Shin-Etsu Silicone

Silicone Resins & Oligomers

Adding Functionality, improving Durability and Reliability

Silicone Resins & Silicone Oligomers

CONTENTS

What are **Silicone Resins?**

On a molecular level, silicone resins are primarily made up of siloxane units (Si-O-Si) which have a high bond energy.
Silicone resin coatings have many useful properties including heat resistance, excellent weatherability, superior dielectric properties and water repellency.

Structures of Silicone Resins

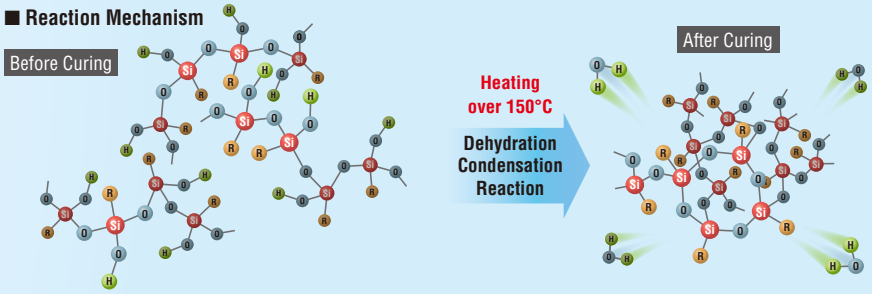
Solidify is possible

Siloxane Structure: 3D Network structure
Molecular Weight: Medium to High
Functional Groups: <Reactive> Silanol Groups (Si-OH),
Vinyl Groups (Si-CH=CH$_2$), Hydrosilyl Groups (Si-H)
<Non-reactive> Methyl Groups, Phenyl Groups

Used as Resin alone

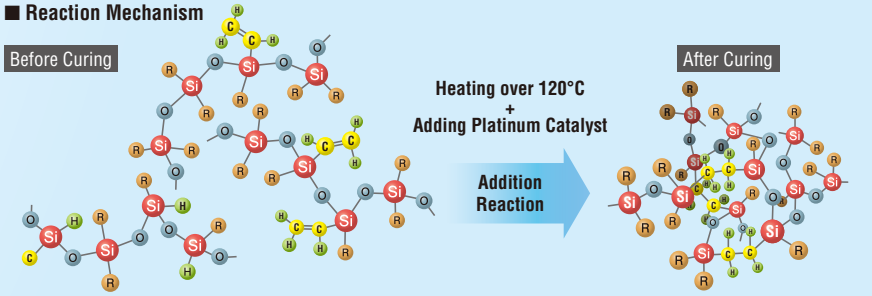
● Dehydration Condensation Cure Type: 1 Part Cure is available

■ **Reaction Mechanism**



● Addition Cure Type: Low Cure Shrinkage

■ **Reaction Mechanism**



R Methyl groups or Phenyl groups

■ **Main Property & Application**

Heat resistance
Electrical Insulation
Weatherability


Heat resistant paints


Moisture proofing and insulation for circuit board


Binders

Used as Organic Resin Modifiers

■ **Reaction mechanism**

Reaction condition: Heating

Dehydration Condensation

Organic resin–C-OH+HO-Si≡ → Organic resin–C-O-Si≡ + H_2O

■ **Main Property & Application**

Heat resistance
Weatherability
Flame retardance


Heat resistant paints


Industrial paints


Polycarbonate flame retardants

What are **Silicone Oligomers?**

Silicone oligomers are relatively low-molecular-weight silicone resins.
These unique products can be used as resins on their own, they can be used to improve the properties of organic resins, or as modifiers to improve interfacial compatibility.

Structures of Silicone Oligomers

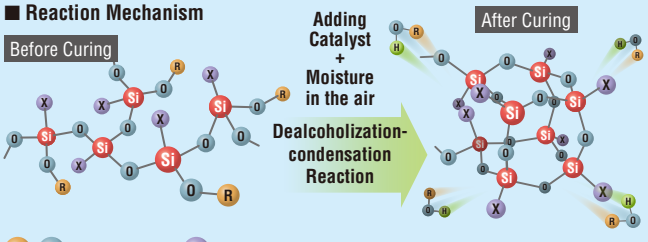
Solventless (Silicone content 100%)

Siloxane Structure: 3D Network structure
Molecular Weight: Low
Functional Groups: <Reactive> Alkoxy Groups (Si-OR), Acrylic Groups, Methacrylic Groups, Epoxy Groups, Mercapto Groups and Vinyl Groups etc..
<Non-reactive> Methyl Groups, Phenyl Groups

Used as resins on their own

● Dealcoholization-condensation Cure Type: Curable at room temperature

■ **Reaction Mechanism**



R O Alkoxy Groups X Methyl groups or Methyl / Phenyl groups and other organic functional groups

■ **Main Property & Application**

Water repellency
Weatherability
High hardness


Body coatings


Floor coatings


Water repellent agents

Used as Organic Resin Modifiers

■ **Reaction Mechanism**

Reaction condition: Room temperature or heating (catalyst should be used together)

① **Dealcoholization-condensation**

Organic resin–C-OH+RO-Si≡ → Organic resin–C-O-Si≡ + R-OH

② **Dehydration Condensation**

Organic resin–C-OH+HO-Si≡ → Organic resin–C-O-Si≡ + H_2O

③ **Chemical Reaction of Acrylic or Epoxy Groups**

■ **Main Property & Application**

Adhesion
Weatherability
Water resistance

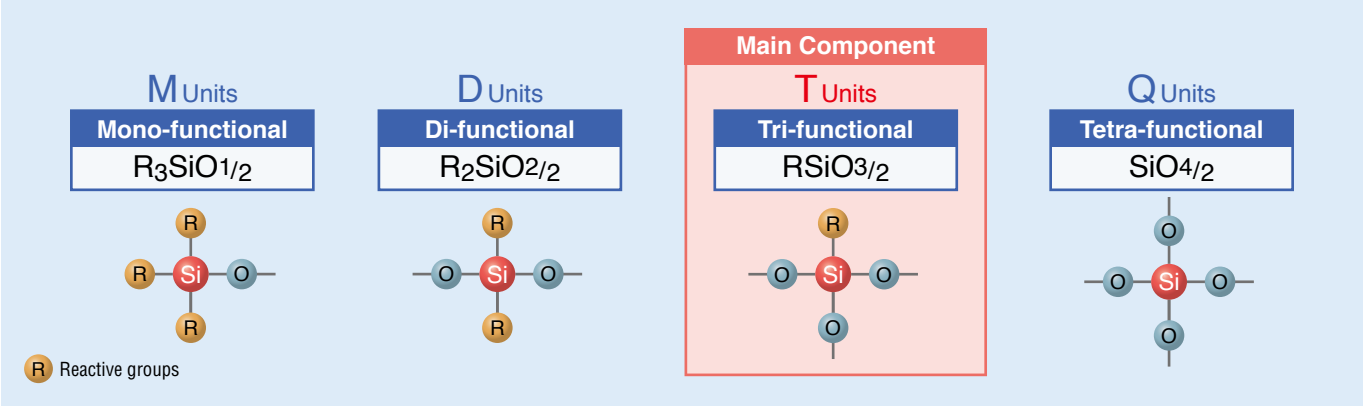

Substrate & Encapsulants


Adhesives

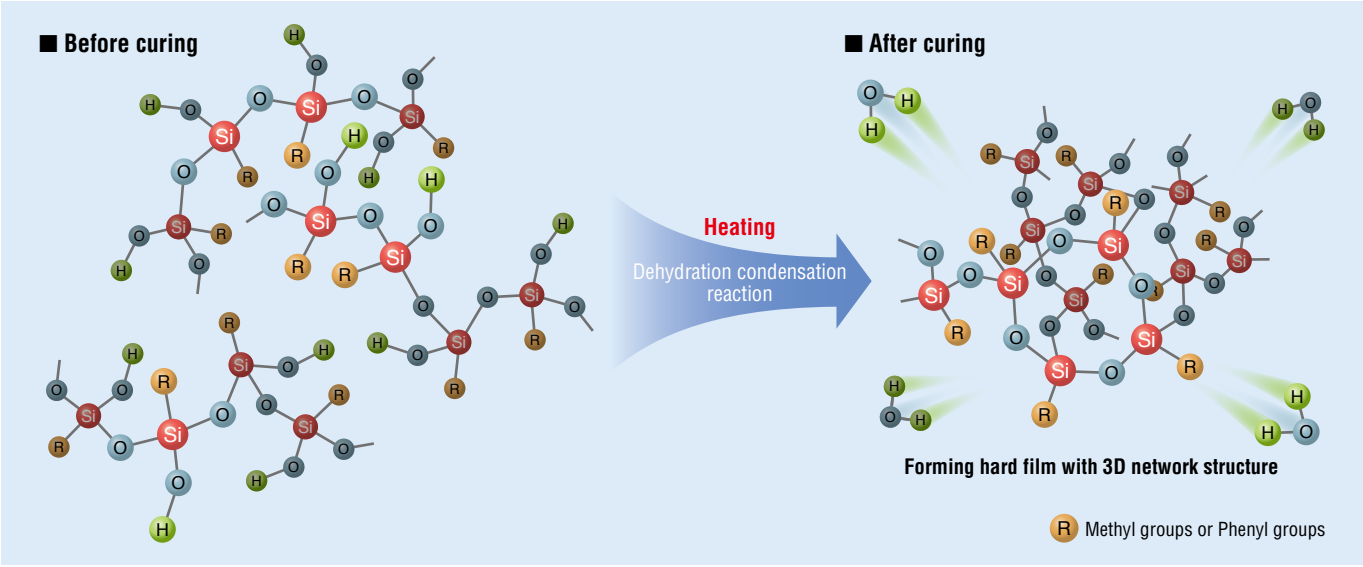

Paints for construction materials

Structures of Silicone Resins

All silicone products are composed of the four units shown below. Silicone resins are composed mainly of T units, and cure to form hard coatings with a 3D network molecular structure. Resins having D units (Di-functional) form flexible films, while those with Q units (Quadri-functional) will form films with higher hardness.



Model of Curing Silicone Resins



Features of Silicone Resins

With their molecular backbone of siloxane units, silicone resins outperform organic resins in heat resistance, weatherability and dielectric properties. Some of their special features are described below.

■ Comparison of Silicone Resins and Organic Resins

Features	**Silicone Resins** [Structure: ≡Si-O-Si≡]		**Organic Resins** [Structure: ≡C-C≡, ≡C-O-C≡]	
Heat resistance	Excellent	≤ 250°C	Excellent	≤ 200°C
Electrical properties	Excellent	Consistent across a wide range of temperatures	Poor	Decline in hot, humid conditions
Water resistance	Excellent	Low hygroscopicity (Due to the orientation of their ≡Si-CH_3)	Poor	High hygroscopicity (Absorbed water does not dissipate easily)
Weatherability	Excellent	Excellent ultraviolet resistance	Poor	
Flame retardancy	Excellent		Poor	Must be used with a fire retardant
Adhesiveness	Excellent	Particularly to inorganic materials	Excellent	Particularly to organic materials
Mechanical strength	Poor	Intermolecular force: Small	Excellent	Intermolecular force: Strong / Crystallinity: Strong
Chemical resistance	Poor	Vulnerable to strong acids and bases	Excellent	

Cure Systems of Silicone Resins

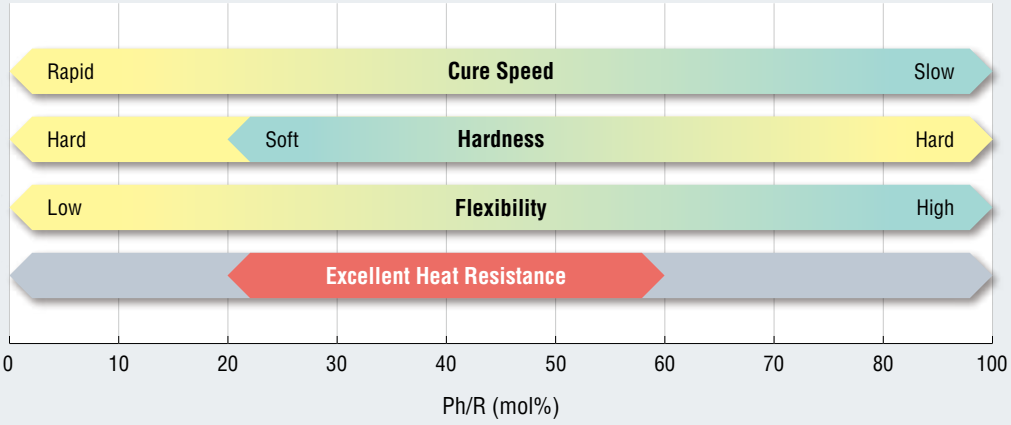
Silicone resins generally rely on one of two cure systems: **dehydration-condensation** and **hydrosilylation**. The majority cure by dehydration-condensation. The cure conditions and advantages of each cure systems are described below.

Cure Systems		Cure Conditions	Features
Condensation reaction	Dehydration condensation	**Structure** Containing silanol groups **Catalysts** Not necessary (But can be used to accelerate the reaction) **Heating** Necessary (Methyl type: 100°C to 200°C, Phenyl type: 180°C to 250°C)	One Componet Cure
Addition reaction	Hydrosilylation	**Structure** Containing –Si–CH=CH_2 and H–Si– **Catalysts** Necessary (Platinum based catalysts) **Heating** Necessary (100°C to 150°C)	Rapid Cure Low Cure Shrinkage

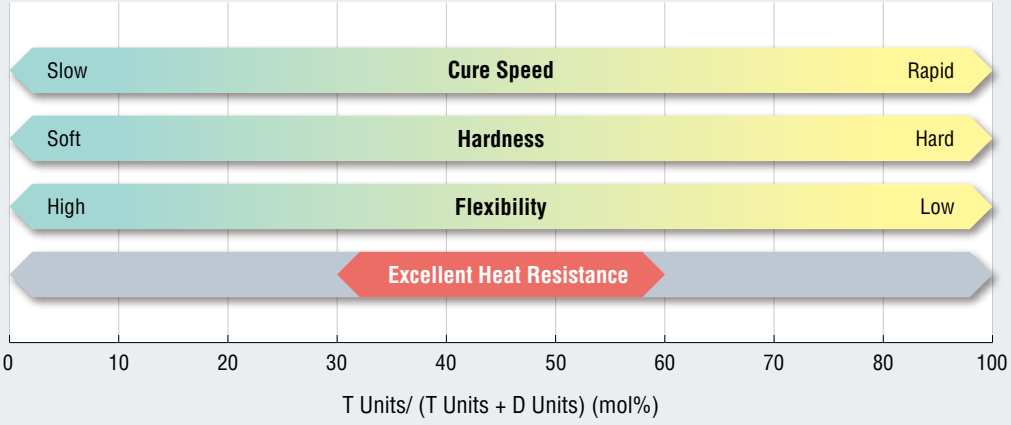
Relationship between Compositions and Characteristics of Silicone Resins

With silicone resins, the cure speed, film hardness, heat resistance and other properties can vary greatly depending on the resin's molecular weight, the types of organic substituents and functional groups it contains. The charts below show the relationship between a silicone resin's characteristics and its compositions, specifically the phenyl group content and ratio of T units to D units.

Effects of Phenyl Group Content



Effects of T Unit Content



Product List

Product name	Type	Non-volatile content 105°C×3 h %	Solvent	Cure speed	Hardness	Compatibility with organic resins	Main applications	Features
KR-220L	Methyl Type	100*1	None	Rapid	High	Low	Heat resistant and flame retardant binders	White flake, excellent heat resistance and flame retardance, very little smoking by heatig
KR-220LP		100*1	None	Rapid	High	Low	Heat resistant and flame retardant binders	Powder type of KR-220L
KR-242A		50	Toluene, isopropyl alcohol	Rapid	High	Low	Heat resistant and flame retardant binders	Excellent heat resistance and flame retardance
KR-251		20	Toluene	Rapid	Medium	Low	Moisture proofing and insulating coatings	Thin hard coating
KR-112	Methyl/Phenyl Type	70	Toluene, xylene	Slow	Low	Medium	Moisture proofing and insulating coatings	Solvent resistant flexible coating
KR-211		70	Xylene	—	—	—	Resin modification	Excellent compatibility
KR-212		70	Xylene	—	—	—	Resin modification	Excellent compatibility, more flexible than KR-211
KR-255		50	Toluene, xylene	Medium	Medium	Medium	Moisture proofing and insulating coatings	Glossy hard coating
KR-271		50	Xylene	Slow	Low	Medium	Heat resistant paints	Excellent heat resistance and flexibility
KR-272		50	Xylene	Slow	Low	Medium	Heat resistant paints	Excellent heat resistance
KR-282		50	Xylene	Slow	Low	Medium	Heat resistant paints	Excellent flexibility and anti-cracking properties
KR-300		50	Xylene	Medium	High	Medium	Heat resistant paints	Excellent heat resistance high hardness coating
KR-311		60	Xylene	Medium	Medium	High	Heat resistant paints	Excellent heat resistance and compatibility with organic resins
X-40-2667A		100*1	None	Medium	Medium	Medium	Molding	Solventless, addition cure type, excellent curability and low shrinkage
X-40-2756		100*1	None	Medium	Medium	Medium	Molding	Solventless, addition cure type, 1 part, high Tg
KR-480		100*1	None	—	—	—	Resin modification	White flake, high phenyl content, excellent compatibility
KR-216	Propyl / Phenyl Type	100*1	None	—	—	—	Resin modification	Solid shape, solventless, excellent compatibility
ES-1001N	Modified Epoxy Resins	45	Xylene, diacetone alcohol, n-butanol	—	—	—	Heat resistant paints	Excellent anti-corrosion property, heat resistance and weatherability
ES-1002T		60	Toluene	—	—	—	Heat resistant paints	Excellent anti-corrosion property and chemical resistance
ES-1023		45	Xylene, diacetone alcohol	—	—	—	Heat resistant paints	Excellent anti-corrosion property
KR-5206	Modified Alkyd Resins	50	Xylene	—	—	—	Heat resistant paints	Excellent flexibility and adhesion
KR-5230	Modified Polyester Resins	60	PGMAC*2	—	—	—	Heat resistant paints	Excellent flexural resistance, heat resistance and weatherability
KR-5234		60	PGMAC*2 (23%) MMBAC*3 (13%) isopropyl alcohol (4%)	—	—	—	Heat resistant paints	Retains glossy appearance under high temperature
KR-5235		60	PGMAC*2 (20%) MMBAC*3 (10%) isobutyl alcohol (10%)	—	—	—	Heat resistant paints	Excellent releasability and non-stick property
KR-114B	Rubber Type	50	Ligroin	—	—	—	Moisture proofing and insulating coatings	Wax-like soft coating, Finished coating can be removed easily with solvents

*1 Active ingredient *2 Propyleneglycol monomethylether acetate *3 3-Methyl-3-methoxybutyl acetate (Not specified values)

Product Lineup

Methyl Silicone Resins

Methyl silicone resins are a type of silicone resin in which the organic substituent groups consist entirely of methyl groups. These resins form very hard films with excellent moistureproofing properties, dielectric properties, water repellency, and release properties.

Methyl / Phenyl Silicone Resins

In methyl phenyl silicone resins, the organic substituent groups consist of methyl groups and phenyl groups. These resins form coatings with excellent heat resistance, mechanical strength, and glossiness.

Organic resin-modified Silicone Resins

Organic resin-modified silicone resins are silicone resins that have been hybridized with other organic resins. They form coatings with the advantages of organic resins (such as mechanical strength and chemical resistance), plus the features associated with silicone resins.

Methyl Type
- KR-220L
- KR-220LP
- KR-242A
- KR-251

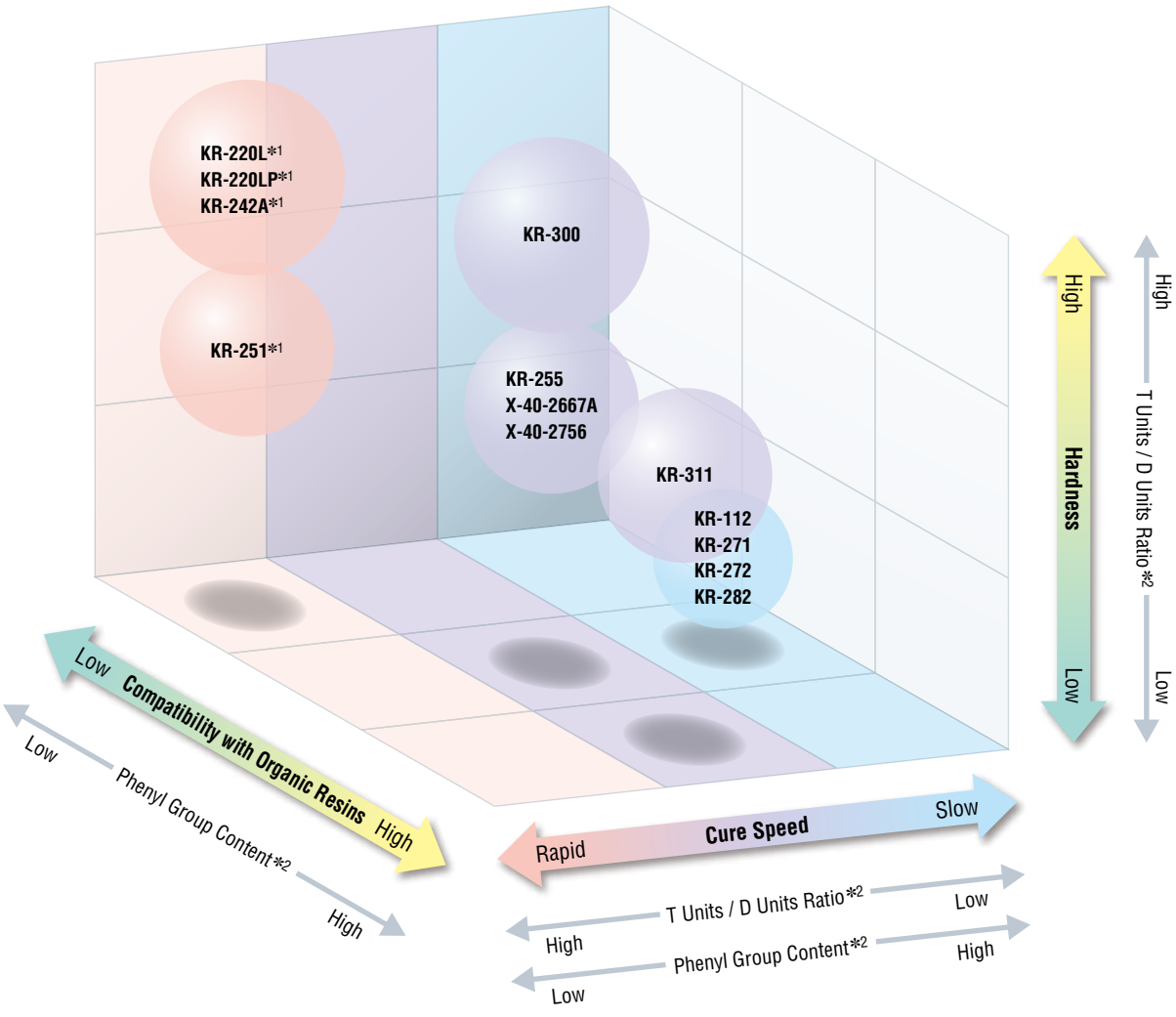
Methyl/Phenyl Type
- KR-112
- KR-211
- KR-212
- KR-255
- KR-271
- KR-272
- KR-282
- KR-300
- KR-311
- X-40-2667A
- X-40-2756
- KR-480

Modified Alkyd Resin
- KR-5206

Modified Polyester Resins
- KR-5230
- KR-5234
- KR-5235

Modified Epoxy Resins
- ES-1001N
- ES-1002T
- ES-1023

Map of Structures and Features



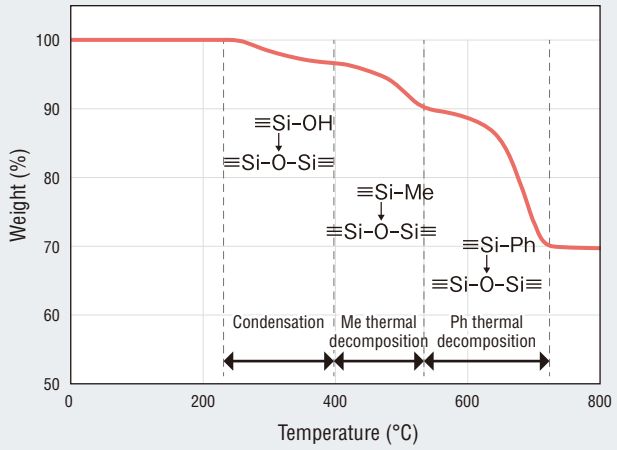
*1 Methyl silicone resin, contains no phenyl groups.
*2 T Units / D Units Ratio and phenyl content are key factors determining hardness, cure speed and compatibility with organic resins, but not all products fit this pattern.

Applications

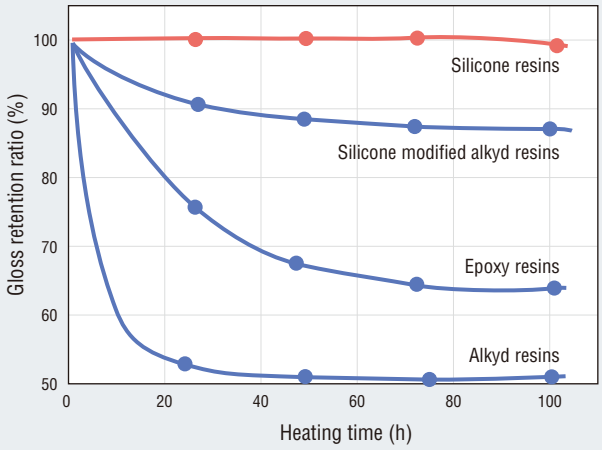
Heat Resistant Paints

With their **excellent heat resistance**, silicone resins are commonly used as **paint vehicles** for high temperature applications (200°C and higher) that are too hot for regular organic resin-based paints. They show good compatibility with common inorganic pigments, and owing to their excellent weatherability and moisture resistance, silicone resins can stand up to the punishment of outdoor exposure. Heat resistant paints come in a variety of product types and compositions depending on the intended application, substrate material and usage temperatures. Many heat resistant paints, are in fact made using silicone resins.

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

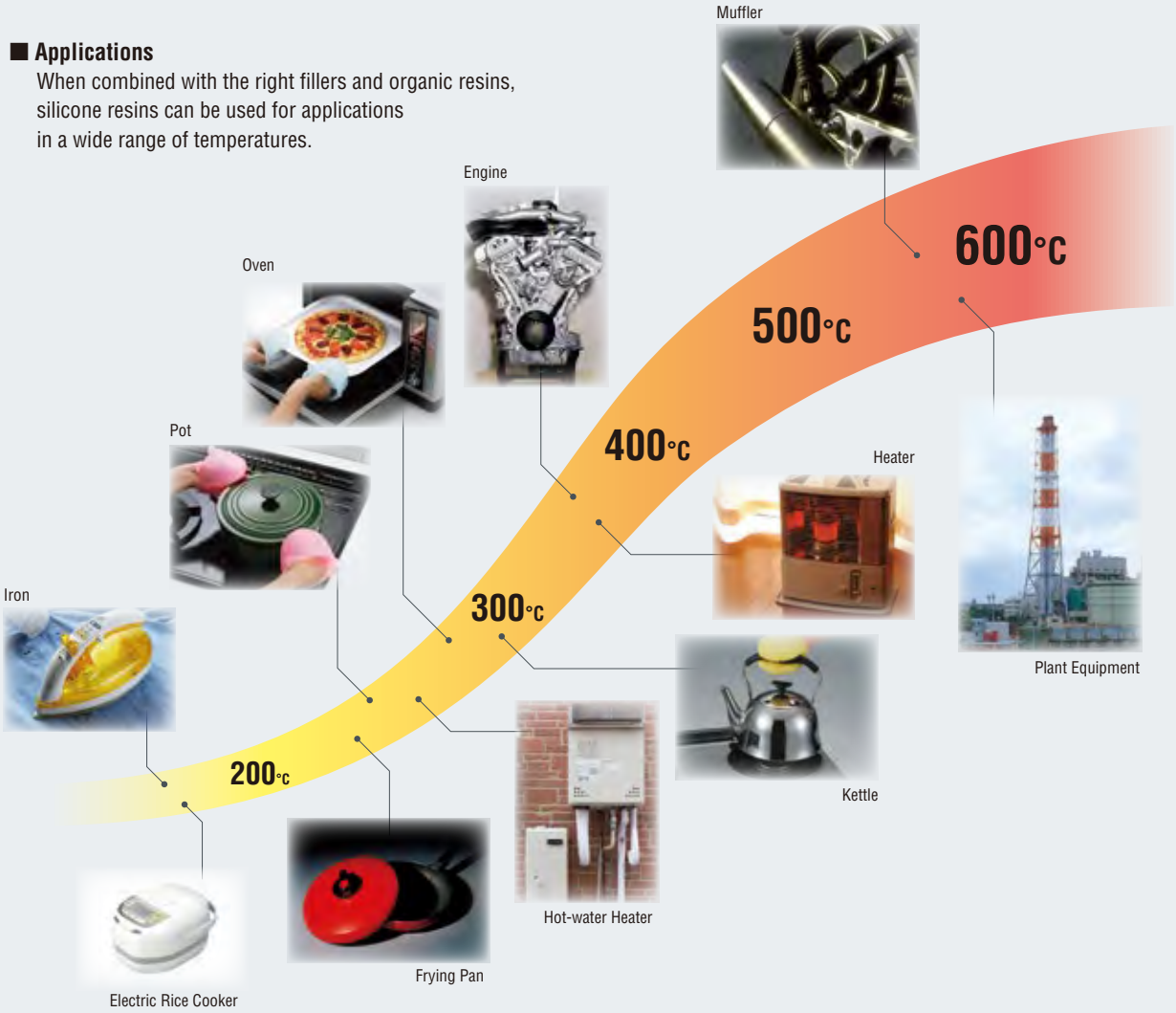


■ **Heat Resistance Comparison Data with Organic Resins (under 250°C)**



■ **Applications**

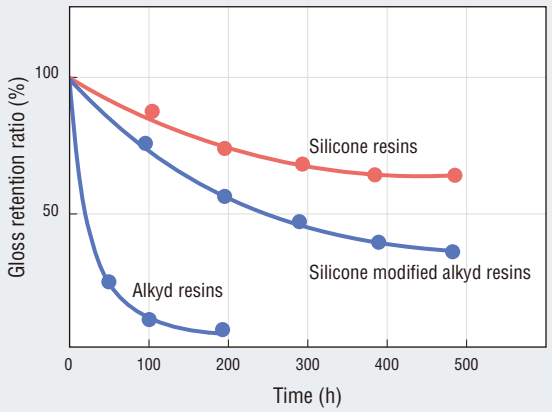
When combined with the right fillers and organic resins, silicone resins can be used for applications in a wide range of temperatures.



Weather Resistant Paints

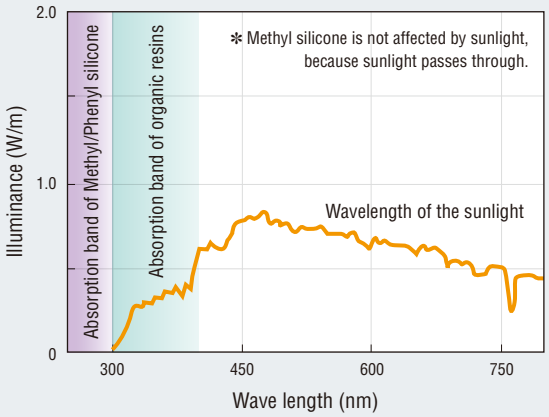
Traditional exterior coatings can deteriorate through exposure to UV rays, heat and water, all resulting in a loss of luster and/or chalking. However **silicone resins are not broken down by UV rays**, **heat or water**. They have much better weatherability than regular organic resins and are commonly used as vehicles for exterior paints.

■ Changes of Weather Resistance Comparison Data with Organic Resins



The graph above shows the gloss retention as tested by weatherometer. With an organic resin (alkyd), the drop is dramatic. But the silicone resin and silicone-modified alkyd resin retain much of their original luster.

■ Sunlight Absorption Comparison Data with Organic Resins

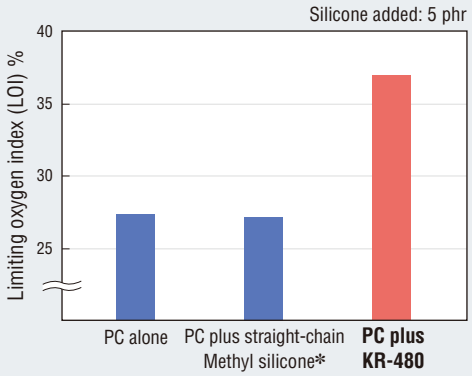


Much of the sunlight reaching the earth's surface is at wavelengths of 300 nm and higher. Most organic resins are susceptible to damage by light in this area of the spectrum. In contrast, Methyl silicone resins absorb almost no light in the UV spectrum, while Methyl/Phenyl silicone resins absorb only light in the spectrum below 280 nm, which means that sunlight has almost no effect.

Resin Modifiers

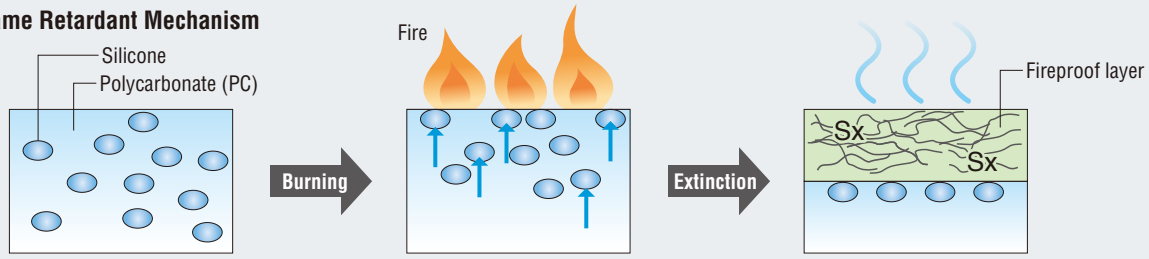
Silicone resins with a high phenyl content have **excellent compatibility with organic resins** and can be used to imbue them with the many features of silicones.
For example, KR-480 can be added to polycarbonate during compounding to improve **flame resistance**. This and other silicone resins are attracting attention as a safer, more **eco-friendly** alternatives to conventional antimony, halogen or phosphate based fire retardants.

■ Flame Retardancy of Polycarbonate when Compounded with KR-480



✻ Weight-average molecular weight of silicone: around 60,000 (Data on PC resin provided by NEC Corp.)

■ Flame Retardant Mechanism



Excellent dispersion
▼
Dissolves & disperses in PC

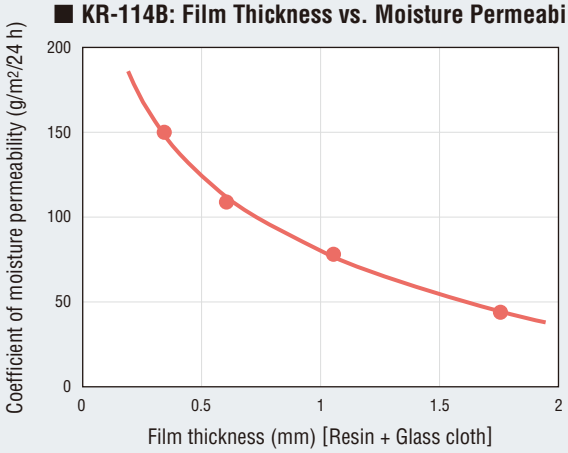
Silicone migrates easily to the surface
▼
Silicone moves quickly to the burning surface

Interaction between PC and phenyl groups in the silicone
▼
Flame-retardant layer forms

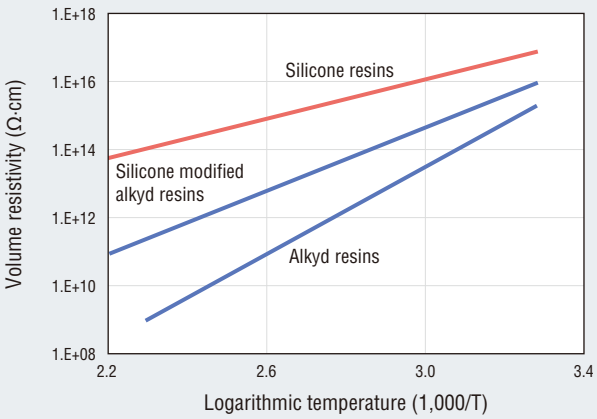
Electrical Insulation Coating

Silicone resins retain **high volume resistivity** (over $1\times10^{13}\Omega\cdot cm$) over a wide temperature range (room temp. to 200°C), and their dielectric properties show little dependence on temperature. In addition, they absorb very little moisture due to the orientation of the methyl groups at the surface of the coating. Features like these are why silicone resins are so often used to **protect electronic components**.

■ KR-114B: Film Thickness vs. Moisture Permeability



■ Temperature Dependence of Volume Resistivity



■ Electrical Properties of Films

Parameter \ Product name		KR-251	KR-255	KR-114B	KR-112
Volume resistivity*1 Ω·cm	Initial	2.1×10^{15}	2.9×10^{15}	2.7×10^{15}	2.9×10^{15}
	Moisture absorption*2	4.4×10^{12}	3.5×10^{12}	2.1×10^{13}	5.3×10^{13}
Relative permittivity*1	50 Hz	3.07	3.06	3.30	3.05
	1,000 Hz	3.06	3.05	3.29	3.15
	100,000 Hz	3.05	3.03	3.28	3.17
Dielectric dissipation factor*1	50 Hz	0.0010	0.0025	0.0035	0.0027
	1,000 Hz	0.0010	0.0023	0.0032	0.0024
	100,000 Hz	0.0016	0.0023	0.0031	0.0021

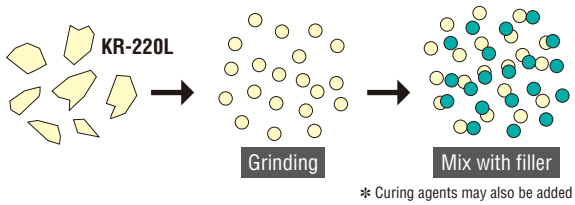
(Not specified values)

*1 Film thickness: 100 µm to 200 µm
*2 Moisture absorption: measured after being left for 4 days at 85°C/85% RH

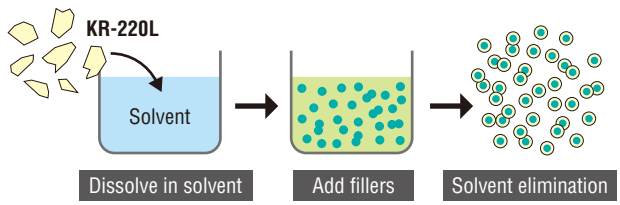
Heat Resistant & Electrical Insulation Binders

With their excellent **heat resistance** and **dielectric properties**, and because they do not soften when heated, silicone resins are used as binders for molding with powdered metals and other materials. And with the increasing popularity of hybrid and electric vehicles and photovoltaics, demand for silicone resins to be used as **binders for coil molding** are on the rise.

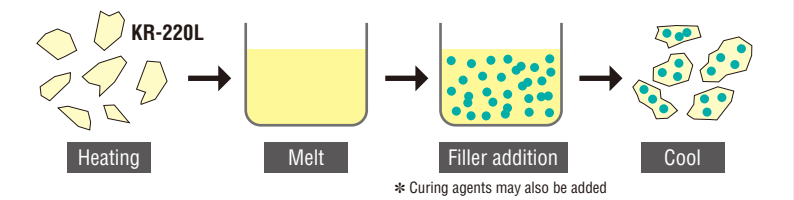
Dry Blend



Solution Blend



Melt Blend



Powder silicone resin

Main Products

KR-220L, KR-220LP Solid Silicone Resins

KR-220L and **KR-220LP** are solid silicone resins that undergo rapid crosslinking when heated.
They are used as binders for inorganic materials, and can be used in molding to produce items with **outstanding heat resistance**, **flame retardance** and **solvent resistance**.
Since solid silicone resins come in **solid form**, the choice of solvent is up to the user.
KR-220L and **KR-220LP** will dissolve in toluene, xylene, isopropyl alcohol and other solvents.

〈Application Examples〉

- Binders for mica laminated plate
  (Support structure for nichrome wire for irons, hair dryers and toasters; heat resistant washers, electrical insulation for high temperature instruments, thermal insulation boards, partition boards for microwave ovens)
- Flame retardant paints
- Binders for electrical & electronic components
- Paints for resistors
- Powder coatings

■ General Properties

Parameter \ Product name	KR-220L	KR-220LP
Appearance	White flake	White powder
OH content wt%	3	3
Softening point °C	67	67
Gelation time 200°C s	240	240

(Not specified values)

KR-480 Solid Silicone Resin for Organic Resin Modification

KR-480 is a solid silicone resin designed for the modification of organic resins.
It has especially **excellent compatibility with polycarbonate resin (PC)**,
and can be added to PC to **improve flame retardance without sacrificing moldability**, **impact resistance or moisture resistance**.

〈Application Examples〉

- Flame retarder for polycarbonate (PC)
- Stress relaxation for epoxy resin

■ General Properties

Parameter \ Product name	KR-480
Appearance	White flake
Softening point °C	90
Active ingredient %	100

(Not specified values)

■ Properties of Polycarbonate Resin (PC) when Compounded with KR-480

Parameter	PC alone	PC with brominated flame retardant	PC with KR-480
Flexural strength kgf/cm²	960	970	930
Flexural modulus kgf/mm²	230	230	220
Impact strength kgf·cm/cm	97	45	80
Heat deflection temperature °C	138	137	134
Rockwell hardness	63	66	60
Melt flow g/min	10.4	10.7	11.8
Flame retardance UL94*1	V-2	V-0	V-0

*1 Test piece thickness: 1.57 mm

(Not specified values)

KR-251 Ultra High Molecular Weight Silicone Resin

KR-251 is a methyl silicone resin with a very high molecular weight.

Common methyl silicone resins
- Very hard film
- Easy to crack
- Heat cure is necessary

KR-251
- The coating film is hard to crack.
- Forms the coating film by air drying alone
- Forms the harder coating film by heating

■ General Properties

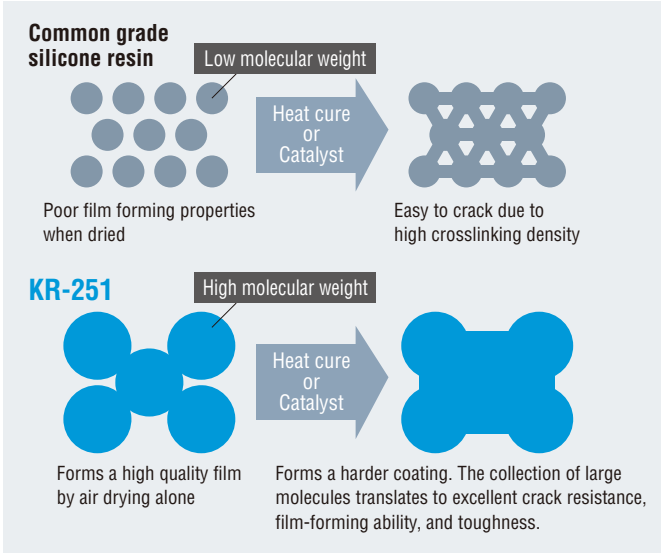
Parameter \ Product name	KR-251
Appearance	Colorless transparent liquid
Non-volatile content 105°C x 3 h %	20
Viscosity at 25°C mm²/s	18
Specific gravity at 25°C	0.92
Acid value	< 2
Solvent	Toluene

(Not specified values)

■ Film Properties

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

Substrate: Polished steel sheet (Not specified values)



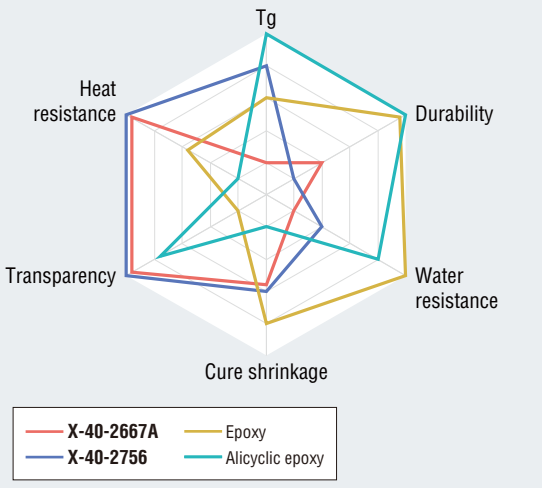
X-40-2667A, X-40-2756 Silicone Resins for Mold making

It is a line of silicone resins for mold making. X-40-2667A and X-40-2756 exhibit excellent heat resistance and have 100 % silicone content. X-40-2756 is easy to handle owing to the 1 part curability and higher Tg.

X-40-2667A (2 part addition cure silicone resin)
- Excellent heat resistance

X-40-2756 (1 part addition cure silicone resin)
- Excellent heat resistance and low-water absorption

■ Comparison Chart of Cured Physical Properties



■ Properties of Molding

Parameter \ Product name	X-40-2667A	X-40-2756	Epoxy	Alicyclic epoxy
Cure system	Addition cure		Acid anhydride cure	
Standard curing conditions	105°C x 2 h + 170°C x 2 h	200°C x 16 h (Tack-free time 1 h)	105°C x 2 h + 170°C x 2 h	
Hardness Shore D	70	67	85	88
Flexural modulus MPa	1,110	707	2,940	3,020
Tg °C	48	150	150	193
Volume change after cure %	-3.3	-3.1	-1.7	-5.3
Boiling water absorption				
Appearance: Before boiling	Transparent	Transparent	Pale yellow	Transparent
Appearance: After boiling	Whitening	Whitening (Transparent after 24 h)	No change	No change
Water absorption ratio %	0.34	0.16	0.28	0.56

■ Molding examples

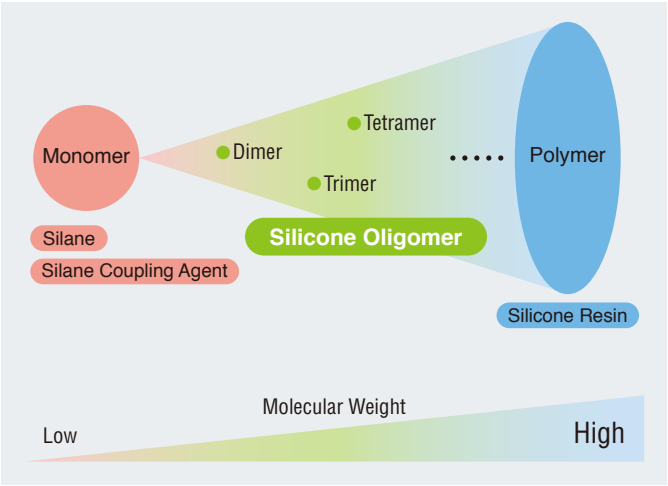
Column (ϕ 8.0 mm)

Sheet (Thickness: 0.2 mm)

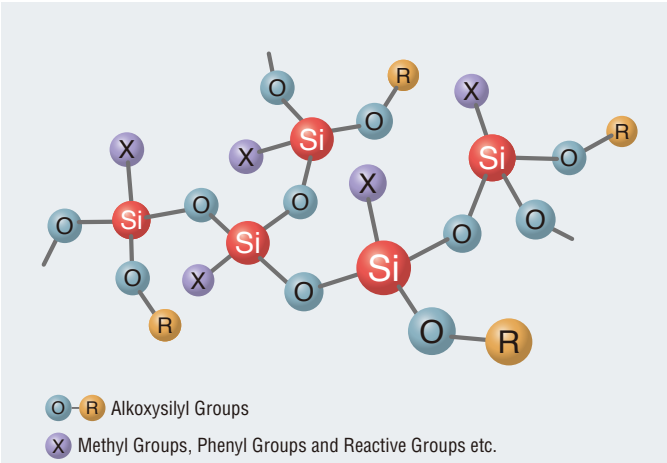
Systems and Structures of Silicone Oligomers

Silicone oligomers is a term used for silicone resins with relatively low molecular weights and whose molecules have a **3D network structure**. They generally consist of dimers and trimers and have **molecular weights up to around 1,000**. Their molecules can be functionalized with a variety of functional groups including methyls, phenyls, alkoxysilyls and reactive functional groups.

■ Position of Silicone Oligomer



■ Model of Chemical Structure



Features of Silicone Oligomers

Silicone oligomers offer the following advantages, which are linked to their structures.

● Solventless They contain no solvents, and they release less alcohol when curing than do monomers.

Used as Organic Resin Modifier

Compatibility with Organic Resins
Owing to the low molecular weight, they have excellent compatibility.

Low Volatile Content
Even in high temperature conditions, there is little evaporation and the active ingredients function as designed.

Large Number of Reaction Sites
More effective than monomers, as there are more sites for reaction with the intended material.

Used as Resins

Room-temperature Cure
When used with a curing agent, silicone oligomers cure at room temperature by reacting with moisture in the air.

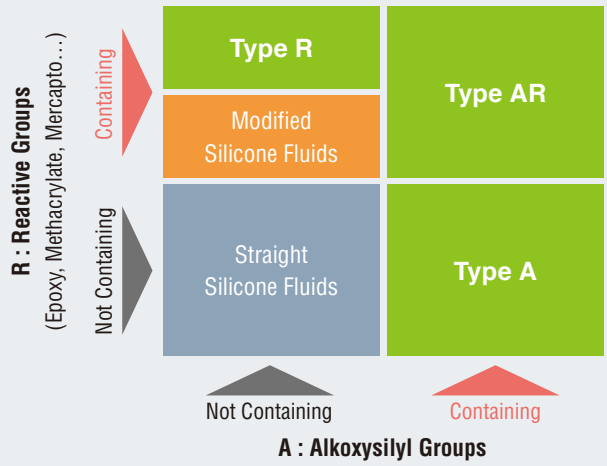
High Hardness
Their relatively low molecular weights mean they will form very hard coatings.

Water Repellency
Silicone oligomers, especially those having methyl groups, form films with excellent water repellency.

Types of Silicone Oligomers

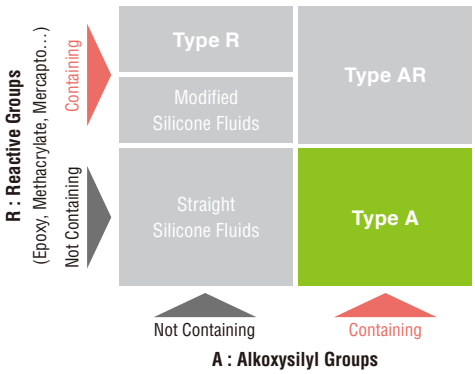
Silicone oligomers can be categorized into three major groups, depending on whether or not they contain **alkoxysilyl groups and reactive groups**. Each type has different functions, and can be used for different purposes and applications.

■ Classification of Silicone Oligomers



Type A Alkoxysilyl Groups: Containing / Reactive Groups: Not Containing

Type A products contain alkoxysilyl groups, but no reactive groups. They may have methyls alone, or have both methyls and phenyls. Their structure is comparable to that of a silicone resin.



Methyl Type

Methyl silicone oligomers hydrolyze easily, and can be used as room-temperature/moisture-cure coating agents when used with the proper curing agent. They will form very hard coatings with excellent water repellency.

Methyl/Phenyl Type

These products have excellent compatibility with organic resins, so they can be used with organic resins as modifiers or as reactive diluents. They can also impart flexibility to coating which is curable due to the reaction with moisture under room temperature. And the coating is made up of methyl oligomers and catalyst.

Product List

Parameter / Product name	Reactive groups	Alkoxy group	Viscosity at 25°C mm²/s	Refractive index at 25°C	Alkoxy group content wt%	Features
KC-89S	Methyl	Methoxy	5	1.394	45	Low DP (degree of polymerization)
KR-515	Methyl	Methoxy	7	1.397	40	Medium DP
KR-500	Methyl	Methoxy	25	1.403	28	Medium DP
X-40-9225	Methyl	Methoxy	100	1.407	24	High DP
X-40-9246	Methyl	Methoxy	80	1.407	12	Improves flexibility
X-40-9250	Methyl	Methoxy	80	1.407	25	Improves flexibility, thick coatings
KR-401N	Methyl/Phenyl	Methoxy	20	1.432	33	Low phenyl content
X-40-9227	Methyl/Phenyl	Methoxy	15	1.460	15	Improves flexibility
KR-510	Methyl/Phenyl	Methoxy	100	1.509	17	Forms high hardness coatings
KR-9218	Methyl/Phenyl	Methoxy	40	1.529	15	Forms medium hardness coatings
KR-213	Methyl/Phenyl	Methoxy	16	1.525	20	High phenyl content

(Not specified values)

Applications

Organic Resin Modifiers

Type A silicone oligomers contain alkoxysilyls, which are useful in and of themselves, or which can be hydrolyzed to form silanols. These oligomers can be used to **modify organic resins** to **improve their heat resistance** and **weatherability**. Alcoholic hydroxyl groups in the organic resin react with alkoxysilyls to release alcohol (dealcoholization condensation), or with silanols to release water (dehydration condensation). Typically, **methyl oligomers are used with water-based organic resins**, and **phenyl oligomers are used with solvent-based organic resins**.

Reaction mechanism

Dealcoholization condensation: Organic resin–C-OH + RO-Si≡ → Organic resin–C-O-Si≡ + R-OH

Dehydration condensation: Organic resin–C-OH + HO-Si≡ → Organic resin–C-O-Si≡ + H_2O

Advantages of Silicone-modified Organic Resins

Acrylic Resins

Through silicone modification, we get the excellent solvent resistance, chemical resistance and durability of acrylic resins plus the weatherability and heat resistance of silicone. Modified acrylic resins are commonly used in paints for construction materials.

Polyester Resins

Through silicone modification, we get the excellent flexural resistance of polyester resins plus the weatherability and heat resistance of silicone. Modified polyester resins are used to produce paints for construction materials, industrial uses, paints for home appliances that operate at high temperatures.

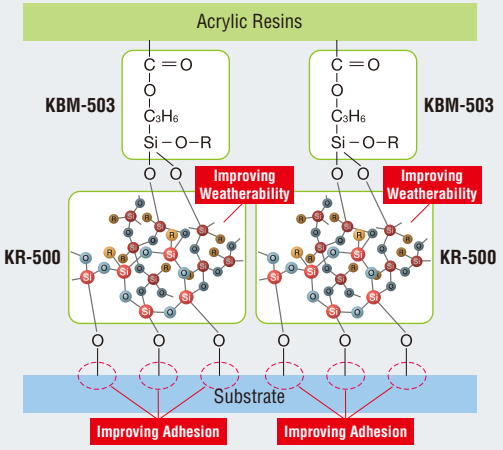
Epoxy Resins

Through silicone modification, we get the excellent corrosion resistance of epoxy resins plus the weatherability and heat resistance of silicone. Modified epoxy resins are used in paints that provide protection against acids and other substances with strong staining potential.

Alkyd Resins

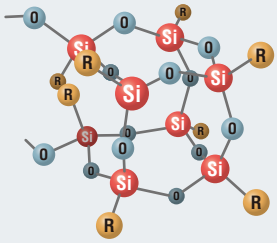
Silicone modification improves the weatherability of alkyd resins. Modified alkyd resins cure at room temperature and are used in paints for storage tanks, ships, bridges and other things that are exposed to the elements.

■ Model of Resin Modification



Room Temperature Moisture Cure Coatings

Model of after cure



2 Part Type

When used with a curing agent, Type A oligomers can be used as **Room-temperature/Moisture-cure coating agents**. They are used as auto body coatings, floor coatings, and in a wide array of other applications.

Cross linking system

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

By using different combinations of oligomers and curing agents, the user has considerable control over the cure speed as well as the hardness, flexibility and thickness of the cured coating. With the choices available, the user can find the right formula for specific purposes and applications.

■ Coating Properties Obtained with Different Combinations of Products and Curing Agents

Parameter / Product name	Catalyst (Additive amount) %	Film thickness μm	Tack-free at 25°C min	Pencil hardness	Flexural strength/ Impact resistance
KR-500	D-20 (2)	25	40	H	±
KR-500	D-20 (4)	25	25	2H	± to –
KR-500	DX-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	+

+: Excellent ±: Satisfactory –: Poor (Not specified values)

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

1 Part Type (Pre-blended)

We offer a range of Type A products which come pre-blended with the optimal curing agents.
With these products, no mixing of curing agents is involved. They can be applied to metal, stone, wood and plastic, where they will cure to form coatings with excellent weatherability and water repellency.
KR-400 is a special **high hardness** formula, **X-40-2327** is **rapid curing**, and **KR-401** offers **excellent flexural strength** and **impact resistance**.

■ Product List

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
KR-400	Methyl	1.2	1.390	30 to 60	5H/2→8H/7	Forms high hardness coatings
X-40-2327	Methyl	0.9	1.382	5 to 10	5H/1	Rapid cure, Finished coating can be recoated.
KR-401	Methyl/Phenyl	20	1.435	30 to 60	3H/7	Excellent flexural strength and impact resistance

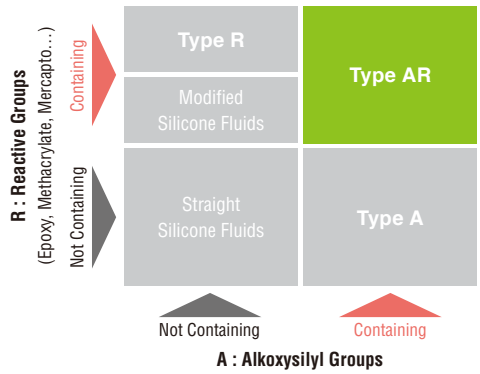
✻ Substrate: polished steel sheet, Film thickness = 10 μm, cured at 25°C/70%RH (Tack-free time varies depending on temperature and humidity) (Not specified values)

Exterior coatings for vehicles

Floor coatings

Type AR Alkoxysilyl Groups: Containing / Reactive Groups: Containing

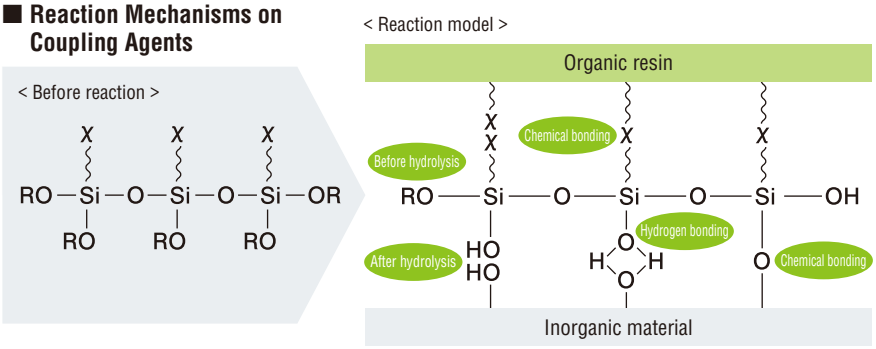
Type AR oligomers contain alkoxysilyl groups and organic reactive functional groups, meaning they can be used to promote adhesion between organic and inorganic materials. Think of them as oligomeric type coupling agents.



RO: Functional groups which bind chemically to inorganic materials (glass, metal, silica stone etc..)
● Methoxy groups ● Ethoxy groups

χ: Functional groups which bind chemically to organic materials such as synthetic resins
● Vinyl groups ● Epoxy groups
● Methacrylic groups ● Mercapto groups

■ Reaction Mechanisms on Coupling Agents



Product List

Parameter / Product name	Reactive groups	Alkoxy group	Viscosity at 25°C mm²/s	Refractive index at 25°C	Alkoxy group content wt%	Features
KR-517	Epoxy	Methoxy/Ethoxy	12	1.414	50	Epoxy equivalent 830 g/mol
X-41-1059A	Epoxy	Methoxy/Ethoxy	30	1.434	42	Epoxy equivalent 350 g/mol
X-24-9590	Epoxy	Methoxy	350	1.448	9.5	Epoxy equivalent 590 g/mol
KR-516	Epoxy/Methyl	Methoxy	50	1.441	17	Epoxy equivalent 280 g/mol
KR-518	Mercapto	Methoxy/Ethoxy	20	1.418	50	Mercapto equivalent 800 g/mol
X-41-1818	Mercapto	Ethoxy	14	1.417	60	Mercapto equivalent 850 g/mol
KR-519	Mercapto/Methyl	Methoxy	5	1.422	30	Mercapto equivalent 450 g/mol
KR-513	Acrylate/Methyl	Methoxy	35	1.450	20	Acrylic equivalent 210 g/mol
X-40-9296	Methacrylate/Methyl	Methoxy	20	1.450	22	Methacryl equivalent 230 g/mol
KR-511	Vinyl/Phenyl	Methoxy	100	1.518	13	Vinyl equivalent 530 g/mol

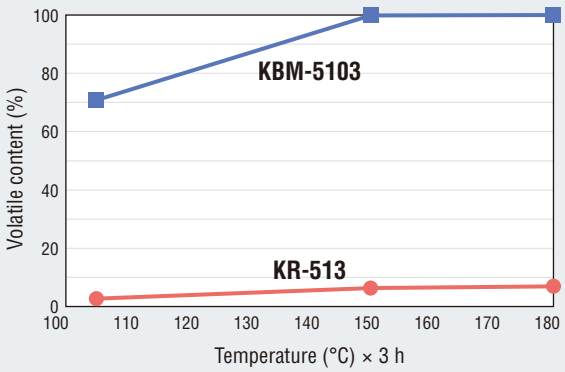
(Not specified values)

Applications

● Coupling Agents

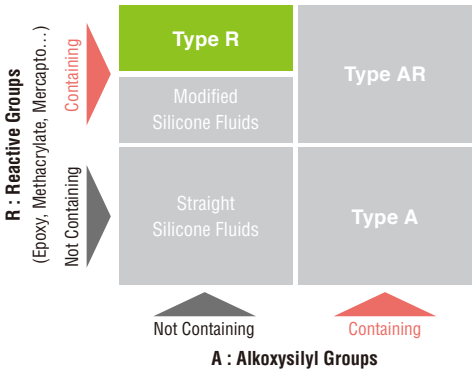
A key difference between these products and monomeric silane coupling agents lies in their **volatility**. Graph on the right is a graph comparing an acrylic oligomer to a silane coupling agent when the two are heated. With the oligomer, the **active ingredient remains in place even at high temperatures**, to better aid with adhesion.

■ **Comparison Data of Volatile Content of Acrylic Oligomer (KR-513) and Silane Coupling Agent (KBM-5103)**



Type R Alkoxysilyl Groups: Not Containing / Reactive Groups: Containing

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 using the same mechanisms as epoxy resins do, while offering excellent heat resistance and high Tg (gloss-transition temperature) that are characteristic of siloxane bonds.
The cyclosiloxane-based oligomers exhibit low shrinkage during curing.



■ Features

- **Silicones which contain reactive functional groups**
- **Relatively low molecular weights, and good compatibility with other materials**
- **Cure with light or heat when an acid generator is added**
- **Cure with heat when an acid anhydride- or amine-based curing agent is added**
- **KR-470 has excellent cure properties and will be very hard & strong after curing.**
- **KR-470 exhibits low shrinkage during curing.**

Product List

■ General Properties

Parameter \ Product name	KR-470	X-40-2678
Number of epoxy functional groups	4	2
Viscosity at 25°C mPa·s	3,000	120
Epoxy equivalent g/mol	200	290

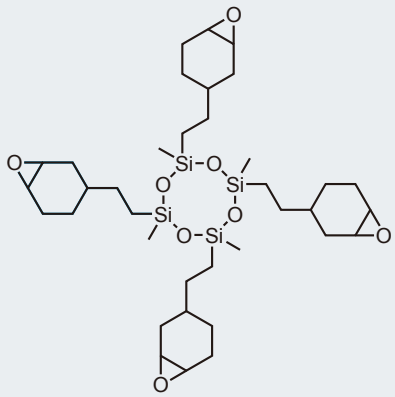
(Not specified values)

■ Comparison Data of Cured Materials

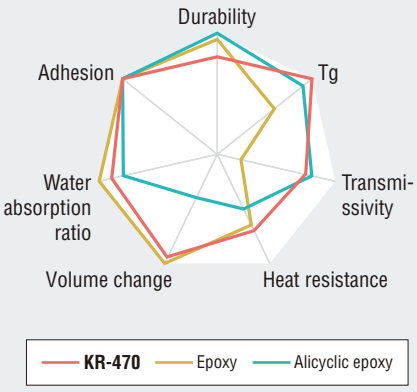
Parameter \ Product name		KR-470	Epoxy	Alicyclic epoxy
Cure system		Acid anhydride curing		
Hardness Shore D		87	85	88
Flexural modulus MPa		2,590	2,940	3,020
Curing shrinkage ratio (Hydrometer method) %		+2.1	–1.7	–5.3
Boiling water absorption ratio %		0.46	0.28	0.56
Tg °C		191	150	193
Coefficient of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

(Not specified values)

■ Basic Structure of KR-470



■ Comparison Chart of Cured Materials



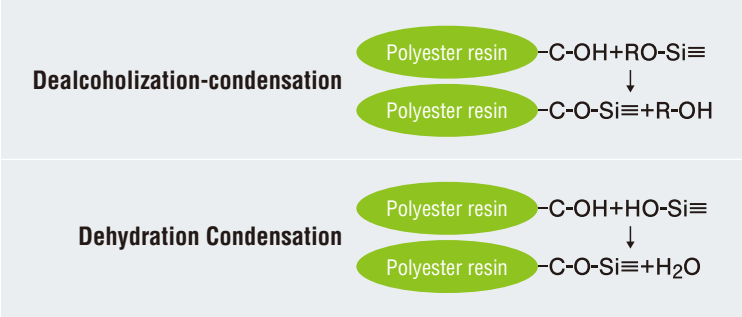
Main Products

Type A KR-510 Methyl/Phenyl Group-containing Alkoxy Oligomer

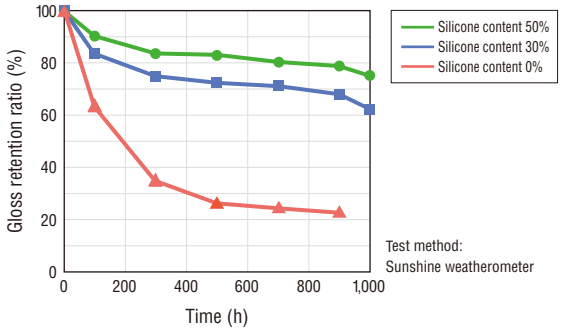
KR-510 is a Methyl/Phenyl silicone oligomer that contains methoxy groups.
Because it has phenyls, **KR-510** has **excellent compatibility** with organic resins.
KR-510 can be mixed with organic resin containing groups that can react with methoxysilyls or be used in a methanol-releasing reaction to produce resins with **improved heat resistance**, **weatherability** and **chemical resistance**. **KR-510** can also be used as a **reactive diluent**.

〈**Application Examples**〉 Imparting siloxane structure of silicone oligomers into polyester resins, weatherability is improved.

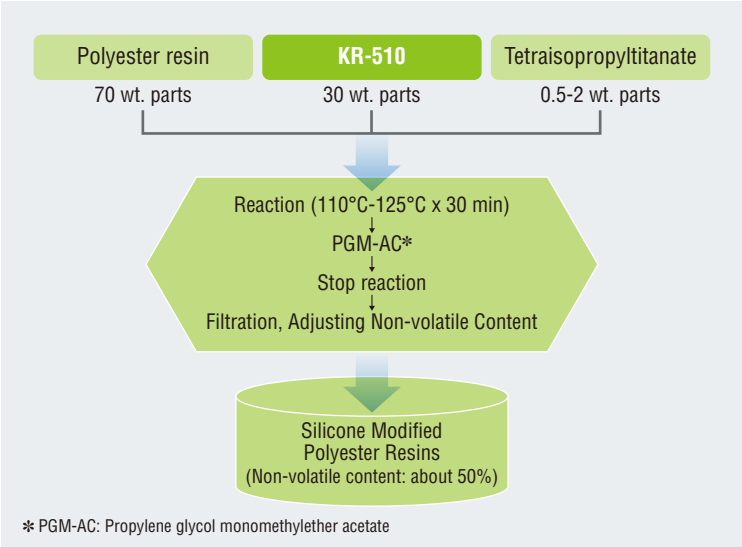
■ Reaction mechanism



■ Weatherability Test Result of Silicone Modified Polyester Resin



■ Polyester Resin Modification with Silicone Oligomers



* PGM-AC: Propylene glycol monomethylether acetate

■ General Properties

Parameter \ Product name	KR-510
Appearance	Colorless transparent liquid
Viscosity at 25°C mm²/s	100
Specific gravity at 25°C	1.16
Refractive index at 25°C	1.509
Methoxy content wt%	17
Active ingredient %	100

(Not specified values)

■ Film Properties

Parameter \ Cure condition	285°C x 1 min	285°C x 10 min
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)

Type AR KR-516/KR-517 Epoxy Group-containing Alkoxy Oligomers

In **KR-516** and **KR-517**, the organic functional groups (epoxy groups) and hydrolysable groups (alkoxy groups) are contained within the same molecule. This allows them to be used as **coupling agents to enhance bonding** between organic resins and inorganic materials. In addition, these oligomers can react with the active hydroxyl groups in an organic resin to form a copolymer. The organic resin will then be **hydrophilic** and have **durable anti-stain properties** and **improved weatherability**.

〈**Application Examples**〉

- Coupling agents
- Hydrophilic anti-stain agents

■ General Properties

Parameter \ Product name	KR-516	KR-517
Appearance	Pale yellow transparent liquid	Pale yellow transparent liquid
Viscosity at 25°C mm²/s	50	12
Specific gravity at 25°C	1.15	1.11
Refractive index at 25°C	1.441	1.414
Epoxy content g/mol	280	830
Active ingredient %	100	100

(Not specified values)

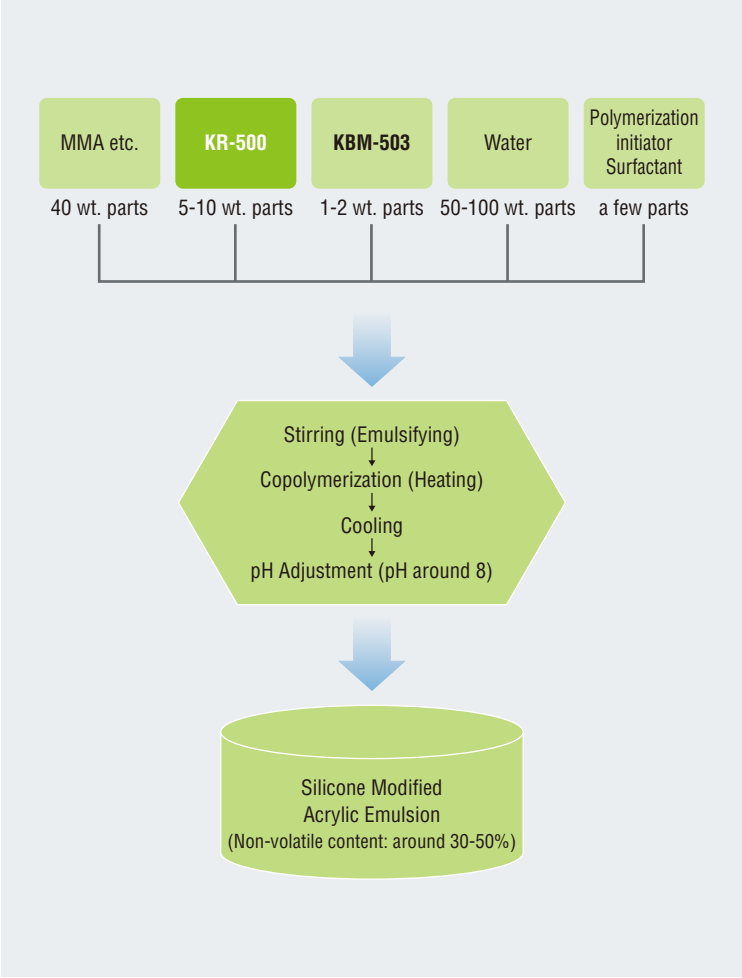
Type A KR-500 Methyl Group-containing Alkoxy Oligomer

KR-500 is methyl silicone oligomer that contains methoxy groups.

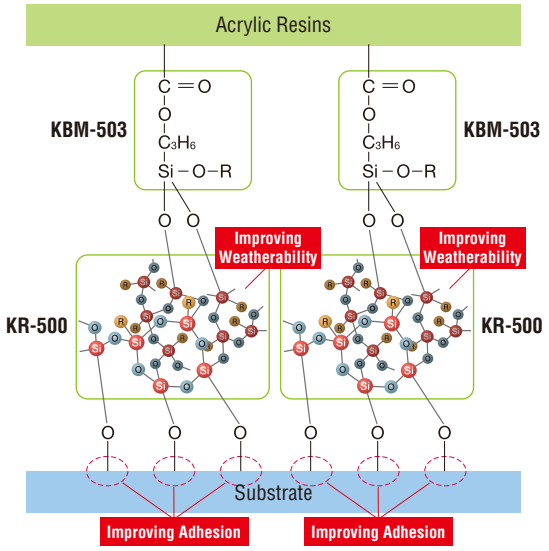
This oligomer can be mixed with organic resin containing groups that can react with methoxysilyls or be used in a methanol-releasing reaction to produce resins with **improved heat resistance**, **weatherability** and **chemical resistance**. Water-borne resin application is available.

〈Application Examples〉

Modification via dehydration-condensation or dealcoholization-condensation. Results in improved adhesion to substrates and enhanced weatherability.



■ Model of Resin Modification



■ General Properties

Parameter \ Product name	KR-500
Features	Medium degree of polymerization
Appearance	Colorless transparent to pale yellow cloudy liquid
Viscosity at 25°C mm²/s	25
Specific gravity at 25°C	1.15
Refractive index at 25°C	1.403
Methoxy content wt%	28
Active ingredient %	100

(Not specified values)

Type AR KR-513 Acrylate Group-containing Alkoxy Oligomer

In **KR-513**, the organic functional groups **(acrylic groups)** and hydrolysable groups (methoxy groups) are contained within the same molecule.

This allows **KR-513** to be used as a **coupling agent to enhance bonding** between organic resins and inorganic materials.

〈Application Examples〉

- Coupling agents

■ General Properties

Parameter \ Product name	KR-513
Appearance	Colorless to pale yellow transparent liquid
Viscosity at 25°C mm²/s	35
Specific gravity at 25°C	1.15
Refractive index at 25°C	1.450
Acrylic equivalent g/mol	210
Active ingredient %	100

(Not specified values)

Product Features & Packaging Options

Category	Product name	Type		Appearance	Non-volatile content 105°C×3 h %	Active ingredient %	Viscosity at 25°C mPa·s	Specific gravity at 25°C	Refractive index at 25°C	Standard curing conditions	
Silicone Resins	KR-220L	Methyl Type		White flake	—	100	—	1.40	—	—	—
	KR-220LP			White powder	—	100	—	1.40	—	—	—
	KR-242A			Colorless transparent liquid	50	—	12 mm²/s	1.04	—	Heat cure*1	200°C×20 min
	KR-251			Colorless transparent liquid	20	—	18	0.92	—	Room temperature cure*2	25°C×20 min
	KR-112	Methyl/Phenyl Type		Colorless transparent to pale yellow translucent liquid	70	—	200 mm²/s	1.06	—	Room temperature cure*2	25°C×15 min
	KR-211			Colorless to pale yellow transparent liquid	70	—	46	1.10	—	—	—
	KR-212			Colorless transparent liquid	70	—	28	1.07		—	—
	KR-255			Colorless to pale brown transparent liquid	50	—	85 mm²/s	1.02	—	Room temperature cure*2	25°C×20 min
	KR-271			Pale yellow transparent liquid	50	—	200	1.01	—	Heat cure*1	250°C×60 min
	KR-272			Pale yellow transparent liquid	50		150	1.01	—	Heat cure	250°C×60 min
	KR-282			Colorless to pale yellow transparent liquid	50	—	150	1.01	—	Heat cure*1	250°C×60 min
	KR-300			Colorless transparent to pale yellow cloudy liquid	50	—	18 mm²/s	1.05		Heat cure*1	250°C×60 min
	KR-311			Pale yellow transparent liquid	60	—	25 mm²/s	1.06		Heat cure*1	250°C×60 min
	X-40-2667A			Pale yellow transparent liquid	—	100	2,000	1.16	1.536	Heat cure*1	200°C×20 min
	X-40-2756			Pale yellow transparent liquid	—	100	1,000	1.13	1.498	Heat cure*1	200°C×180 min (Tack-free 1h)
	KR-480			White flake	—	100	—	—	—	—	—
	KR-216	Propyl/Phenyl Type		Pale yellow transparent solid	—	100	—	0.60	—	—	—
	ES-1001N	Modified Organic Resin	Epoxy Resins	Pale yellow transparent liquid	45	—	350	1.01	—	Heat cure*1	200°C×30 min
	ES-1002T			Pale yellow transparent liquid	60	—	400	1.04	—	Heat cure*1	200°C×60 min
	ES-1023			Pale yellow transparent liquid	45	—	250	1.00	—	Heat cure*1	200°C×30 min
	KR-5206		Alkyd Resins	Pale yellow transparent liquid	50	—	400	0.99	—	Room temperature cure*2	25°C×30 min
	KR-5230		Polyester Resins	Colorless to yellow transparent liquid	60	—	440	1.13	—	Heat cure*1	200°C×30 min
	KR-5234			Pale yellow transparent liquid	60	—	400	1.11	—	Heat cure	180°C×20 min
	KR-5235			Colorless to pale yellow transparent liquid	60	—	210	1.10	—	Heat cure*1	200°C×20 min
	KR-114B	Rubber Type		Colorless transparent liquid	50	—	1,000 mm²/s	0.86	—	Room temperature cure*2	25°C×20 min
Silicone Oligomers	KC-89S	A	Methyl Type	Colorless transparent liquid	—	100	5 mm²/s	1.08	1.394	—	—
	KR-515			Colorless transparent liquid	—	100	7 mm²/s	1.11	1.397	—	—
	KR-500			Colorless transparent to pale yellow cloudy liquid	—	100	25 mm²/s	1.15	1.403	—	—
	X-40-9225			Colorless transparent liquid	—	100	100 mm²/s	1.18	1.407	—	—
	X-40-9246			Colorless to pale yellow transparent liquid	—	100	80 mm²/s	1.09	1.407	—	—
	X-40-9250			Colorless transparent to pale brown cloudy liquid	—	100	80 mm²/s	1.11	1.407	—	—
	KR-401N		Methyl/Phenyl Type	Colorless transparent liquid	—	100	20 mm²/s	1.12	1.432		
	X-40-9227			Colorless transparent liquid	—	100	15 mm²/s	1.07	1.460	—	—
	KR-510			Colorless transparent liquid	—	100	100 mm²/s	1.16	1.509	—	—
	KR-9218			Colorless to pale yellow transparent liquid	—	100	40 mm²/s	1.11	1.529	—	—
	KR-213			Colorless to pale yellow transparent liquid	—	100	16 mm²/s	1.11	1.525	—	—
	KR-400		Coatings Methyl Type	Colorless to pale yellow transparent liquid	—	100	1.2 mm²/s	0.97	1.390	Room temperature cure*2	25°C×30 - 60 min
	X-40-2327			Colorless to pale yellow transparent liquid	—	100	0.9 mm²/s	0.95	1.382	Room temperature cure*2	25°C×5 - 10 min
	KR-401		Coatings Methyl/Phenyl Type	Pale yellow transparent liquid	—	100	20 mm²/s	1.12	1.435	Room temperature cure*2	25°C×30 - 60 min
	KR-517	A R	Epoxy Type	Pale yellow transparent liquid	—	100	12 mm²/s	1.11	1.414	—	—
	X-41-1059A			Colorless transparent to yellow cloudy liquid	—	100	30 mm²/s	1.14	1.434	—	—
	X-24-9590			Pale brown transparent liquid	—	100	350 mm²/s	1.06	1.448	—	—
	KR-516		Epoxy/Methyl Type	Pale yellow transparent liquid	—	100	50 mm²/s	1.15	1.441	—	—
	KR-518		Mercapto Type	Colorless to pale red transparent liquid	—	100	20 mm²/s	1.13	1.418	—	—
	X-41-1818			Colorless transparent to pale red cloudy liquid	—	100	14 mm²/s	1.10	1.417	—	—
	KR-519		Mercapto/Methyl Type	Colorless transparent liquid	—	100	5 mm²/s	1.11	1.422	—	—
	KR-513		Acrylic/Methyl Type	Colorless to pale yellow transparent liquid	—	100	35 mm²/s	1.15	1.450	—	—
	X-40-9296		Methacrylic/Methyl Type	Colorless transparent liquid	—	100	20 mm²/s	1.12	1.450	—	—
	KR-511		Vinyl/Phenyl Type	Colorless to pale yellow transparent liquid	—	100	100 mm²/s	1.11	1.518	—	—
	KR-470	R	Alicyclic Epoxy Type	Colorless transparent liquid	—	100	3,000	1.10	1.487	—	—
	X-40-2678			Colorless to pale yellow transparent liquid	—	100	120	1.04	1.465	—	—

*1 Conditions until material becomes ethanol resistant *2 Time until material is no longer tacky *3 Propyleneglycol monomethylether acetate *4 3-Methyl-3-methoxybutyl acetate
*5 2 L round cans *6 Fiber drums *7 Mini-drums *8 Paper bags *9 Glass bottles *10 20 L round cans

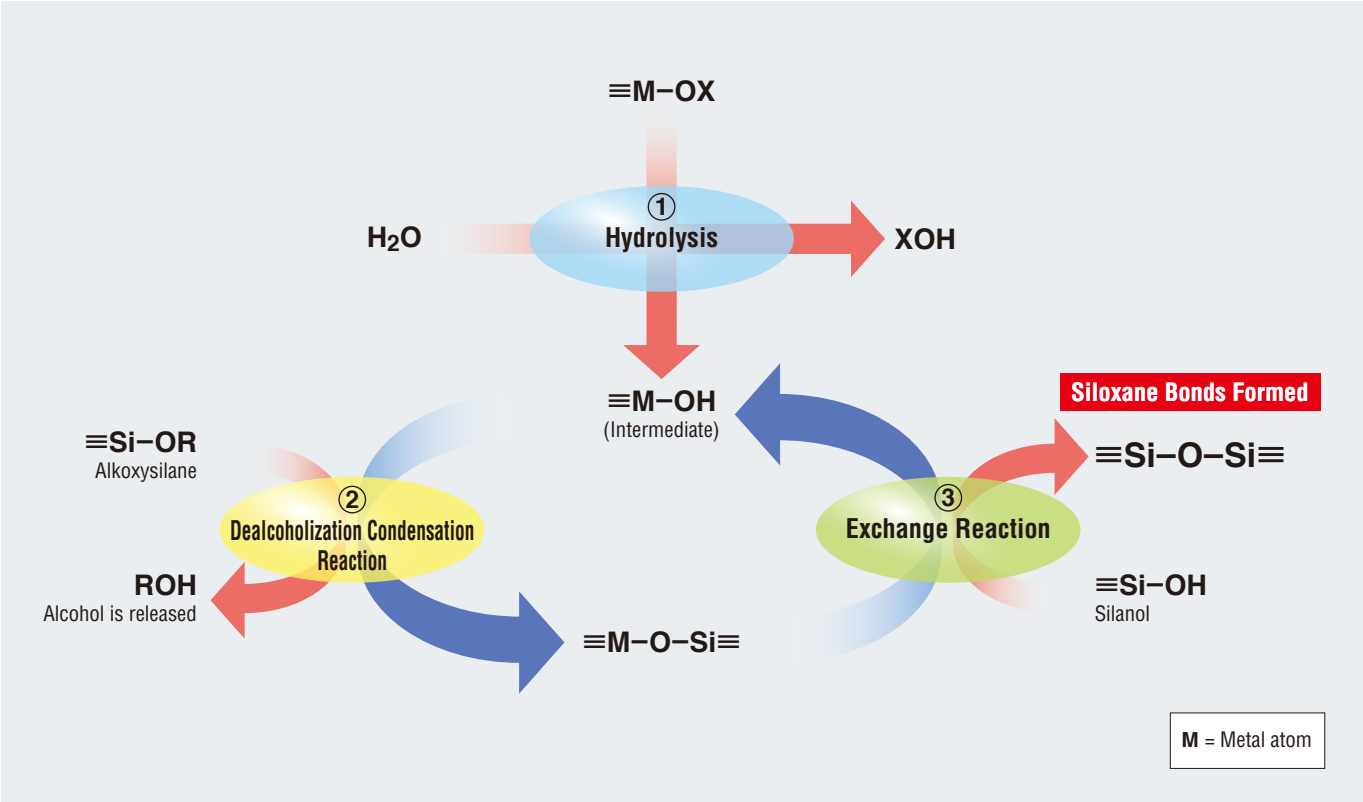
Solvent	Main applications	Features	UN hazard classification	Packaging		
				1L cans	18L cans	200L drums
None	Heat resistant and flame retardant binders	White flake, excellent heat resistance and flame retardance, very little smoking by heating	Not applicable	1 kg*5	10 kg*6	—
None	Heat resistant and flame retardant binders	Powder type of KR-220L	Not applicable	1 kg*5	10 kg*6	—
Toluene, isopropyl alcohol	Heat resistant and flame retardant binders	Excellent heat resistance and flame retardance	UN-1866	1 kg	20 kg*7	200 kg
Toluene	Moisture proofing and insulating coatings	Thin hard coating	UN-1866	1 kg	15 kg	160 kg
Toluene, xylene	Moisture proofing and insulating coatings	Solvent resistant flexible coating	UN-1866	1 kg	16 kg	—
Xylene	Resin modification	Excellent compatibility	UN-1866	1 kg	18 kg	180 kg
Xylene	Resin modification	Excellent compatibility, more flexible than KR-211	UN-1866	1 kg	18 kg	200 kg
Toluene, xylene	Moisture proofing and insulating coatings	Glossy hard coating	UN-1866	1 kg	20 kg*7	200 kg
Xylene	Heat resistant paints	Excellent heat resistance and flexibility	UN-1866	1 kg	20 kg*7	200 kg
Xylene	Heat resistant paints	Excellent heat resistance	UN-1866	1 kg	20 kg*7	200 kg
Xylene	Heat resistant paints	Excellent flexibility and anti-cracking properties	UN-1866	1 kg	20 kg*7	200 kg
Xylene	Heat resistant paints	Excellent heat resistance high hardness coating	UN-1866	1 kg	18 kg	200 kg
Xylene	Heat resistant paints	Excellent heat resistance and compatibility with organic resins	UN-1866	1 kg	20 kg*7	200 kg
None	Molding	Solventless, addition cure type, excellent curability and low shrinkage	Not applicable	1 kg	18 kg	—
None	Molding	Solvent less, addition cure type, 1 part, high Tg	Not applicable	1 kg	18 kg	—
None	Resin modification	White flake, high phenyl content, excellent compatibility	Not applicable	1 kg*5	20 kg*8	—
None	Resin modification	Solid shape, solvent less, excellent compatibility	Not applicable	1 kg	10 kg*6	—
Xylene, diacetone alcohol, n-butanol	Heat resistant paints	Excellent anti-corrosion property, heat resistance and weatherability	UN-1866	1 kg	18 kg*7	200 kg
Toluene	Heat resistant paints	Excellent anti-corrosion property and chemical resistance	UN-1866	1 kg	18 kg*7	200 kg
Xylene, diacetone alcohol	Heat resistant paints	Excellent anti-corrosion property	UN-1866	1 kg	18 kg*7	180 kg
Xylene	Heat resistant paints	Excellent flexibility and adhesion	UN-1866	1 kg	16 kg*7	200 kg
PGMAC*3	Heat resistant paints	Excellent flexural resistance, heat resistance and weatherability	UN-1866	1 kg	18 kg*7	200 kg
PGMAC*3(23%), MMBAC*4(13%) isopropyl alcohol (4%)	Heat resistant paints	Retains glossy appearance under high temperature	UN-1866	1 kg	18 kg	200 kg
PGMAC*3(20%), MMBAC*4(10%) isobutyl alcohol (10%)	Heat resistant paints	Excellent releasability and non-stick property	UN-1866	1 kg	18 kg*7	200 kg
Ligroin	Moisture proofing and insulating coatings	Wax-like soft coating, Finished coating can be removed easily with solvents	UN-1866	1 kg	15 kg*7	170 kg
None	Coatings, resin modification	Low DP (degree of polymerization)	Not applicable	1 kg	20 kg*7	200 kg
None	Coatings, resin modification	Medium DP	UN-1992	1 kg	18 kg	200 kg
None	Coatings, resin modification	Medium DP	UN-1993	1 kg	18 kg*7	200 kg
None	Coatings, resin modification	High DP	Not applicable	1 kg	18 kg	200 kg
None	Coatings, resin modification	Improves flexibility	UN-1993	1 kg	18 kg	200 kg
None	Coatings, resin modification	Improves flexibility, thick coatings	Not applicable	1 kg	18 kg	—
None	Coatings, resin modification	Low phenyl content	UN-1993	1 kg	18 kg	—
None	Coatings, resin modification	Improves flexibility	Not applicable	1 kg	18 kg	—
None	Resin modification	Forms high hardness coatings	Not applicable	1 kg	18 kg	200 kg
None	Resin modification	Forms medium hardness coatings	Not applicable	1 kg	18 kg	200 kg
None	Resin modification	High phenyl content	Not applicable	1 kg	18 kg	200 kg
None	Coatings	Forms high hardness coatings	UN-1993	1 kg	18 kg*7	180 kg
None	Coatings	Rapid cure, Finished coating can be recoated	UN-2924	1 kg*9	18 kg*10	—
None	Coatings	Excellent flexural and impact resistance	UN-1993	1 kg	18 kg	—
None	Coupling agents	Epoxy equivalent 830 g/mol	Not applicable	1 kg	16 kg	—
None	Coupling agents	Epoxy equivalent 350 g/mol	UN-1993	1 kg	18 kg	—
None	Coupling agents	Epoxy equivalent 590 g/mol	Not applicable	1 kg	16 kg	—
None	Coupling agents	Epoxy equivalent 280 g/mol	Not applicable	1 kg	18 kg	—
None	Coupling agents	Mercapto equivalent 800 g/mol	UN-1993	1 kg	16 kg	—
None	Coupling agents	Mercapto equivalent 850 g/mol	UN-1993	1 kg	18 kg	—
None	Coupling agents	Mercapto equivalent 450 g/mol	Not applicable	1 kg	16 kg	—
None	Coupling agents	Acrylic equivalent 210 g/mol	Not applicable	1 kg	18 kg	—
None	Coupling agents	Metacryl equivalent 230 g/mol	Not applicable	1 kg	18 kg	—
None	Flame retardant, coupling agents	Vinyl equivalent 530 g/mol	Not applicable	1 kg	18 kg	—
None	Molding	Low cure shrinkage, Epoxy equivalent 200 g/mol	Not applicable	1 kg	18 kg	—
None	Molding	Crack resistance, Epoxy equivalent 290 g/mol	Not applicable	1 kg	18 kg	—

(Not specified values)

Catalysts

Product name	Type	Active ingredient %	Metal content %	Solvent	Applicable products and cure conditions			Additive amount wt%	Features
					Applicable products	Structure	Heating		
D-220	Phosphoric acid type	25	—	Isopropyl alcohol	Resin	Silanol groups	Necessary	5 to 10	Very high activity
X-40-2309A	Phosphoric acid type	100	—	—	Resin	Silanol groups	Necessary	10 to 50	High activity, can accelerate curing; contains reactive diluent
					Oligomer (TypeA)	Alkoxysilyl groups	Not necessary		
D-25	Titanium type	100	14	—	Resin	Silanol groups	Necessary	0.5 to 3	Higher activity than D-20
					Oligomer (TypeA)	Alkoxysilyl groups	Not necessary		
D-20	Titanium type	100	21	—	Resin	Silanol groups	Necessary	2 to 5	Mild reactivity
					Oligomer (TypeA)	Alkoxysilyl groups	Not necessary		
DX-175	Titanium type	50	8	Toluene	Resin	Silanol groups	Necessary	3 to 5	Solvent diluting type (Easy to use)
					Oligomer (TypeA)	Alkoxysilyl groups	Not necessary		
DX-9740	Aluminum type	100	9	—	Resin	Silanol groups	Necessary	0.5 to 5	Forms high hardness coatings
					Oligomer (TypeA)	Alkoxysilyl groups	Not necessary		
CAT-AC	Aluminum type	50	4	Toluene	Resin	Silanol groups	Necessary	0.5 to 10	Solvent diluting type (Easy to use)
					Oligomer (TypeA)	Alkoxysilyl groups	Not necessary		
KP-390	Amine type	50	—	n-butanol	Modified epoxy resins	Epoxy groups	Not necessary	5 to 15	Mild reactivity
D-15	Zinc type	27	4	Xylene, mineral turpentine	Resin	Silanol groups	Necessary	1 to 3	Low reactive type
D-31	Iron type	70	8	Mineral turpentine	Resin	Silanol groups	Necessary	1 to 5	Low reactive type

■ Reaction Mechanism of Metal Catalysts



Handling Precautions

1. Seal container tightly and store in a cool, dark place (25°C or below, out of direct sunlight) with good ventilation. Keep away from heat and flame. Moreover, avoid some contaminations (acids, bases and certain organo-metallic compounds) to prevent polymerization and gelation.

2. When painting, coating, curing or drying, be sure to keep the product away from heat and flame, and provide adequate ventilation.

3. When exposed to moisture or humidity, most silicone resins and oligomers will hydrolyze and undergo a chemical change that involves the release of methanol or ethanol. In the case of KR-401, 1-butanol is released. For this reason, their containers should not be left open, but rather sealed tightly after use to keep out moisture and humidity. Ideally, air in the container should first be replaced with dry nitrogen.

4. Containers used for silicone resins and oligomers should be made of sheet steel, stainless steel or tinplate, and should be welded or externally soldered. Silicone resins and oligomers should not come in contact with lead, solder or zinc.

5. Contamination by organic varnishes and certain other substances will reduce the performance of the product.

6. Use of Curing Agents
   When using a curing agent to speed up the curing process, be sure to determine the appropriate type, amount and curing conditions, and see that curing is done in the proper conditions. Be aware of the pot life after adding curing agents. Curing agents for silicone resins and oligomers are typically formulated with aluminum (Al) chelates or zinc (Zn), iron (Fe), cobalt (Co) and manganese (Mn) octylates or naphthalates. The table below will give a rough idea of the amount of metal that will be used compared to that of the resin.

Al (Aluminum)	0.02 to 0.1%
Zn (Zinc)	0.05 to 0.3%
Fe (Iron)	0.05 to 0.3%
Co (Cobalt)	0.05 to 0.3%
Mn (Manganese)	0.05 to 0.3%

7. Use of Pigments and Fillers
   Silicone resins and oligomers may react with lead (Pb), calcium (Ca) and chromium (Cr) based pigments or with zinc oxide during the manufacturing process or in storage and will start to gel. Exposure to acids, bases and certain organometallic compounds may have adverse effects on curing properties and shelf life or, in the case of X-40-2667A, cause the release of hydrogen gas. When compounding with fillers or pigments, it is important to perform tests to determine the effects of adding these materials prior to actual use.

Safety and Hygiene

1. Silicone resins and oligomers may cause skin irritation. When handling the products, take care to avoid contact with the skin and mucous membranes by wearing protective glasses and protective gloves.
   In case of skin contact, immediately wipe off with dry cloth and then flush thoroughly with running water. In case of accidental eye contact, flush immediately with plenty of clean water for at least 15 minutes and then seek medical attention. Contact lens wearers must take special care. If the products get into the eye, the contact lens may become stuck to the eye.

2. Solvent type silicone resins contain volatile solvents and have high vapor pressure at room temperature. When handling the product, make sure there is adequate ventilation to avoid breathing the solvent vapors. In general, these solvents or products which contain these solvents should be handled according to the applicable EHS regulations.

3. In a small place with poor ventilation, please wear a protective mask. And it is recommended to install a local exhaust ventilation system. If you become uncomfortable by inhaling the vapors, move to an area with fresh air immediately.

4. Keep out of reach of children.

5. Please read the Safety Data Sheets (SDS) before use. SDS can be obtained from our Sales Department.

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