



# Silanes and Silicones for Epoxy Resins

## Modifying Epoxy Resin Performance

**Adhesion**

**Rheology**

**Optical Properties**

**Controlled Release**

**Dielectric Properties**

**Thermal Stress Relaxation**

**Low Temperature Properties**

- **Silane Coupling Agents**
- **Epoxy Functional Silicones**
- **Silane and Silicone Hardeners**
- **Organosilane Modified Silica**



*Enabling Your Technology*



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Telephone: General 215-547-1015  
Order Entry 888-734-8344  
215-547-2484  
FAX: 215-547-2484  
Internet: [www.gelest.com](http://www.gelest.com)  
e-mail: [sales@gelest.com](mailto:sales@gelest.com)  
Correspondence: 11 East Steel Rd.  
Morrisville, PA 19067

**For further information consult our web site at: [www.gelest.com](http://www.gelest.com)**

### In Europe:

#### Gelest Inc.

Stroofstrasse 27 Geb.2901  
65933 Frankfurt am Main,  
Germany  
Tel: +49-(0)-69-3800-2150  
Fax: +49-(0)-69-3800-2300  
e-mail: [info@gelestde.com](mailto:info@gelestde.com)  
Internet: [www.gelestde.com](http://www.gelestde.com)

### In Japan:

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research quantities contact:

#### AZmax Co. Ltd. Tokyo Office

TEKKO KAIKAN 5F  
3-2-10 Kayabacho Nihonbashi  
Chuo-ku, Tokyo 103-0025  
Tel: 81-3-6661-1090  
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9F, No.155, Sec.1, Keelung Rd, Taipei.  
Taiwan  
Tel: +886-2-27621985  
Fax: +886-2-27532400  
website: <http://www.kellychemical.com>  
e-mail: [chem@kellychemical.com](mailto:chem@kellychemical.com)

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Singapore 577182  
Tel: 65-6358-3185  
Fax: 65-6353-2542  
e-mail: [support@gulfchem.com.sg](mailto:support@gulfchem.com.sg)

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India  
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Fax: 91-96-19190510  
e-mail: [vasantlyadav@yahoo.co.in](mailto:vasantlyadav@yahoo.co.in)

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# Silanes & Silicones for Epoxy Resins

The outstanding properties of epoxy resins—toughness, rigidity, elevated temperature performance, chemical resistance and adhesive properties have enabled their acceptance in a wide range of critical electronic, optical and aerospace applications. Silicon-based materials play key roles in extending the range of physical properties of conventional epoxy resin systems enabling acceptance in applications with challenging requirements such as ULSI encapsulation, die-attach adhesives, optical component mounting, aerospace nanocomposites, UV-cure controlled release and controlled coefficient of friction coatings.

The main categories of silicon-based materials used in conjunction with epoxy resins are:

- **Silane Coupling Agents** (p.1). These find applications as adhesion promoters for composites, coatings and adhesives.

- **Difunctional and Multifunctional Epoxy Terminated Silicones** (p.10). These include lower molecular weight siloxanes with discrete structures and higher molecular weight silicones with either pendant or terminal epoxy functionalization. Depending on specific structures and formulations they selectively impart a wide range of properties associated with silicones—low-stress, low temperature properties, dielectric properties, release, and optical stability.

- **Silicone Resin Modifiers-Monofunctional Silicones** (p.12). Siloxane and silicone diluents can reduce viscosity of epoxy systems as well as lower surface tension allowing ease of handling, facilitating higher filler loading and infiltration of prepregs and fine structural components.

- **Cycloaliphatic Silanes and Silicones** (p.13). These materials, characterized by a combination of cycloaliphatic and siloxane structures, have outstanding weathering characteristics, controlled release and coefficient of friction along with excellent electrical properties. They can be cured either by cationic UV photoinitiators or conventional epoxy hardeners.

- **Silane and Silicone Hardeners** (p.14). These materials, include siloxane and silicone with diamine, polyamine and dianhydride functionalities.

- **Organosilane Modified Silica Nanoparticles** (p.16). A range of silica structures from 20 nm to 1 micron have been modified with silanes to reduce hydroxyl content allowing improved dispersion. Other versions have monolayers with isolated amine functionality, providing controlled interactions with resins.

With proper selection, formulators can achieve a balance of performance properties, thereby taking advantage of the unique properties of epoxies and silicones.

## General Comparison of Silicone & Bisphenol Based Epoxies

	Silicone Epoxies	Bisphenol Epoxies
<b>Electrical Properties</b>		
Dielectric Constant	2.4-3.0	3.5-5.0
Chloride, Ionic Impurities	<25ppm	30-1000ppm
<b>Optical</b>		
Color, Gardner	<1	>1
Refractive Index	1.40-1.47	1.57-1.60
<b>Thermal</b>		
Low Temp. (Tg)	<-60°C	~60°C
Thermal Stress Relaxation (piezo)	-2 to -3	-6 to -7

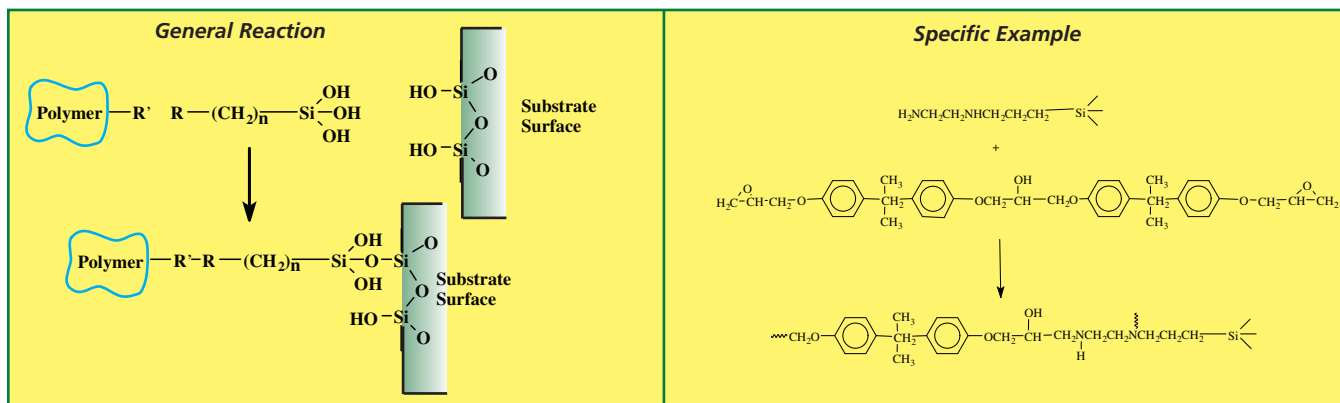
## Silane Coupling Agents

Silane Coupling Agents find applications as adhesion promoters for composites and coatings. Silanes have the ability to form covalent bonds with inorganic substrates and epoxy resins.

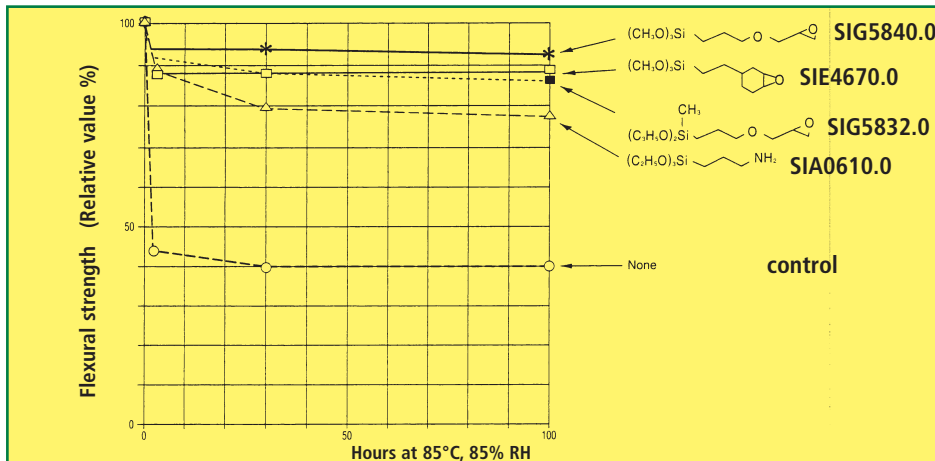
Most commonly, epoxycyclohexyl and glycidoxy functional silanes are used to pretreat fillers or

are blended with the epoxy resin. Amine functional silanes can likewise be used to pretreat the filler or blended with the hardener component of two-part systems. Treatment of fillers in epoxy adhesives improves dispersibility, increases mechanical properties and improves humidity resistance.

## Epoxy Coupling Reactions



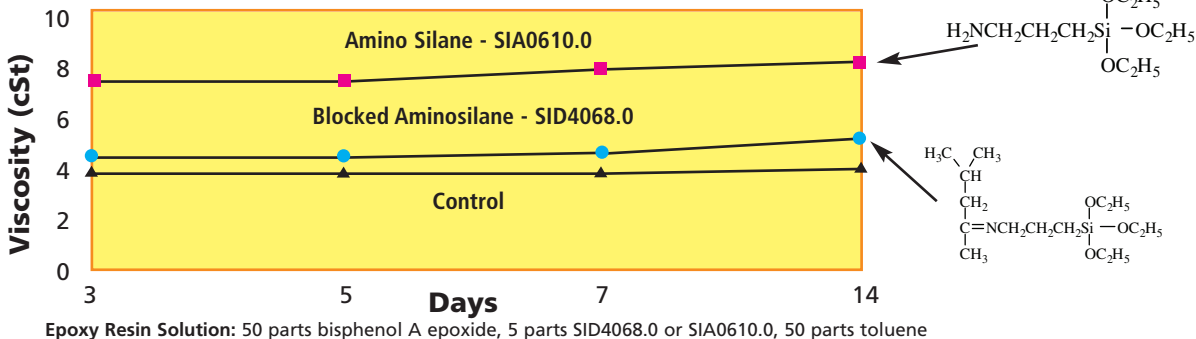
### Humidity Resistance vs. Flexural Strength of Epoxy Molding Compounds



Single-component liquid cure epoxy adhesives and coatings employ dimethylbutylidene blocked amino silanes. These materials show excellent storage stability in resin systems, but are activated by moisture provided by water adsorbed on

substrate surfaces or from humidity. Deblocking begins in minutes and is generally complete within two hours in sections with a diffusional thickness of less than 1mm.

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



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

Primer coatings for metal substrates utilize dipodal silanes to improve wet adhesion. Comparative results for the addition of a non-functional dipodal silane (SIB1817.0bis(triethoxysilyl)ethane) in an EVA system are shown below. Epoxy systems use

non-functional dipodal silanes in conjunction with epoxysilanes. Functional dipodal silanes such as SIB1833.0 bis(triethoxysilylpropyl)amine are used with aminosilanes.

### Effect of dipodal -SiCH<sub>2</sub>CH<sub>2</sub>Si- on the bond strength of a crosslinkable ethylene-vinyl acetate primer formulation

Primer on metal 10% in <i>i</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)

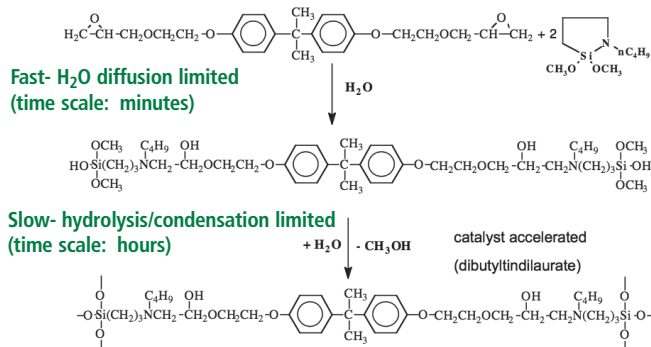
\*90° peel strength after 2 h in 80°C water.

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

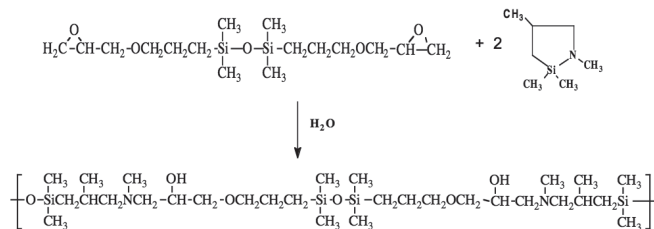
In low moisture conditions, stable mixtures of cyclic azasilanes and compounds or polymers containing epoxy groups can be formed. When exposed to moisture, there is a high speed ring-opening of the cyclic azasilane, which deprotects amine functionality. The amine functionality can react with epoxy functionality, forming hybrid silox-

ane/silsesquioxane-epoxy materials. Examples include a moisture-cure epoxy system with bisphenol A and N-n-butyl-aza-2,2-dimethoxysilacyclopentane (SIB1932.4) [left]. Moisture-initiated chain extension was demonstrated with a difunctional epoxy siloxane (DMS-E09) and N-methyl-aza-2,2,4-trimethylsilacyclopentane (SIM6501.4) [right].

**Cyclic Azasilane Moisture-Cure Epoxies**



**Cyclic Azasilane Moisture-Initiated Reaction with Epoxides: Chain Extension**



**Silane Coupling Agents for Epoxy Resins Selection Chart**

Resin Type	Coupling Agent Class	Suggestions for Primary Screening	
Epoxy (linear aliphatic or bisphenol A)	Amine	SIA0591.0	SIT8398.0
	Anhydride	SIT8192.6	
	Blocked Amine	SID4068.0	
	Epoxy	SIG5840.0	SIG5832.0
Epoxy, UV Cure (cycloaliphatic)	Amine	SIA0591.0	SIT8398.0
	Epoxy	SIE4668.0	SIE4670.0
Epoxidized Rubber	Sulfur/Mercapto	SIM6476.0	SIM6474.0

**Amino Functional Silanes**

name MW bp/mm (mp) D<sub>4</sub><sup>20</sup> n<sub>D</sub><sup>20</sup>

**Activated and Enhanced Silanes**

SIA0610.A1  
SIVATE™ A610 Activated Amine Functional Silane  
flashpoint: 90°C (194°F) viscosity: 3.5 cSt.  
High speed reactivity. Does not require moisture activation for deposition. Improves adhesion and mechanical bond strength compared to conventional coupling agents  
[919-30-2] TSCA HMIS: 3-2-1-X 25g 100g 2.0kg 16kg

SIA0610.E1  
SIVATE™ E610 Enhanced Amine Functional Silane  
flashpoint: 91°C (196°F) viscosity: 2.5 cSt.  
Imparts composites and primers with long-term durability in wide range of environments. Improves corrosion resistance of metal substrates  
TSCA HMIS: 3-2-1-X 25g 100g 2.0kg 16kg

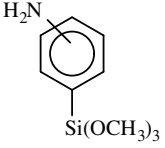
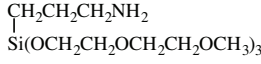
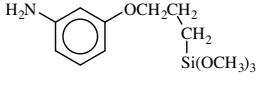
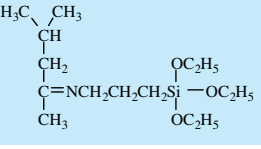
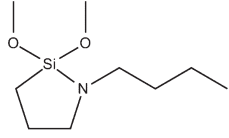
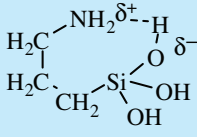
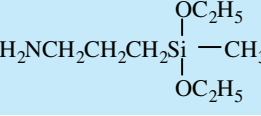
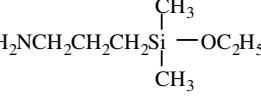
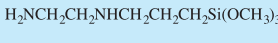
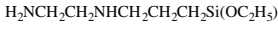
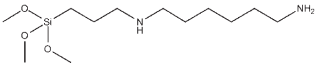
**Monoamine Functional Silanes - Trialkoxy**

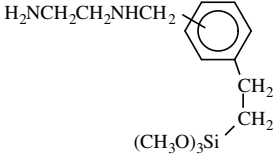
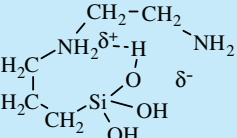
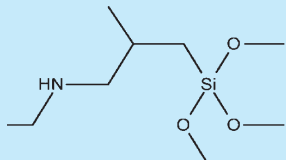
SIA0610.0  
3-AMINOPROPYLTRIEHOXYSILANE  
C<sub>9</sub>H<sub>23</sub>NO<sub>3</sub>Si AMEO, GAPS  
flashpoint: 104°C (220°F)  
ΔHvap: 11.8 kcal/mole  
viscosity: 1.6 cSt.  
versatile coupling agent  
most widely used coupling agent for epoxy coatings  
[919-30-2] TSCA HMIS: 3-1-1-X 25g 2.0kg 16kg

SIA0611.0  
3-AMINOPROPYLTRIMETHOXYSILANE  
C<sub>6</sub>H<sub>17</sub>NO<sub>3</sub>Si  
hydrolysis rate vs AMEO (SIA0610.0): 6:1  
[13822-56-5] TSCA HMIS: 3-2-1-X 25g 2kg 18kg

SIA0587.07  
4-AMINO-3,3-DIMETHYLBUTYLTRIMETHOXYSILANE,  
AMINONEOHXYLTRIMETHOXYSILANE  
C<sub>9</sub>H<sub>23</sub>NO<sub>3</sub>Si  
flashpoint: 97°C (207°F)  
Sterically hindered primary amine coupling agent  
Non-yellowing aminosilane coupling agent for flexible adhesives and sealants  
[157923-74-5] TSCA HMIS: 3-1-1-X 25g 100g 2kg

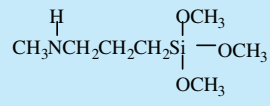
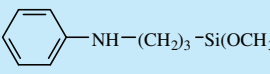
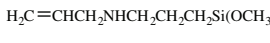
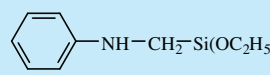
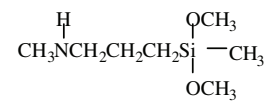
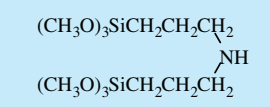
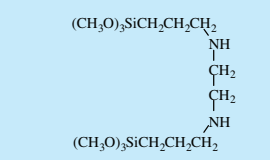
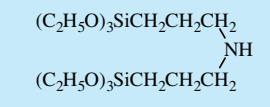
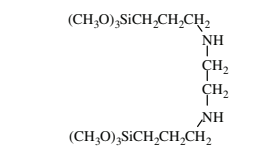
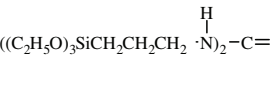
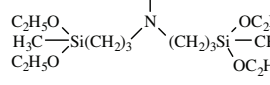
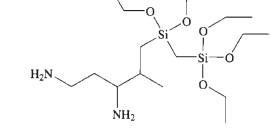
Commercial

	name	MW	bp/mm (mp)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>	
	SIA0599.2 AMINOPHENYLTRIMETHOXYSILANE, mixed isomers typically 60-70% para, 30-40% meta C <sub>9</sub> H <sub>15</sub> NO <sub>3</sub> Si flashpoint: 180°C (356°F) for pure isomers, see SIA0559.0, SIA0559.1- coupling agent for polyimides used in electronics [33976-43-1] HMIS: 3-1-1-X	213.31	110-4°/0.6	1.19		
	SIA0614.0 3-AMINOPROPYLTRIS(METHOXYETHOXY- ETHOXY)SILANE, 95% C <sub>18</sub> H <sub>41</sub> NO <sub>9</sub> Si coupling agent for melt compounding of polyamides and epoxies. [87794-64-7] HMIS: 3-2-1-X	443.61	flashpoint: 68°C (155°F)	1.066	1.448	
	SIA0598.0 3-(m-AMINOPHENOXY)PROPYLTRIMETHOXY- SILANE, tech-95 amber liquid C <sub>12</sub> H <sub>21</sub> NO <sub>4</sub> Si [55648-29-8] TSCA HMIS: 3-1-1-X	271.39	125-135°/0.5	1.02	1.495	
<b>Blocked Monoamine Functional Silanes - Alkoxy</b>						
	SID4068.0 3-(1,3-DIMETHYLBUTYLIDENE)AMINO- PROPYLTRIETHOXYSILANE C <sub>15</sub> H <sub>33</sub> NO <sub>3</sub> Si coupling agent for epoxy coatings blocked amine - moisture deblocked [116229-43-7] TSCA HMIS: 2-2-1-X	303.52	134°/5 flashpoint: 131°C (268°F)	0.93	1.437 <sup>25</sup>	Commercial
	SIB1932.4 N-n-BUTYL-AZA-2,2-DIMETHOXYSILA- CYCLOPENTANE C <sub>9</sub> H <sub>21</sub> NO <sub>2</sub> Si [618914-44-6] TSCA HMIS: 3-2-1-X	203.36	69-71°/3 flashpoint: 85°C (185°F)	0.941	1.438	
<b>Monoamine Functional Silanes - Water-borne</b>						
	SIA0608.0 AMINOPROPYLSILANETRIOL, 22-25% in water C <sub>3</sub> H <sub>11</sub> NO <sub>3</sub> Si mainly oligomers pH: 10.0-10.5 internal hydrogen bonding stabilizes solution [29159-37-3] TSCA HMIS: 2-0-0-X	137.21	flashpoint: >110°C(230°F)	1.06		Commercial
<b>Monoamine Functional Silanes - Dialkoxy</b>						
	SIA0605.0 3-AMINOPROPYLMETHYLDIETHOXYSILANE C <sub>8</sub> H <sub>21</sub> NO <sub>2</sub> Si coupling agent for foundry resins [3179-76-8] TSCA HMIS: 3-2-1-X	191.34	85-8°/8 TOXICITY- oral rat, LD50: 4760mg/kg flashpoint: 85°C(185°F)	0.916	1.4272	
<b>Monoamine Functional Silanes - Monoalkoxy</b>						
	SIA0603.0 3-AMINOPROPYLDIMETHYLETHOXYSILANE C <sub>7</sub> H <sub>19</sub> NOSi Δ Hform: 147.6 kcal/mole [18306-79-1] TSCA HMIS: 3-2-1-X	161.32	78-9°/24 flashpoint: 73°C (163°F) 5.0g	0.857 <sup>25</sup>	1.427 <sup>25</sup>	
<b>Diamine Functional Silanes - Trialkoxy</b>						
	SIA0591.0 N-(2-AMINOETHYL)-3-AMINOPROPYLTRI- METHOXYSILANE N-[3-(TRIMETHOXSILYL)PROPYL]ETHYLENEDIAMINE DAMO C <sub>8</sub> H <sub>22</sub> N <sub>2</sub> O <sub>3</sub> Si visc: 6.5 cSt Ce: 0.8 γc, treated surface: 36.5 dynes/cm coupling agent for epoxy adhesives with good film forming properties and copper/brass adhesion [1760-24-3] TSCA HMIS: 3-1-1-X	226.36	140°/15 flashpoint: 150°C (302°F)	1.019 <sup>25</sup>	1.450 <sup>25</sup>	Commercial
	SIA0590.5 N-(2-AMINOETHYL)-3-AMINOPROPYLTRI- ETHOXYSILANE, 95% C <sub>11</sub> H <sub>28</sub> N <sub>2</sub> O <sub>3</sub> Si [5089-72-5] TSCA HMIS: 3-1-1-X	264.55	156°/15 flashpoint: 148°C (298°F)	0.994	1.4367 <sup>25</sup>	
	SIA0594.0 N-(6-AMINOHEXYL)AMINOPROPYLTRIMETHOXYSILANE, 95% C <sub>12</sub> H <sub>30</sub> N <sub>2</sub> O <sub>3</sub> Si [51895-58-0] HMIS: 3-1-1-X	278.47	160-5°/0.15 flashpoint: 110°C (230°F)	1.11	1.4501	

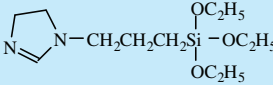
	name	MW	bp/mm (mp)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>	
$H_2NCH_2CH_2NH(CH_2)_{11}Si(OCH_3)_3$	SIA0595.0 N-(2-AMINOETHYL)-11-AMINOUNDECYL-TRIMETHOXYSILANE $C_{16}H_{38}N_2O_3Si$ coupling agent with extended spacer-group for remote substrate binding HMIS: 3-1-1-X	334.57	155-9°/0.4	0.873 <sup>25</sup>	1.4515	5.0g
	SIA0588.0 (AMINOETHYLAMINOMETHYL)PHENETHYL-TRIMETHOXYSILANE, 90% mixed m,p isomers $C_{14}H_{26}N_2O_3Si$ coupling agent for polyimides [74113-77-2] TSCA HMIS: 3-1-1-X	298.46	126-30°/0.2 flashpoint: > 110°C(>230°F)	1.02	1.5083	25g 100g
$H_2N(CH_2CHO)_2CH_2CHNHCH_2CH_2CH_2Si(OCH_3)_3$	SIA0599.4 N-3-[(AMINO(POLYPROPYLENOXY))AMINO-PROPYLTRIMETHOXYSILANE, 60-65% coupling agent with film-forming- capability HMIS: 2-2-1-X	337-435	3-4 propyleneoxy units	0.984	1.4508	25g
<b>Diamine Functional Silanes - Water-borne</b>						
	SIA0590.0 N-(2-AMINOETHYL)-3-AMINOPROPYL-SILANETRIOL, 25% in water mainly oligomers $C_5H_{17}N_2O_3Si$ internal hydrogen bonding stabilizes solution [68400-09-9] TSCA HMIS: 2-0-0-X	180.28	flashpoint: >110°C(230°F) pH: 10.0-10.5	1.00		
$H_2NCH_2CH_2NHCH_2CH_2CH_2Si(OCH_3)_2$	SIA0589.0 N-(2-AMINOETHYL)-3-AMINOPROPYLMETHYL-DIMETHOXYSILANE $C_8H_{22}N_2O_2Si$ [3069-29-2] TSCA HMIS: 3-1-1-X	206.36	265° flashpoint: 90°C(194°F) auto-ignition temp: 280°C specific wetting surface: 380 m <sup>2</sup> /g	0.975 <sup>25</sup>	1.4447 <sup>25</sup>	25g 2.0kg 16kg
$H_2NCH_2CH_2NHCH_2CH(CH_3)CH_2Si(OCH_3)_2$	SIA0587.5 N-(2-AMINOETHYL)-3-AMINOISOBUTYL-METHYLDIMETHOXYSILANE, 95% $C_9H_{24}N_2O_2Si$ [23410-40-4] TSCA HMIS: 3-2-1-X	220.39	131°/15 flashpoint: 96°C(205°F)	0.960	1.4518	25g
$H_2NCH_2CH_2NHCH_2CH(CH_3)CH_2Si(OCH_3)$	SIA0587.2 (AMINOETHYLAMINO)-3-ISOBUTYLDI-METHYLMETHOXYSILANE, 95% $C_9H_{24}N_2OSi$ [31024-49-4] HMIS: 3-2-1-X	204.39	85-9°/2	0.900 <sup>25</sup>	1.4513 <sup>25</sup>	25g
<b>Triamine Functional Silanes</b>						
$H_2NCH_2CH_2HNCH_2CH_2NH(CH_2)_2Si(OCH_3)_3$	SIT8398.0 (3-TRIMETHOXYSILYLPROPYL)DIETHYLENE-TRIAMINE, 95% $C_{10}H_{27}N_3O_3Si$ hardener, coupling agent for epoxies [35141-30-1] TSCA HMIS: 3-1-1-X	265.43	114-8°/2 flashpoint: 137°C(279°F) γ of treated surface: 37.5 dynes/cm	1.030	1.4590	100g 2.0kg 18kg
$C_4H_9NCH_2CH_2CH_2Si(OCH_3)_3$	SIB1932.2 n-BUTYLAMINOPROPYLTRIMETHOXYSILANE $C_{10}H_{25}NO_3Si$ coupling agent for urethane coatings [31024-56-3] TSCA HMIS: 2-2-1-X	235.40	102°/3.5 flashpoint: 110°C (230°F)	0.947	1.4246 <sup>25</sup>	25g 2.0kg 17kg
	SIE4886.0 N-ETHYLAMINOISOBUTYLTRIMETHOXYSILANE $C_9H_{23}NO_3Si$ adhesion promoter for polyurethane coatings [227085-51-0] TSCA HMIS: 3-2-1-X	221.37	95°/10 flashpoint: 91°C(196°F)	0.952 <sup>25</sup>	1.4234	25g 100g 2.0kg

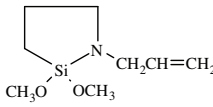
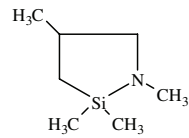
Commercial

Commercial

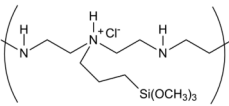
	name	MW	bp/mm (mp)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>	
	SIM6500.0 N-METHYLAMINOPROPYLTRIMETHOXY-SILANE C <sub>7</sub> H <sub>19</sub> NO <sub>3</sub> Si pK <sub>a</sub> <sup>25</sup> H <sub>2</sub> O: 5.18 orient's liquid crystals [3069-25-8] TSCA HMIS: 3-2-1-X	193.32	106°/30 flashpoint: 82°C(179°F) γc of treated surface: 31 dynes/cm	0.978 <sup>25</sup>	1.4194	Commercial
		25g	2.0kg	15kg		
	SIP6724.0 N-PHENYLAMINOPROPYLTRIMETHOXY-SILANE, 95% C <sub>12</sub> H <sub>21</sub> NO <sub>3</sub> Si oxidatively stable coupling agent for polyimides, phenolics, epoxies [3068-76-6] TSCA HMIS: 3-1-1-X	255.38	132-5°/0.3 flashpoint: 165°C(329°F) specific wetting surface: 307m <sup>2</sup> /g	1.07	1.504	Commercial
		25g	2.0kg	18kg		
	SIA0400.0 3-(N-ALLYLAMINO)PROPYLTRIMETHOXY-SILANE, 95% C <sub>9</sub> H <sub>21</sub> NO <sub>3</sub> Si coupling agent for polyesters coupling agent for acrylic coatings for glass containers <sup>1</sup> . 1. Y. Hashimoto et al, Eur. Pat. Appl. EP 289,325, 1988 [31024-46-1] TSCA HMIS: 3-2-1-X	219.36	106-9°/25 flashpoint: 88°C(190°F)	0.989 <sup>25</sup>	1.4990 <sup>25</sup>	
		10g		50g		
	SIP6723.7 N-PHENYLAMINOMETHYLTRIETHOXY-SILANE C <sub>13</sub> H <sub>23</sub> NO <sub>3</sub> Si [3473-76-5] HMIS: 3-2-1-X	269.42	135-7°/4	1.004 <sup>25</sup>	1.485 <sup>25</sup>	
		25g	100g	2kg		
	SIM6498.0 N-METHYLAMINOPROPYLMETHYL-DIMETHOXY-SILANE C <sub>7</sub> H <sub>19</sub> NO <sub>2</sub> Si [31024-35-8] HMIS: 3-2-1-X	177.32	93°/25 flashpoint: 80°C(176°F)	0.9173 <sup>25</sup>	1.4224 <sup>25</sup>	
		25g		100g		
<b>Dipodal Amine Functional Silanes</b>						
	SIB1833.0 BIS(TRIMETHOXSILYLPROPYL)AMINE, 95% C <sub>12</sub> H <sub>31</sub> NO <sub>6</sub> Si <sub>2</sub> dipodal coupling agent [82985-35-1] TSCA HMIS: 3-1-1-X	341.56	152°/4 flashpoint: 113°C (235°)	1.040	1.4320	Commercial
		25g	2.0kg	18kg		
	SIB1834.0 BIS[(3-TRIMETHOXSILYL)PROPYL]-ETHYLENEDIAMINE, 62% in methanol C <sub>14</sub> H <sub>36</sub> N <sub>2</sub> O <sub>6</sub> Si <sub>2</sub> dipodal coupling agent for polyamides with enhanced hydrolytic stability [68845-16-9] TSCA HMIS: 3-4-1-X	384.62	flashpoint: 11°C(52°F)	0.89		Commercial
		25g	2.0kg	16kg		
	SIB1824.5 BIS(TRIETHOXSILYLPROPYL)AMINE, 95% C <sub>18</sub> H <sub>43</sub> NO <sub>6</sub> Si <sub>2</sub> HYDROLYTIC SENSITIVITY: 7 Si-OR reacts slowly with water/moisture [13497-18-2] TSCA HMIS: 2-2-1-X	425.71	160°/0.6 flashpoint: >140°C (284°F)	0.97		Commercial
		25g	100g	2kg		
	SIB1834.1 BIS[(3-TRIMETHOXSILYL)PROPYL]-ETHYLENEDIAMINE, 95% C <sub>14</sub> H <sub>36</sub> N <sub>2</sub> O <sub>6</sub> Si <sub>2</sub> coupling agent for polyamides with enhanced hydrolytic stability [68845-16-9] TSCA HMIS: 3-2-1-X	384.62	flashpoint: >110°C(>230°F)	1.050		Commercial
		10g		50g		
	SIB1828.0 BIS[3-(TRIETHOXSILYL)PROPYL]UREA, 60% in ethanol C <sub>19</sub> H <sub>44</sub> N <sub>2</sub> O <sub>7</sub> Si <sub>2</sub> [69465-84-5] HMIS: 2-1-1-X	440.66		0.923		Commercial
		25g		100g		
	SIB1620.0 BIS(METHYLDIETHOXSILYLPROPYL)AMINE 95% C <sub>16</sub> H <sub>39</sub> NO <sub>4</sub> Si <sub>2</sub> dipodal coupling agent [31020-47-0] HMIS: 2-1-1-X	365.66	155°/0.6	0.937	1.4385	Commercial
		25g		100g		
	SIA0587.6 1-[3-(2-AMINOETHYL)-3-AMINOISOBUTYL]-1,1,3,3,3-PENTAETHOXY-1,3-DISILAPROPANE, 95% C <sub>17</sub> H <sub>42</sub> N <sub>2</sub> O <sub>5</sub> Si <sub>2</sub> [1621184-23-3] HMIS: 3-1-1-X	410.70	130-140°/0.5 10g	0.990		

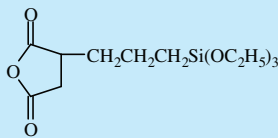


	name	MW	bp/mm (mp)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>		
	<b>Specialty Amine Functional Silanes</b>						
	SIT8187.5 N-(3-TRIETHOXYSILYL)PROPYL- 4,5-DIHYDROIMIDAZOLE 3-(2-IMIDAZOLIN-1-YL)PROPYLTRIETHOXYSILANE C <sub>12</sub> H <sub>26</sub> N <sub>2</sub> O <sub>3</sub> Si coupling agent for elevated temperature cure epoxy resins. [58068-97-6] TSCA HMIS: 2-1-1-X	274.43	134°/2 flashpoint: >110°C (>230°F)	1.005	1.452		Commercial
	SIU9055.0 UREIDOPROPYLTRIETHOXYSILANE, 50% in methanol C <sub>10</sub> H <sub>24</sub> N <sub>2</sub> O <sub>4</sub> Si contains ureidopropyltrimethoxysilane and related transesterification products coupling agent for polyamides, area-formaldehyde resins [23779-32-0] TSCA HMIS: 2-4-1-X	264.40	(-97°)mp flashpoint: 14°C (58°F)	0.92	1.386		
SIU9058.0 UREIDOPROPYLTRIMETHOXYSILANE C <sub>7</sub> H <sub>18</sub> N <sub>2</sub> O <sub>4</sub> Si [23843-64-3] TSCA HMIS: 2-3-1-X	222.32	217-225° flashpoint: 99°C (210°F)	1.150	1.386 <sup>25</sup>	2kg		

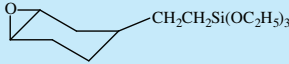
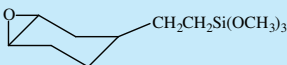
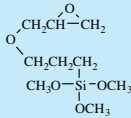
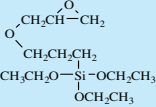

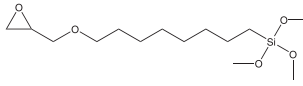
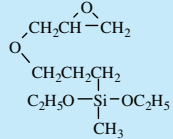
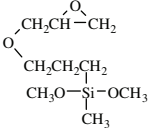
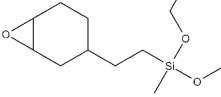
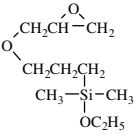
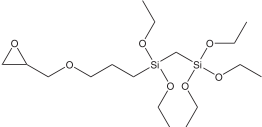
	<b>Cyclic Azasilanes</b>						
	SIA0415.0 N-ALLYL-AZA-2,2-DIMETHOXYSILACYCLOPENTANE C <sub>8</sub> H <sub>17</sub> NO <sub>2</sub> Si HMIS: 3-3-1-X	187.31	52-4°/3			10g	
	SIA0592.0 N-AMINOETHYL-AZA-2,2,4-TRIMETHYL- SILACYCLOPENTANE C <sub>8</sub> H <sub>20</sub> N <sub>2</sub> Si coupling agent for vapor phase modification of nanoparticles – see also SID3543.0 [18246-33-8] HMIS: 3-2-1-X	172.35	54-6°/2	0.905	1.4769	10g	
	SIB1932.4 N-n-BUTYL-AZA-2,2-DIMETHOXYSILACYCLOPENTANE C <sub>9</sub> H <sub>21</sub> NO <sub>2</sub> Si [618914-44-6] TSCA HMIS: 3-2-1-X	203.36	69-71°/3 flashpoint: 85°C (185°F)	0.941	1.438	25g	
	SID3543.0 2,2-DIMETHOXY-1,6-DIAZA-2-SILACYCLO- OCTANE C <sub>7</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub> Si [182008-07-7] HMIS: 3-2-1-X	190.32	71-3°/2.5 (61-2°)mp			25g	
	SIM6501.4 N-METHYL-AZA-2,2,4-TRIMETHYLSILA- CYCLOPENTANE C <sub>7</sub> H <sub>17</sub> NSi employed in vapor phase modification of nanoparticles – see also SIB1932.4 [18387-19-4] TSCA HMIS: 3-4-1-X	143.30	137° flashpoint: 14°C (58°F)	0.813	1.4308	100g	

### Polyamine Silanes

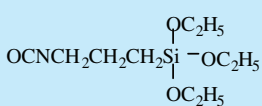
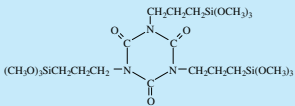
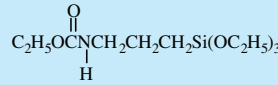
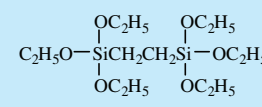
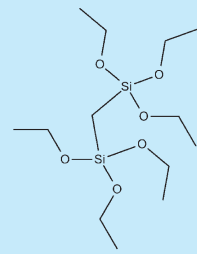
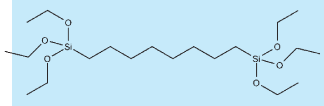
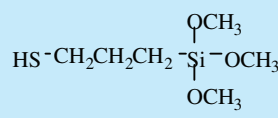
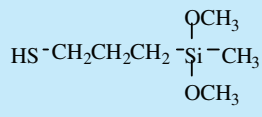
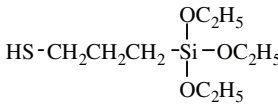
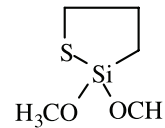
	SSP-060 TRIMETHOXYSILYLPROPYL MODIFIED (POLYETHYLENIMINE), 50% in isopropanol viscosity: 125-175 cSt. ~20% of nitrogens substituted [136856-91-2]/[37251-86-8] TSCA HMIS: 2-4-1-X			0.92	flashpoint: 12°C (54°F)	2kg
	SSP-065 DIMETHOXYSILYLPROPYL MODIFIED (POLYETHYLENIMINE), 50% in isopropanol viscosity: 100-200 cSt. ~20% of nitrogens substituted [125441-88-5] TSCA HMIS: 2-4-1-X			0.92	flashpoint: 12°C (54°F)	3kg

	<b>Anhydride Functional Silane</b>					
	SIT8192.6 3-(TRIETHOXYSILYL)PROPYLSUCCINIC ANHYDRIDE, 95% 3-(TRIETHOXYSILYL)PROPYLDIHYDRO-3,5-FURANDIONE C <sub>13</sub> H <sub>24</sub> O <sub>6</sub> Si hardener, coupling agent for epoxy resins acetic acid-catalyzed hydrolysis yields succinic acid derivative. [93642-68-3] TSCA HMIS: 2-1-1-X	304.41	135°/0.2 flashpoint: >100°C (>212°F)	1.070	1.4405	2kg

## Epoxy Functional Silanes

	name	MW	bp/mm (mp)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>	
<b>Epoxy Functional Silanes - Trialkoxy</b>						
	SIE4668.0 2-(3,4-EPOXYCYCLOHEXYL)ETHYLTRIETHOXSILANE C <sub>14</sub> H <sub>28</sub> O <sub>4</sub> Si coupling agent for water-borne emulsions [10217-34-2] TSCA HMIS: 2-1-1-X	288.46	114-7°/0.4 flashpoint: 104°C(220°F)	1.015	1.4455	Commercial
	SIE4670.0 2-(3,4-EPOXYCYCLOHEXYL)ETHYL-TRIMETHOXSILANE C <sub>11</sub> H <sub>22</sub> O <sub>4</sub> Si viscosity: 5.2 cSt coefficient of thermal expansion: 0.8 x 10 <sup>-3</sup> vapor pressure, 152°: 10mm ring epoxide more reactive than glycidoxypropyl systems. UV initiated polymerization of epoxy group with weak acid donors. forms UV-curable coating resins by controlled hydrolysis! 1. J. Crivello et al, Chem. Mater. 9, 1554, 1997. [3388-04-3] TSCA HMIS: 3-1-1-X	246.38	95-7°/0.25 flashpoint: 146°C(295°F) γc of treated surface: 39.5 dynes/cm specific wetting surface: 317 m <sup>2</sup> /g	1.065	1.449	
	SIG5840.0 (3-GLYCIDOXYPROPYL)TRIMETHOXSILANE 3-(2,3-EPOXYPROPOXY)PROPYLTRIMETHOXSILANE C <sub>9</sub> H <sub>20</sub> O <sub>5</sub> Si coupling agent for epoxy composites employed in electronic "chip" encapsulation. [2530-83-8] TSCA HMIS: 3-1-1-X	236.34	120°/2 (<-70°)mp TOXICITY- oral rat, LD50: 8,400 mg/kg	1.070	1.4290	
	SIG5839.0 (3-GLYCIDOXYPROPYL)TRIETHOXSILANE C <sub>12</sub> H <sub>26</sub> O <sub>5</sub> Si viscosity: 3 cSt [2602-34-8] TSCA HMIS:3-2-1-X	278.42	124°/3 flashpoint: 144°C(291°F)	1.00	1.425	
	SIE4675.0 5,6-EPOXYHEXYLTRIETHOXSILANE C <sub>17</sub> H <sub>26</sub> O <sub>4</sub> Si [86138-01-4] HMIS: 3-2-1-X	262.42	115-9°/1.5 flashpoint: 99°C(210°F) 10g	0.960 <sup>25</sup>	1.4254 <sup>25</sup>	
	SIG5810.0 8-GLYCIDOXYOCTYLTRIMETHOXSILANE, 95% C <sub>14</sub> H <sub>30</sub> O <sub>5</sub> Si viscosity: 6-7 cSt [1239602-38-0] HMIS:3-2-1-X		306.47 Adhesion promoter with improved slubility in acrylic resins			
<b>Epoxy Functional Silanes - Dialkoxy</b>						
	SIG5832.0 (3-GLYCIDOXYPROPYL)METHYLDIETHOXY-SILANE C <sub>11</sub> H <sub>24</sub> O <sub>4</sub> Si viscosity: 3.0 cSt [2897-60-1] TSCA HMIS: 2-1-1-X	248.39	122-6°/5 TOXICITY- oral rat, LD50: >2000mg/kg flashpoint: 122°C(252°F)	0.978 <sup>25</sup>	1.431	Commercial
	SIG5836.0 (3-GLYCIDOXYPROPYL)METHYLDIMETHOXSILANE C <sub>9</sub> H <sub>20</sub> O <sub>4</sub> Si relative hydrolysis rate vs. SIG5840.0: 7.5:1 [65799-47-5] TSCA-L HMIS: 3-1-1-X	220.34	100°/4 flashpoint: 105°C (221°F)	1.02	1.431 <sup>25</sup>	
	SIE4666.0 2-(3,4-EPOXYCYCLOHEXYL)ETHYLMETHYLDIEHOXSILANE C <sub>13</sub> H <sub>26</sub> O <sub>3</sub> Si UV polymerizeable monomer [148-35-3] HMIS: 2-2-1-X	258.43	114-7°/1 25g	0.976 <sup>25</sup>	1.4248 <sup>25</sup>	
<b>Epoxy Functional Silanes - Monoalkoxy</b>						
	SIG5825.0 (3-GLYCIDOXYPROPYL)DIMETHYLETHOXY-SILANE C <sub>10</sub> H <sub>22</sub> O <sub>3</sub> Si coupling agent for epoxy nanocomposites [17963-04-1] TSCA HMIS: 3-2-1-X	218.37	100°/3 flashpoint: 87°C(189°F)	0.950	1.4337 <sup>25</sup>	
<b>Dipodal Epoxy Functional Silanes</b>						
	SIG5837.0 1-(3-GLYCIDOXYPROPYL)-1,1,3,3,3-PENTAETHOXY-1,3-DISILAPROPANE, 95% C <sub>17</sub> H <sub>38</sub> O <sub>7</sub> Si <sub>2</sub> Forms hydrolysis resistant films [1621184-20-0] HMIS: 3-2-1-X	410.65	125-9°/0.1 2.5g	1.003		

## Isocyanate and Masked Isocyanate Functional Silanes

	name	MW	bp/mm (mp)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
	<b>Isocyanate Functional Silanes - Trialkoxy</b> SII6455.0 3-ISOCYANATOPROPYLTRIETHOXYSILANE, 95% C <sub>10</sub> H <sub>21</sub> NO <sub>4</sub> Si coupling agent for urethanes, polyols, amines. [24801-88-5] TSCA HMIS: 3-2-1-X	247.37	130°/20 flashpoint: 80°C(176°F)	0.99	1.419
	25g 100g 2.0kg				
	<b>Masked Isocyanate Silanes</b> SIT8717.0 TRIS(3-TRIMETHOXYSILYLPROPYL)ISOCYANURATE, 95% C <sub>21</sub> H <sub>45</sub> N <sub>3</sub> O <sub>12</sub> Si <sub>3</sub> [26115-70-8] TSCA HMIS: 2-1-1-X	615.86	flashpoint: 102°C(216°F)	1.170	1.4610
	25g/ 100g 2.0kg			viscosity: 325-350 cSt.	
	SIT8188.0 TRIETHOXYSILYLPROPYLETHYLCARBAMATE C <sub>12</sub> H <sub>27</sub> NO <sub>5</sub> Si masked isocyanate - deblocks >160°C [17945-05-0] TSCA HMIS: 2-1-1-X	293.44	124-6°/0.5 flashpoint: 95°C(203°F)	1.015	1.4321
	25g 100g 2kg				
<b>Non-Functional Dipodal Silanes</b>					
	SIB1817.0 BIS(TRIETHOXYSILYL)ETHANE HEXAETHOXYDISILETHYLENE C <sub>14</sub> H <sub>34</sub> O <sub>6</sub> Si <sub>2</sub> ΔHvap: 101.5 kJ/mole additive to silane coupling agent formulations that enhances hydrolytic stability employed in corrosion resistant coatings/primer for steel and aluminum <sup>1,2</sup> . 1. W. Van Ooij et al, J. Adhes. Sci. Tech. 11, 29, 1997 2. W. Van Ooij et al, Chemtech., 28, 26, 1998. [16068-37-4] TSCA-S HMIS: 3-1-1-X	354.59	96°/0.3 flashpoint: 107°C(225°F) vapor pressure, 150°: 10mm TOXICITY - oral rat, LD50: 161mg/kg	0.957	1.4052
	25g 100g 2.0kg				
	SIB1821.0 BIS(TRIETHOXYSILYL)METHANE 4,4,6,6-TETRAETHOXY-3,7-DIOXA-4,6-DISILANONANE C <sub>13</sub> H <sub>32</sub> O <sub>6</sub> Si <sub>2</sub> Intermediate for sol-gel coatings, hybrid inorganic-organic polymers Forms methylene-bridged mesoporous structures. <sup>1</sup> Forms modified silica membranes that separate propylene/propane mixtures. <sup>2</sup> 1. Zhang, W et al. <i>Chem. Mater.</i> <b>2005</b> , 17, 6407. 2. Kanezashi, M. et al. <i>J. Membr. Sci.</i> <b>2012</b> , 415-416, 478. [118418-72-9] TSCA-L HMIS: 3-2-1-X	340.56	114-5°/3.5	0.9741	1.4098
	25g 100g				
	SIB1824.0 1,8-BIS(TRIETHOXYSILYL)OCTANE C <sub>20</sub> H <sub>46</sub> O <sub>6</sub> Si <sub>2</sub> Employed in sol-gel synthesis of mesoporous structures Crosslinker for moisture-cure silicone RTVs with improved environmental resistance Sol-gels α,ω-bis(trialkoxysilyl)alkanes reported. <sup>1</sup> 1. Loy, D.A. et al. <i>J. Am. Chem. Soc.</i> <b>1999</b> , 121, 5413. [52217-60-4] TSCA HMIS: 2-2-1-X	438.76	172-5°/0.75	0.926	1.4240
	25g 100g				
<b>Sulfur Functional Silanes</b>					
	SIM6476.0 3-MERCAPTOPROPYLTRIMETHOXYSILANE C <sub>6</sub> H <sub>16</sub> O <sub>3</sub> SSi viscosity: 2 cSt γc of treated surface: 41 dynes/cm specific wetting surface: 348 m <sup>2</sup> /g [4420-74-0] TSCA HMIS: 3-2-1-X	196.34	93°/40 TOXICITY- oral rat, LD50: 2380mg/kg flashpoint: 96°C(205°F) primary irritation index: 0.19	1.051 <sup>25</sup>	1.450 <sup>25</sup>
	100g 2kg 18kg				
	SIM6474.0 3-MERCAPTOPROPYLMETHYLDIMETHOXYSILANE C <sub>6</sub> H <sub>16</sub> O <sub>2</sub> SSi intermediate for silicones in thiol-ene UV cure systems [31001-77-1] TSCA HMIS: 3-2-1-X	180.34	96°/30 flashpoint: 93°C (199°F)	1.00	1.4502
	100g 2kg 18kg				
	SIM6475.0 3-MERCAPTOPROPYLTRIETHOXYSILANE, 95% C <sub>9</sub> H <sub>22</sub> O <sub>3</sub> SSi TOXICITY- oral rat, LD50: > 2000mg/kg [14814-09-6] TSCA HMIS: 2-2-1-X	238.42	210° flashpoint: 88°C(190°F)	0.9325	1.4331
	25g 100g 2kg				
	SID3545.0 2,2-DIMETHOXY-1-THIA-2-SILACYCLOPENTANE C <sub>5</sub> H <sub>12</sub> O <sub>2</sub> SSi reagent for modification of silver and gold surfaces; coupling agent for rubber HYDROLYTIC SENSITIVITY: 8 reacts rapidly with moisture, water, protic solvents [26903-85-5] HMIS: 3-3-1-X	164.29	57-8°/7	1.094	
	25g				

Commercial

## Difunctional and Multifunctional Epoxy Terminated Silicones

These include lower molecular weight siloxanes with discrete structures and higher molecular weight silicones with either pendant or terminal epoxy functionalization. Depending on specific structures and formulations, they selectively impart a wide range of properties, associated with silicones - low-stress, low temperature properties, dielectric properties and release. Properties of cured silicone modified epoxies vary from hydrophilic to hydrophobic depending on the epoxy content, degree of substitution and ring-opening of epoxides to form diols. The ring-strained epoxy cyclohexyl group is more reactive than the epoxypropoxy group and undergoes thermally or chemically induced reactions with nucleophiles including protic surfaces such as cellulose or polyacrylate resins.

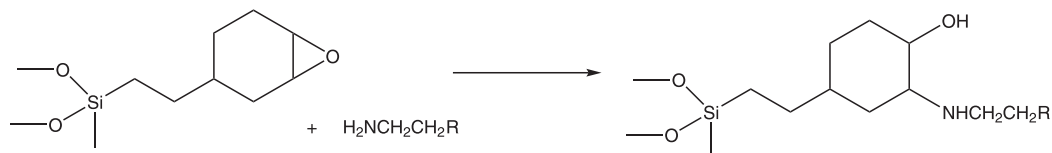
The compatibility of epoxy functional silicones with conventional epoxies varies. In simple unfilled systems, total solubility is required. For filled systems, it is often desirable to consider systems that are miscible but have only limited solubility since microphase separation can allow a mechanism for stress-relief.

Epoxy silicones with methoxy groups can be used to improve adhesion to substrates such as titanium, glass or silicon. They also can improve chemical resistance of coatings by forming siloxane crosslinks upon exposure to moisture.

### Silicone - Epoxy Compatibility

Gelest Product	Epoxy Type		
	Bisphenol	Polyglycol	Cycloaliphatic
SIB1092.0	miscible	soluble	soluble
SIB1110.0	soluble	soluble	soluble
SIB1115.0	soluble	soluble	soluble
SIG5820.0	insoluble	insoluble	soluble
MCR-E11	insoluble	insoluble	insoluble
MCS-E15	insoluble	insoluble	insoluble
DMS-E09	soluble	soluble	soluble
DMS-E11	insoluble	miscible	miscible
PMS-E11	soluble	soluble	soluble
ECMS-127	insoluble	insoluble	insoluble
EMS-622	insoluble	miscible	insoluble

(10% silicone 90% epoxy)

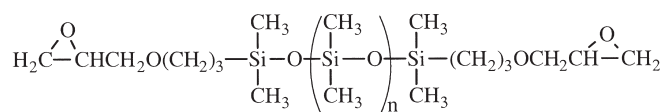


A UV initiator for cycloaliphatic epoxides is OMBO037 described in the Catalyst Section (p. 14). Epoxy functional siloxane copolymers with polyalkyleneoxide functionality provide hydrophilic textile finishes.

## Difunctional Low MW Siloxanes

	name	MW	bp/mm (mp)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>	
	SIB1092.0 BIS[2-(3,4-EPOXYCYCLOHEXYL)ETHYL]- TETRAMETHYLDISILOXANE, 90% C <sub>20</sub> H <sub>38</sub> O <sub>3</sub> Si <sub>2</sub> viscosity: 40cSt. UV-initiated polymerization with weak acid donors [18724-32-8] TSCA HMIS: 2-1-1-X	382.69	(-34°)mp	0.998	1.4758	
		25g		100g		
	SIB1110.0 1,5-BIS(GLYCIDOXYPROPYL)-3-PHENYL- 1,1,3,5-PENTAMETHYLTRISILOXANE C <sub>23</sub> H <sub>42</sub> O <sub>6</sub> Si <sub>3</sub> monomer for silicone-modified epoxy resins HMIS: 2-1-0-X	498.84		1.106	1.4763	
		25g				
	SIB1115.0 1,3-BIS(GLYCIDOXYPROPYL)TETRAMETHYL- DISILOXANE C <sub>16</sub> H <sub>34</sub> O <sub>5</sub> Si <sub>2</sub> monomer for silicone modified epoxy resins end-capper for epoxy terminated silicones [126-80-7] TSCA HMIS: 3-1-0-X	362.61	184-7°/2 (-46 to -50°)mp	0.996	1.452	Commercial
		25g	flashpoint: 110°C (230°F) viscosity: 10-12 cSt.	100g	2kg	

## Difunctional Polymeric Siloxanes



### Epoxypropoxypropyl Terminated PolyDimethylsiloxanes

[102782-97-8] TSCA

Code	Viscosity	Molecular Weight	Epoxy - Eq/kg	Specific Gravity	Refractive Index	Price 100g	Price 1kg
DMS-E09	8-11	363	5.5	0.99	1.446		
DMS-E11	12-18	500-600	1.9-2.2	0.98	1.419		
DMS-E12	20-35	1000-1400	1.6-1.9	0.98	1.417		
DMS-E21	100-140	4500-5500	0.45-3.5	0.98	1.408		

### Epoxycyclohexylethyl Terminated PolyDimethylsiloxanes

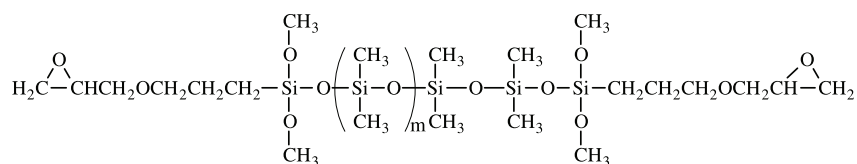
[102782-98-9] TSCA

DMS-EC13	25-35	900-1100	1.9-2.0	0.99	1.433		
DMS-EC17	60-80	3200-3600	0.5-0.7	0.98	1.412		

### Epoxypropoxypropyl Terminated PolyPhenylMethylsiloxanes

[102782-98-9] TSCA

PMS-E11	15-30	500-600	3.6-4.0	1.01	1.475		
PMS-E15	30-50	1200-1500	1.0-1.7	1.01	1.490		

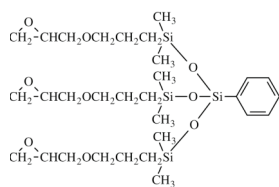


### Epoxypropoxypropyl)dimethoxysilyl Terminated PolyDimethylsiloxanes

[188958-73-8] TSCA

DMS-EX21	80-120	3500-4000	0.48-0.5	0.98	1.408		
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## Multifunctional Low MW Siloxanes



#### name

SIT8715.6  
TRIS(GLYCIDOXYPROPYLDIMETHYLSILOXY)-  
PHENYLSILANE, 95% amber liquid  
 $\text{C}_{30}\text{H}_{56}\text{O}_9\text{Si}_4$   
[90393-83-2] HMIS: 2-1-0-X

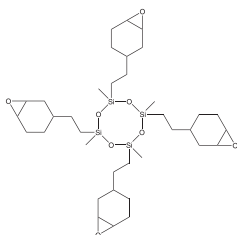
**MW**    **bp/mm (mp)**    **D<sub>4</sub><sup>20</sup>**    **n<sub>D</sub><sup>20</sup>**

673.11    (-73°)mp  
viscosity: 30-35 cSt.

1.05    1.4742<sup>25</sup>

25g

100g



SIT7281.5  
TETRAKIS[(EPOXYCYCLOHEXYL)ETHYL]TETRAMETHYL-  
CYCLOTETRASILOXANE tech-95

737.23

1.14    1.487

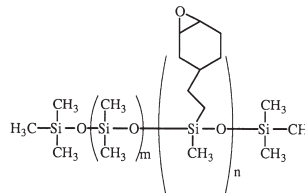
$\text{C}_{36}\text{H}_{64}\text{O}_8\text{Si}_4$   
Polymerized by cationic photoinitiators or anhydrides

viscosity: 300 cSt.

[121225-98-7] HMIS: 2-2-1-X

25g

## Multifunctional Polymeric Siloxanes



### (Epoxy cyclohexylethylMethylsiloxane) Dimethylsiloxane Copolymers

CAS: [6772-95-2] TSCA

Code	Viscosity	Molecular Weight	Mole % (Epoxy cyclohexylethylMethylSiloxane)	Specific Gravity	Refractive Index	Price 100g	Price 1 kg	Price 10 kg
ECMS-127	500-1200	18,000-15,000	1-2	0.98	1.407			
ECMS-227	650-800	18,000-20,000	2-3	0.98	1.407			
ECMS-327	650-850	18,000-20,000	3-4	0.99	1.409			
ECMS-924	300-450	10,000-12,000	8-10	0.97	1.421			

### (EpoxypropoxypropylMethylsiloxane)-(Dimethylsiloxane) Copolymers

CAS: [68440-71-1] TSCA

EMS-622	200-300	7,000-9,000	5-7	0.99	1.412			
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### (2-3% Epoxy cyclohexylethylMethylsiloxane)(10-15% MethoxypolyalkyleneoxyMethylSiloxane)-(Dimethylsiloxane) Terpolymer

CAS: [69669-36-9] TSCA

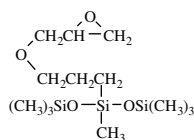
EBP-234	4000-5000	25,000-36,000	0.75-0.80	1.03	1.445			
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## Silicone Resin Modifiers - Monofunctional Silicones

Siloxane and silicone diluents can reduce the viscosity of epoxy systems as well as lowering surface tension allowing ease of handling, facilitating higher filler loading and infiltration of prepregs and fine structural components. Monofunctional silicone compounds with molecular weights high enough to be considered polymers are sometimes referred to as

macromers. Copolymerization of macromers with traditional monomers offers a route to polymers with properties that are usually associated with grafting. Modification of organic polymers with silicon-containing macromers has led to new applications in coatings and pigment vehicles.

## Monofunctional Low MW Siloxanes



**name**

SIG5820.0  
(3-GLYCIDOXYPROPYL)BIS(TRIMETHYL-SILOXY)METHYLSILANE

$C_{13}H_{32}O_4Si_3$   
[7422-52-8] TSCA HMIS: 3-1-1-X

**MW**

336.65

**bp/mm (mp)**

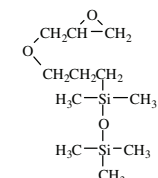
96°/0.5  
flashpoint: >110°C (>230°F)

**D<sub>4</sub><sup>20</sup>**

0.910

**n<sub>D</sub><sup>20</sup>**

1.4206



SIG5838.0

(3-GLYCIDOXYPROPYL)PENTAMETHYL-DISILOXANE

$C_{11}H_{26}O_3Si_2$   
[18044-44-5] HMIS: 3-2-0-X

262.50

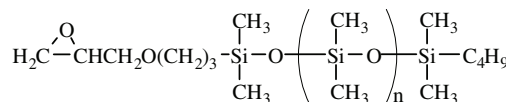
81°/1.5  
flashpoint: 83°C (181°F)

0.915<sup>25</sup>

1.4267

5.0g

## Monofunctional Polymeric Siloxanes (Macromers)



### Mono-(2,3-Epoxy)Propylether Terminated PolyDimethylsiloxane-asymmetric

CAS: [127947-26-6] TSCA

Code	Viscosity	Molecular Weight	Specific Gravity	Refractive Index	Price/100g
MCR-E11	10-15	1000	1.420	0.96	
MCR-E21	100-120	5000	1.408	0.97	

### Mono-(2,3-Epoxy)Propylether Functional PolyDimethylsiloxanes-symmetric

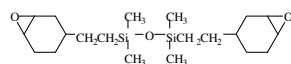
Code	Viscosity	Molecular Weight	Specific Gravity	Refractive Index	Price/100g	Price/1kg
MCS-E15	45-55	800-900	1.398	1.09		

## Cycloaliphatic Silanes and Silicones

These materials, characterized by a combination of cycloaliphatic and siloxane structures, have outstanding weathering characteristics, controlled release and coefficient of friction and excellent electrical properties. They can be cured either by cationic UV photoinitiators or conventional epoxy hardeners. In cationic UV-cure systems the cycloaliphatic epoxy

silicones combine the properties of reactive diluents with surfactant properties. The release properties can be employed to make parting layers for multilayer films. If high levels of epoxy functional silicones are used in UV cure formulations, cationic photoinitiators with hydrophobic substitution are preferred.

### Difunctional Siloxanes



name	MW	bp/mm (mp)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
SIB1092.0 BIS[2-(3,4-EPOXYCYCLOHEXYL)ETHYL]- TETRAMETHYLDISILOXANE C <sub>20</sub> H <sub>38</sub> O <sub>3</sub> Si <sub>2</sub> viscosity: 40cSt. UV-initiated polymerization with weak acid donors [18724-32-8 TSCA HMIS: 2-1-1-X	382.69	(-34°)mp	0.998	1.4758
	25g		100g	

### Epoxycyclohexylethyl Terminated PolyDimethylsiloxanes

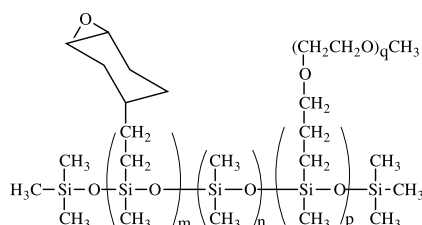
Code	Viscosity	M.W.	Epoxy - Eq/kg	Specific Gravity	Refractive Index	Price/ 100g
DMS-EC13	25-35	900-1100	1.9-2.0	0.99	1.433	
DMS-EC17	60-80	3200-3600	0.5-0.7	0.98	1.412	
DMS-EC31	800-1200	40,000	0.04-0.06	0.98	1.410	

### Multifunctional Siloxanes

#### (EpoxycyclohexylethylMethylsiloxane)-Dimethylsiloxane Copolymers

CAS: [6772-95-2] TSCA

Code	Viscosity	Molecular Weight	Mole % (Epoxycyclohexyl)-ethylMethylSiloxane	Specific Gravity	Refractive Index	Price/100g	Price/ 1 kg	Price/10 kg
ECMS-127	500-1200	12,000-15,000	1-2	0.98	1.407			
ECMS-227	650-800	18,000-20,000	2-3	0.98	1.407			
ECMS-327	650-850	18,000-20,000	3-4	0.99	1.409			
ECMS-924	300-450	10,000-12,000	8-10	0.97	1.421			



#### (2-3% EpoxycyclohexylethylMethylsiloxane)(10-15% MethoxypolyalkyleneoxyMethylSiloxane)-(Dimethylsiloxane) Terpolymer

CAS: [69669-36-9] TSCA

Code	Viscosity	Molecular Weight	Epoxy- Eq/kg	Specific Gravity	Refractive Index	Price/100g	Price/ 1 kg	Price/10 kg
EBP-234	4000-5000	25,000-36,000	0.75-0.80	1.03	1.445			

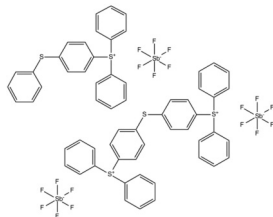
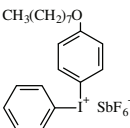
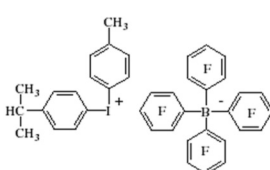
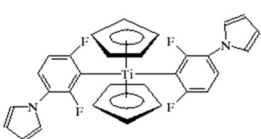
#### (EpoxypropoxypropylMethylsiloxane)-(Dimethylsiloxane) Copolymers

CAS: [68440-71-1] TSCA

Code	Viscosity	Molecular Weight	Epoxy- Eq/kg	Specific Gravity	Refractive Index	Price/100g	Price/ 1 kg
EMS-622	200-300	7,000-9,000	5-7	0.99	1.412		

## Photoinitiators

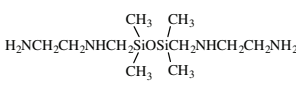
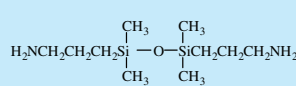
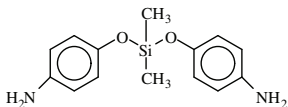
Gelest offers cationic and long-wavelength UV initiators that are hydrophobic and soluble in silicone systems.

name	MW	bp/mm (mp)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
 <p>OMAN076 (THOPHENOXYPHENYL)DIPHENYLSULFONIUMHEXAFLUOROANTIMONATE-BIS(BIS(DIPHENYLSULFONIUM)DIPHENYLTHIO)ETHER HEXAFLUOROANTIMONATE BLEND, 50% in propylene carbonate C<sub>24</sub>H<sub>19</sub>F<sub>6</sub>S<sub>2</sub>SB AMBER LIQUID UV initiator for cationic polymerizations, e.g. cycloaliphatic epoxides [71449-78-0]/[89452-37-9] TSCA HMIS: 3-1-1-X</p>	607.28	(145°)Cfp	1.40	
 <p>OMAN071 p-(OCTYLOXYPHENYL)PHENYLIODONIUM-HEXAFLUOROANTIMONATE C<sub>20</sub>H<sub>26</sub>F<sub>6</sub>IOSb [121239-74-5] TSCA 3-1-1-X</p>	645.07	(57-8°)mp		25g
 <p>OMBO037 (p-ISOPROPYLPHENYL)(p-METHYLPHENYL)-IODONIUM TETRAKIS(PENTAFLUOROPHENYL)BORATE C<sub>40</sub>H<sub>18</sub>BF<sub>2</sub>OI UV max: 235nm UV initiator for cycloaliphatic epoxide functionalized silicones [178233-72-2] TSCA HMIS: 2-1-0-X</p>	1015.7	(120-133°)mp		TOXICITY- oral rat, LD50: 1500-2000mg/kg 5.0g
 <p>OMTI014 BIS(2,6-DIFLUORO-3-(1-HYDROXYRROL-1-YL)-PHENYL)TITANOCENE 534.4 (160-170°)mp color: orange-yellow soluble: acetone, methylethylketone, &gt; hexanediol diacrylate, toluene visible (blue-green) light and UV photoinitiator long wavelength photoinitiator with Al- (488nm) and FD Nd/YAG- (532nm) lasers [12051-32-3] TSCA HMIS: 3-2-1 store&lt;5°</p>				10g

## Silane and Silicone Hardeners

### Difunctional Siloxane Curing Agents

These materials include siloxanes and silicones with diamine, polyamine structures, and dianhydride structures.

name	MW	bp/mm (mp)	D <sub>4</sub> <sup>20</sup>	n <sub>D</sub> <sup>20</sup>
 <p>SIB1021.5 1,3-BIS(2-AMINOETHYLAMINOMETHYL)-TETRAMETHYLDISILOXANE C<sub>10</sub>H<sub>30</sub>N<sub>4</sub>O<sub>2</sub>Si<sub>2</sub> curing agent for epoxies [83936-41-8] HMIS: 3-2-0-X</p>	278.55	140-5°/2	0.941	
 <p>SIB1024.0 BIS(3-AMINOPROPYL)TETRAMETHYLDISILOXANE C<sub>10</sub>H<sub>28</sub>N<sub>2</sub>O<sub>2</sub>Si<sub>2</sub> flexibilizing hardener for epoxies, endcapper for aminopropyl terminated silicones [2469-55-8] TSCA HMIS: 3-2-0-X</p>	248.52	132-9°/11 flashpoint: 91°C(196°F) pKb: 5.5	0.897 <sup>25</sup>	1.4480 <sup>25</sup>
 <p>SIB1022.0 BIS(p-AMINOPHENOXY)DIMETHYLSILANE C<sub>14</sub>H<sub>18</sub>N<sub>2</sub>O<sub>2</sub>Si intermediate for polyimides [1223-16-1] HMIS: 3-1-0-X</p>	274.39	195-9°/0.5 (64°)mp flashpoint: >110°C(>230°F)		25g

Commercial



**Aminopropyl Terminated PolyDimethylsiloxanes**

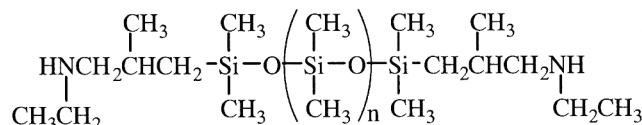
CAS: [106214-84-0] TSCA

Code	Viscosity	Molecular Weight	% Amine (NH <sub>2</sub> )	Specific Gravity	Refractive Index	Price/100g	Price/1kg
DMS-A11	10-15	850-900	3.2-3.8	0.98	1.412		
DMS-A12	20-30	900-1000	3.0-3.2	0.98	1.411		
DMS-A15	50-60	3000	1.0-1.2	0.97	1.408		
DMS-A21	100-120	5000	0.6-0.7	0.98	1.407		
DMS-A31	900-1100	25,000	0.11-0.12	0.98	1.407		
DMS-A32	1800-2200	30,000	0.08-0.09	0.98	1.404		
DMS-A35	4000-6000	50,000	0.05-0.06	0.98	1.404		

**Reduced Volatility Grade**

DMS-A32R*	1900-2300	30,000	0.08-0.09	0.98	1.404		
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\*total volatiles, 4 hours @ 150°C: 2.0 wt% maximum



**N-Ethylaminoisobutyl Terminated PolyDimethylsiloxane**

CAS: [254891-17-3] TSCA

Code	Viscosity	Molecular Weight	% Amine (NH)	Specific Gravity	Refractive Index	Price/100g	Price/1kg
DMS-A211	8-12	800-1000	2.8-3.2	0.93	1.422		
DMS-A214	32-40	2500-3000	1.0-1.4	0.96	1.411		

## Multifunctional Siloxane Curing Agents

**AminopropylMethylsiloxane - Dimethylsiloxane Copolymers**

CAS: [99363-37-8] TSCA

Code	Viscosity	Molecular Weight	Mole % (Aminopropyl) MethylSiloxane	Specific Gravity	Refractive Index	Price/100g	Price/3kg
AMS-132	80-100	4500-5500	2-3	0.96	1.404		
AMS-152	120-180	7000-8000	4-5	0.97	1.408		
AMS-162	80-120	4000-5000	6-7	0.97	1.410		
AMS-163	1800-2200	50,000	6-7	0.97	1.411		
AMS-191	40-60	2000-3000	9-11	0.97	1.412		
AMS-1203	900-1100	20,000	20-25	0.98	1.426		

**AminoethylaminopropylMethylsiloxane - Dimethylsiloxane Copolymers**

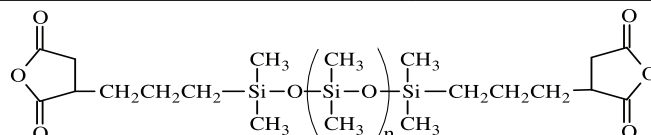
CAS: [71750-79-3] TSCA

Code	Viscosity	Mole % (Diamino-propyl)MethylSiloxane	Specific Gravity	Refractive Index	Price/100g	Price/3kg
AMS-233	900-1200	2-4	0.98	1.407		
AMS-2202	300-500	18-24	0.98	1.41		

**AminoethylaminoisobutylMethylsiloxane - Dimethylsiloxane Copolymers**

CAS: [106842-44-8] TSCA

Code	Viscosity	Mole % (Diamino-isobutyl)MethylSiloxane	Specific Gravity	Refractive Index	Price/100g	Price/3kg
AMS-242	120-150	3-5	0.97	1.404		



### Anhydride Functional Silicones

Anhydride functional silicones offer outstanding color stability as curing agents for epoxy resins.

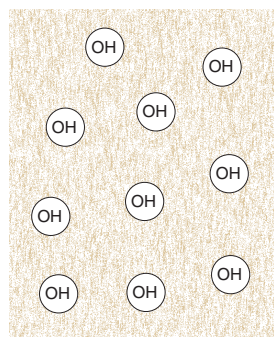
**Succinic Anhydride Terminated PolyDimethylsiloxane**

Code	Viscosity	Molecular Weight	Specific Gravity	Refractive Index	Price/25g	Price/100g
DMS-Z21	75-100	600-800	1.06	1.436		

## Organosilane-Modified Silica Nanoparticles

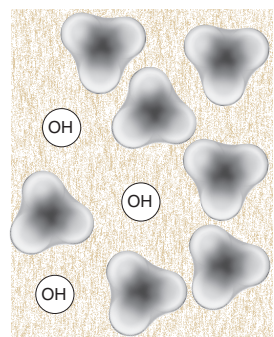
A range of silica structures from 20nm to 1 micron have been modified with silanes to reduce hydroxyl content allowing improved dispersion. Other versions have monolayers with isolated secondary amine functionality, providing controlled

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.



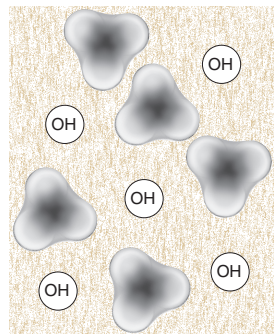
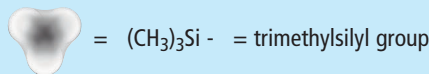
**name**  
SIS6960.0  
SILICON DIOXIDE, amorphous  
fumed silica  
SiO<sub>2</sub>  
surface area, 200m<sup>2</sup>/g  
isoelectric point: 2.2  
[112945-52-5] TSCA HMIS: 2-0-0-X

**MW** 60.09  
**bp/mm (mp)** (>1600°)mp  
**D<sub>4</sub><sup>20</sup>** 2.2  
**n<sub>D</sub><sup>20</sup>** 1.46  
TOXICITY- oral rat, LD50: 8160mg/kg  
ultimate particle size: 0.02μ  
γc: 44  
pH, (4% aqueous slurry): 3.5-4.5  
500g 2kg



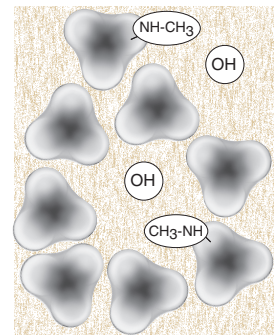
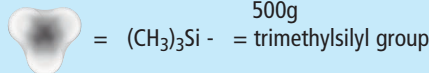
SIS6962.0  
SILICON DIOXIDE, amorphous  
HEXAMETHYLDISILAZANE TREATED  
fumed silica, HMDZ TREATED  
SiO<sub>2</sub>  
carbon content: 3%  
approximate ratio: (CH<sub>3</sub>)<sub>3</sub>Si/HO-Si: 2/1  
[68909-20-6] TSCA HMIS: 2-0-0-X

60.09 (>1600°)mp 2.2 1.46  
surface area, 150-200m<sup>2</sup>/g  
ultimate particle size: 0.02μ  
500g 2kg



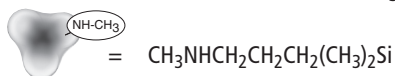
SIS6962.1M30  
SILICON DIOXIDE, amorphous  
HEXAMETHYLDISILAZANE TREATED  
fumed silica, HMDZ TREATED  
SiO<sub>2</sub>  
carbon content: 2-3%  
calculated ratio: (CH<sub>3</sub>)<sub>3</sub>Si/HO-Si: 1/1  
[68909-20-6] TSCA HMIS: 2-0-0-X

60.09 (>1600°)mp 2.2 1.46  
surface area, 150-200m<sup>2</sup>/g  
ultimate particle size: 0.02μ  
500g 2kg



SIS6962.1N30  
SILICON DIOXIDE, amorphous  
CYCLIC AZASILANE/HEXAMETHYLDISILAZANE TREATED  
fumed silica, N-Methylaminopropylfunctional  
SiO<sub>2</sub>  
carbon content: 4-7%  
calculated ratio: CH<sub>3</sub>NHCH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>Si/(CH<sub>3</sub>)<sub>3</sub>Si:HO-Si:1/2/1  
[68909-20-6] TSCA HMIS: 2-0-0-X

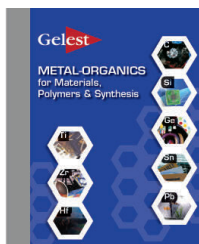
60.09 (>1600°)mp 2.2 1.46  
surface area, 150-200m<sup>2</sup>/g  
ultimate particle size: 0.02μ  
500g



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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.

## Related Gelest Product Literature



### *Metal-Organics for Material & Polymer Technology*

The latest Gelest handbook provides many new compounds with applications on optical, microelectronic, diagnostic and materials applications. Highly referenced listings and device applications are presented.

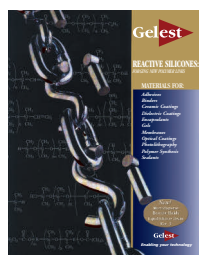
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### *Silicon Compounds: Silanes and Silicones*

Detailed chemical properties and reference articles for compounds. The Handbook of silane and silicone chemistry includes scholarly reviews as well as detailed information on various applications.

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### *Reactive Silicones: Forging New Polymer Links*

The 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.

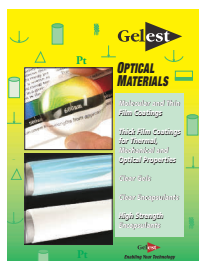
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### *Silicone Fluids - Stable, Inert Media*

Design and Engineering properties for conventional silicone fluids as well as thermal, fluorosilicone, hydrophilic and low temperature grades are presented in 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.

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### *Optical Materials: Optical Materials*

This brochure showcases a wide range of optical materials. Product offerings include optical grade silicone encapsulants with refractive indices ranging from 1.39 to 1.50, optical grade hard resin coatings with refractive indices ranging from 1.55-1.64, refractive index matching fluids, and UV-active/Fluorescent molecular coatings.

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### *Silane Coupling Agents*

Silane coupling agents enhance adhesion, increase mechanical properties of composites, improve dispersion of pigments and fillers and immobilize catalysts and biomaterials. This brochure describes chemistry, techniques, applications and physical properties of silane coupling agents.



11 East Steel Road  
Morrisville, PA 19067  
USA  
Tel: (215) 547-1015  
Toll-Free: (888) 734-8344  
Fax: (215) 547-2484  
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**In Europe:**

**Gelest Inc.**

Stroofstrasse 27 Geb.2901  
65933 Frankfurt am Main,  
Germany  
Tel: +49-(0)-69-3800-2150  
Fax: +49-(0)-69-3800-2300  
e-mail: [info@gelestde.com](mailto:info@gelestde.com)  
Internet: [www.gelestde.com](http://www.gelestde.com)



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