

CONCRETE FLOORS

PRODUCT OVERVIEW



Cardolite
Chemistry for Tomorrow



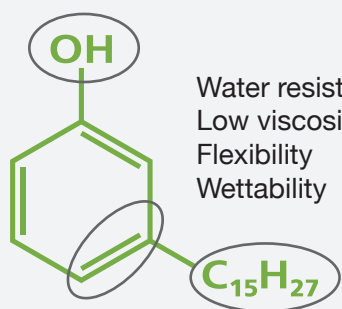
Cardolite Corporation is a privately held manufacturer of the world's largest variety of products derived from cashew nutshell liquid (CNSL). CNSL is an annually renewable resource that does not interfere with the food chain. The unique properties of CNSL are used to develop and produce a wide range of specialty curing agents, resins, and diluents for coatings, adhesives, composites, foams, and friction applications.

With 30 years of experience, Cardolite is the leader in the production and development of high quality CNSL based materials across the globe. Cardolite's manufacturing facilities in Zhuhai, Guangdong (China), and Mangalore, Karnataka (India), have the unique capability to consistently process CNSL from any source to the desired properties.

To further advance CNSL technology, Cardolite operates state-of-the-art research facilities in the USA, China, and India. By using CNSL as a primary building block, these laboratories are able to develop epoxy hardeners, modifiers, and resins for concrete coatings and adhesives with performance advantages over some traditional, petrochemical based chemistries. In addition, these facilities are equipped with application testing machines such as mechanical testers, thermal analysis DSC and TGA, dynamic mechanical analysis, impact and pull off adhesion testers, and QUV and salt spray chambers amongst others. The Technical Service group uses the comprehensive test capability of these laboratories to develop relevant performance data that helps customers accelerate time to market.

Cardolite continues to invest heavily in research, technical support, manufacturing, and market development to meet the ongoing needs of the flooring industry with innovative, renewable CNSL based products.

Low temperature cure
Fast cure
Excellent adhesion



Chemical and thermal shock resistance

Water resistance
Low viscosity
Flexibility
Wettability

CNSL Technology

Cardanol is a unique natural phenolic material obtained by distilling CNSL and serves as the primary building block for Cardolite products. The molecule is composed of an aromatic ring with an OH group and a long aliphatic side chain, which brings valuable intrinsic benefits to coatings and adhesive materials. The aromatic ring provides a strong chemical resistant backbone while the OH group gives high bond strength and good reactivity for fast and low temperature cure. The side chain provides excellent water resistance, good flexibility, low viscosity, and extended pot life. Most Cardolite products are high in bio-content.



Cardolite Products

Cardolite offers a variety of epoxy amine curing agents, epoxy modifiers, and epoxy and polyol resins based on CNSL technology for use in the formulation of a wide range of high performance epoxy and polyurethane coatings and adhesives for concrete floors.

The Mannich reaction of CNSL, formaldehyde, and certain amines is called a phenalkamine. Phenalkamines are epoxy curing agents that offer unique benefits to coatings formulators such as fast and low temperature cure, low viscosity solvent free systems, great overall chemical and mechanical properties, excellent water resistance, and very good bond strength under unfavorable conditions. Cardolite phenalkamines are ideal for two-component, ambient-cured epoxy coatings and adhesives.

Cardolite resin and modifier portfolio is comprised of reactive and non-reactive epoxy

diluents and multi-purpose modifiers that not only lower viscosity, but also improve flexibility, surface tolerance and early water resistance, and some grades can also accelerate cure without compromising other properties. Moreover, tests have shown that Cardolite modifiers can be formulated to increase bond strength and improve adhesion on oily or damp surfaces. These products are an excellent alternative to substances of high concern such as nonyl phenol and can be used in one-component heat-cured adhesives or in two-component field-applied coatings and adhesives applications.

Cardolite polyol resins are very hydrophobic in nature, which results in good water resistance and reduced moisture sensitivity during cure with isocyanate. Different grades are developed to meet application-specific performance requirements such as improved UV resistance, or better chemical resistance.

Epoxy Curing Agents Phenalkamines for Primers and Self-leveling



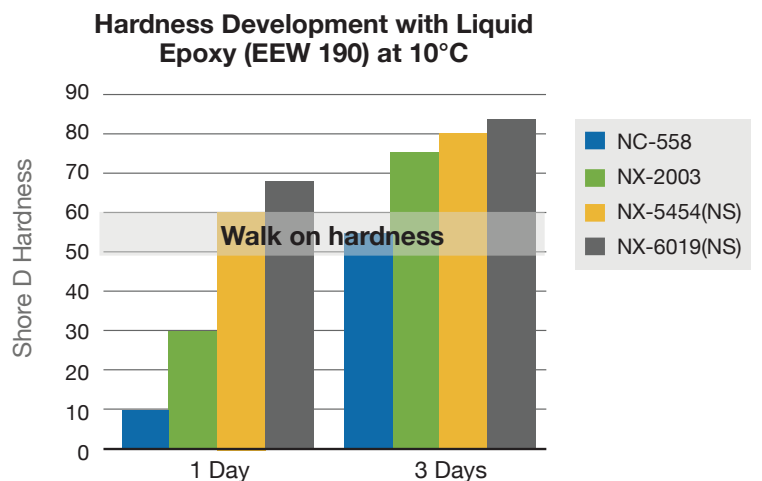
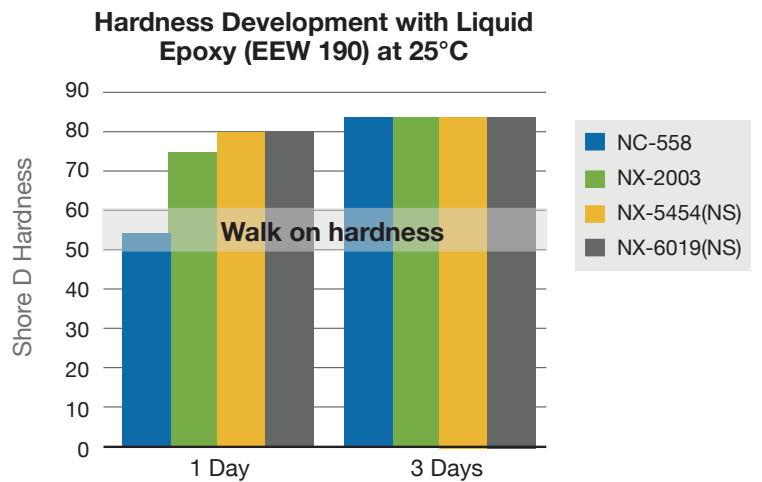
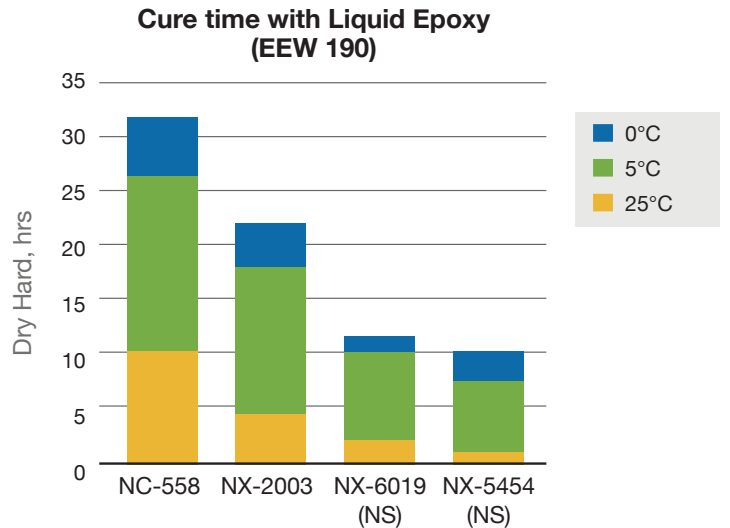
Fast Cure in Extreme Weather

Cardolite phenalkamines exhibit fast cure and hardness development even at freezing temperatures, enable non-critical mix ratios, and show a nice film appearance due to good compatibility with epoxy resins. However, due to the long aliphatic side chain of cardanol, phenalkamines also provide extended pot life and good impact resistance despite the fast cure.

The fast and low temperature cure combined with the good pot life properties of phenalkamines allows for wider floor coating application window and quicker return to service. Moreover, by reaching a high level of crosslinking very quickly and not having a narrow mix ratio, failure risks are lowered and problems are avoided when environmental conditions rapidly change after application.

Hydrophobicity

Cardolite curing agents are very hydrophobic due to the long aliphatic chain of the cardanol, which results in excellent water resistance and very low permeability compared to other amine curing agents commonly used in the floor coating industry. The low permeability of systems cured with phenalkamines helps prevent blisters from being formed on the floor coating when water vapor present in the concrete rises to the surface.





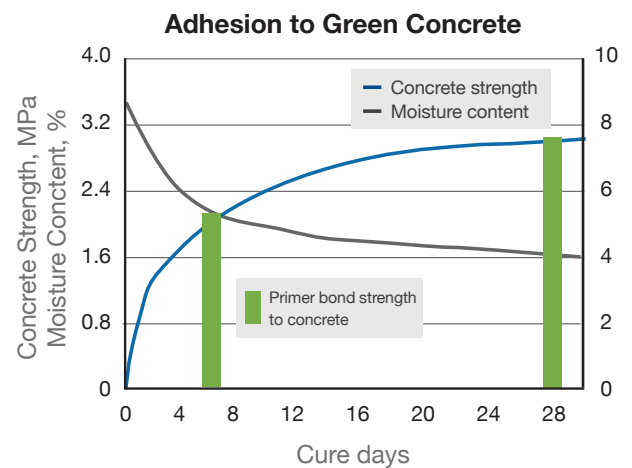
Chemical Resistance

Phenalkamines exhibit excellent chemical resistance to a variety of chemicals due to its aromatic ring and high crosslinking density. The combination of chemical resistance and excellent adhesion to concrete provided by phenalkamines, protects coatings from being damaged by chemical spills or leaks in environments as encountered in factories, platforms, and warehouses. Phenalkamines can be designed to withstand:

- Alcohols & Solvents: ethanol, xylene, gasoline, jet fuel, diesel, toluene, etc.
- Acids & Alkali: sulfuric acid, caustic, hydrochloric acid, etc.
- Others: juices, wines, olive oil, etc.
- Sea water, hot water, and distilled water

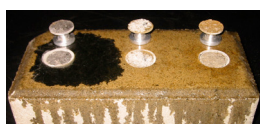
Adhesion to Damp, Oily, and Green Concrete

The hydrophobicity of phenalkamines coupled with fast cure allow floor primers to quickly develop strong bonds to dry, damp, oily, and green concrete. Concrete requires 28 days to fully cure, but primers based on some phenalkamines can develop adhesion with concrete sooner. However, adhesion tests need to be done on each system to determine coating earliest application time.



Adhesion to Oily Concrete

Phenalkamine-based Epoxy Primer	Pull off Adhesion (MPa)	Rupture Mode
Diesel engine oil contaminated concrete	2.8/4.1 oil/no oil	concrete
Gasoline engine oil contaminated concrete	4.1/4.1 oil/no oil	concrete



The image shows concrete surface contaminated with diesel oil (left), nothing (middle), gasoline oil (right).

Adhesion to Dry and Damp Concrete

Phenalkamine-based Epoxy Primer	Pull off Adhesion (MPa)	Rupture Mode
24 hours dry concrete	6.90	50% dolly 50% concrete
3 weeks dry concrete	6.90	Dolly to adhesive
3 weeks damp concrete	3.45	100% concrete



This image shows adhesion failure occurs in the concrete and not between dolly/coating and concrete.

Epoxy Curing Agents Waterborne

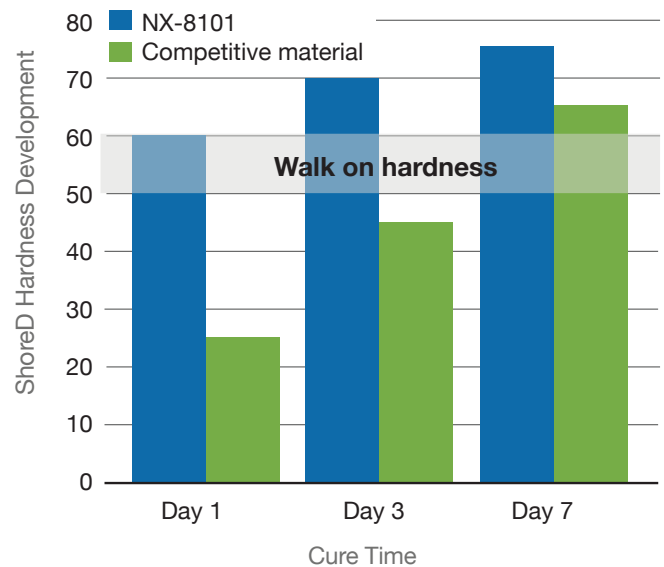
The NX-8100 Series is the first CNSL-based waterborne curing agent product line available in the market. Phenalkamine grade NX-8101 is designed for cost effective water-based metal primers that require high corrosion protection and concrete epoxy primers and self-levelers that require quick return-to-service, and excellent adhesion to concrete and top coats. This new low odor epoxy curing agent is supplied in water and does not contain or require any solvents in the formulation to deliver excellent performance. Its good compatibility with standard liquid epoxy and solid epoxy dispersions, and easy reducibility in water, broadens its use and allows for cost effective industrial coatings.

Advantages:

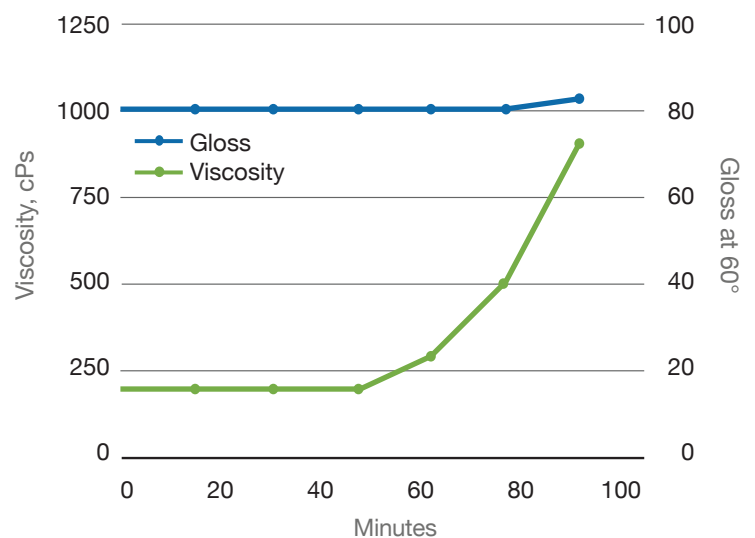
- Completely solvent-free!
- Fast cure and hardness development even at 10°C and 80% relative humidity
- Excellent adhesion over dry and damp concrete and to different metal substrates
- Compatible with standard liquid epoxy and solid epoxy dispersions
- Good formulation latitude:
 - Do not demand emulsifiers
 - Wide compatibility
 - Systems easily reducible in water
- Excellent self-leveling properties
- Visible end of pot life
- Good stain resistance (household and industrial products)
- Low color, good film appearance



**Shore D Hardness at 10°C and 80%RH
Self-leveling formulation**



NX-8101 End of Pot Life



Epoxy Curing Agents

Phenalkamines for Top Coats and Self-Leveling

Weatherability

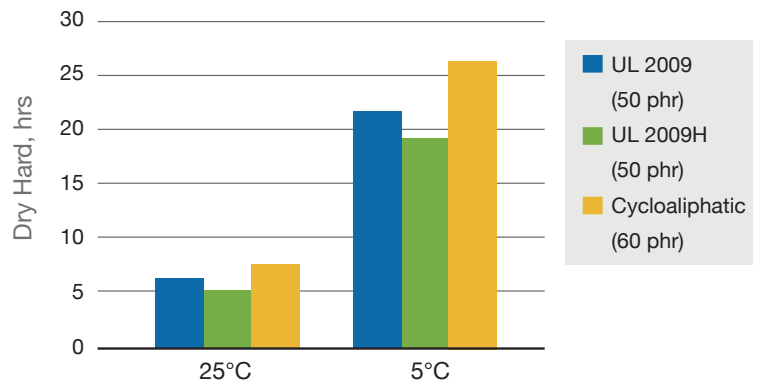
Cardolite offers some specially designed phenalkamines that exhibit good weatherability compared to other amine curing agents. These products show similar or less yellowing than cycloaliphatic curing agents when exposed to sunlight. In addition, these curing agents form a glossy film even at high humidities.

As with other phenalkamines, these products exhibit fast cure and hardness development even at lower temperatures, enable non-critical mix ratio, and provide good impact resistance. They provide excellent water and chemical resistance ensuring top coat durability in industrial environments. Moreover, these curing agents are very resistance to osmotic blistering and provide very good adhesion to primer or concrete. They can also be used in self-leveling coatings to reduce the number of raw materials and inventory.

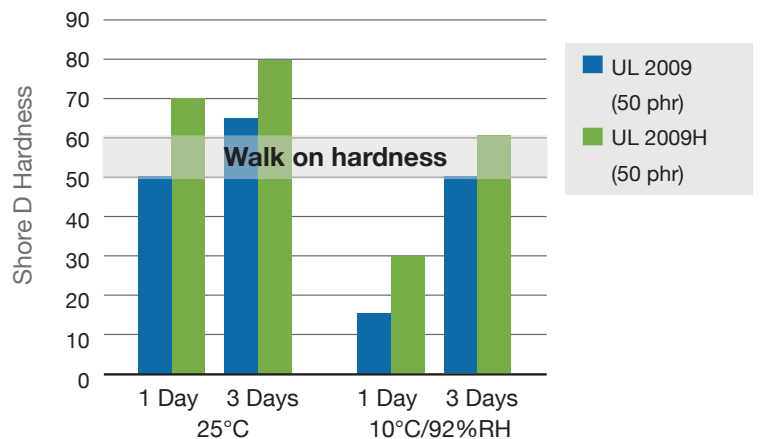
Early Water Resistance

The combination of fast reactivity at a broad temperature range and high hydrophobicity from the cardanol building block results in very good early water resistance in coatings formulated with phenalkamines. This performance property can be of benefit in case of rain or spill shortly after the application of the top coat.

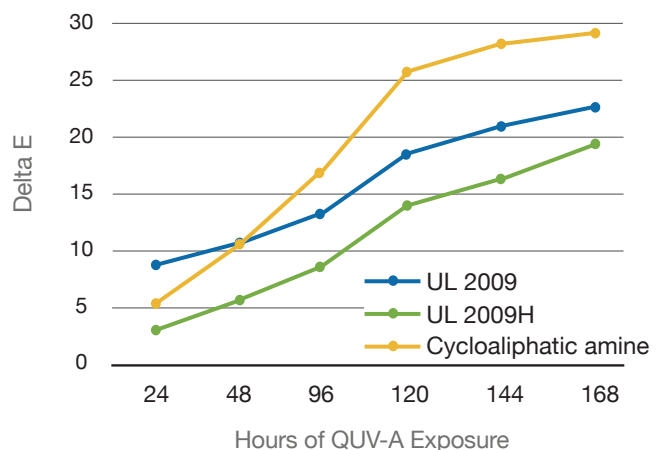
Cure time with Liquid Epoxy (EEW 190)



Hardness Development with Liquid Epoxy (EEW 190) at 25°C and 10°C



Color Stability UL 2009 Family



Phenalkamine Curing Agent Property Selection Chart

Product	Viscosity ¹ @ 25°C (cPs)	Type	Color ² (Gardner)	Amine Value ³ (mg KOH/g)	AHEW ⁴	Gel Time ⁵ (min)	Thin Film ⁶ Dry Hard Time (hours)		
							25°C	5°C	0°C
NC-558	900	solvent free	17	340	95	70	10	27	32
NX-2003	620	solvent free	10	360	95	35	4.5	18.5	22
NX-2003D	700	solvent free	13	357	95	30	4.5	15	24
NX-5454(NS)	1,080	solvent free	11	275	133	18	2	7.5	10
NX-6019(NS)	1,200	solvent free	11	290	133	21	2.5	10	11.5
NX-2007	265	benzyl alcohol	4	310	113	50	2	16	23.5
NX-2009	370	benzyl alcohol	7	310	95	31	4	12	20.5
Ultra LITE 2009	330	benzyl alcohol	1	277	95	34	6	22	32
Ultra LITE 2009SF	5,900	solvent free	2	424	62	43	7	22	n/a
Ultra LITE 2009H	150	benzyl alcohol	1	355	95	29	5	19	30
Ultra LITE 2009HSF	500	solvent free	2	550	62	42	n/a	n/a	n/a
NT-5901	454	non-CNSL benzyl alcohol	1	264	113	55	7.5	n/a	n/a
NX-8101	35,000	50% solids waterborne	8	160	270	45	3	9	n/a

¹ASTM D2196 ²ASTM D1544 ³ASTM D2074 ⁴Theoretical based on total product weight ⁵50g at 25°C (with LER EEW 190) ⁶ASTM D5895 @ 200 micron

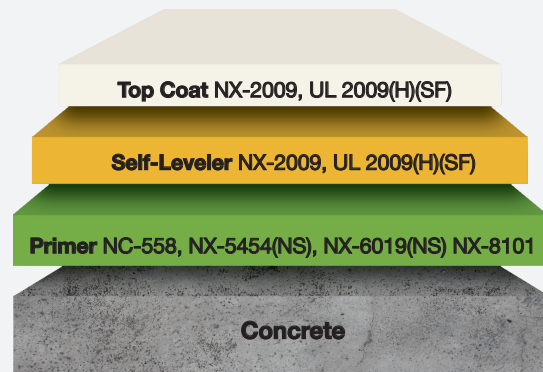
Phenalkamine Curing Agent Performance

Curing Agent	T _g ⁷ (°C)	Tensile Strength (MPa)	Flexural Strength (MPa)	Compressive Strength (MPa)	Elastic Modulus (MPa)	Lap Shear ⁸ (MPa)
NC-558	61	41	105	56	1,985	21
NX-2003	74	55	94	76	2,384	20
NX-2003D	79	51	108	75	2,309	20
NX-5454(NS)	60	47	88	72	2,019	12
NX-2007	70	57	105	88	3,170	14
NX-2009	57	51	101	80	2,500	20
Ultra LITE 2009SF	73	65	119	112	3,159	15

⁷DSC ⁸Sand blasted substrate
 Test specimen cured at 40°C for 16 hours with liquid epoxy (EEW 190)

Application Selection Chart

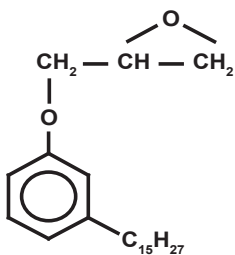
Cardolite offers curing agents for all concrete coating layers. Hardeners recommended as primers offer excellent adhesion to damp, oil contaminated, and dry concrete. Hardeners suggested as top coats provide excellent UV resistance. All of these products have good self-leveling properties with very low viscosities, fast cure, and friendly mix ratios for easy application. The products indicated on the right are the preferred choices.



Epoxy Diluents and Modifiers

In addition to epoxy curing agents, Cardolite offers a line of cardanol derived epoxy diluents and modifiers that provides tools to formulators looking to add unique properties to their floor coatings.

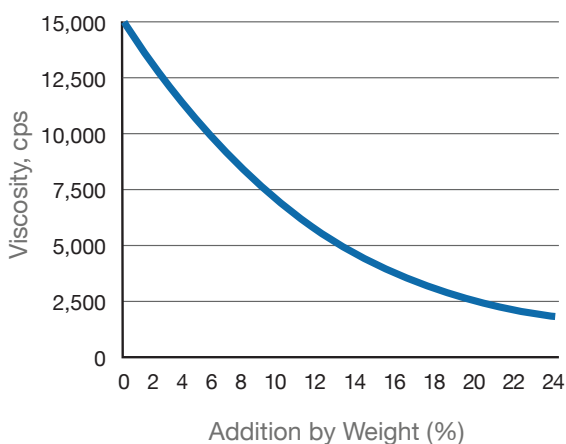
Cardolite NC-513/Ultra LITE 513



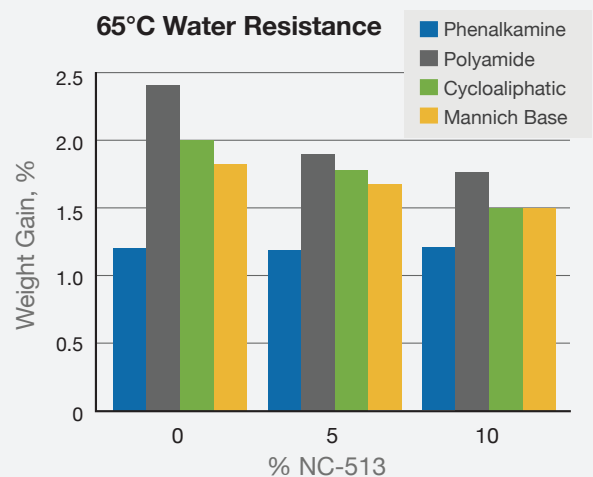
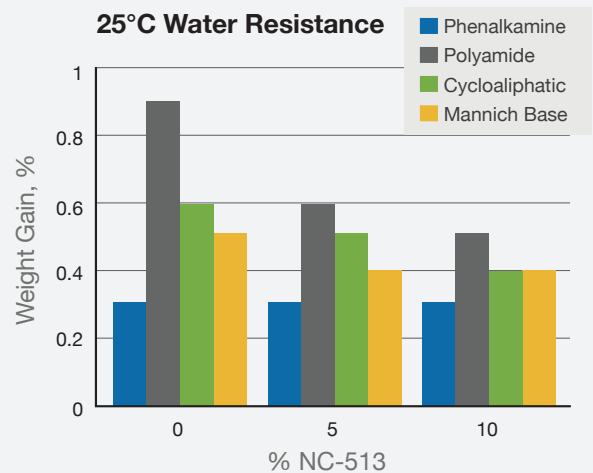
Cardolite Ultra LITE 513 and NC-513 are low viscosity, monofunctional epoxy reactive diluents that can be used to increase flexibility, impact resistance, and water resistance. These reactive diluents are ideal

for formulating low emission and low odor solvent-free floor coatings. Their good reactivity means that these diluents react completely into the epoxy network, which can increase the bond strength. Ultra LITE 513 is a lower viscosity, higher purity, and lighter color version of NC-513. Both grades have a similar chemical make-up and have favorable labeling. They are excellent replacements for toxic or environmentally unfriendly glycidyl ether based diluents.

NC-513 and Ultra LITE 513 Dilution Curve (25°C with Liquid Epoxy Resin, EEW=191)

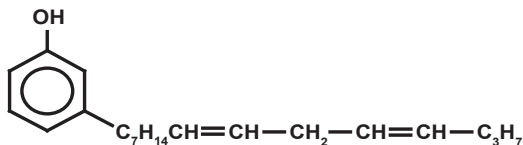


Cardolite NC-513/Ultra LITE 513 Water Resistance





Cardolite NX-202x Series

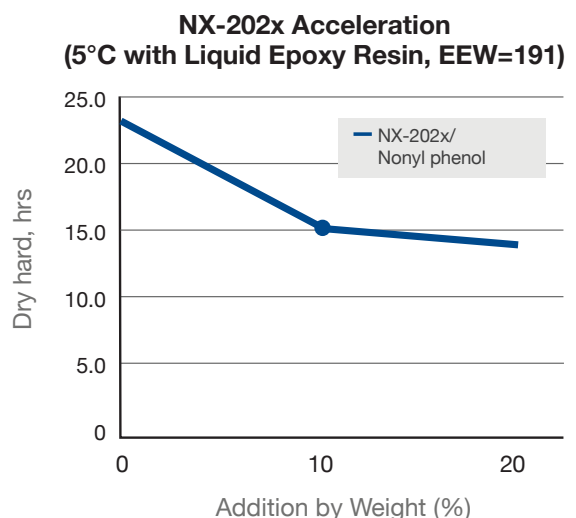
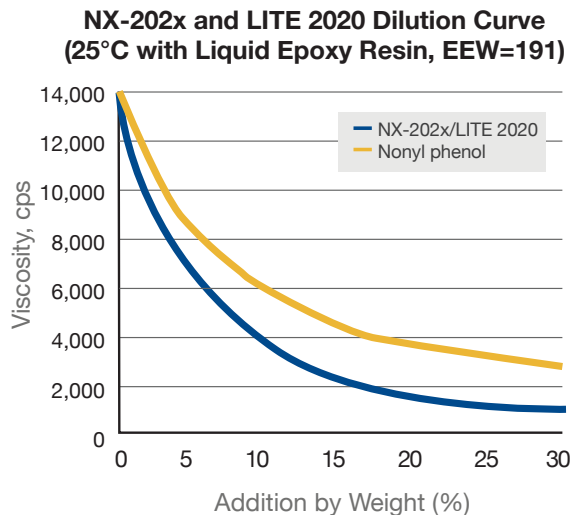
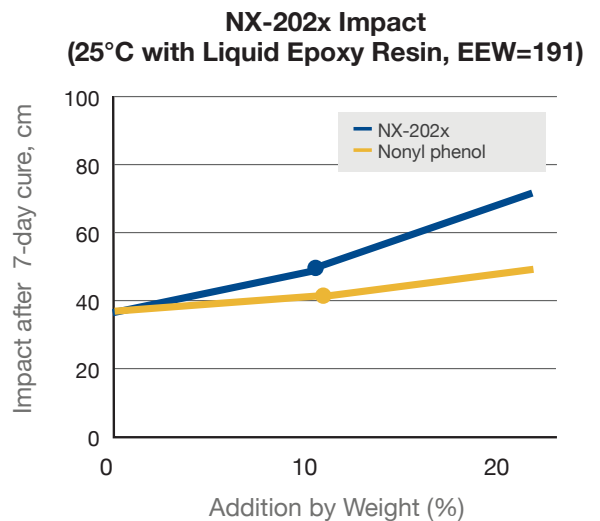


Cardolite NX-202x products are low viscosity multipurpose resin modifiers. The long hydrophobic aliphatic side chain of the cardanol molecule gives these products a very low viscosity and provides excellent early water resistance and corrosion protection. By using NX-202x products as epoxy diluents and accelerators, high solids or solvent free formulations can be achieved with enhanced workability and faster cure without sacrificing other performance properties. In addition, the flexibility of the side chain helps increase impact resistance of the final coating.

Different Grades Available:

- NX-2024: low odor, light color cardanol
- NX-2025: low odor, light color, high purity cardanol
- Ultra LITE 2023: Gardner color 1, wet color stable
- NX-2023: Gardner color ≤ 6 , wet color stable
- NX-2023D: Gardner color ≤ 10 , wet color stable
- NX-2026: Gardner color ≤ 2 , wet color stable

These products are a good alternative to synthetic phenolic diluents that have unfavorable labeling.



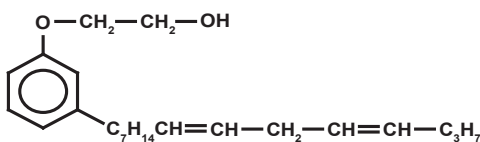
Epoxy Diluent, and Modifier Property Selection Chart

Product	Type	Typical Color ¹ (Gardner)	Typical Viscosity ² (cPs)	EEW ³	Hydrolyzable Chlorine (%)
NC-513	Reactive diluent	9	40 - 70	425 - 575	≤ 2
Ultra LITE 513	Reactive diluent	1	20 - 35	350 - 425	≤ 0.5
NC-514	Epoxy resin	17	25,000	350 - 500	≤ 2
NC-541S	Epoxy resin	12	2,000	350 - 500	≤ 0.5
NC-547	Epoxy novolac resin	18	28,000	550 - 850	≤ 2.5
LITE 2020	Nonreactive resin modifier	≤ 14	30 - 115	-	-
LITE 2100	Hydrocarbon resin modifier	≤ 4	450 - 750	-	-
LITE 2100R	Hydrocarbon resin modifier	≤ 4	500 - 1000	-	-
NX-2023D	Nonreactive resin modifier	≤ 15	80 - 140	-	-
NX-2023	Nonreactive resin modifier	≤ 6	40 - 100	-	-
Ultra LITE 2023	Nonreactive resin modifier	1	40 - 100	-	-
NX-2024	Nonreactive resin modifier	4 - 9	45 - 60	-	-
NX-2025	Nonreactive resin modifier	≤ 5	≤ 60	-	-
NX-2026	Nonreactive resin modifier	≤ 2	≤ 60	-	-

¹ ASTM D1544, ² ASTM D2196 at 25°C, ³ ASTM D1652, ⁴ ASTM D1726

* LITE 2020 and LITE 2100 not approved for sale in Europe

Cardolite LITE 2020*



Cardolite LITE 2020 is a low viscosity multipurpose resin modifier. This resin is non-volatile and is therefore useful for formulating environmentally friendly solvent free coatings. Due to its unique chemical structure, LITE 2020 is more efficient than traditional hydrocarbon resins in reducing viscosity despite being higher in viscosity. Its hydrophobic nature allows for good water resistance.

Cardolite LITE 2100*(R)

Cardolite LITE 2100(R) are low color and low viscosity cashew nutshell liquid modified hydrocarbon resins designed to enable high solids and solvent free formulations by lowering the viscosity of epoxy resins more efficiently than typical phenol based hydrocarbon resins and by improving overall system compatibility for better film formation. These products can increase hardness development of the coating while providing improved flexibility and impact resistance. Moreover, LITE 2100(R) show very good UV resistance with excellent gloss retention for use in lighter color coatings.

CNSL Polyol Resins

Cardolite CNSL-based polyols have unique qualities compared to widely known polyester and polyether polyols, and other natural oil based polyols. CNSL polyols are very hydrophobic because of the long aliphatic chain of cardanol, the absence of ester bonds (hydrolyzable), and fewer ether oxygen atoms compared to typical polyether polyols (less hydrophilic). This hydrophobicity provides excellent water resistance and less moisture sensitivity during cure with isocyanate for increased durability of the final polyurethane system. In addition, CNSL polyols show fast cure with isocyanates minimizing the amount of catalysts required and allowing for quick return-to-service.

Different from other renewable polyols obtained from soy and castor oil, CNSL polyols have an aromatic structure that translates into excellent thermal resistance and chemical resistance to acid and alkaline solutions. Moreover, the combination of aromaticity and long aliphatic chain delivers hydrolytic stability and mechanical strength to CNSL-based polyols.

Advantages:

- Excellent water and moisture resistance
- Quick return-to-service
- Excellent acid and alkali resistance
- Can be tailored for different applications
- Available in low to high functionality
- Very good hydrolytic stability
- Renewable technology
- Favorable labeling

Polyol Property Selection Chart

Product	Type	Typical Color ¹ (Gardner)	Typical Viscosity ² (cPs)	Hydroxyl Value ³ (mg KOH/g)	Hydroxyl Eq. ⁴ Weight (g/mole)
NX-9001	CNSL Polyol - hydrophobic, less moisture sensitivity, flexibility	18	2,000	175	320
NX-9001LV	Low Viscosity NX-9001	18	1,000	175	320
LITE 9001	Low color NX-9001	6	2,000	175	320
NX-9005	Non-CNSL Branched Polyol - good UV resistance	5	3,000	170	330
NX-9007	CNSL Branched Polyol - good UV resistance	14	2,900	175	320

¹ ASTM D1544, ² ASTM D2196 at 25°C, ³ ASTM D1957, ⁴ Calculated





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