Silicones for Paints & Coatings

Shin-Etsu Silicone

Take your products to the next

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.

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*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.

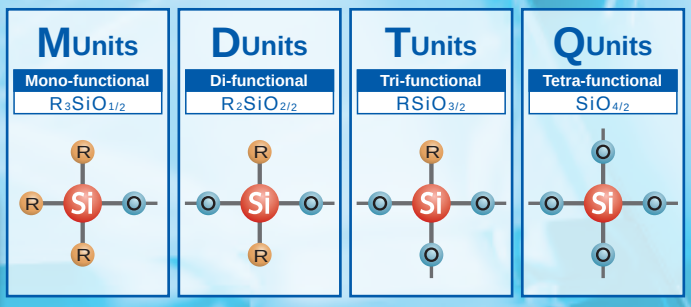
level with Shin-Etsu Silicones.

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.



R Organic group (including methyl group, phenyl group and reactive functional group)

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

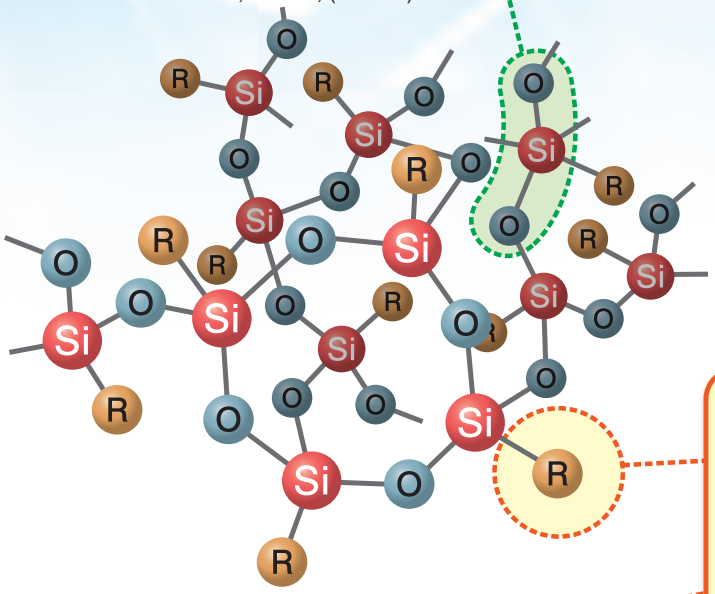
- **Helical molecule & low intermolecular force: Excellent water repellency, defoaming, and release properties (interfacial characteristics); gas permeable. Physical properties are not strongly temperature dependent.**

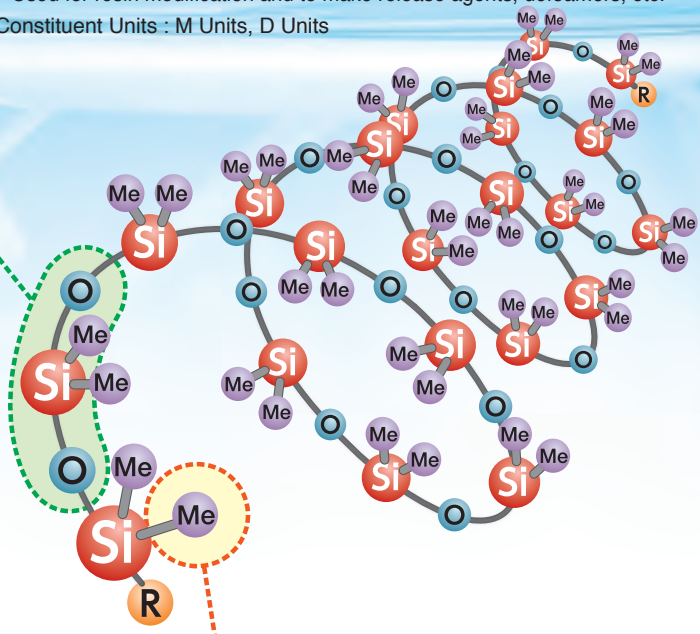
■ Structure of Fluid

- 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 : M Units, D 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)

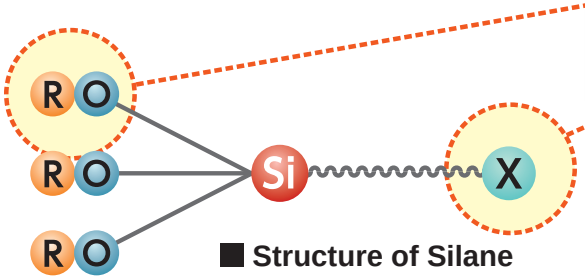




Characteristics imparted by organic groups

- **Primary Organic Groups**

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



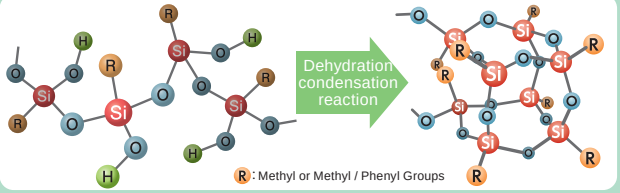
■ Structure of Silane

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

Product Map – 4 Types of Silicone Usage –

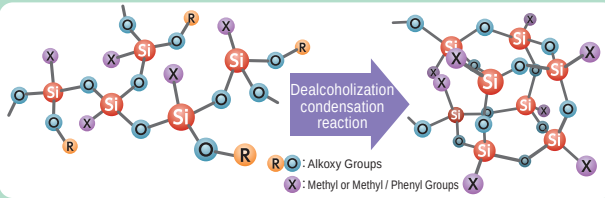
Silicone based Resins

Silicone Resins

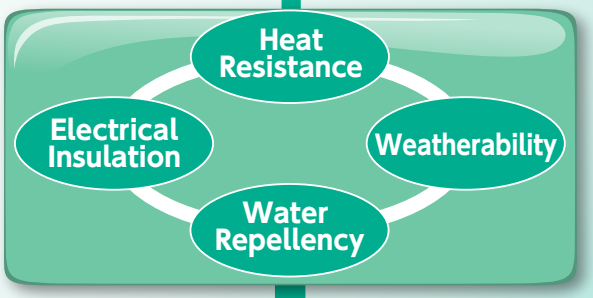


Structure: Resin having **a high molecular weight** and 3D siloxane network structure.
Features: With excellent film-forming abilities, coatings can range from very hard to flexible.

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.



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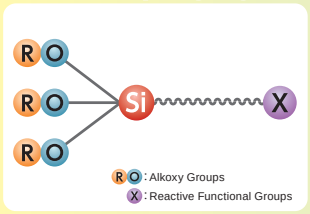
Base Resins Components of

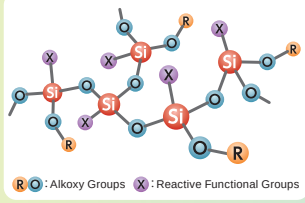
Resin Hybridization Agents

Silane Coupling Agents



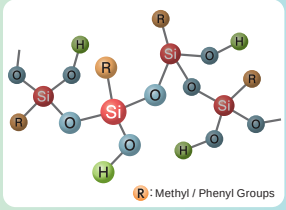
Structure: Monomers whose molecules contain alkoxy groups and reactive functional groups.
Features: While alkoxy groups improve adhesion to inorganic materials, reactive functional groups improve adhesion to organic materials.

Silicone Oligomers (Type AR)



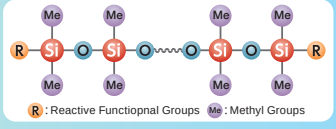
Structure: Resin having relatively a low molecular weight and 3D siloxane network structure. Molecules contain alkoxy groups and **reactive functional groups**.
Features: Can be used as an organic resin modifier or reactive diluents.

Silicone Resins



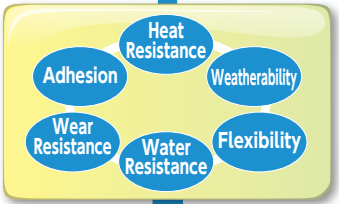
Structure: Resin having a high molecular weight and 3D siloxane network structure.
Features: With excellent film-forming abilities, coatings can range from very hard to flexible.

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.

Acrylic Resins



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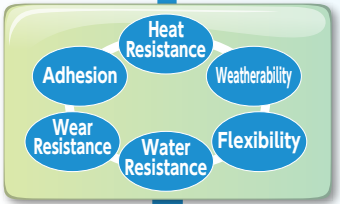
Polyester & Alkyd Resins



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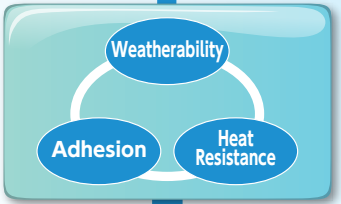
Epoxy Resins



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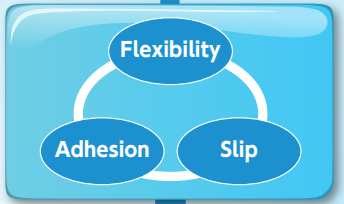
Urethane Resins



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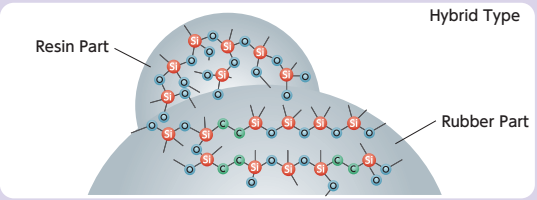
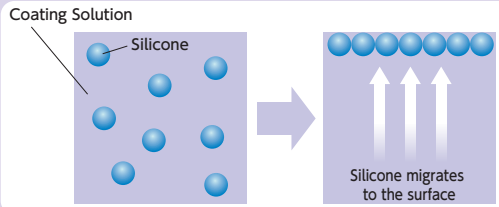
Surface Modifiers for Coating

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.

- Leveling
- Heat Resistance
- Deforming
- Weatherability
- Hydrophilic Anti-staining
- Slip
- Light Diffusion
- Antistatic
- Matting

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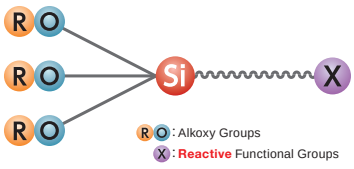
Additives

Paints & Coatings

Pigments & Fillers

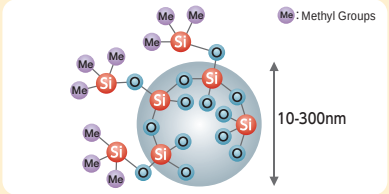
Surface Modifiers for Pigments & Fillers

Silane Coupling Agents



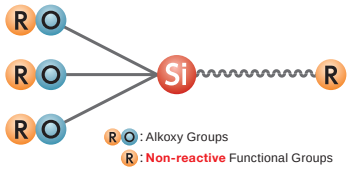
Structure: Monomers whose molecules contain alkoxy groups and reactive functional groups.
Features: While alkoxy groups improve adhesion to inorganic materials, reactive functional groups improve adhesion to organic materials.

Spherical Silica Fine Particles



Structure: 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.

Alkoxy Silanes



Structure: Monomers whose molecules contain alkoxy groups.
Features: Alkoxy groups act to improve adhesion to inorganic materials and modify the surface energy of the substrate.

- Adhesion
- Dispersibility
- Flowability

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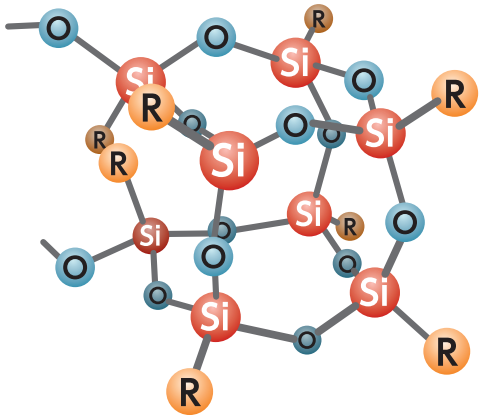
Silicone Resins

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.

●Model of Cured Silicone Resins



■Features

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

■ Product List

Product name	Type	Non-volatile content 105°C×3h %	Solvent	Cure speed	Hardness	Compatibility with organic resins	Main applications	Cure conditions	Applicable type	Features	TSCA
KR-220L	Methyl	100*1	None	Rapid	High	Low	Heat resistant and flame retardant binders	Baking	Powder, solvent	White flake, excellent heat resistance and flame retardance, very little smoking upon heating	Listed
KR-220LP		100*1	None	Rapid	High	Low	Heat resistant and flame retardant binders	Baking	Powder, solvent	Powder type of KR-220L	Listed
KR-242A		50	Toluene, isopropyl alcohol	Rapid	High	Low	Heat resistant and flame retardant binders	Baking	Solvent	Excellent heat resistance and flame retardance	Not Listed
KR-251		20	Toluene	Rapid	Medium	Low	Water proofing and insulating coatings	Baking, room temperature	Solvent	Thin hard coating	Listed
KR-255	Methyl / Phenyl	50	Toluene, xylene	Medium	Medium	Medium	Water proofing and insulating coatings	Baking, room temperature	Solvent	Glossy hard coating	Listed
KR-282		50	Xylene	Slow	Low	Medium	Heat resistant paints	Baking	Solvent	Excellent flexibility and anti-cracking properties	Listed
KR-300		50	Xylene	Medium	High	Medium	Heat resistant paints	Baking	Solvent	Excellent heat resistance high hardness coating	Not Listed
KR-311		60	Xylene	Medium	Medium	High	Heat resistant paints	Baking	Solvent	Excellent heat resistance and compatibility with organic resins	Listed
ES-1001N	Epoxy modified resin	45	Xylene, diacetone alcohol, n-butanol	-	-	-	Heat resistant paints	Baking	Solvent	Excellent anti-corrosion property, heat resistance and weatherability	Listed
ES-1002T		60	Toluene	-	-	-	Heat resistant paints	Room temperature*4	Solvent	Excellent anti-corrosion property and chemical resistance	Listed
ES-1023		45	Xylene, diacetone alcohol	-	-	-	Heat resistant paints	Baking	Solvent	Excellent anti-corrosion properties	Not Listed
KR-5206	Alkyd modified resin	50	Xylene	-	-	-	Heat resistant paints	Room temperature	Solvent	Excellent flexibility and adhesion	Not Listed
KR-5230	Polyester modified resin	60	PGMAC*2	-	-	-	Heat resistant paints	Baking	Solvent	Excellent flexural resistance, heat resistance and weatherability	Listed
KR-5234		60	PGMAC*2, MMBAC*3, isobutyl alcohol	-	-	-	Heat resistant paints	Baking	Solvent	Retains glossy appearance under high temperature	Not Listed
KR-5235		60	PGMAC*2, MMBAC*3, isobutyl alcohol	-	-	-	Heat resistant paints	Baking	Solvent	Excellent releasability and non-stick properties	Not Listed

(Not specified values)

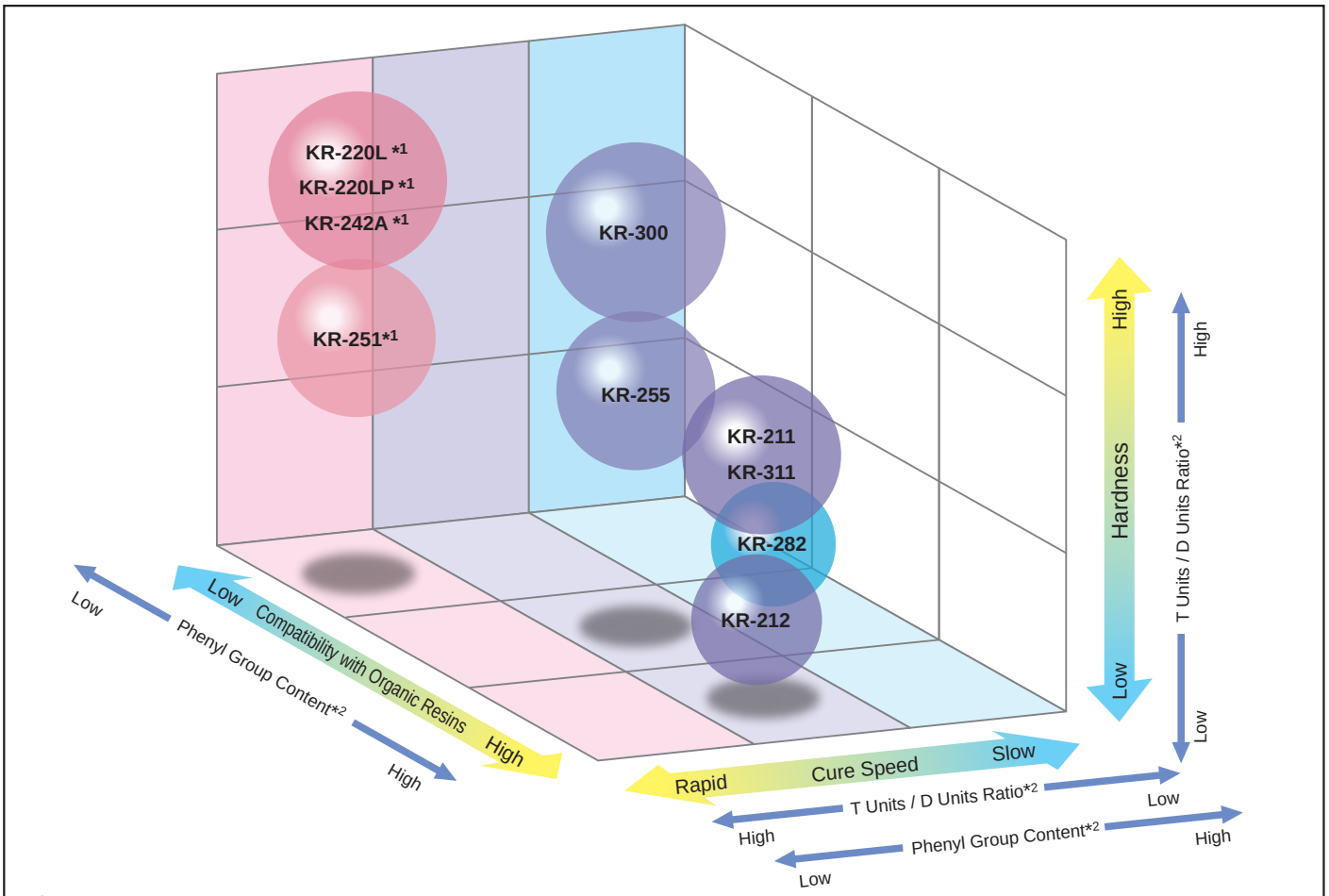
*1 Active ingredient
*2 PGMAC : Propylene glycol monomethylether acetate
*3 MMBAC : 3-Methyl-3- methoxybutyl acetate
*4 ES-1002T must be used with KP-390 (cross-linker).

■Products Types and Properties

Property \ Type	Methyl type	Methyl / Phenyl type	Epoxy modified resin	Alkyd modified resin	Polyester modified resin
Heat resistance	++	++	+	+	+
Hardness	++	+	±	±	±
Weatherability	++	++	-	+	+
Flexibility	-	-	±	+	+
Anti-corrosion property	±	±	++	±	±

* ++:Excellent +: Good ±: Satisfactory -: Poor

■ Map of Structures and Features

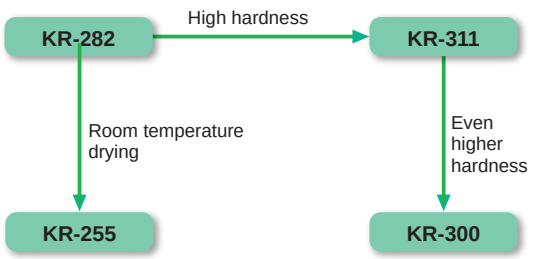


*1 Methyl silicone resin that contains no phenyl groups.

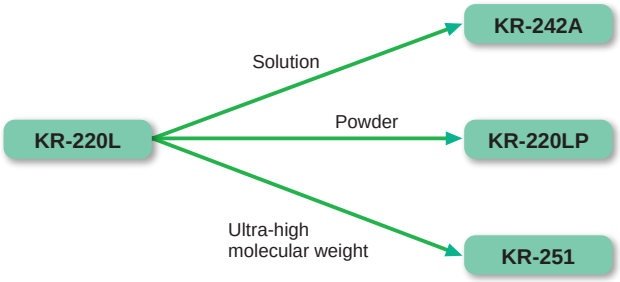
*2 T Units / D Units Ratio and phenyl content are key factors determining hardness, cure speed and compatibility with organic resins, but not all products fit this pattern.

■ Product Type

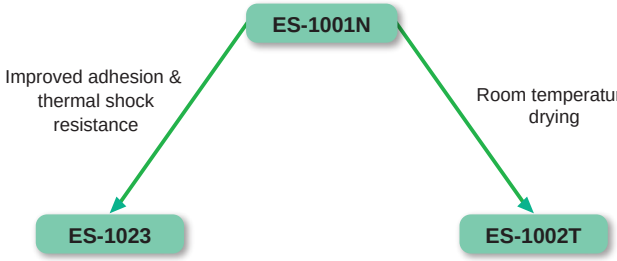
Methyl / Phenyl Type



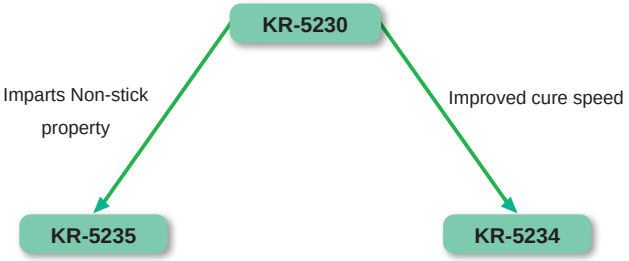
Methyl Type



Epoxy Type



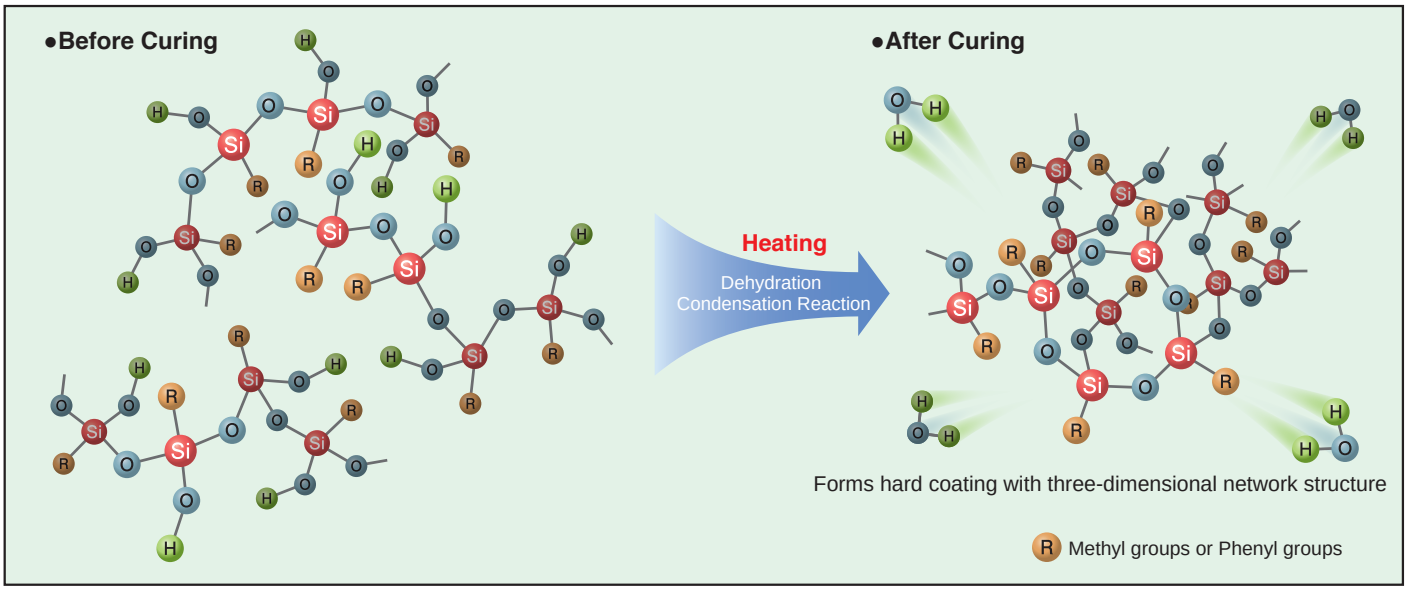
Polyester Type



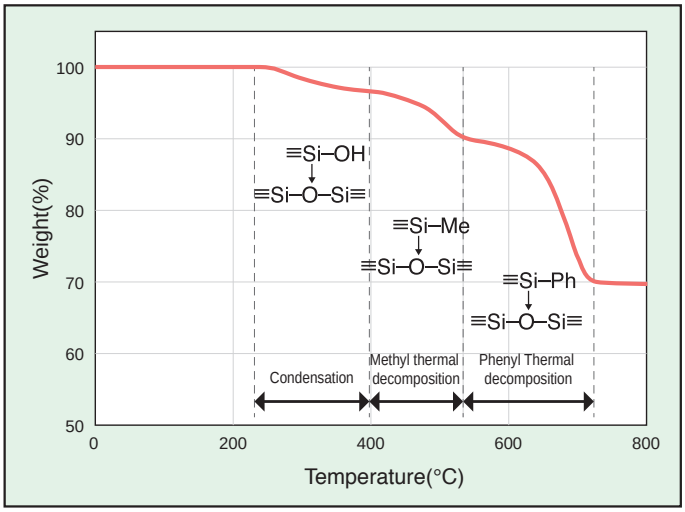
Features of Silicone Resins

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.

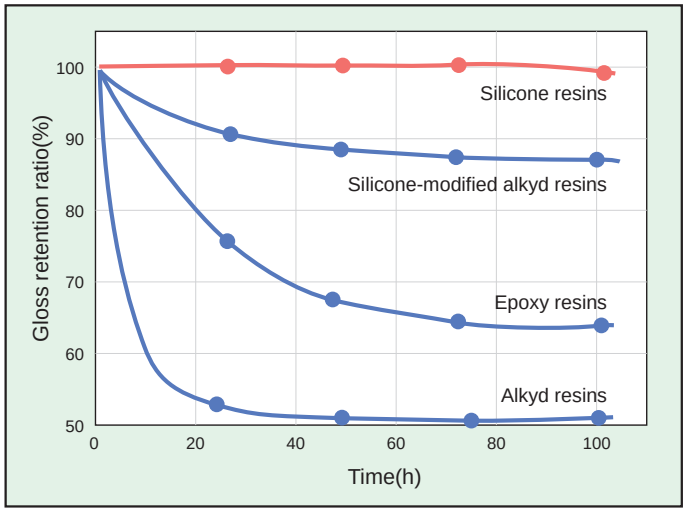
■Model of Silicone Resins



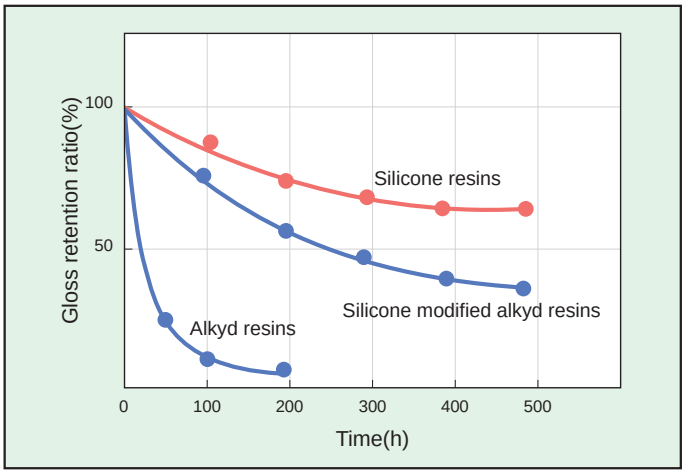
■Weight Loss Data in air at High Temperature (Methyl/Phenyl Type)



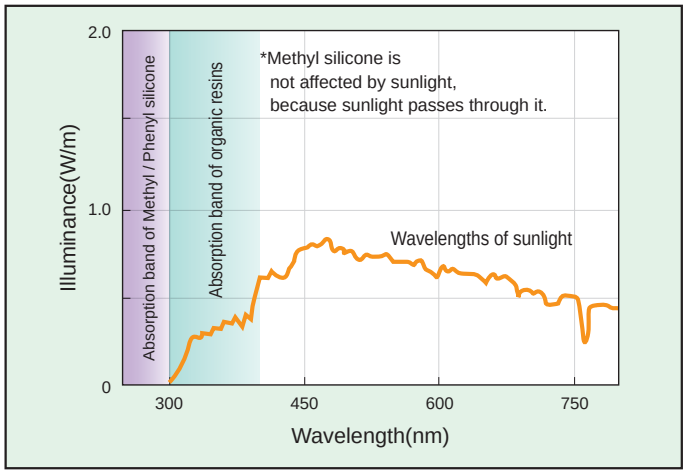
■Heat Resistance : Comparison Data with Organic Resins (under 250°C)



■Weather Resistance : Comparison Data with Organic Resins



■Sunlight Absorption : Comparison Data with Organic Resins



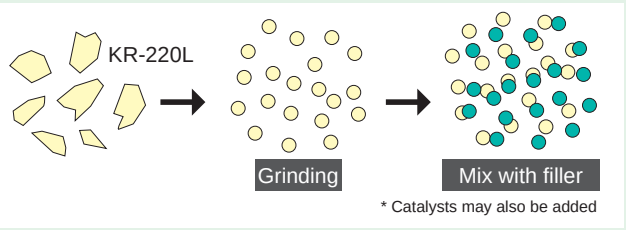
Unique Silicone Resins

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

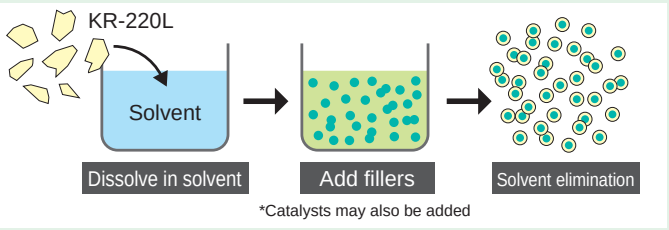
Solid Silicone Resin KR-220L

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.

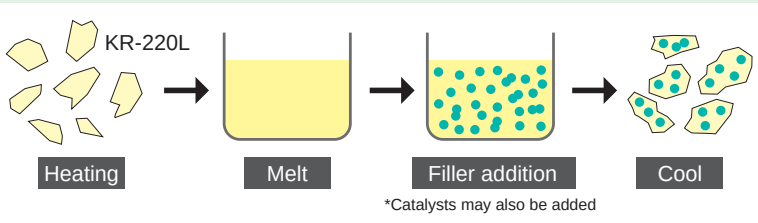
●Dry Blend



●Solution Blend



●Melt Blend

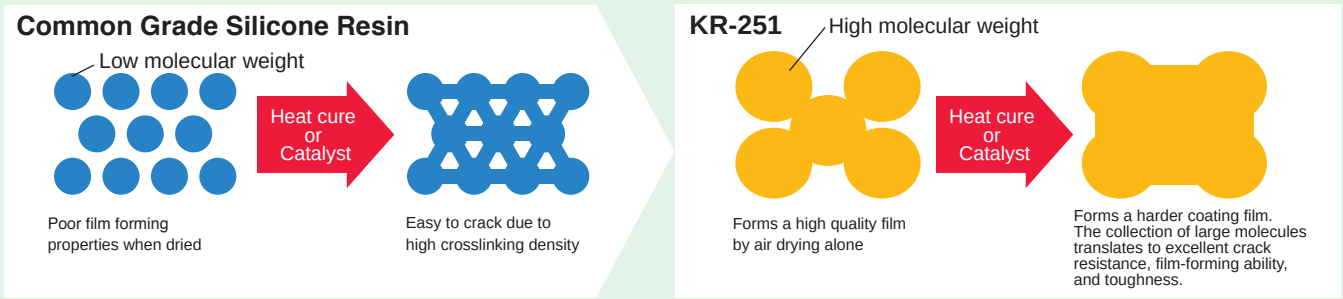


●Powdered Silicone Resin

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 resists cracking even after heat-curing.

●Model of Coating Structure



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%

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

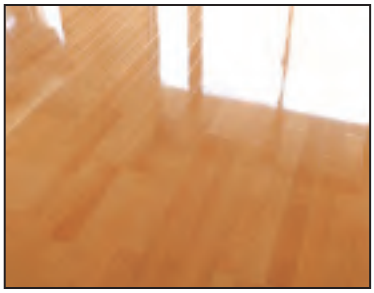
2. Applying the top coat
Baking : 150°C-200°C×20 to 30 min.

2-Part Room Temperature Moisture Cure Coatings

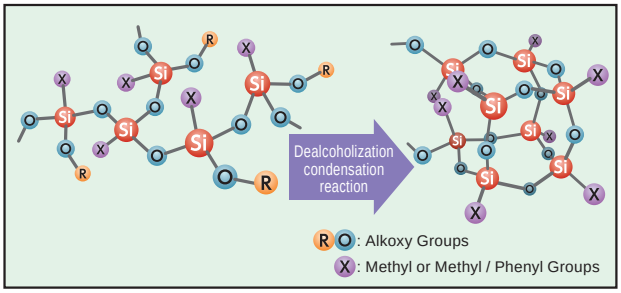
Type A silicone oligomers (please refer P.4) are used with a curing agent to produce coatings that cure at ambient temperatures and humidities. In recent years, these oligomers have been widely used for exterior automotive coatings and interior floor coatings.

●Exterior Automotive Coatings

●Interior Floor Coatings



●Model of Molecular Structure of a Coating



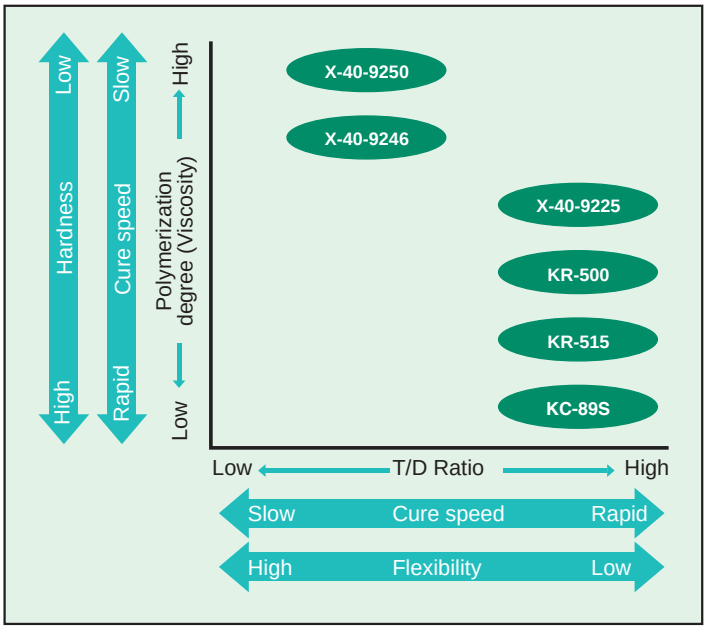
Cross linking system $2 \equiv Si–OR + 2H_2O \rightarrow (2 \equiv Si–OH + 2ROH) \rightarrow \equiv Si–O–Si\equiv + H_2O + 2ROH$

Product Lineup

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



■Methyl / Phenyl Type

Features : Excellent water repellency, cure speed

Product name	Features	TSCA
KR-401N	Excellent curability, Gloss	Listed
X-40-9227	Imparts flexibility	Listed
KR-510	Forms high hardness coating	Listed
KR-9218	Forms medium hardness coating	Listed

■Catalysts Lineup

Product name	Type	Adding amount wt%	Features	TSCA
D-220	Phosphoric acid	5-10	Very high activity	Listed
X-40-2309A	Phosphoric acid	10-50	High activity, can accelerate curing	Listed
D-25	Titanium	0.5-3	Higher activity than D-20	Listed
D-20	Titanium	2-5	Slow reactivity	Listed
DX-175	Titanium	3-5	Solvent diluted type (Easy to use)	Listed
DX-9740	Aluminum	0.5-5	Forms high hardness coatings	Listed
CAT-AC	Aluminum	0.5-10	Solvent diluted type (Easy to use)	Listed

■Blending Examples and Film Properties

Parameter / Product name	Catalyst (adding amount) %	Film thickness μm	Tack free 25°C min	Pencil hardness	Flexural resistance / Impact resistance
KR-500*1	D-20(2)	25	40	H	±
KR-500	D-20(4)	25	25	2H	±--
KR-500	DX-9740(5)	25	100	5H	-
X-40-9225*1	D-20(3)	30	60	H	+
KR-500/ X-40-9250*1 (=80/20)	D-20(2)	80	75	F	+

(Not specified values)

+ : Excellent ± : Satisfactory - : Poor

*Substrate : Polished steel sheet, Cure conditions : 25°C / 70% RH × 7days (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.

Parameter / Product name	Reactive groups	Viscosity at 25°C mm²/s	Refractive index at 25°C	Tack free at 25°C min	Pencil hardness / curing days	Features	TSCA
KR-400	Methyl	1.2	1.390	30-60	5H/2days → 8H/7days	Forms high hardness coatings	Listed
X-40-2327	Methyl	0.9	1.382	5-10	5H/1day	Rapid cure, Finished coating can be recoated.	Listed
KR-401	Methyl / Phenyl	20	1.435	30-60	3H/7days	Excellent flexural strength and impact resistance	Listed

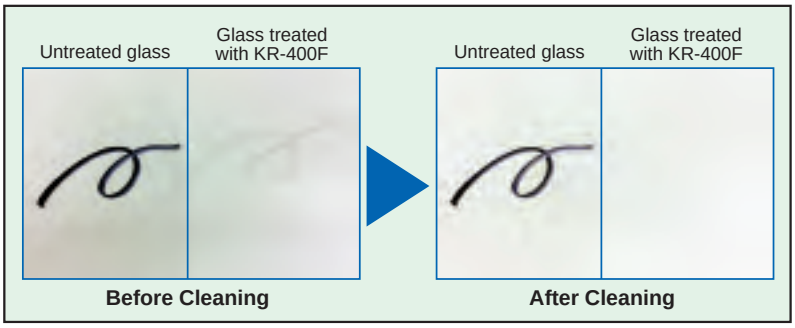
*Substrate : Polished steel sheet, Cure conditions : 25°C / 70% RH × 7days (Tack-free time varies depending on temperature and humidity) (Not specified values)

New Products

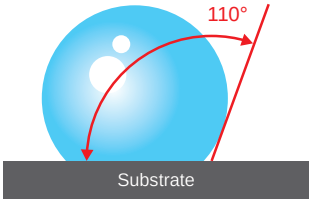
Our product offerings include coating agents with special features such as enhanced water repellency, antistatic properties and UV shielding abilities.

Fluorine-containing type KR-400F

Features: Fluorine is incorporated for enhanced slip property, water repellency and antifouling properties.



Water Contact Angle on a KR-400F Film

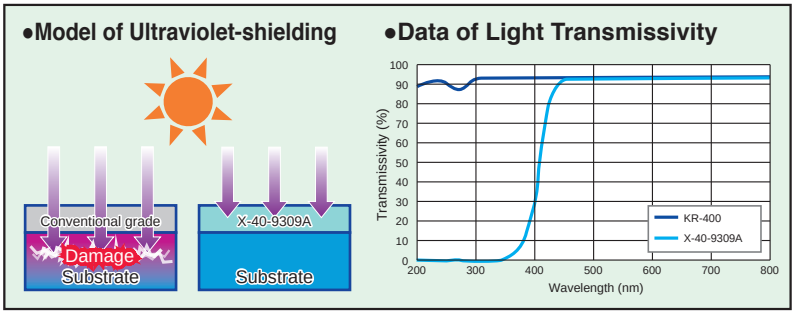


Parameter / Product name	Viscosity at 25°C mm²/s	Tack free at 25°C min	Pencil hardness after 7 days	TSCA
KR-400F	1.2	30-60	8H	Not Listed

(Not specified values)

Ultraviolet-shielding type X-40-9309A

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

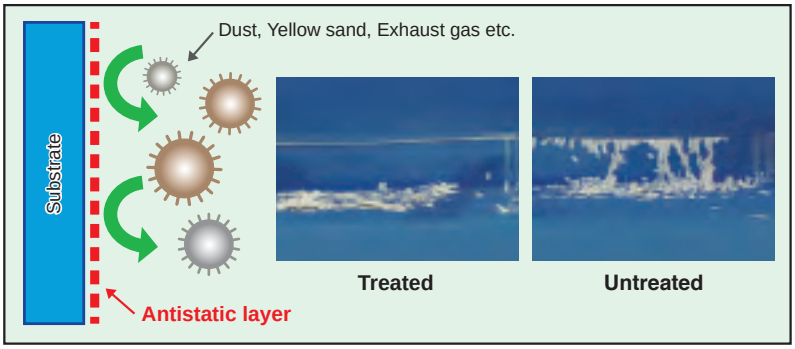


Parameter / Product name	Viscosity at 25°C mm²/s	Tack free at 25°C min	Pencil hardness after 7 days	TSCA
X-40-9309A	1.4	120	5H	Not Listed

(Not specified values)

Antistatic type X-40-2450X

Features: Forms an antistatic layer on surfaces, thus making them less likely to attract dirt and dust.



Parameter / Product name	Viscosity at 25°C mm²/s	Tack free at 25°C min	Pencil hardness after 7 days	TSCA
X-40-2450X	1.0	90	6H	Not Listed

(Not specified values)

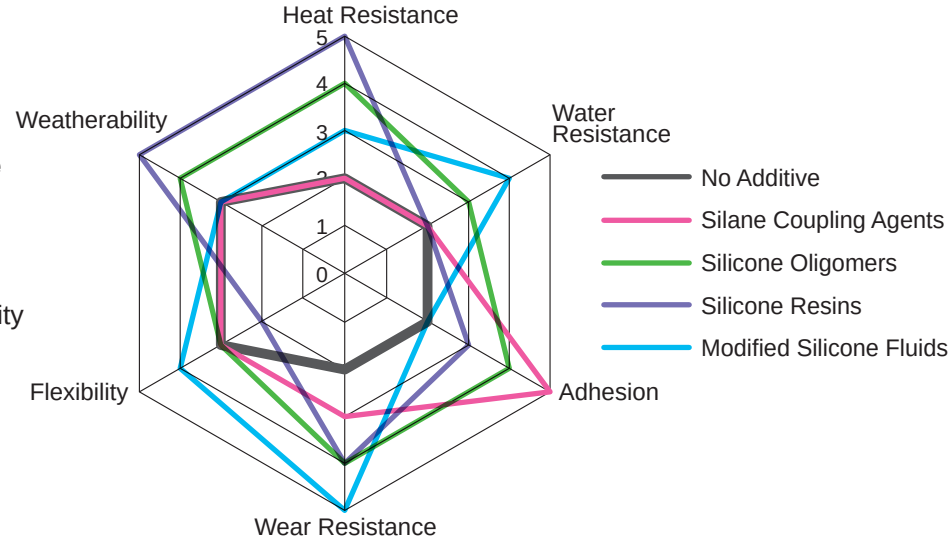
Acrylic Resins

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



■Product List Water type, Solvent type

Product category	Product name	Type	Active ingredient %	Solvent	Applicable type	Recommended adding amount %	Features	TSCA
Silane coupling agents (Radical reaction type)	**KBM-1003**	Vinyl	100	None	Water or solvent	0.5-2.0	Methoxy tri-functional	Listed
	KBM-503	Methacrylic	100	None	Water or solvent	0.5-2.0	Methoxy tri-functional	Listed
	KBE-503	Methacrylic	100	None	Water or solvent	0.5-2.0	Ethoxy tri-functional	Listed
	KBM-502	Methacrylic	100	None	Water or solvent	0.5-2.0	Methoxy di-functional	Not Listed
	KBE-502	Methacrylic	100	None	Water or solvent	0.5-2.0	Ethoxy di-functional	Not Listed
Silane coupling agents (Room temperature cure type)	**KBM-303**	Epoxy	100	None	Water or solvent	0.5-2.0	Alicyclic epoxy	Listed
	KBM-403	Epoxy	100	None	Water or solvent	0.5-2.0	Glycidyl	Listed
	KBM-603	Amino	100	None	Water or solvent	0.5-2.0	Diamine	Listed
	KBE-903	Amino	100	None	Water or solvent	0.5-2.0	Primary amine	Listed
Silicone oligomers	**KC-89S**	Methyl	100	None	Water or solvent	10-20	Low DP (degree of polymerization)	Listed
	KR-515	Methyl	100	None	Water or solvent	10-20	Medium DP	Listed
	KR-500	Methyl	100	None	Water or solvent	10-20	Medium DP	Listed
	KR-510	Methyl / Phenyl	100	None	Solvent	10-20	Excellent compatibility	Listed
Silicone resins	**KR-211**	Methyl / Phenyl	70	Xylene	Solvent	10-50	Excellent compatibility	Listed
	KR-212	Methyl / Phenyl	70	Xylene	Solvent	10-50	Excellent flexibility and compatibility	Listed
	KR-216	Propyl / Phenyl	100	None	Solvent	10-50	Solid type	Listed
Modified silicone fluids	**X-22-174ASX**	Single-end Methacrylic	100	None	Solvent	0.5-20	Short chain length	Listed
	X-22-174BX	Single-end Methacrylic	100	None	Solvent	0.5-20	Medium chain length	Listed
	KF-2012	Single-end Methacrylic	100	None	Solvent	0.5-20	Long chain length	Listed

(Not specified values)

■Application Examples

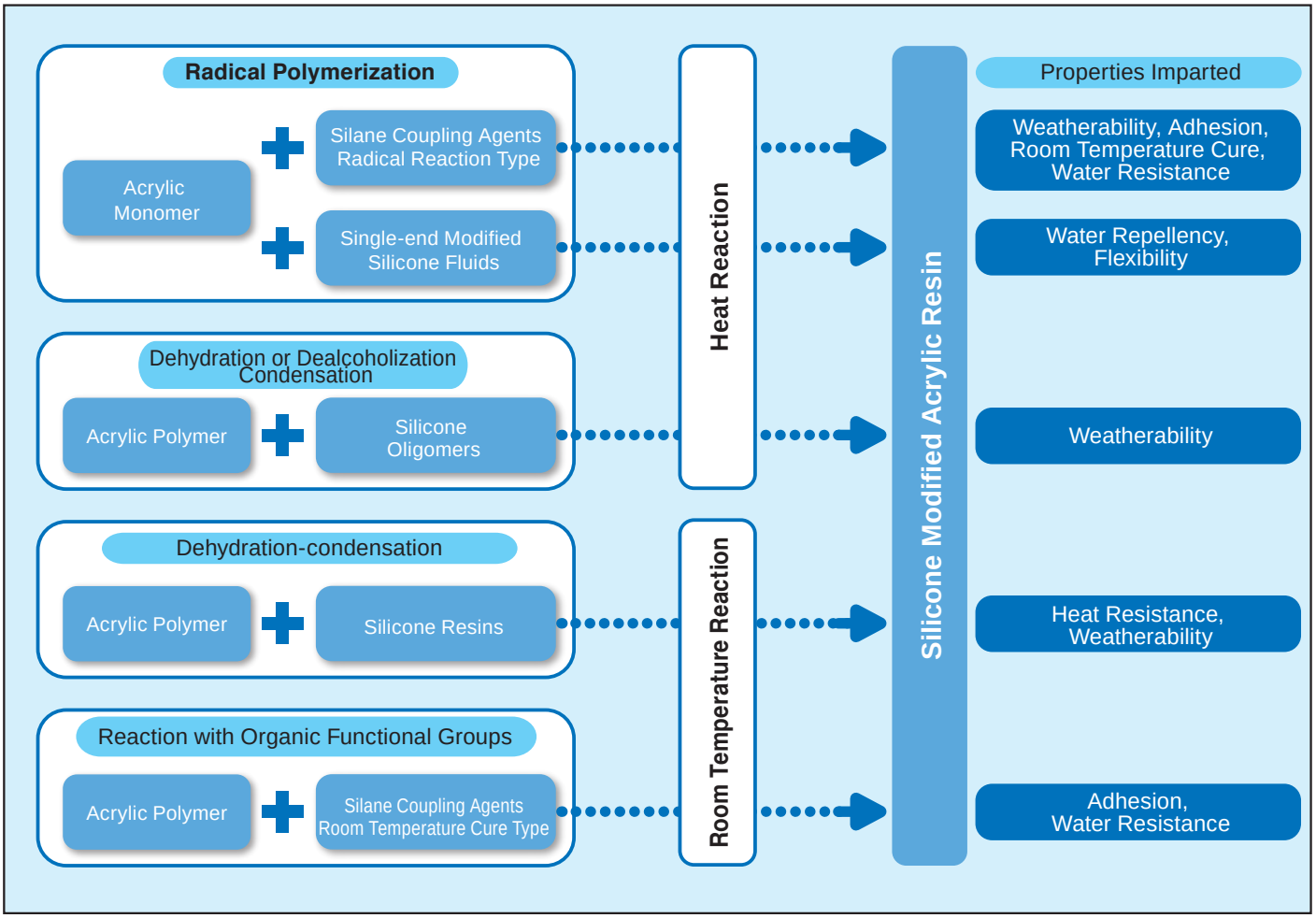
- Construction exterior parts
- Heavy-duty anticorrosion, exterior building (Chemical plant)
- Automotive paint (Car, Train)
- Automotive parts
- Display, electrical equipment

●Exterior construction parts

●Hard coating

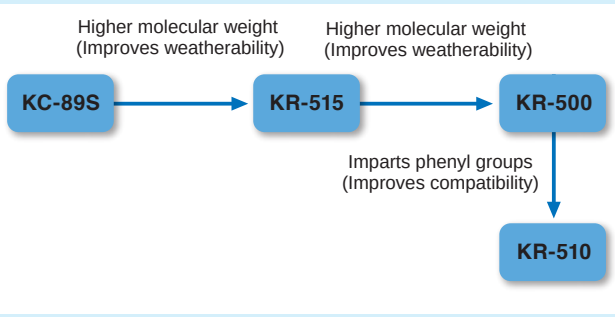
●Heavy-duty anticorrosion paint

■Process of silicone hybridization Water, Solvent type

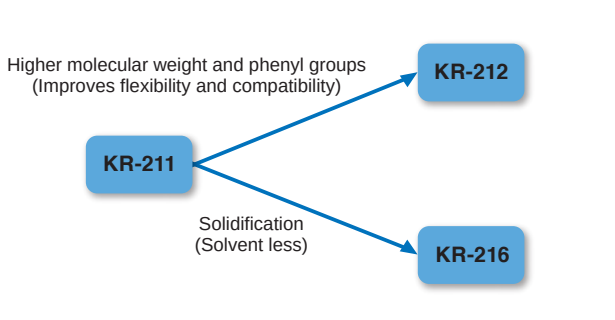


■Product Type

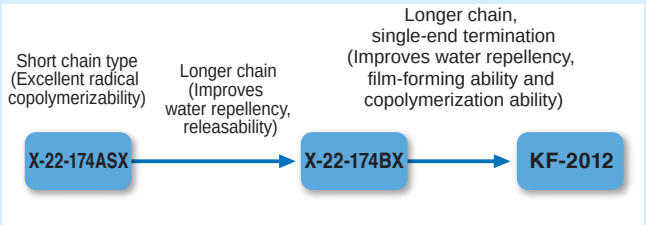
●Silicone Oligomers



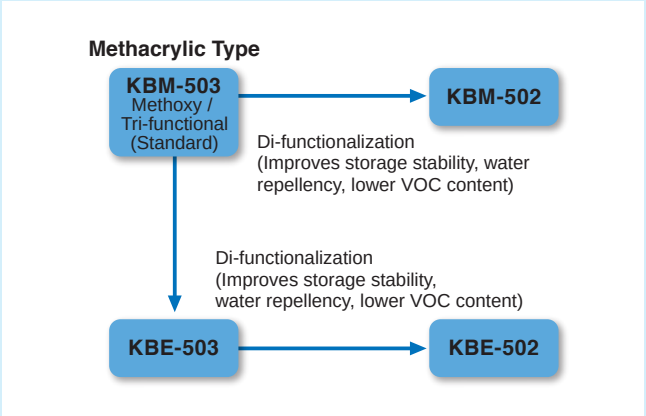
●Silicone Resins



●Modified Silicone Fluids



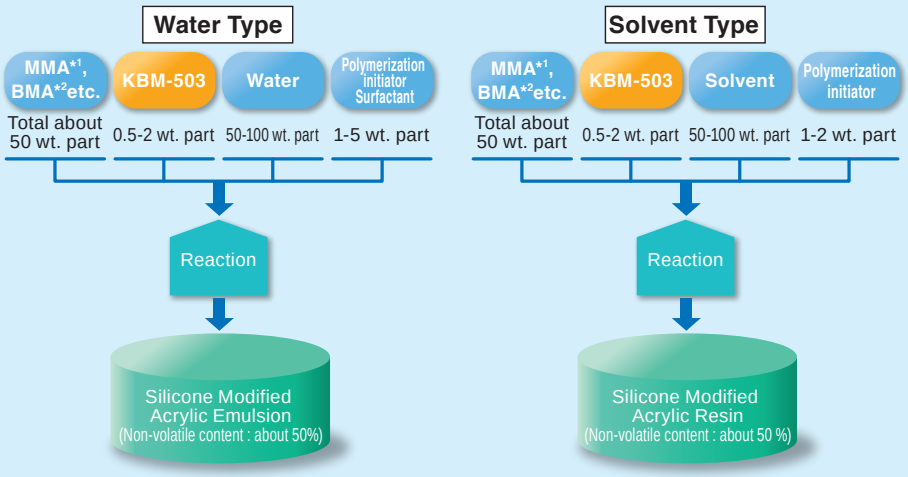
●Silane Coupling Agents Radical Reaction Type



■Synthesis Examples of Heat Reaction Type

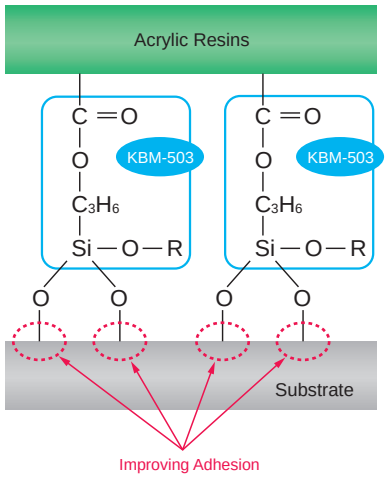
●Modification via Radical Polymerization using KBM-503

Results in improved adhesion to substrates and improved moisture resistance.



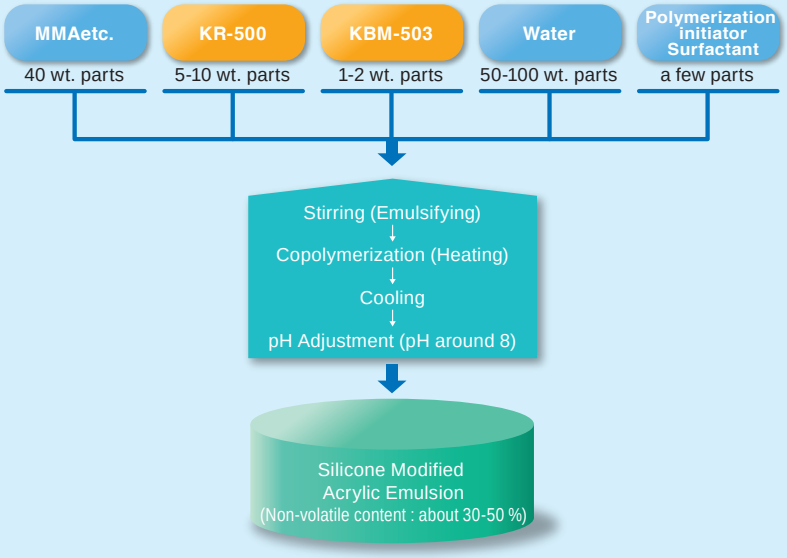
*1 MMA=Methyl methacrylate *2 BMA=Butyl methacrylate

●Model of Resin Modification

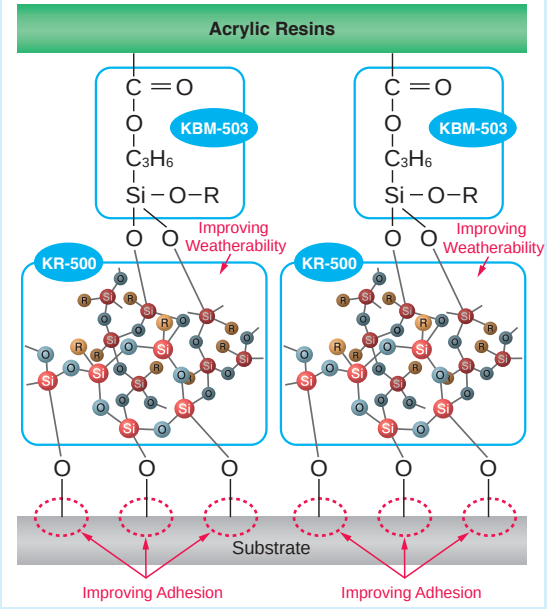


●Modification via Dehydration-condencsation or Dealcoholization-condensation using KR-500.

Results in improved adhesion to substrates and enhanced weatherability.

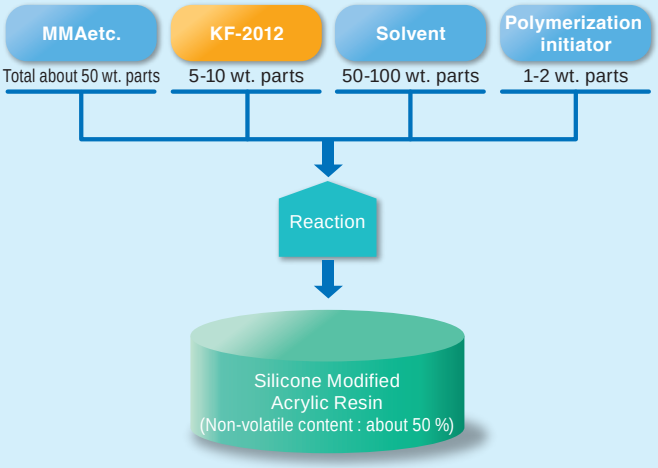


●Model of Resin Modification

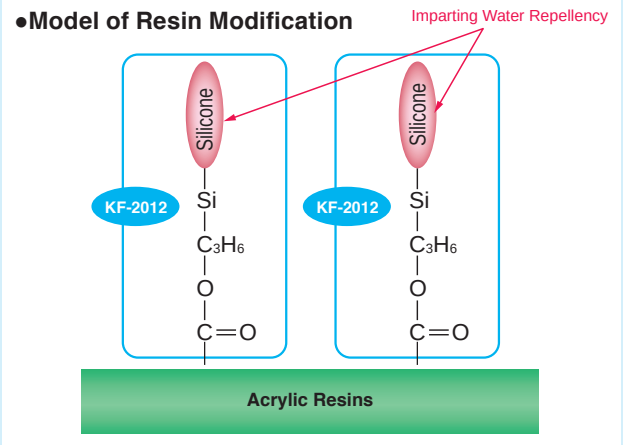


●Modification via Radical Polymerization using KF-2012.

Silicone chains are grafted onto the acrylic resin, thereby improving the surface characteristics and water repellency.



●Model of Resin Modification

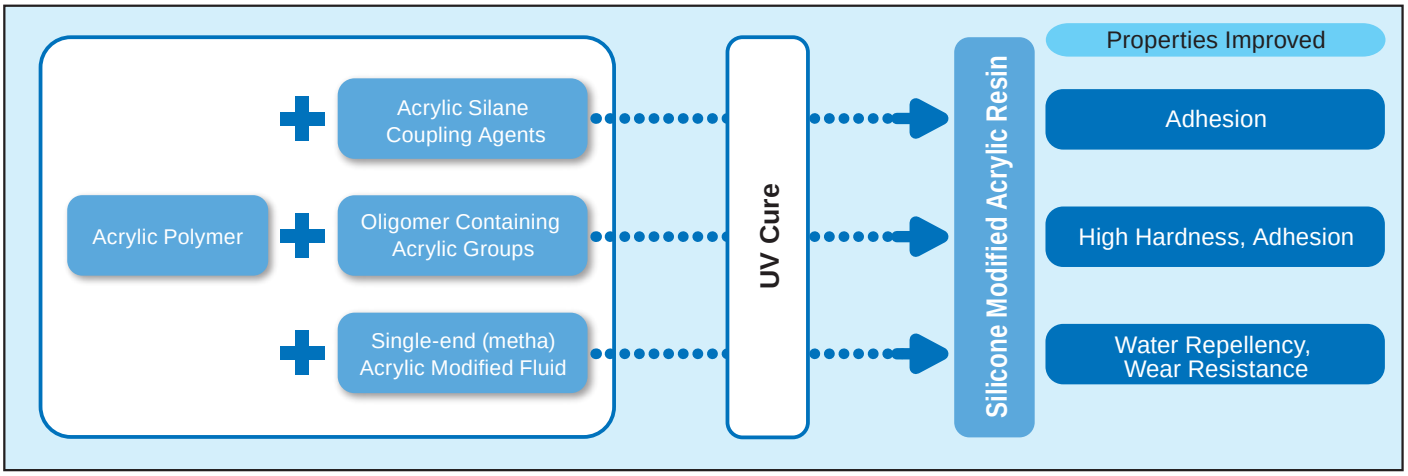


■Product List UV type

Product category	Product name	Type	Active ingredient %	Solvent	Applicable type	Recommended adding amount %	Features	TSCA
Silane coupling agents	**KBM-5103**	Acrylic	100	None	UV	1-50	Standard product	Listed
	X-12-1048	Acrylic	100	None	UV	1-50	Acrylic group / Si ratio = 1	Not Listed
	X-12-1050	Acrylic	100	None	UV	1-50	Polymer type, Acrylic group / Si ratio = 5	Not Listed
Silicone oligomers	**KR-513**	Acrylic / Methyl	100	None	UV	10-50	Condensation cure type of KBM-5103	Not Listed
	X-40-9308	Acrylic	100	None	UV	10-50	High hydrolyzability	Not Listed
Modified silicone fluids	**X-22-164A/B**	Dual-end Methacrylic	100	None	UV	10-50	Slip property	Listed
	X-22-2445	Dual-end acrylic	100	None	UV	10-50	Leveling property	Listed

(Not specified values)

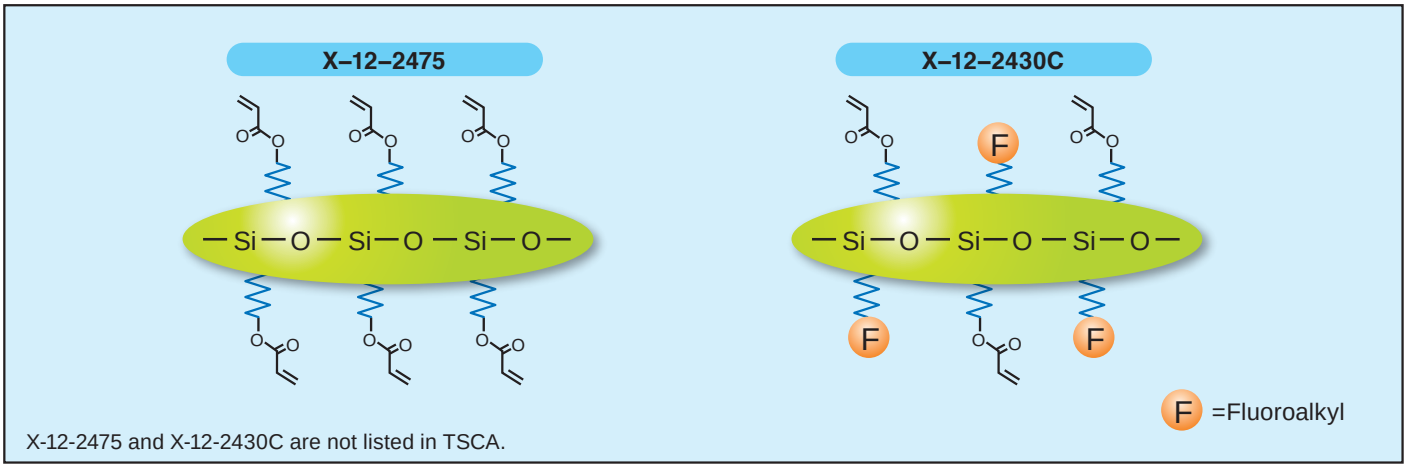
■Process of Silicone Hyblidization : UV Type



■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



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

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/cm^2 Nitrogen substitution

●Durability Testing

Product name	Pencil hardness	Taber abrasion test ΔHaze(500g load, 100 rotations)
KR-513	2H	3.0
X-12-1050	2H	3.0
X-40-9308	2H	3.0
X-12-2475	3H	2.5
X-12-2430C	2H	3.0
Blank	H	4.0

(Not specified values)

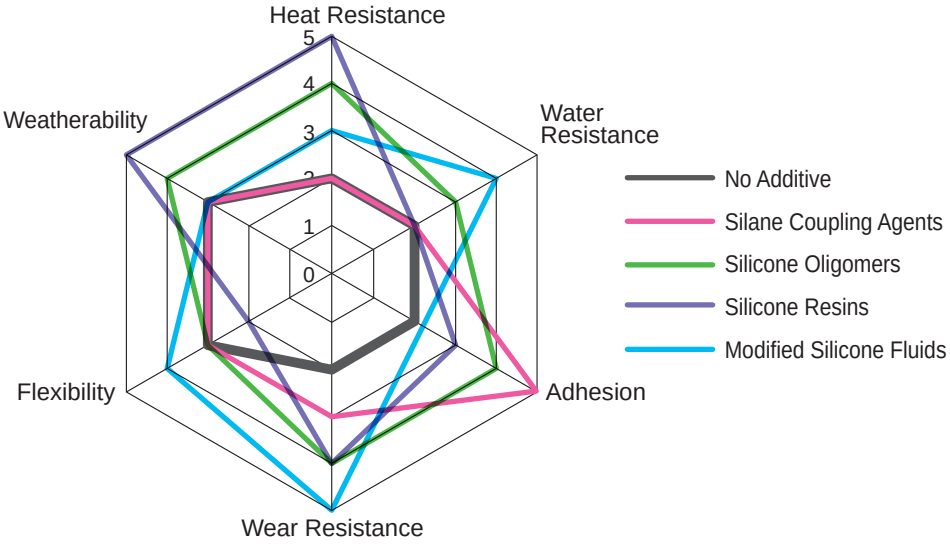
Polyester & Alkyd Resins

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 Imparted to Polyester & Alkyd Resins



■Product List

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

(Not specified values)

■Application Examples

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

●Painted Steel

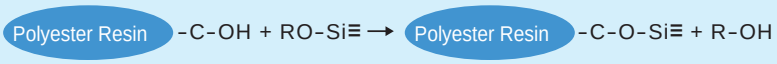
●Tanks

■ Synthesis Examples

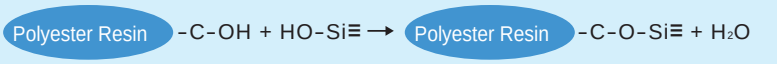
Weatherability is improved by inserting KR-510 into the polyester resin.

●Reaction Mechanisms

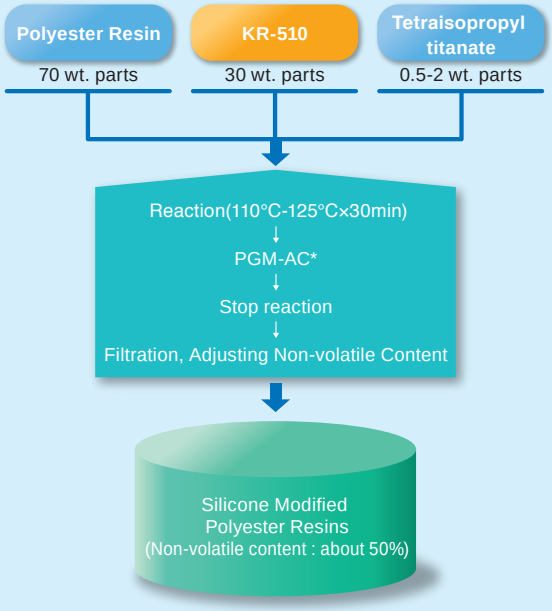
Dealcoholization condensation reaction



Dehydration condensation



●Polyester Resin Modification with Silicone Oligomers



*PGM-AC:Propylene glycol monomethylether acetate

●General Properties

Parameter \ Product name	KR-510
Appearance	Colorless to pale yellow slightly clowdy liquid
Viscosity at 25°C mm²/s	100
Specific gravity at 25°C	1.16
Refractive index at 25°C	1.509
Active ingredient %	100

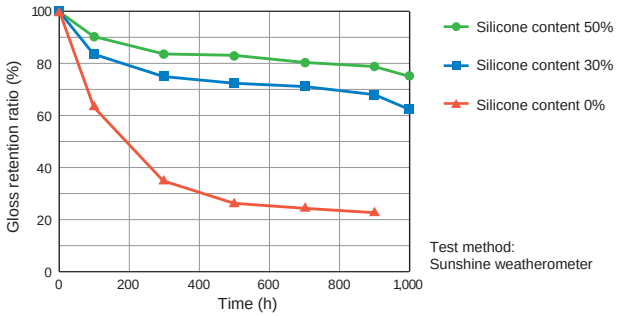
(Not specified values)

●Film Properties

Parameter \ Cure condition	285°C×1min	285°C×10min
Pencil hardness	2H	4H
Adhesion (cross cut adhesion test)	100/100	100/100
Impact resistance Dupont test cm	Min.50	Min.50
MEK* rubbing times	100	Min.100
Xylene rubbing times	10	Min.100

*MEK : Methyl ethyl ketone (Not specified values)

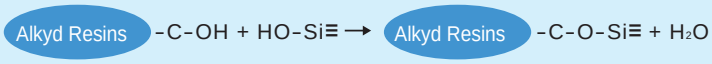
●Weatherability Test Result of Silicone Modified Polyester Resin



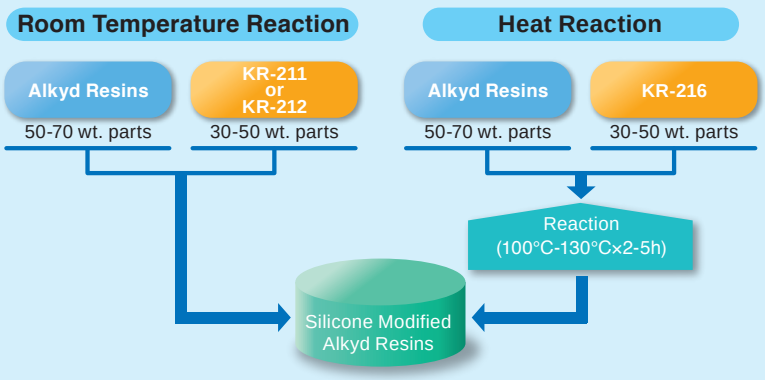
Heat resistance is improved by inserting a high-molecular-weight silicone resin into the alkyd resin.

●Reaction Mechanisms

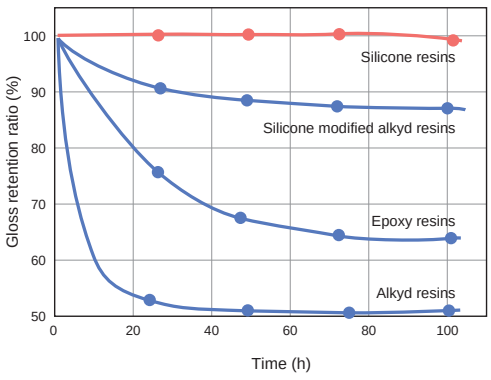
Dehydration condensation



●Alkyd Resin Modification with Silicone Oligomer



●Heat Resistance Comparison Data at 250°C



●Product Type

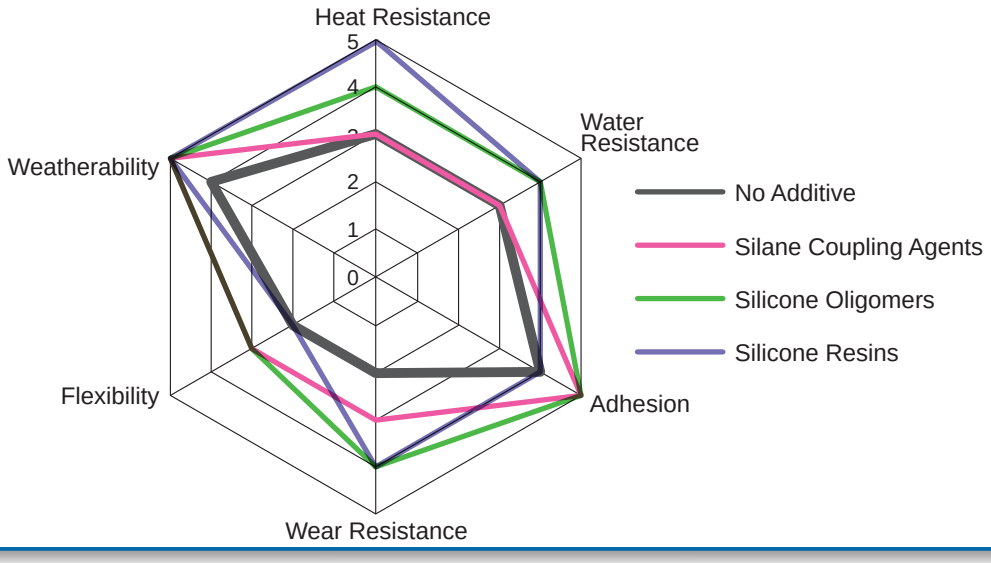
Epoxy Resins

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



■Product List

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

(Not specified values)

■ Application Examples

- • Heavy-duty
  (Bridges, Tanks, Steel structures)
- • Marine paint

●Bridge

●Pipes

●Marine Paint

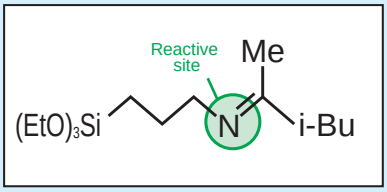
Protected Functional Group Silane Coupling Agent KBE-9103P

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



●General Properties

Parameter	Product name	KBE-9103P
Purity at 25°C	GC%	min. 95
Viscosity at 25°C	mm²/s	3.0

(Not specified values)

●Storage Stability in Epoxy Resins

[Blend] JER827 made by Mitsubishi Chemical Corporation 50 wt. part
Toluene 50 wt. part
Silane Coupling Agents 5 wt. part

Viscosity

Days	Product name	No additive	KBE-9103P	KBE-903
After 3 days	mm²/s	4.2	4.4	7.8
After 14 days	mm²/s	4.3	4.7	8.6

(Not specified values)

●Adhesion Tests with Epoxy Internal-addition Adhesives

[Blend] JER827 made by Mitsubishi Chemical Corporation 100 wt. part
Silane Coupling Agents 5 wt. part
Triethylenetetramine 5 wt. part

Substrate : Aluminum

Condition	Product name	No additive	KBE-9103P	KBE-903
Initial strength	MPa	3.9	7.6	6.1
After water resistance test (95°C×10h)	MPa	3.4	6.4	5.2

(Not specified values)

Substrate : Steel

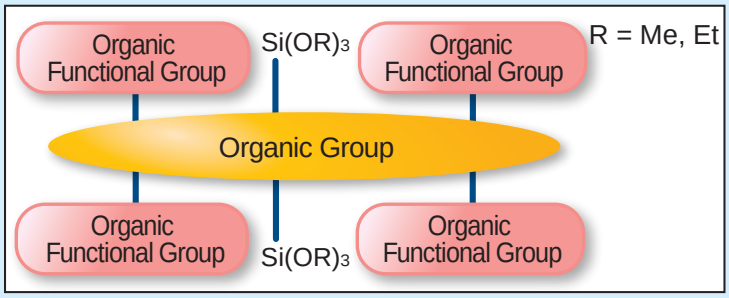
Condition	Product name	No additive	KBE-9103P	KBE-903
Initial strength	MPa	12.4	17.8	15.7
After water resistance test (95°C×10h)	MPa	9.3	14.1	13.5

(Not specified values)

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.

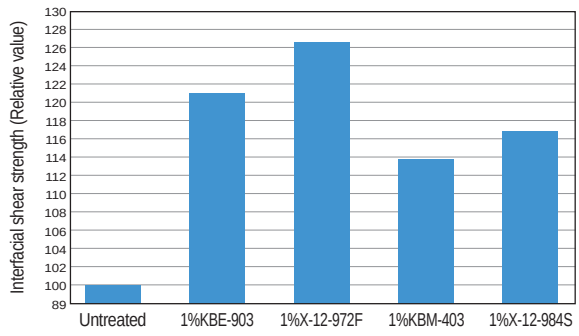
●Chemical Structure of Multi Functional Silane Coupling Agents



●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

●Interface Adhesion Test of Glass / Epoxy Resin



Test method

(1) 1% aqueous solution applied to glass substrate.
(2) Cured material [EPIKOTE 828 (epoxy resin made by Mitsubishi Chemical Corp.) / triethylenetetramine] is prepared, adhesive strength is tested.

*Calculated against baseline value of 100 for adhesion to untreated substrate.

■Product List

Organic functional group	Product name	Alkoxy group	Number of reactive groups per Si	Viscosity mm²/s	Reactive group equivalent g/mol	Note
Amino	**X-12-972F**	EtO	5	8.6	600	15% Ethanol solution
Epoxy	**X-12-981S**	EtO	3	1,000	290	-
	X-12-984S	EtO	3	2,000	270	-

(Not specified values)

■Synthesis Example

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

●Reaction Mechanism

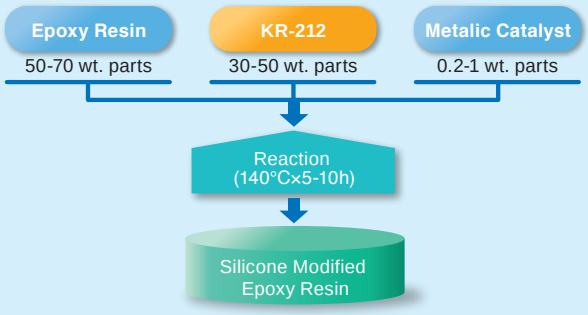
Dehydration condensation: Epoxy Resin-C-OH + HO-Si≡ → Epoxy Resin-C-O-Si≡ + H_2O

●General Properties

Product name	Type	Appearance	Viscosity at 25°C mPa•s	Viscosity at 25°C mm²/s	Specific gravity at 25°C	Solvent
KR-212	Methyl / Phenyl type	Colorless transparent liquid	28	8.6	1.07	Xylene

(Not specified values)

●Modification Example with Silicone Resins



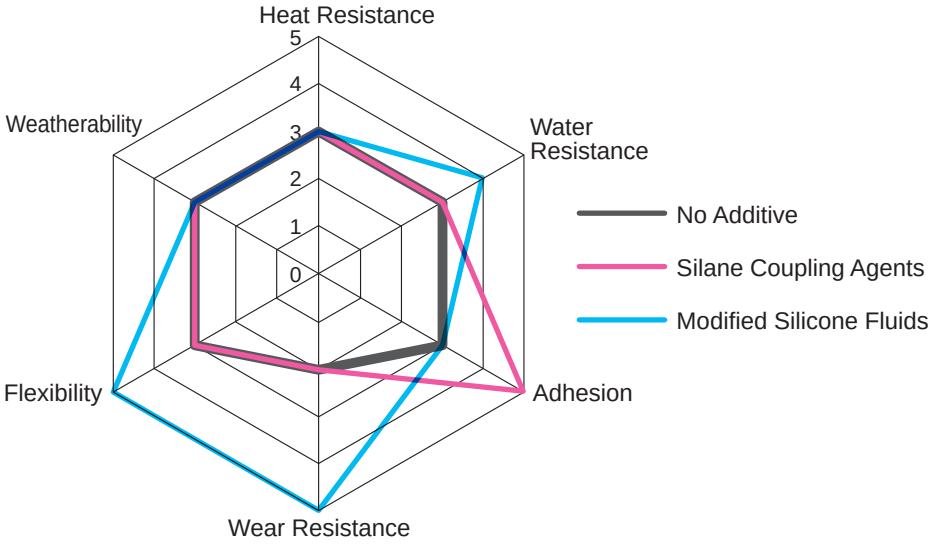
Urethane Resins

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 Imparted to Urethane Resins



■Product List

Product category	Product name	Type	Active ingredient %	Solvent	Applicable type	Recommended adding amount %	Features	TSCA
Silane Coupling Agents	**KBE-9103P**	Amino	100	None	Water or solvent	0.5-2.0	Protected functional group	Listed
	KBM-9659	Isocyanurate	100	None	Water or solvent	0.5-2.0	Multi-functional	Listed
	X-12-5263HP	Amino	100	None	Water or solvent	0.5-2.0	Bis amine	Listed
	X-12-1056ES	Mercapto group protected	100	None	Water or solvent	0.5-2.0	Protected functional group, low odor	Not Listed
	KBE-9007	Isocyanate	100	None	Water or solvent	0.5-2.0	Ethoxy tri-functional	Listed
	KBM-403	Epoxy	100	None	Water or solvent	0.5-2.0	Methoxy tri-functional	Listed
Modified Silicone Fluids	**KF-6000**	Dual-end carbinol	100	None	Water or solvent	0.5-20	Excellent compatibility	Listed
	KF-6001	Dual-end carbinol	100	None	Water or solvent	0.5-20	Flexibility, wear resistance	Listed
	KF-6002	Dual-end carbinol	100	None	Water or solvent	0.5-20	Flexibility, wear resistance	Listed
	X-22-170BX	Single-end carbinol	100	None	Water or solvent	0.5-10	Excellent compatibility	Not Listed
	X-22-176DX	Single-end diol	100	None	Water or solvent	0.5-10	Surface slick property	Not Listed

(Not specified values)

■Application Examples

- Construction parts
- Consumer electronics parts
- Automotive interior parts

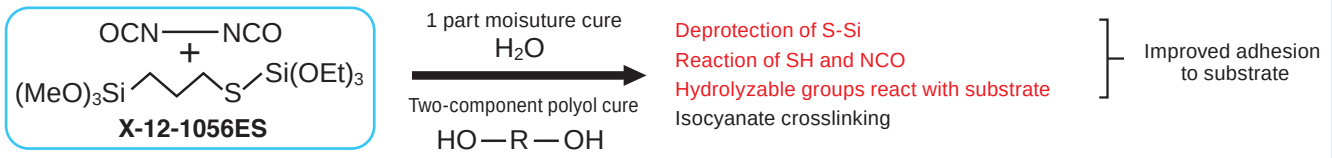
●Synthetic Leathers for Automotive

●Interior Sealant

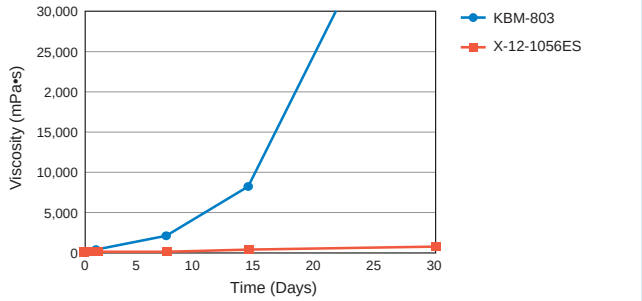
Protected Functional Group Silane Coupling Agent X-12-1056ES

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.

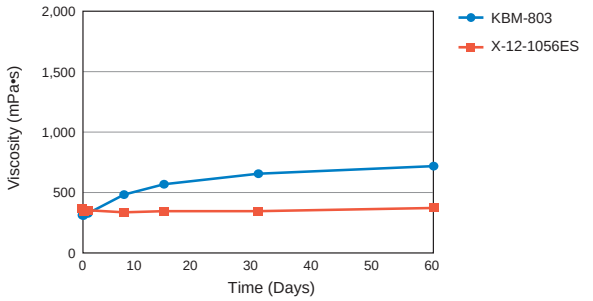
●Application Example of Protected Mercapto Group Silane Coupling Agent X-12-1056ES



●Stability with Isocyanate Compounds



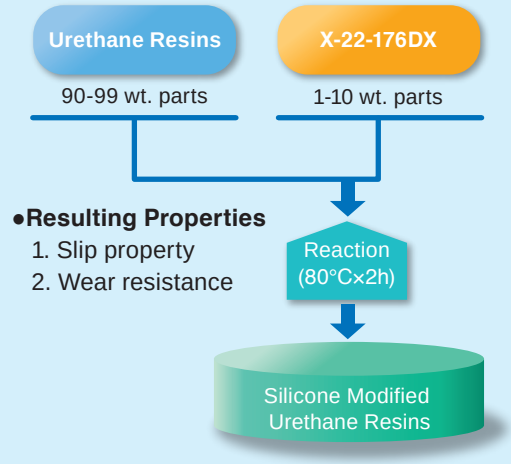
Change in viscosity when mixed with aromatic isocyanate (M-200)
Condition : Silane 5 wt% added, storage at 50°C



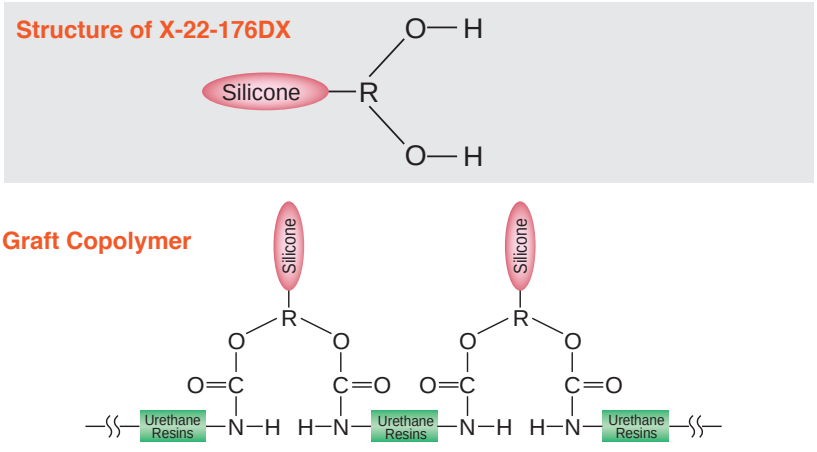
Change in viscosity when mixed with aromatic isocyanate (TLA-100)
Condition : Silane 5 wt% added, storage at 50°C

■Synthesis Examples

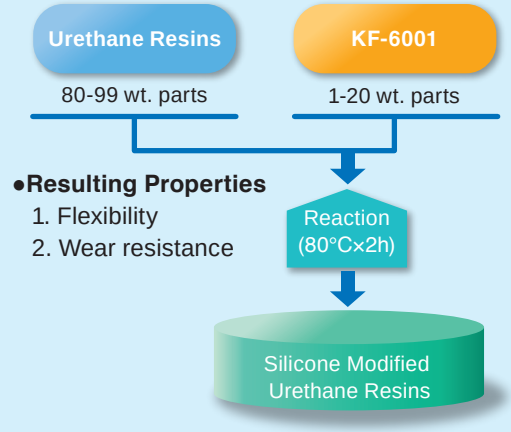
●Modification Example with Single-end Diol Fluids



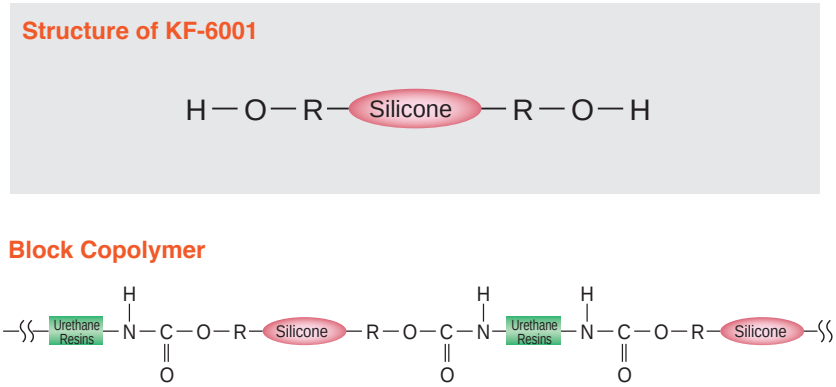
●Model of Graft Copolymer



●Modification Example with Dual-end Carbinol Fluids

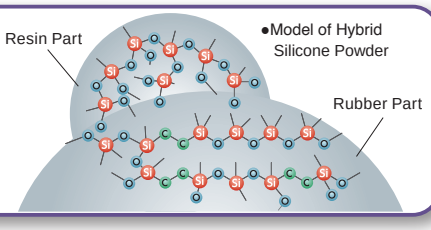


●Model of Block Copolymer



Silicone Powders

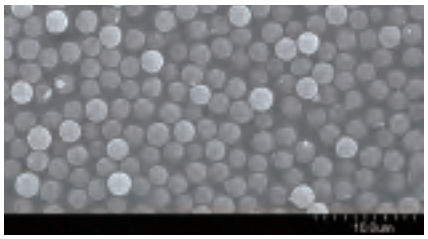
Shin-Etsu has developed a unique line of silicone powders which fall into three categories: Hybrid Silicone Powder, Silicone Rubber Powder and Silicone Resin Powder. These products impart a variety of properties (i.e. lubricity, wear resistance and light diffusion) into coating agents and paints.



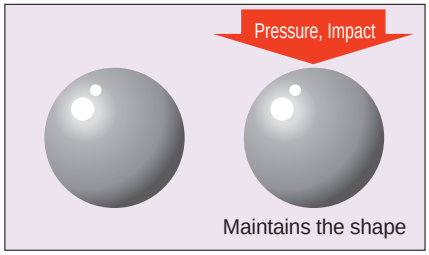
Silicone Resin Powder

Molecular structure: 3D network structure

●KMP-706 by Scanning with Electron Microscope



●Model of Silicone Resin Powder



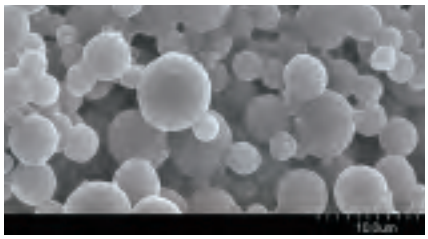
●Features

Heat resistance	++
Weatherability	++
Dispersibility into resins	++
With organic solvents	No swelling

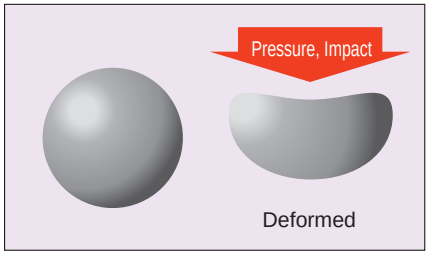
Silicone Rubber Powder

Molecular structure: Straight-chain crosslinked polymer

●KMP-594 by Scanning with Electron Microscope



●Model of Silicone Rubber Powder



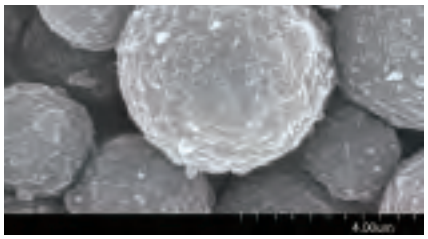
●Features

Heat resistance	+
Weatherability	++
Dispersibility into resins	±
With organic solvents	Swelling

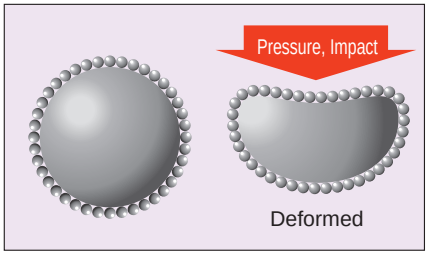
Hybrid Silicone Powder

Form: Rubber powders covered with resin

●KMP-600 by Scanning with Electron Microscope



●Model of Hybrid Silicone Powder

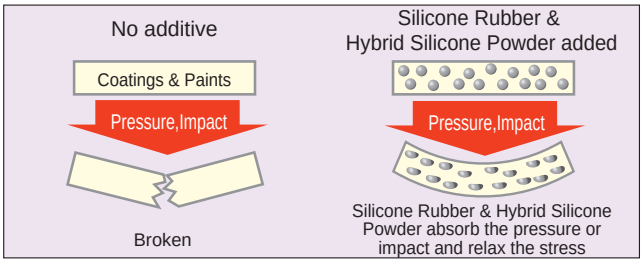


●Features

Heat resistance	+
Weatherability	++
Dispersibility into resins	++
With organic solvents	Rubber part swells

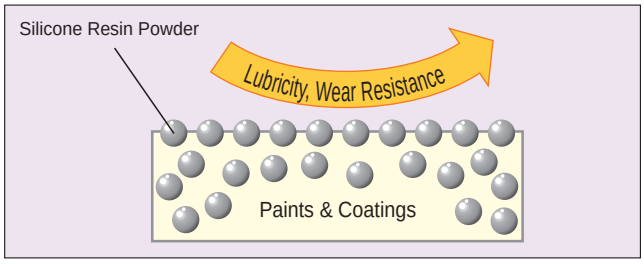
■Enhanced Properties

●Stress Relaxation, Impact Resistance



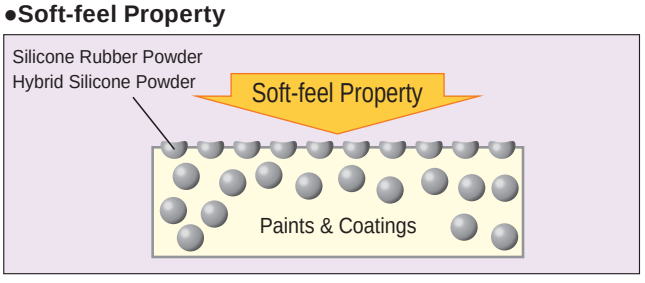
Resin Powder	-
Rubber Powder	++
Hybrid Powder	++

●Lubricity, Wear Resistance



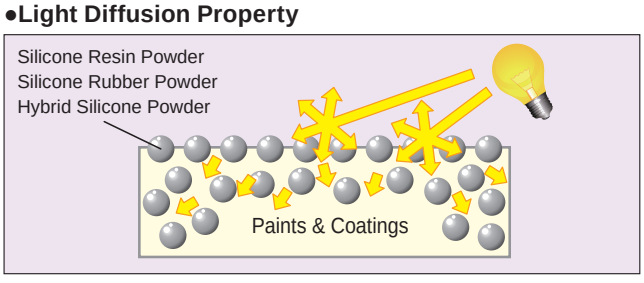
Resin Powder	++
Rubber Powder	+
Hybrid Powder	++

●Soft-feel Property



Resin Powder	-
Rubber Powder	++
Hybrid Powder	++

●Light Diffusion Property



Resin Powder	++
Rubber Powder	++
Hybrid Powder	++

* ++:Excellent +: Good ±: Satisfactory -: Poor

■Product List

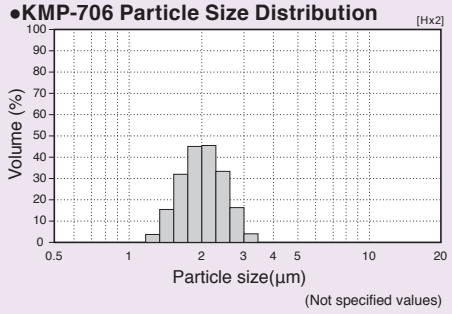
Type \ Parameter	Product name	Shape	Average particle size μm	Particle size distribution μm	True specific gravity	Moisture content %	Rubber hardness Durometer A	Refractive index		TSCA
								Rubber part	Resin part	
Silicone resin powder	**KMP-706**	Spherical	2	1-4	1.3	1	-	-	1.43	Listed
	KMP-701	Spherical	3.5	1-6	1.3	1	-	-	1.43	Listed
	X-52-1621	Spherical	5	1-8	1.3	1	-	-	1.43	Listed
	X-52-854	Spherical	0.7	0.2-5	1.3	1	-	-	1.43	Listed
Silicone rubber powder	**KMP-594**	Spherical	5	1-10	0.97	0.1	30	1.41	-	Listed
	KMP-597	Spherical	5	1-10	0.97	0.1	30	1.41	-	Listed
	KMP-598	Spherical	13	2-30	0.97	0.1	30	1.41	-	Listed
Hybrid silicone powder	**KMP-600**	Spherical	5	1-15	0.99	0.1	30	1.41	1.43	Listed
	KMP-601	Spherical	12	2-25	0.98	0.1	30	1.41	1.43	Listed
	KMP-602	Spherical	30	4-60	0.98	0.1	30	1.41	1.43	Listed
	KMP-605	Spherical	2	0.7-5	0.99	0.1	75	1.42	1.43	Listed
	X-52-7030	Spherical	0.8	0.2-2	1.01	0.1	75	1.42	1.43	Listed

(Not specified values)

■Product Data

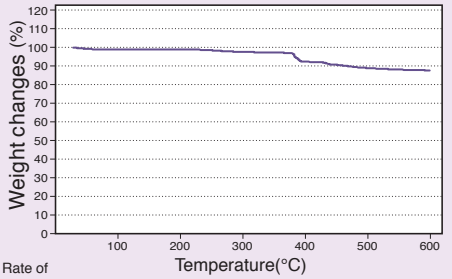
Silicone Resin Powder

●KMP-706 Particle Size Distribution



(Not specified values)

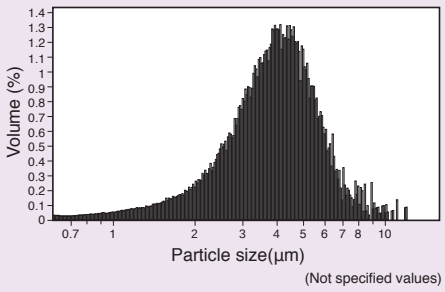
●KMP-706 Heat Resistance
(Weight changes vs. temperatures)



Rate of temperature increase: 10°C/min
Atmosphere: Air
(Not specified values)

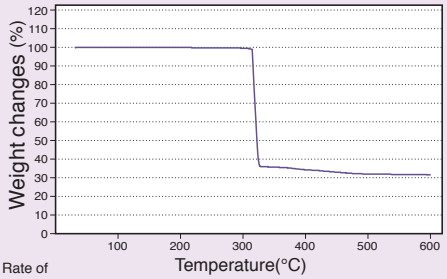
Silicone Rubber Powder

●KMP-594 Particle Size Distribution



(Not specified values)

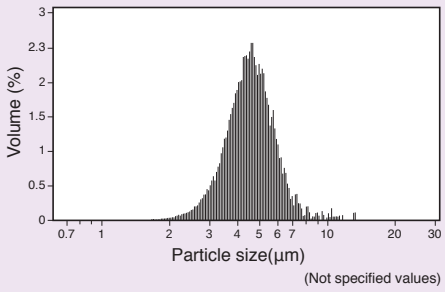
●KMP-594 Heat Resistance
(Weight changes vs. temperatures)



Rate of temperature increase: 10°C/min
Atmosphere: Air
(Not specified values)

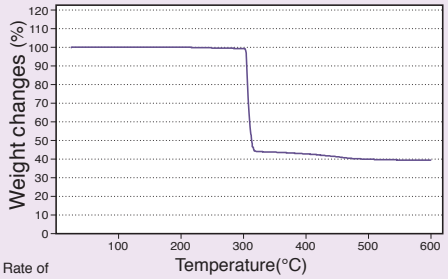
Hybrid Silicone Powder

●KMP-600 Particle Size Distribution



(Not specified values)

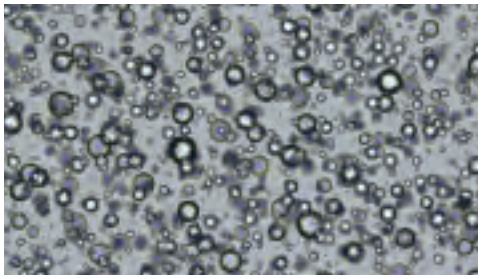
●KMP-600 Heat Resistance
(Weight changes vs. temperatures)



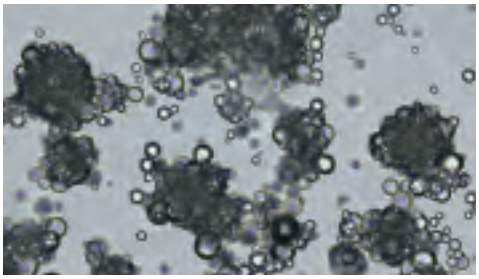
Rate of temperature increase: 10°C/min
Atmosphere: Air
(Not specified values)

■Dispersibiilty

Dispersibility in liquid epoxy resin



●Hybrid Silicone Powder KMP-601



●Silicone Rubber Powder *

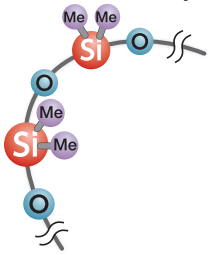
*Applying a shearing force improves dispersibility of silicone rubber powders in resin.

KP Series

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



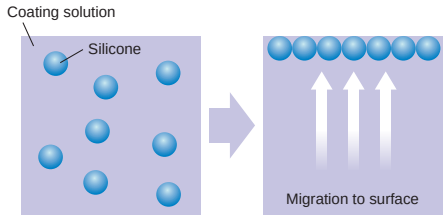
1.Low surface tension

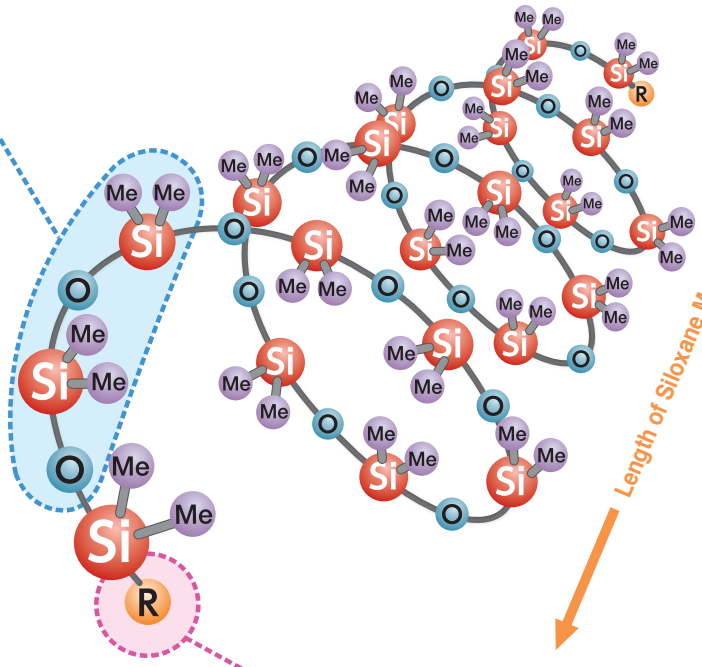
Silicone fluids have very low surface tension.

Types of liquid	Suface tension(25°C) mN/m
Dimethyl silicone KF-96	21
Toluene	28
Mineral oil	30
Glycerin	63
Water	72

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

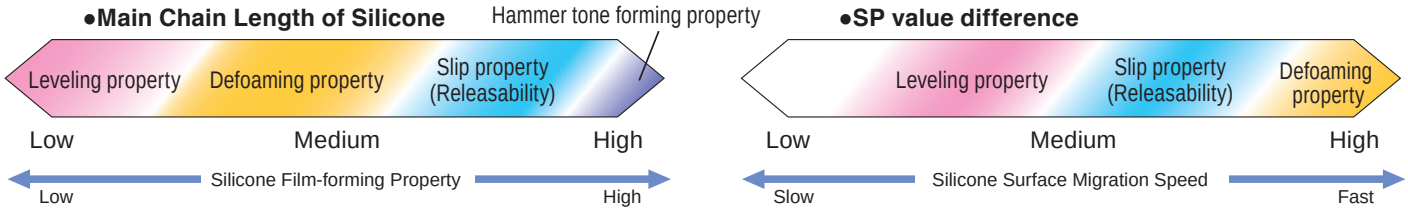
Compatibility with organic resin solutions. Surface tension can be controlled by changing the type of organic functional group.

R
Organic functional group

Type	Features
Polyether	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.
Polyol	Organic groups having a relatively compact structure with large numbers of hydroxyl groups. Silicone rich, and yet strongly hydrophilic with high polarity.
Acrylic	Organic groups composed of acrylic polymers. Have good film-forming ability and compatibility with acrylic resins.
Fatty acid ester	Organic groups with the same basic structure as alkyd resins.Highly compatible especially with alkyd resins.
Phenyl	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.
Fluorine	Silicones dissolve very well in aromatic solvents 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.
Alkyl Aralkyl	Introducing alkyl or aralkyl groups will produce an additive with balanced performance and higher hydrophobicity.
Polyester	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.

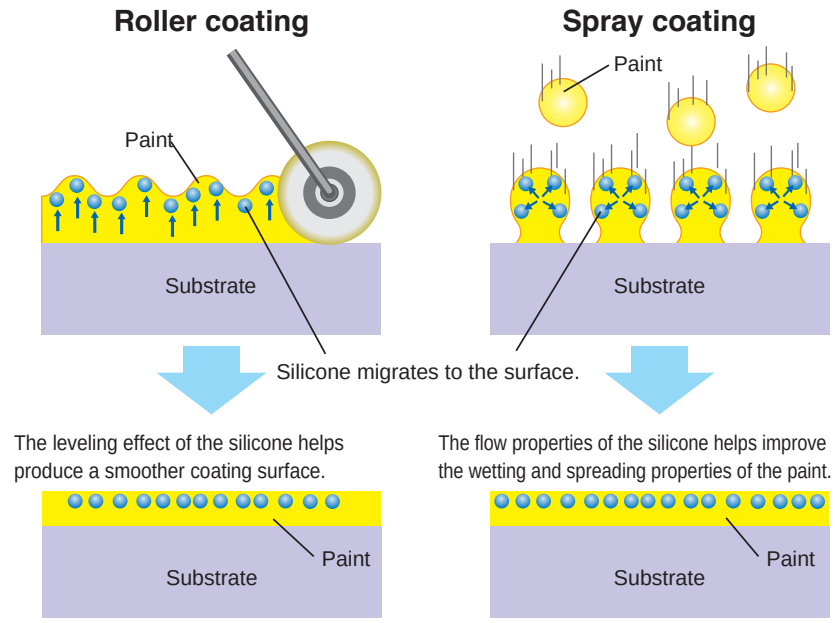
■ Relationship between Silicone Structure and Development Property

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.



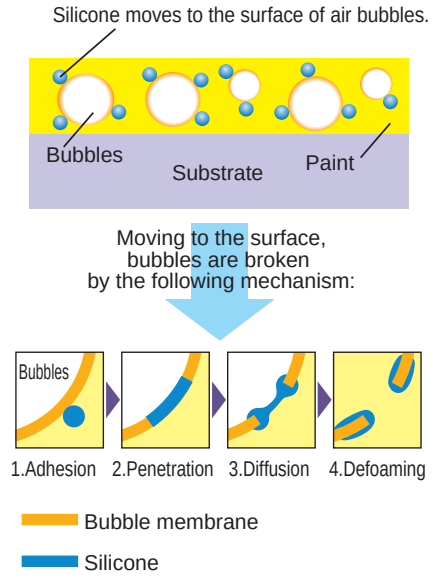
Main Applications and Functional Mechanism

●Leveling Agent (Improves Flowability)



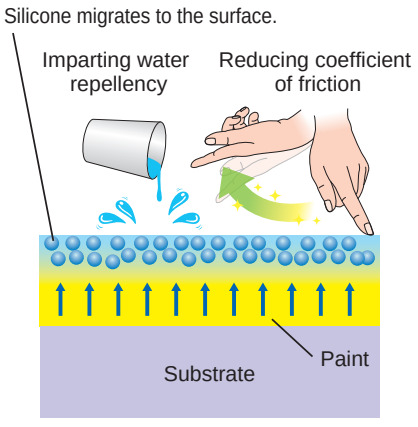
The difference in surface tension between the silicone and the paint results in improved wetting and smoothness.

●Defoaming Agent



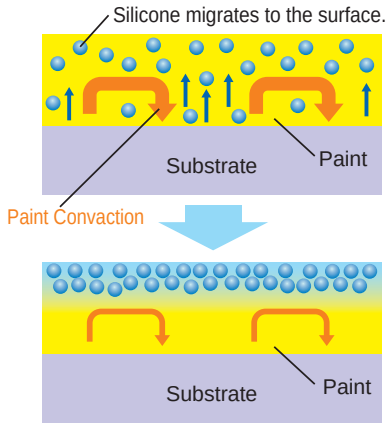
Defoaming / foam-inhibiting effect is related to differences in the polarity and compatibility between the paint and silicone.

●Slip Agent (Releasability Imparter)



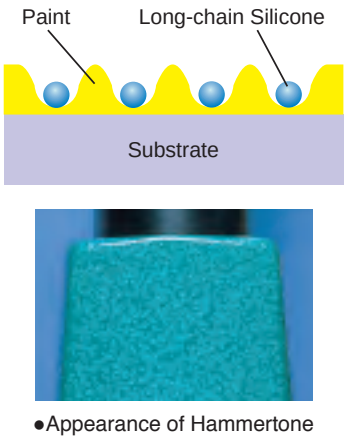
Silicone migrates to the surface, resulting in
- Improved slip property
- Improved antiblocking properties
- Improved scratch and chip resistance
- Improved antifouling properties

●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.

●Hammertone Agent



●Appearance of Hammertone

Long-chain silicones can encourage cissing and can thus be added to paints when a hammertone finish is desired.

■Product List

Application	Type	Product name	Solubility parameter	Molecular weight level (Length of siloxane main chain)	Active Ingredient %	Solvent	Water type applicability*1	Standard adding amount wt%	TSCA
Leveling	Polyether modified	**KP-124**	8.2	Medium	100	-	±	0.005-1.0	Listed
		KP-109	8.2	High	50	PGM*2	±	0.01-1.0	Not Listed
		KP-110	8.3	Small	100	-	++	0.05-5.0	Listed
		KP-121	8.4	Small	100	-	±	0.01-1.0	Listed
		KP-118	8.4	Medium	100	-	±	0.01-1.0	Listed
		KP-341	8.6	Medium	100	-	±	0.01-2.0	Listed
		KP-112	8.7	High	100	-	+	0.01-2.0	Listed
		KP-125	8.7	Medium	100	-	+	0.01-1.0	Listed
		KP-101	8.7	High	100	-	+	0.01-1.0	Listed
		KP-106	8.9	Small	100	-	++	0.01-2.0	Listed
		KP-120	10.0	High	100	-	+	0.02-4.0	Listed
	Polyol modified	**KP-105**	10.4	Medium	30	PGM*2	+	0.05-10.0	Not Listed
		KP-104	11.6	Medium	30	PGM*2	++	0.1-15.0	Not Listed
	Acrylic resin modified	**KP-611**	9.2	High	50	Butyl acetate	-	0.1-10.0	Not Listed
	Fatty acid ester modified	**KP-626**	8.4	High	10	Butyl acetate	-	0.02-2.0	Listed
	Phenyl modified	**KP-327**	7.7	Small	100	-	-	0.001-0.2	Listed
		KP-323	8.2	Small	100	-	-	0.002-0.5	Listed
		KP-322	8.4	Medium	100	-	-	0.005-1.0	Listed
	Fluorine modified	**KP-625**	7.1	Small	5	DAA*3	-	0.001-2.0	Listed
	Alkyl or Aralkyl modified	**KP-623**	8.5	High	10	Isododecane	-	0.002-4.0	Listed
		KP-624	8.8	Medium	10	ECH*4	-	0.001-2.0	Listed
		KP-620	9.2	Medium	100	-	-	0.0002-0.4	Listed
Defoaming		**KP-623**	8.5	High	10	Isododecane	-	0.002-4.0	Listed
	Fluorine modified	**KP-625**	7.1	Small	5	DAA*3	-	0.001-2.0	Listed
		KP-651	7.2	High	8	MXHF*5	-	0.0003-0.5	Not Listed
	(Compound)	**KP-652**	-	-	100	-	-	0.0001-0.1	Listed
	(Compound emulsion)	**KP-650**	-	-	55	Water	++	0.001-0.2	Listed
Slip	(Dimethyl silicone)	**KP-310**	7.4	Ultra high	10	Toluene	-	0.0005-2.0	Listed
	Polyether modified	**KP-109**	8.2	High	50	PGM*2	++	0.02-2.0	Not Listed
		KP-306	8.3	High	10	Xylene	-	0.1-10.0	Not Listed
		KP-301	8.7	Medium	10	Toluene	-	0.2-20.0	Listed
	Polyester resin modified	**KP-621**	9.1	High	10	Toluene / Xylene	-	0.2-10.0	Listed
Release	(For solvent type)	**KP-369**	7.4	Small	100	-	-	0.05-2.0	Listed
		KP-368	7.4	Medium	100	-	-	0.05-2.0	Listed
	(For water type)	**KP-126**	8.6	High	100	-	++	0.2-10.0	Listed

*1 ++ = Excellent + = Good ± = Satisfactory - = Not applicable
*2 PGA = Propylene glycolmonomethyl 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.

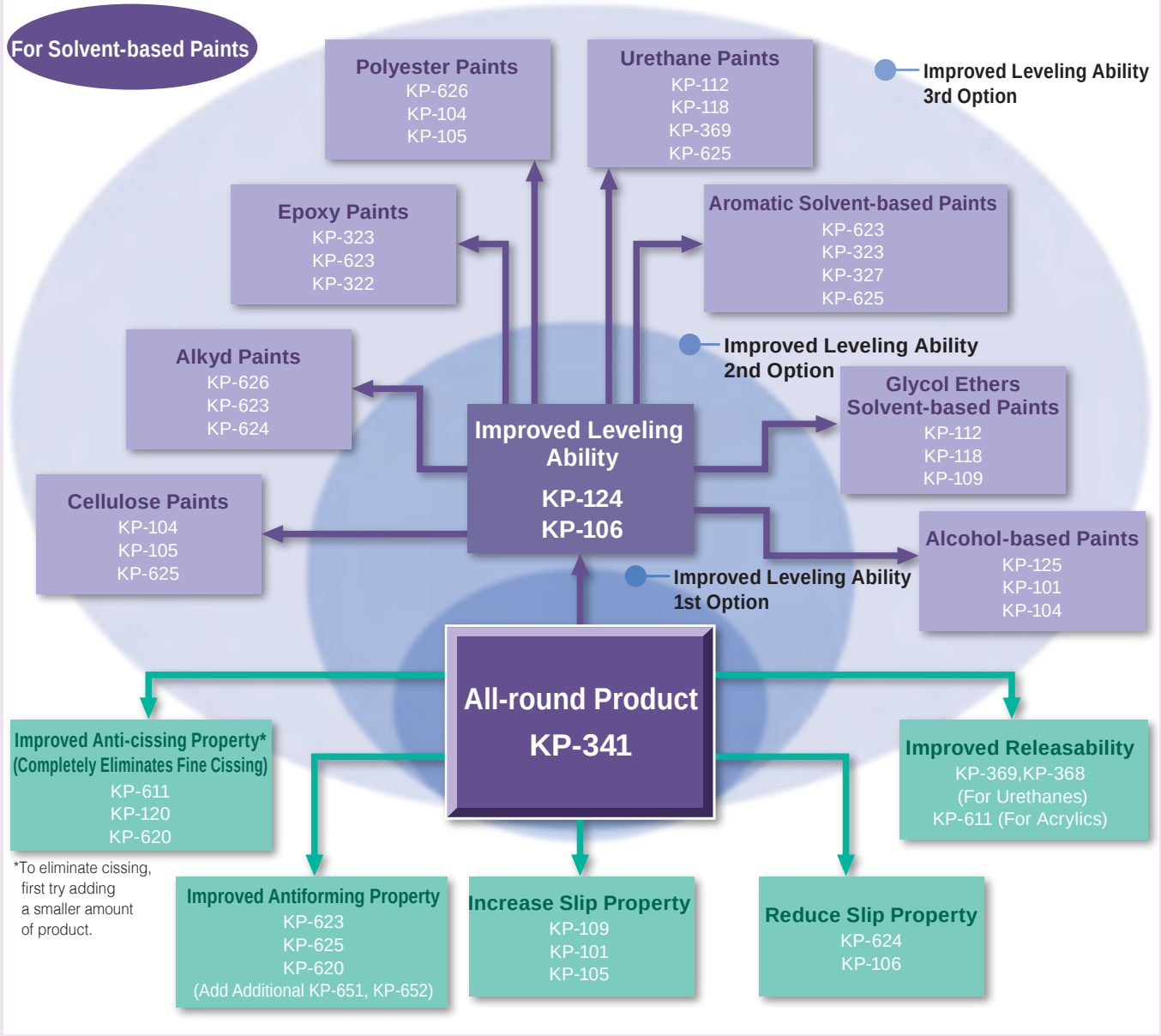
Types of solvent	SP value	Boiling point ℃	Silicone Solubility
Isooctane	7.0	99	++
n-heptane	7.4	98	++
Diethyl ether	7.4	35	+
3-methoxy-3-methyl-butyl acetate	8.5	188	+
Methyl isobutyl ketone	8.4	116	+
Ethyl acetate-n-butyl	8.5	126	+
Propylene glycol monomethylether acetate	8.7	146	+
Xylene	8.8	138	++
Toluene	8.9	111	++
Ethyl acetate	9.1	77	+
Diacetone alcohol	9.2	168	+
Methyl ethyl ketone	9.3	80	+
Ethylcellosolve	9.9	136	-
Acetone	10.0	56	±
Propylene glycolmonomethyl ether	10.5	120	-
Tert-butanol	10.6	83	-
Isobutanol	11.0	107	±
n-butanol	11.1	118	±
Isopropyl alcohol	11.5	82	+
Dimethylformamide	12.0	153	-
Ethanol	12.8	78	-
Propylene carbonate	13.3	242	-
Ethylene glycol	14.2	198	-
Methanol	14.8	65	-
Water	23.4	100	-

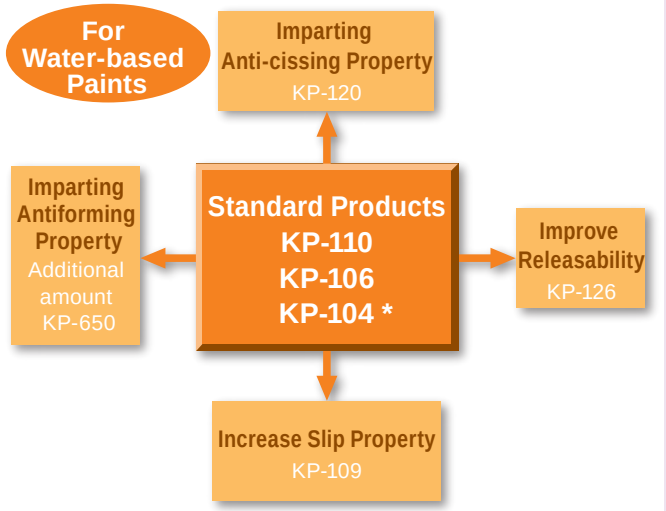
Types of polymer	SP value (Theoretical value)
Fluorine resin (PTFE)	6.2
Polyethylene	7.9
Polypropylene	8.0
Alkyd resin (long-oil)	7-9
SBR Rubber	8.1-8.7
NBR Rubber	8.8-9.5
Polystyrene	8.6-9.7
Acrylic resin (Polystearyl methacrylate)	7.8
Acrylic resin (Polybutyl acrylate)	9.0
Acrylic resin (Polymethyl methacrylate)	9.5
Acrylic resin (Polymethyl acrylate)	10.0
Acrylic resin (Polymethacrylate)	10.7
Polyvinyl acetate	9.4
Polyvinyl chloride	9.5-9.7
Polycarbonate	9.7
Epoxy resin	9.7-10.9
Amino resin	9.6- 10.1
Polyurethane resin	10.0-11.0
Cellulose acetate	10.0
Ethyl cellulose	10.3
Polyester resin (PET)	10.7
Nitrocellulose	10.6-11.5
Phenol resin	11.5
Polyamide resin (Nylon-66)	13.6
Polyvinyl alcohol	23.4

*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.

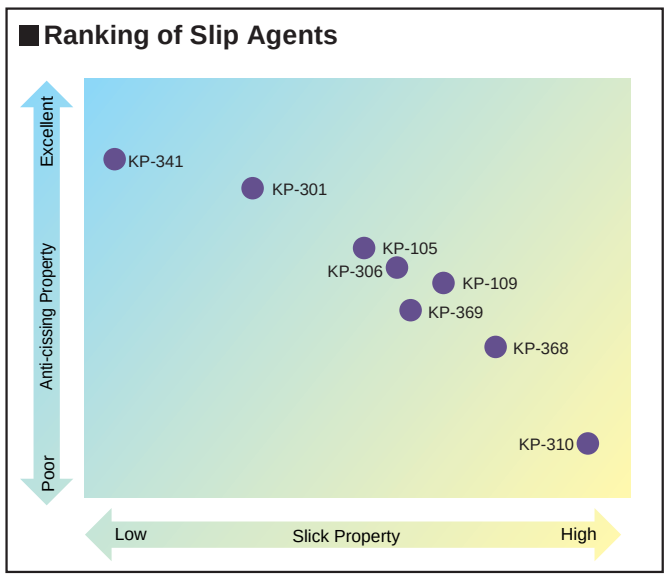
KP Series Selection Guide, Arranged by Purpose

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





* KP-104: Works especially well with water-soluble resins such as Polyvinyl Alcohol.



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.

●Resulting Properties

•Excellent antistatic agent

●Test Result of Antistatic Properties

Parameter \ Product name		X-40-2450	Ionic liquid*4
Surface resistivity Ω	Initial	4×10^{10}	$>10^{13}$
	After water wiping test*1	1×10^{11}	$>10^{13}$
	After immersion test in water*2	3×10^{11}	$>10^{13}$
	After heating test*3	8×10^{11}	$>10^{13}$

(Not specified values)

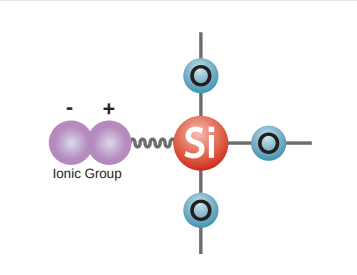
•Mix ratio : Dipentaerythritol hexaacrylate / 2-Hydroxy-2-Methyl-1-Phenyl-Propane-1-one / Methyl ethyl ketone / X-40-2450 = 48.8 / 2.4 / 48.8 / 2.0
•Substrate : PET (Cosmo Shine A4300) made by TOYOBO CO., LTD.
•Cure conditions : 600mJ/cm² under a nitrogen atmosphere
•Film thickness : 5μm
*1 After rubbing 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°C×5h), wiped off remaining water and took the measurements.
*3 Measured after heating the cured specimen (105°C×1 day).
*4 $(n\text{-}C_8H_{17})_3(CH_3)N^+(CF_3SO_2)_2N^-$

●General Properties

Parameter \ Product name	X-40-2450
Form of silicone	Siloxane
Appearance	Colorless transparent liquid
Non-volatile content %	55
Viscosity mm²/s	2.5
Specific gravity 25°C	0.97
Solvent	Methyl ethyl ketone
TSCA	Not Listed

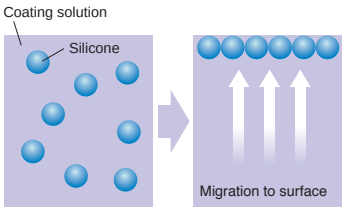
(Not specified values)

●Structural Model



●Comparison of Antistatic Properties

●Mechanism of Silicone Action



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.

●Resulting Properties

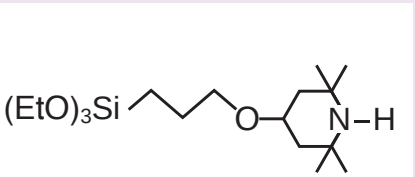
•Improves UV resistance
•Improves adhesion

●General Properties

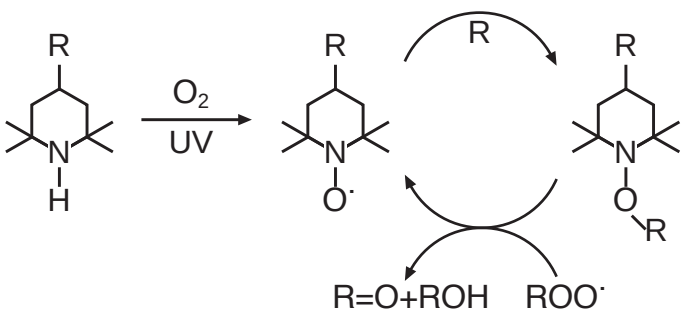
Parameter \ Product name	TMPS-E
Viscosity at 25°C mm²/s	8.0
Specific gravity at 25°C	0.95
Refractive index at 25°C	1.44
Active ingredient %	100
TSCA	Not Listed

(Not specified values)

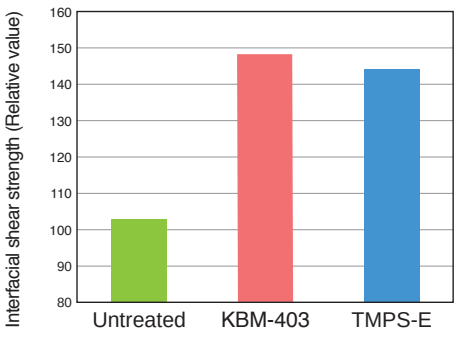
●Chemical Structure of TMPS-E



●Reaction Mechanism



●Adhesion Test Data of Glass / Epoxy Resin Interface



Hydrophilic Anti-stain Agents KP-912, KP-913, KP-914

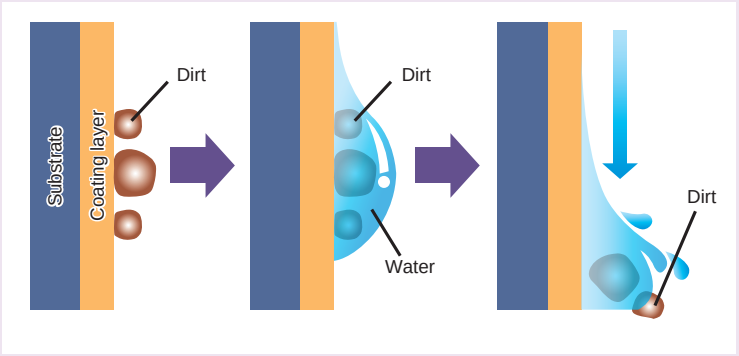
KP-912, KP-913 and KP-914 are silicone oligomers that contain alkoxysilyl groups.
When mixed with water, alkoxysilyl groups hydrolyze to form hydrophilic silanols groups, properties which allow these products to function as antifouling agents in paints for construction materials.
KP-913 shows its hydrophilic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

●General Properties

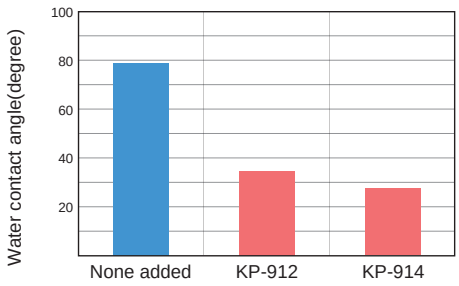
Parameter / Product name	Alkoxy Groups	Viscosity at 25°C mm²/s	Refractive index at 25°C	Alkoxy group content wt%	TSCA
KP-912	Methoxy / Ethoxy	12	1.414	50	Not Listed
KP-913	Methoxy	350	1.448	9.5	Not Listed
KP-914	Methoxy / Ethoxy	20	1.418	50	Not Listed

(Not specified values)

●Antifouling Mechanism



●Hydrophilicity of Coatings with Oligomers Added



Test conditions: Fluoropolymer paint with 5 phr of oligomer
Water contact angle measured
after immersion for 16 h in 2.5% sulfuric acid solution.

Benzotriazole Group Silane X-12-1214A

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

●Resulting Properties

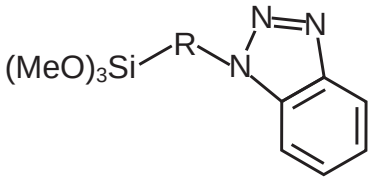
•Protects metal against corrosion (Especially for copper, silver and aluminum)

●General Properties

Parameter / Product name	X-12-1214A
Viscosity at 25°C mm²/s	170
Active ingredient %	100
TSCA	Not Listed

(Not specified values)

●Chemical Structure of X-12-1214A



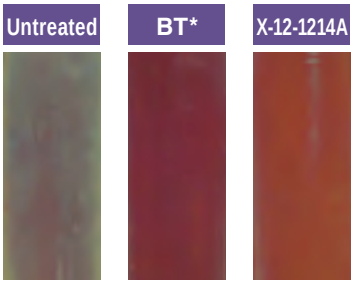
●Anti Rust Treatment on Copper plates

<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 Na_2S aqueous solution for 5 min.
2. After drying, plate surface is observed.

*BT: benzotriazole

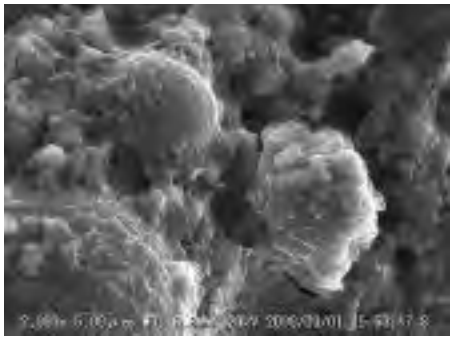
Alkoxy Silanes & Silane Coupling Agents

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

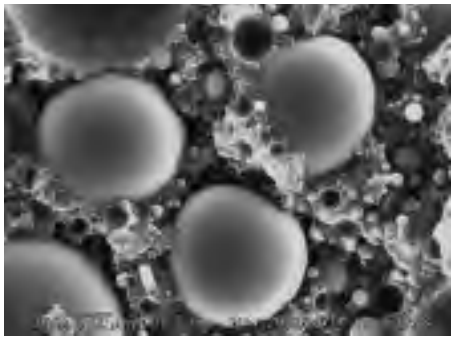
■Product List

Product category	Functional group	Product name	Chemical structure	Features	TSCA
Silane coupling agents	Alkenyl	KBM-1003	$(MeO)_3Si$	Vinyl silane, standard product	Listed
		KBM-1083	$(MeO)_3Si$	Long-chain spacer type of KBM-1003	Listed
	Epoxy	KBM-403	$(MeO)_3Si$	Epoxy silane, standard product	Listed
		KBM-4803	$(MeO)_3Si$	Long-chain spacer type of KBM-403	Not Listed
	Methacrylic	KBM-503	$(MeO)_3Si$	Methacrylic silane, standard product	Listed
		KBM-5803	$(MeO)_3Si$	Long-chain spacer type of KBM-503	Not Listed
	Amine	KBM-603	$(MeO)_3Si$	Diamino silane	Listed
		KBE-903	$(EtO)_3Si$	Monoamino silane	Listed
		KBM-6803	$(MeO)_3Si$	Long-chain spacer type of KBM-603	Not Listed
Alkoxy silanes	Alkyl	KBE-3063	$(EtO)_3Si$	Long chain alkyl (C6), ethoxy type	Listed
		KBM-3063	$(MeO)_3Si$	Long chain alkyl (C6), methoxy type	Listed
		KBE-3083	$(EtO)_3Si$	Long chain alkyl (C8), ethoxy type	Listed
		KBM-3103C	$(MeO)_3Si$	Long chain alkyl (C10), methoxy type	Listed
	Fluoroalkyl	KBM-7103	$(MeO)_3Si$	Fluorinated silane. Water repellency, oil repellency	Listed

■Fractured Composite Resin Compounded with Spherical Silica



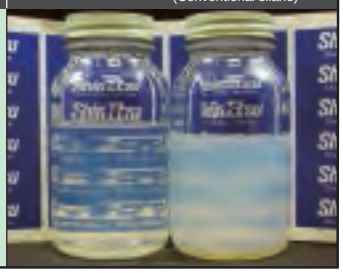
●Silica Treated with KBM-503.
Base Resin is Unsaturated Polyester.



●Untreated Silica

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

●Evaluation of Inorganic Filler Dispersion

Product name	KBM-5803*	KBM-503 (Conventional silane)
Appearance		

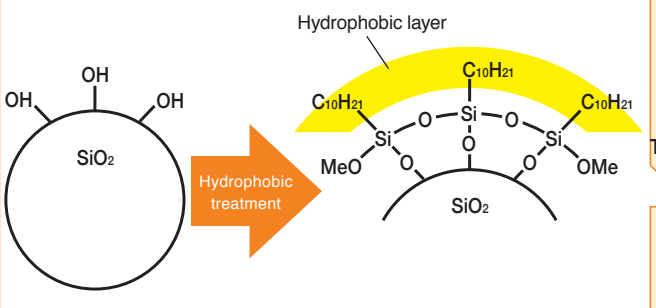
*Left: KBM-5803 by improving dispersibility, transparency was improved.

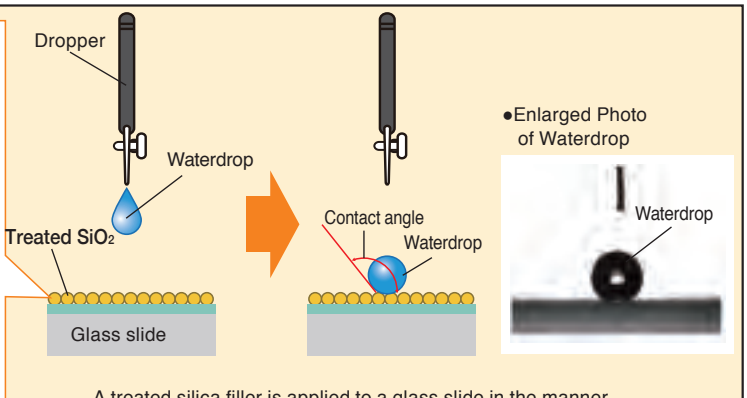
Formulation

Silane treated silica 10wt%
Multifunctional acrylic compounds 90wt%

■Model of Surface Hydrophobization Using Silanes

●Conceptual Diagram of Silica Surface Treated with KBM-3103C

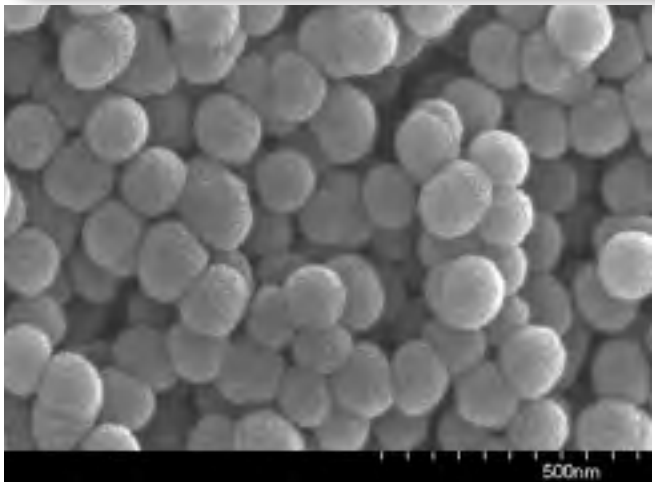




A treated silica filler is applied to a glass slide in the manner shown above, then the water contact angle is measured.

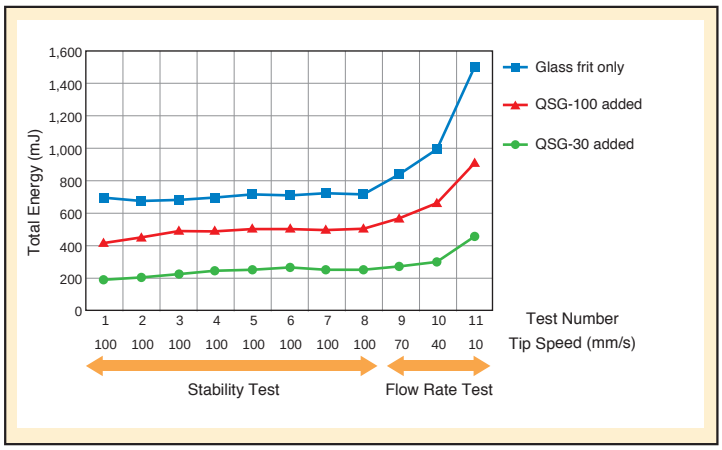
Spherical Silica Fine Particles

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.



●QSG-100

■Improved Flowability of Glass Frits



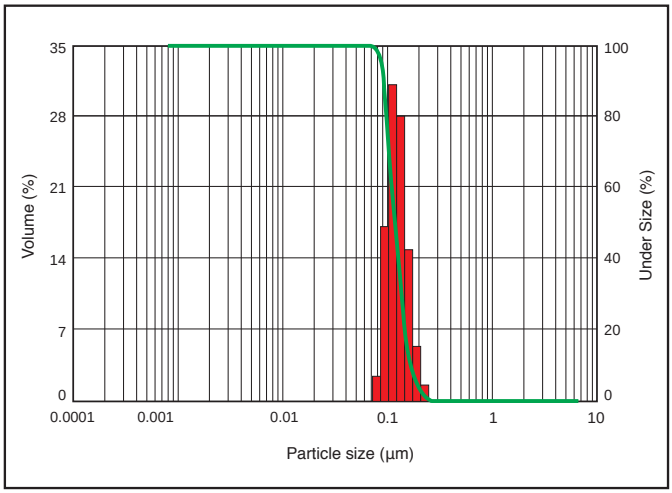
■Product List

Parameter \ Product name		QSG-100	QSG-80	QSG-30
Appearance		White powder	White powder	White powder
Shape		Spherical	Spherical	Spherical
Average particle size	nm*	110	80	30
Bulk density	g/cm^3	0.44	0.44	0.46
True specific gravity		1.8	1.8	1.8
Specific surface area	m^2/g	25	40	143
Hydrophobicity	%	67	67	67
Production method		Sol-Gel		
TSCA		Listed	Listed	Listed

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

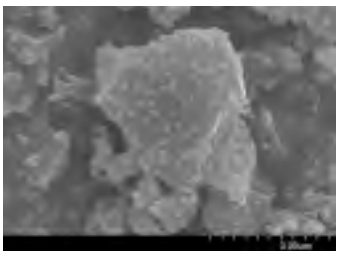
(Not specified values)

■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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The Development and Manufacture of Shin-Etsu Silicones are based on the following registered international quality and environmental management standards.

Gunma Complex	ISO 9001 ISO 14001 (JCQA-0004 JCQA-E-0002)
Naoetsu Plant	ISO 9001 ISO 14001 (JCQA-0018 JCQA-E-0064)
Takefu Plant	ISO 9001 ISO 14001 (JQA-0479 JQA-EM0298)

CM009

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This is an edited version of the product data released on Aug. 2017.