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from DOW CORNING

A Guide to Silane Solutions

Fiberglass and Composites

Fiberglass and Composites

Silane coupling agents are a critical component of fiberglass-reinforced polymers. The glass is very hydro-philic and attracts water to the interface. Without silane treatment on the surface, the bond between the glass fiber and the resin would weaken and eventually fail. Silane coupling agents are used on fiberglass for general-purpose reinforced plastic applications, such as automotive, marine, sporting goods and building construction, as well as for high-performance applications in printed circuit boards and aerospace composites. XIAMETER® brand silanes figure prominently in the trend toward increasingly more durable, higher-strength plastic composites.

The chemical structure of the organic group in a silane coupling agent has a great effect on its performance in a composite, as measured by improvement of strength properties under wet and dry conditions. A wet-aging test, usually in boiling water, will show differences in the effectiveness of various silanes.

Fiberglass for general-purpose applications is treated with a dilute aqueous sizing bath consisting of a combination of ingredients (organic film formers, lubricants, antistats and a silane coupling agent). The silane must be soluble in the aqueous bath at levels of 0.2 to 1 percent. Normally, if a water bath is acidified with acetic acid to a pH of 4, even hydrophobic silanes will dissolve in the bath at low concentrations and give the stability needed to treat the fiberglass. Certain silanes, such as aminosilanes, are more hydrophilic and will dissolve at high concentrations in water even without pH adjustment. The size is applied to the fiberglass at the glass fiber manufacturing plant immediately after the glass fibers are extruded and bundled into glass fiber rovings.

Depositing the silane as a silsequioxane (organosilicon with three oxygen atoms shared with other silicon atoms) on a surface and measuring the weight loss by thermal gravimetric analysis (TGA) can determine the thermal stability of the silane. Results of isothermal TGA at 300ºC (572ºF) for several silanes are shown in Figure 1.

The improvement in thermal stability of a fiberglass-polyimide composite is shown in Table 1.

Some of the benefits imparted to fiberglass-reinforced plastics by XIAMETER® silanes include:

- Improved mechanical strength of the composites
- Improved electrical properties
- Improved resistance to moisture attack at the interface
- Improved wet-out of the glass fiber
- Improved fiber strand integrity, protection, and handling
- Improved resistance to hot solder during fabrication
- Improved performance in cycling tests from hot to cold extremes

Table 2 suggests silanes for evaluation with various fiberglass-reinforced polymer systems.

Figure 1. Thermal stability of silanes at 300ºC (572ºF), TGA.

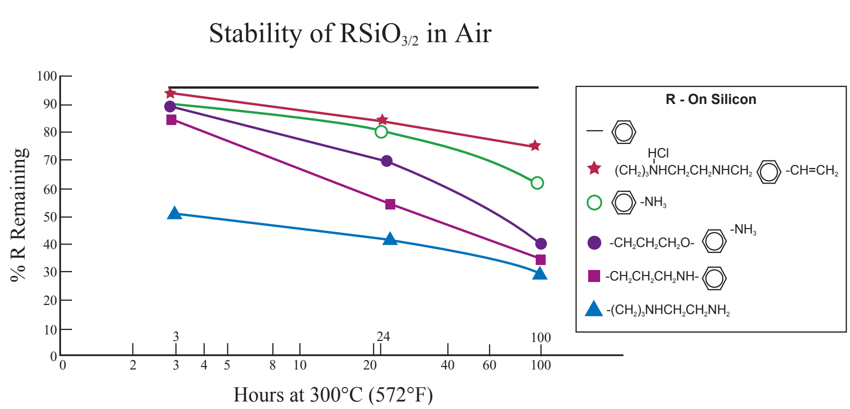

Table 1. Thermal Stability of Mixed Silanes – Phenyl + Amino, S-Glass/Polyimide Laminates

	Coupling Agents on Glass	
Properties of Laminates, MPa	9:1 Blend, Silane A and C	Aminosilane Alone, Silane B
Flexural Strength, initial	544	476
1000 hr @ 260°C (500°F)	409	258
2000 hr @ 260°C (500°F)	306	134

XIAMETER® brand silane:
A: OFS-6124 Ph-$Si(OCH_3)_3$
B: OFS-6011 $H_2N(CH_2)_3Si(OCH_2CH_3)$
C: OFS-6020 $H_2N(CH_2)_3NH(CH_2)_2Si(OCH_3)_3$

Table 2. Silane Coupling Agent Recommendations for Various Polymers – Matching Organoreactivity to Polymer Type

Organic Reactivity	Application (suitable polymers)
Amino	Acrylic, Nylon, Epoxy, Phenolics, PVC, Urethanes, Melamines, Nitrile Rubber
Benzylamino	Epoxies for PCBs, Polyolefins, All Polymer Types
Chloropropyl	Urethanes, Epoxy, Nylon, Phenolics, Polyolefins
Disulfido	Organic Rubber
Epoxy	Epoxy, PBT, Urethanes, Acrylics, Polysulfides
Epoxy/Melamine	Epoxy, Urethane, Phenolic, PEEK, Polyester
Mercapto	Organic Rubber
Methacrylate	Unsaturated Polyesters, Acrylics, EVA, Polyolefin
Tetrasulfido	Organic Rubber
Ureido	Asphaltic Binders, Nylon, Phenolics; Urethane
Vinyl	Graft to Polyethylene for Moisture Crosslinking, EPDM Rubber, SBR, Polyolefin
Vinyl-benzyl-amino	Epoxies for PCBs, Polyolefins, All Polymer Types

Product Information

A complete list of XIAMETER® brand silanes for use as fiberglass and composite applications is available at **xiameter.com**.

In addition, Dow Corning Corporation also offers a wide variety of *Dow Corning®* brand specialty silicone material and service options as well as other silicon-based materials available to help you keep your innovative edge in the marketplace. Visit **dowcorning.com** to learn more about the many additional silicone and silicon-based options available to you from Dow Corning.

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