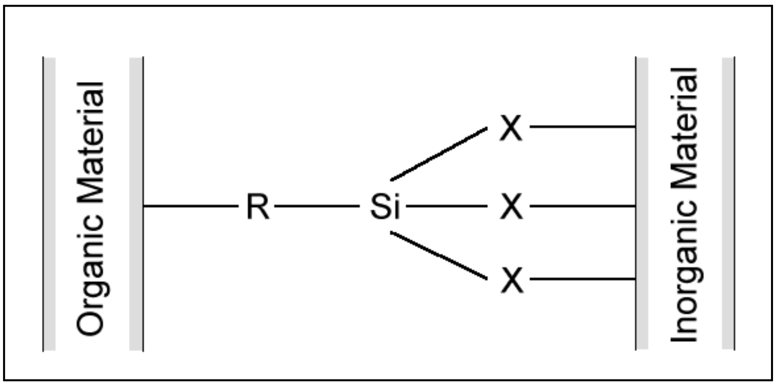
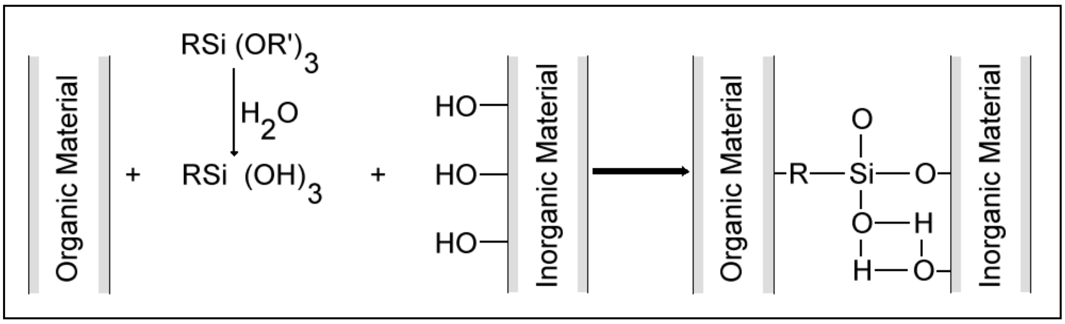
I. INTRODUCTION:

Silane coupling agents are generally illustrated:



Silicone (Si) is the center of the silane molecule which contains an organic functional group (R) [ex: vinyl, amino, chloro, epoxy, mercapto, etc.], with a second functional group (X) [ex: methoxy, ethoxy, etc.]. The functional group (R) will attach to an organic resin while the functional group (X) attaches to an inorganic material or substrate to achieve a "coupling" effect.

Silane coupling agents are predominately used as mediators, binding organic materials to inorganic materials. As a result silanes will improve the electrical and mechanical strength properties of materials in wet or dry conditions.



Silane coupling agents are primarily used in reinforced plastics and electric cables composed of crosslinked polyethylene. Other uses include resins, concrete, sealant primers, paint, adhesives, printing inks and dyeing auxiliaries.

The inorganic group (X) of the silane molecule will hydrolyze to produce silanol, which forms a metal hydroxide or siloxane bond with the inorganic material. The organic group (R) of the silane molecule will react with the organic material to produce a covalent bond. As a result the organic material and the inorganic material are tightly bound together after heating.

II. BASIC APPROACHES FOR USING SILANE COUPLING AGENTS:

There are three basic approaches for using silane coupling agents. The silane can be used to treat the surface of the inorganic materials before mixing with the organic resin or it can be added directly to the organic resin or holistic mixing (in organic-inorganic mixture).

1 The Surface Treatment of Inorganic Materials

1.1 Glass fiber

Dip glass fiber into 0.1-0.5% silane coupling agent – water solution(or water-ethanol solution) and air-dry, at last dealing in desiccatore with 110-120℃ for 5-10 minutes.

1.2 Inorganic filler

1.2.1 The effect with different kinds of fillers

Fillers: A filler which contains an excess of hydroxyl groups on the surface is especially effective.

Much more effect	Silica, alumina, glass, quartz, porcelain clay
Much effect	Mica, talc, clay, water and alumina, grammiteiron dust, potassium titanic acid
Ratherish effect	Asbestos, ferric oxide, zinc oxide, carborundum, silicon nitride
Not very Effect	calcium carbonate, carbon, barium sulphate,boron

There are three general methods for treating the surfaces of inorganic filler materials before they are added to the organic resins.

(1) Wet Method

By mixing a slurry of the inorganic materials in a dilute solution of the silane coupling agent, a highly uniform and precise surface treatment of the inorganic material can be obtained.

(2) Dry Method

A high shear, high speed, mixer is used to disperse the silane coupling agent into the inorganic materials. The silane is generally applied either neat or as a concentrated solution. When compared to the Wet Method, the Dry Method is most often preferred for large-scale production, treating a large amount of filler in a relatively short time and generating relatively little mixed waste; however, it is more difficult to obtain uniform treatment with this method.

(3).Spray Method

Spray the silane coupling agent on high temperature filler that was just taken out from furnace. The method may omit dry procedure and make the process simplify, but pay attention to perflation and ignite.

2 Addition To Organic Materials

Compared to the methods for the surface treatment of inorganic materials, adding the silane to the organic resin is more widely used in industries because of its excellent process efficiency, although curing may be more difficult. There are two general methods.

(1) Integral Blending

This method involves simple blending of the silane coupling agent into the composite formula as the inorganic and organic materials are mixed together.

(2) Master Batch

In this method, the silane coupling agent is first added to a small amount of the organic resin material to form what is referred to as a "master batch". In general, the silane coupling agent dosage is 0.2-2% or so. Usually in the form of pellets or large granules,

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the master batch can be easily added along with the pellets of the organic resin when producing the composite materials. Pay attention to bodying and generate gelatin phenomena by silane coupling agent.

3 Holistic mixing (in Organic-Inorganic mixture)

Directly add the diluent of silane cupling agent and organic solvent when mixing organic resins and inorganic fillers. The silane coupling agent dosage is 0.2—2% or so.

III. Calculating the Quantity of Silane Required:

The silicone molecule is preferably attached to the surface of the inorganic material as a primer to form a mono-layer. Applying a silane as a primer will produce optimum coupling results between the substrate and the resin to be applied. When used as a primer the required amount of silane can be calculated by the following:

$$\text{Amount of silane (g)} = \frac{\text{Amount of filler (g)} \times \text{Surface area } (m^2/g)}{\text{Minimum coating area of silane coupling agent } (m^2/g)}$$

The actual values may deviate from the calculated value depending on the surface condition of the filler or the silane treating process. The following values may be used as guidelines when the value is unknown. A dilution of 1% silane to filler may be considered as standard. Generally 0.3% to 0.5% is recommended.

Surface area of filler (m^2/g)	
E-glass	0.1 - 0.12
Quartz	1 - 2
Kolin	7
Clay	7
Talc	7
Aluminum polysilicate	1
Calcium carbonate	5
Calcium silicate	2.6

IV. Reactivity:

The alkoxy groups of the coupling agents react with water to form silanol groups which immediately form covalent bonds by dehydration and condensation:

$$RSi(OR')_3 + 3\,H_2O \xrightarrow{-\,3R'OH} RSi(OH)_3 \xrightarrow{-3/2\,H_2O} RSiO_{3/2}$$

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APPENDIX 1.

Product Name	Minimum Coverage Area(m^2/g)
PC1110	436
PC1100	353
PC3100	330
PC4100	314
PC2300	398
PC1220	380
PC1200	351

APPENDIX 2.

End-use Applications	Benfits
Adhesives	Moisture initiated crosslinking of resins, improved wet adhesion, improved chemical resistance, weatherability and filler/resin coupling.
Coatings	Moisture initiated crosslinking of resins, improved wet adhesion, chemical and corrosion resistance, weatherability, pigment dispersion and scrub resistance.
Crude Oil Extraction	Consolidation of down-hole fines
Glass Fibers	Coupling of resins with fiber for improved resiliency of insulation batts; better wet strength retention and electrical properties of FRP composites, and improved fiber strand integrity, protection and handling.
Filler Treatment	Improved coupling of resins with fillers and bettter filler dispersion in thermoset and thermoplastic resins.
Foundry	Coupling of resins with sand for improved foundry core strength.
Polymer Modification	Moisture-cure crosslinking to give improved environmental and chemical resistance.
Printing Inks	Improved adhesion, release and wetting.
Rubber and Elastomers	Coupling of resins with minerals for improved composite strength, toughness, abrasion resistance, rolling resistance, wet electrical properties and rheology control.
Sealants	Moisture initiated crosslinking of resins, improved wet adhesion, chemical resistance, filler dispersion, weatherability and rheology.
Textiles	Altered textile hand and water repellency, and improved dye receptivity.
Thermoplastics	Moisture curable XLPE for Wire & Cable and Pipe, Mineral and Pigment treatment for dispersibility and coupling and reinforcement coupling for high performance thermoplastics.

NOTES: The choice of a SiSiB® Silane is specific to resin type and application. The Selection Guidelines is provided to help you select the appropriate SiSiB® Silane for various polymer (resin) systems. It should be considered merely a starting point. The selection of the preferred silane for a specific end-use application may require specific experimentation.

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