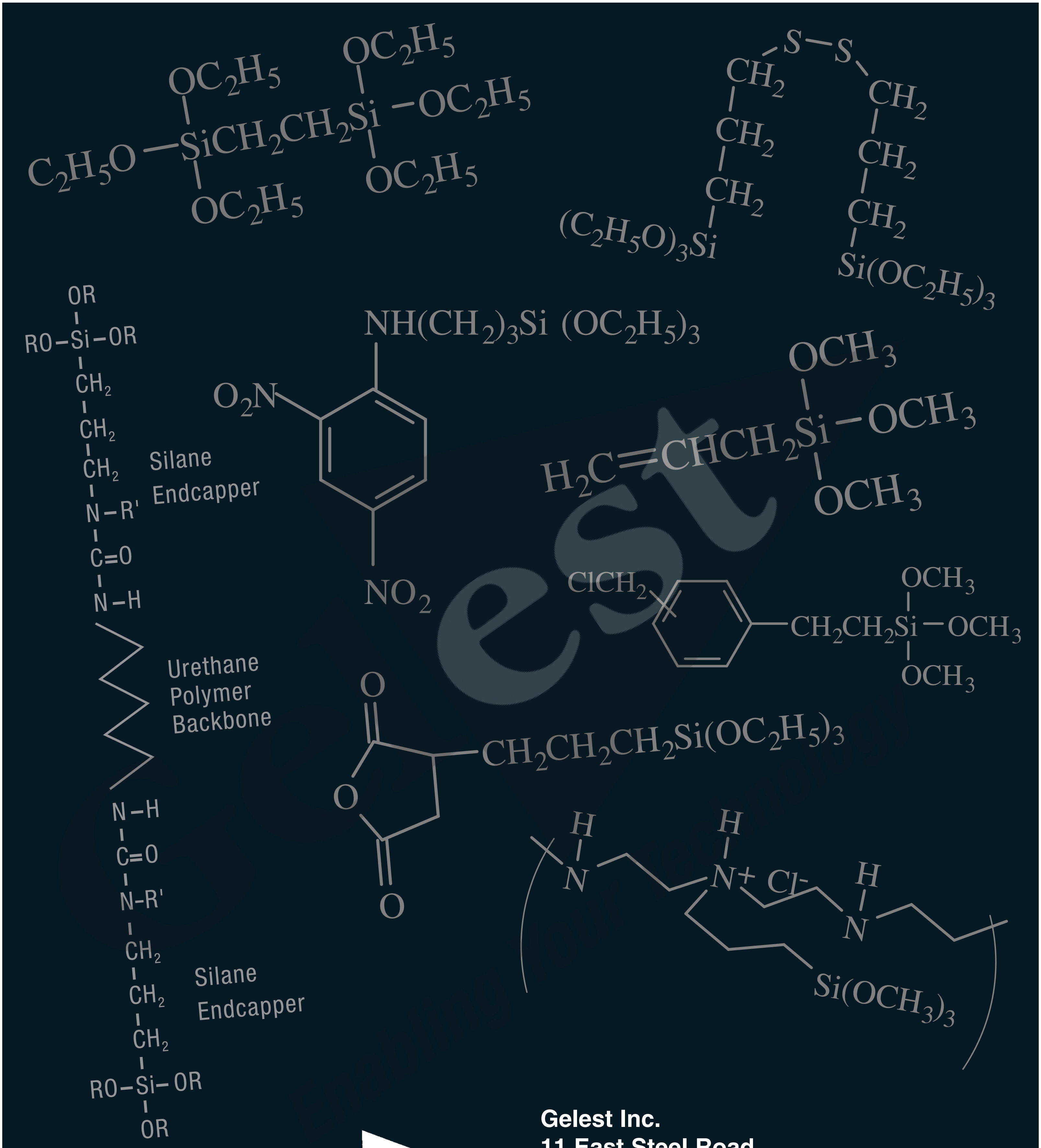

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