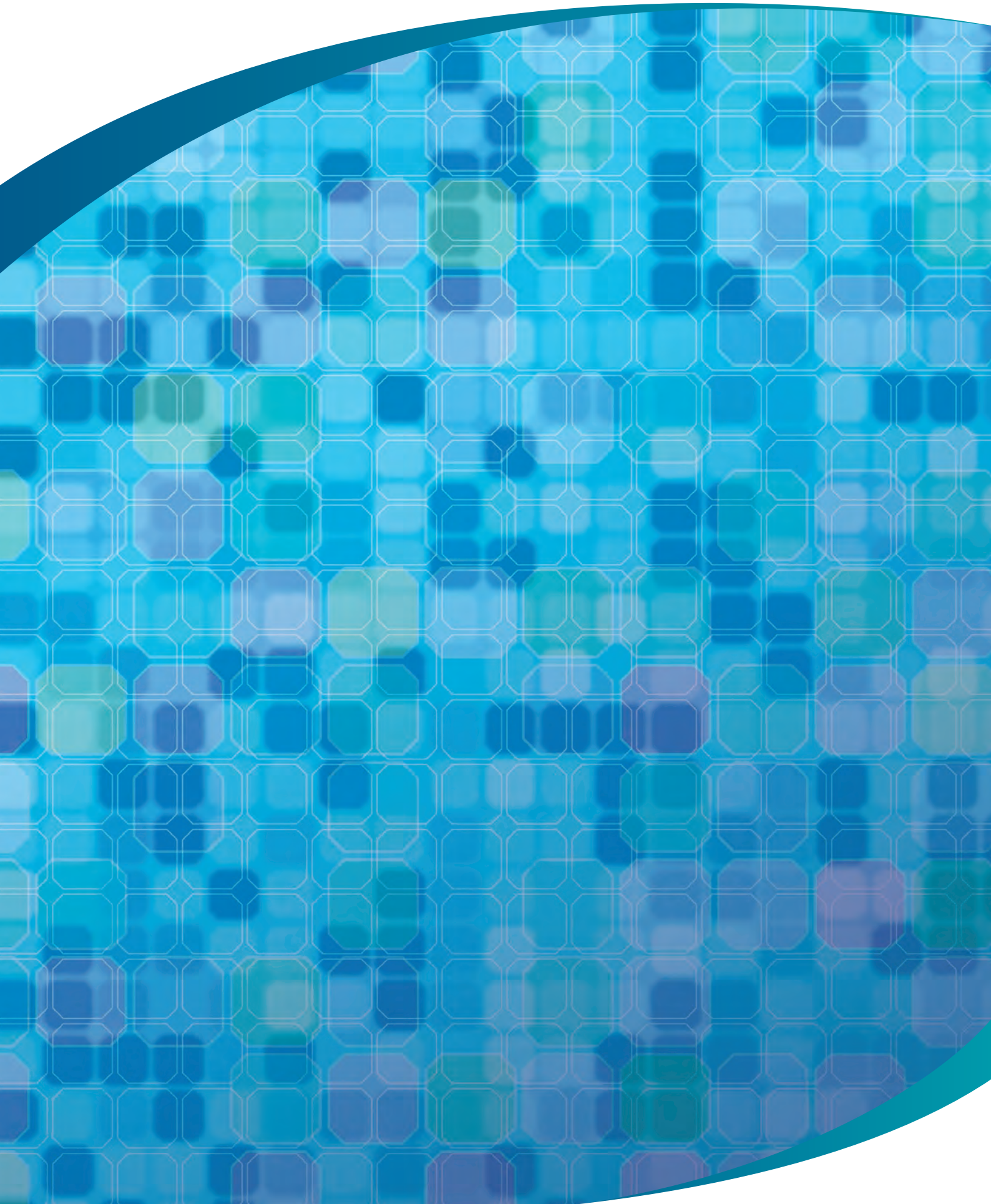
New Products Guide
-Silicones to Highly Functionalize Plastics-

Shin-Etsu Silicone

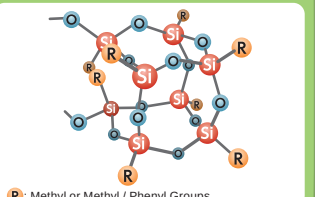


Silicones to Highly Functionalize Resins

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

Silicone based Resins

Silicone Resins & Oligomers

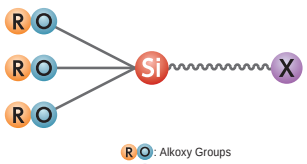


Heat Resistance, Weatherability, Electrical Insulation, Water Repellency, Oil Repellency

Page 7

Organic & Inorganic Hybridization Agents

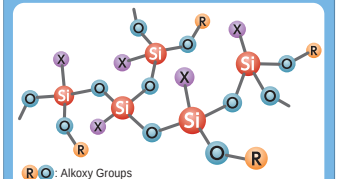
Silane Coupling Agents



Adhesion, Filler Dispersibility

Page 4-5

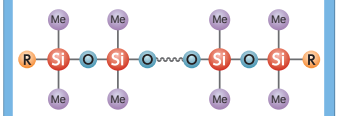
Silicone Oligomers



Heat Resistance, Adhesion, Weatherability

Page 6

Modified Silicone Fluids

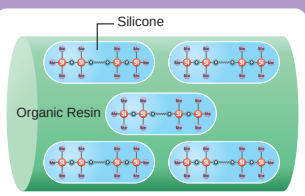


Cold Resistance, Impact Resistance, Flexibility, Lubricity, Wear Resistance, Releasability

Page 2

Blend-in Materials

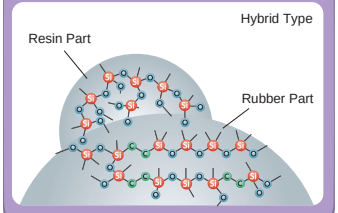
Silicone Master Pellets



Lubricity, Wear Resistance, Releasability, Impact Resistance, Stress Relaxation

Page 2

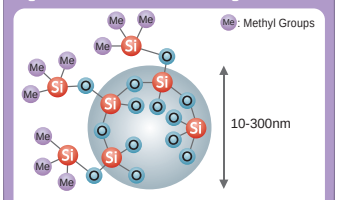
Silicone Powders



Light Dispersibility, Stress Relaxation, Lubricity, Weatherability, Wear Resistance

Page 3

Spherical Silica Fine particles



Improve Flowability, Stress Relaxation

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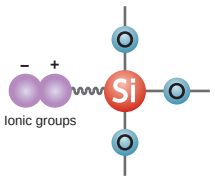
Silicone Surface Modifiers

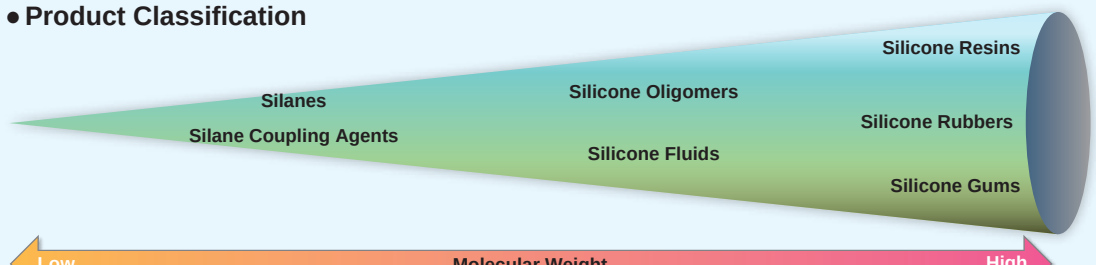
Ionic Silicone Oligomer



Antistatic Property

Page 6

● Product Classification



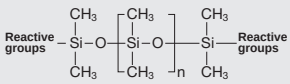
Modified Silicone Fluids

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

Enhanced properties

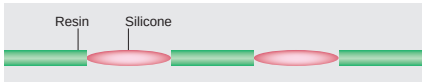
Heat resistant
Cold resistant
Weather resistant
Impact resistant
Flexibility

Dual-end reactive silicone fluids



Compounds

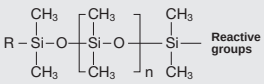
Block copolymer



Enhanced properties

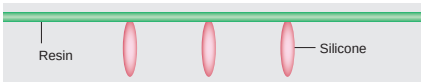
Lubricating property
Release property
Wear resistant
Water repellent

Single-end reactive silicone fluids



Compounds

Graft copolymer



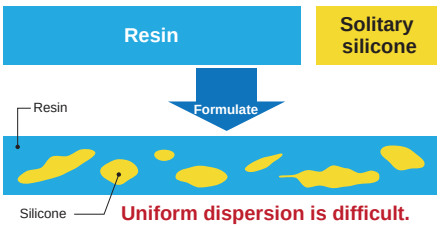
Reactive groups \ Types of resins		Thermoset resin		Thermoplastic resin				
		Polyurethane	Epoxy	Acrylic	Polyimide	Polyamide	Polycarbonate	Polyester
Amino groups			●		●	●		
Epoxy groups			●					●
Hydroxyl groups	Carbinol type	●						●
	Diol type	●						●
	Polyether type	●						●
	Phenol type		●				●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

Silicone Master Pellets

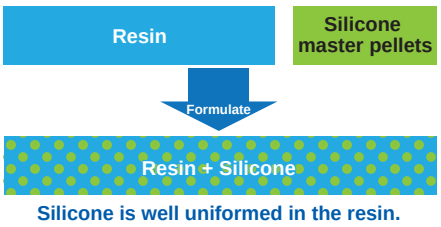
By blending few amounts of Silicone Master Pellets with resin, it is easy to obtain a compound in which the silicone is evenly dispersed.

Enhanced properties

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



Uniform dispersion is difficult.



Silicone is well uniformed in the resin.

Parameter / Product name	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

(Not specified values)

Silicone Master Pellets

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

Contact to → Sales and Marketing Department I Phone:+81-(0)3-3246-5132

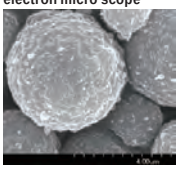
Silicone Powders

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.

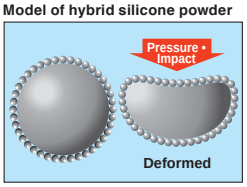
Hybrid Silicone Powder

Form : Rubber powders covered with resin

KMP-600 by scanning with electron micro scope



Model of hybrid silicone powder



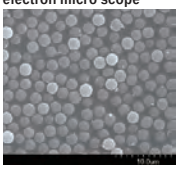
Features

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

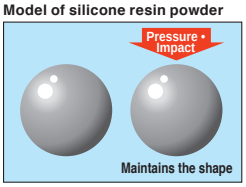
Silicone Resin Powder

Molecular structure : 3D network structure

KMP-706 by scanning with electron micro scope



Model of silicone resin powder



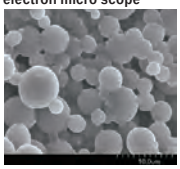
Features

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

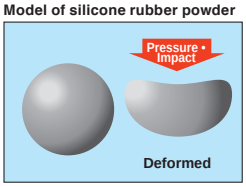
Silicone Rubber Powder*

Molecular structure: Straight-chain crosslinked polymer

KMP-597 by scanning with electron micro scope



Model of silicone rubber powder



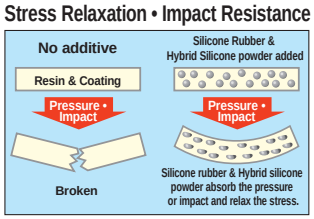
Features

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

＊There are also aqueous dispersion of silicone rubber power.

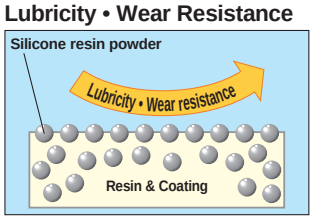
Enhanced Properties

Stress Relaxation • Impact Resistance



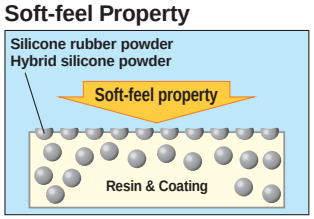
Hybrid powder	++
Resin powder	–
Rubber powder	++

Lubricity • Wear Resistance



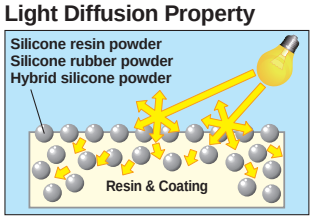
Hybrid powder	++
Resin powder	++
Rubber powder	+

Soft-feel Property



Hybrid powder	++
Resin powder	–
Rubber powder	++

Light Diffusion Property



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*	Emmulsion	2	-	-	-	-	-	-
	X-52-1133*	Emmulsion	5	-	-	-	-	-	-

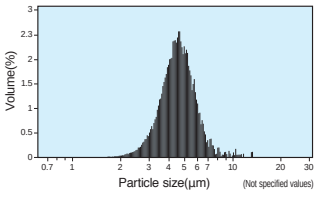
*Aqueous dispersion of silicone rubber power. By drying spherical powders are obtained.

(Not specified values)

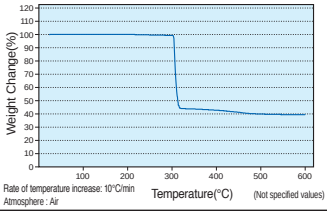
Product Data

Hybrid silicone powder

- KMP-600 Particle size distribution

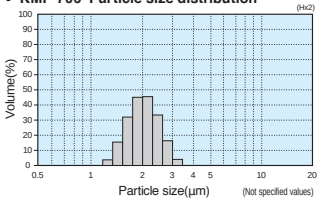


- KMP-600 Heat resistance (Weight changes vs. temperatures)

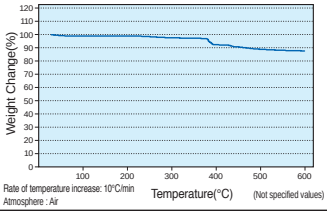


Silicone resin powder

- KMP-706 Particle size distribution

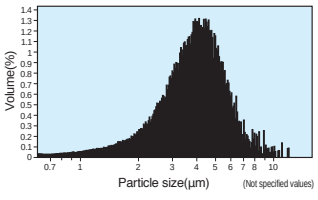


- KMP-706 Heat resistance (Weight changes vs. temperatures)

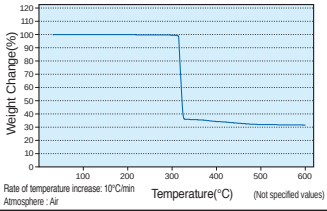


Silicone rubber powder

- KMP-597 Particle size distribution

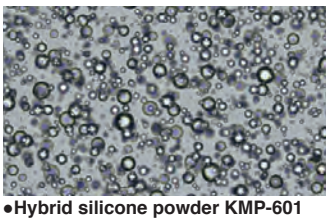


- KMP-597 Heat resistance (Weight changes vs. temperatures)

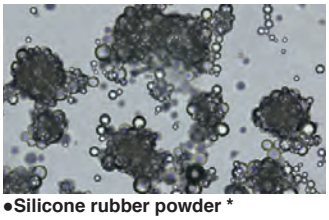


Dispersibility

Dispersibility in liquid epoxy resin



●Hybrid silicone powder KMP-601



●Silicone rubber powder *

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

Contact to → Sales and Marketing Department I Phone:+81-(0)3-3246-5132

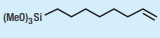
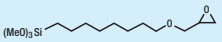
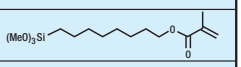
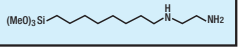
Long-Chain Spacer Silane Coupling Agents

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

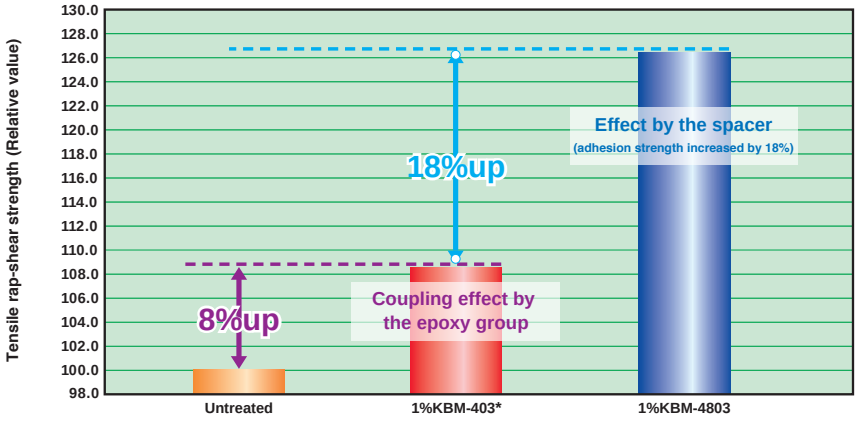
General Properties

Product name	Chemical name	Organic functional groups	Chemical structure
KBM-1083	7-Octenyltrimethoxysilane	Olefin	
KBM-4803	8-Glycidoxyoctyltrimethoxysilane	Epoxy	
KBM-5803	8-Methacryloxyoctyltrimethoxysilane	Methacrylic	
KBM-6803	N-2-(aminoethyl)-8-aminooctyltrimethoxysilane	Amine	

Applications

- Organic / Inorganic adhesion improver

Glass/Epoxy, coupling performance evaluation



*KBM-403 : 3-Glycidoxypropyl trimethoxysilane

- Surface treatment of inorganic filler

Evaluation of inorganic filler dispersion

Samples	KBM-5803*	KBM-503 (Conventional grade)
Appearance		

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

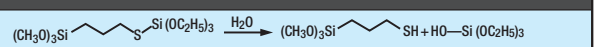
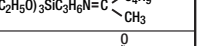
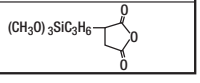
Formulation

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

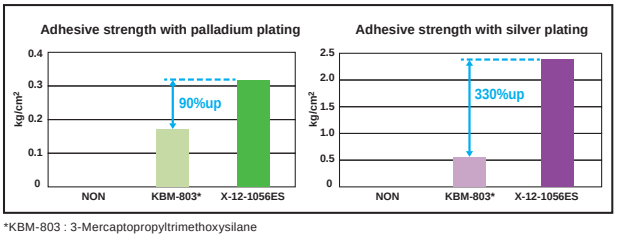
Protected Functional Group Silanes

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
X-12-1056ES	3-(Triethoxysilylthio)propyltrimethoxysilane	
	Examples of reactions	
		
KBE-9103P	3-Triethoxysilyl-N-(1,3 dimethyl-butylidene) propylamine	
X-12-967C	3-(Trimethoxysilyl)propylsuccinic anhydride	

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



*KBM-803 : 3-Mercaptopropyltrimethoxysilane

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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

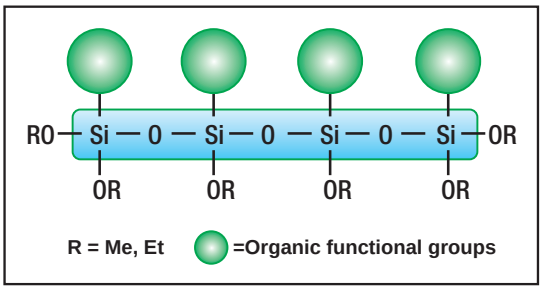
Coupling Agents (Alkoxy Oligomer Type)

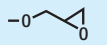
Owing to 100% of active ingredients, Coupling Agents (Alkoxy Oligomer Type) with siloxane back bone reduce generation quantity of alcohol. By choice of organic groups, it can achieve hydrophilic treatment on surfaces of coating as paint additives, or adapt adhesion (rework property) as additives for 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 / Product name	Organic functional groups		Alkoxy groups
KR-517	Epoxy		MeO-/EtO-
KR-516			MeO-
KR-513	Acrylate		MeO
X-41-1805	Mercapto	—SH	MeO-/EtO-
X-41-1810			MeO

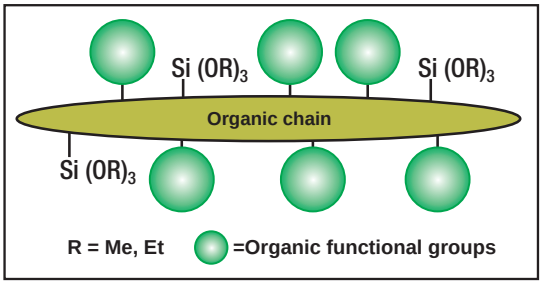
Silane Coupling Agents (Multifunctional Group Type)

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 / Product name	Organic functional groups		Alkoxy groups	Functional group equivalent(per Si(OR)3)	Features
X-12-972F	Amine	—NH_2	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

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Silicone Oligomers

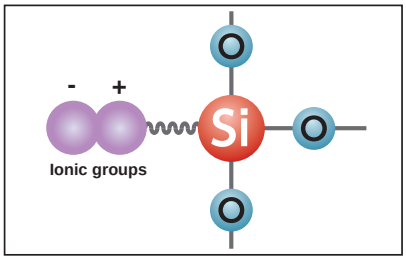
Ionic Silicone Oligomer X-40-2450

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.

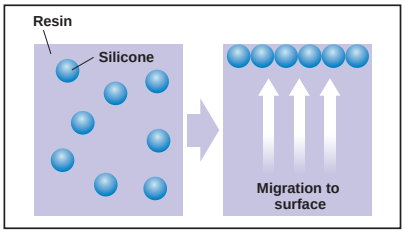
Features

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

Structural Model



Mechanism of Silicone Action



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^2/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 reisn, adding into coating agents

* Methylethylketone

(Not specified values)

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)

*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 $(n\text{-}C_8H_{17})_3(CH_3)N^+(CF_3SO_2)_2N^-$

- 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^2 under a nitrogen atmosphere
- Film thickness : 5μm

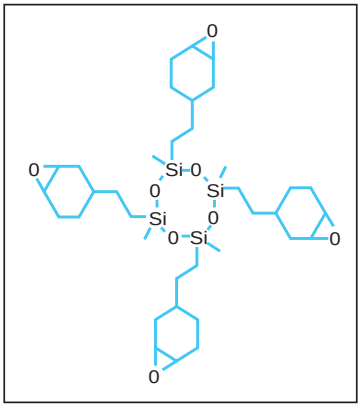
Silicone Oligomers Containing Alicyclic Epoxy Groups

**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.**

Basic Structure of KR-470



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

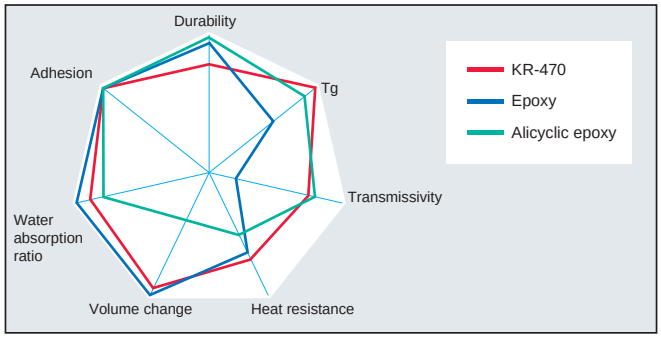
(Not specified values)

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 expantion ($\times10^{-5}$/K) < Tg	9.7	7.7	6.9
Coefficient of liner expantion ($\times10^{-5}$/K) > Tg	15.4	17.6	16.2

(Not specified values)

Comparison Chart of Cured Materials



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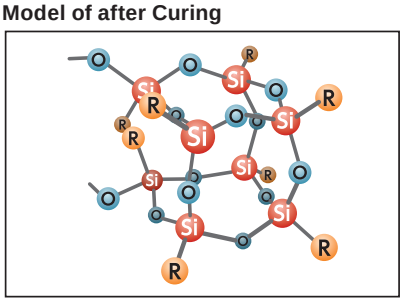
Silicone Resins & Oligomers

Silicone Oligomer Type Coatings

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

Cross linking mechanism $2 \equiv Si{-}OR + 2H_2O \rightarrow (2 \equiv Si{-}OH + 2ROH) \rightarrow \equiv Si{-}O{-}Si \equiv + H_2O + 2ROH$

Model of after Curing

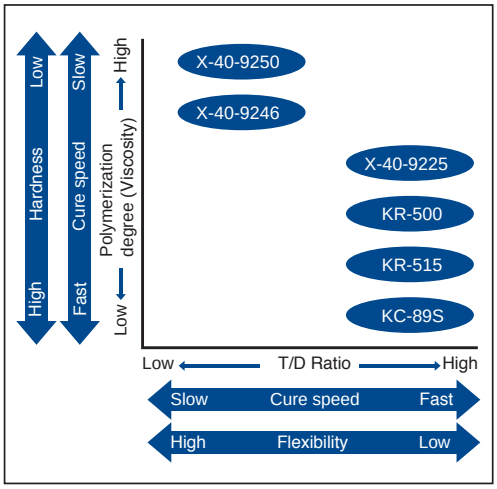


Product & Catalyst line up

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

Product line up

Methyl Type
Features : Water repellency, Excellent curability



Methyl / Phenyl Type
Features : Gloss, Excellent flexibility

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 μm	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	+

(Not specified values)

Result : + = Excellent ± = Satisfactory – = Poor

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

Ultra High Molecular Weight Silicone Resin KR-251

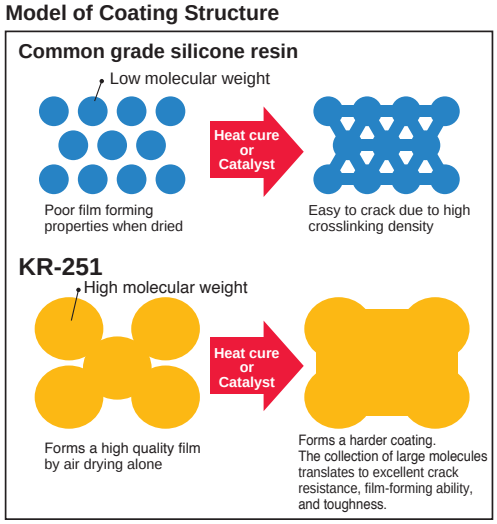
KR-251 is a methyl silicone resin with a very high molecular weight.
With KR-251, the molecular weight has been increased as much as possible without causing gelation.

Features

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

Model of Coating Structure



General property

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

(Not specified values)

Film properties

Clear coating		
Curing condition	25°C×1day	150°C×30min
Film thickness	8μm	8μm
Pencil hardness	HB	F

Substrate : Polished steel sheet (Not specified values)

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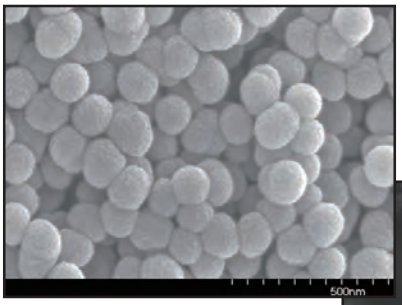
Spherical Silica Fine Particles

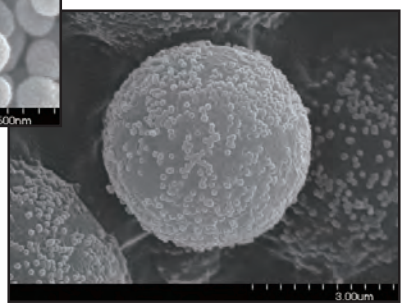
With very small average particle size, narrow distribution and its hydrophobized surface, Spherical Silica Fine Particles have a superior flowability, dispersion, water repellency and lubricity.

Features

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



● QSG-100



● Adherence of QSG-100 to polystyrene particles

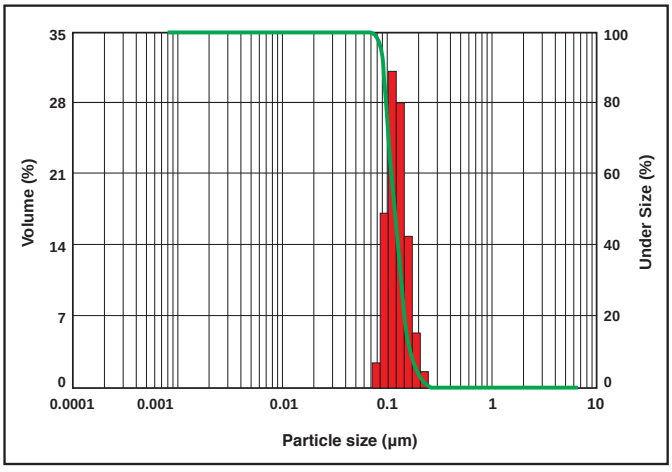
General Properties

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/cm³	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 m²/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)

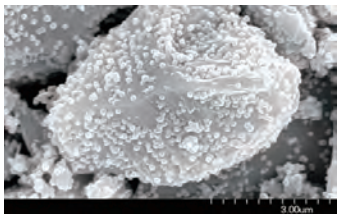
(Not specified values)

Particle Size Distribution QSG-100

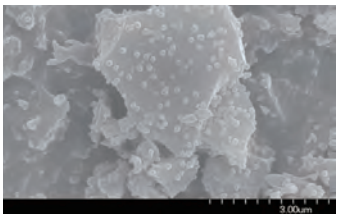


(Not specified values)

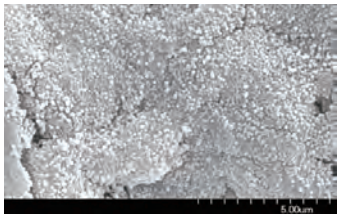
Adhesion State with Various Powders QSG-100



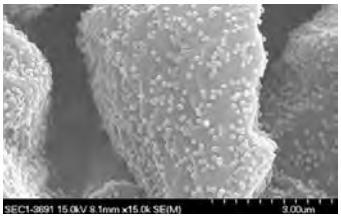
● Metal silicons



● Glass frits



● Surface of Nylons



● Polyester particles

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

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

https://www.shinetsusilicone-global.com/

This is an edited version of the product data released on Feb. 2019.