Silane Coupling Agents Application

Power Chemical Corporation Limited

SiSiB® SILANES

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Silane Coupling Agents Industrial Applications

Silane coupling agents belong to a class of organosilane compounds having at least two reactive groups of different types bonded to the silicon atom in a molecule. One of the reactive groups of different types (ex. methoxy, ethoxy and silanol hydroxy groups) is reactive with various inorganic materials such as glass, metals, silica sand and the like to form a chemical bond with the surface of the inorganic material while the other of the reactive groups (ex, vinyl, epoxy, methacryl, amino and mercapto groups) is reactive with various kinds of organic materials or synthetic resins to form a chemical bond.

As a result of possessing these two types of reactive groups, silane coupling agents are capable of providing chemical bonding between an organic material and an inorganic material.

This unique property of silane coupling agents is utilized widely in the application of the silane coupling agents for the surface treatment of glass fiber products, performance improvement of fiber-reinforced plastics by the direct admixture to the synthetic resin, improvement of paints and other coating materials and adhesives, modification of surface properties of inorganic fillers, surface priming of various substrate materials, etc.

When a silane coupling agent is used in a thermosetting resin-based fiber-reinforced material, remarkable improvements are obtained in the mechanical and electrical properties of the material and the effect is more remarkable when the material is used in a wet or humid condition.

Application of silane coupling agents to thermoplastic resin-based fiber-reinforced materials is also actively performed along with the efforts to develop a silane coupling agent having further enhanced coupling effects.

◆ Polyester Resins Application
Best results are obtained in an unsaturated polyester-based FRP by using a vinyl – or methacryloxy-containing silane as the silane coupling agent. Remarkable improvements are made in the mechanical strengths and electrical characteristics as well as in the appearance of FRP of an unsaturated polyester resin by using the silane coupling agent, especially when the FRP is used in a wet or humid condition.

◆ Polyester Resin Concrete Application
Resin concretes are advantageous over ordinary cement concrete in respect of lighter weight, better resistance adjoins chemicals, higher electric insulation, more rapid curing, etc. and accepted as a useful material in oceanic technology and others.
◆ **Epoxy Resins Application**
Application to epoxy resin laminated plates
Epoxy resin laminated plates are manufactured by wet lay-up lamination or dry-up lamination. The latter method is performed as the major current of modern technology for the reasons in the manufacturing process and the characteristics of the products. A variety of curing agents are used including aliphatic amines, aromatic amines and acid anhydrides while the properties of the laminated plate product largely depend on the type of the curing agent.

Best results are obtained in the improvements of glass cloth reinforced epoxy resin plates by the use of an epoxy or amino-containing silane as the silane coupling agent.

◆ **Phenolic Resins Application**
Phenolic resins are used in laminated products, brake shoes, grinding stones, shell molding, etc.

◆ **Shell Molding Application**
The amount of a phenolic resin or furan resin as binder of silica sand for casting mold can be reduced by using a silane coupling agent by virtue of the great increase in the strength of the mold. Saving of the binder resin is also advantageous by the decrease in the volume of the decomposition gas contributing to the increase on the yield of acceptable products. Aminosilanes are recommended for this purpose. Usually, the silane coupling agent is admixed with the binder resin or with the curing catalyst of the resin. When blending with the resin is desired, SiSiB PC1220, a di-functional aminosilane, is the recommended silane coupling agent for storage.

◆ **Elastomers Formulated with White Fillers Application**
White fillers compounded with elastomers include finely divided silica fillers, calcium carbonate, clays, and alumina. Usually, no chemical bond is formed between the surfaces of these white fillers and the elastomer molecules. This is the reason for the poorer dispersibility and reinforcing performance of these fillers in elastomers than in carbon blacks.

The reinforcing performance of white fillers in an organic elastomer can be greatly improved by the addition of a silane coupling agent.

◆ **Thermoplastic Resins Application**
Although the mechanism of the activity exhibited by a silane coupling agent has not yet been understood for thermoplastic resins having no organic functional groups, silane coupling agents are indeed effective on thermoplastic resins as reported by Sterman, et al., who determined the flexural strength of various kinds of FRTP (fiber-reinforced thermoplastics) prepared using glass cloths treated with a variety of
silanes.

The application of silane coupling agents to polyolefins such as polyethylene and polypropylene is also under active investigation and Stemman et al. have reported that the combined use of an organic peroxide and a double bond-containing silane such as vinyl silanes and methacrylic silanes is effective on polypropylene in remarkably improving the properties of the FRTP of the polymer.

Hartlein has reported that a good coupling agent for polypropylene is 3-mercaptopropyl trimethoxysilane and a synergistic effect can be obtained by the combined use of an aminoalkyl silane and a highly chlorinated compound such as a chlorinated xylene.

It is also reported that the strength of FRTP is remarkably improved by the combined use of an aminoalkyl silane and a highly chlorinated compound such as a chlorinated xylene.

Plueddemann has reported that the hydrochloride of a vinyl benzyl aminoakyl silane is an excellent coupling agent for thermoplastic resins.

◆ Glass Fiber-reinforced Thermoplastic Resins Application
  Glass fiber-reinforced resins prepared by impregnating a thermoplastic resin such as nylon, polyester, etc., with glass fibers have excellent mechanical characteristics, heat resistance, dimensional stability and other properties and are widely used as parts in automobiles and electric instruments.

◆ Filler-formulated Thermoplastic Resins Application
  Addition of a silane coupling agent is effective in improving the mechanical properties of thermoplastic resins impregnated with an inorganic filler, though not so remarkably as in the case of glass cloth-laminated plates.

◆ Synthetic Resin Modification Application
  Following effects are expected when an organic synthetic resin is modified by a silane coupling agent with a chemical reaction taking place between them.
  (1) The adhesive bonding is improved between the resin and an inorganic substrate material.
  (2) Crosslinkable groups having reactivity can be introduced into the resin.
  (3) Heat resistance and weathering resistance of the resin can be improved depending upon the extent of modification.

As an example case (2), the hydrolysis and silanol condensation reaction of alkoxysilyl groups in the presence of water to form a stable siloxane linkage is utilized in crosslinking polyethylenes, sealing materials, thermosetting acrylic resins, etc.
Primer Application

The use of a silane coupling agent as a primer is a widely practiced technique for the improvement of the adhesive bonding between a sealing material such as a polyurethane-or polysulfide-based sealant and the surface of an inorganic substrate such as metal or glass, since otherwise the adhesive bonding strength between them is rather poor. In particular, aminosilanes are recommended for this purpose although they are not always quite satisfactory with respect to water resistance.

Silane coupling agents are generally effective as a primer for the polysulfide- and polyurethane-based sealing materials.