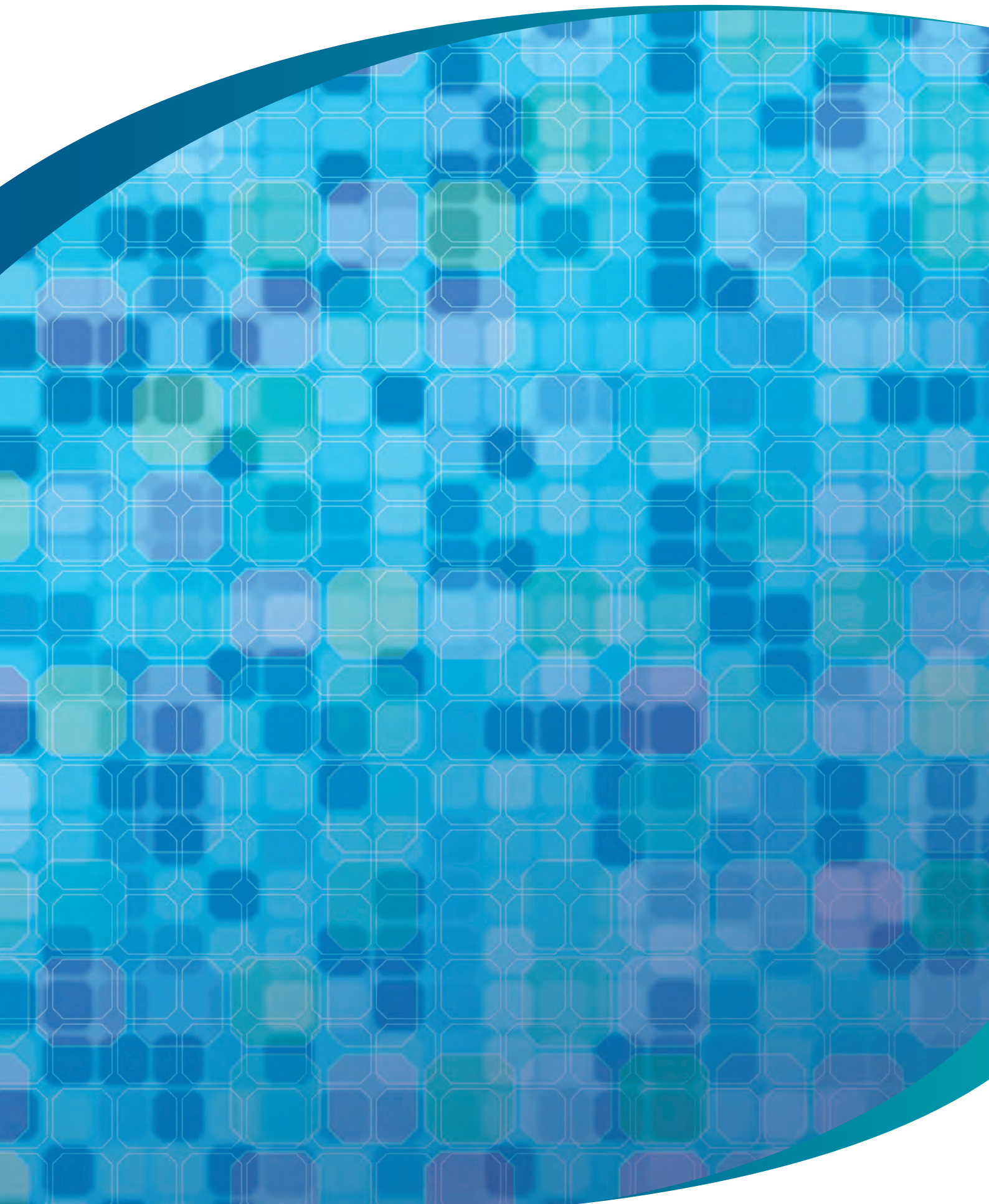


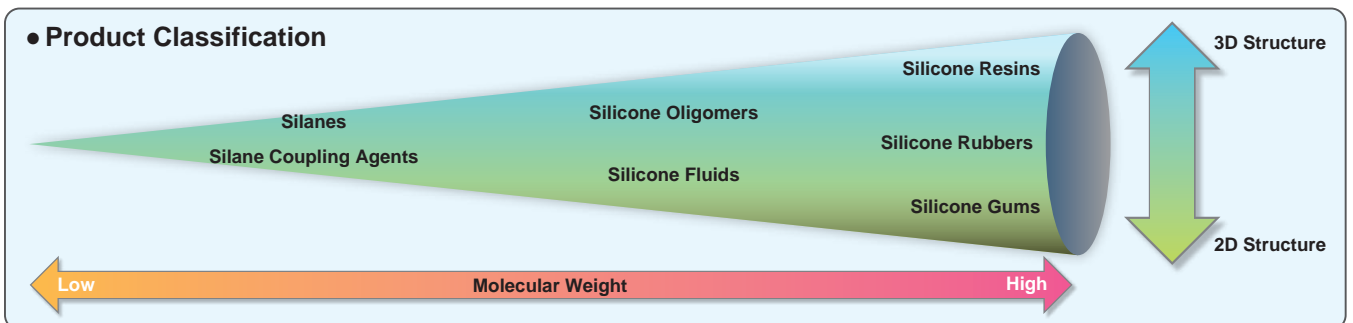
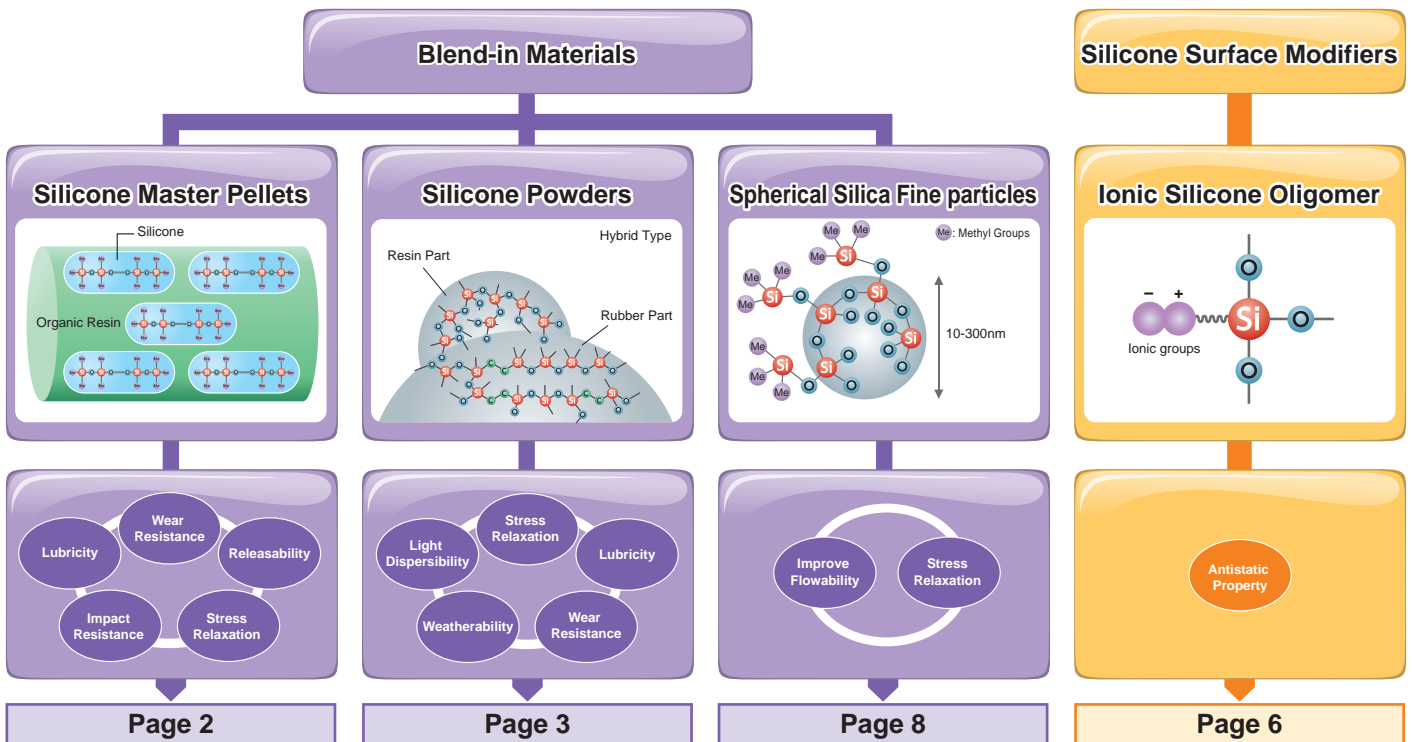
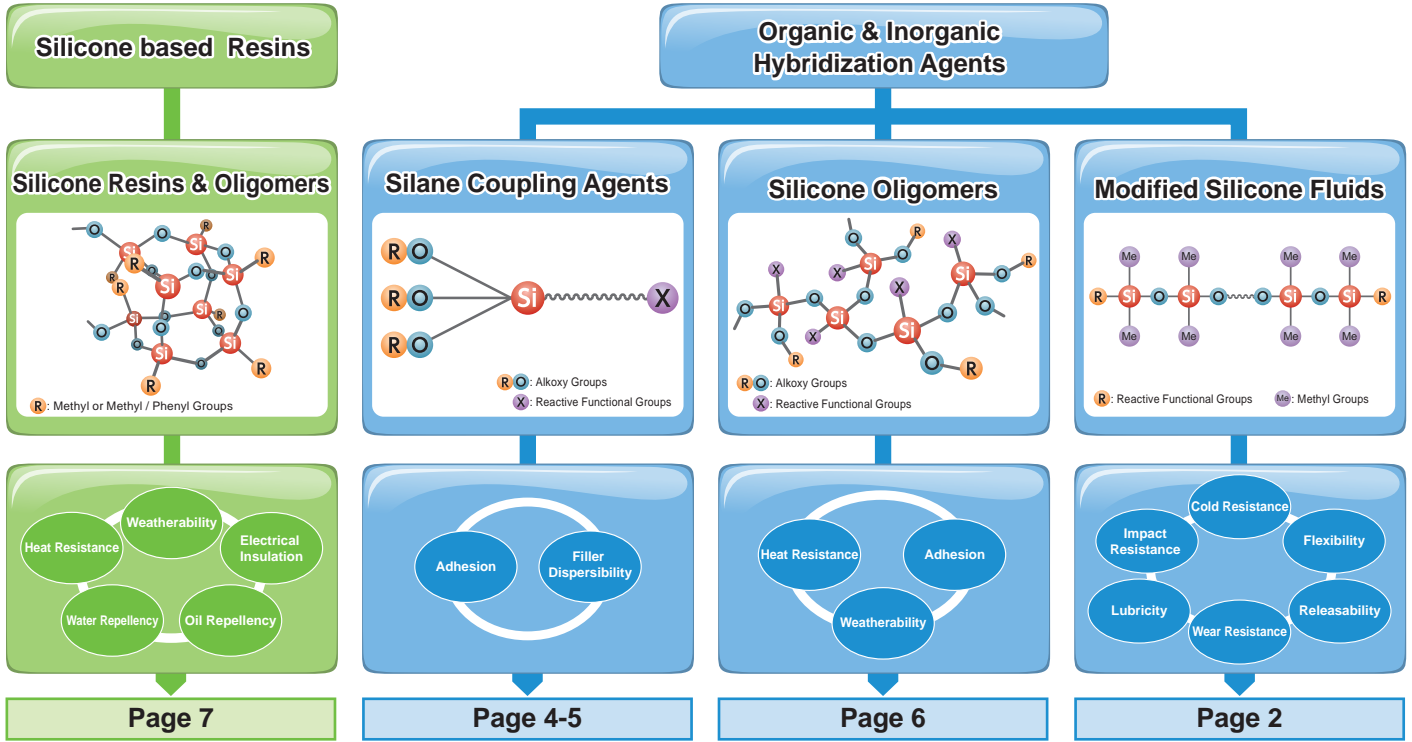
# New Products Guide

## -Silicones to Highly Functionalize Plastics-



# Silicones to Highly Functionalize Resins

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



# Modified Silicone Fluids

Modified Silicone Fluids which bind various reactive groups exhibit a variety of properties by reacting with organic resin.

**Enhanced properties**

- Heat resistant
- Cold resistant
- Weather resistant
- Impact resistant
- Flexibility

**Dual-end reactive silicone fluids**

$$\text{Reactive groups} - \text{Si}(\text{CH}_3)_2 - \text{O} - \text{Si}(\text{CH}_3)_2 - \text{O} - \text{Si}(\text{CH}_3)_2 - \text{Reactive groups}$$

↓  
Compounds

**Block copolymer**

**Enhanced properties**

- Lubricating property
- Release property
- Wear resistant
- Water repellent

**Single-end reactive silicone fluids**

$$\text{R} - \text{Si}(\text{CH}_3)_2 - \text{O} - \text{Si}(\text{CH}_3)_2 - \text{O} - \text{Si}(\text{CH}_3)_2 - \text{Reactive groups}$$

↓  
Compounds

**Graft copolymer**

Reactive groups	Types of resins	Thermoset resin		Thermoplastic resin				
		Polyurethane	Epoxy	Acrylic	Polyimide	Polyamide	Polycarbonate	Polyester
Amino groups			●		●	●		
Epoxy groups			●					●
Hydroxyl groups	Carbinol type	●						●
	Diol type	●						●
	Polyether type	●						●
	Phenol type		●				●	●
Methacryl groups			●					
Carboxyl groups			●			●		●
Mercapto groups				●				
Acidanhidride groups			●		●	●		●

# Silicone Master Pellets

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

**Enhanced properties**

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

Resin + Solitary silicone

↓ Formulate

Silicone — **Uniform dispersion is difficult.**

Resin + Silicone master pellets

↓ Formulate

Resin + Silicone

**Silicone is well uniformed in the resin.**

Parameter	Resin	Silicone content %	MFRg / 10mins	MFR Test condition
X-22-2101	Homo Polypropylene	50	33	210°C / 2.16kg
X-22-2125H	Low density polyethylene	50	20	190°C / 2.16kg
X-22-2138B	Ethylene vinylacetate copolymer	40	5	190°C / 2.16kg
X-22-2102	Polyacetal	40	55	190°C / 2.16kg
X-22-2184-30	ABS	30	45	220°C / 2.16kg



Silicone Master Pellets

(Not specified values)

We can discuss the Silicone formulation with your preferred resin. Please do not hesitate to contact us.

# Silicone Powders

Shin-Etsu has developed a unique line of silicone powders which fall into three categories: Hybrid Silicone Powder, Silicone Resin Powder and Silicone Rubber Powder.

**Hybrid Silicone Powder**  
Form : Rubber powders covered with resin  
KMP-600 by scanning with electron micro scope

Model of hybrid silicone powder

**Features**

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

**Silicone Resin Powder**  
Molecular structure : 3D network structure  
KMP-706 by scanning with electron micro scope

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-597 by scanning with electron micro scope

Model of silicone rubber powder

**Features**

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

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

## Enhanced Properties

**Stress Relaxation • Impact Resistance**

**Features**

Hybrid powder	++
Resin powder	-
Rubber powder	++

**Lubricity • Wear Resistance**

**Features**

Hybrid powder	++
Resin powder	++
Rubber powder	+

**Soft-feel Property**

**Features**

Hybrid powder	++
Resin powder	-
Rubber powder	++

**Light Diffusion Property**

**Features**

Hybrid powder	++
Resin powder	++
Rubber powder	++

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

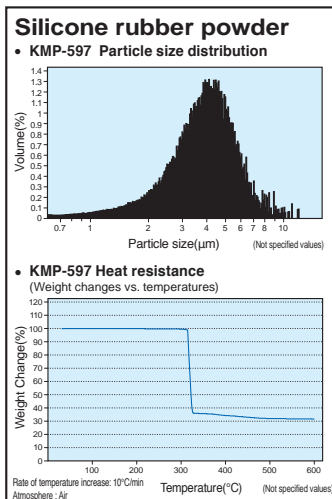
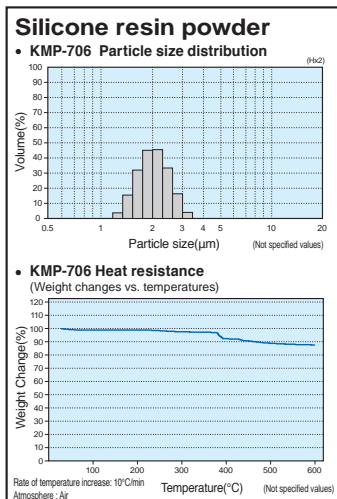
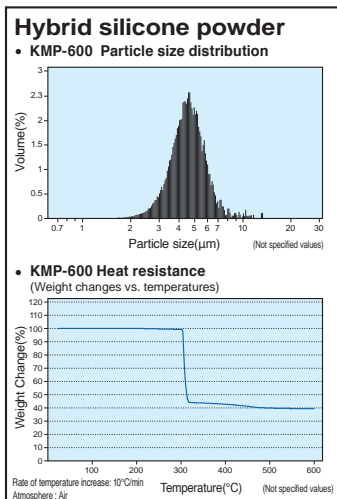
## General Properties

Type	Parameter	Product name	Shape	Average particle size μm	Particle size distribution μm	True specific gravity	Moisture content %	Rubber hardness Durometer A	Refractive index	
									Rubber part	Resin part
Hybrid silicone powder		KMP-600	Spherical powder	5	1-15	0.99	0.1	30	1.41	1.43
		KMP-601	Spherical powder	12	2-25	0.98	0.1	30	1.41	1.43
		KMP-602	Spherical powder	30	4-60	0.98	0.1	30	1.41	1.43
		KMP-605	Spherical powder	2	0.7-5	0.99	0.1	75	1.42	1.43
		X-52-7030	Spherical powder	0.8	0.2-2	1.01	0.1	75	1.42	1.43
Silicone resin powder		KMP-706	Spherical powder	2	1-4	1.3	1	-	-	1.43
		KMP-701	Spherical powder	3.5	1-6	1.3	1	-	-	1.43
		X-52-1621	Spherical powder	5	1-8	1.3	1	-	-	1.43
		X-52-854	Spherical powder	0.7	0.2-5	1.3	1	-	-	1.43
Silicone rubber powder		KMP-597	Spherical powder	5	1-10	0.97	0.1	30	1.41	-
		KMP-598	Spherical powder	13	2-30	0.97	0.1	30	1.41	-
		KM-9729*	Emulsion	2	-	-	-	-	-	-
		X-52-1133*	Emulsion	5	-	-	-	-	-	-

\*Aqueous dispersion of silicone rubber powder. By drying spherical powders are obtained.

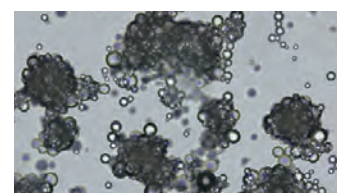
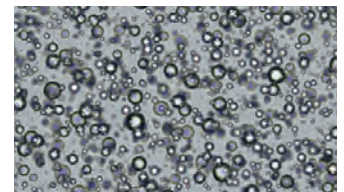
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## Product Data



## Dispersibility

Dispersibility in liquid epoxy resin



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

# Long-Chain Spacer Silane Coupling Agents

With maximum freedom of functional group, Long-Chain Spacer Silane Coupling Agents improve reactivity. It improves flexibility and impact resistance in hybrid of resin and inorganic filler. And, with increased compatibility, it is possible to improve transparency of reactant in resin and inorganic filler, and high load inorganic filler into resins.

## Features

- Increased hydrophobicity (Lipophilicity)
- Increased flexibility

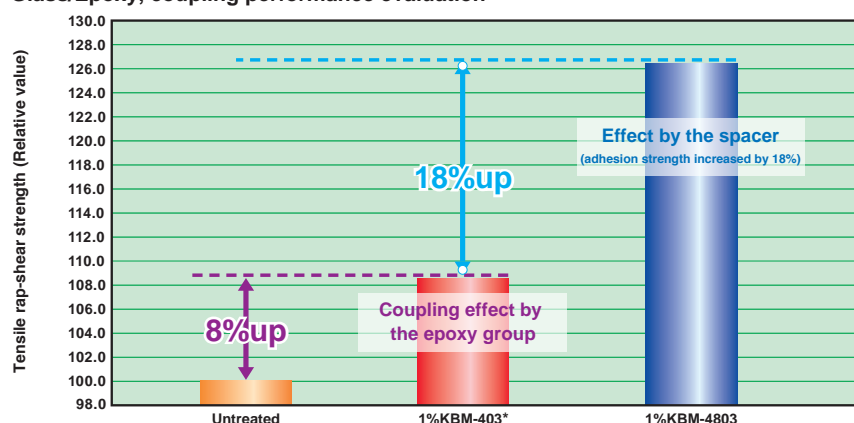
## General Properties

Product name	Chemical name	Organic functional groups	Chemical structure
<b>KBM-1083</b>	7-Octenyltrimethoxysilane	Olefin	<chem>(MeO)3Si(CH2)7CH=CH2</chem>
<b>KBM-4803</b>	8-Glycidioxyoctyltrimethoxysilane	Epoxy	<chem>(MeO)3Si(CH2)8O(CH2)2C1OC1</chem>
<b>KBM-5803</b>	8-Methacryloxyoctyltrimethoxysilane	Methacrylic	<chem>(MeO)3Si(CH2)8O(CH2)2C=C(C)C</chem>
<b>KBM-6803</b>	N-2-(aminoethyl)-8-aminoctyltrimethoxysilane	Amine	<chem>(MeO)3Si(CH2)8NH(CH2)2NH2</chem>

## Applications

- Organic / Inorganic adhesion improver

Glass/Epoxy, coupling performance evaluation



\*KBM-403 : 3-Glycidioxypropyl trimethoxysilane

- Surface treatment of inorganic filler

Evaluation of inorganic filler dispersion



\*Left : KBM-5803  
Owing to the improved dispersibility, transparency is improved.

### Formulation

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

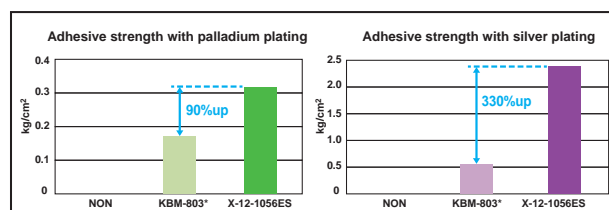
# Protected Functional Group Silanes

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

## General Properties

Product name	Chemical name	Chemical structure
<b>X-12-1056ES</b>	3-(Triethoxysilylthio)propyltrimethoxysilane	<chem>(CH3O)3Si(CH2)3S-Si(OC2H5)3</chem>
	Examples of reactions	<chem>(CH3O)3Si(CH2)3S-Si(OC2H5)3 + H2O -&gt; (CH3O)3Si(CH2)3SH + HO-Si(OC2H5)3</chem>
<b>KBE-9103P</b>	3-Triethoxysilyl-N-(1,3 dimethyl-butylidene) propylamine	<chem>(C2H5O)3SiC3H6N=C(CH3)2C4H9</chem>
<b>X-12-967C</b>	3-(Trimethoxysilyl)propylsuccinic anhydride	<chem>(CH3O)3SiC3H6-C4H4O2</chem>

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



\*KBM-803 : 3-Mercaptopropyltrimethoxysilane

# Silane Coupling Agents (Polymer Type)

Shin-Etsu Chemical developed 2 types of coupling agents (polymer type) containing a number of reactive organic groups.

- 1) Coupling Agents (Alkoxy Oligomer Type) which are partial hydrolysates of conventional coupling agent
- 2) Silane Coupling Agents (Multifunctional Group Type) with organic backbone

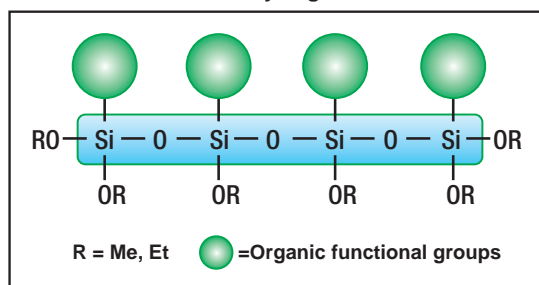
## Coupling Agents (Alkoxy Oligomer Type)

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

## Features

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

Structural model of alkoxy oligomers



Parameter	Organic functional groups	Alkoxy groups
Product name		
KR-517	Epoxy 	MeO-/EtO-
KR-516		MeO-
KR-513	Acrylate 	MeO
X-41-1805	Mercapto -SH	MeO-/EtO-
X-41-1810		MeO

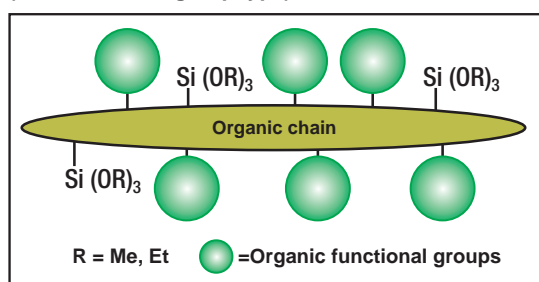
## Silane Coupling Agents (Multifunctional Group Type)

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

## Features

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

Structural model of silane coupling agents (multifunctional group type)



Parameter	Organic functional groups	Alkoxy groups	Functional group equivalent(per Si(OR) <sub>3</sub> )	Features
Product name				
X-12-972F	Amine -NH <sub>2</sub>	EtO	5	15%EtOH sol. Water solubility
X-12-981S	Epoxy 	EtO	3	Water resistance
X-12-984S		EtO	3	Hydrophilicity
X-12-1048	Acrylate 	MeO	1	Curable by UV exposure
X-12-1050			5	Curable by UV exposure
X-12-1154	Mercapto -SH	MeO	3	Adhesion to metal
X-12-1159L	Isocyanate -NCO	MeO	2	Adhesion to metal

# Silicone Oligomers

## Ionic Silicone Oligomer X-40-2450

X-40-2450 is a silicone oligomer created through the silicone modification of an ionic liquid. By introducing ionic groups into siloxane structure, X-40-2450 has silicone's unique properties including antistatic properties.

### Features

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

#### General properties

Parameter	Product name	X-40-9310	X-40-2450	X-40-2750
Types of silicone		Silane	Siloxane	Siloxane
Appearance		Colorless to pale yellow transparent liquid	Colorless transparent liquid	Colorless transparent liquid
Non-volatile content	%	99	55	99
Viscosity	mm <sup>2</sup> /s	160	2.5	750
Specific gravity		1.24	0.97	1.17
Solvent		None	MEK*1	None
Expected properties		Adhesion, dispersibility, antistatic property	Antistatic property, releasability	Antistatic property, releasability
Application examples		Adding and dispersing into resins	Adding into coating agents	Mixing with resin, adding into coating agents

\*Methyl ethyl ketone

(Not specified values)

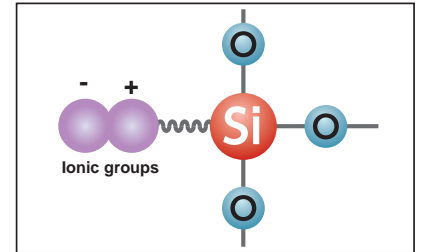
#### Test Result of Antistatic Properties

Parameter	Product name	X-40-2450	Ionic liquid*4
Surface resistivity Ω	Initial	4×10 <sup>10</sup>	>10 <sup>13</sup>
	After water wiping test*1	1×10 <sup>11</sup>	>10 <sup>13</sup>
	After immersion test in water*2	3×10 <sup>11</sup>	>10 <sup>13</sup>
	After heating test*3	8×10 <sup>11</sup>	>10 <sup>13</sup>

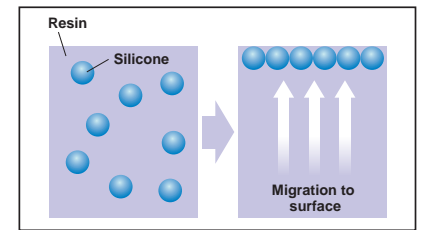
(Not specified values)

- \*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×1day).
- \*4  $(n-C_6H_{11})_2(CH_3)N^+(CF_3SO_2)_2N^-$
- 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<sup>2</sup> under a nitrogen atmosphere
- Film thickness : 5µm

#### Structural Model



#### Mechanism of Silicone Action



## Silicone Oligomers Containing Alicyclic Epoxy Groups

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

### Features

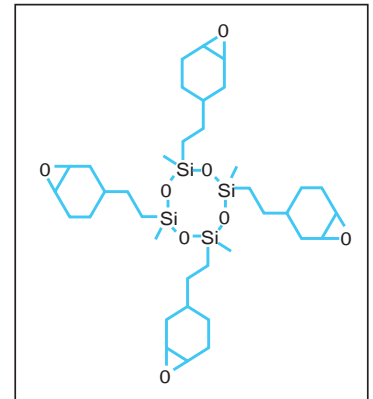
With its cyclic siloxane structure, KR-470 exhibits almost no shrinkage during curing. Its molecular structure is specified, meaning that reactions are easy to control. Cures with light or heat with the addition of an acid generator, acid anhydride, or amine-type catalyst. Excellent compatibility owing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

### General Properties

Parameter	Product name	KR-470	X-40-2678
One point		Low cure shrinkage	Difunctional (Improved crack resistance)
Numbers of Epoxy functional groups		4	2
Viscosity	mPa / s	3,000	120
Epoxy equivalent	g/mol	200	290

(Not specified values)

#### Basic Structure of KR-470

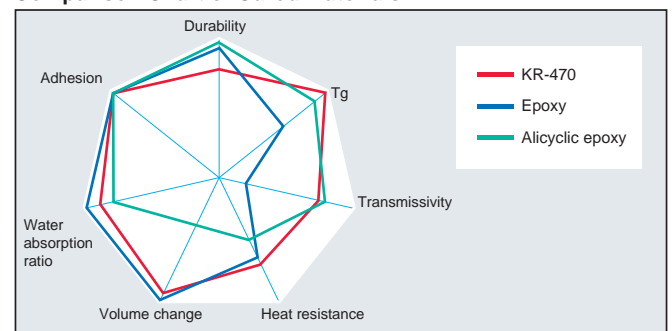


### Comparison data of cured material

Parameter	Product name	KR-470	Epoxy	Alicyclic epoxy
Cure system		Acid anhydride curing	Acid anhydride curing	
Hardness Shore D		87	85	88
Flexural modulus	MPa	2,590	2,940	3,020
Curing shrinkage areometry	%	2.1	-1.7	-5.3
Boiling water absorption ratio	%	0.46	0.28	0.56
Tg	°C	191	150	193
Coefficient of liner expansion (×10 <sup>-5</sup> /K)	< Tg	9.7	7.7	6.9
	> Tg	15.4	17.6	16.2

(Not specified values)

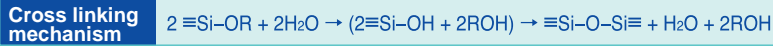
#### Comparison Chart of Cured Materials



# Silicone Resins & Oligomers

## Silicone Oligomer Type Coatings

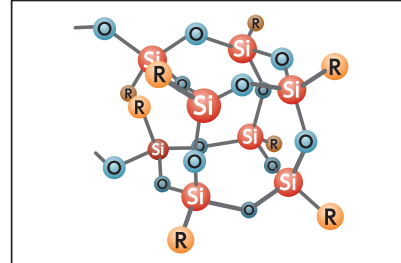
Silicone Oligomer Type Coating Agents contain alkoxy-silyl groups and cure at ambient temperatures and humidities with the use of a curing agent. They form very hard, glossy coatings that are highly resistant to heat and light, owing to their 3D siloxane structures.



## Product & Catalyst line up

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

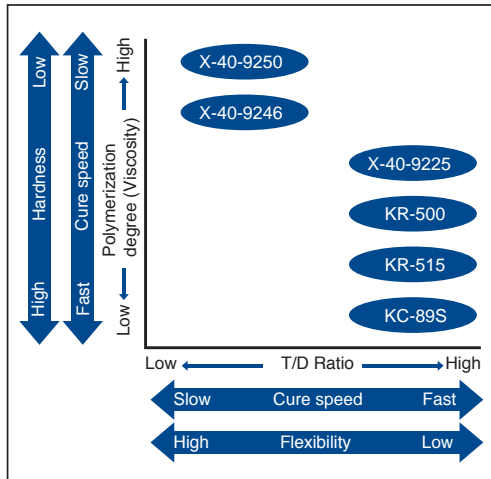
Model of after Curing



### Product line up

#### Methyl Type

Features : Water repellency, Excellent curability



#### Methyl / Phenyl Type

Features : Gloss, Excellent flexibility

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

### Catalyst Line Up

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

### Formulation Example and Film Properties

Product name	Parameter	Catalyst (Additive amount) %	Film thickness $\mu\text{m}$	Tack free 25°C min	Pencil hardness	Flexural resistance / Impact resistance
KR-500		D-20(2)	25	40	H	±
KR-500		D-20(4)	25	25	2H	± - -
KR-500		D-9740(5)	25	100	5H	-
X-40-9225		D-20(3)	30	60	H	+
KR-500/ X-40-9250 (=80/20)		D-20(2)	80	75	F	+

Result : + = Excellent ± = Satisfactory - = Poor

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

(Not specified values)

## Ultra High Molecular Weight Silicone Resin KR-251

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

### Features

#### Common methyl silicone resins

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

#### KR-251

- The coating film is hard to crack.
- Form the coating film by air drying
- Form the harder coating film by heating

### General property

Parameter	Product name	KR-251
Appearance		Colorless transparent liquid
Non-volatile content 105°C x 3h	%	20
Viscosity 25°C	mm <sup>2</sup> /s	18
Specific gravity 25°C		0.92
Acid value		< 2
Solvent		Toluene

(Not specified values)

#### Film properties

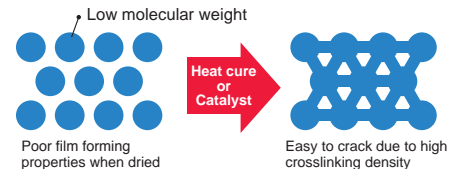
Clear coating		
Curing condition	25°C x 1 day	150°C x 30 min
Film thickness	8 $\mu\text{m}$	8 $\mu\text{m}$
Pencil hardness	HB	F

Substrate : Polished steel sheet

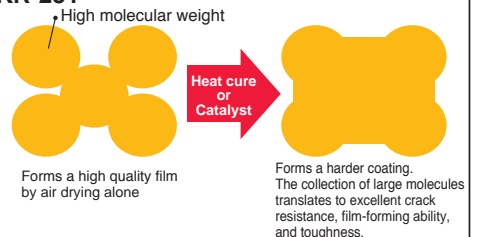
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### Model of Coating Structure

#### Common grade silicone resin



#### KR-251

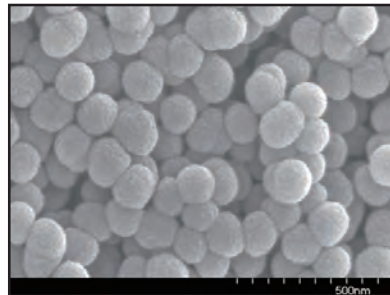


# Spherical Silica Fine Particles

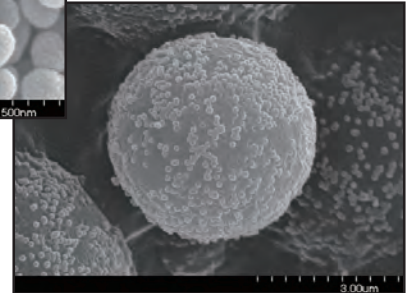
With very small average particle size, narrow distribution and its hydrophobized surface, Spherical Silica Fine Particles have a superior flowability, dispersion, water repellency and lubricity.

## Features

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



• QSG-100



• Adherence of QSG-100 to polystyrene particles

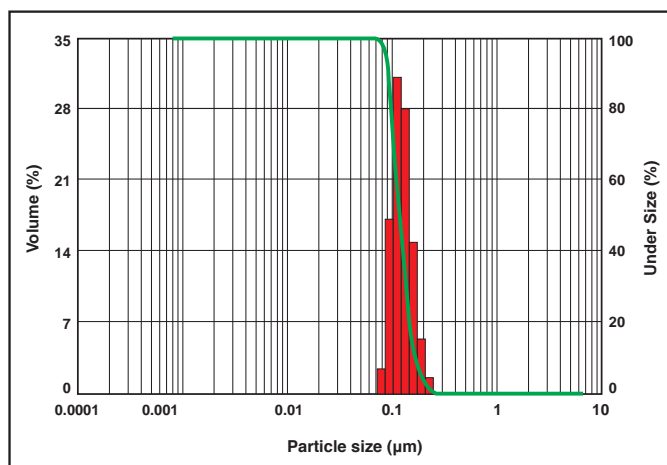
## General Properties

Parameter	Product name	QSG-170	QSG-100	QSG-90	QSG-80	QSG-30	QSG-10
Appearance		White powder					
Shape		Spherica					
Average particle size*	nm	170	110	90	80	30	15
Bulk density	g/cm <sup>3</sup>	0.44	0.44	0.44	0.44	0.22	0.22
True specific gravity		1.8	1.8	1.8	1.8	1.8	1.8
Specific surface area	m <sup>2</sup> /g	16	25	30	40	150	160
Hydrophobicity, Methanol wettability	%	67	67	67	67	67	72
Production method		Sol-Gel					

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

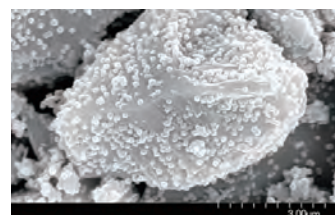
(Not specified values)

## Particle Size Distribution QSG-100

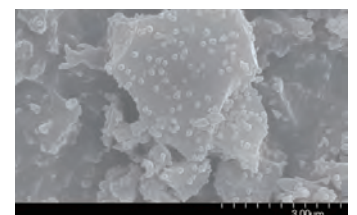


(Not specified values)

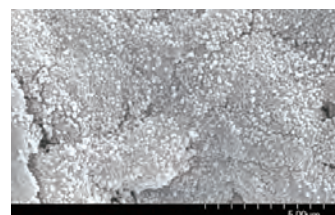
## Adhesion State with Various Powders QSG-100



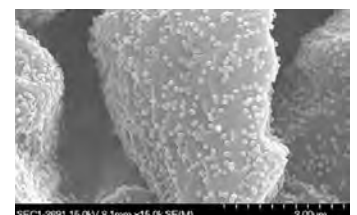
• Metal silicons



• Glass frits



• Surface of Nylons



• Polyester particles

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