



Enabling Your Technology

SIVATE™ A610

Activated Amine Functional Silane



The benefits of activated silanes are:

- High speed reactivity
- Improvements in adhesion
- Higher mechanical bond strength (flexural, tensile and impact)
- Moisture activation not required prior to deposition

Applications Include:

- Tie-layer bonding between organic and inorganic substrates in multi-layer packaging
- High-speed automatic epoxy adhesive bonding
- Primers for high-speed UV cure systems, particularly acrylated urethanes
- Integral blend (dry-processing) of resin-polymers combinations

SIVATE™ A610 can be used in adhesion promotion applications between inorganic materials and organic polymers such as EVA and PVAC when applied on a 100% actives basis or from a solution in aprotic solvents such as hydrocarbons and tetrahydrofuran. Within seconds, initial bonding is formed with the surface in an "A-stage." When applied out of aqueous systems this activated silane is an effective coupling agent for epoxies, phenolic resins, polyurethanes, and polyamides. After exposure to moisture, the bond strengthens over several hours, depending on conditions, to achieve ultimate "B-stage" bond strength (moisture cure stage).

Product Code: SIA0610.A1

Density: 0.97

pH value: (1:1 in water): ~ 11

Viscosity: 5-10 cSt.

Flashpoint: >110°C (>230°F)

Availability:

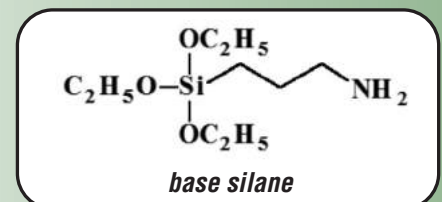
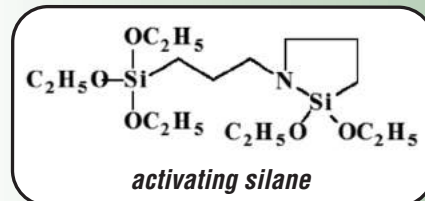
2 kg bottles, 16 kg pails, 180 kg drums

Compared to conventional silanes, SIVATE™ Silanes:

- React at high speed (seconds compared to hours)
- Do not require moisture or hydrolysis to initiate surface reactivity
- React with a greater variety of substrates
- Inhibit moisture initiated crack propagation on vitreous surfaces

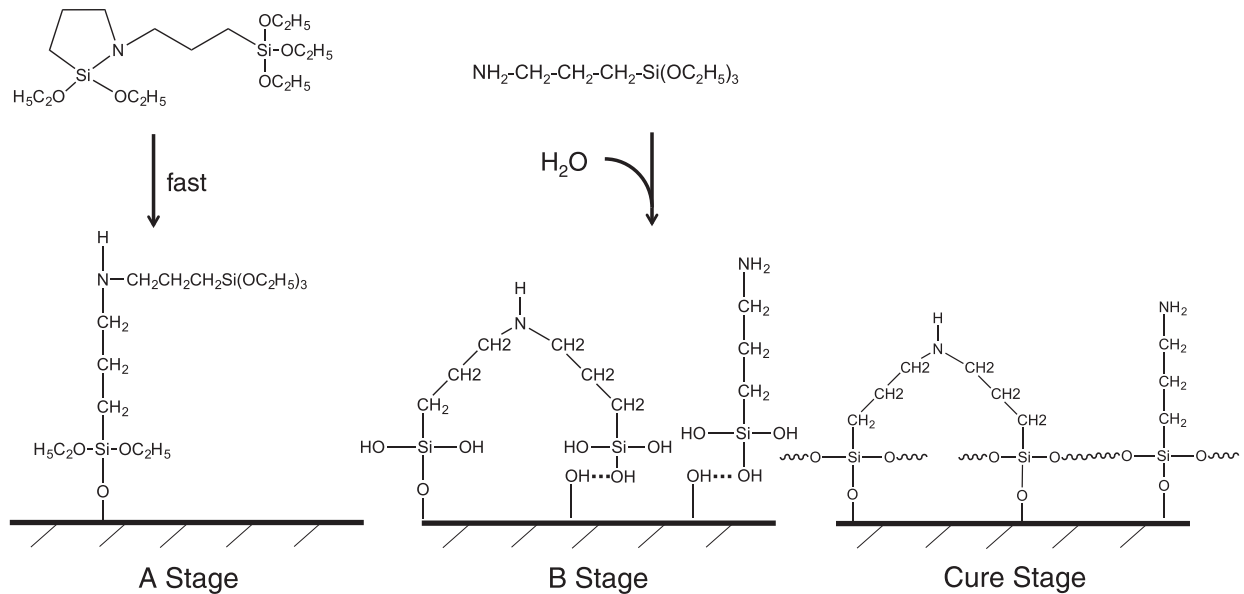
Activation of silanes is effected by combining a cyclic azasilane with an amino functional silane. The cyclic azasilane reacts with a wider variety of hydroxyl groups with reaction speeds more than 100 times faster than the base silane, providing instant adhesion. Once reacted with the substrate, the cyclic azasilane forms a secondary amine that catalyzes the moisture-initiated condensation reactions of the balance of the silane components, establishing maximum bond strength.

Adhesion and bonding proceeds with a wider variety of substrates including poorly reactive inorganic substrates such as titanium, copper, and aluminum as well as difficult organic substrates such as polyvinyl alcohol and cellulosic resins.

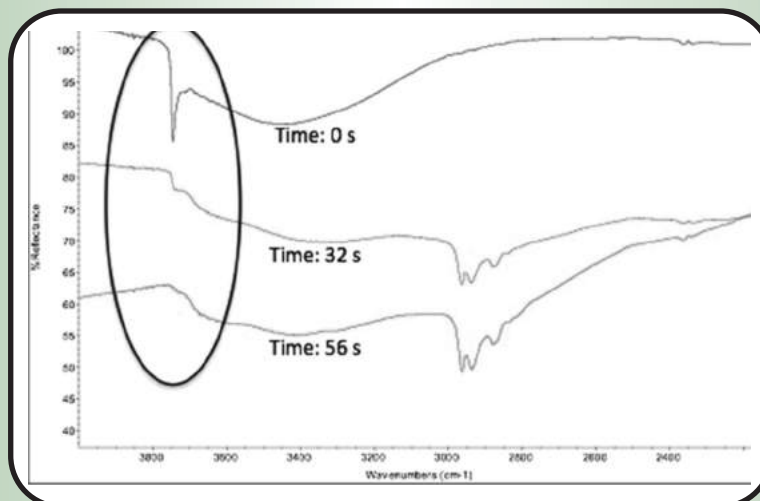


How do activated silanes work? (Mechanism and Chemistry)

The reaction of activated silanes is driven by the thermodynamically favored formation of a silicon-oxygen bond, and is >85% complete in less than 15 seconds, reacting with more than three times as many hydroxyl groups as the conventional ethoxysilane achieves in 1 hour. Once the ring is opened, the secondary amine promotes the condensation of silanols formed from the base silane component with the substrate, more than doubling the kinetics of reactivity for hydrolytic deposition.



Reaction of activating silane with surface during deposition



DRIFT Spectra monitoring the disappearance of the terminal hydroxyl peak over exposure time as the terminal hydroxyls react with a cyclic azasilane



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SIVATE™ E610

Enhanced Amine Functional Silane



The benefits of enhanced silanes are:

- Performance extended to non-siliceous surfaces
- Improved corrosion resistance of metal substrates
- Superior film-forming properties in primer applications
- Higher bond strength in aggressive aqueous conditions
- Impart composites and primers with long-term durability in a wide range of environments

Applications Include:

- Adhesive primers for metallic and siliceous substrates
- Coupling agent for thermoset and thermoplastic composites
- Functional Micro-Particles for use in adhesives and sealants
- Corrosion inhibiting primer for paints and coatings on ferrous and non-ferrous substrates

SIVATE™ E610 can be used in coatings and composite applications where conventional silanes are unable to withstand environments in which water and moisture initiate and propagate failure. Enhanced silanes use a conventional silane as a base silane for organic reactivity and combine it with a compatible dipodal silane which stabilizes interfacial bonding. In many instances time to failure is extended 100x beyond controls. After as short a period of 24 hours at exposure to ambient moisture, composites formulated with enhanced silanes demonstrate tensile and flexural strengths superior to composites formulated with conventional silanes. The general mechanism for higher performance is the ability of enhanced silanes to form tightly cross-linked networks adjacent to substrates that are more hydrophobic than conventional silanes. In general, enhanced silanes replace conventional silanes on a 1:1 basis. Preferred deposition is 100% or as a solution in dry solvents such as ethanol or toluene. The cure is dependent on moisture adsorbed on the treated substrate or adsorption from the atmosphere.

Product Code: SIA0610.E1

Density: 0.948 g/mL
pH value: pH (1:1): ~ 11
Viscosity: 2.0 cSt.
Flashpoint: >91°C (>196°F)

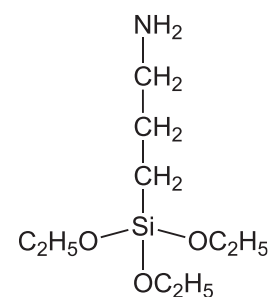
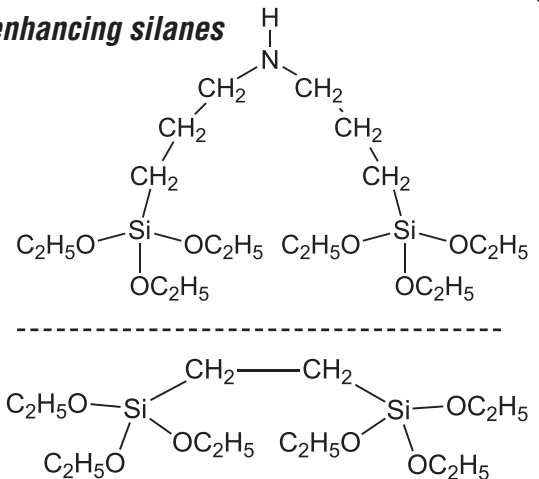
Availability:
2 kg bottles, 16 kg pails, 180 kg drums

Compared to conventional silanes, SIVATE™ enhanced silanes:

- Improve mechanical properties
- Form coatings on a greater range of substrates
- Increase durability of coatings, primers and composites to long-term environmental exposure

Enhancement of silanes is effected by incorporation of functional and non-functional dipodal silanes. The dipodal silane combines with the functional silane to form a tight conformal network of siloxane bonds, reduces water adsorption at the interface and, most importantly, forms multiple oxane bonds with the substrate. In comparison with conventional silanes, which potentially bond form 3 oxane bonds to the substrate, dipodal silanes can form up to 6 oxane bonds with the substrate. Theoretical studies suggest that the dipodal silanes could have up to 10⁶x greater stability in aqueous environments than conventional silanes.

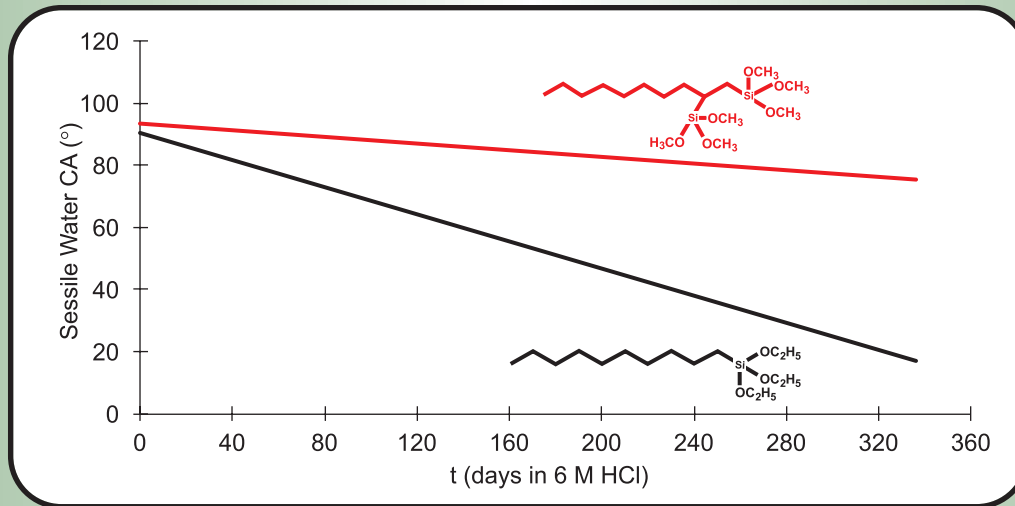
enhancing silanes



base silane

How do enhanced silanes work? (Mechanism and Chemistry)

The network and film-forming reaction of enhanced silane formulation is clearly demonstrated by observing the hydrolytic stability of films formed from the pure dipodal enhancing silane.



Non-functional dipodal silanes, are resistant to hydrolysis and form high integrity films on a variety of substrates, but by themselves lack the ability to bond with organic polymers in coatings, adhesives and composites. However, they significantly enhance the film integrity of base silanes that are responsible for bonding with organic polymers. The integrity, barrier and bonding properties of silanes are optimized by combining a base silane with both functional and non-functional dipodal silanes.

Barrier Properties (microporosity) of silanes on cold-rolled steel

As measured by Electrochemical Impedance Spectroscopy (EIS)

	R_p (ohm-cm ²)
Control	<1
SIA0610.0	2
SIVATE™ E610	20

Properties for 4-6% aqueous silane solutions applied and then cured at 150° for 4 hours forming coatings 80-120 nm thick. R_p represents a polarization associated with electrolyte transport through pores.

While initial bond strengths of enhanced silanes are similar to the base silane ageing under high humidity conditions or in aqueous immersion, within 24 hours there is typically a significant increase in retention in properties.

70% Fused Silica Filled Epoxy Molding Compound (85°C/85% RH)

	0 hrs	5 hrs	24 hrs.	100hrs
Control	100%	45%	40%	40%
SIA0610.0	100%	88%	80%	77%
SIVATE™ E610	100%	96%	92%	90%

Flexural Strength – relative values

Thermoplastics in which there is little opportunity for covalent chemical bonding, but rely on polar interactions and/or hydrogen bonding show dramatic increases in mechanical properties.

30% Glass Fiber Reinforced Polysulfone

	As Molded	Conditioned 24h @ 55% RH
Control	13,700 psi	10,600 psi
SIA0591.0	18,600 psi	12,000 psi
SIVATE™ E591	18,400 psi	17,200 psi



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SIVATE™ A200

Activated Acrylate Functional Silane



The benefits of activated silanes are:

- High speed reactivity
- Improvements in adhesion
- Higher mechanical bond strength (flexural, tensile and impact)
- Moisture activation not required prior to deposition

Applications Include:

- Primers for fiberoptic cladding
- Coupling agent for light-cure acrylic nanocomposites
- Adhesion promoter for high-speed UV cure systems, particularly acrylated urethanes

SIVATE™ A200 can be used in adhesion promotion applications between inorganic materials, particularly vitreous substrates with radical-cure resins when applied on a 100% actives basis as a primer or incorporated at a 0.5-2.0% level with low water content UV curable resins. Photoinitiators should be “hydroxyl-free.” The silane or blended silane-resin combination must be stored in sealed containers under dry conditions until use. Within seconds of application initial bonding is formed with surface in an “A-stage.” After exposure to moisture, the bond strengthens over several hours, depending on conditions, to achieve ultimate “B-stage” bond strength (moisture cure stage).

Product Code: SIA0200.A1

Density: 1.03

pH value: (1:1 in water): ~ 10

Viscosity: 2-3 cSt.

Flashpoint: >65°C (>150°F)

Availability:

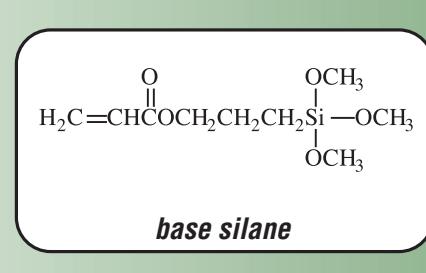
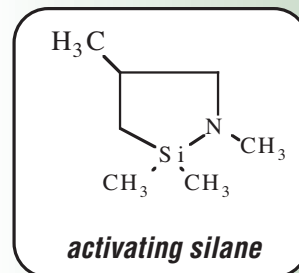
2 kg bottles, 16 kg pails, 180 kg drums

Compared to conventional silanes, SIVATE™ Silanes:

- Radcure: UV, EB, Visible Light
- React at high speed (seconds compared to hours)
- Do not require moisture or hydrolysis to initiate surface reactivity
- React with a greater variety of substrates
- Inhibit moisture initiated crack propagation on vitreous surfaces

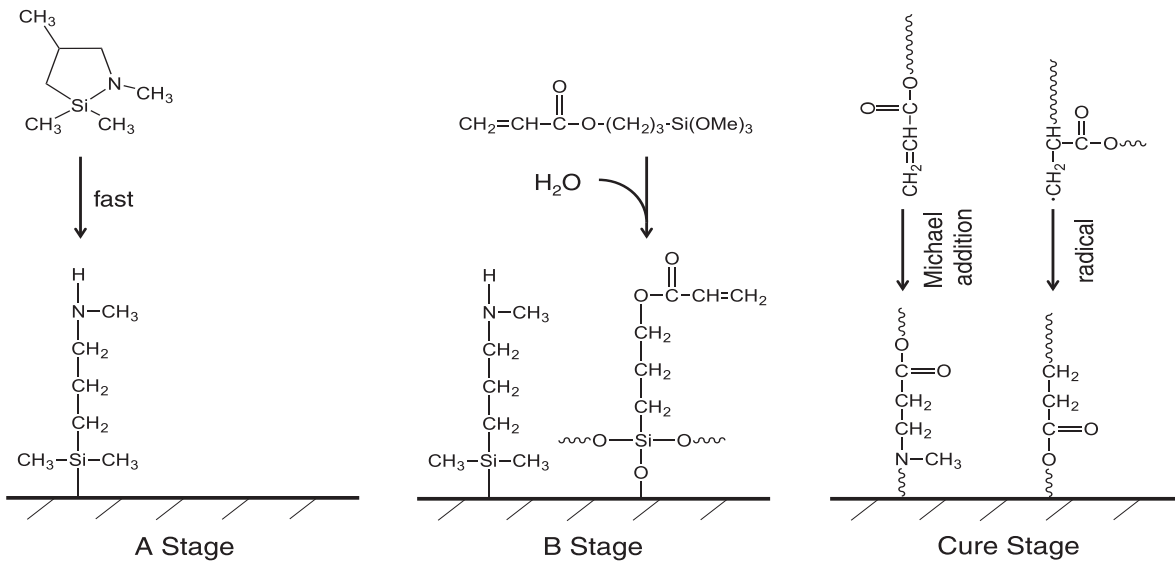
Activation of silanes is effected by combining a cyclic azasilane with an acrylate functional silane. The cyclic azasilane reacts with a wider variety of hydroxyl groups with reaction speeds more than 100 times faster than the base silane, providing instant adhesion. Once reacted with the substrate, the cyclic azasilane forms a secondary amine that catalyzes the moisture-initiated condensation reactions of the balance of the silane components, establishing maximum bond strength.

Adhesion and bonding proceeds with a wider variety of substrates. In contrast to conventional silanes, SIVATE™ activated silanes react with newly formed glass surfaces, reducing crack propagation associated with moisture adsorption.

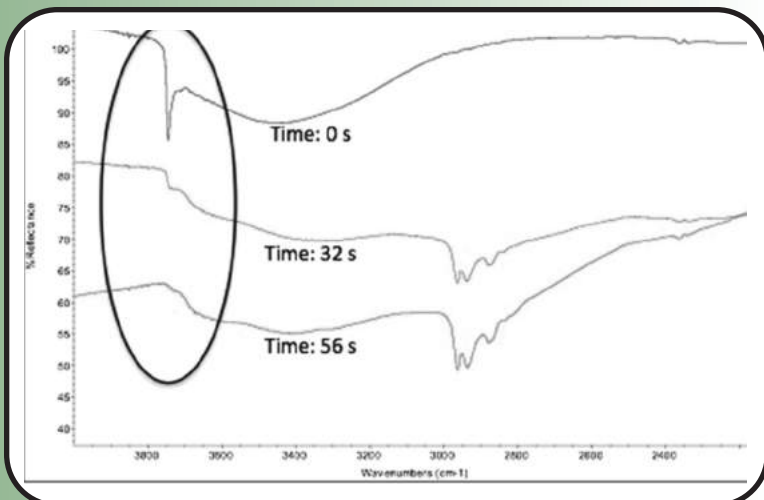


How do activated silanes work? (Mechanism and Chemistry)

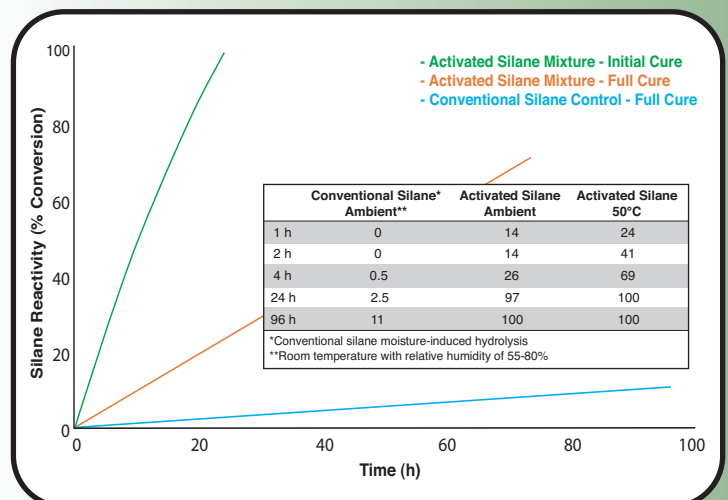
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Reaction of activating silane with surface during deposition



DRIFT Spectra monitoring the disappearance of the terminal hydroxyl peak over exposure time as the terminal hydroxyls react with a cyclic azasilane



Reaction Kinetics of the activated silane with an acrylate polymer



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