

Consumer Solutions

Mineral and Filler Treatment

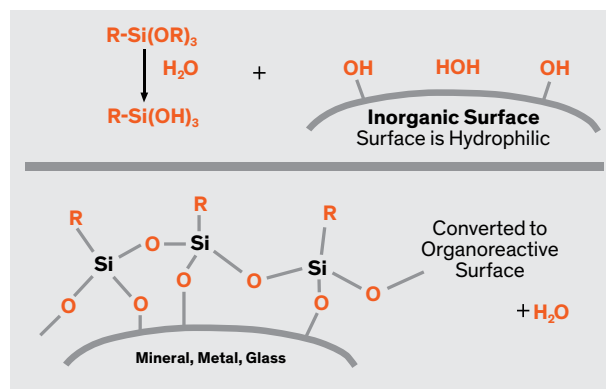
A Guide to Silane Solutions



Mineral fillers have become increasingly important additives and modifiers for organic polymers. The metal hydroxyl groups on the surface of minerals are usually hydrophilic and incompatible with organic polymers. Alkoxysilanes are a natural fit to treat the surface of the mineral to make it more compatible and dispersible in the polymer, or even to make the filler a reinforcing additive. In addition to plastics applications, the use of silane-modified minerals in organic rubber, especially tires, has become increasingly important.

Minerals with silicon and aluminum hydroxyl groups on their surfaces are generally very receptive to bonding with alkoxysilanes. The treatment of a mineral surface by an organosilane is depicted below.

Treatment of a mineral surface by an organosilane

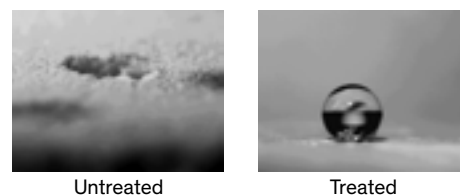


Benefits of Silane Treatment

Silane treatment can improve processing, performance, and durability of mineral-modified products by:

- Improving adhesion between the mineral and the polymer
- Improving wet-out of the mineral by the polymer
- Improving dispersion of the mineral in the polymer
- Improving electrical properties
- Increasing mechanical properties
- Reducing the viscosity of the filler/polymer mix

Example of transforming a mineral filler from hydrophilic to hydrophobic with a phenyl-functional silane



Untreated

Treated

Silane Treatment Effectiveness

Silane coupling agents have been effectively used in filled polymer systems with silica (both fumed and precipitated), glass beads, quartz, sand, talc, mica, clay, and wollastonite. Other metal hydroxyl groups, such as magnesium hydroxide, iron oxide, copper oxide, and tin oxide, may be reactive to a lesser extent, but often benefit from silane treatment. Traditionally, silane coupling agents give poor bonding to carbon black, graphite, and calcium carbonate.



Applying Silanes to Fillers

Minerals are treated with either neat silane or a solution of silane in water and/or alcohol. With a neat silane, the absorbed water on the filler surface is often sufficient to hydrolyze the alkoxy silane and simultaneously bond the silane to the filler surface. It is important that the filler be coated uniformly through the use of intensive mixing, such as with a Henschel mixer. Commercial processes are continuous, often in heated chambers, followed by further heat treatment to remove byproducts of alcohol and water and to complete the bonding of the silane to the surface.

Treatment Level

The loading level of silane on the filler surface is a function of the surface area of the filler. While it was previously thought that one monolayer of silane should be sufficient, experimentation has shown that several layers of silane give optimal results. For example, typical fillers with average particle sizes of 1 to 5 microns often give best results when treated with about 1% silane (based on weight of the filler). The optimal level of silane treatment should be determined experimentally.

Silane Choice

The choice of which silane to use in a particular application is determined by the nature of the desired benefit. All alkoxy silanes will bond to a receptive filler or mineral surface. If the silane treatment is designed to provide surface hydrophobicity, then a silane with a hydrophobic group, such as butyl, octyl, fluorocarbon, or phenyl, should be chosen. If the silane treatment is designed to provide compatibility of the mineral in a polymer matrix, then the nature of the organic group on the silane should be similar to the chemical structure of the polymer (i.e., an octyl or longer-chain alkyl group will help provide compatibility and dispersibility of the mineral in a polyolefin matrix). If the silane treatment is to bond a filler to a polymer matrix, then an organo-reactive silane should be chosen that would bond chemically to reactive sites present in the polymer.

Product Information

A complete list of silanes for mineral and filler treatment is available at consumer.dow.com/silanes.

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