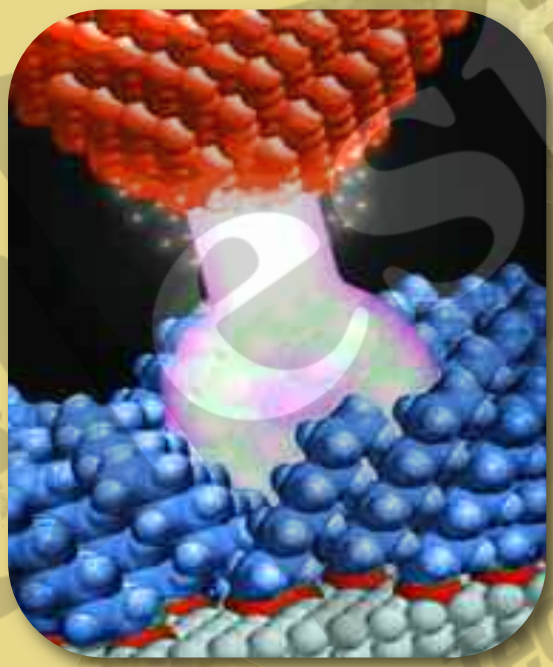
Gelest

Enabling Your Technology

Micro-Particle Surface Modification



Innovating Particle Functionalization

Gelest Provides Chemistries And Deposition Technologies For Micro-Particle Modifications That Dramatically Enhance:

- Color
- Polarity
- Adhesion
- Dispersion
- Rheological Behavior
- Photo, Chemical, Thermal Stability
- Moisture & Corrosion Resistance
- Mechanical & Electrical Properties

Surface Modification Sol

COUPLING THE PARTICLE TO THE APPLICATION

Inputs

Particle

SILICEOUS
- natural
- synthetic

NON-SILICEOUS
- natural
- synthetic

SPECIALTY
- metallic
- fluorescent
- luminescent
- phosphorescent

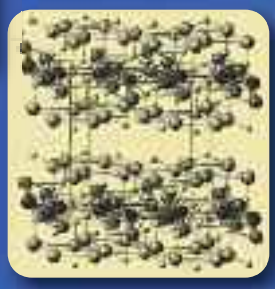
Physical Properties

- *DENSITY*
- *ASPECT RATIO*
- *SURFACE AREA*
- *CONTACT ANGLE*
- *CHEMISORPTION*
- *ELECTROPHORETIC MOBILITY*
- *PORE SIZE & VOLUME*
- *PARTICLE SIZE DISTRIBUTION*

Talc

Clinoptilolite

Pyrophyllite



Phlogopite Mica

Perlite

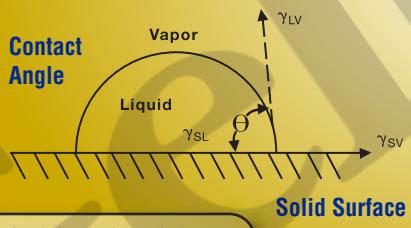
Muscovite Mica

LUTIONS

CHEMICAL CONSIDERATIONS

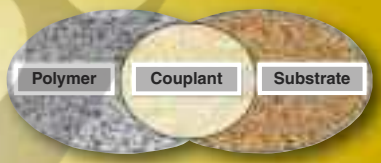
SURFACE PROPERTIES

OLEOPHILICITY
OLEOPHOBICITY
ZETA POTENTIAL
HYDROPHILICITY
HYDROPHOBICITY



BONDING MECHANISMS

IONIC BONDING
METALLIC BONDING
COVALENT BONDING
AROMATIC BONDING
HYDROGEN BONDING
ACID BASE INTERACTIONS
CRYSTALLINITY MODIFICATION
WETTING & SURFACE AREA EFFECTS
INTERPENETRATING POLYMERIC NETWORKS



SILANE EFFECTIVENESS ON INORGANICS

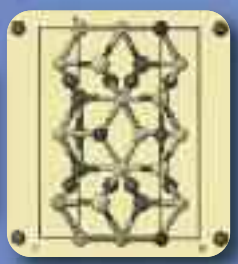
	SUBSTRATES
EXCELLENT	Silica
	Quartz
	Glass
	Aluminum (AlO(OH))
	Alumino-silicates (e.g. clays)
GOOD	Silicon
	Copper
	Tin (SnO)
	Talc
	Inorganic Oxides (e.g. Fe_2O_3, TiO_2, Cr_2O_3)
	Steel, Iron
	Asbestos
	Nickel
	Zinc
SLIGHT	Lead
	Marble, Chalk ($CaCO_3$)
	Gypsum ($CaSO_4$)
	Barytes ($BaSO_4$)
POOR	Graphite
	Carbon Black

Petalite

Kaolinite

Attapulgite

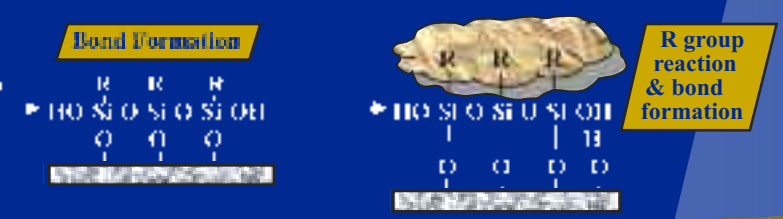
Hectorite



Quartz

Lepidolite

Chabazite



MONOLAYER
POLYLAYER

MIXED DEPOSITION

LAYER-BY-LAYER DEPOSITION

SOLUTIONS

Anhydrous liquid phase deposition of chlorosilanes, methoxysilanes, aminosilanes and cyclic azasilanes is preferred for small particles and nano-featured substrates. Toluene, tetrahydrofuran or hydrocarbon solutions are prepared containing 5% silane. The mixture is refluxed for 12-24 hours with the substrate to be treated. It is washed with the solvent. The solvent is then removed by air or explosion-proof oven drying. No further cure is necessary. This reaction involves a direct nucleophilic displacement of the chloride as HCl or methoxide as methanol by the surface silanol. If monolayer deposition is desired, substrates should be predried at 150°C for 4 hours. Bulk deposition results if adsorbed water is present on the substrate. This method is cumbersome for large scale preparations and rigorous controls must be established to ensure reproducible results. More reproducible coverage is obtained with mono-chlorosilanes.

Bulk deposition onto powders, e.g. filler treatment, is usually accomplished by a spray-on method. It assumes that the total amount of silane necessary is known and that sufficient adsorbed moisture is present on the filler to cause hydrolysis of the silane. The silane is prepared as a 25% solution in alcohol. The powder is placed in a high intensity solid mixer, e.g. twin cone mixer with intensifier. The methods are most effective. If the filler is dried in trays, care must be taken to avoid wicking or skinning of the top layer of treated material by adjusting heat and air flow.

Integral blend methods are used in composite formulations. In this method the silane is used as a simple additive. Composites can be prepared by the addition of alkoxysilanes to dry-blends of polymer and filler prior to compounding. Generally 0.2 to 1.0 weight percent of silane (of the total mix) is dispersed by spraying the silane in an alcohol carrier onto a preblend. The addition of the silane to non-dispersed filler is not desirable in this technique since it can lead to agglomeration. The mix is dry-blended briefly and then melt compounded. Vacuum devolatization of byproducts of the silane reaction during melt compounding is necessary to achieve optimum properties. Properties are sometimes enhanced by adding 0.5-1.0% of tetrabutyl titanate or benzyldimethylamine to the silane prior to dispersal.

Vapor Phase Deposition, silanes can be applied to substrates under dry aprotic conditions by chemical vapor deposition methods. These methods favor mono-layer deposition. Although under proper conditions almost all silanes can be applied to substrates in the vapor phase, those with vapor pressures >5 torr at 100°C have achieved the greatest number of commercial applications. In closed chamber designs, substrates are supported above or adjacent to a silane reservoir and the reservoir is heated to sufficient temperature to achieve 5mm vapor pressure. Alternatively, vacuum can be applied until silane evaporation is observed. In still another variation the silane can be prepared as a solution in toluene, and the toluene brought to reflux allowing sufficient silane to enter the vapor phase through partial pressure contribution. In general, substrate temperature should be maintained above 50° and below 120° to promote reaction. Cyclic azasilanes deposit the quickest, usually less than 5 minutes. Amine functional silanes usually deposit rapidly (within 30 minutes) without a catalyst. The reaction of other silanes requires extended reaction times, usually 4-24 hours. The reaction can be promoted by addition of catalytic amounts of amines.

Reactor for slurry treatment of powders. Separate filtration and drying steps are required.

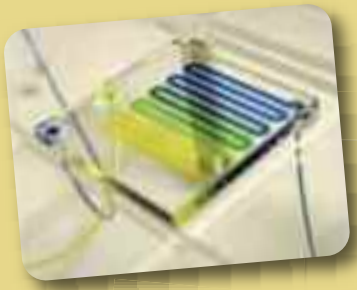
Ribbon blenders are used for blending or surface modification of micro-particles.

Vacuum tumble dryers are used for slurry treatment of micro-particles.

Twin-cone blenders with intensive mixing bars are used for silanes and metal-organics onto micro-particles.

Surface Modification Solutions for a plethora of applications

- Glass
- Energy
- Textiles
- Displays
- Ceramics
- Digital Inks
- Thermosets
- Biomaterials
- Printing Inks
- Quantum Dots
- Semiconductor
- Thermoplastics
- Chromatography
- Nano-Composites
- Imaging & Printing
- Advanced Composites
- Optics & Optoelectronics








Understanding characteristics that may affect the performance of surface modified micro-particles can dramatically improve the performance in many applications and markets:

Micro - Particle Properties

- *morphology*
- *crystal lattice*
- *polymorphism*
- *semiconductive*
- *surface characteristics*

Micro - Particle Dramatic Effects

- *rheological behavior*
- *hiding power, color strength*
- *dispersion, solubility, polarity*
- *photo, chemical, thermal stability*
- *mechanical & electrical properties*
- *moisture & corrosion resistance*

Gelest

Micro-Particle Surface Modification

GELEST, INC.

provides focused technical solutions for surface modification applications and maintains the capabilities to handle flammable, corrosive and air sensitive materials. Headquartered in Morrisville, PA *Gelest* is recognized worldwide as an innovator, manufacturer and supplier of commercial and research quantities of silanes, metal-organics and silicones, serving advanced technology markets through a material science driven approach.

For additional information on Gelest's Surface Modification Technology or to inquire on how we may assist in *Enabling Your Technology,* please contact:

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