Silicones for Paints & Coatings

Silicone based Resins

Surface Modifiers for Coating

Resin Hybridization Agents

Surface Modifiers for Pigments & Fillers
In our quest to serve the complex needs of users in diverse industries, Shin-Etsu Silicone has developed in excess of 5,000 different products. We brought our technical expertise to bear in the field of coating agents and paints to develop a wide array of products. Our Silicone based Resins, Resin Hybridization Agents, Surface Modifiers for Coating, and Surface Modifiers for Pigments & Fillers are used extensively to make your products meet the demanding needs of your customers.

Take your products to the next level with Shin-Etsu Silicones.

*For information on handling precautions and packaging, see the catalog for the relevant product. Please read the Safety Data Sheet (SDS) before use. SDS can be obtained from our Sales Departments.
Silicones are a type of hybrid material which has properties of both organic and inorganic materials.

**Features of Silicones**

Silicones are a type of hybrid material which has properties of both organic and inorganic materials.

**Structures of Silicones**

All silicone products are composed of the four basic units shown at right. How they are combined will determine the category in which the product falls.

**Features of materials with siloxane bonds**

- High bonding energy (106 kcal/mol): Resists breakdown from heat and light. Around 25% higher bonding energy than C-C bonds.

**Features of materials with siloxane chain**

- Helical molecule & low intermolecular force: Excellent water repellency, defoaming, and release properties (interfacial characteristics); gas permeable. Physical properties are not strongly temperature dependent.

**Structure of Resin**

- Three-dimensional network structure composed primarily of T Units.
- Owing to their dense structures, silicone resins outperform other silicones in weatherability and heat resistance.

- Used for resin modification and to make heat- and weather-resistant paints.
- Constituent Units: D Units, T Units, (Q Units)

**Structure of Fluid**

- Dimethyl polysiloxane composed primarily of D Units.
- Low surface tension, with excellent water repellency and release properties.

- Used for resin modification and to make release agents, defoamers, etc.
- Constituent Units: D Units, T Units

**Features of Silicones**

- High bonding energy (106 kcal/mol): Resists breakdown from heat and light. Around 25% higher bonding energy than C-C bonds.

- Helical molecule & low intermolecular force: Excellent water repellency, defoaming, and release properties (interfacial characteristics); gas permeable. Physical properties are not strongly temperature dependent.

**Characteristics imparted by organic groups**

- **Primary Organic Groups**
  - Methyl groups: hydrophobicity
  - Phenyl groups: compatibility with resins, heat resistance
  - Polyether groups: hydrophilicity
  - Alkoxyl groups: adhesiveness, moisture-cure properties
  - Amino groups: reactive with epoxies and other resins
  - (Meth)acryl groups: radical polymerization

**Structure of Silane**

- Each molecule contains two functional groups with different reactivity.
- Constituent Units: M Units, D Units, T Units, Q Units

**Structure of Resin**

- Three-dimensional network structure composed primarily of T Units.
- Owing to their dense structures, silicone resins outperform other silicones in weatherability and heat resistance.

- Used for resin modification and to make heat- and weather-resistant paints.
- Constituent Units: D Units, T Units, (Q Units)
Product Map – 4 Types of Silicone Usage –

Silicone based Resins

Silicone Resins
- Structure: Resin having a high molecular weight and 3D siloxane network structure.
- Features: With excellent film-forming abilities, coatings can range from very hard to flexible.

Silicone Oligomers (Type A)
- Structure: Resin having a relatively low molecular weight and 3D siloxane network structure. Molecules contain alkoxy groups and non-reactive functional groups.
- Features: Can be used as coating materials, or to modify organic resins.

Base Resins

Resin Hybridization Agents

Silane Coupling Agents
- Structure: Monomers whose molecules contain alkoxy groups and reactive functional groups.
- Features: While alkoxy groups improve adhesion to inorganic materials, reactive functional groups improve adhesion to organic materials.

Silicone Oligomers (Type AR)
- Structure: Resin having relatively a low molecular weight and 3D siloxane network structure. Molecules contain alkoxy groups and reactive functional groups.
- Features: Can be used as an organic resin modifier or reactive diluents.

Silicone Resins
- Structure: Resin having a high molecular weight and 3D siloxane network structure.
- Features: With excellent film-forming abilities, coatings can range from very hard to flexible.

Modified Silicone Fluids
- Structure: 2D siloxane main chain with reactive or non-reactive functional groups in the side chains and on the ends.
- Features: Silicone fluids having reactive functional groups can be used for the modification of organic resins.

Components of Paints & Coatings

Acrylic Resins

Polyester & Alkyd Resins

Epoxy Resins

Urethane Resins

Heat Resistance

Electrical Insulation

Weatherability

Water Repellency

Adhesion

Weather Resistance

Flexibility

Weathering

Adhesion

Heat Resistance

Weather Resistance

Flexibility

Adhesion

Slip

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Surface Modifiers for Coating

Silicone Powders
- **Structure (3 types):** Resin, rubber & resin coated rubber
- **Features:** Available in a variety of particle sizes to meet a range of requirements.

KP Series
- **Features:** Surface Modifiers designed to use as leveling agents, defoamers, slip agents, and in paints and coatings.

Surface Modifiers for Pigments & Fillers

Silane Coupling Agents
- **Structure:** Monomers whose molecules contain alkoxy groups and reactive functional groups.
- **Features:** While alkoxy groups improve adhesion to inorganic materials, reactive functional groups improve adhesion to organic materials.

Spherical Silica Fine Particles
- **Structure:** Very small particle size with narrow particle size distribution. Particle surfaces are treated to give them extra water repellency.
- **Features:** Monodisperse, less aggregation. Highly adhesive to various powders. Improves flowability.

Additives
- **Pigments & Coatings**

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Silicone based Resins

Silicone resins are composed primarily of T Units and have a 3D structure. Silicone resins form coatings with excellent heat resistance and weatherability. Unmodified silicones include methyl and methyl phenyl resins, while the organic resin-modified types include epoxy-modified, polyester-modified, and alkyd-modified resins.

**Features**
- Heat Resistance
- Weatherability
- Flexibility
- High Hardness
- Anti-corrosion Properties
- Electrical Insulation

## Product List

<table>
<thead>
<tr>
<th>Product name</th>
<th>Type</th>
<th>Non-volatile content</th>
<th>Solvent</th>
<th>Cure speed</th>
<th>Hardness</th>
<th>Compatibility with organic resins</th>
<th>Main applications</th>
<th>Cure conditions</th>
<th>Applicable type</th>
<th>Features</th>
<th>TSCA</th>
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</thead>
<tbody>
<tr>
<td>KR-220L</td>
<td>Methyl</td>
<td>100 (^*1)</td>
<td>None</td>
<td>Rapid</td>
<td>High</td>
<td>Low</td>
<td>Heat resistant and flame retardant binders</td>
<td>Baking</td>
<td>Powder, solvent</td>
<td>White flake, excellent heat resistance and flame retardance, very little smoking upon heating</td>
<td>Listed</td>
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<tr>
<td>KR-220LP</td>
<td>Methyl</td>
<td>100 (^*1)</td>
<td>None</td>
<td>Rapid</td>
<td>High</td>
<td>Low</td>
<td>Heat resistant and flame retardant binders</td>
<td>Baking</td>
<td>Powder, solvent</td>
<td>Powder type of KR-220L</td>
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<tr>
<td>KR-242A</td>
<td>Toluene, isopropyl alcohol</td>
<td>50</td>
<td>Rapid</td>
<td>High</td>
<td>Low</td>
<td>Heat resistant and flame retardant binders</td>
<td>Baking</td>
<td>Solvent</td>
<td>Excellent heat resistance and flame retardance</td>
<td>Not Listed</td>
<td></td>
</tr>
<tr>
<td>KR-251</td>
<td>Toluene</td>
<td>20</td>
<td>Rapid</td>
<td>Medium</td>
<td>Low</td>
<td>Water proofing and insulating coatings</td>
<td>Baking, room temperature</td>
<td>Solvent</td>
<td>Thin hard coating</td>
<td>Listed</td>
<td></td>
</tr>
<tr>
<td>KR-255</td>
<td>Toluene, xylene</td>
<td>50</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Water proofing and insulating coatings</td>
<td>Baking, room temperature</td>
<td>Solvent</td>
<td>Glossy hard coating</td>
<td>Listed</td>
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<tr>
<td>KR-282</td>
<td>Xylene</td>
<td>50</td>
<td>Slow</td>
<td>Low</td>
<td>Medium</td>
<td>Heat resistant paints</td>
<td>Baking</td>
<td>Solvent</td>
<td>Excellent flexibility and anti-cracking properties</td>
<td>Listed</td>
<td></td>
</tr>
<tr>
<td>KR-300</td>
<td>Xylene</td>
<td>50</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Heat resistant paints</td>
<td>Baking</td>
<td>Solvent</td>
<td>Excellent heat resistance and high hardness coating</td>
<td>Not Listed</td>
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</tr>
<tr>
<td>KR-311</td>
<td>Xylene</td>
<td>60</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td>Heat resistant paints</td>
<td>Baking</td>
<td>Solvent</td>
<td>Excellent heat resistance and compatibility with organic resins</td>
<td>Listed</td>
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<tr>
<td>KR-216</td>
<td>Propyl</td>
<td>100 (^*1)</td>
<td>None</td>
<td>Slow</td>
<td>Medium</td>
<td>High</td>
<td>Resin modification</td>
<td>Baking</td>
<td>Powder, solvent</td>
<td>Solid shape, solventless, excellent compatibility</td>
<td>Listed</td>
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<tr>
<td>ES-1001N</td>
<td>Epoxy</td>
<td>45</td>
<td>Xylene, diacetone alcohol, n-butanol</td>
<td>-</td>
<td>-</td>
<td>Heat resistant paints</td>
<td>Baking</td>
<td>Solvent</td>
<td>Excellent anti-corrosion property, heat resistance and weatherability</td>
<td>Listed</td>
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<tr>
<td>ES-1002T</td>
<td>Epoxy</td>
<td>60</td>
<td>Toluene</td>
<td>-</td>
<td>-</td>
<td>Heat resistant paints</td>
<td>Baking, room temperature*4</td>
<td>Solvent</td>
<td>Excellent anti-corrosion property and chemical resistance</td>
<td>Listed</td>
<td></td>
</tr>
<tr>
<td>ES-1023</td>
<td>Epoxy</td>
<td>45</td>
<td>Xylene, diacetone alcohol</td>
<td>-</td>
<td>-</td>
<td>Heat resistant paints</td>
<td>Baking</td>
<td>Solvent</td>
<td>Excellent anti-corrosion properties</td>
<td>Not Listed</td>
<td></td>
</tr>
<tr>
<td>KR-5206</td>
<td>Alkyd</td>
<td>50</td>
<td>Xylene</td>
<td>-</td>
<td>-</td>
<td>Heat resistant paints</td>
<td>Baking, room temperature*4</td>
<td>Solvent</td>
<td>Excellent flexibility and adhesion</td>
<td>Not Listed</td>
<td></td>
</tr>
<tr>
<td>KR-5230</td>
<td>Alkyd</td>
<td>60</td>
<td>PGMAC(^*2), MMBAC(^*3), isobutyl alcohol</td>
<td>-</td>
<td>-</td>
<td>Heat resistant paints</td>
<td>Baking</td>
<td>Solvent</td>
<td>Excellent flexural resistance, heat resistance and weatherability</td>
<td>Listed</td>
<td></td>
</tr>
<tr>
<td>KR-5234</td>
<td>Alkyd</td>
<td>60</td>
<td>PGMAC(^*2), MMBAC(^*3), isobutyl alcohol</td>
<td>-</td>
<td>-</td>
<td>Heat resistant paints</td>
<td>Baking</td>
<td>Solvent</td>
<td>Retains glossy appearance under high temperature</td>
<td>Not Listed</td>
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<tr>
<td>KR-5235</td>
<td>Alkyd</td>
<td>60</td>
<td>PGMAC(^*2), MMBAC(^*3), isobutyl alcohol</td>
<td>-</td>
<td>-</td>
<td>Heat resistant paints</td>
<td>Baking</td>
<td>Solvent</td>
<td>Excellent releasability and non-stick properties</td>
<td>Not Listed</td>
<td></td>
</tr>
</tbody>
</table>

* \(^*1\) Active ingredient
* \(^*2\) PGMAC : Propylene glycol monomethylether acetate
* \(^*3\) MMBAC : 3-Methyl-3-methoxybutyl acetate
* \(^*4\) ES-1002T must be used with KP-390 (cross-linker).

## Products Types and Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Type</th>
<th>Methyl type</th>
<th>Methyl / Phenyl type</th>
<th>Epoxy modified resin</th>
<th>Alkyd modified resin</th>
<th>Polyester modified resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat resistance</td>
<td>**</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Hardness</td>
<td>++</td>
<td>+</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>Weatherability</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Flexibility</td>
<td>-</td>
<td>-</td>
<td>±</td>
<td>±</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Anti-corrosion property</td>
<td>±</td>
<td>±</td>
<td>++</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
</tbody>
</table>

* ++:Excellent  +: Good ±: Satisfactory -: Poor (Not specified values)
Methyl silicone resin that contains no phenyl groups.

T Units / D Units Ratio and phenyl content are key factors determining hardness, cure speed and compatibility with organic resins, but not all products fit this pattern.

*1 Methyl silicone resin that contains no phenyl groups.

*2 T Units / D Units Ratio and phenyl content are key factors determining hardness, cure speed and compatibility with organic resins, but not all products fit this pattern.

**Map of Structures and Features**

**Product Type**

**Methyl / Phenyl Type & Propyl / Phenyl Type**

- **Methyl Type**
  - Solution: KR-242A
  - Powder: KR-220LP
  - Ultra-high molecular weight: KR-251

- **Epoxy Type**
  - Improved adhesion & thermal shock resistance: ES-1001N
  - Room temperature drying: ES-1023
  - Even higher hardness: KR-311

- **Polyester Type**
  - Imparts Non-stick property: KR-5230
  - Improved cure speed: KR-5234

**KR-251**

- High hardness
- Room temperature drying
- Even higher hardness
- Improved adhesion & thermal shock resistance

- **KR-255**
  - Even higher hardness
  - Room temperature drying

- **KR-300**
  - Improved adhesion & thermal shock resistance

- **KR-212**
  - High hardness
Silicone resins are used in a wide range of applications. Taking advantage of 3D molecular structures, silicone resins exhibit excellent heat resistance, weatherability, and electrical insulation.

- **Model of Silicone Resins**

- **Before Curing**

- **After Curing**

- **Heat Resistance: Comparison Data with Organic Resins (under 250°C)**

- **Weather Resistance: Comparison Data with Organic Resins**

- **Sunlight Absorption: Comparison Data with Organic Resins**

*Methyl silicone is not affected by sunlight, because sunlight passes through it.*
Unique Silicone Resins

Technology perfected over several decades created a line of silicone resins with unique performance features.

Solid Silicone Resin KR-220L

Solid silicone resin consisting of 100% active content. Available in flake or powder form. Heat-cured resin, and because it is a liquid at temperatures between 80°–150°C, it can be used without a solvent. Can be used to make binders and powder coatings. And because it dissolves in toluene and isopropyl alcohol, KR-220L offers a great number of possibilities in the ways it can be used.

- **Dry Blend**
  - KR-220L
  - Grinding
  - Mix with filler
  - *Catalysts may also be added

- **Solution Blend**
  - KR-220L
  - Solvent
  - Dissolve in solvent
  - Add fillers
  - Solvent elimination
  - *Catalysts may also be added

- **Melt Blend**
  - KR-220L
  - Heating
  - Melt
  - Filler addition
  - Cool
  - *Catalysts may also be added

Ultra High Molecular Weight Silicone Resin KR-251

KR-251 is a methyl silicone resin with a very high molecular weight. Due to its excellent film-forming ability, KR-251 forms coatings with just a simple drying process. In addition, because it contains D units, KR-251 forms coatings that resist cracking even after heat-curing.

- **Model of Coating Structure**
  - **Common Grade Silicone Resin**
    - Low molecular weight
    - Heat cure or Catalyst
    - Heat cure or Catalyst
    - Easy to crack due to high crosslinking density

  - **KR-251**
    - High molecular weight
    - Heat cure or Catalyst
    - Forms a high quality film by air drying alone
    - Forms a harder coating film.

    The collection of large molecules translates to excellent crack resistance, film-forming ability, and toughness.

Highly Durable Heat Resistant Paint Resins ES-1023/KR-311

The combination of the epoxy-modified silicone resin ES-1023 (with its outstanding corrosion resistance and adhesiveness) and the unmodified silicone resin KR-311 (with its high heat resistance), a highly durable and heat resistant coating is formed.

- **Application Examples**
  - **Blending example of base coating**
    - ES-1023: 30wt%
    - Zinc powder: 40wt%
    - Talc: 10wt%
    - Xylene: 20wt%
  - **Blending example of top coating**
    - KR-311: 40wt%
    - Ceramic black: 20wt%
    - Talc: 20wt%
    - Xylene: 20wt%

  - **Base coat**
    - ES-1023
    - Substrate: Steel plate
  - **Top coat**
    - KR-311
    - Base coat: ES-1023
    - Substrate: Steel plate

1. **Applying the base coat**
   - Baking: 150°C-180°C×20 to 30 min.

2. **Applying the top coat**
   - Baking: 150°C-200°C×20 to 30 min.
Type A silicone oligomers (please refer P.4) are used with a curing agent to produce coatings that cure at ambient temperatures and humidities. In recent years, these oligomers have been widely used for exterior automotive coatings and interior floor coatings.

2-Part Room Temperature Moisture Cure Coatings

With a range of silicone oligomers and curing agents to choose from, the user has a great degree of control over the cure speed, hardness, or flexibility of the cured coating.

With silicone oligomers, the degree of polymerization and ratio of 3D crosslinking (T Units) to 2D crosslinking (D Units) will influence such properties as curing speed and the hardness and/or flexibility of the coating. For example, by combining a methyl silicone oligomer with a lesser proportion of a phenyl oligomer, a coating with enhanced flexibility and glossiness is produced.

Methyl Type

Features : Excellent water repellency, cure speed

<table>
<thead>
<tr>
<th>Product name</th>
<th>Features</th>
<th>TSCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>KR-401N</td>
<td>Excellent curability, Gloss</td>
<td>Listed</td>
</tr>
<tr>
<td>X-40-2227</td>
<td>Imparts flexibility</td>
<td>Listed</td>
</tr>
<tr>
<td>KR-510</td>
<td>Forms high hardness coating</td>
<td>Listed</td>
</tr>
<tr>
<td>KR-9218</td>
<td>Forms medium hardness coating</td>
<td>Listed</td>
</tr>
</tbody>
</table>

Phenyl Type

Features : Excellent water repellency, cure speed

<table>
<thead>
<tr>
<th>Product name</th>
<th>Type</th>
<th>Adding amount wt%</th>
<th>Features</th>
<th>TSCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-220</td>
<td>Phosphoric acid</td>
<td>5-10</td>
<td>Very high activity</td>
<td>Listed</td>
</tr>
<tr>
<td>X-40-2309A</td>
<td>Phosphoric acid</td>
<td>10-50</td>
<td>High activity can accelerate curing</td>
<td>Listed</td>
</tr>
<tr>
<td>D-25</td>
<td>Titanium</td>
<td>0.5-3</td>
<td>Higher activity than D-20</td>
<td>Listed</td>
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<tr>
<td>D-20</td>
<td>Titanium</td>
<td>2-5</td>
<td>Slow reactivity</td>
<td>Listed</td>
</tr>
<tr>
<td>DX-175</td>
<td>Titanium</td>
<td>3-5</td>
<td>Solvent diluted type (Easy to use)</td>
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<tr>
<td>DX-9740</td>
<td>Aluminum</td>
<td>0.5-6</td>
<td>Forms high hardness coating</td>
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<tr>
<td>CAT-AC</td>
<td>Aluminum</td>
<td>0.5-10</td>
<td>Solvent diluted type (Easy to use)</td>
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Blending Examples and Film Properties

<table>
<thead>
<tr>
<th>Product name</th>
<th>Parameter</th>
<th>Catalyst (adding amount) %</th>
<th>Film thickness μm</th>
<th>Tack free 25℃ min</th>
<th>Pencil hardness</th>
<th>Flexural resistance / Impact resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>KR-500</td>
<td>D-20(2)</td>
<td>D-20(2)</td>
<td>25</td>
<td>40</td>
<td>H</td>
<td>+</td>
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<tr>
<td>KR-500</td>
<td>D-20(3)</td>
<td>DX-9740(5)</td>
<td>25</td>
<td>100</td>
<td>5H</td>
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<tr>
<td>X-40-9225</td>
<td>D-20(3)</td>
<td>D-20(3)</td>
<td>30</td>
<td>60</td>
<td>H</td>
<td>+</td>
</tr>
<tr>
<td>X-40-9250</td>
<td>D-20(2)</td>
<td>D-20(2)</td>
<td>80</td>
<td>75</td>
<td>F</td>
<td>+</td>
</tr>
</tbody>
</table>

*: Excellent ± : Satisfactory - : Poor

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

*1 KR-500 and X-40-9225 are listed in TSCA. X-40-9250 is not listed in TSCA.
1-Part Room Temperature Moisture Cure Coatings

These coating agents come pre-mixed with a curing agent. These one-component products cure at room temperature with exposure to moisture in the air. KR-400 is designed to produce high hardness coatings. X-40-2327 is fast curing, while KR-401 produces coatings with high flex resistance and impact resistance.

### New Products

Our product offerings include coating agents with special features such as enhanced water repellency, antistatic properties and UV shielding abilities.

#### Fluorine-containing type KR-400F

**Features:** Fluorine is incorporated for enhanced slip property, water repellency and anti fouling properties.

**Water Contact Angle on a KR-400F Film**

110°

**Model of Ultraviolet-shielding**

**Data of Light Transmissivity**

#### Ultraviolet-shielding type X-40-9309A

**Features:** The silicone coating resists breakdown from UV rays, and also helps prevent degradation of the underlying substrate.

#### Antistatic type X-40-2450X

**Features:** Forms an antistatic layer on surfaces, thus making them less likely to attract dirt and dust.
We have products designed for use with water-based, solvent-based, and UV-cure acrylic resins.

### Resulting Properties
- Better heat resistance
- Higher weatherability
- Improved water repellency
- Increased flexibility
- Enhanced wear resistance
- Better water resistance
- Improved adhesion
- Higher hardness
- Room-temperature curability

### Properties that can be Imparted to Acrylic Resins

<table>
<thead>
<tr>
<th>Heat Resistance</th>
<th>Water Resistance</th>
<th>Flexibility</th>
<th>Adhesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Additive</td>
<td>Silane Coupling Agents</td>
<td>Silicone Oligomers</td>
<td>Silicone Resins</td>
</tr>
</tbody>
</table>

### Product List Water type, Solvent type

<table>
<thead>
<tr>
<th>Product category</th>
<th>Product name</th>
<th>Type</th>
<th>Active ingredient %</th>
<th>Solvent</th>
<th>Applicable type</th>
<th>Recommended adding amount %</th>
<th>Features</th>
<th>TSCA</th>
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</thead>
<tbody>
<tr>
<td>Silane coupling agents (Radical reaction type)</td>
<td>KBM-1003</td>
<td>Vinyl</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-2.0</td>
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<td>KBM-503</td>
<td>Methacrylic</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-2.0</td>
<td>Methoxy tri-functional</td>
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<td>Methacrylic</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-2.0</td>
<td>Ethoxy di-functional</td>
<td>Not Listed</td>
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<td>Silane coupling agents (Room temperature cure type)</td>
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<td>KBM-403</td>
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<td>100</td>
<td>None</td>
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<td>KBE-903</td>
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<td>Silicone oligomers</td>
<td>KC-89S</td>
<td>Methyl</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
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<td>Low DP (degree of polymerization)</td>
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<td>KR-515</td>
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<td>KR-500</td>
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<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>10-20</td>
<td>Medium DP</td>
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<td></td>
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<tr>
<td>KR-510</td>
<td>Methyl / Phenyl</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>10-20</td>
<td>Excellent compatibility</td>
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<tr>
<td>KR-211</td>
<td>Methyl / Phenyl</td>
<td>70</td>
<td>Xylene</td>
<td>Solvent</td>
<td>10-50</td>
<td>Excellent compatibility</td>
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<td>Methyl / Phenyl</td>
<td>70</td>
<td>Xylene</td>
<td>Solvent</td>
<td>10-50</td>
<td>Excellent flexibility and compatibility</td>
<td>Listed</td>
<td></td>
</tr>
<tr>
<td>KR-216</td>
<td>Propyl / Phenyl</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>10-50</td>
<td>Solid type</td>
<td>Listed</td>
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<td>Silicone resins</td>
<td>X-22-174ASX</td>
<td>Single-end Methacrylic</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>0.5-20</td>
<td>Short chain length</td>
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<tr>
<td>X-22-174BX</td>
<td>Single-end Methacrylic</td>
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<td>None</td>
<td>Solvent</td>
<td>0.5-20</td>
<td>Medium chain length</td>
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<td>KF-2012</td>
<td>Single-end Methacrylic</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>0.5-20</td>
<td>Long chain length</td>
<td>Listed</td>
<td></td>
</tr>
</tbody>
</table>

### Application Examples
- Construction exterior parts
- Heavy-duty anticorrosion, exterior building (Chemical plant)
- Automotive paint (Car, Train)
- Automotive parts
- Display, electrical equipment

![Exterior construction parts](image1)

![Hard coating](image2)

![Heavy-duty anticorrosion paint](image3)
Resin Hybridization Agents

Process of silicone hybridization

Water, Solvent type

Radical Polymerization

- Acrylic Monomer + Silane Coupling Agents Radical Reaction Type
- Single-end Modified Silicone Fluids

Heat Reaction

- Weatherability, Adhesion, Room Temperature Cure, Weatherability, Water Resistance
- Water Repellency, Flexibility

Dehydration or Dealcoholization Condensation

- Acrylic Polymer + Silicone Oligomers

Silane Coupling Agents Radical Reaction Type

- Room Temperature Cure Type
- Heat Resistance, Weatherability
- Adhesion, Water Resistance

Dehydration-condensation

- Acrylic Polymer + Silicone Resins

Reaction with Organic Functional Groups

- Acrylic Polymer + Silane Coupling Agents Room Temperature Cure Type

Properties Imparted

Silicone Oligomers
- Higher molecular weight (Improves weatherability)
- Higher molecular weight (Improves weatherability)
  - Imparts phenyl groups (Improves compatibility)
  - KR-510

Modified Silicone Fluids
- Short chain type (Excellent radical copolymerizability)
- Longer chain (Improves water repellency, releasability)
- Longer chain, single-end termination (Improves water repellency, film-forming ability and copolymerization ability)

Silicone Oligomers
- Higher molecular weight and phenyl groups (Improves flexibility and compatibility)
- KR-212
  - KR-211
  - Solidification (Solvent less)
  - KR-216

Silicone Resins
- Higher molecular weight and phenyl groups (Improves flexibility and compatibility)
- KR-212
  - KR-211
  - Solidification (Solvent less)

Silane Coupling Agents Radical Reaction Type

- Methacrylic Type
  - Methoxy / Tri-functional (Standard)
  - KBM-503
    - Di-functionalization (Improves storage stability, water repellency, lower VOC content)
    - KBM-502
  - Di-functionalization (Improves storage stability, water repellency, lower VOC content)
  - KBE-503 → KBE-502

Product Type
**Synthesis Examples of Heat Reaction Type**

**Modification via Radical Polymerization using KBM-503**
Results in improved adhesion to substrates and improved moisture resistance.

**Water Type**
- MMA*, BMA** etc.
- KBM-503: 0.5-2 wt. part
- Water: 50-100 wt. part
- Polymerization Initiator Surfactant: 1-5 wt. part

**Reaction**
- Silicone Modified Acrylic Emulsion (Non-volatile content: about 50%)

**Solvent Type**
- MMA*, BMA** etc.
- KBM-503: 0.5-2 wt. part
- Solvent: 50-100 wt. part
- Polymerization Initiator Surfactant: 1-2 wt. part

**Reaction**
- Silicone Modified Acrylic Emulsion (Non-volatile content: about 50%)

---

**Modification via Dehydration-condensation or Dealkoholization-condensation using KR-500.**
Results in improved adhesion to substrates and enhanced weatherability.

- MMA etc.: 40 wt. parts
- KR-500: 5-10 wt. parts
- KBM-503: 1-2 wt. parts
- Water: 60 wt. parts
- Polymerization Initiator Surfactant: a few parts

**Stirring (Emulsifying)**
**Copolymerization (Heating)**
**Cooling**
**pH Adjustment (pH around 8)**

**Reaction**
- Silicone Modified Acrylic Emulsion (Non-volatile content: about 30-50%)

---

**Modification via Radical Polymerization using KF-2012.**
Silicone chains are grafted onto the acrylic resin, thereby improving the surface characteristics and water repellency.

- MMA etc.: Total about 50 wt. parts
- KF-2012: 5-10 wt. parts
- Solvent: 50-100 wt. parts
- Polymerization Initiator: 1-2 wt. parts

**Reaction**
- Silicone Modified Acrylic Resin (Non-volatile content: about 50%)

---

*1 MMA = Methyl methacrylate  
*2 BMA = Butyl methacrylate
Resin Hybridization Agents

Product List UV type

<table>
<thead>
<tr>
<th>Product category</th>
<th>Product name</th>
<th>Type</th>
<th>Active ingredient %</th>
<th>Solvent</th>
<th>Applicable type</th>
<th>Recommended adding amount %</th>
<th>Features</th>
<th>TSCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silane coupling agents</td>
<td>KBM-5103</td>
<td>Acrylic</td>
<td>100</td>
<td>None</td>
<td>UV</td>
<td>1-50</td>
<td>Standard product</td>
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<tr>
<td></td>
<td>X-12-1048</td>
<td>Acrylic</td>
<td>100</td>
<td>None</td>
<td>UV</td>
<td>1-50</td>
<td>Acrylic group / Si ratio = 1</td>
<td>Listed</td>
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<tr>
<td></td>
<td>X-12-1050</td>
<td>Acrylic</td>
<td>100</td>
<td>None</td>
<td>UV</td>
<td>1-50</td>
<td>Polymer type, Acrylic group / Si ratio = 5</td>
<td>Listed</td>
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<td>Silicone oligomers</td>
<td>KR-513</td>
<td>Acrylic / Methyl</td>
<td>100</td>
<td>None</td>
<td>UV</td>
<td>10-50</td>
<td>Condensation cure type of KBM-5103</td>
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<tr>
<td></td>
<td>X-40-9308</td>
<td>Acrylic</td>
<td>100</td>
<td>None</td>
<td>UV</td>
<td>10-50</td>
<td>High hydrolyzability</td>
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<td>Modified silicone fluids</td>
<td>X-22-164A/B</td>
<td>Dual-end Methacrylic</td>
<td>100</td>
<td>None</td>
<td>UV</td>
<td>10-50</td>
<td>Slip property</td>
<td>Listed</td>
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<tr>
<td></td>
<td>X-22-2445</td>
<td>Dual-end acrylic</td>
<td>100</td>
<td>None</td>
<td>UV</td>
<td>10-50</td>
<td>Leveling property</td>
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</tbody>
</table>

(Not specified values)

■ Process of Silicone Hyblidization : UV Type

Properties Improved
- Adhesion
- High Hardness, Adhesion
- Water Repellency, Wear Resistance

Hard Coating Application
Silicone oligomers containing acrylic groups can be used with acrylic coating resins to produce coatings with higher hardnesses. In addition to the products described above, Shin-Etsu has other with unique molecular structures like those shown below.

Chemical Structures

Acrylic Coating Material Blend Ratio
Dipentaerythritol triacrylate : 80 wt. part
Hexanediol diacrylate : 20 wt. part
2-Hydroxy-2-methyl-1 phenyl-plopane-1-one : 10 wt. part
The above acrylic coating / Si material = 100 / 50 wt. part

Application / Cure Method
Film thickness : about 20μm
Substrate : POLYCASE made by Sumitomo Bakelite Co., Ltd. ECK100 clear 2mm thickness
UV curing condition : High-pressure mercury vaper lump 600mJ/cm² Nitrogen substitution

■ Durability Testing

<table>
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<tr>
<th>Product name</th>
<th>Pencil hardness</th>
<th>Taber abrasion test 2Haze(500g load, 100 rotations)</th>
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<tbody>
<tr>
<td>KR-513</td>
<td>2H</td>
<td>3.0</td>
</tr>
<tr>
<td>X-12-1050</td>
<td>2H</td>
<td>3.0</td>
</tr>
<tr>
<td>X-40-9308</td>
<td>2H</td>
<td>3.0</td>
</tr>
<tr>
<td>X-12-2475</td>
<td>3H</td>
<td>2.5</td>
</tr>
<tr>
<td>X-12-2444</td>
<td>3H</td>
<td>2.0</td>
</tr>
<tr>
<td>X-12-2430C</td>
<td>2H</td>
<td>3.0</td>
</tr>
<tr>
<td>Blank</td>
<td>H</td>
<td>4.0</td>
</tr>
</tbody>
</table>

(Not specified values)

X-12-2475 and X-12-2430C are not listed in TSCA. X-12-2444 is listed in TSCA.

X-12-2444* = Fluoroalkyl

*This product is diluted with multi functional acrylate solution.
Polyester and alkyd resins are inherently flexible and chemically resistant. By giving these the heat resistance and weatherability of a silicone, we create a much more durable resin.

**Resulting Properties**
- Better heat resistance
- Higher weatherability
- Increased flexibility
- Enhanced wear resistance
- Better water resistance
- Better cold resistance
- Improved adhesion

**Properties that can be Impacted to Polyester & Alkyd Resins**

<table>
<thead>
<tr>
<th>Product category</th>
<th>Product name</th>
<th>Type</th>
<th>Active ingredient %</th>
<th>Solvent</th>
<th>Applicable type</th>
<th>Recommended loading %</th>
<th>Features</th>
<th>TSCA</th>
</tr>
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<tbody>
<tr>
<td>Silane Coupling Agents</td>
<td>KBM-503</td>
<td>Methacrylic</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>0.5-2.0</td>
<td>Methoxy tri-functional</td>
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<td>KBE-503</td>
<td>Methacrylic</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>0.5-2.0</td>
<td>Ethoxy tri-functional</td>
<td>Listed</td>
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<td>KBM-502</td>
<td>Methacrylic</td>
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<td>None</td>
<td>Solvent</td>
<td>0.5-2.0</td>
<td>Methoxy di-functional</td>
<td>Not Listed</td>
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<tr>
<td></td>
<td>KBE-502</td>
<td>Methacrylic</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>0.5-2.0</td>
<td>Ethoxy di-functional</td>
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<td></td>
<td>KBM-5103</td>
<td>Acrylic</td>
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<td>None</td>
<td>Solvent</td>
<td>0.5-2.0</td>
<td>Excellent reactivity</td>
<td>Listed</td>
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<tr>
<td>Silicone Oligomers</td>
<td>KC-89S</td>
<td>Methyl</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>10-20</td>
<td>Low DP (degree of polymerization)</td>
<td>Listed</td>
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<td>KR-515</td>
<td>Methyl</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>10-20</td>
<td>Medium DP</td>
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<td>KR-500</td>
<td>Methyl</td>
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<td>None</td>
<td>Solvent</td>
<td>10-20</td>
<td>Medium DP</td>
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<td>KR-510</td>
<td>Methyl / Phenyl</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>10-20</td>
<td>Compatibility</td>
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<td>Silicone Resins</td>
<td>KR-211</td>
<td>Methyl / Phenyl</td>
<td>70</td>
<td>Xylene</td>
<td>Solvent</td>
<td>10-50</td>
<td>Excellent compatibility</td>
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<tr>
<td></td>
<td>KR-212</td>
<td>Methyl / Phenyl</td>
<td>70</td>
<td>Xylene</td>
<td>Solvent</td>
<td>10-50</td>
<td>Excellent flexibility, compatibility</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>KR-216</td>
<td>Propyl / Phenyl</td>
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<td>None</td>
<td>Solvent</td>
<td>10-50</td>
<td>Solid type</td>
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<td>Modified Silicone Fluids</td>
<td>KF-2201</td>
<td>Phenol modified</td>
<td>100</td>
<td>None</td>
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<tr>
<td></td>
<td>X-22-3701E</td>
<td>Carboxylic acid modified</td>
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<td>None</td>
<td>Solvent</td>
<td>0.5-10</td>
<td>Release property</td>
<td>Listed</td>
</tr>
</tbody>
</table>

**Application Examples**
- Building exterior parts
  (Rolled Steel)
- Consumer electronics parts
  (Facility, Equipment)
- Construction parts
- Automotive paints (Car, Train)

Painted Steel

Tanks
Resin Hybridization Agents

### Synthesis Examples

Weatherability is improved by inserting KR-510 into the polyester resin.

**● Reaction Mechanisms**
- **Dealkalization condensation reaction**
  \[\text{Polyester Resin} - \text{C-OH} + \text{RO-Si} \rightleftharpoons \text{Polyester Resin} - \text{C-O-Si} + \text{R-OH}\]
- **Dehydration condensation**
  \[\text{Polyester Resin} - \text{C-OH} + \text{HO-Si} \rightleftharpoons \text{Polyester Resin} - \text{C-O-Si} + \text{H}_{2}\text{O}\]

**● Polyester Resin modification with Silicone Oligomers**

<table>
<thead>
<tr>
<th>Product</th>
<th>Appearance</th>
<th>Viscosity at 25℃</th>
<th>Specific gravity at 25℃</th>
<th>Refractive index at 25℃</th>
<th>Active ingredient</th>
</tr>
</thead>
<tbody>
<tr>
<td>KR-510</td>
<td>Colorless to pale yellow slightly cloudy liquid</td>
<td>25</td>
<td>1.15</td>
<td>1.403</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Not specified values*  *MEK : Methyl ethyl ketone*  *Xylene rubbing*  *Silicone content 50%*  *Silicone content 30%*  *Silicone content 0%*

Heat resistance is improved by inserting a high-molecular-weight silicone resin into the alkyd resin.

**● Reaction Mechanisms**
- **Dehydration condensation**
  \[\text{Alkyd Resins} - \text{C-OH} \rightleftharpoons \text{Alkyd Resins} - \text{C-O-Si} + \text{H}_{2}\text{O}\]

**● Alkyd Resin modification with Silicone Oligomer**

<table>
<thead>
<tr>
<th>Product</th>
<th>Room Temperature Reaction</th>
<th>Heat Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkyd Resins</td>
<td>50-70 wt. parts</td>
<td>30-50 wt. parts</td>
</tr>
<tr>
<td>KR-211 or KR-212</td>
<td>50-70 wt. parts</td>
<td>30-50 wt. parts</td>
</tr>
</tbody>
</table>

**● Heat Resistance Comparison Data at 250℃**

- Silicone resins
- Silicone modified alkyd resins
- Epoxy resins
- Alkyd resins

**● Product Type**
- KR-211
  - Higher molecular weight, higher phenyl content (improved flexibility, compatibility)
- KR-212
  - Solidification (Solventless)
- KR-216
Shin-Etsu produces a line of silane coupling agents and silicone oligomers that help improve adhesion to substrates, and silicone oligomers and silicone resins that help improve the heat resistance and weatherability of epoxy resins.

**Resulting Properties**
- Better heat resistance
- Higher weatherability
- Improved adhesion
- Better water resistance

**Properties that can be Imparted to Epoxy Resins**
- Better heat resistance
- Higher weatherability
- Improved adhesion
- Better water resistance

---

**Product List**

<table>
<thead>
<tr>
<th>Product category</th>
<th>Product name</th>
<th>Type</th>
<th>Active ingredient</th>
<th>%</th>
<th>Solvent</th>
<th>Applicable type</th>
<th>Recommended adding amount %</th>
<th>Features</th>
<th>TSCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silane Coupling Agents</td>
<td>KBM-403</td>
<td>Epoxy</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>0.5-2.0</td>
<td>Standard product</td>
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<tr>
<td></td>
<td>X-12-981S</td>
<td>Epoxy</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>0.5-2.0</td>
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</tr>
<tr>
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<td>X-12-984S</td>
<td>Epoxy</td>
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<td>None</td>
<td>Solvent</td>
<td>0.5-2.0</td>
<td>Multi-functional type</td>
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<tr>
<td></td>
<td>KBE-903</td>
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<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>0.5-2.0</td>
<td>Standard product</td>
<td>Listed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>KBE-9103P</td>
<td>Amino</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>0.5-2.0</td>
<td>Protected functional group type</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>X-12-972F</td>
<td>Amino</td>
<td>15</td>
<td>Ethanol</td>
<td>Solvent</td>
<td>0.5-2.0</td>
<td>Ethanol solution, Multi functional type</td>
<td>Not Listed</td>
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</tr>
<tr>
<td>Silicone Oligomers</td>
<td>KR-516</td>
<td>Epoxy / Methyl</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>0.5-2.0</td>
<td>Epoxy equivalent 280g/mol</td>
<td>Not Listed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>KR-517</td>
<td>Epoxy</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>0.5-2.0</td>
<td>Epoxy equivalent 830g/mol</td>
<td>Not Listed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>KR-500</td>
<td>Methyl</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>10-20</td>
<td>Standard product</td>
<td>Listed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>KR-510</td>
<td>Phenyl</td>
<td>100</td>
<td>None</td>
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<td>10-20</td>
<td>Standard product</td>
<td>Listed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X-40-2670</td>
<td>Epoxy</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>10-50</td>
<td>Cyclic siloxane, Epoxy equivalent 200g/mol</td>
<td>Not Listed</td>
<td></td>
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<tr>
<td>Silicone Resins</td>
<td>KR-211</td>
<td>Methyl / Phenyl</td>
<td>70</td>
<td>Xylene</td>
<td>Solvent</td>
<td>10-50</td>
<td>Standard product</td>
<td>Listed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>KR-212</td>
<td>Methyl / Phenyl</td>
<td>70</td>
<td>Xylene</td>
<td>Solvent</td>
<td>10-50</td>
<td>Excellent flexibility, compatibility</td>
<td>Listed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>KR-216</td>
<td>Propyl / Phenyl</td>
<td>100</td>
<td>None</td>
<td>Solvent</td>
<td>10-50</td>
<td>Solid type</td>
<td>Listed</td>
<td></td>
</tr>
</tbody>
</table>

---

**Application Examples**
- Heavy-duty
  (Bridges, Tanks, Steel structures)
- Marine paint

- Bridge
- Pipes
- Marine Paint
Protected Functional Group Silane Coupling Agent KBE-9103P

The functional group is protected in KBE-9103P, which means the silane can be mixed with materials that are chemically incompatible. The user can also expect improved adhesion.

- **Resulting Properties**
  - More stable compositions (epoxy resins)
  - Improved adhesion

- **Chemical Structure of KBE-9103P**

---

Multi Functional Silane Coupling Agent

These silane coupling agents contain an organic polymer chain with alkoxy groups and several organic functional groups. Their large number of reaction sites helps guarantee better adhesion. Because their main components are low in volatility and they have good film-forming ability, these silane coupling agents can also be used as primers.

- **Chemical Structure of Multi Functional Silane Coupling Agents**

---

**Features and Resulting Properties**
- Many sites for reaction with resins → Improved coupling performance
- Low volatility → Less silane required
- Film-forming ability → Can be used as primer
- Contain trialkoxysilyl groups → Improved adhesion

---

**Product List**

<table>
<thead>
<tr>
<th>Organic functional group</th>
<th>Product name</th>
<th>Alkoxy group</th>
<th>Number of reactive groups per Si (Not specified values)</th>
<th>Viscosity mm/s</th>
<th>Reactive group equivalent g/mol</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amino</td>
<td>X-12-972F</td>
<td>EIO</td>
<td>5</td>
<td>8.6</td>
<td>600</td>
<td>15% Ethanol solution</td>
</tr>
<tr>
<td>Epoxy</td>
<td>X-12-981S</td>
<td>EIO</td>
<td>3</td>
<td>1,000</td>
<td>290</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>X-12-984S</td>
<td>EIO</td>
<td>3</td>
<td>2,000</td>
<td>270</td>
<td>-</td>
</tr>
</tbody>
</table>

**Synthesis Example**

Heat resistance is improved by inserting KR-212 into the epoxy resin.

- **Reaction Mechanism**
  - Dehydration condensation
  - \[ -\text{C}-\text{OH} + \text{HO}-\text{Si} \equiv \rightarrow \text{Epoxy Resin} -\text{C}-\text{O}-\text{Si} \equiv + \text{H}_2\text{O} \]

- **General Properties**

---

**Modification Example with Silicone Resins**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Type</th>
<th>Appearance</th>
<th>Viscosity at 25°C mPa•s</th>
<th>Viscosity at 25°C mm/s</th>
<th>Specific gravity at 25°C</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>KR-212</td>
<td>Methyl / Phenyl type</td>
<td>Colorless</td>
<td>28</td>
<td>8.6</td>
<td>1.07</td>
<td>Xylene</td>
</tr>
</tbody>
</table>

(Not specified values)
Many types of polyurethane (e.g. thermoplastic polyurethane and synthetic leathers) can be modified with silicones to improve adhesion, flexibility, wear resistance and slip property.

**Resulting Properties**
- Better heat resistance
- Higher weatherability
- Increased flexibility
- Enhanced wear resistance
- Improved adhesion
- Better water resistance
- Improved slip property

**Properties that can be Impacted to Urethane Resins**

- **Heat Resistance**
- **Weatherability**
- **Water Resistance**
- **Adhesion**
- **Flexibility**

**Product List**

<table>
<thead>
<tr>
<th>Product category</th>
<th>Product name</th>
<th>Type</th>
<th>Active ingredient %</th>
<th>Solvent</th>
<th>Applicable type</th>
<th>Recommended adding amount %</th>
<th>Features</th>
<th>TSCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silane Coupling Agents</td>
<td>KBE-9103P</td>
<td>Amino</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-2.0</td>
<td>Protected functional group</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>KBM-9659</td>
<td>Isocyanurate</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-2.0</td>
<td>Multi-functional</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>X-12-5263HP</td>
<td>Amino</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-2.0</td>
<td>Bis amine</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>X-12-1056ES</td>
<td>Mercapto group protected</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-2.0</td>
<td>Protected functional group, low odor</td>
<td>Not Listed</td>
</tr>
<tr>
<td></td>
<td>KBE-9007</td>
<td>Isocyanate</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-2.0</td>
<td>Ethoxy tri-functional</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>KBM-403</td>
<td>Epoxy</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-2.0</td>
<td>Methoxy tri-functional</td>
<td>Listed</td>
</tr>
<tr>
<td>Modified Silicone Fluids</td>
<td>KF-6000</td>
<td>Dual-end carbinol</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-20</td>
<td>Excellent compatibility</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>KF-6001</td>
<td>Dual-end carbinol</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-20</td>
<td>Flexibility, wear resistance</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>X-22-170BX</td>
<td>Single-end carbinol</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-10</td>
<td>Excellent compatibility</td>
<td>Not Listed</td>
</tr>
<tr>
<td></td>
<td>X-22-176DX</td>
<td>Single-end diol</td>
<td>100</td>
<td>None</td>
<td>Water or solvent</td>
<td>0.5-10</td>
<td>Surface slick property</td>
<td>Not Listed</td>
</tr>
</tbody>
</table>

**Application Examples**

- Construction parts
- Consumer electronics parts
- Automotive interior parts

- Synthetic Leathers for Automotive
- Interior Sealant
**Protected Functional Group Silane Coupling Agent X-12-1056ES**

The organic functional group in X-12-1056ES is protected. This means the user may be able to use a one-component formulation where a two-component formulation was once required, or that the Silane Coupling Agent can be added at the same time as reactive materials because unwanted reactions are prevented. It also means a greatly increased shelf life.

### Application Example of Protected Mercapto Group Silane Coupling Agent X-12-1056ES

![Diagram of the reaction of SH and NCO](image)

- Deprotection of S-Si
- Reaction of SH and NCO
- Hydrolyzable groups react with substrate
- Isocyanate crosslinking

### Stability with Isocyanate Compounds

![Graphs showing change in viscosity](image)

- Change in viscosity when mixed with aromatic isocyanate (M-200)
  - Condition: Silane 5 wt% added, storage at 50°C
  - **KBM-803**: 2,000 mPa•s at 0 days, increases to 15,000 mPa•s at 30 days
  - **X-12-1056ES**: 2,000 mPa•s at 0 days, increases to 15,000 mPa•s at 30 days

### Synthesis Examples

#### Modification Example with Single-end Diol Fluids

**Urethane Resins**
- 90-99 wt. parts

**X-22-176DX**
- 1-10 wt. parts

### Resulting Properties

1. Slip property
2. Wear resistance

#### Model of Graft Copolymer

**Structure of X-22-176DX**

![Structure of X-22-176DX](image)

**Graft Copolymer**

#### Modification Example with Dual-end Carbinol Fluids

**Urethane Resins**
- 80-99 wt. parts

**KF-6001**
- 1-20 wt. parts

### Resulting Properties

1. Flexibility
2. Wear resistance

#### Model of Block Copolymer

**Structure of KF-6001**

![Structure of KF-6001](image)

**Block Copolymer**

![Diagram of the reaction of SH and NCO](image)
Shin-Etsu has developed a unique line of silicone powders which fall into three categories: Hybrid Silicone Powder, Silicone Rubber Powder and Silicone Resin Powder. These products impart a variety of properties (i.e. lubricity, wear resistance and light diffusion) into coating agents and paints.

### Silicone Resin Powder
- **Molecular structure:** 3D network structure
  - **Features:**
    - Heat resistance: ++
    - Weatherability: ++
    - Dispersibility into resins: ++
    - With organic solvents: No swelling

### Silicone Rubber Powder
- **Molecular structure:** Straight-chain crosslinked polymer
  - **Features:**
    - Heat resistance: +
    - Weatherability: ++
    - Dispersibility into resins: ±
    - With organic solvents: Swelling

### Hybrid Silicone Powder
- **Form:** Rubber powders covered with resin
  - **Features:**
    - Heat resistance: +
    - Weatherability: ++
    - Dispersibility into resins: ++
    - With organic solvents: Rubber part swells

### Enhanced Properties

#### Stress Relaxation, Impact Resistance
- No additive
- Coatings & Paints
  - Pressure, Impact
- Silicone Rubber & Hybrid Silicone Powder added
  - Silicone Rubber & Hybrid Silicone Powder absorb the pressure or impact and relax the stress
- Resin Powder: -
  - Rubber Powder: +
  - Hybrid Powder: ++

#### Lubricity, Wear Resistance
- Silicone Resin Powder
  - Lubricity, Wear Resistance
- Resin Powder: ++
  - Rubber Powder: +
  - Hybrid Powder: ++

#### Soft-feel Property
- Silicone Rubber Powder
  - Paints & Coatings
  - Hybrid Silicone Powder
  - Soft-feel Property
- Resin Powder: -
  - Rubber Powder: +
  - Hybrid Powder: ++

#### Light Diffusion Property
- Silicone Resin Powder
  - Silicone Rubber Powder
  - Hybrid Silicone Powder
  - Paints & Coatings
  - Light Diffusion Property
- Resin Powder: ++
  - Rubber Powder: ++
  - Hybrid Powder: ++
### Product List

<table>
<thead>
<tr>
<th>Parameter Type</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>
<th>TSCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicone resin powder</td>
<td>KMP-590</td>
<td>Spherical</td>
<td>2</td>
<td>1-4</td>
<td>1.3</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1.43</td>
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<tr>
<td></td>
<td>KMP-701</td>
<td>Spherical</td>
<td>3.5</td>
<td>1-6</td>
<td>1.3</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1.43</td>
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<tr>
<td></td>
<td>X-52-1621</td>
<td>Spherical</td>
<td>5</td>
<td>1-8</td>
<td>1.3</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1.43</td>
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<tr>
<td></td>
<td>X-52-654</td>
<td>Spherical</td>
<td>0.7</td>
<td>0.2-5</td>
<td>1.3</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1.43</td>
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<tr>
<td>Silicone rubber powder</td>
<td>KMP-594</td>
<td>Spherical</td>
<td>5</td>
<td>1-10</td>
<td>0.97</td>
<td>0.1</td>
<td>30</td>
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<td>KMP-597</td>
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<td>5</td>
<td>1-10</td>
<td>0.97</td>
<td>0.1</td>
<td>30</td>
<td>1.41</td>
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<td></td>
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<td>2-30</td>
<td>0.97</td>
<td>0.1</td>
<td>30</td>
<td>1.41</td>
<td>-</td>
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<td>X-52-875</td>
<td>Association</td>
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<td>1-100</td>
<td>0.97</td>
<td>0.1</td>
<td>35</td>
<td>1.41</td>
<td>-</td>
</tr>
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<td>Hybrid silicone powder</td>
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<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>
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<td></td>
<td>KMP-601</td>
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<td>2-25</td>
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<td>30</td>
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<td>1.43</td>
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<td>4-60</td>
<td>0.98</td>
<td>0.1</td>
<td>30</td>
<td>1.41</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td>KMP-605</td>
<td>Spherical</td>
<td>2</td>
<td>0.7-5</td>
<td>0.99</td>
<td>0.1</td>
<td>75</td>
<td>1.42</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td>X-52-7078C *</td>
<td>Spherical</td>
<td>2</td>
<td>0.7-5</td>
<td>1.00</td>
<td>0.1</td>
<td>50</td>
<td>1.41</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td>X-52-7030</td>
<td>Spherical</td>
<td>0.8</td>
<td>0.2-2</td>
<td>1.01</td>
<td>0.1</td>
<td>75</td>
<td>1.42</td>
<td>1.43</td>
</tr>
</tbody>
</table>

* X-52-7078C Reduced low molecular weight siloxane type of KMP-605

### Product Data

**Silicone Resin Powder**
- **KMP-590 Particle Size Distribution**
- **KMP-590 Heat Resistance**
  (Weight changes vs. temperatures)

**Silicone Rubber Powder**
- **KMP-594 Particle Size Distribution**
- **KMP-594 Heat Resistance**
  (Weight changes vs. temperatures)

**Hybrid Silicone Powder**
- **KMP-600 Particle Size Distribution**
- **KMP-600 Heat Resistance**
  (Weight changes vs. temperatures)

### Dispersibility
Dispersibility in liquid epoxy resin

- **Hybrid Silicone Powder KMP-601**
- **Silicone Rubber Powder** *
  *Applying a shearing force improves dispersibility of silicone rubber powders in resin.*
The KP Series of coating surface modifiers are highly effective in small amounts. They can be added to paints and coatings to help prevent defects and for surface modification.

### Features of Polysiloxane

**Structure of dimethylsiloxane**

Silicone fluids have very low surface tension.

<table>
<thead>
<tr>
<th>Types of liquid</th>
<th>Surface tension (25°C) mN/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimethyl silicone KF-96</td>
<td>21</td>
</tr>
<tr>
<td>Toluene</td>
<td>28</td>
</tr>
<tr>
<td>Mineral oil</td>
<td>30</td>
</tr>
<tr>
<td>Glycerin</td>
<td>63</td>
</tr>
<tr>
<td>Water</td>
<td>72</td>
</tr>
</tbody>
</table>

1. **Low surface tension**
   - Silicone fluids have very low surface tension.

2. **Surface migration**
   - They migrate easily to the surface of resins.

3. **Length of siloxane chains**
   - Can be controlled
     - Shorter chains: Better compatibility with resins, solvents, lower surface tension and improved flow properties.
     - Longer chains: May be incompatible with resin, solvents, and produce hammertone effects (cissing).

### Features Provided by the Organic Reactive Groups

<table>
<thead>
<tr>
<th>Organic functional group</th>
<th>Features Provided by the Organic Reactive Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyether</td>
<td>Organic groups consisting of chains of repeated ethylene oxide units (EO) or propylene oxide units (PO), or a combination of the two. A high proportion of EO units translates to strong hydrophilicity and water solubility, and good compatibility with acrylic and urethane resins. A high proportion of PO units translates to strong hydrophobicity.</td>
</tr>
<tr>
<td>Polyol</td>
<td>Organic groups having a relatively compact structure with large numbers of hydroxyl groups. Silicone rich, and yet strongly hydrophilic with high polarity.</td>
</tr>
<tr>
<td>Acrylic</td>
<td>Organic groups composed of acrylic polymers. Have good film-forming ability and compatibility with acrylic resins.</td>
</tr>
<tr>
<td>Fatty acid ester</td>
<td>Organic groups with the same basic structure as alkyd resins. Highly compatible especially with alkyd resins.</td>
</tr>
<tr>
<td>Phenyl</td>
<td>Highly compatible with resins having large numbers of aromatic rings (e.g. epoxies). Because they are hydrophobic, these groups have poor compatibility with hydrophilic resins.</td>
</tr>
<tr>
<td>Fluorine</td>
<td>Silicone fluids have very low surface tension and thus show little activity in aromatic solvent-based paints. Fluorine modification will produce an agent with a surface tension-reducing and defoaming effect in aromatic solvent-based paints and coatings. Poor compatibility with many resins means there can be a risk of cissing or other problems.</td>
</tr>
<tr>
<td>Alkyl</td>
<td>Introducing alkyl or aralkyl groups will produce an additive with balanced performance and higher hydrophobicity.</td>
</tr>
<tr>
<td>Aralkyl</td>
<td></td>
</tr>
<tr>
<td>Polyester</td>
<td>Organic groups composed of polyester polymers. Higher molecular weights than most other organic groups. Have good film-forming ability and particularly good compatibility with polyester paints and coatings.</td>
</tr>
</tbody>
</table>

Compatibility with organic resin solutions. Surface tension can be controlled by changing the type of organic functional group.
Surface Modifiers for Coating

Main Applications and Functional Mechanism

**Leveling Agent (Improves Flowability)**
- The leveling effect of the silicone helps produce a smoother coating surface.

**Defoaming Agent**
- Silicone moves to the surface of air bubbles.
- Defoaming / foam-inhibiting effect is related to differences in the polarity and compatibility between the paint and silicone.

**Slip Agent (Releasability Imparter)**
- Silicone migrates to the surface, resulting in:
  - Improved slip property
  - Improved antifouling properties
  - Improved scratch and chip resistance

**Anti-floating / Anti-flooding Agents**
- The silicone migrates to the coating surface to form a layer that helps prevent color irregularities caused by pigment separation. This separation can be caused by convection currents that form in the coating as it dries.

**Hammer Tone Agent**
- Long-chain silicones can encourage cissing and can thus be added to paints when a hammer tone finish is desired.

**Relationship between Silicone Structure and Development Property**
Depending on the silicone chain length and the difference between the solubility parameters (SP) of the KP series and paint/coating, the KP series can show leveling, defoaming or slip improvement.

- **Main Chain Length of Silicone**
  - Leveling property
  - Defoaming property
  - Slip property (Releasability)

- **SP Value Difference**
  - Leveling property
  - Slip property (Releasability)
  - Defoaming property

- **Silicone Surface Migration Speed**
  - Low
  - Medium
  - High

The difference in surface tension between the silicone and the paint results in improved wetting and smoothness.

Substrate → Paint → Substrate

Silicone migrates to the surface.

The flow properties of the silicone help improve the wetting and spreading properties of the paint.

Bubbles → Substrate → Paint

Moving to the surface, bubbles are broken by the following mechanism:

1. Adhesion
2. Penetration
3. Diffusion
4. Defoaming

Defoaming / foam-inhibiting effect is related to differences in the polarity and compatibility between the paint and silicone.
### Surface Modifiers for Coating

**KP Series**

## Product List

<table>
<thead>
<tr>
<th>Application</th>
<th>Type</th>
<th>Product name</th>
<th>Solubility parameter</th>
<th>Molecular weight level (Length of siloxane with chain)</th>
<th>Active Ingredient %</th>
<th>Solvent</th>
<th>Water type applicability*</th>
<th>Standard adding amount (wt%)</th>
<th>TSCA Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leveling</strong></td>
<td>Polyether modified</td>
<td>KP-124</td>
<td>8.2</td>
<td>Medium</td>
<td>100</td>
<td>-</td>
<td>±</td>
<td>0.005-1.0</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KP-109</td>
<td>8.2</td>
<td>High</td>
<td>50</td>
<td>PGM*2</td>
<td>+</td>
<td>0.15-1.0</td>
<td>Not Listed</td>
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<tr>
<td></td>
<td></td>
<td>KP-110</td>
<td>8.3</td>
<td>Small</td>
<td>100</td>
<td>-</td>
<td>++</td>
<td>0.05-5.0</td>
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<tr>
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<td></td>
<td>KP-121</td>
<td>8.4</td>
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<td>-</td>
<td>±</td>
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<td>KP-103</td>
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<td>Medium</td>
<td>100</td>
<td>-</td>
<td>±</td>
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<tr>
<td></td>
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<td>KP-341</td>
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<td>Medium</td>
<td>100</td>
<td>-</td>
<td>±</td>
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<tr>
<td></td>
<td></td>
<td>KP-112</td>
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<td>High</td>
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<td>-</td>
<td>±</td>
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<tr>
<td></td>
<td></td>
<td>KP-125</td>
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<td>100</td>
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<td>+</td>
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<tr>
<td></td>
<td></td>
<td>KP-101</td>
<td>8.7</td>
<td>High</td>
<td>100</td>
<td>-</td>
<td>+</td>
<td>0.01-1.0</td>
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<tr>
<td></td>
<td></td>
<td>KP-106</td>
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<td>100</td>
<td>-</td>
<td>++</td>
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<tr>
<td></td>
<td></td>
<td>KP-120</td>
<td>10.0</td>
<td>High</td>
<td>100</td>
<td>-</td>
<td>+</td>
<td>0.02-4.0</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>Polyol modified</td>
<td>KP-105</td>
<td>10.4</td>
<td>Medium</td>
<td>30</td>
<td>PGM*2</td>
<td>+</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>KP-104</td>
<td>11.6</td>
<td>Medium</td>
<td>30</td>
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<td></td>
<td>Acrylic resin modified</td>
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<tr>
<td></td>
<td>Fatty acid ester modified</td>
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<td>High</td>
<td>10</td>
<td>Butyl acetate</td>
<td>-</td>
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<tr>
<td></td>
<td>Pheny1 modified</td>
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<td>KP-323</td>
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<td>Small</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>0.002-0.5</td>
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<td></td>
<td>KP-322</td>
<td>8.4</td>
<td>Medium</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>0.005-1.0</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>Fluorine modified</td>
<td>KP-625</td>
<td>7.1</td>
<td>Small</td>
<td>5</td>
<td>DAA*3</td>
<td>-</td>
<td>0.001-2.0</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>Alkyl or</td>
<td>KP-623</td>
<td>8.5</td>
<td>High</td>
<td>10</td>
<td>Isodoecane</td>
<td>-</td>
<td>0.002-4.0</td>
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</tr>
<tr>
<td></td>
<td>Aralkyl modified</td>
<td>KP-624</td>
<td>8.8</td>
<td>Medium</td>
<td>10</td>
<td>ECH*4</td>
<td>-</td>
<td>0.01-2.0</td>
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<tr>
<td></td>
<td></td>
<td>KP-620</td>
<td>9.2</td>
<td>Medium</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>0.0002-0.4</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>Fluorine modified</td>
<td>KP-625</td>
<td>7.1</td>
<td>Small</td>
<td>5</td>
<td>DAA*3</td>
<td>-</td>
<td>0.001-2.0</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>(Compound)</td>
<td>KP-651</td>
<td>7.2</td>
<td>High</td>
<td>8</td>
<td>MXHF*5</td>
<td>-</td>
<td>0.0003-0.5</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>(Compound emulsion)</td>
<td>KP-650</td>
<td>-</td>
<td>-</td>
<td>55</td>
<td>Water</td>
<td>++</td>
<td>0.001-0.2</td>
<td>Listed</td>
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<tr>
<td></td>
<td>(Dimethyl silicone)</td>
<td>KP-310</td>
<td>7.4</td>
<td>Ultra high</td>
<td>10</td>
<td>Toluene</td>
<td>-</td>
<td>0.0005-2.0</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>Polyether modified</td>
<td>KP-109</td>
<td>8.2</td>
<td>High</td>
<td>50</td>
<td>PGM*2</td>
<td>++</td>
<td>0.02-2.0</td>
<td>Not Listed</td>
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<tr>
<td></td>
<td></td>
<td>KP-306</td>
<td>8.3</td>
<td>High</td>
<td>10</td>
<td>Xylene</td>
<td>-</td>
<td>0.1-1.0</td>
<td>Not Listed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KP-301</td>
<td>8.7</td>
<td>Medium</td>
<td>10</td>
<td>Toluene</td>
<td>-</td>
<td>0.2-2.0</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>Polyester resin modified</td>
<td>KP-621</td>
<td>9.1</td>
<td>High</td>
<td>10</td>
<td>Toluene / Xylene</td>
<td>-</td>
<td>0.2-10.0</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>(For solvent type)</td>
<td>KP-369</td>
<td>7.4</td>
<td>Small</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>0.05-2.0</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td>(For water type)</td>
<td>KP-368</td>
<td>7.4</td>
<td>Medium</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>0.05-2.0</td>
<td>Listed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KP-126</td>
<td>8.6</td>
<td>High</td>
<td>100</td>
<td>-</td>
<td>++</td>
<td>0.2-10.0</td>
<td>Listed</td>
</tr>
</tbody>
</table>

*1 ++ = Excellent  + = Good  ± = Satisfactory  - = Not applicable  
*2 PAG = Polyglycol monoalkyl ether  
*3 DAA = Diacetone alcohol  
*4 ECH = Ethylcyclohexane  
*5 MXHF = m-xylenehexafluoride  
(Not specified values)

## Reference: SP values (solvents & polymers)

The SP values are reference values. Values may vary depending on calculation method.

### Types of solvent

<table>
<thead>
<tr>
<th>Types of solvent</th>
<th>SP value</th>
<th>Boiling point °C</th>
<th>Silicone Solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isocyanate</td>
<td>7.0</td>
<td>99</td>
<td>++</td>
</tr>
<tr>
<td>n-Heptane</td>
<td>7.4</td>
<td>96</td>
<td>++</td>
</tr>
<tr>
<td>Diethyl ether</td>
<td>7.4</td>
<td>35</td>
<td>+</td>
</tr>
<tr>
<td>3-methoxy-3-methyl-butyl acetate</td>
<td>8.5</td>
<td>188</td>
<td>+</td>
</tr>
<tr>
<td>Methyl isobutyl ketone</td>
<td>8.4</td>
<td>116</td>
<td>+</td>
</tr>
<tr>
<td>Ethyl acetate-n-butyl</td>
<td>8.5</td>
<td>126</td>
<td>+</td>
</tr>
<tr>
<td>Propylene glycol monomethyl ether acetate</td>
<td>8.7</td>
<td>146</td>
<td>+</td>
</tr>
<tr>
<td>Xylene</td>
<td>8.8</td>
<td>138</td>
<td>+</td>
</tr>
<tr>
<td>Toluene</td>
<td>8.9</td>
<td>111</td>
<td>++</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>9.1</td>
<td>77</td>
<td>±</td>
</tr>
<tr>
<td>Diacetone alcohol</td>
<td>9.2</td>
<td>168</td>
<td>±</td>
</tr>
<tr>
<td>Methyl ethyl ketone</td>
<td>9.3</td>
<td>80</td>
<td>±</td>
</tr>
<tr>
<td>Ethyloxysiloxane</td>
<td>9.9</td>
<td>136</td>
<td>±</td>
</tr>
<tr>
<td>Acetone</td>
<td>10.0</td>
<td>56</td>
<td>±</td>
</tr>
<tr>
<td>Propylene glycol monoalkyl ether</td>
<td>10.5</td>
<td>120</td>
<td>-</td>
</tr>
<tr>
<td>Tert-butanol</td>
<td>10.6</td>
<td>83</td>
<td>±</td>
</tr>
<tr>
<td>Isobutanol</td>
<td>11.0</td>
<td>107</td>
<td>±</td>
</tr>
<tr>
<td>n-Butanol</td>
<td>11.1</td>
<td>118</td>
<td>±</td>
</tr>
<tr>
<td>Isopropyl alcohol</td>
<td>11.5</td>
<td>82</td>
<td>+</td>
</tr>
<tr>
<td>Dimethylformamide</td>
<td>12.0</td>
<td>153</td>
<td>-</td>
</tr>
<tr>
<td>Ethanol</td>
<td>12.8</td>
<td>78</td>
<td>-</td>
</tr>
<tr>
<td>Propylene carbonate</td>
<td>13.5</td>
<td>242</td>
<td>-</td>
</tr>
<tr>
<td>Ethylene glycol</td>
<td>14.2</td>
<td>198</td>
<td>-</td>
</tr>
<tr>
<td>Methanol</td>
<td>14.8</td>
<td>65</td>
<td>-</td>
</tr>
<tr>
<td>Water</td>
<td>23.4</td>
<td>100</td>
<td>-</td>
</tr>
</tbody>
</table>

*Dimethyl silicone fluid has an SP value of 7.2, while the SP value of a methyl phenyl silicone fluid can be 9 or higher, depending on phenyl content.*

### Types of polymer

<table>
<thead>
<tr>
<th>Types of polymer</th>
<th>SP value (Dissolution value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorine resin (PTFE)</td>
<td>6.2</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>7.9</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>8.0</td>
</tr>
<tr>
<td>Alkyd resin (long-oil)</td>
<td>7.9</td>
</tr>
<tr>
<td>SBR Rubber</td>
<td>8.1-8.7</td>
</tr>
<tr>
<td>NBR Rubber</td>
<td>8.8-9.5</td>
</tr>
<tr>
<td>Epoxy resin</td>
<td>9.6-10.1</td>
</tr>
<tr>
<td>Polurethane resin</td>
<td>10.0-11.0</td>
</tr>
<tr>
<td>Cellulose acetate</td>
<td>10.0</td>
</tr>
<tr>
<td>Polyvinyl chloride</td>
<td>9.5-9.7</td>
</tr>
<tr>
<td>Epoxy resin</td>
<td>9.7-10.9</td>
</tr>
<tr>
<td>Polyvinyl acetate</td>
<td>9.4</td>
</tr>
<tr>
<td>Polyurethane resin</td>
<td>9.6-10.1</td>
</tr>
<tr>
<td>Polyurethane resin</td>
<td>10.0-11.0</td>
</tr>
<tr>
<td>Cellulose acetate</td>
<td>10.0</td>
</tr>
<tr>
<td>Polyvinyl alcohol</td>
<td>13.6</td>
</tr>
<tr>
<td>Cellulose acetate</td>
<td>23.4</td>
</tr>
</tbody>
</table>
KP Series Selection Guide, Arranged by Purpose

*This map is offered as a guide for product selection.

For Solvent-based Paints

Polyester Paints
- KP-626
- KP-104
- KP-105

Epoxy Paints
- KP-323
- KP-623
- KP-322

Alkyd Paints
- KP-626
- KP-623
- KP-624

Cellulose Paints
- KP-104
- KP-105
- KP-625

For Water-based Paints

Imparting Anti-cissing Property
- KP-120

Standard Products
- KP-110
- KP-106
- KP-104 *

Imparting Anti-forming Property
- Additional amount KP-650

Improve Releasability
- KP-126

Increase Slip Property
- KP-109

Reduce Slip Property
- KP-624
- KP-106

Ranking of Slip Agents

- Excellent
- KP-341
- KP-301
- KP-105
- KP-106
- KP-306
- KP-369
- KP-109
- KP-368
- KP-310

Poor

Low: Slick Property
High
Other Highly Functional Products

Ionic Silicone Oligomer X-40-2450

X-40-2450 is a silicone oligomer created through the silicone modification of an ionic liquid. When added in small amounts to resins, X-40-2450 migrates easily to the coating surface, improving its heat resistance, and provides long-lasting antistatic properties.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Initial</th>
<th>After water wiping test</th>
<th>After immersion test in water</th>
<th>After heating test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface resistivity (Ω)</td>
<td>$4 \times 10^{11}$</td>
<td>$1 \times 10^{10}$</td>
<td>$3 \times 10^{11}$</td>
<td>$8 \times 10^{11}$</td>
</tr>
<tr>
<td>Ionic liquid</td>
<td>$&gt; 10^{13}$</td>
<td>$&gt; 10^{13}$</td>
<td>$&gt; 10^{13}$</td>
<td>$&gt; 10^{13}$</td>
</tr>
</tbody>
</table>

- Mix ratio: Dipentaerythritol hexaacrylate / 2-Hydroxy-2-Methyl-1-Phenyl-Propane-1-one / Methyl ethyl ketone / X-40-2450 = 48.8 / 2.4 / 48.8 / 2.0
- Substrate: PET (Cosmo Shine A4300) made by TOYOBO CO., LTD.
- Cure conditions: 600mJ/cm$^2$ under a nitrogen atmosphere
- Film thickness: 5μm
- *1 After rubbing the cured specimen 50 times with wet absorbent cotton, wiped off remaining water and took the measurements.
- *2 After submerging the cured specimen into water (25℃×5h), wiped off remaining water and took the measurements.
- *3 Measured after heating the cured specimen (105℃×1 day).
- *4 (n-C$_8$H$_{17}$)$_3$(CH$_3$)$_N$ + (CF$_3$SO$_2$)$_2$N-

Photostabilizing Group Silane TMPS-E

TMPS-E is a silane coupling agent that contains photostabilizing groups. TMPS-E neutralizes free radicals formed through exposure to light, thus protecting resins against degradation.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Product name</th>
<th>X-40-2450</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form of silicone</td>
<td>Siloxane</td>
<td></td>
</tr>
<tr>
<td>Appearance</td>
<td>Colorless transparent liquid</td>
<td></td>
</tr>
<tr>
<td>Non-volatile content</td>
<td>%</td>
<td>55</td>
</tr>
<tr>
<td>Viscosity</td>
<td>mm/s</td>
<td>2.5</td>
</tr>
<tr>
<td>Specific gravity 25℃</td>
<td></td>
<td>0.97</td>
</tr>
<tr>
<td>Solvent</td>
<td>Methyl ethyl ketone</td>
<td></td>
</tr>
<tr>
<td>TSCA</td>
<td>Not Listed</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Product name</th>
<th>TMPS-E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity at 25℃</td>
<td>mm$^2$/s</td>
<td>8.0</td>
</tr>
<tr>
<td>Specific gravity 25℃</td>
<td></td>
<td>0.95</td>
</tr>
<tr>
<td>Refractive index at 25℃</td>
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<td>1.44</td>
</tr>
<tr>
<td>Active ingredient</td>
<td>%</td>
<td>100</td>
</tr>
<tr>
<td>TSCA</td>
<td>Not Listed</td>
<td></td>
</tr>
</tbody>
</table>

Chemical Structure of TMPS-E

(TeO)$_3$Si

Adhesion Test Data of Glass / Epoxy Resin Interface
**Hydrophilic Anti-stain Agents  KP-912, KP-913, KP-914**

KP-912, KP-913 and KP-914 are silicone oligomers that contain alkoxyisilyl groups. When mixed with water, alkoxyisilyl groups hydrolyze to form hydrophilic silanols groups, properties which allow these products to function as antifouling agents in paints for construction materials. KP-913 shows its hydrophilic properties earlier.

### General Properties

<table>
<thead>
<tr>
<th>Product name</th>
<th>Parameter</th>
<th>Alkoxy Groups</th>
<th>Viscosity at 25°C mm²/s</th>
<th>Refractive index at 25°C</th>
<th>Alkoxy group content wt%</th>
<th>TSCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>KP-912</td>
<td></td>
<td>Methoxy / Ethoxy</td>
<td>12</td>
<td>1.414</td>
<td>50</td>
<td>Not Listed</td>
</tr>
<tr>
<td>KP-913</td>
<td></td>
<td>Methoxy</td>
<td>350</td>
<td>1.448</td>
<td>9.5</td>
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</tr>
<tr>
<td>KP-914</td>
<td></td>
<td>Methoxy / Ethoxy</td>
<td>30</td>
<td>1.418</td>
<td>50</td>
<td>Not Listed</td>
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</tbody>
</table>

(Not specified values)

### Antifouling Mechanism

![Antifouling Mechanism Diagram]

### Hydrophilicity of Coatings with Oligomers Added

![Hydrophilicity Graph]

**Benzotriazole Group Silane X-12-1214A**

X-12-1214A contains a common corrosion inhibitor (benzotriazole) plus an alkoxyisilyl group. By improved adhesion to metals, X-12-1214A helps ensure long-lasting protection against corrosion.

### Resulting Properties

- Protects metal against corrosion (Especially for copper, silver and aluminum)

### General Properties

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Product name</th>
<th>X-12-1214A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity at 25°C mm²/s</td>
<td>170</td>
<td></td>
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<tr>
<td>Active ingredient %</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>TSCA</td>
<td>Not Listed</td>
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</tr>
</tbody>
</table>

(Not specified values)

### Chemical Structure of X-12-1214A

![Chemical Structure Diagram](MeO)₃Si

### Anti Rust Treatment on Copper plates

**<Specimen preparation>**

1. Copper plate is cleaned to remove sulfur and washed with water.
2. Plate is immersed in a 1 wt% solution of benzotriazole or a silane coupling agent for 5 min.
3. Drying

**<Heat Resistance Test>**

1. Plate was left in a constant temperature chamber at 150°C for 5 hours.
2. Copper plate surface is observed.

**<Sulfide Corrosion Test>**

1. Plates were immersed in a 100 ppm Na₂S aqueous solution for 5 min.
2. After drying, plate surface is observed.

![Rust Treatment Images](Untreated BT* X-12-1214A)

*BT: benzotriazole*
Silanes and silane coupling agents can be used as surface treatments for pigments and fillers to improve their compatibility with resins and improve adhesion.

**Product List**

<table>
<thead>
<tr>
<th>Product category</th>
<th>Functional group</th>
<th>Product name</th>
<th>Chemical structure</th>
<th>Features</th>
<th>TSCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silane coupling agents</td>
<td>Alkenyl</td>
<td>KBM-1003</td>
<td>(MeO)₃Si—CH₂—CH=CH₂</td>
<td>Vinyl silane, standard product</td>
<td>Listed</td>
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<td></td>
<td></td>
<td>KBM-1083</td>
<td>(MeO)₃Si—CH₂—CH₂</td>
<td>Long-chain spacer type of KBM-1003</td>
<td>Listed</td>
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<tr>
<td></td>
<td>Epoxy</td>
<td>KBM-403</td>
<td>(MeO)₃Si—CH₂—O</td>
<td>Epoxy silane, standard product</td>
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<td></td>
<td>KBM-4803</td>
<td>(MeO)₃Si—CH₂—O</td>
<td>Long-chain spacer type of KBM-403</td>
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<tr>
<td></td>
<td>Methacrylic</td>
<td>KBM-503</td>
<td>(MeO)₃Si—CH₂—CH₂—CH=CH₂</td>
<td>Methacrylic silane, standard product</td>
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<tr>
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<td></td>
<td>KBM-5803</td>
<td>(MeO)₃Si—CH₂—O</td>
<td>Long-chain spacer type of KBM-503</td>
<td>Not Listed</td>
</tr>
<tr>
<td></td>
<td>Amine</td>
<td>KBE-903</td>
<td>(EtO)₃Si—NH₂</td>
<td>Monoamino silane</td>
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<td>KBM-603</td>
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<td>Diamino silane</td>
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<td>KBM-6803</td>
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<tr>
<td>Alkoxy silanes</td>
<td>Alkyl</td>
<td>KBE-3063</td>
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<tr>
<td></td>
<td></td>
<td>KBE-3063</td>
<td>(MeO)₃Si—CH₂—CH₂—CH₂</td>
<td>Long chain alkyl (C6), methoxy type</td>
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<td></td>
<td>KBE-3080</td>
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<td></td>
<td>KBE-3103C</td>
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<td>Long chain alkyl (C10), methoxy type</td>
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<td>Fluoroalkyl</td>
<td>KBE-7103</td>
<td>(MeO)₃Si—CF₃</td>
<td>Fluorinated silane. Water repellency, oil repellency</td>
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</table>

**Fractured Composite Resin Compounded with Spherical Silica**

- Silica Treated with KBM-503. Base Resin is Unsaturated Polyester.
- Untreated Silica

**Surface Treatment of Organic Filler with Long-chain Spacer Silane Coupling Agents**

- Evaluation of Inorganic Filler Dispersion

**Model of Surface Hydrophobization Using Silanes**

- Conceptual Diagram of Silica Surface Treated with KBM-3103C
- Enlarged Photo of Waterdrop

A treated silica filler is applied to a glass slide in the manner shown above, then the water contact angle is measured.

**Formulation**

Silane treated silica 10wt% Multifunctional acrylic compounds 90wt%
Spherical Silica Fine Particles are extremely small and have a narrow particle size distribution. Particle surfaces have been treated to be extra hydrophobic. The particles thus have excellent dispersibility, water repellency, lubricity, flow properties, and can be added to other powders, in a dry process, to improve those powder’s performance. Spherical Silica Fine Particles can be used with organic pigments and fillers as well as inorganic ones.

**Product List**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>QSG-100</th>
<th>QSG-80</th>
<th>QSG-30</th>
<th>QCB-100</th>
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<tbody>
<tr>
<td>Appearance</td>
<td>White powder</td>
<td>White powder</td>
<td>White powder</td>
<td>White powder</td>
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<tr>
<td>Shape</td>
<td>Spherical</td>
<td>Spherical</td>
<td>Spherical</td>
<td>Spherical</td>
</tr>
<tr>
<td>Average particle size nm*</td>
<td>110</td>
<td>80</td>
<td>30</td>
<td>200 (90-690)</td>
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<tr>
<td>Bulk density g/cm³</td>
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<td>0.44</td>
<td>0.46</td>
<td>0.56</td>
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<tr>
<td>True specific gravity</td>
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<td>1.8</td>
<td>1.8</td>
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<tr>
<td>Specific surface area m²/g</td>
<td>25</td>
<td>40</td>
<td>143</td>
<td>27</td>
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<td>Hydrophobicity %</td>
<td>67</td>
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<td>67</td>
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<td>Production method</td>
<td>Sol-Gel</td>
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<td>TSCA</td>
<td>Listed</td>
<td>Listed</td>
<td>Listed</td>
<td>Listed</td>
</tr>
</tbody>
</table>

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

(Not specified values)

**Particle Size Distribution of QSG-100**

**Adhesion on various surfaces by QSG-100**

- Metal Silicons
- Glass Frits
- Surface of Nylon
- Styrene Particle
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