Kukdo Epoxy Resins & Hardeners

Oct. 2003

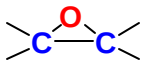
KUKDO CHEMICAL CO., LTD.

www.kukdo.com

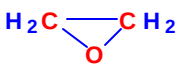
Epoxy Resin and Its Classification

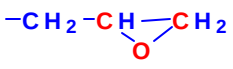
Definition of Epoxy group

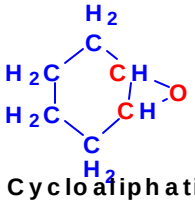
A three-membered ring consisting of an oxygen atom attached to two carbon atoms.

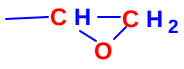
Epoxy group 

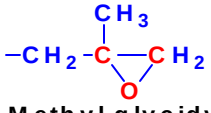
Epoxy resin means 'polymer (liquid or solid) that contains at least two reactive Epoxy groups'.

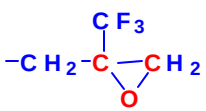

Ethylene Oxide

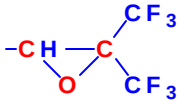

Glycidyl

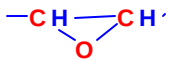

Cycloaliphatic


Terminal epoxide(Vinyl epoxy)


Methyl glycidyl

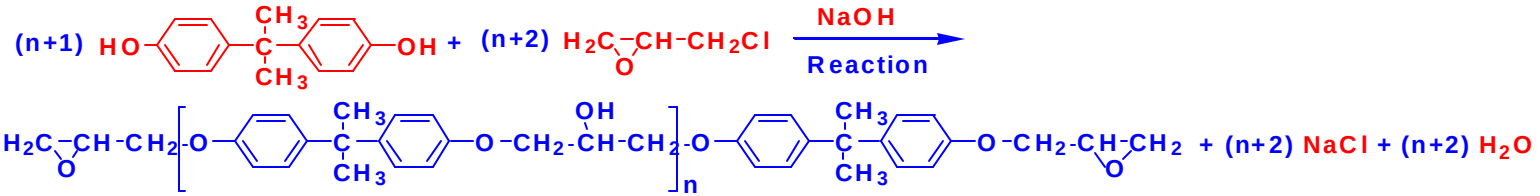

Trifluoromethyl glycidyl


Bis(trifluoromethyl)

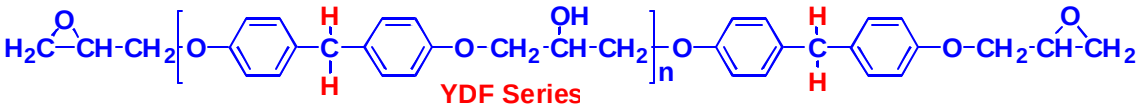

Internal epoxide

Type of Epoxy Resins

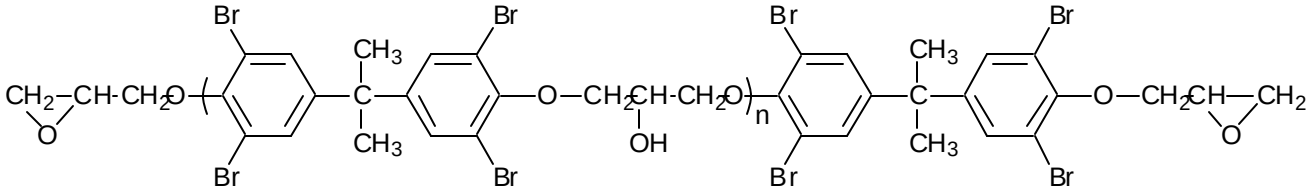
< DGEBA: Bisphenol-A type Epoxy >



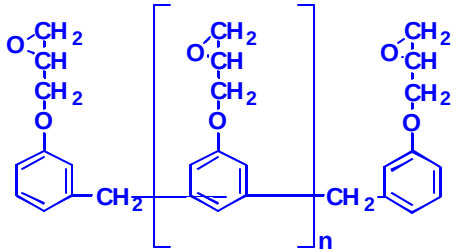
< Bisphenol-F type Epoxy >



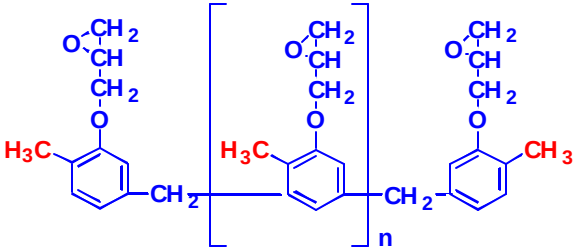
< Brominated Epoxy resin >



< Novolac Epoxy resin >

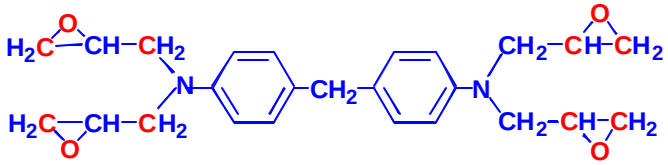


Phenol Novolac Epoxy Resin (YDPN- 631 / 638)

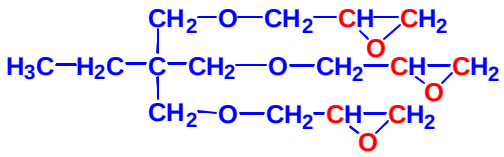


Cresol Novolac Epoxy Resin (YDCN-500 series)

< Multi-functional Epoxy resin >

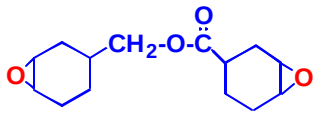


Tetra- functional Epoxy resin YH-434

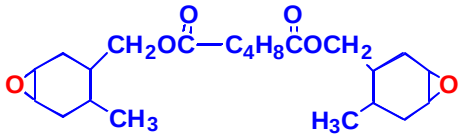


Tri-functional Epoxy resin YH-300

< Cycloaliphatic Epoxy resin >

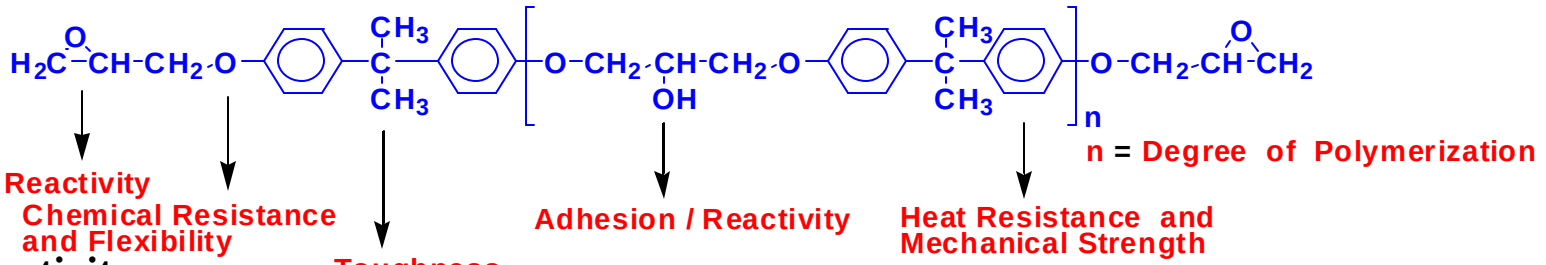


ERL-4221



ERL-4299

Performance and Characteristics of Epoxy resin



1) Reactivity

Epoxy group with good reactivity and secondary Alcoholic hydroxyl group are present in Epoxy resin.

(1) Curing by Epoxy group

a) Amine b) Anhydride c) Others

(2) Curing by Hydroxyl group

a) Isocyanate b) Phenolic resin c) Urea resin ring

2) Free rotation of benzene core is difficult because of the strong bonding strength between benzene core and Isopropyl group ---> Providing Excellent chemical resistance, Adhesion Strength, high heat resistance.

3) Ether group in molecule gives chemical resistance and flexibility.

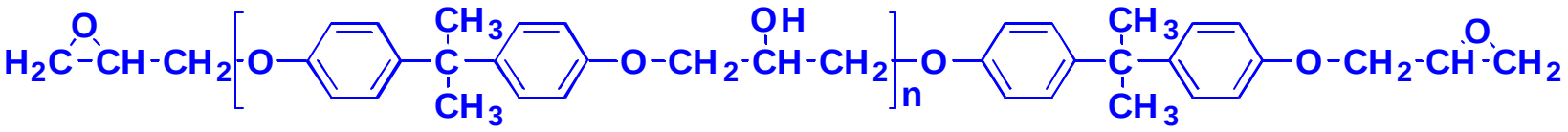
4) Regular distribution of hydrophilic hydroxyl group and hydrophobic hydrocarbon in the molecular structure gives excellent adhesion.

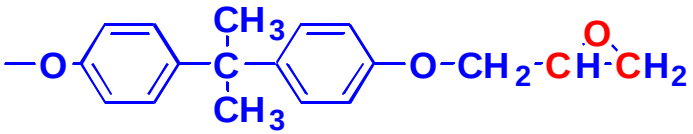
< Cured Properties >

	n	Molecular wt. E.E.W	Flexibility	Impact resistance	Compressive strength	Chemical Resistance
YD-128	0.12 – 0.13	Low	Poor	Poor	Good	Good
YD-134	0.15 – 0.16	↕	↕	↕	↕	↕
YD-011	2.1 - 2.2					
YD-014	5.4 - 5.5					
YD-017	11.0 – 12.0	High	Good	Good	Poor	Poor

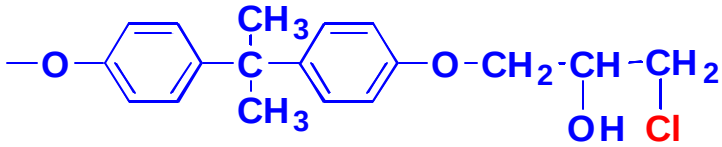
Cured Properties vs Terminated Functional Group of EPOXY RESIN

Epoxy resin's Terminated Functional Group

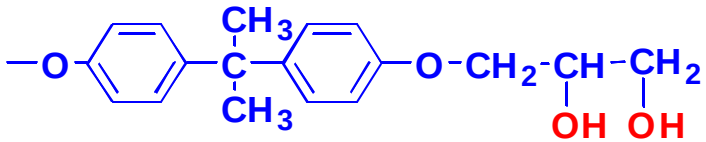




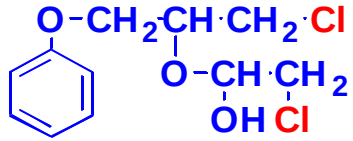
Epoxy Group



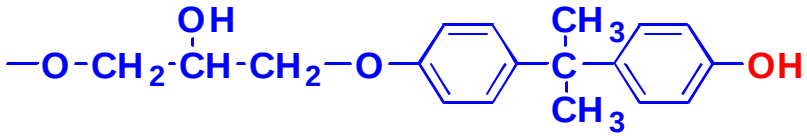
Hydrolyzable Chroline



Alpha Glycol, Alpha Diol



Total Chlorine



Phenolic OH Group

Epoxy Functional Group Contents (=Purity)

$$= \frac{\text{Epoxy Equivalent Weight (E.E.W.) X 100}}{\text{E.E.W. + a-Diol + Hydrolyzable Chlorine + Phenolic OH}} \quad (\%)$$

Fig. 1 Gel Time vs Hy-Cl Content

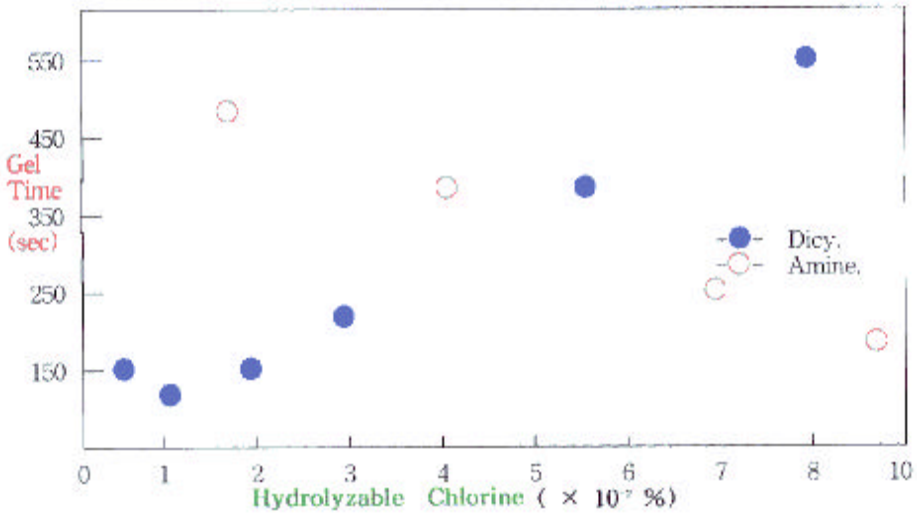


Fig. 2 Gel Time vs α-Diol

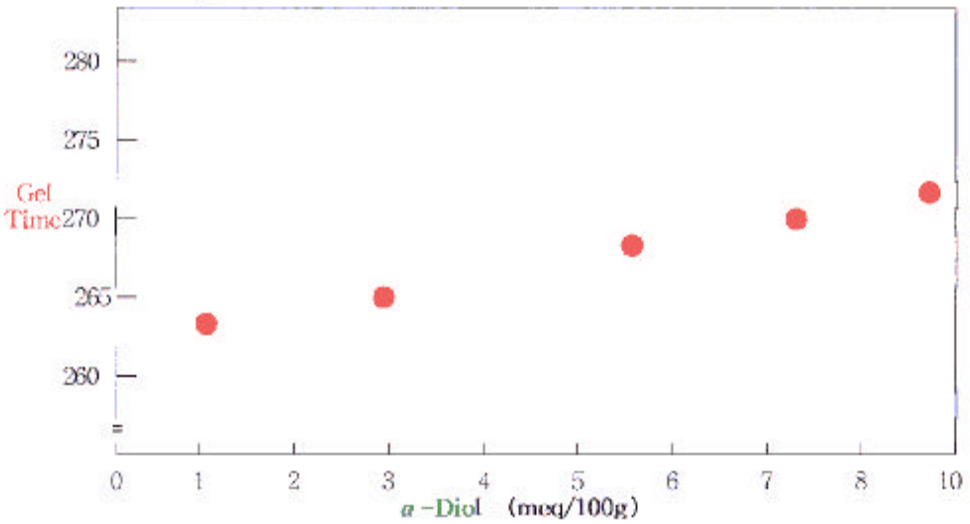


Fig. 3 Gel-Conversion vs Hy-Cl content

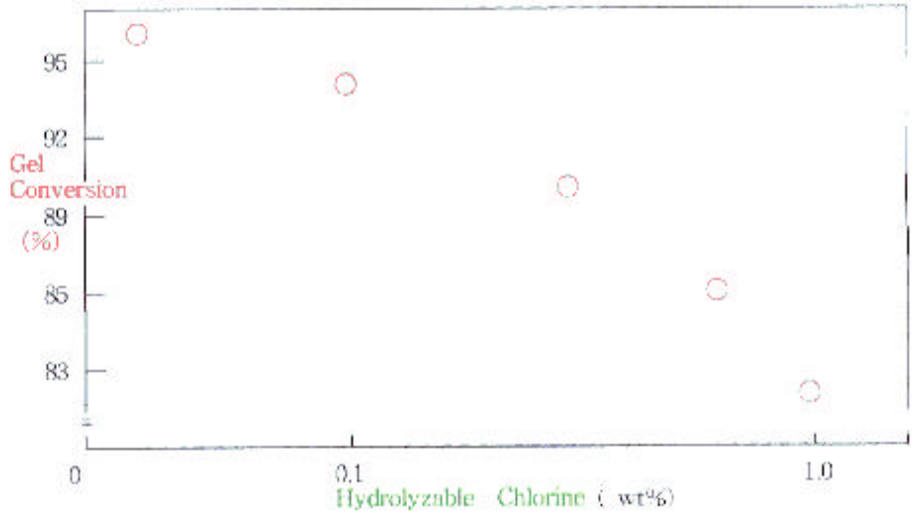


Fig. 4 Gel-conversion vs α-Diol

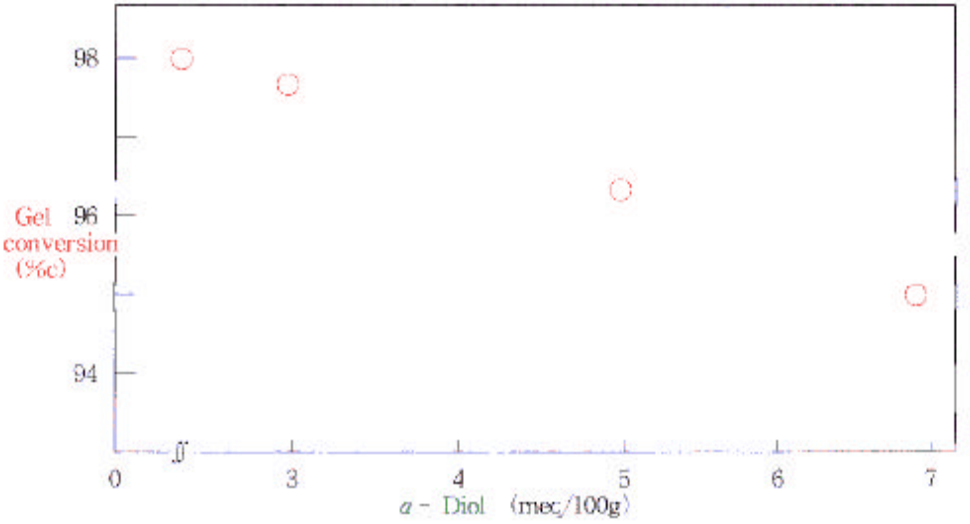


Fig. 5 Tg vs Hy-Cl content

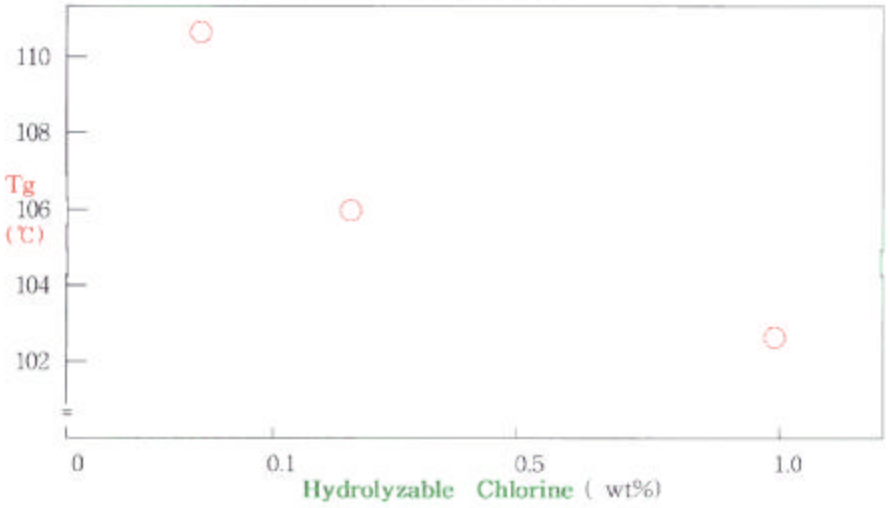
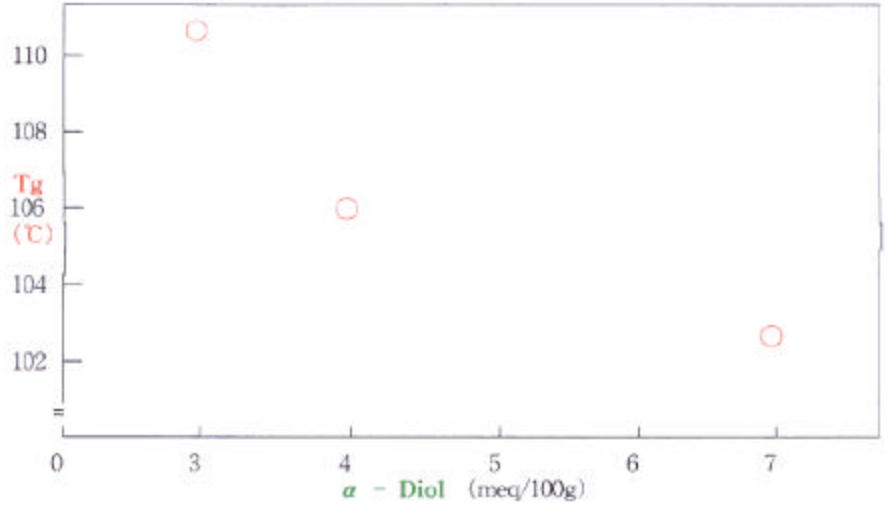


Fig. 6 Tg vs α-Diol

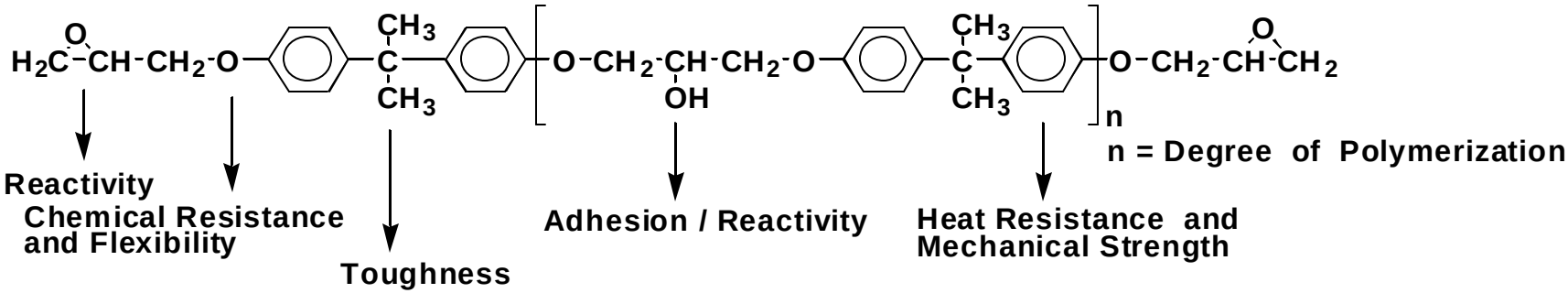


< Important Factors to decide Formulation and Cured properties>

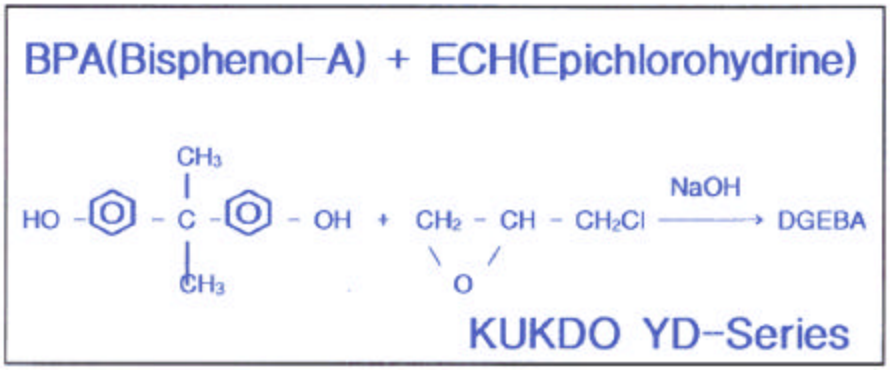
1) Base Epoxy resins : Chemical structure, Molecular weight
2) Curatives : Chemical structure, Mixing ratio
3) Curing condition : Temperature (ambient cure, heat cure), Curing Time
4) Application : Substrate, Materials, Applying method and final Usage
5) Fillers : Organic and inorganic pigment
6) Additives : functional additives, Diluents, Solvent
7) Modifier : Extender, other resin, reactive monomer and oligomer
8) Pot life and shelf life

KUKDO EPOXY Resins and Curatives

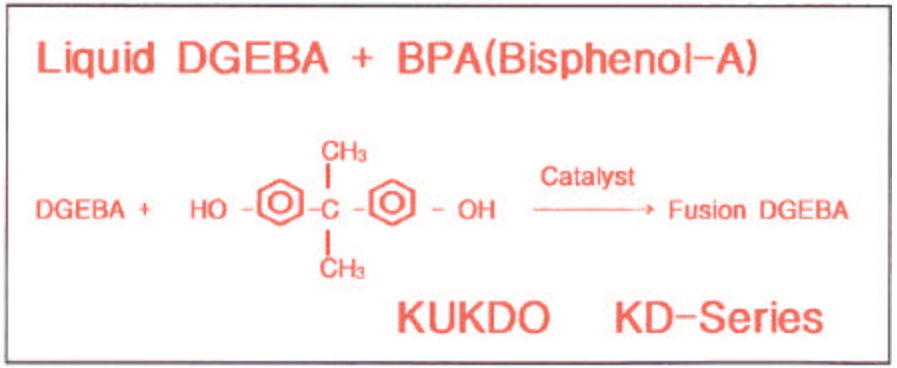
DGEBPA Type Epoxy resins



< Taffy Process >



< Fusion Process >



Taffy process is suitable for the mass production scale with consistency of the qualities and Fusion process is suitable for the various grades of small production scale with some acceptable allowance of the qualities in every batch.

<COMPARISON BETWEEN TAFFY & FUSION METHOD PRODUCTS>

Items	TAFFY PROCESS	FUSION PROCESS
Resin viscosity	Low	High
Deviation of the batches	Small	High
Consistency of the resin	Good	Relatively bad
Pigment loading	High	Low
Viscosity of the Formulated paint	Low	High
Flowing property Of the formulated paint	High	Low
Flexibility of cured film	Comparably high	Comparably low
Theoretical chemical resistance	It depends on the resin impurities	
Reactivity	It depends on the resin impurities	

TAFFY PROCESS				FUSION PROCESS			
PRODUCT	E.E.W.	S.P.(°C)	M.P.(°C)	PRODUCT	E.E.W.	S.P.(°C)	M.P.(°C)
YD-012	649.2	83	53.88	KD-242G	664.1	88	58.73
YD-053	725	88	56.54	KD-243C	756.3	93	57.68
YD-013K	797.7	92	58.22	KD-213	774.8	94	59.33
YD-013K55	820	93.5	58.76	KD-213C	790.8	109	61.65
YD-057	900	96	61.55	KD-214CR	900.2	99.6	62.59
YD-014	938.1	97.5	64.85	KD-214C	934.3	102	70.53

KUKDO High Solid & Non-solvent System

Grade	EEW g/eq	Viscosity cps @ 25°C	Hy-CI wt %	Color Gardner	Comment
YD-112	170-185	500-700	0.1 max.	1 max.	PGE modified BPA
YD-113	170-185	500-700	0.2 max.	1 max.	CGE modified BPA
YD-114	190-210	500-700	0.05 max.	0.7 max.	C_{12}~C_{14} modified BPA
YD-114E	190-210	700-1,000	0.05 max.	0.7 max.	C_{12}~C_{14} modified BPA
YD-114F	185-205	450-750	0.05 max.	1 max.	C_{12}~C_{14} modified BPA/BPF
YD-114EF	180-200	750-1,200	0.05 max.	1 max.	C_{12}~C_{14} modified BPA/BPF
YD-114BR	195-215	800-1,200	0.05 max.	1 max.	C_{12}~C_{14} modified BPA/BPF
YD-115	185-205	1,100-2,800	0.2~0.3 max.	0.7 max.	C_{12}~C_{14} modified BPA
YD-119	180-200	200-600	0.1 max.	1 max.	Neo-E modified BPA
YD-153	190-200	1,000-1,500	0.1 max.	1 max.	C_{12}~C_{14} modified BPA/BPF
YDF-170	160-180	2,000-4,000	0.1 max.	1 max.	Standard BPF
YDF-175	160-180	2,000-5,000	0.2 max.	1 max.	Less crystalline BPF
YDF-175S	165-180	2,000-5,000	0.3 max.	1 max.	Non crystalline BPF
YDF-161	170-180	5,000-7,000	0.1 max.	1 max.	BPA/BPF
YDF-161H	170-180	6,000-8,000	0.1 max.	1 max.	BPA/BPF
YDF-162	170-180	7,000-10,000	0.1 max.	1 max.	BPA/BPF
YDF-164	180-190	500-800	0.1 max.	1 max.	C_{12}~C_{14} modified BPA
YD-134L	213-225	N-R *1	0.1 max.	1 max.	BPA
YD-134C	225-250	P-U *1	0.1 max.	1 max.	BPA
YD-134	230-270	P-U *1	0.1 max.	1 max.	BPA
YD-158	400-450	2,000-4,000	0.1 max.	1 max.	modified BPA

*1 Gardner viscosity Butyl Carbitol NV =70% solution viscosity

EPOXY Resin for Packaging and Coil coating(PCM)

Grade	EEW g/eq	Viscosity Gardner	Softening Point Ball & Ring (℃)	Comment
YD-134	230-270	P-U	-	Semi-solid
YD-011	450-500	D-F	60-70	Type 1 Taffy
YD-011H	530-570	F-J	70-80	Type 1.5 Taffy
KD-211E	455-485	E-G	65-75	Type 1 Fusion
KD-211G	500-550	F-J	70-80	Type 1.5 Fusion
YD-014	900-1,000	Q-U	91-102	Type 4 Taffy
KD-214C	875-975	2,000-4,000*2	95-105	Type 4 Fusion
KD-214M	1,150-1,250	5,000-6,000*2	105-110	Type 5 Fusion
YD-216	1,515-1,665	1,450-1,680*1	105-115	Type 6 Fusion
YD-216H	1,650-1,800	1,500-1,800*1	115-125	Type 6.5 Fusion
YD-017T	1,700-1,900	X-Z	115-130	Type 7 Fusion / Packaging
YD-017	1,750-1,950	Y-Z_1	117-127	Type 7 Fusion / Packaging
YD-017KC	2,000-2,200	1,500-2,200*1	110-120	Type 7 Fusion / Coil, PCM
YD-019	2,550-2,900	5,000-10,000*1	130-145	Type 9 Fusion / Packaging
YD-020L	3,500-4,300	Z_3~Z_5	135-145	Type 10 Fusion / Packaging
YD-020	4,000-5,500	Z_5~Z_6	140-155	Type 10 Fusion / Packaging
KU-400T40		3,000-4,800	-	Mw=20,000-30,000 / Coil, PCM
KU-420K40		1,700-3,000	-	Mw=18,000-28,000 / Coil, PCM

*1 Gardner Holdt Method Butyl Carbitol NV=40%, *2 Melt viscosity cps at 175°C

KUKDO Epoxy Molding/Potting/Encapsulation system

Grade	EEW g/eq	Viscosity cps @ 25°C	Softening Point(°C)	NV (wt%)	Comment
YC-195	360-400	500-700[1)]	50-60	100	Large scale electrical molding, YC-195H
YC-195B	370-420	380-550[1)]	-	100	Large scale electrical molding, YC-195H
YC-205	200-250	900-1500	-	100	Ambient temp.curing type, Good Impact
YC-220	180-195	10,000-13,000	-	100	Potting,molding,encapsulation,KC-305H
KC-305	185-195	9,500-13,000	-	100	Potting, molding, encapsulation
YC-230	185-200	10,000-15,000	-	100	Electrical casting molding, YC-230H
KC-335	185-195	8,500-15,000	-	100	Electrical casting molding, KC-335H
YD-158	400-450	2,000-4,000	-	100	Potting, molding, Good Impact

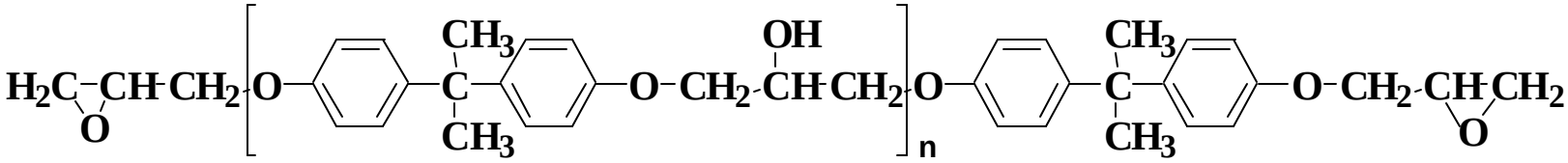
[1)] cps @ 120°C

KUKDO Epoxy F/W,Laminating/Pultrusion/Composite system

Grade	EEW g/eq	Viscosity cps @ 25°C	NV(wt%)	Comment
KBR-1728	175-190	6,500-9,500	100	F/W, Laminating, Composite, KBH-1085/1085S
KBR-1727	180-190	8,000-9,000	100	F/W, Laminating, Composite, KBH-1085/1085S
KBR-1729	170-190	5,000-6,000	100	F/W, Laminating, RTM, KBH-1085,1085S
KBR-1753	175-190	6,500-9,500	100	F/W, Laminating, Composite, KBH-1085/1085S
KBR-1760	180-190	5,000-6,000	100	Pultrusion for pipe, rod(~100mmØ)

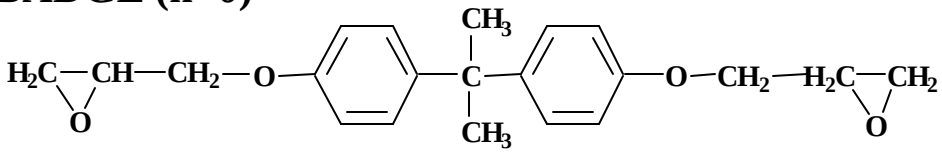
BADGE/BPA free Epoxy Resin

*** DGEBA (General BPA type Epoxy)**

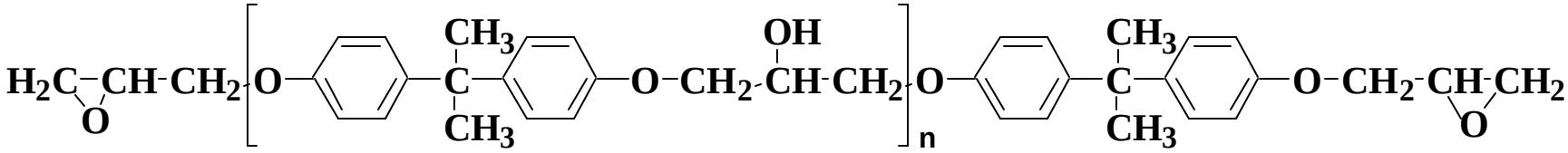


n = 0, 1, 2, 3, 4 …

*** BADGE (n=0)**

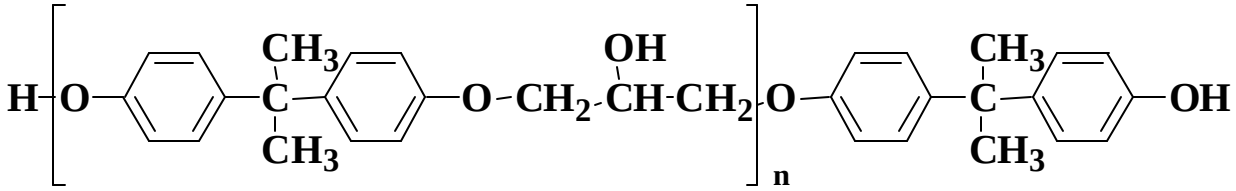


*** BADGE free type Epoxy (KD-6812)**



n = 1, 2, 3, 4 …

*** KD-452 (BPA Free Phenolic Hardener)**



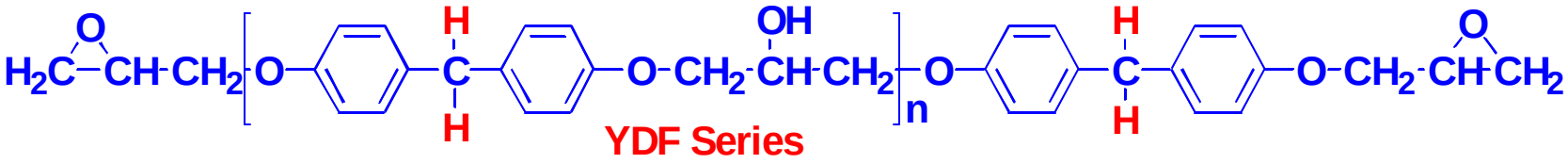
n = 1, 2, 3, 4 …

BADGE/BPA free Epoxy Resin

Grade	EEW(g/eq)	Melt Viscosity[1)]	Softening Point(°C)	BPA(ppm)	BADGE(ppm)	Comment
KD-6712	600-700	750-1750	80-90	Max.1	Max.500	For powder coating
KD-6714	900-1,000	3,000-7,000	90-105	Max.1	Max.400	For powder coating
KD-6717	1,700-1,900	2,000-3,500[2)]	115-130	Max.1	Max.50	For can coating
KD-6719	2,500-2,900	5,000-11,000[2)]	130-145	Max.1	Max.50	For can coating
KD-6812	600-700	1,000-2,000	80-90	Max.1	Max.500	For powder coating
KD-6814	850-950	4,000-8,000	90-105	Max.1	Max.400	For powder coating
KD-6817	1,700-1,900	2,000-3,500[2)]	115-130	Max.1	Max.50	For can coating
KD-6819	2,500-2,900	5,000-11,000[2)]	130-145	Max.1	Max.50	For can coating
KD-452	490-570[3)]	2,000-4,000	95-105	Max.500	-	For powder coating

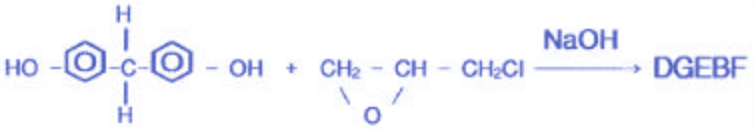
[1)] Melt Viscosity cps at 150°C
[2)] Solution Viscosity cps at 25°C, Butyl Carbitol NV=40%
[3)] Ph-OH equivalent weight

Bisphenol F type Epoxy Resins



< Taffy Process >

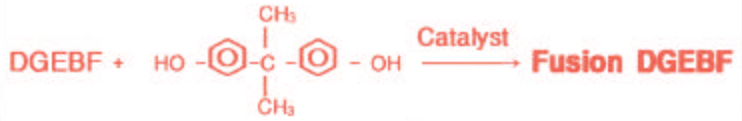
BPF(Bisphenol-F) + ECH(Epichlorohydrine)



KUKDO YDF-100, 2000Series

< Fusion Process for BPA/F >

Liquid DGEBA + BPF(Bisphenol-F) or
Liquid DGEBF + BPA



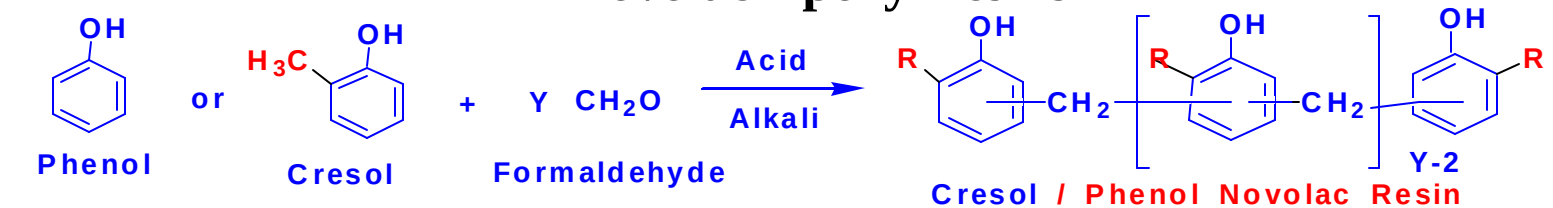
KUKDO YDF/KDF-Series

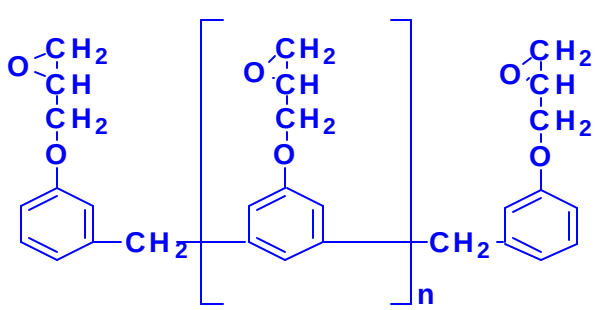
YDF-170	Standard Liquid BPF Resin
YDF-175	Non Crystallization BPF Liquid Resin
YDF-161, 162	BPA/BPF Modified Liquid Epoxy Resin
YD-114F, 114EF	BPA/BPF/Reactive Diluents Modified Epoxy Resin
YDF-2001 ~ 2004	BPF Taffy Process Solid Epoxy Resin
YDF-2022 ~ 2030	BPF Fusion Process Solid Epoxy Resin

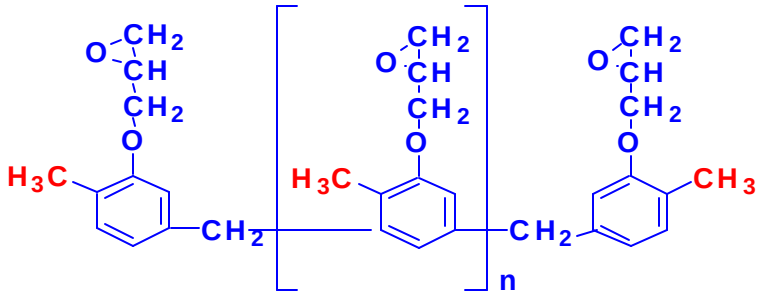
< Properties >

1) Low viscosity for good flow
2) High reactivity
3) Good Chemical resistance
4) Good corrosive resistance

Novolac Epoxy Resins







YDPN-631	**Low Viscosity Phenol Novolac Epoxy Resin**
YDPN-636	**Medium Viscosity Phenol Novolac Epoxy Resin**
YDPN-637	**DGEBA Modified Phenol Novolac Epoxy Resin**
YDPN-644	**High Viscosity Phenol Novolac Epoxy Resin**
YDPN-638	**Standard Phenol Novolac Epoxy Resin**
YDPN-641	**Solid Phenol Novolac Epoxy Resin**
YDCN-500	**Taffy process Series o-Cresol Novolac Epoxy Resin**
KDCN-500	**Fusion Method Series o-Cresol Novolac Epoxy Resin**

< Properties >

1) **High reactivity (Heat-curing system)**
2) **Excellent Heat resistance**
3) **Excellent Chemical resistance**
4) **Good Mechanical properties**
5) **Good Adhesion**

Phenol Novolac/Cresol Novolac EPOXY Resin

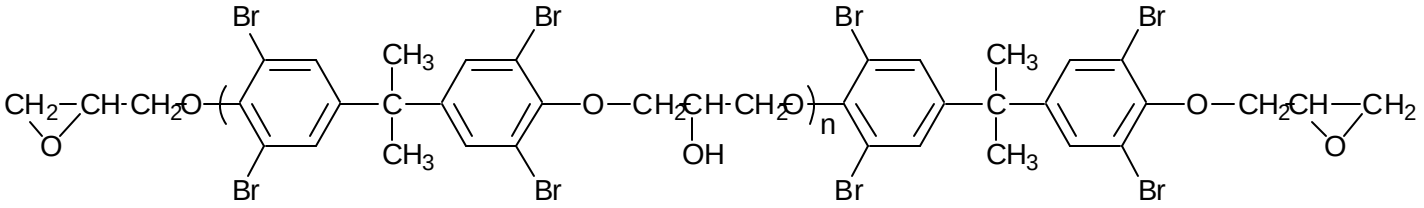
Grade	EEW g/eq	Viscosity	Softening Point Ball & Ring (℃)	Comment
YDPN-631	165-185	1,000-3,000 *1	-	Low viscosity n=0.2
YDPN-636	170-180	2,000-8,000 *1	-	Medium Viscosity n=1.0
YDPN-637	180-190	3,000-6,000 *1	-	BPA/PN Epoxy
YDPN-638	170-180	16,000-25,000 *3	-	Standard PN Epoxy n=1.6
YDPN-641	170-190	800-1,100 *2	-	High Molecular Taffy n=2.5
YDPN-644	195-235	32,000-52,000 *3	-	High Molecular Fusion
*1 cps@50°C,	*2 cps@150°C,	*3 cps@60°C		
YDCN-500-4P	220-212	-	60-63	Taffy OCN Epoxy
YDCN-500-5P	200-212	-	63-66	Taffy OCN Epoxy
YDCN-500-7P	200-212	-	66-70	Taffy OCN Epoxy
YDCN-500-8P	200-212	-	68-72	Taffy OCN Epoxy
YDCN-500-10P	200-212	-	70-74	Taffy OCN Epoxy
YDCN-500-80P	190-220	-	75-85	Taffy OCN Epoxy
YDCN-500-90P	190-220	-	85-95	Taffy OCN Epoxy
KDCN-527	210-230	-	68-78	Fusion OCN Epoxy
KDCN-528	215-235	-	75-85	Fusion OCN Epoxy
KDCN-529	215-235	-	90-100	Fusion OCN Epoxy

Brominated Epoxy Resins

TBBA + ECH ---NaOH----> **DGETBA** **< Taffy Process >** **High Brominated Epoxy**

DGEBA + TBBA ---Catalyst----> **DGETBA** **< Fusion Process >** **Low Brominated Epoxy**

DGEBA + TBBA ---Catalyst----> **DGETBA + DGEBA** ------> **DGETBA < Additional Reaction >**



Grade	Bromine	E.E.W./Mw	S.P./Solvent	Characteristics
YDB-400	High Bromine(50%)	400±20 g/eq	64-74°C	Paper Phenolic Laminate
YDB-500A80	Low Bromine(20%)	475-520 g/eq	Acetone 20%	FR-4 Epoxy Laminate
YDB-424A80	Low Bromine(20%)	442-458 g/eq	Acetone 20%	FR-4, Multi-layer Laminate
YDB-406	High Bromine(50%)	620-680g/eq	90-110°C	ENPLA(ABS,HIPS)
YDB-408	High Bromine(50%)	690-750g/eq	102-112°C	ENPLA(ABS,HIPS)
YDB-416	High Bromine(55%)	1,500-1,700	105-115°C	ENPLA(ABS,HIPS,PBT)Half Capped type
KB-560	High Bromine(59%)	900-1,400	95-105°C	ENPLA(ABS,HIPS)Full Capped type
KB-562P	High Bromine(58%)	1,700-2,300	113-120°C	ENPLA(ABS,HIPS)Full Capped type
KB-563P	High Bromine(55%)	3,000-4,000	135-145°C	ENPLA(ABS,PBT)Full Capped type

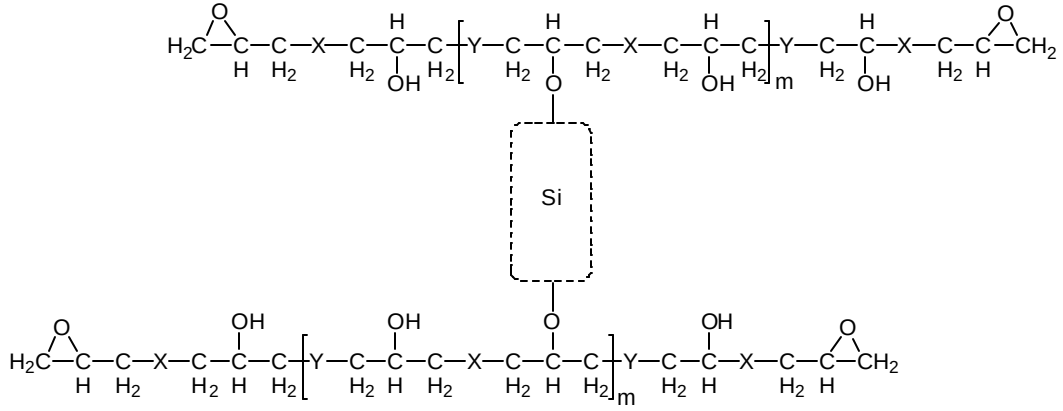
< Properties >

1) Flame Retardant Properties **2) Good Mechanical Properties**

3) Good Electrical Properties **4) Good Chemical Properties**

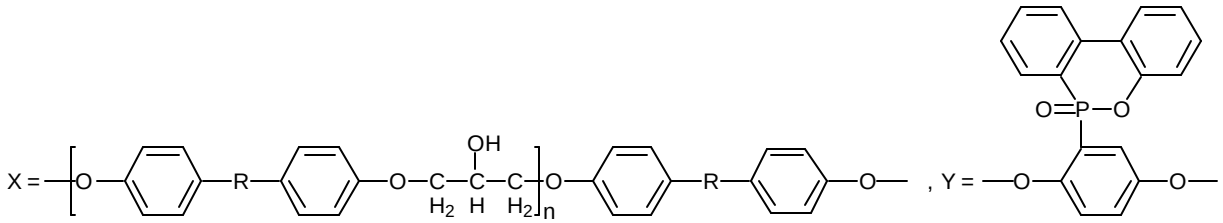
5) Good Dimension Stability

Non-Halogen Flame Retardant Epoxy Resins



R = $C(CH_3)_2$

Patent No. : US 6,534,601



Grade	EEW g/eq	S.P/Solvent	Viscosity cps@25 °C	Characteristics
KDP-550	560-620	95-105	-	RCC type
KDP-550MC65	560-620	M.C 35%	2,000-3,000	FR-4 Epoxy Laminate

< Properties >

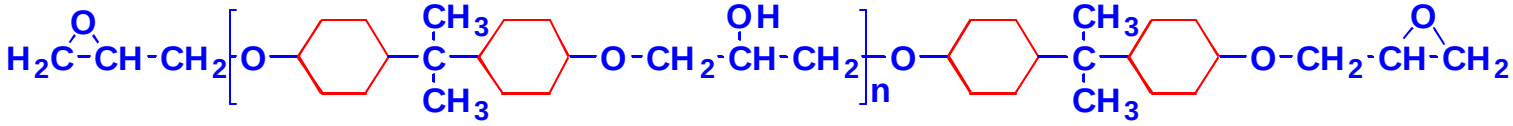
1) Non-Halogen Flame Retardant Properties **2) Good Mechanical Properties**

3) Good Electrical Properties **4) Good Chemical Properties**

5) Good Dimension Stability **6) Good Thermal Stability**

HBPA Type Epoxy Resin

HBPA + ECH ----------> DGEHBA



Grade	EEW(g/eq)	Viscosity (cps@25°C)	Softening Point(°C)	Comment
ST-1000	190-210	1,000-2,000	-	Modified HBPA Liquid resin
ST-2000	200-220	2,000-3,000	-	Low Viscosity Liquid HBPA
ST-3000	220-240	2,500-4,000	-	Standard Liquid HBPA resin
ST-5080	550-650	-	78 – 88	Solid BPA/HBPA Epoxy resin
ST-5100	900-1,100	-	95 – 105	Solid BPA/HBPA Epoxy resin
ST-4000D	650-750	-	85 – 95	100% Hydrogenated Solid Epoxy
ST-4100D	900-1,050	-	95 - 105	100% Hydrogenated Solid Epoxy
KT-5500	Solid 100% Hydrogenated Epoxy Resin with High EEW			
KT-6000,8000	Solid 100% Hydrogenated Epoxy Resin with Low EEW/High Functionality			

<Properties>

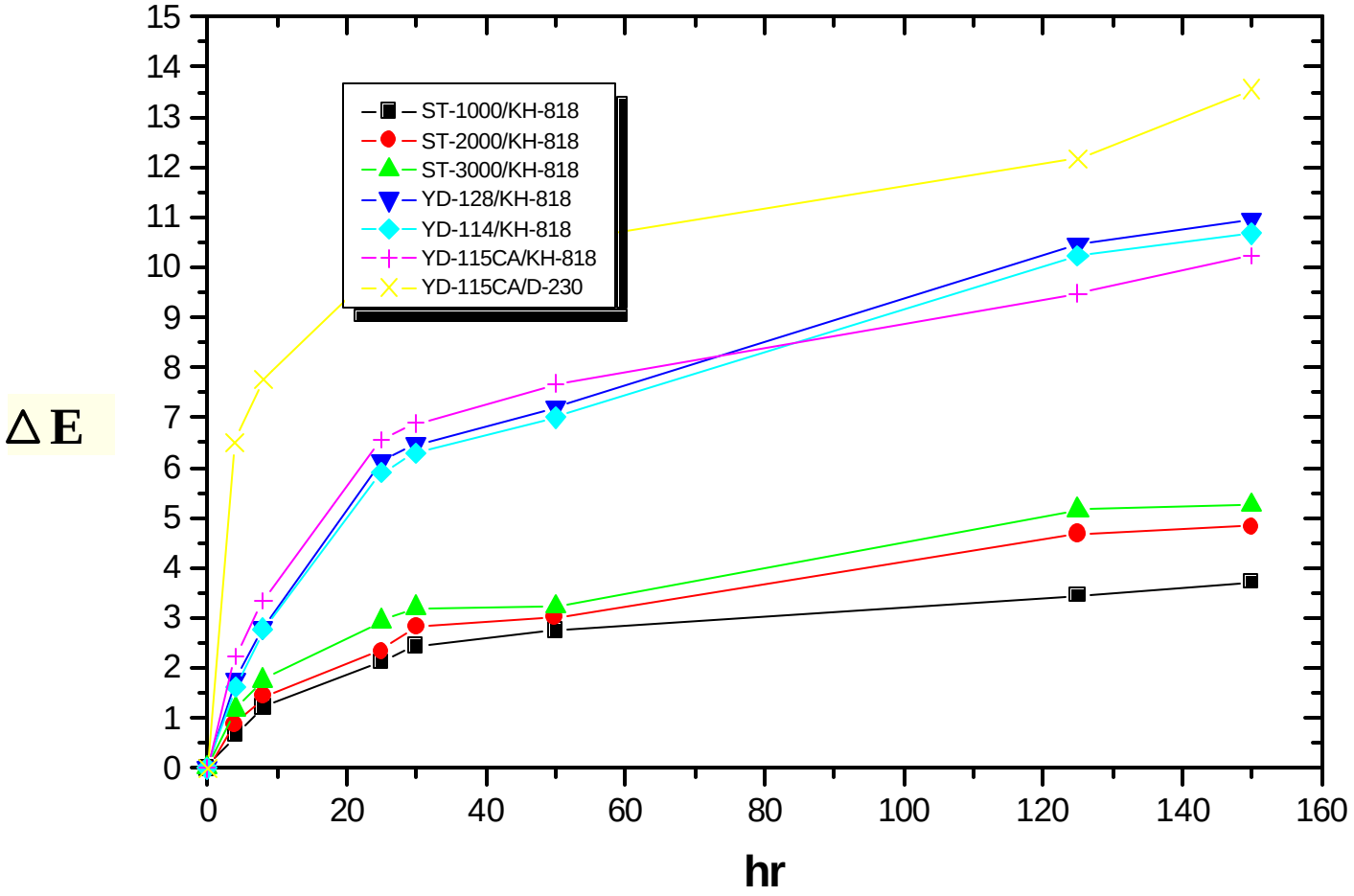
1) Excellent weathering resistance, Excellent Chalking Resistance

2) Low viscosity **3) Good Chemical Resistance**

4) Good compatibility with other Resins such as Alkyd, Polyester, Acrylic Resin

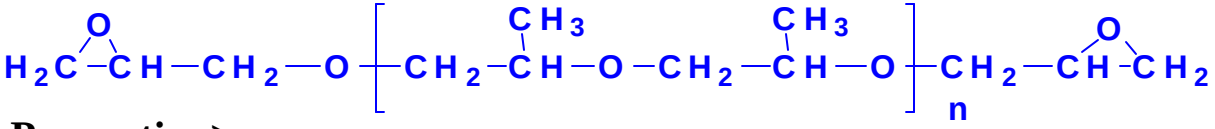
5) Slightly slower curable reactivity **6) Moderate Mechanical Properties**

Q-UV TEST(45℃)


ΔE
ST-1000/KH-818
ST-2000/KH-818
ST-3000/KH-818
YD-128/KH-818
YD-114/KH-818
YD-115CA/KH-818
YD-115CA/D-230
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
20
40
60
80
100
120
140
160
hr

KUKDO Flexible Epoxy

Polyaliphatic Epoxy



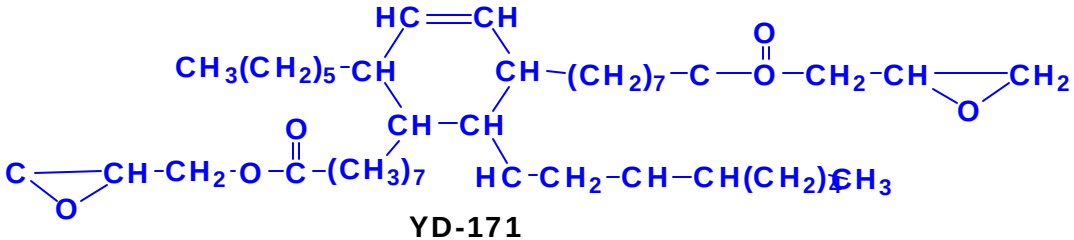
PG-207

< Properties >

1) Excellent Flexibility
2) Low Viscosity
3) Excellent Clarity & low Color
4) Dimensional Stability
5) Good reactivity as a chain extender

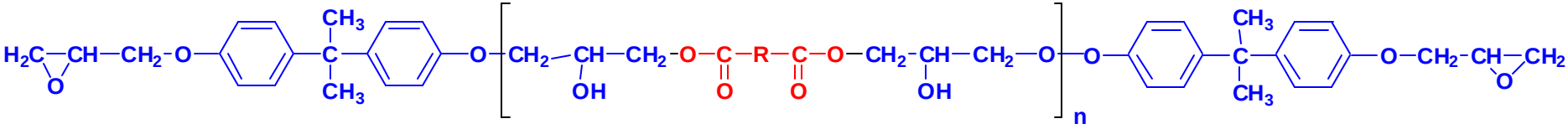
Dimer modified Epoxy

< Taffy Process Product >



YD-171

< Fusion Process Product >



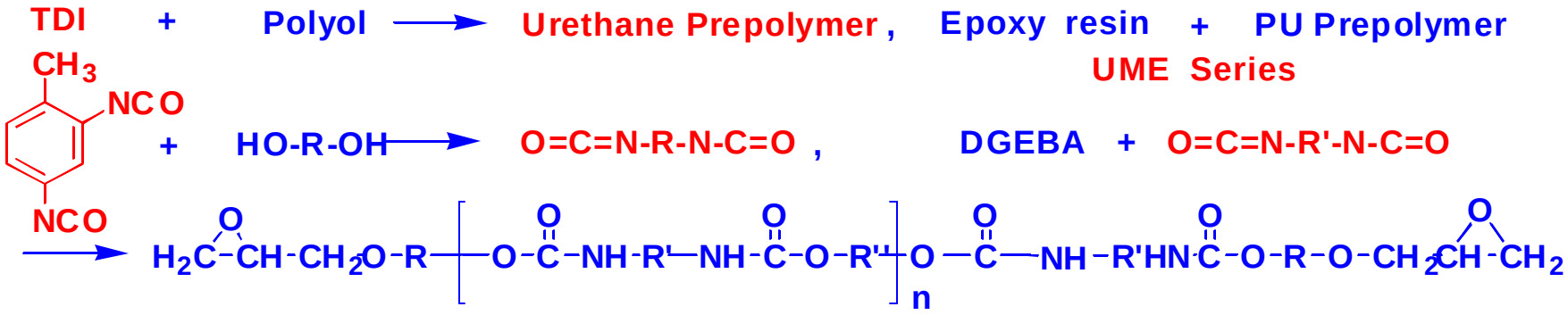
YD-172 type

< Properties >

1) Good Flexibility
2) Semi-solid
3) Excellent Adhesion
4) Non-Volatile

IPN Epoxy Resins

Urethane Modified Epoxy resin



Rubber modified Epoxy resin

ATBN

CTBN + DGEBA ----------> Rubber modified Epoxy Resin

NBR

BR **KR-100~200 Series : BR Modified Epoxy Resin**

Acrylic Rubber **KR-600 series : Acrylic Rubber Modified Epoxy**

< Properties >

1) Toughness 2) Flexibility 3) Small Heat resistance Defect 4) Good Adhesion

5) Good mechanical properties

Acrylic Core-Shell Rubber Modified Epoxy Resins

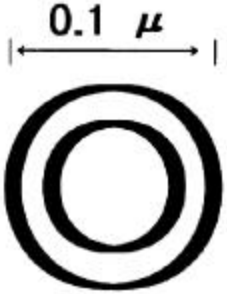
KUKDO KR-600 series resins contain specially designed for fine particle of Acrylic rubber Core-shell homogeneously. It provides the products with good heat resistance resistance and mechanical properties (flexibility strength, tensile strength, modulus of elasticity, break strength, and shear adhesion strength, etc.).

Shell Tg= 110℃

Core Tg=−40℃

Especially, with the various types curing agent (Anhydride acid, DICY, DDM, Polyamide amine,etc.), it offers improvement and reinforcement of uniform properties. Fine particle (0.5μ) of Core shell gives uniform properties compared to rubber blended epoxy resin and graft modified epoxy resin.

Similar concept with Acrylic Core shell, Silicone Core-Shell system is considerable as a commercial product for high performance flexible application.



Shell Tg= 70～140℃

Core Tg= － 110℃

Specification of Rubber modified Epoxy Resins

ITEM	EEW	Softening Point(°C)	Color	Viscosity(cps) Melt viscosity(cps)	Acid value (mgKOH/g)	Comment
KR-628	220-240	-	Milky white	40,000-60,000	-	A.Core-shell
KR-627	190-215	-	Milky white	15,000-30,000	-	A.Core-shell
KR-692	675-775	82-98	Milky white	-	-	A.Core-shell
KR-693	800-900	90-105	Milky white	-	-	A.Core-shell
KR-170	200-235	-	5 max.	30,000-60,000	0.1 max.	CTBN rubber
KR-207	175-205	-	5 max.	2,000-3,000	0.1 max.	CTBN rubber
KR-208	270-330	-	5 max.	8,000-12,000	0.1 max.	NBR rubber
KR-450	400-500	-	5 max.	250,000-400,000	0.1 max.	CTBN rubber
KR-102	1,100-1,300	100-110	5 max.	4,000-15,000 *1)	0.1 max.	CTBN rubber
KR-102F	1,100-1,300	100-110	5 max.	4,000-15,000 *1)	0.1 max.	FDA grade
KR-140L	1,100-1,300	95-105	5 max.	3,000-15,000 *1)	0.1 max.	CTBN rubber
KR-104F	1,100-1,300	95-105	5 max.	3,000-15,000 *1)	0.1 max.	FDA grade
KR-224	1,100-1,300	-	5 max.	4,000-25,000 *1)	0.1 max.	CTBN rubber
KR-225	1,100-1,300	-	5 max.	4,000-25,000 *1)	0.1 max.	CTBN rubber
KSR-1000*3)	1,100-1,300	-	Milky white	1,000-5,000 *2)	-	Silicone rubber

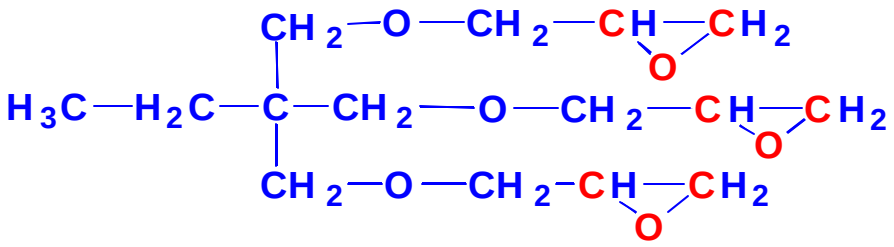
*1) Melt viscosity cps at 150 °C

*2) Melt viscosity cps at 175 °C

*3) Patent No. : US 6,355,740

Multi-functional Epoxy Resins

Tri-Functional Epoxy Resin



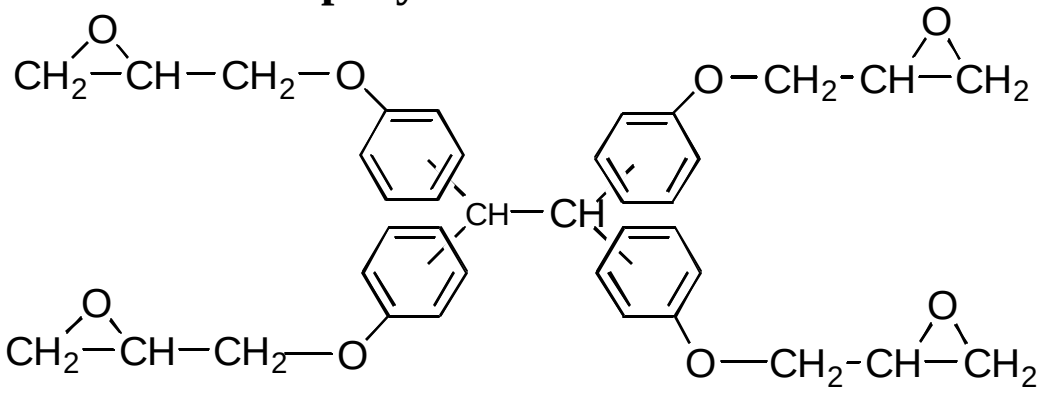
Tri - functional Epoxy resin
YH-300 series

< Properties >

1) Low Viscosity 2) Good Reactivity 3) Good Compatibility

4) Low Volatile 5) Good mechanical properties

Tetra-Functional Epoxy Resin



KDT-4400

< Properties >

1) High Heat Resistance 2) Good Adhesion 3) Good Chemical Resistance

KUKDO Waterborne EPOXY Emulsion System

Grade	EEW *1 (g/eq)	Viscosity cps @ 25 °C	NV (wt%)	Basic Resin	Specific Gravity	pH	Particle Size (μm)
KEM-128R	195-215	2,000-8,000	100	YD-128	1.13	6~7	-
KEM-128M	200-220	7,000-15,000	100	YD-128	1.13	6 ~7	-
KEM-128-70	195-210	1,000-1,0000	70	YD-128	1.14	6~7	1 max.
KEM-134-60	260-300	1,000-1,0000	60	YD-134	1.08	6~7	1 max.
KEM-101-50	450-550	1,000-1,0000	47	YD-011	1.08	6~7	2 max.
KEM-012-50	600-670	1,000-10,000	50	YD-012	1.08	6~7	2 max.
KEM-014-50	930-990	1,000-10,000	50	YD-014	1.07	6~7	2 max.
KEM-500-90P40	205-245	10-100	40	YDCN-500-90P	-	6~7	2 max.
KEM-638-60	190-210	1,000-10,000	60	YDPN-638	1.07	6~7	2 max.
KEM-172-60	380-430	1,000-10,000	60	YD-172	1.07	6~7	2 max.

*1 solid base resin

Grade	Amine value (mgKOH/g) *1	Viscosity cps @ 25°C	NV (wt%)	Color Gardner	Specific Gravity	Mixing ratio phr(YD-128)
KH-723	260-300	20,000-45,000	100	12 max.	1.05	70
KH-721	190-240	10,000-20,000	80	6 max.	1.12	80 ~ 100
KH-748	190-250	5,000-15,000	80	6 max.	1.10	80 ~ 100
KH-700	200-260	3,000-10,000	80	6 max.	1.10	80 ~ 100

*1 solid base hardener

KUKDO Epoxy Hardener

POLYAMIDE AMINE
G-700, 5022, 0331, 0930, 0240, 1034, 640

< Properties >

1) Excellent Flexibility 2) Long Pot life 3) Good Adhesion
4) Low Exothermic in Reaction 5) Excellent Water Resistance

Polyamide / Properties	G-700	G-5022	G-0331	G-0240
Amine value	95	220	310	400
Viscosity	High	←	→	Low
Color		None variable		
Mixing ratio	High	←	→	Low
Curing time	Long	←	→	Short
HDT	Low	←	→	High
Hardness	Low	←	→	High
Adhesion		None variable		
Flexibility	High	←	→	Low
Acid resistance	High	←	→	Low
Alkali resistance		None variable		
Solvent resistance	Low	←	→	High
Water resistance	High	←	→	Low
Weathering	High	←	→	Low

Epoxy Curing Agent Polyamide

Curing agent	Type	Amine value (mgKOH/g)	Viscosity (cps@25℃)	color (Gardner) Max.	Gel time (min@25℃, 150g Scale)	PRINCIPAL APPLICATION
G-700	Amide	95	Semisolid	12	-	Solvent-based maintenance coating Fast dry, good water resistance
G-5022	Amide/ Imidazoline	220	60,000(cps@40℃)	12	200	High-viscosity polyamide provide high flexibility, long pot-life and good chemical resistance
G-0930	Amide	300	10,000(cps@40℃)	12	100	Sealants and Putties: Flexible cable-joining compounds
G-0331	Amide	310	3500	12	70	Epoxy tile grouts
G-1034	Amide	340	15,000	12	140	Adhesives
G-640	Amide/ Imidazoline	350	10,000	12	140	Standard high imidazoline content polyamide. coatings, castings, adhesives, laminating
G-0240	Amide	400	2,250	12	50	Low viscosity polyamide. faster cure than G-5022,G-0930 linings, coatings

Polyamido Amine

G-A0533, G-A0432

< Properties >

1) Fast Curing 2) Low Viscosity 3) Good Mechanical Properties

Curing Agent	Amine Value (mgKOH/g)	Viscosity (cps@25°C)	Color(G) Max.	Acid Value (mgKOH/g)	Principal Application
G-A0533	310-350	500-1,000	14	3 max.	Construction, Mortar
G-A0432	320-380	200-600	14	7 max.	Construction, Mortar

High-solids Hardener

GX-460, GX-483

< Properties >

1) High solid coating system 2) Good compatibility with liquid epoxy resin

Curing Agent	Amine Value (mgKOH/g)	Viscosity (cps@25°C)	Color(G) Max.	N.V(wt%) Theoretical	Principal Application
GX-460	230-270	3,000-6,000	12	90	High solid coating (Maintenance & Marine)
GX-483	180-220	2,700-6,400	12	100	High solid coating (Maintenance & Marine)

Polyamide Adduct

GX-328K, 422, 433, 450TI60, 450XB70, 451XB70, 533

< Properties >

1) Excellent workability 2) Fast drying of coated film 3) High gloss

Curing Agent	Amine Value (mgKOH/g)	Viscosity (cps@25°C)	Color(G) Max.	N.V(wt%) Theoretical	Acid Value (mgKOH/g)	Solvents
GX-328K	210-250	1,500-4,500	12	75-77	3 max.	Xylene
GX-422	110-150	Z-Z_3 *1)	12	58-62	3 max.	Xylene/Butanol
GX-433	165-185	1,000-2,000	12	63-67	3 max.	Xylene
GX-450TI60	120-140	800-1,500	12	58.5-61.5	3 max.	Toluene/Isopropanol
GX-450XB70	145-165	4,500-8,500	12	68.5-71.5	3 max.	Xylene/Butanol
GX-451XB70	145-165	4,500-8,500	12	68.5-71.5	3 max.	Xylene/Butanol
GX-533	260-320	800-2,000	9	100	3 max.	-

*1) Solution Viscosity : Gardner Holdt Method

Aromatic Amine Modified Hardener

DDM Modified and Adducts

TH-400 Series

< Properties >

1) Good Chemical Resistance
2) Good Mechanical Properties
3) Good Electrical Properties
4) Good Heat Resistance

Curing Agent	Viscosity (cps@25°C)	A.H.E.W (g/eq)	Mixing Ratio (vs. YD-128)	Appearance
TH-431	3,200-6,300	110-120	60 phr	Reddish brown clear liquid
TH-432	300-1,000	110-120	60 phr	Reddish brown clear liquid
TH-451	14,000-23,000	110-120	60 phr	Reddish brown clear liquid
TH-452	1,500-2,500	110-120	60 phr	Reddish brown clear liquid
TH-427U	200-800	110-120	60 phr	Reddish brown clear liquid
TH-438D	2,500-5,000	110-120	60 phr	Reddish brown clear liquid
TH-436	1,000-2,500	70-80	40 phr	Reddish brown clear liquid
TH-439	200-800	85-105	50 phr	Reddish brown clear liquid
TH-430	3,000-6,000	110-120	60 phr	Reddish brown clear liquid
TH-438	14,000-23,000	110-120	60 phr	Reddish brown clear liquid

*** Reference Data**

Aliphatic Amine Modified Hardener

KH-500 Series

< Properties >

1) Good Chemical Resistance **2) Fast Drying and Low Temperature curable**
3) High Humidity Curing **4) Good Mechanical Properties**
5) Amine-Blushing Improvement

Curing Agent	Amine Value (mgKOH/g)	Viscosity (cps@25°C)	Color(G) Max.	Mixing Ratio (vs. YD-128)
KH-500	450-500	500-4,000	10	30-40 phr
KH-500F	450-500	500-4,000	10	35-40 phr
KH-505	300-370	500-2,500	10	45-60 phr
KH-506	340-400	500-2,500	9	35-40 phr
KH-550	360-420	100-200	8	44-55 phr

Cycloaliphatic Amine Modified Hardener

KH-800 Series

IPDA, 1,3-BAC Adduct

< Properties >

1) Excellent Chemical Resistance
2) Fast Drying and Low Temperature Curable
3) Self Leveling Low Viscosity
4) Good Mechanical Properties
5) Long Pot life
6) Good Color, Clarity

Base amine of product & Counter type

Product	Viscosity [1]	phr [2]	Pot life [3]	Base Amine	Counter type
KH-811	2,000-6,000	35	25min	TMD	HY-837
KH-812	30-150	45	25min	IPDA	HY-2963
KH-814	30-100	45	30min	IPDA	HY-2964
KH-815	100-1,000	60	20min	IPDA	-
KH-816	300-500	60	40min	IPDA	A-1618
KH-817	1,000-3,000	50	60min	IPDA	-
KH-818B	100-300	60	15min	1.3BAC	-
KH-819	80-100	45	20min	IPDA	A-2489
KH-831	400-1,000	45	40min	1.3BAC	-

1. Viscosity : cps at 25°C
2. E.E.W : 186, parts per a hundred resin
3. Pot life : scale 100g

Product / Comparison	KH-531	KH-506	KH-809	KH-808	KH-831	KH-816	KH-819
Gel time/25°C (100g scale)	40min	15min	40min	8min	50min	50min	30min
Viscosity(cps/25°C)	300-1,000	500-2,000	400-900	200-500	400-1,000	300-500	50-150
Water-spot resistance	G	EX	G	EX	G	G	G
Amine-blush	G	EX	G	EX	G	G	G
Leveling	EX	G	EX	EX	EX	EX	EX
ShoreD After 5 days	75	86	74	84	81	78	82
Odor	low odor	low odor	general	strong	general	general	General
Characteristic	spring,fall	winter	spring,fall	winter	spring,fall	spring,fall	spring,fall

EX : Excellent, G : Good, P : Poor, B : bad

Anhydride Curing Agent

KH-1085, 1085S, 1088
(MNA, MTHPA, MHHPA)

< Properties >

1) Long Pot life
2) High Heat Resistance
3) Low Exothermic & Shrink
4) Excellent Electrical Properties

Cured Properties of Epoxy Hardeners

1) Color and Appearance (Good>Poor)
Cycloaliphatic amine>Aliphatic amine>Polyamide>Aromatic amine

2) Pot life (Short>Long)
Aliphatic amine>Cycloaliphatic amine>Aromatic amine>Polyamide

3) Film Drying Property (Fast>Slow)
Aliphatic amine Solvent Type>Aliphatic amine (Non solvent type)>Polyamide Adduct>Cycloaliphatic>Modified Aromatic>amine Polyamide>Aromatic amine

4) Low temperature curable property (Mannich reaction or at using accelerator) (Good>Poor)
Aliphatic amine>Cycloaliphatic>Modified Aromatic amine>Polyamide Adduct> Amido amine>Polyamide>Aromatic amine

5) Adhesion (Good>Poor)
Polyamide>Amido Amine>Cycloaliphatic amine>Aliphatic amine>Aromatic amine

6) Solvent resistance (Good>Poor)
Cycloaliphatic>Modified Aromatic amine>Amido amine>Aliphatic amine>Polyamide

7) Acid resistance (Good>Poor)
Aromatic amine>Cycloaliphatic amine>Amido amine>Aliphatic amine>Polyamide

8) Water resistance (Good>Poor)
Polyamide>Amido Amine>Cycloaliphatic amine>Aliphatic amine>Aromatic amine

Stoichiometry of curing agents

$$\text{Mixing ratio (phr)} = \frac{\text{A.H.E.W.(Active Hydrogen equivalent Weight)}}{\text{Epoxy equivalent}} \times 100$$

a) Polyamine Curatives

$$\text{A.H.E.W.} = \frac{\text{Amine molecular weight}}{\text{No. of activated hydrogen}}$$

b) Polyamide amine Curatives

$$\text{phr(Per hundred resin)} = \text{Alpha} \times \frac{\text{A.H.E.W.(Active Hydrogen Equivalent Weight)}}{\text{Epoxy Equivalent Weight}} \times 100$$

Alpha Value		
	Tensile strength	0.9 ~ 1
	Bending strength	0.7 ~ 0.8
	Compressive strength	0.6 ~ 0.7
	Adhesion strength	0.8 ~ 1.4
	H.D.T.	1.0

Targeted Properties	Portion of Polyamide Amine		
	Low	Mid.	High
Flexibility	→	Increase	←
Hardness	→	Decrease	←
Curing time	→	Decrease	←
Pot life	→	Decrease	←
Acid resistance	→	Decrease	←
Alkali resistance	→	No change	←
Solvent resistance	→	Decrease	←
Water resistance	→	Increase	←

c) Anhydride Curatives

$$(\text{phr}) = C \times \frac{\text{A.H.E.W.(Active Hydrogen Equivalent Weight)}}{\text{Epoxy Equivalent Weight}} \times 100$$

C = 0.85 (without accelerator)

C = 0.55 (when using acid as accelerator)

C = 1.0 (when using tertiary-amine as an accelerator)

$$\text{Anhydride A.H.E.W.} = \frac{\text{Molecular weight of Anhydride}}{\text{No. of anhydride functionality}}$$

d) Amine/Epoxy Adduct Curatives

(Amine M mole(Mw) / Epoxy M' mole(Mw') system)

$$\text{Adduct A.H.E.W.} = \frac{\text{Amine Mw} \times M \times \text{Epoxy Mw'} \times M'}{\text{activated hydrogen No of Amine} \times M - \text{Functionality of Epoxy} \times M'}$$

e) Amines Mixture Curatives

$$\frac{\text{Amount of Amine A}}{\text{A.H.E.W of Amine A}} + \frac{\text{Amount of Amine B}}{\text{A.H.E.W of Amine B}} = \frac{100}{\text{A.H.E.W. of Mixture (g/eq)}}$$