PENCHEM®

5G光通讯
高端热固化
粘结剂知识

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Content

Part A: Chemistry of Adhesives

- ✓ Epoxy
- ✓ Silicone

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PART A

Chemistry of Adhesive

Introduction

❖ The basic definition of an adhesive as used by the Adhesive Sealant Council in America is A material used for bonding that exhibits flow at the time of application.

❖ For a material to perform as an adhesive it must have four main requirements:

- It must "wet" the surfaces - that is it must flow out over the surfaces that are being bonded, displacing all air and other contaminates that are present.
- It must adhere to the surfaces - That is after flowing over the whole surface area it must start to adhere and stay in position and become "tacky".
- It must develop strength - The material must now change its structure to become strong or non-tacky but still adherent.
- It must remain stable - The material must remain unaffected by age, environmental conditions and other factors as long as the bond is required.

Introduction

❖ The raw materials for adhesives are mainly polymeric materials, both naturally occurring and synthetic.

❖Epoxy is one of the synthetic adhesives.

❖Epoxy resin has excellent properties on mechanical strength, chemical resistance, electrical insulation. This is due to epoxy resin is able to have various different properties as it is combined and cured together with various curing agents.

❖Generally, epoxy resins can be cured by several methods

❖Curing take place either under increased or ambient temperature as conventional thermal curing method, or as it is an alternative – radiation curing – such as UV curing methods.

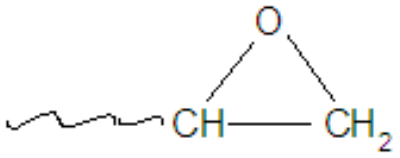
PART A1

HEAT CURABLE EPOXY ADHESIVE

EPOXY RESINS

What are Epoxy resins?

- A family of thermoset resins which have the following chemical group (oxirane):



Oxirane group

- When it reacted with a hardener (or curing agent), they set to a hard mass which does not melt or dissolve in solvents.

One part epoxy adhesive

- One part epoxy adhesive require a latent curing agents or cationic thermal initiator, which it does not react with epoxy resin at or below room temperature, but will react with epoxy resin at elevated temperature.
- Example of latent curing agents are dicyanodiamide (DICY) and epoxy - amine / imidazole adduct.

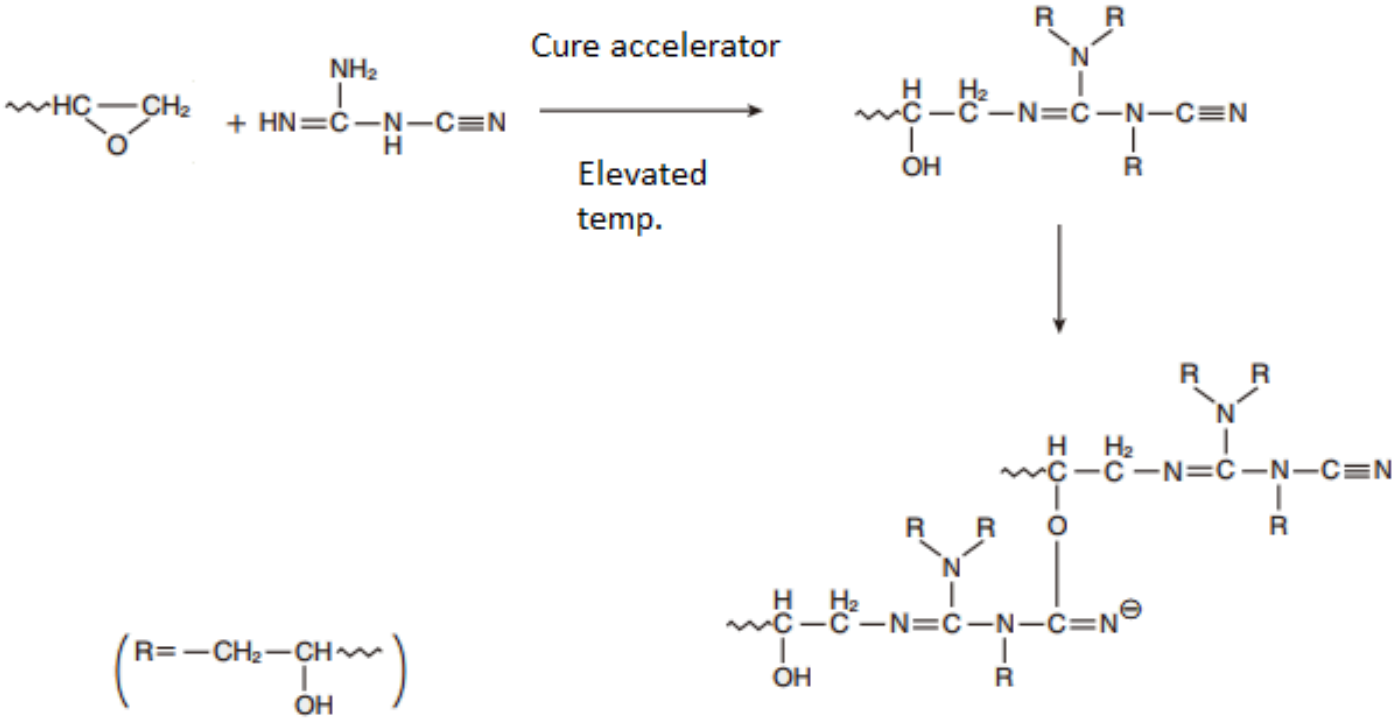
- An epoxy-amine/imidazole adduct is formed by partial react of the amine/imidazole with the epoxy resins.

One part epoxy adhesive

- Formulated epoxy / DICY composition have excellent storage stability (> 2 weeks) but it must be cure at high temperature, ≥150^{0}C , for long time. An accelerator will be added to reduce the curing temperature and curing time.
- Meanwhile, epoxy formulated epoxy-amine / imidazole adduct curing agent have good storage stability and cure at lower temperature (80 to 120 ^{0}C).
- One part epoxy formulated with cationic thermal initiator can be cure rapidly at elevated temp. (100 to 150 ^{0}C).

Crosslinking reaction of epoxy resins

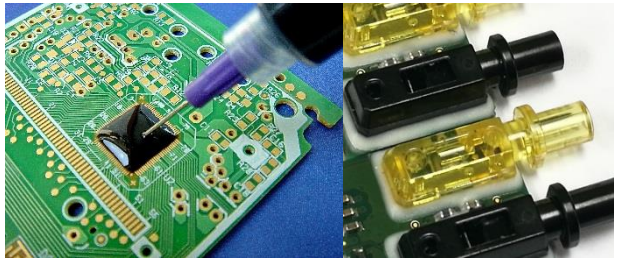
1) Epoxy-DICY reaction mechanism



Dicyandiamide (DICY) is a solid latent hardener that reacts with both the epoxy terminal groups and the secondary hydroxyl groups from epoxy. It will then become soluble and cure with epoxy when exposed to 145 to 160°C. Thus, a cure accelerator is commonly use to reduce cure times or cure temperatures (eg. 120 °C).

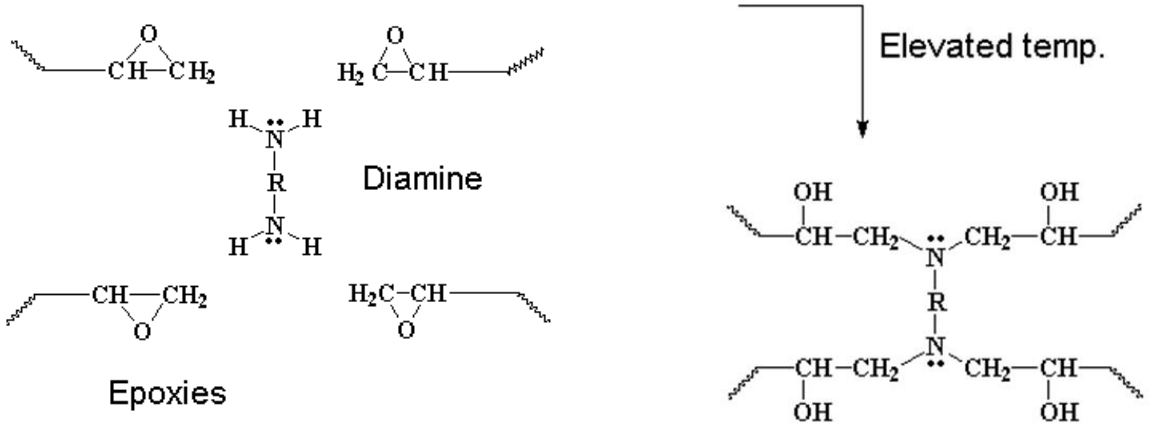
Dicyandiamide

- Structural and Filling



Product	Viscosity cPs@25°C	Hardness	Tg °C	Linear Shrinkage（%）	Special Feature
GL616	25,000	D85	122	1.51	Heat curable structural adhesive, white color, high adhesion strength, suitable for bonding of lens to PCB. Room temperature stable 1-part adhesive for 200days. Fulfill UBDH 2000hrs.
EN525	30,820	D90	152	1.45	Heat curable structural adhesive, white color, high adhesion strength, suitable for bonding of lens to PCB. Fulfill UBDH 2000hrs.
EN485	52,000	D85	140	1.32	Heat curable structural adhesive, black color, high adhesion strength to gold, Nickel, Kovar, PCB, low CTE and low shrinkage. Fulfill UBDH 2000hrs.

2) Epoxy-amine reaction mechanism



The epoxy is partial reacted with the amine and formed a stable solid curing agent for use in epoxy adhesive, which is stable at room temperature for 1 to 7 days. Upon exposure to the desired melting temp. (>80^{0}C) , and cure progresses rapidly.

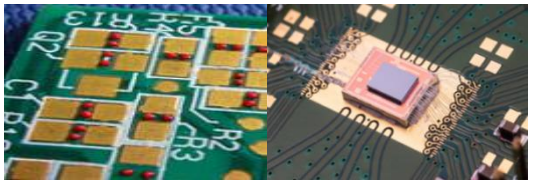
Tertiary Amines

- Structural, Die Attach, Sealant and Bonding

Product	Viscosity cPs@25°C	Hardness	Tg °C	Linear Shrinkage (%)	Special Feature
GL614-4	42,000	D83	121	1.51	Heat curable structural adhesive, white color, high adhesion strength, suitable for bonding of metals and PCB. Fulfill UBDH 2000hrs and high pressure products. Snap curable within 5mins at 160C.
CB603-2	40,550	D86	118	1.3	Heat curable structural adhesive, white color, high adhesion strength, suitable for bonding of lens, ABS, Aluminum to PCB. Fulfill UBDH 1000hrs. Low temperature curable at 80C/40mins
AG803	25,000	D86	108	0.66	Heat curable structural adhesive, high electrically conductivity, high adhesion strength, suitable for bonding of die attach. Fulfill UBDH 2000hrs.
EN418-2	21,000	D88	136	0.66	Heat curable structural adhesive, black color, high adhesion strength to gold, Nickel, Kovar, PCB, low CTE and low shrinkage. Curable at 85C-120C/1-2hr. Fulfill UBDH 2000hrs.
EN418-12	9,850	D86	122	0.68	Heat curable structural adhesive, black color, high adhesion strength to gold, Nickel, Kovar, PCB, low CTE and low shrinkage. Curable from 85C-120C/1-2hrs. Fulfill UBDH 2000hrs.
EN418-17	56,462	D90	118	0.61	Controlled bondline thickness at 250um. Heat curable structural adhesive, black color, high adhesion strength to gold, Nickel, Kovar, PCB, low CTE and low shrinkage. Curable from 85C-120C/1-2hrs. Fulfill UBDH 2000hrs.

Anhydride

- Silver Conductive Epoxy

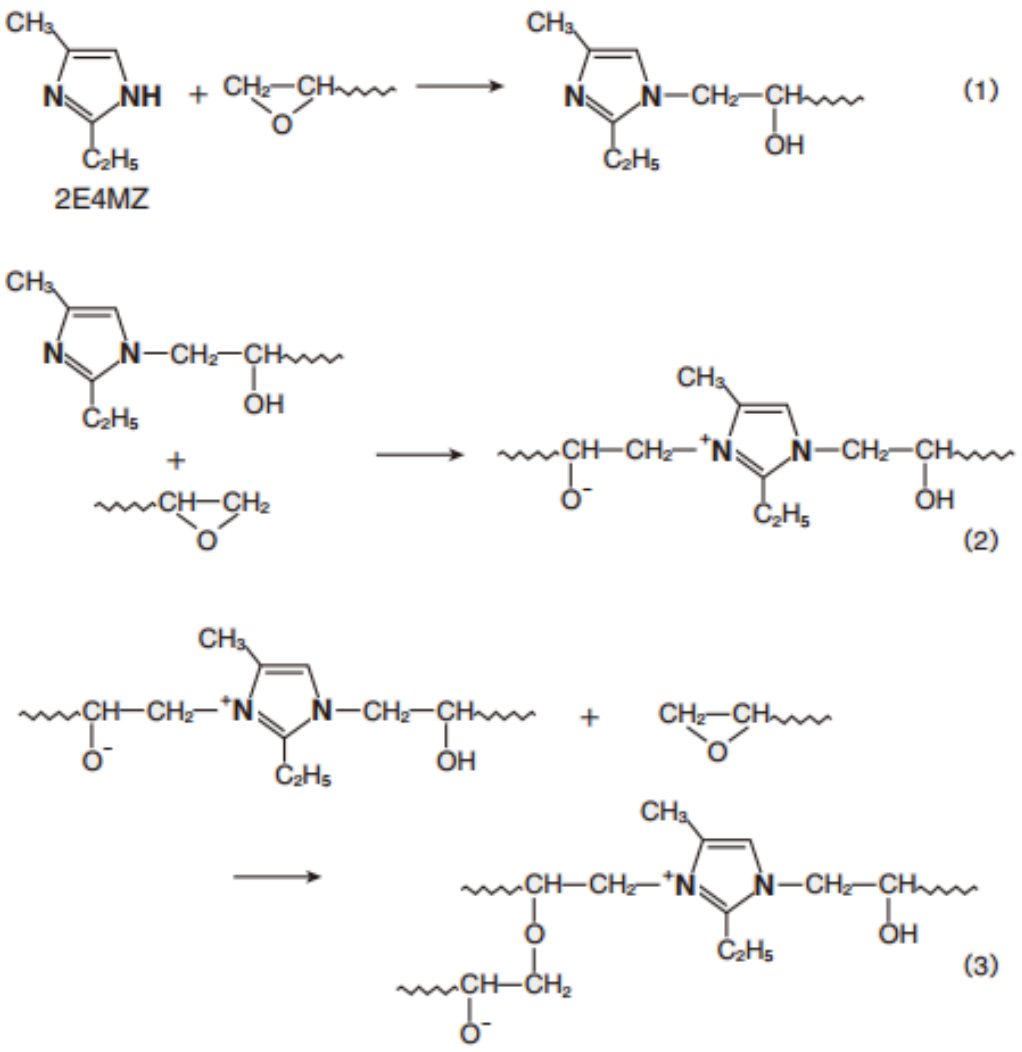


Product	Viscosity cPs@25°C	Hardness	Special Feature
AG824	7,000	D77	Low viscosity Silver epoxy, high Tg, high adhesion and low volume resistivity. Fulfill UBDH 2000hrs.
AG824-1	11,348	D77	Control of bondline thickness at 50um. Low viscosity Silver epoxy, high Tg, high adhesion and low volume resistivity. Fulfill UBDH 2000hrs.
AG829-1	6,325	-	Spray-able silver EMI shielding coating. Low viscosity Silver conductive epoxy, and low volume resistivity. Fulfill UBDH 1000hrs.

3) Epoxy-imidazole reaction mechanism

Similar to epoxy-amine adduct, epoxy-imidazole will melt and cure at temp. (>80^{0}C). Generally, imidazole offers improved adhesion to metals, better thermal properties and retention of mechanical properties at more elevated temperatures.

Unlike DICY, imidazole system shows lower cure exothermic reaction, it will not char or burn at high temp. curing and bulk quantity curing.



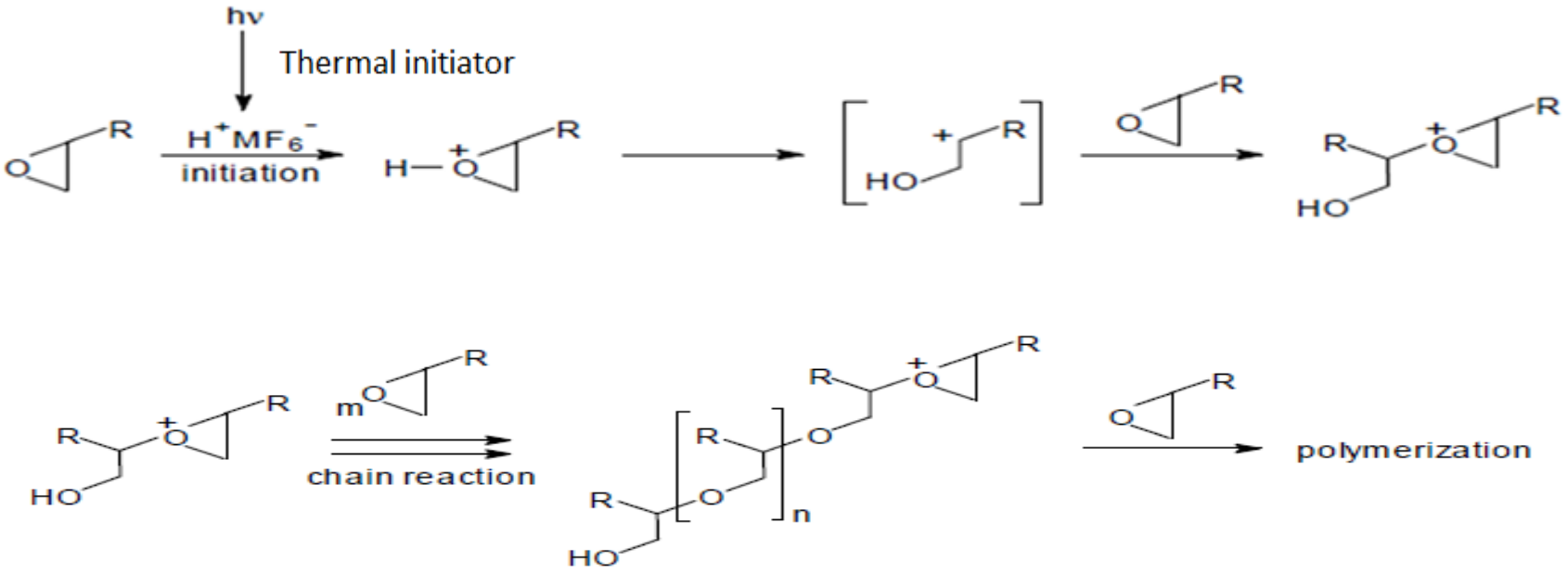
Imidazole's

- Structural and Gap Filling Epoxy

Product	Viscosity cPs@25°C	Hardness	Tg °C	Linear Shrinkage (%)	Special Feature
GL168	45,085	D85	123	1.55	Heat curable structural adhesive, white color, high adhesion strength, suitable for bonding of lens to PCB. Fulfill UBDH 2000hrs.
GL158	35,000	D85	119	1.52	Heat curable structural adhesive, white color, high adhesion strength, suitable for bonding of lens to PCB. Fulfill UBDH 2000hrs.
TH737-1	154,870	D94	132	1.06	Thermally conductive adhesive at 2.6W/mk. Heat curable structural adhesive, white color, high adhesion strength to gold, Nickel, Kovar, PCB, low CTE and low shrinkage. Fulfill UBDH 2000hrs.
TH737-6	159,900	D91	123	1.10	Thermally conductive adhesive at 2.3W/mk. Heat curable structural adhesive, white color, high adhesion strength to gold, Nickel, Kovar, PCB, low CTE and low shrinkage. Fulfill UBDH 2000hrs.

4. Cationic Polymerization

Once a cationic initiator molecules is converted into a strong acid species, that initiates polymerization. This type epoxy curing system generally cure very rapid at elevated temp. (snap cure epoxy).



Cationic polymerization

- Underfill and Die Attached

Product	Viscosity cPs@25°C	Hardness	Tg °C	Linear Shrinkage (%)	Special Feature
DA669	45,085	D85	123	1.55	Flexible die attach. Heat curable structural adhesive, black color, good adhesion strength, suitable for bonding of flexible die attach. Fulfill UBDH 1000hrs.
DA669-4	6,500	D84	117	1.20	Heat curable jetting adhesive, black color, high adhesion strength, suitable for bonding of dam on PCB and die attach for microelectronic semiconductor chips. Fulfill UBDH 1000hrs.
UF253-1	1200	D88	128	0.98	Low CTE at 31ppm/k underfill. Heat curable structural adhesive, black color, high adhesion strength to gold, Nickel, Kovar, PCB, low CTE and low shrinkage. Fulfill UBDH 2000hrs.

PART A2

HEAT CURABLE SILICONE ADHESIVE

PART 1: SILICONES

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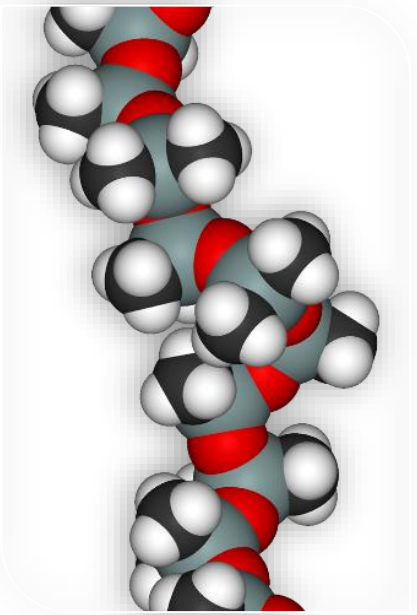
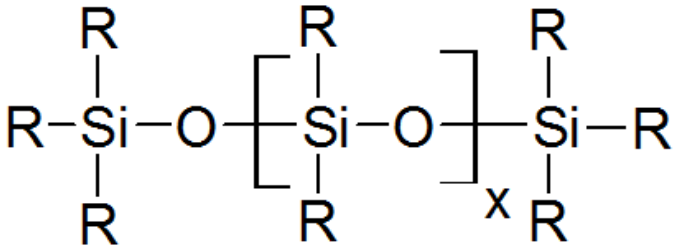
What is silicone?

- Also know as **polysiloxanes**.
- An **inorganic polymer** with silicon-oxygen backbone (⋯ -Si-O-Si-O-Si-O- ⋯) with organic side groups (R) attached to the silicon atoms, which are four-coordinate.





R = methyl ($-CH_3$), phenyl ($-C_6H_5$), vinyl ($-CH=CH_2$), hydride (-H), etc.

X = 0, 1, 2, …. or more

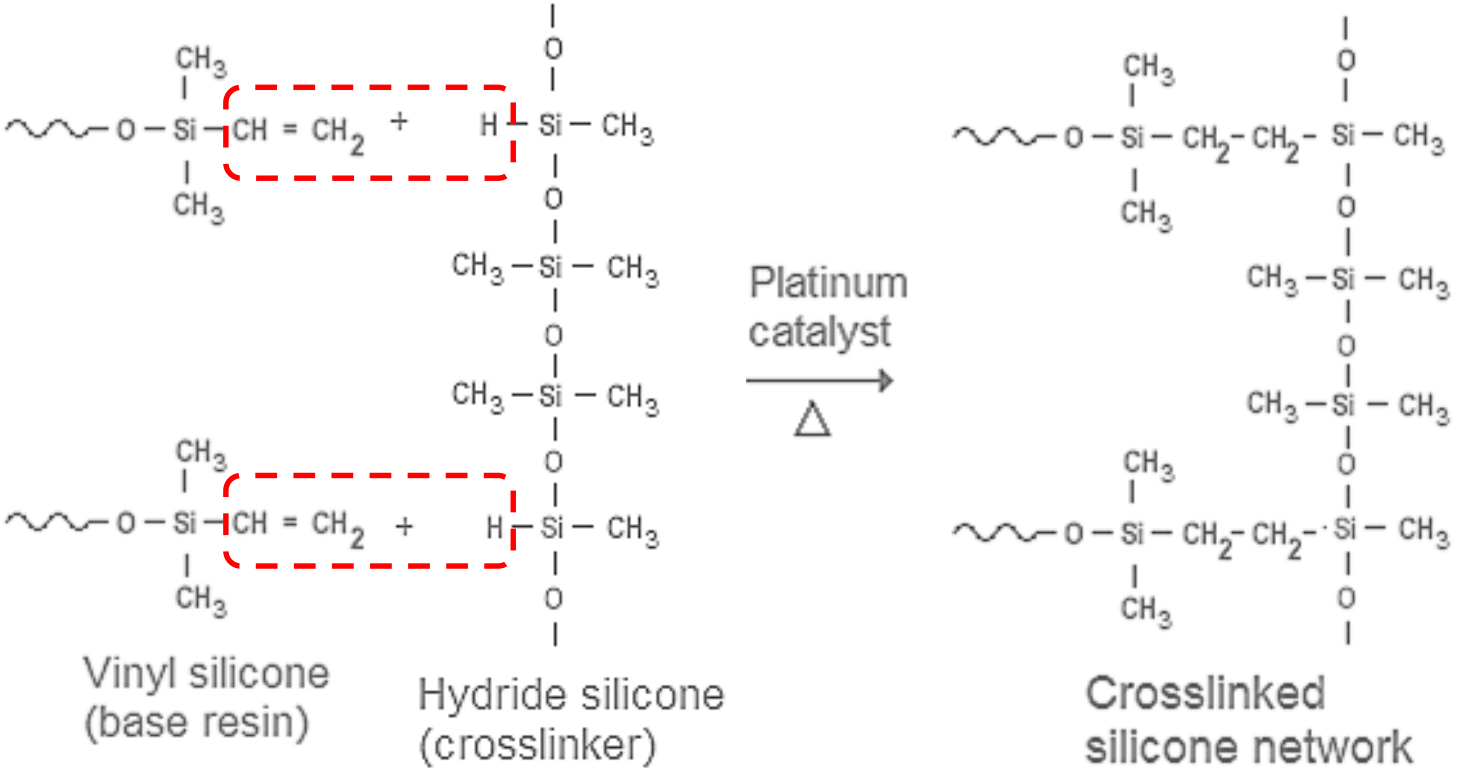
Crosslinking reaction of silicones

During crosslinking reaction, the individual silicone polymer chains are linked together to form one giant molecule.

Silicones can be crosslinked via:

1) **Platinum cure (Addition cure)**
2) **Moisture cure (Condensation cure)**
3) **Peroxide cure (Free radical polymerization)**

Addition cure silicone



In addition cure silicone system, it consist of vinyl silicone, hydride silicone and platinum catalyst.

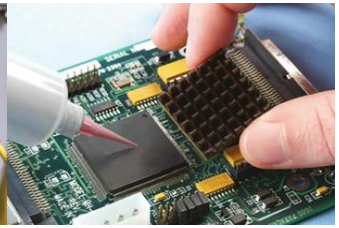
Addition Cure

- Silicone Gasket, gap filling, gold wire production

Product	Viscosity cPs@25°C	Hardness	Tg °C	RI 589nm	Special Feature
EM 120-1	5,500,000	A40	-	-	80dm shielding for up-to 400G product application. Fulfill UBDH 2000hrs.
EM 122	539,000	A46	-	-	100dm shielding for up-to 800G and above product application. Fulfill UBDH 2000hrs.
OP993-13	3,942	gel	-97	1.429	Low RI heat Curable adhesive · ultra-low outgassing · Suitable for RI Matching and gap filling application. Fulfill UBDH 2000hrs
EN893-2	4,300	00 53	-98	1.429	Low RI Heat Curable adhesive · ultra-low outgassing · Suitable for gold wire protection and gap filling application. Fulfill UBDH 2000hrs

Thermal Management Material

- Thermal Pad and Thermal Putty



Product	Type	Hardness	Thermal Conductivity W/mK	Special Feature
Dispensable Thermal Putty				
TH280-1	Non-Silicone		4	Automatic Dispensable, medium thermal conductivity, low outgassing, ULV0 94 and ultra-low bleed. Fulfill UBDH2000hrs.
TH855-1	Silicone	-	7.5	Automatic Dispensable, high thermal conductivity, low outgassing, ULV0 94 and low bleed. Fulfill UBDH 2000hrs.
TH855-3	Silicone	-	7.5	Automatic Dispensable, high thermal conductivity, low outgassing, ULV0 94 and ultra-low bleed. Fulfill UBDH 2000hrs.
TH949-1	Silicone	-	11	Dispensable, high thermal conductivity, low outgassing, ULV0 94 and ultra-low bleed. Fulfill UBDH 2000hrs.
Non-electrical Conductive Thermal Pad				
TH221-3	Non- Silicone	40-50	1.5	Low thermal conductivity, low outgassing, UL 94 V0. Fulfill MSL 2000hrs.
TH223-1	Non- Silicone	60-70	7	Medium thermal conductivity, low outgassing, UL 94 V0. Fulfill MSL 2000hrs.
TH228	Non- Silicone	60-70	8	Medium thermal conductivity, low outgassing, UL 94 V0. Fulfill MSL 2000hrs.
TH817	Silicone	80	17	Extreme high thermal conductivity, low outgassing, UL 94 V0.

Addition Cure Systems	Condensation Cure Systems
No by-products released	Liberate alcohol / volatile by-product during cure
Low odour	Odour smell
Low cure shrinkage (dimensional stable)	Higher cure shrinkage
Can cure in completely sealed assemblies	Depth of cure limitation (moisture unable to penetrate through thick section, must avoid closed curing system)
Sensitive to cure inhibition	Virtually no cure inhibition (suitable to contact with most of materials)
Work time and cure rate can be adjustable (fast cure to slow cure)	Cure upon expose to atmospheric moisture. Usually short work time.
Cure may be either room temperature cure (RTV) or heat accelerated (HTV).	Cure only at ambient temperature (preferred 25 to 40˚C)
High tear strength and tough, range from ultra soft to hard rubber, can be formulated upon requirement.	Moderate strength, durable and elasticity.
More expensive	Generally cheaper

Example of substances will inhibit addition cure silicone system

Addition cure system is sensitive to:

- **Sulfur compounds** (mercaptans, sulfates, sulfides, sulfites, thiols and rubbers vulcanized with sulfur will inhibit contacting surfaces)
- **Nitrogen compounds** (amides, amines, imides, nitriles)
- **Tin compounds** (condensation-cure silicones, stabilized PVC)
- **Moisture**
- **Phosphate compounds**

Specific Property	Epoxy	Silicone (methyl based)
Refractive index	> 1.50	1.40 – 1.42
Hardness	High (shore D)	Low to medium Gel to Rubber (shore OO to shore A)
Temperature stability (°C)	65 to 180	-60 to 250
UV resistance	Poor to moderate	Excellent
Mositure resistance	Poor to moderate	Good
Tg (°C)	> 80	< -100
CTE (ppm/°C)	45 - 100	> 120
Tensile strength (MPa)	20 - 35	0.5 - 10
Elongation @ break (%)	< 30	50 - 400
Compression set	Poor	Good
Electrical insulation	Good	Excellent
Flammability resistance	Poor to moderate	Good
Adhesion	Excellent	Moderate to good
Halogen content (chlorine)	High	Low
Cost	Low	High
Health risks	Might induce allergy reaction	Non hazardous

THANK YOU!

For more information, please contact our technical and commercial team, who will be always pleased to help.

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