



DENACOL

Nagase ChemteX Epoxy compound



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Specialty epoxies DENACOL

DENACOL is specialty epoxies manufactured by glycidyl etherification/esterification of various alcohols and carboxylic acids using our proprietary process. We have a variety of mono-functional and multi-functional epoxies, including water-soluble epoxies, that can be used for various applications requiring the high reactivity of the epoxy group.

Features of DENACOL

Feature

01 Multi-functional aliphatic Epoxy

While having flexibility and weather resistance derived from their aliphatic structures, multi-functional epoxies can form structures having strong crosslinked networks. In addition, it has high reactivity and can react at lower temperature. It can be used in various applications such as cross-linker for polymers, flexibilizer, adhesion promoter, adhesive, and modifier for fibers/paper.



grades

EX-600 series, EX-300 series, EX-500 series, EX-321, EX-421

02 Sustainable

① High water solubility

Many grades of DENACOL are water-soluble which enables VOC-free, environment-friendly waterborne formulations. They can also be used for water-based application.

*DENACOL do not generate formaldehyde.

Epoxy resin/water=mixing ratio of 1/9



Water-soluble type DENACOL

Bisphenol A type epoxy

※Appearance when mixing epoxy resin and water

grade

EX-614B, EX-300 series(Excluding EX-321), EX-421, EX-500 series, EX-800 series, EX-900 series(Excluding EX-931)

② GREEN DENACOL

High bio-based epoxy



GREEN DENACOL is biobased epoxy compound made from plant-derived raw material. The raw material change from conventional petroleum-based to biobased has enable the production of sustainable epoxy crosslinkers. It also contributes to the reduction of CO₂ emissions through photosynthesis of the raw material plants.

03 Various Applications

Through advanced synthesis technology, it is possible to control properties such as epoxy value, chlorine content, viscosity, and water solubility, even with the same parent structure. Additionally, the high reactivity of the epoxy group allows for a wide range of applications.

Coatings



Electronic materials



Flexibilizers



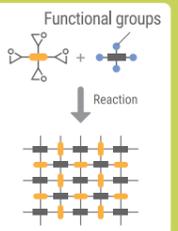
Classification

Classification

We have various grades to meet your needs.
Please use this guide to select the optimum product.

Multi-functional type

Use of multi-functional epoxies can improve dimensional stability and thermal and chemical resistance due to a strong three-dimensional crosslinked structure.



Hydrophilic

- EX-614B
- EX-313
- EX-314
- EX-421
- EX-512
- EX-521

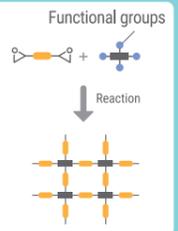
Hydrophobic

- EX-622
- EX-321

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Di-functional type

The use of di-functional epoxy enables a more flexible cured product due to lower crosslinking density and reduced brittleness.



Hydrophilic

- EX-810
- EX-811
- EX-850
- EX-851
- EX-821
- EX-830
- EX-832
- EX-841
- EX-920

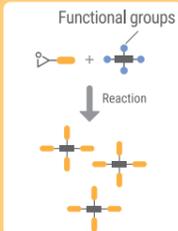
Hydrophobic

- EX-931
- EX-201
- EX-211
- EX-212
- EX-252

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Mono-functional type

Monofunctional epoxies are modifiers to impart unique properties.



Hydrophilic

- EX-145

Hydrophobic

- EX-146
- EX-192
- EX-731

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Low chlorine type

These epoxy compounds have significantly low chlorine content. They can be used as reactive diluents for electronic materials, coatings and other applications

Multi-functional type

- EX-321L
- EX-1610

Di-functional type

- EX-214L
- EX-810P
- EX-991L
- EX-201-IM

Mono-functional type

- EX-142-IM
- EX-146P

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High bio-based type

GREEN DENACOL

GREEN DENACOL is biobased epoxy compound made from plant-derived raw materials. It has enabled the production of sustainable epoxy crosslinkers by the raw materials' change from conventional petroleum-based to plant-based.

Multi-functional type

- GEX-313
- GEX-512
- GEX-521
- GEX-614B
- GEX-622

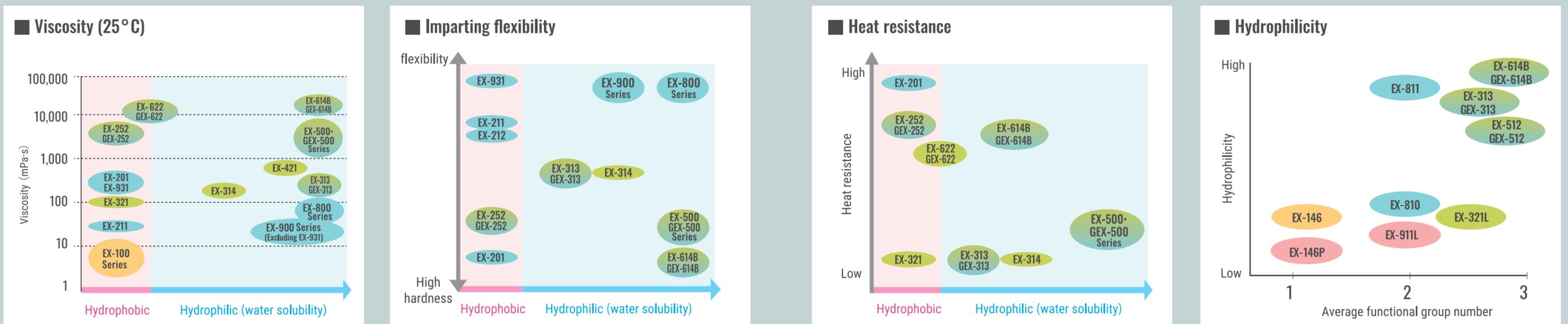
Di-functional type

- GEX-252

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Selection guide

Selection Guide



Multi-functional type

Multi-functional epoxies with various backbone structures such as sorbitol, glycerin and pentaerythritol can be used as cross-linker, adhesion promoter and modifier for fibers/paper.

Many grades are water-soluble, suitable for working in water-based applications such as fiber and paper manufacturing; they are also VOC-free, environment-friendly crosslinkers.



EX-600 series

EX-600 series are aliphatic multi-functional epoxies based on sorbitol. We have a wide range of grades with different water solubility.

While being aliphatic, it has high reactivity due to high functionality and it forms a structure having good heat resistance and strength due to high crosslinking density.

Chemical name	Sorbitol Polyglycidyl Ether						
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-614B	173	94	5,000	10.1	3 (G)	20kg, 200kg	Paint, Textile
EX-622	191	Insoluble	11,800	19.4	2 (G)	20kg, 220kg	Paint, Adhesive, Textile

EX-300-500 series

EX-300-500 series are aliphatic multi-functional epoxy based on glycerin, diglycerin, polyglycerin.

Low viscosity and multi-functional, they can be used in a wide range of application.

Chemical name	Glycerol Polyglycidyl Ether						
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-313	141	99	150	9.0	10	20kg, 200kg	Paint, Textile Adhesive
EX-314	144	64	170	11.5	20	20kg, 200kg	Adhesive

Test condition
 Epoxy equivalent: Measured by perchloric acid method
 Total chlorine content: Dissociation of covalent type chlorine with metallic sodium and then quantified by Holhart method
 Water solubility : Dissolution rate when 10 parts of DENACOL is dissolved in 90 parts of water at room temperature, less than 20% is insoluble.
 Viscosity (25°C) : Heptler viscometer or B type viscometer.
 Color value : APHA or Gardner (G)

Chemical name	Trimethylolpropane Polyglycidyl Ether						
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-321	140	27	130	7.5	10	20kg, 200kg	Paint, Adhesive, Reactive diluent

Chemical name	Diglycerol Polyglycidyl Ether						
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-421	159	88	650	9.6	1 (G)	20kg, 200kg	Textile, paint

Chemical name	Polyglycerol Polyglycidyl Ether							
Chemical structure								
Product name	n	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-512	2	168	100	1,300	6.5	40	20kg, 220kg	Textile, paint
EX-521	3	183	100	4,400	6.4	10	20kg	

Di-functional type

Difunctional epoxies based on polyethylene glycol, polypropylene glycol, hexanediol, phthalic acid and other. They are used as highly water-soluble crosslinking agents, resin modifiers, etc. Many grades are low viscosity and can be used as a reactive diluent.



EX-800 series

The EX-800 series are aliphatic Difunctional epoxies based on (poly) ethylene glycol. All grades have low viscosity and high water solubility.

It is possible to control crosslinking density, impart hydrophilicity and flexibility by selecting the chain length.

Wide ranges of applications including crosslinker for water-based acrylic paint, surface treatment agent for polyester fiber and paper treatment

Chemical name		Ethylene, Polyethylene Glycol Diglycidyl Ether						
Chemical structure								
Product name	n	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-810	1	113	100	20	0.6	20	20kg, 200kg	Water-based cross-linker, Hydrophilizer, Flexibilizer
EX-811	1	132	98	20	9.7	10	20kg, 200kg	
EX-850	2	122	100	20	0.5	30	20kg, 200kg	
EX-851	2	150	99	30	7.5	10	20kg, 200kg	
EX-821	4	185	100	40	4.5	30	20kg, 200kg	
EX-830	9	268	100	70	0.3	40	20kg, 200kg	
EX-832	9	284	100	90	7.3	10	20kg	
EX-841	13	372	100	110	1.9	30	20kg	

Chemical name		Polypropylene Glycol Diglycidyl Ether						
Chemical structure								
Product name	n	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-920	3	176	100	20	0.8	100	18kg	Water-based cross-linker, Textile, Resin modifier
EX-931	11	471	Insoluble	130	3.9	20	18kg	Textile, Adhesive, Flexibilizer

Chemical name		Resorcinol Diglycidyl Ether					
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-201	117	Insoluble	250	0.7	3(G)	20kg	Adhesion for electronic materials

Chemical name		Neopentyl Glycol Diglycidyl Ether					
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-211	138	Insoluble	20	5.7	10	18kg, 200kg	Reactive diluent

Chemical name		1,6- Hexanediol Diglycidyl Ether					
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-212	151	Insoluble	20	6.1	30	18kg, 200kg	Reactive diluent

Chemical name		Hydrogenated bisphenol A Diglycidyl Ether					
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-252	213	Insoluble	2,200	4.5	10	20kg, 200kg	Paint, UV curable resin

Mono-functional type

Mono-functional epoxy can be used as reactive diluent, resin stabilizer, and more.
Both hydrophilic and hydrophobic grades are available depending on your needs.



Chemical name		Phenyl (EO)5 Glycidyl Ether					
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-145	400	100	60	0.3	60	20kg, 200kg	Hydrophilic diluent Reactive diluent

Chemical name		Tert-butyl Phenyl Glycidyl Ether					
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-146	225	Insoluble	20	0.3	<1 (G)	18kg, 200kg	Reactive diluent

Chemical name		Glycidyl Ether of a Mixture of C11-C15 Alcohol					
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-192	281	Insoluble	8	4	10	15kg, 170kg	Hydrophilic diluent Reactive diluent

Chemical name		N- Glycidyl Phthalate					
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Viscosity (mPa·s)	Bulk density (g/cm³)	Appearance	Packaging	Application example	
EX-731	216	(mp.95°C)	0.5	white powder	20kg	Adhesion for structural materials Adhesion modifier	

Low chlorine type

Low-chlorine type epoxy compound

This is a low-chlorine type epoxy compound with a chlorine content reduced to a minimum of 100 ppm. It is suitable for use as a reactive diluent or coating material in electronic materials, where chlorine-induced degradation is a critical concern. A broad product lineup is available, ranging from mono- to multifunctional types, and from aliphatic to aromatic structures.



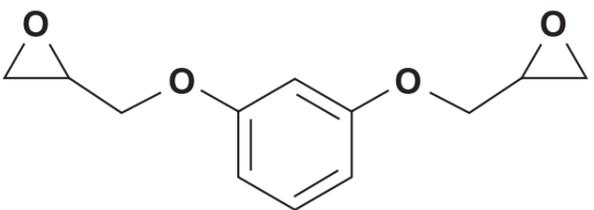
Chemical name	Trimethylolpropane Polyglycidyl Ether						
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-321L	130	Insoluble	300	0.3	30	18kg	Reactive diluent for electronic materials

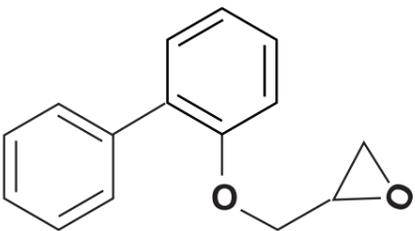
Chemical name	Multi-Functional Aliphatic type						
Chemical structure	Non-disclosure						
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-1610	170	100	2,200	0.5	1 (G)	18kg	Paint, Adhesion for electronic materials

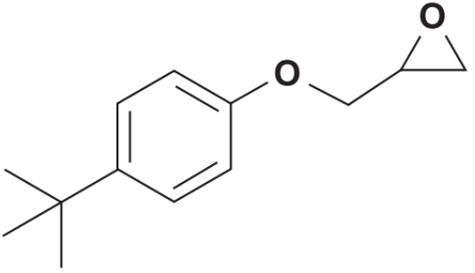
Chemical name	1,4-Butanediol Diglycidyl Ether						
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-214L	115	100	15	0.3	1 (G)	18kg, 200kg	Reactive diluent for electronic materials

Chemical name	Ethylene Glycol Diglycidyl Ether						
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-810P	95	100	180	0.01	10	20kg	Water-based crosslinker & hydrophilic flexibilizer for electronic materials

Chemical name	Not disclosed						
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa·s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-991L	450	Insoluble	180	0.1	200	18kg	Crosslinker & Hydrophilic Flexibilizer for Electronics

Chemical name	Resorcinol Diglycidyl Ether						
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-201-IM	120	Insoluble	400	0.06	5 (G)	20kg	Adhesion for electronic materials

Chemical name	2-Phenylphenol Glycidyl Ether						
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-142-IM	240	Insoluble	290	0.03	70	18kg	Reactive diluent & Resin stabilizer for electronic materials

Chemical name	p-tert-Butyl Phenyl Glycidyl Ether						
Chemical structure							
Product name	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
EX-146P	210	Insoluble	17	0.01	1 (G)	18kg	Reactive diluent for electronic materials

High bio-based type GREEN DENACOL

Earth-friendly materials are nothing special for us.

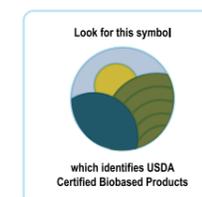
GREEN DENACOL

High bio-based epoxy compound

GREEN DENACOL is biobased epoxy compound made from plant-derived raw materials. By switching from conventional petroleum-based (non-renewable) raw materials to bio-based (plant-derived) alternatives, we contribute to improved sustainability and reduced CO₂ emissions. These materials offer a high bio-based content along with excellent chemical properties, allowing for product selection tailored to specific applications and purposes.

USDA Certified and JORA Biomass Mark Approved *

*Excludes certain products.



Biopreferred label



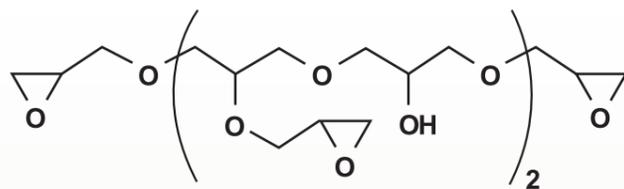
Biomass Mark

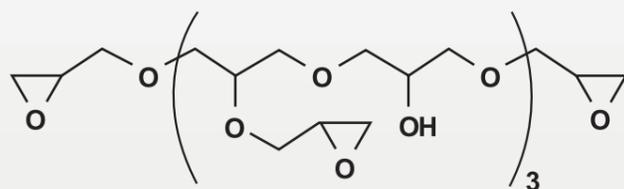
(Example mark of GREEN DENACOL GEX-313)

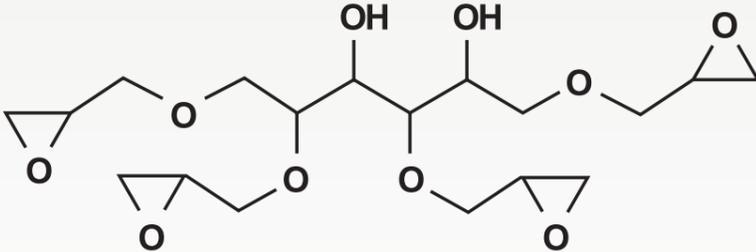
GREEN DENACOL has obtained certification as a bio-based product under the USDA BioPreferred® Program, a certification system operated by the United States Department of Agriculture to support the market expansion of biobased products. Additionally, the product has been awarded the Biomass Mark, indicating compliance with standards related to environmental sustainability and safety.

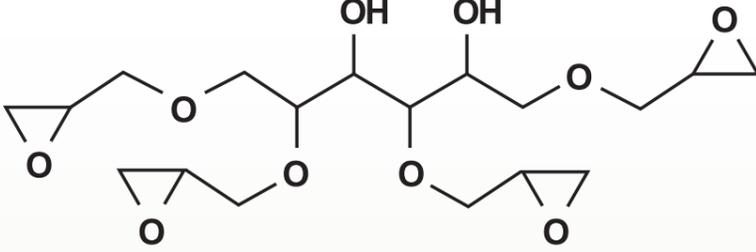
*Biomass Mark is a goal for environmental products that utilize plant-derived resources (biomass) and whose quality and safety comply with relevant regulations, standards, and specifications in Japan.

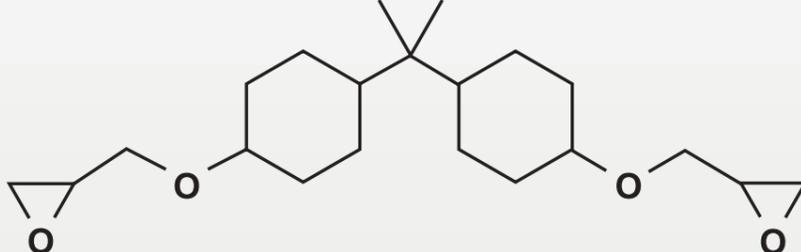
Chemical name		Glycerol Polyglycidyl Ether						
Chemical structure								
Product name	Biobased Content (%)	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
GEX-313	99	141	99	150	9	10	20kg, 220kg	Paint, Adhesive, Textile

Chemical name		Polyglycerol Polyglycidyl Ether						
Chemical structure								
Product name	Biobased Content (%)	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
GEX-512	99	168	100	1,300	6.5	40	20kg, 220kg	Paint, Adhesive, Textile

Chemical name		Polyglycerol Polyglycidyl Ether						
Chemical structure								
Product name	Biobased Content (%)	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
GEX-521	99	183	100	4,400	6.4	10	20kg, 220kg	Paint, Adhesive, Textile

Chemical name		Sorbitol Polyglycidyl Ether						
Chemical structure								
Product name	Biobased Content (%)	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
GEX-622	99	191	Insoluble	11,800	19.4	2 (G)	18kg, 200kg	Paint, Adhesive, Textile

Chemical name		Sorbitol Polyglycidyl Ether						
Chemical structure								
Product name	Biobased Content (%)	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
GEX-614B	80	173	94	5,000	10.1	3 (G)	20kg, 200kg	Paint, Textile

Chemical name		Hydrogenated Bisphenol A Diglycidyl Ether						
Chemical structure								
Product name	Biobased Content (%)	Epoxy equivalent (g/eq.)	Water Solubility Rate (%)	Viscosity (mPa · s)	Total chlorine content (%)	Color value	Packaging	Application example
GEX-252	32	213	Insoluble	2,200	4.5	10	18kg, 200kg	Paint, UV curing resin

Cross-linking agent for coatings

Water resistance improver for acrylic resins

Features

- Water resistance is improved by adding DENACOL to a water-soluble acrylic resin.

Recommended Grade

EX-614B EX-313 EX-810



Time until coating whitening (Measured as the time required for the coating to whiten during immersion in a 70°C mixed water bath)

Resin	Cross-linking agent	DENACOL Additive Amount (Parts by Weight)	Curing Temperature	Curing Time				
				0.1hours	1hours	4hours	8hours	24hours
Acrylic polymer	EX-614B	4	25°C	-	4minutes	10minutes	25minutes	> 6hours
			40°C	-	4minutes	10minutes	25minutes	> 6hours
			80°C	-	> 6hours	-	-	-
			100°C	> 6hours	-	-	-	-

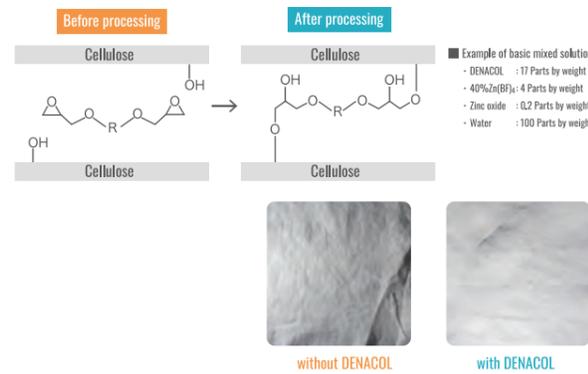
Coating Conditions : Coated on glass plate using No.24 bar coater.

Fiber treatment agent

Anti-wrinkle agent for cotton fibers

Features

- The structure is stabilized by crosslinking the hydroxyl groups in cellulose fibers, resulting in improved wrinkle resistance.
- This wrinkle resistance is utilized in products such as handkerchiefs and shirts.



Recommended Grade

EX-810 EX-861 EX-313

Resin Stabilizers

Halogen catcher

Features

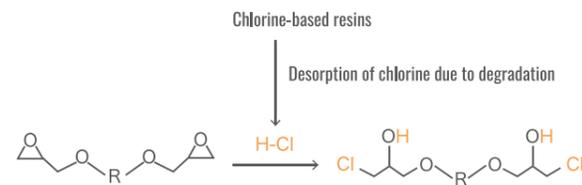
- Functions as a catcher of chlorine that is desorbed from chlorine-based resins (prevents resin deterioration)
- Capturing hydrochloric acid to prevent acid deterioration and corrosion

Example of use

- In cases such as vinyl chloride emulsions, epoxy is used for aqueous resins.
- Prevention of acid-induced degradation and corrosion by capturing hydrochloric acid.

Recommended Grade

EX-121 EX-146 EX-192



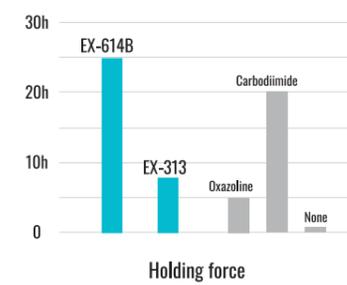
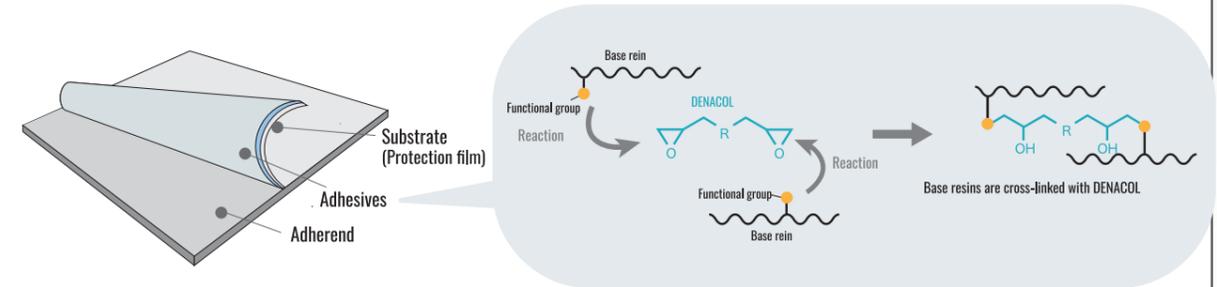
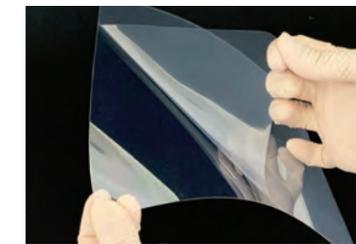
Adhesives

Features

- Cross-linking of functional groups of the base resins reduce the adhesive residue on the adherend.

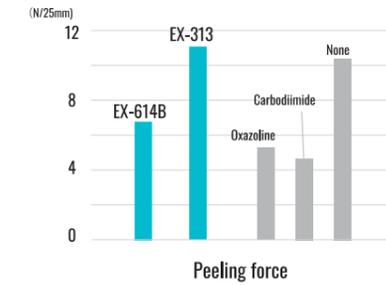
Recommended Grade

EX-313 EX-421 EX-614B EX-512



Preparation of Adhesive tape

Acrylic resin emulsion(N.V. 65wt%) : Cross linker (as Solid) = 100 : 0.6
 Substrate : PET film
 Thickness : 30µm
 Cure condition : 100°C·2min→60°C·24 h

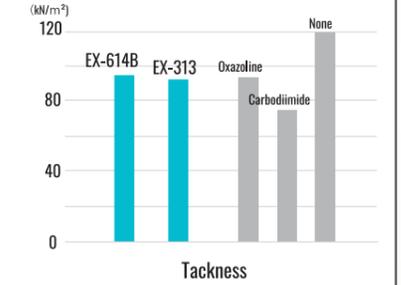


Holding force Test Conditions

Substrate: SUS (Stainless Steel)
 Load: 1 kg

Peel Test Conditions

Substrate: SUS (Stainless Steel)
 Peel Angle: 180°
 Peel Speed: 300 mm/min



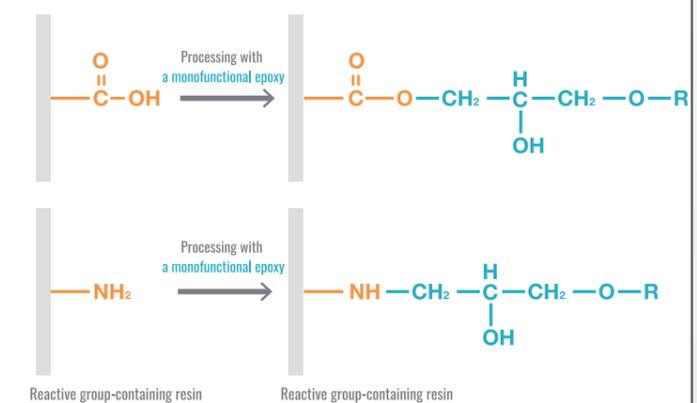
Resin modifier

Features

- Application of monofunctional type epoxy
- Increases hydrophilicity or hydrophobicity of the base resins that contain reactive functional groups.

Recommended Grade

Hydrophilizing agent EX-145 EX-171
 Hydrophobizing agent EX-145 EX-192



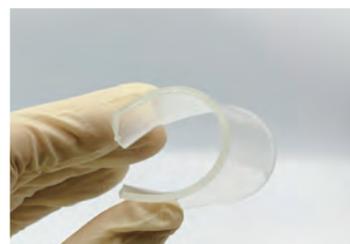
Flexibilizer

Features

- Improves the flexibility of epoxy curing agent

Recommended Grade

EX-991L EX-830



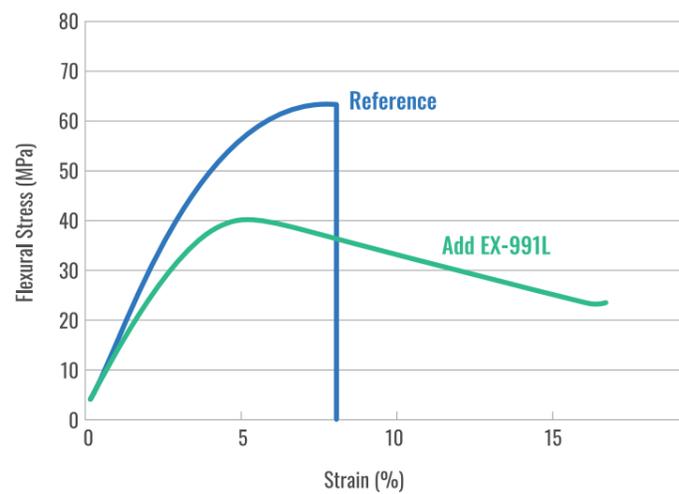
Formulation ingredient

	Component	Add EX-991L (Parts by weight)	Reference (Parts by weight)
Base resin	EP-BPA(Bisphenol A Liquid Epoxy Resins)	70	100
Flexibility-imparting agent	DENACOL EX-991L	30	0
Curing agent	Isophoronediamine	17	24

※Curing conditions : 80°C*4h ⇒ 150°C*1h

Measurement data

Test item	Add EX-991L	Reference
Tg (°C)	80	158
Storage modulus (GPa)	1.4	2.2
Flexural strength (MPa)	79	125
Flexural modulus (GPa)	2.0	2.8
Water absorption rate (%)	0.8	0.3



Reactive diluents for electronic materials

Features

- Addition of low-viscosity DENACOL to high-viscosity base resin improves handling property.
- Unlike dilution with solvents, DENACOL has reactive functional groups, so there is no need to remove solvents before curing, and it can be cured with them.

Recommended Grade

EX-212L EX-214L EX-810P EX-991L
EX-146P EX-201-IM EX-142-IM EX-321L



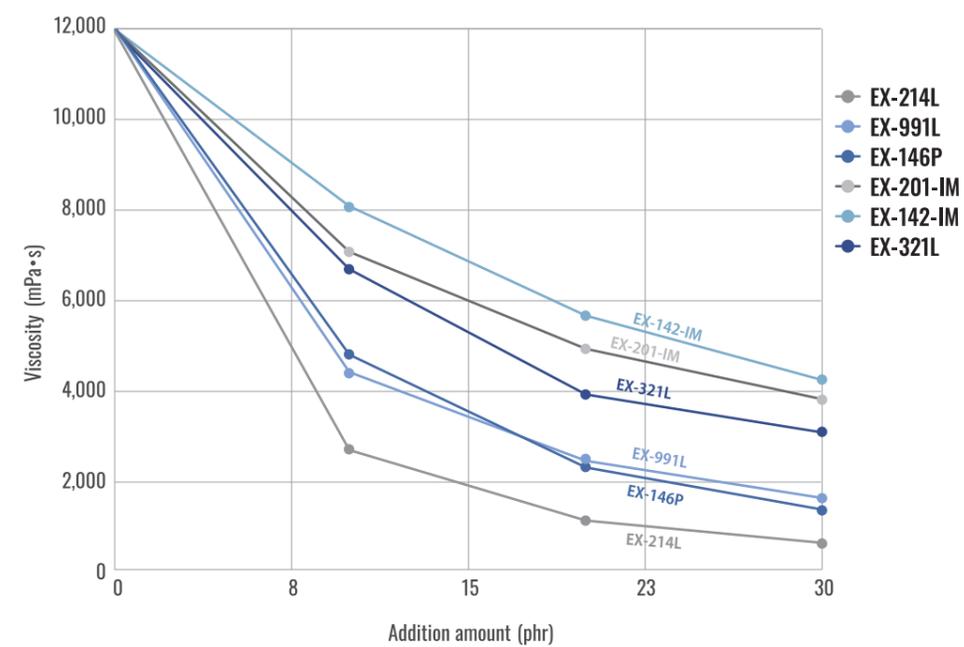
without DENACOL



with DENACOL

Resin	Product name	Total chlorine content (%)	Viscosity (m · Pas)			
			No addition	Addition amount 10phr	Addition amount 20phr	Addition amount 30phr
Bisphenol A Liquid Epoxy Resins	EX-214L	0.3	12,000	2,650	1,110	608
	EX-991L	0.1	12,000	4,360	2,430	1,610
	EX-146P	0.01	12,000	4,760	2,290	1,360
	EX-201-IM	0.06	12,000	7,040	4,900	3,790
	EX-142-IM	0.03	12,000	8,050	5,640	4,200
	EX-321L	0.3	12,000	6,680	3,900	3,040

※Measurement conditions : Viscosity was measured using BPA-type liquid epoxy resin (100 parts by weight) with varying amounts of DENACOL added.



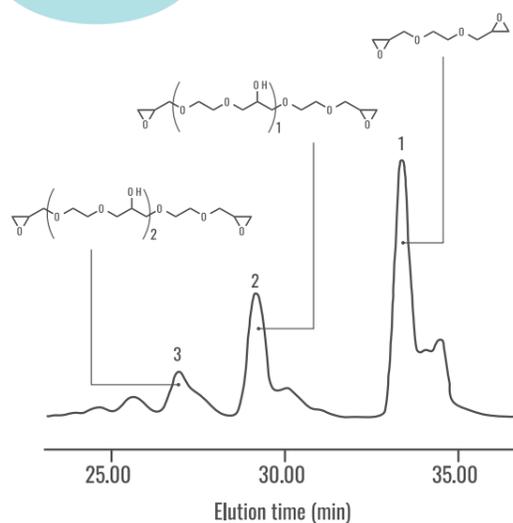
Composition

Analysis data by GPC (Gel Permeation Chromatography)

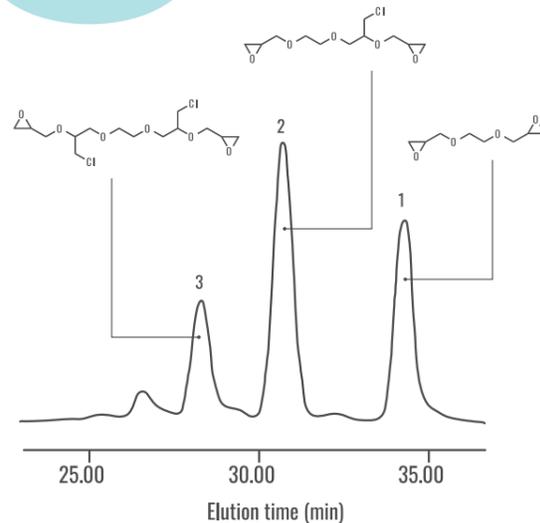
(The structural formula described is an estimate.)

GPC analysis condition	
Column	TSK GEL G2000 H ₈ -2
Flow rate	1.0ml/min
Eluent	THF
Concentration	0.5%
Detector	RI

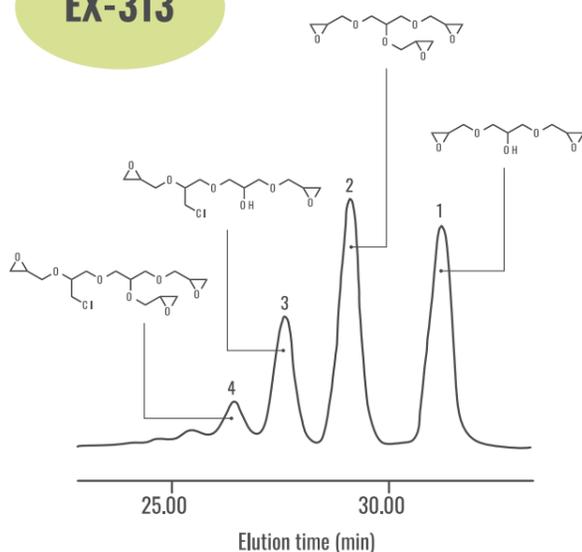
EX-810



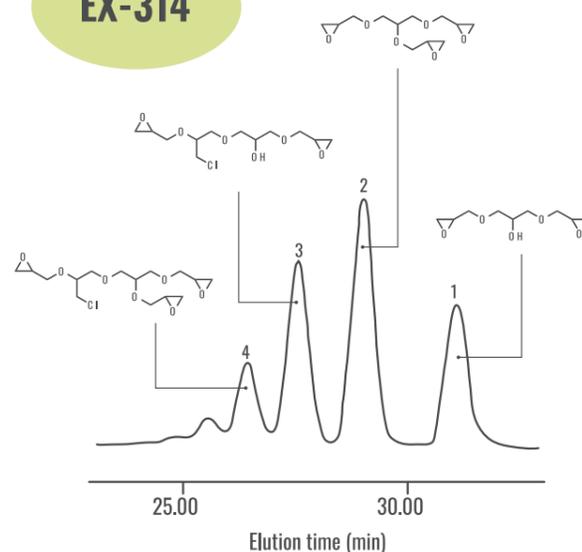
EX-811



EX-313



EX-314



Property of DENACOL

(1) Boiling point

Product name	Boiling point (°C / mmHg)
EX-810、EX-811 *1	125 / 5
EX-211*2	125 / 1
EX-313、EX-314 *3	195 / 1.5
EX-146	165~170 / 14

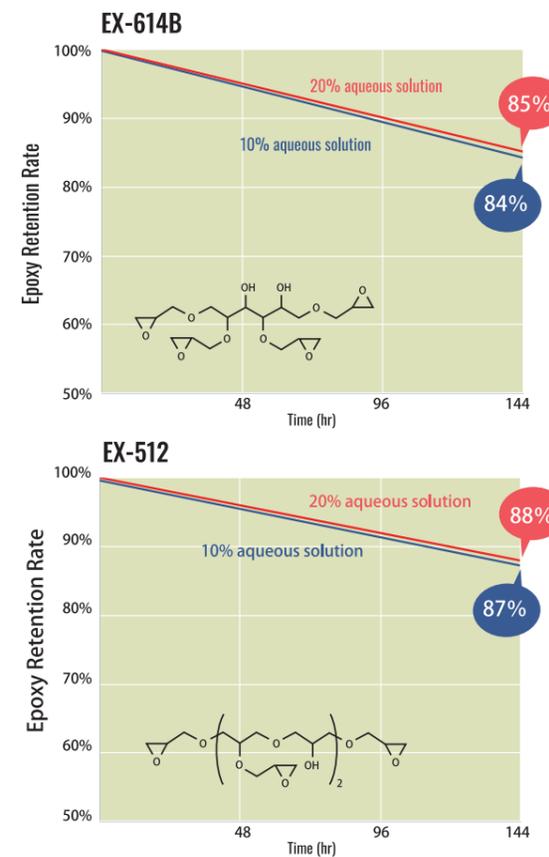
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 * 3 : Boiling point of glycerol triglycidyl ether as the main component.

(2) Loss on drying (1g, 10min)

Product name	180°C (%)	200°C (%)	230°C (%)
EX-810	28	-	-
EX-920	24	-	-
EX-314	1	9	16

(4) Stability of epoxy groups in aqueous solution

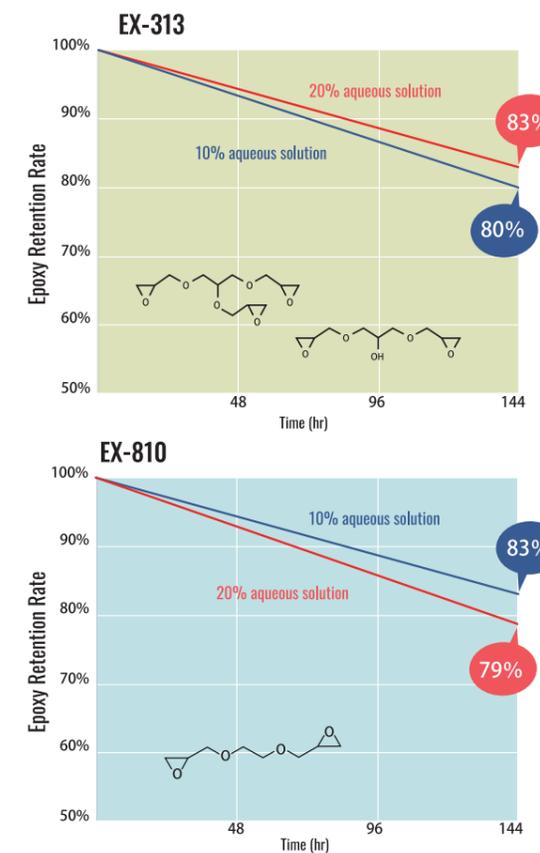
(Epoxy Retention Rate at 25°C)



(3) Epoxy stability

Product name	Epoxy residual rate (%)	
	Room temperature (1year)	100°C (24hr)
EX-811、EX-314	99	99
EX-810	98	98
EX-313	97	97
EX-832、EX-841	≥ 99	≥ 99
EX-614B	98	95

10% aqueous solution: DENACOL/Water = 1/9 mixture
 20% aqueous solution: DENACOL/Water = 2/8 mixture



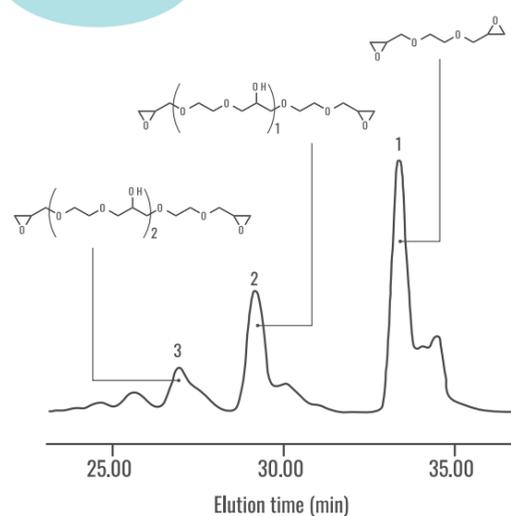
Composition

Analysis data by GPC (Gel Permeation Chromatography)

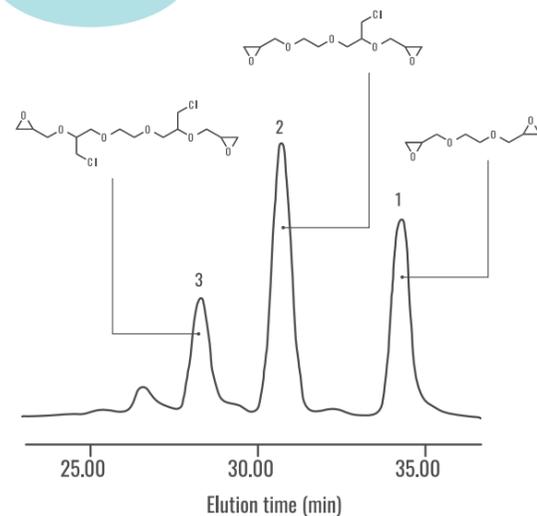
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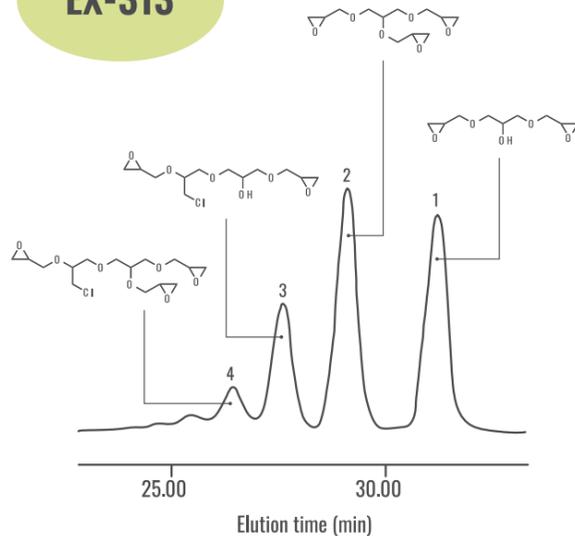
EX-810



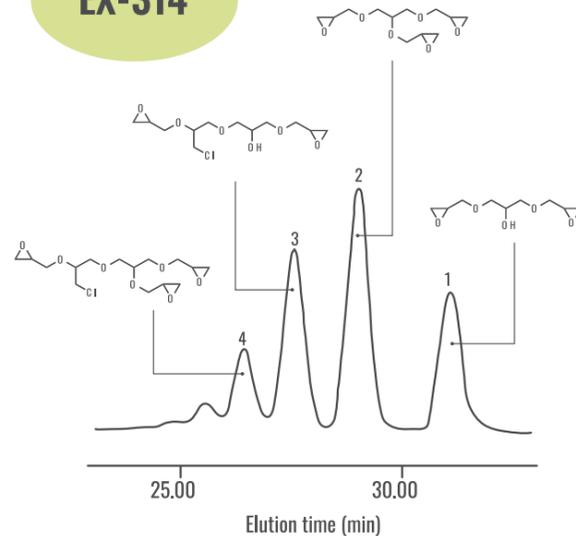
EX-811



EX-313



EX-314



Property of DENACOL

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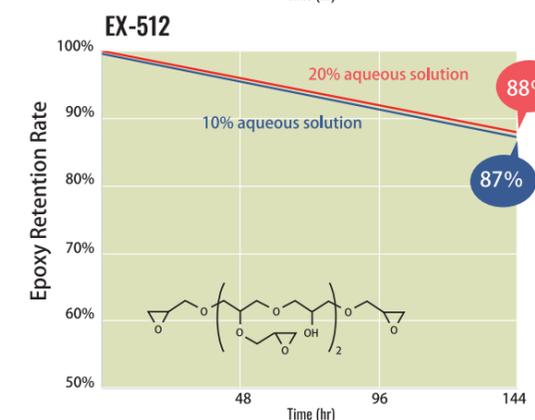
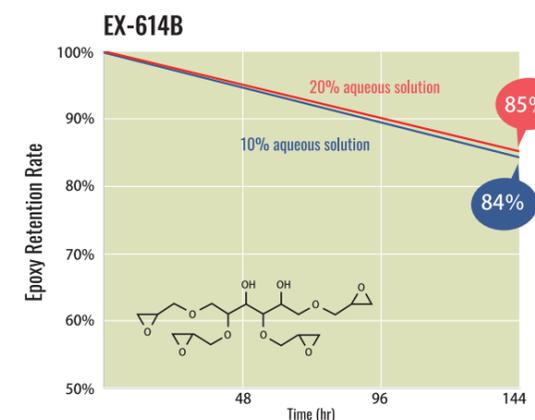
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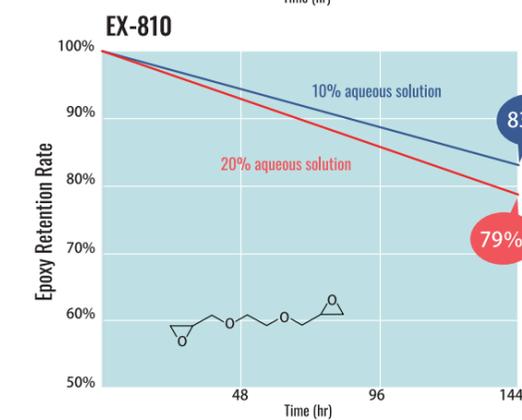
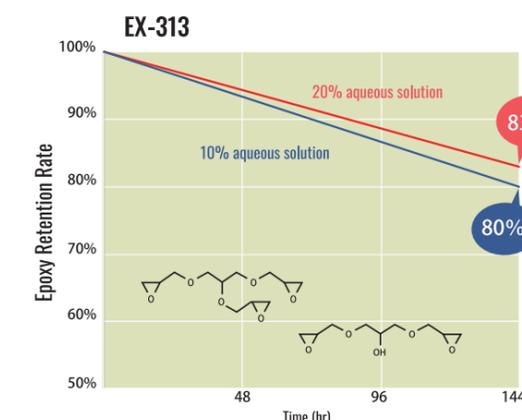
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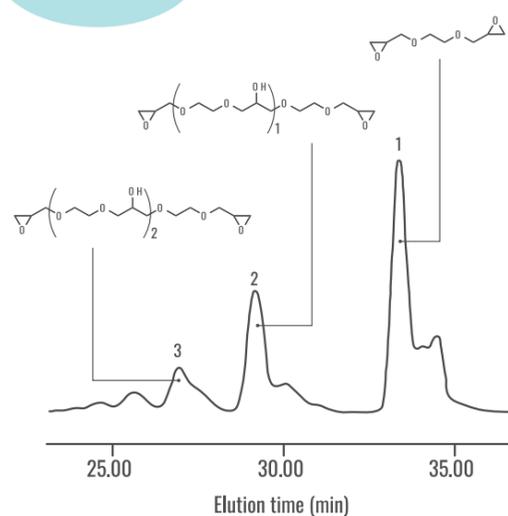
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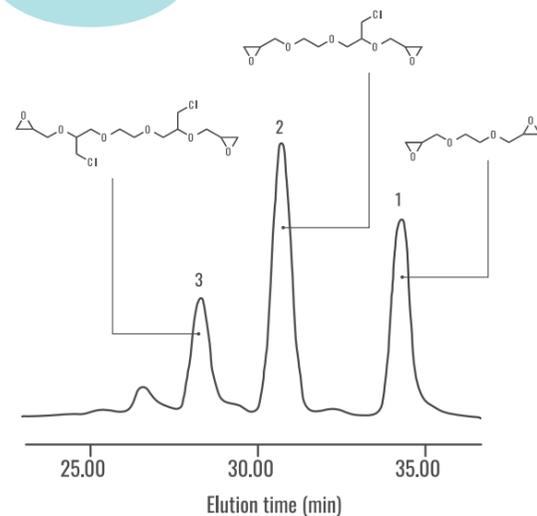
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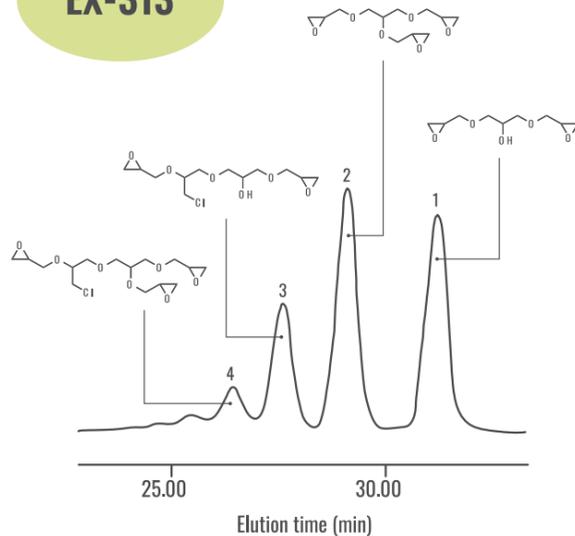
EX-810



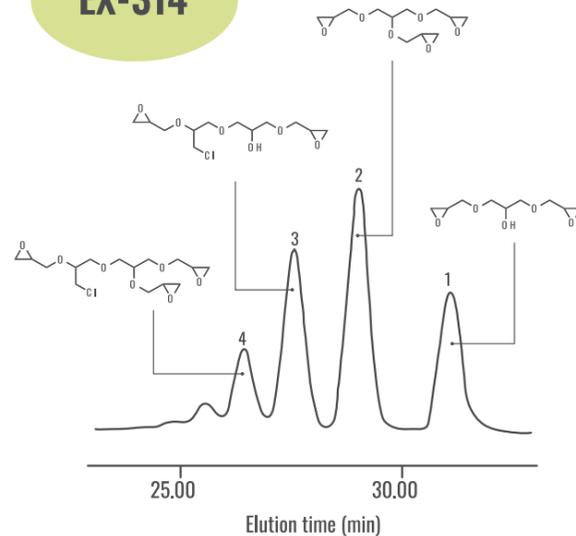
EX-811



EX-313



EX-314



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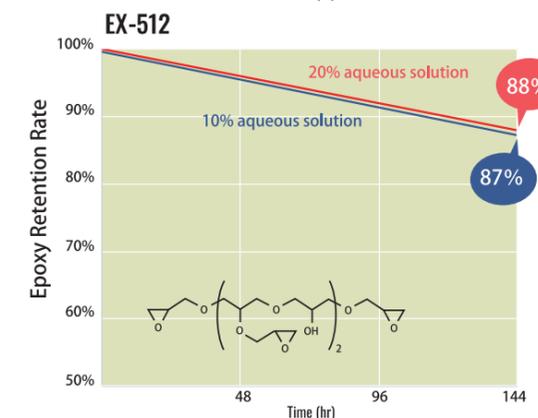
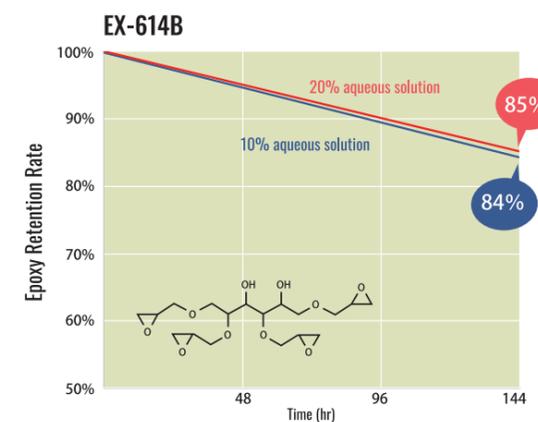
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(4) Stability of epoxy groups in aqueous solution

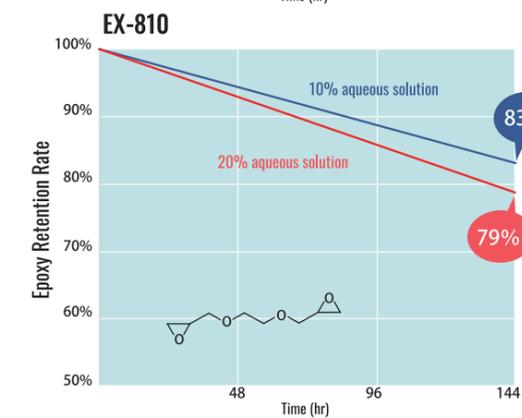
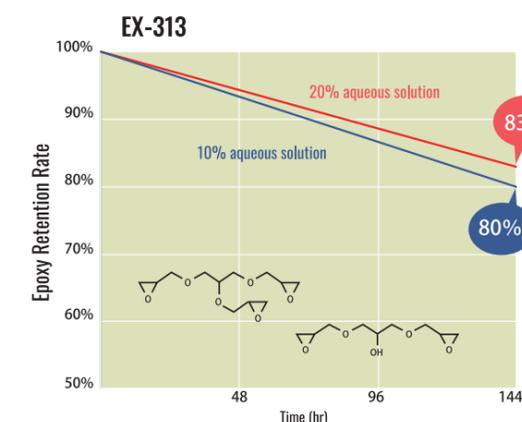
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(3) Epoxy stability

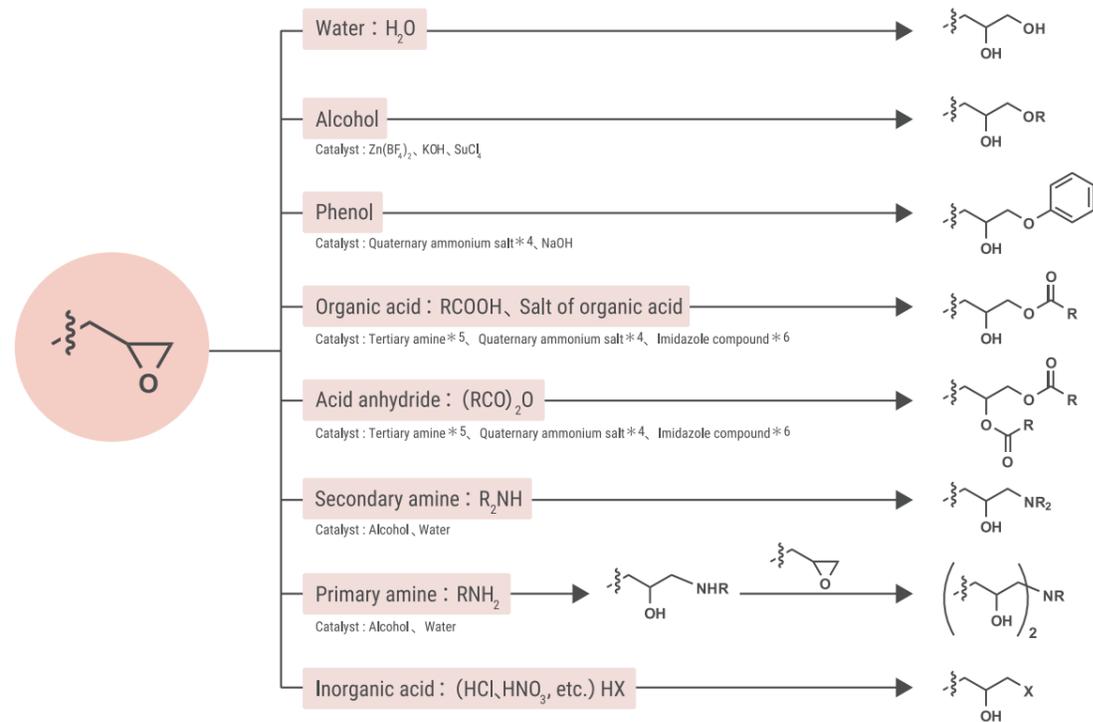
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10% aqueous solution: DENACOL/Water = 1/9 mixture
 20% aqueous solution: DENACOL/Water = 2/8 mixture



Reaction of epoxy group

The following are representative reaction examples. The reaction rate and properties of reaction products depend on the structure of the epoxy, the solvent and the reaction conditions, etc.



Polymerization reaction



Crosslinking reaction (A polymer having active hydrogen)



The epoxy group also reacts with the following substances

Acetal	Ketone	Thiol	Carbon dioxide	Thionyl chloride
Alkyl halide	Halohydrin phosphine	Acetoacetate	Benzene (Friedel-Crafts reaction)	Aldehyde
Isocyanate	Phosphorus oxychloride	Acyl halide	hydrocyanic acid	Grignard reagent
Ethylenimine	Sodium sulfite	Amide	Phthalimide	Hydrogen sulfide
Halohydrin	Thiocyanate	Ammonia	Thiocyanic acid	Phosphorous acid

- * 4 : Quaternary ammonium salt Benzyltriethylammonium Chloride, Tetramethylammonium Chloride, etc.
- * 5 : Tertiary amine Benzyltrimethylamine, tributylamine, tris (dimethylamino) methylphenol, etc.
- * 6 : Imidazole compound 2-methyl-4-ethylimidazole, 2-methylimidazole, etc.

Reactivity of DENACOL (Reaction rate between DENACOL and various active hydrogens)

Numerical value: Epoxy conversion rate(%)

Major classification	Multi-functional								Di-functional										Mono-functional		Reaction conditions			
	Reaction conditions		Glycerin		Diglycerin	Polyglycerin		Trimethylolpropane Diglycerin	Ethylene glycol		Diethylene glycol		Polyethylene glycol			Propylene, polypropylene glycol		1,6-hexanediol	Hydrogenated Bisphenol A	Bisphenol A		p-tert-phenol	C12-C13 Alcohol	
Product name	EX-614B	EX-622	EX-313	EX-314	EX-421	EX-512	EX-521	EX-321	EX-810	EX-811	EX-850	EX-851	EX-821	EX-830	EX-832	EX-920	EX-931	EX-212	EX-252	-	EX-146	EX-192		
Water	-	-	37	27	31	38	37	-	35	34	-	35	39	37	38	34	-	-	-	-	-	-	-	90 parts water / 10 parts DENACOL < Outside temperature 80 ° C, 3hr >
Water (pH=13)	-	-	51	41	-	49	36	-	37	43	-	-	42	46	42	37	-	-	-	-	-	-	-	Water (pH 13) 90 parts / DENACOL 10 parts < External temperature 50 ° C for 2 hours >
n-Butyl alcohol	75	68	78	76	76	76	78	70	63	79	32	41	38	35	17	21	50	83	93	73	21	78	n-Butyl alcohol 1mol / DENACOL 1epoxy eq. / 45%Zn (BF4) 2 vs. alcohol 2% < temp.50 ° C 2hr >	
sec-Butyl alcohol	-	-	70	66	Gelation after 120 minutes	-	-	-	54	81	-	-	-	-	13	18	-	-	-	-	-	-	-	Sec-butyl alcohol 1 mol / DENACOL 1 epoxy equivalent / 45% Zn (BF 4) 2 to alcohol 2% < external temperature 50 ° C. for 2 hours >
n-Butyric acid	49	44	55	48	46	47	42	46	53	44	46	39	-	25	29	33	11	35	41	46	33	27	n-butyric acid 1mol / DENACOL 1 epoxy equivalent / Pyridine to acid 4% < External temperature 70 ° C. 2 hours >	
Iso-Butyric acid	-	-	54	53	49	-	-	-	56	45	-	-	-	-	34	38	-	-	-	-	-	-	-	Iso-butyric acid 1 mol / DENACOL 1 epoxy equivalent / pyridine to acid 4% < external temperature 70 ° C. for 2 hours >
n-Butylamine	Gelation after 15 minutes	Gelation after 60 minutes	Gelation after 8 minutes	Gelation after 75 minutes	Gelation after 50 minutes	Gelation after 120 minutes	Gelation after 120 minutes	Gelation after 120 minutes	56	74	51	61	91	16	19	55	13	47	Gelation after 50 minutes	Gelation after 100 minutes	37	43	N-butylamine 1 mol / DENACOL 2 epoxy equivalent < external temperature 70 ° C. for 2 hours >	
Diethylamine	92	81	84	86	78	90	92	67	42	56	-	67	27	25	31	60	21	29	31	72	32	43	Diethylamine 1 mol / DENACOL 2 epoxy equivalent < external temperature 50 ° C. for 2 hours >	
o-Cresol	62	55	70	66	Gelation after 120 minutes	64	67	-	65	62	68	-	55	36	36	49	10	50	65	69	54	35	O-cresol 1 mol / DENACOL 1 epoxy equivalent / pyridine to acid 4% < external temperature 70 ° C. for 2 hours >	
Phthalic anhydride	Gelation after 75 minutes	Gelation after 110 minutes	45	40	36	Gelation after 120 minutes	Gelation after 120 minutes	-	36	41	Gelation after 120 minutes	-	25	20	20	26	7	32	13	41	10	4	Phthalic anhydride 1 mol / DENACOL 2 epoxy equivalent / pyridine to 4% / dioxane (solvent) < reaction concentration 62.5% external temperature 70 ° C. 2 h >	

Solubility of DENACOL

solvent	EX-146	EX-192	EX-212	EX-313	EX-321	EX-421	EX-521	EX-614B	EX-622	EX-810	EX-811	EX-832	EX-931
Methanol	○	○	○	○	○	○	○	○	△	○	○	○	○
Ethanol	○	○	○	○	○	○	△	○	△	○	○	○	○
Isopropyl alcohol	○	○	○	○	○	△	△	△	△	○	○	○	○
Butyl cellosolve	○	○	○	○	○	○	○	○	○	○	○	○	○
Butyl cellosolve acetate	○	○	○	○	○	○	○	○	○	○	○	○	○
Methyl ethyl ketone	○	○	○	○	○	○	○	○	○	○	○	○	○
Ethyl acetate	○	○	○	○	○	○	○	○	○	△	○	○	○
Butyl acetate	○	○	○	○	○	○	△	○	○	△	○	○	○
Toluene	○	○	○	△	○	△	△	△	○	○	△	○	○
Water	×	×	×	○	△	○	○	○	×	○	△	△	×
Chloroform	○	○	○	○	○	○	○	○	○	○	○	○	○
Dioxane	○	○	○	○	○	○	○	○	○	○	○	○	○

Condition: 10 parts DENACOL / 90 parts of solvent mixed at room temperature

○ : Soluble △ : Partly soluble × : Insoluble

Index

[Grade]

EX-142-IM	13	EX-321	6	EX-841	7
EX-145	9	EX-321L	11	EX-850	7
EX-146	9	EX-421	6	EX-851	7
EX-146P	13	EX-512	6	EX-920	7
EX-1610	11	EX-521	6	EX-931	7
EX-192	10	EX-614B	5	EX-991L	12
EX-201	8	EX-622	5	GEX-252	16
EX-201-IM	13	EX-731	10	GEX-313	15
EX-211	8	EX-810	7	GEX-512	15
EX-212	8	EX-810P	12	GEX-521	15
EX-214L	12	EX-811	7	GEX-614B	16
EX-252	8	EX-821	7	GEX-622	16
EX-313	5	EX-830	7		
EX-314	5	EX-832	7		

Precautions for safe handling

Follow all the precautions

- Please read the Safety Data Sheet (SDS) before use

Safety measures and emergency measures

- DENACOL may cause skin problems if it touches the skin etc. Please use protective gloves, protective eyewear, protective cream etc, and not to touch directly. If it adheres to the skin etc, immediately rinse with running water and then rinse with soapy water.
- Inhalation of mist or steam of DENACOL may cause damage to the trachea. Please use exhaust equipment to provide. If inhaled, please move to a place with fresh air and rest.
- In case of disability, please get medical attention, diagnosis.

About reaction

- DENACOL is dangerous if it reacts with lower amines, acidic catalysts, etc., causing severe exothermic reactions. Please carry out preliminary experiments. Please use with careful attention to safety.

No fires

- Do not use or store in a place with a fires.

About storage

- DENACOL may deteriorate if stored for long periods at high temperature. Storage in a cool and dark place is recommended.
- Keep container tightly closed.

For each property and data introduced in this catalog, it is a representative value, not a guaranteed value.
We may change the contents without notice due to product improvement.