Silicones to Highly Functionalize Resins

With a Variety of Product Lineups, Shin-Etsu Silicone Contributes to Highly Functionalize Your Products.

- **Silicone based Resins**
- **Silicone Resins & Oligomers**
- **Silane Coupling Agents**
- **Silicone Oligomers**
- **Modified Silicone Fluids**
- **Organic & Inorganic Hybridization Agents**
- **Blend-in Materials**
- **Silicone Master Pellets**
- **Silicone Powders**
- **Spherical Silica Fine particles**
- **Silicone Surface Modifiers**
- **Ionic Silicone Oligomer**

**Product Classification**
- Silanes
- Silane Coupling Agents
- Silicone Oligomers
- Silicone Fluids
- Silicone Resins
- Silicone Rubbers
- Silicone Gums

- Molecular Weight: Low to High
- 3D Structure
- 2D Structure

Page 7
Page 4-5
Page 6
Page 2
Page 3
Page 8
Page 2
Modified Silicone Fluids which bind various reactive groups exhibit a variety of properties by reacting with organic resin.

<table>
<thead>
<tr>
<th>Reactive groups</th>
<th>Types of resins</th>
<th>Thermoset resin</th>
<th>Thermoplastic resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amino groups</td>
<td>Polyurethane</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Epoxy groups</td>
<td>Epoxy</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Hydroxyl groups</td>
<td>Carbinol type</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td></td>
<td>Diol type</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td></td>
<td>Polyether type</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td></td>
<td>Phenol type</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Methacryl groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carboxylic groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mercapto groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acidanhydride groups</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

By blending few amounts of Silicone Master Pellets with resin, it is easy to obtain a compound in which the silicone is evenly dispersed.

Enhanced properties
- Lubricating property, Release property
- Anti-blocking property, Impact resistant
- Stress relaxation, Coloring property

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Resin</th>
<th>Silicone content %</th>
<th>MFRg / 10mins</th>
<th>MFR Test condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Homo Polypropylene</td>
<td>50</td>
<td>33</td>
<td>210°C / 2.16kg</td>
</tr>
<tr>
<td>Name</td>
<td>Low density polyethylene</td>
<td>50</td>
<td>20</td>
<td>190°C / 2.16kg</td>
</tr>
<tr>
<td>X-22-2138B</td>
<td>Ethylene vinylacetate copolymer</td>
<td>40</td>
<td>5</td>
<td>190°C / 2.16kg</td>
</tr>
<tr>
<td>X-22-2102</td>
<td>Polyacetal</td>
<td>40</td>
<td>55</td>
<td>190°C / 2.16kg</td>
</tr>
<tr>
<td>X-22-2184-30</td>
<td>ABS</td>
<td>30</td>
<td>45</td>
<td>220°C / 2.16kg</td>
</tr>
</tbody>
</table>

We can discuss the Silicone formulation with your preferred resin. Please do not hesitate to contact us.
Shin-Etsu has developed a unique line of silicone powders which fall into three categories: Hybrid Silicone Powder, Silicone Resin Powder, and Silicone Rubber Powder.

**Enhanced Properties**

- **Stress Relaxation - Impact Resistance**
  - No additive
  - Silicone Rubber & Hybrid Silicone added
  - Resin & Coating
  - Pressure Impact

<table>
<thead>
<tr>
<th>Hybrid powder</th>
<th>Resin powder</th>
<th>Rubber powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>++</td>
<td>–</td>
<td>++</td>
</tr>
</tbody>
</table>

- **Lubricity - Wear Resistance**
  - Silicone resin powder
  - Hybrid powder
  - Resin & Coating

- **Soft-feel Property**
  - Silicone rubber powder
  - Hybrid silicone powder
  - Resin & Coating

- **Light Diffusion Property**
  - Silicone resin powder
  - Hybrid silicone powder
  - Resin & Coating

**General Properties**

<table>
<thead>
<tr>
<th>Type</th>
<th>Parameter</th>
<th>Product name</th>
<th>Shape</th>
<th>Average particle size μm</th>
<th>Particle size distribution μm</th>
<th>True Specific gravity</th>
<th>Moisture content %</th>
<th>Rubber hardness Durometer A</th>
<th>Refractive index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid silicone powder</td>
<td>KMP-600</td>
<td>Spherical powder</td>
<td>5</td>
<td>1-15</td>
<td>0.99</td>
<td>0.1</td>
<td>30</td>
<td>1.41</td>
<td>1.43</td>
</tr>
<tr>
<td>Silicone resin powder</td>
<td>KMP-605</td>
<td>Spherical powder</td>
<td>2</td>
<td>0.75</td>
<td>0.99</td>
<td>0.1</td>
<td>30</td>
<td>1.41</td>
<td>1.43</td>
</tr>
<tr>
<td>Silicone rubber powder</td>
<td>KMP-597</td>
<td>Spherical powder</td>
<td>5</td>
<td>1.10</td>
<td>0.97</td>
<td>0.1</td>
<td>30</td>
<td>1.41</td>
<td>1.43</td>
</tr>
</tbody>
</table>

* * * : Excellent * : Good ± : Satisfactory – : Poor

**Product Data**

- **Hybrid silicone powder**
  - KMP-600
    - Particle size distribution
    - Heat resistance (Weight changes vs. temperatures)

- **Silicone resin powder**
  - KMP-706
    - Particle size distribution
    - Heat resistance (Weight changes vs. temperatures)

- **Silicone rubber powder**
  - KMP-597
    - Particle size distribution
    - Heat resistance (Weight changes vs. temperatures)

**Dispersibility**

- **Dispersibility in liquid epoxy resin**
  - Hybrid silicone powder KMP-601
  - Silicone rubber powder

* * *: There are also aqueous dispersion of silicone rubber powder.

*Aqueous dispersion of silicone rubber powder. By drying spherical powders are obtained. (Not specified values)
With maximum freedom of functional group, Long-Chain Spacer Silane Coupling Agents improve reactivity. It improves flexibility and impact resistance in hybrid of resin and inorganic filler. And, with increased compatibility, it is possible to improve transparency of reactant in resin and inorganic filler, and high load inorganic filler into resins.

**Features**
- Increased hydrophobicity (Lipophilicity)
- Increased flexibility

**Applications**
- Organic / Inorganic adhesion improver
- Glass/Epoxy, coupling performance evaluation

**Protected Functional Group Silanes**
Protected functional group silanes have protected organic reactive groups. With protected functional group silanes, creating 1 component materials, which were formerly 2 component materials, or simultaneously adding a reaction system is possible, but was difficult due to the reactivity of silanes. And protected functional group silanes exhibit highly improved storage stability.

**General Properties**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Chemical name</th>
<th>Organic functional groups</th>
<th>Chemical structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-12-1056ES</td>
<td>3-(Triethoxysilylthio)propyltrimethoxysilane</td>
<td></td>
<td>(CH3O)3SiCH2S(CH3)CH2Si(OC2H5)3</td>
</tr>
<tr>
<td>KBE-9103</td>
<td>3-Triethoxysilyl(1,3 dimethyl-butylidene) propylamine</td>
<td></td>
<td>(CH3O)3SiCH2N(CH2CH3)2CH2Si(OC2H5)3</td>
</tr>
<tr>
<td>X-12-967C</td>
<td>3-(Trimethoxysilyl)propylsuccinic anhydride</td>
<td></td>
<td>(CH3O)3SiC3H6O2CCH2CH2O2C2H5</td>
</tr>
</tbody>
</table>

**Comparison of adhesion of X-12-1056ES and KBM-803(conventional grade)**

*KBM-803 : 3-Mercaptopropyltrimethoxysilane
Shin-Etsu Chemical developed 2 types of coupling agents (polymer type) containing a number of reactive organic groups.
1) Coupling Agents (Alkoxy Oligomer Type) which are partial hydrolysates of conventional coupling agent
2) Silane Coupling Agents (Multifunctional Group Type) with organic backbone

**Coupling Agents (Alkoxy Oligomer Type)**

Owing to 100% of active ingredients, Coupling Agents (Alkoxy Oligomer Type) with siloxane back bone reduce generation quantity of alcohol. By choice of organic groups, it can achieve hydrophilic treatment on surfaces of coating as paint additives, or adapt adhesion (rework property) as additives for adhesive.

**Features**
- Partial hydrolysis condensation of silane coupling agent
- Large numbers of reactive functional groups with resins
- Film formulation property
- Low volatility

![Structural model of alkoxy oligomers](image)

**Silane Coupling Agents (Multifunctional Group Type)**

Silane coupling agent with organic backbone contains a number of alkoxy groups and organic functional groups. Owing to a number of reaction points, the user can expect improved adhesion. It is useful for primer, since its primary component is low volatility and it has a film formulation property.

**Features**
- Hydrolyzable groups are trialkoxysilyl groups.
- Large numbers of reactive functional groups with resins
- Film formulation property
- Low volatility

![Structural model of silane coupling agents (multifunctional group type)](image)
With its cyclic siloxane structure, KR-470 exhibits almost no shrinkage during curing. Its molecular structure is specified, meaning that reactions are easy to control. Cures with light or heat with the addition of an acid generator, acid anhydride, or amine-type catalyst. Excellent compatibility owing to low molecular weight.

### Features

When added in small amounts to resins, X-40-2450 migrates easily to the coating surface.

### Silicone Oligomers Containing Alicyclic Epoxy Groups

Silicone oligomers contain only epoxy groups as their reactive functional groups, and can be formulated to cure by way of an acid anhydride, photo-cationic or thermal-cationic curing system. Silicone oligomers cure by the same mechanisms as do epoxy resins, while offering excellent heat resistance and high Tg (glass-transition temperature) that are characteristic of siloxane bonds. The cyclosiloxane-based oligomers exhibit low shrinkage during curing.

### Features

With its cyclic siloxane structure, KR-470 exhibits almost no shrinkage during curing. Its molecular structure is specified, meaning that reactions are easy to control. Cures with light or heat with the addition of an acid generator, acid anhydride, or amine-type catalyst. Excellent compatibility owing to low molecular weight.
Silicone Resins & Oligomers

Silicone Oligomer Type Coatings

Silicone Oligomer Type Coating Agents contain alkoxyisilyl groups and cure at ambient temperatures and humidities with the use of a curing agent. They form very hard, glossy coatings that are highly resistant to heat and light, owing to their 3D siloxane structures.

Cross linking mechanism: $2 \text{Si-OR} + 2 \text{H}_2\text{O} \rightarrow (2\text{Si-OH} + 2\text{ROH}) \rightarrow \text{Si-O-Si} + \text{H}_2\text{O} + 2\text{ROH}$

Product & Catalyst line up

By using different types of silicone oligomers and curing agents, the user can obtain coatings that vary widely in their curing speed and hardness or flexibility.

Product line up

**Methyl Type**
- Features: Water repellency, Excellent curability

**Methyl / Phenyl Type**
- Features: Gloss, Excellent flexibility

Catalyst Line Up

<table>
<thead>
<tr>
<th>Product name</th>
<th>Type</th>
<th>Addition amount with</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-20</td>
<td>Methyl siloxane</td>
<td>0-10</td>
<td>Very high activity</td>
</tr>
<tr>
<td>X-40-225BA</td>
<td>Phosphoric acid</td>
<td>15-95</td>
<td>High activity, can accelerate curing.</td>
</tr>
<tr>
<td>D-25</td>
<td>Titanium</td>
<td>0.5-3</td>
<td>Higher activity than D-20</td>
</tr>
<tr>
<td>D-20</td>
<td>Titanium</td>
<td>2-5</td>
<td>Slow reactivity</td>
</tr>
<tr>
<td>DX-175</td>
<td>Titanium</td>
<td>3-5</td>
<td>Solvent diluted type (Easy to use)</td>
</tr>
<tr>
<td>DX-9740</td>
<td>Aluminum</td>
<td>0.5-5</td>
<td>Forms high hardness coating</td>
</tr>
<tr>
<td>CAT-AC</td>
<td>Aluminum</td>
<td>0.5-10</td>
<td>Solvent diluted type (Easy to use)</td>
</tr>
</tbody>
</table>

Formulation Example and Film Properties

<table>
<thead>
<tr>
<th>Parameter</th>
<th>D-20(2)</th>
<th>D-20(4)</th>
<th>D-9740(5)</th>
<th>D-20(3)</th>
<th>D-20(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Film thickness</td>
<td>25μm</td>
<td>25μm</td>
<td>25μm</td>
<td>30μm</td>
<td>80μm</td>
</tr>
<tr>
<td>Tack free 25℃ min</td>
<td>40</td>
<td>20</td>
<td>5H</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>Pencil hardness</td>
<td>H</td>
<td>2H</td>
<td>F</td>
<td>H</td>
<td>F</td>
</tr>
<tr>
<td>Penetration resistance</td>
<td>±</td>
<td>±</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Substrate: Polished steel sheet, Cure conditions: 25℃ / 70% RH×7days (Tack-free time varies depending on temperature and humidity)

Ultra High Molecular Weight Silicone Resin KR-251

KR-251 is a methyl silicone resin with a very high molecular weight. With KR-251, the molecular weight has been increased as much as possible without causing gelation.

**Features**
- Very hard film
- Easy to crack
- Heat cure is necessary

**General property**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>KR-251</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Colorless transparent liquid</td>
</tr>
<tr>
<td>Non-volatile content @105℃ × 3h %</td>
<td>20</td>
</tr>
<tr>
<td>Viscosity 35℃ mm²/s</td>
<td>18</td>
</tr>
<tr>
<td>Specific gravity 25℃</td>
<td>0.92</td>
</tr>
<tr>
<td>Acid value</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>Solvent</td>
<td>Toluene</td>
</tr>
</tbody>
</table>

**Film properties**

**Clear coating**
- Curing condition: 25℃×1day
- Film thickness: 8μm
- Pencil hardness: H

**Film properties**
- Substrate: Polished steel sheet

**Common methyl silicone resins**
- Low molecular weight
- Poor film forming properties when dried
- Easy to crack due to high crosslinking density
- Poor heat resistance

**Common grade silicone resin**
- Low molecular weight
- Forms a high quality film by air drying alone
- Forms a harder coating.
- The collection of large molecules translates to excellent crack resistance, film forming ability, and toughness.

**Model of Coating Structure**

**Model of after Curing**

Contact to: Sales and Marketing Department  II  Phone: +81-(0)3-3246-5131
Spherical Silica Fine Particles

With very small average particle size, narrow distribution and its hydrophobized surface, Spherical Silica Fine Particles have a superior flowability, dispersion, water repellency and lubricity.

Features

● Narrow particle size distribution, monodisperse and no aggregation.
● Fine adhesion to various powders and it improves the flowability

General Properties

<table>
<thead>
<tr>
<th>Parameter</th>
<th>QSG-170</th>
<th>QSG-100</th>
<th>QSG-90</th>
<th>QSG-80</th>
<th>QSG-30</th>
<th>QSG-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shape</td>
<td>White powder</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average particle size* (nm)</td>
<td>170</td>
<td>110</td>
<td>90</td>
<td>80</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>Bulk density (g/cm³)</td>
<td>0.44</td>
<td>0.44</td>
<td>0.44</td>
<td>0.44</td>
<td>0.22</td>
<td>0.22</td>
</tr>
<tr>
<td>True specific gravity</td>
<td>1.8</td>
<td>1.8</td>
<td>1.8</td>
<td>1.8</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Specific surface area (m²/g)</td>
<td>16</td>
<td>25</td>
<td>30</td>
<td>40</td>
<td>150</td>
<td>160</td>
</tr>
<tr>
<td>Hydrophobicity, Methanol wettability (%)</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>72</td>
</tr>
<tr>
<td>Production method</td>
<td>Sol-Gel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The average particle size by dynamic light scattering (Laser Doppler)

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