



Cardolite

The World Leader in Cashew Liquid Technology

| Coating Products Portfolio





Cardolite Corporation



Cardolite Corporation is a privately held manufacturer of the world's largest variety of products derived from cashew nutshell liquid (CNSL), a renewable natural resource. The unique properties of CNSL are used to develop and produce a wide range of specialty curing agents, resins, and diluents for marine, heavy duty, industrial, protective, and floor coating applications.

With over 25 years of experience, Cardolite is the leader in the production of quality CNSL based materials used in the coatings industry. The company's customer base includes all types of coating companies ranging from the world's largest paint producers to small specialty manufacturers. With sales offices, representatives, and distribution facilities in the Americas, Europe, and Asia, Cardolite prides itself on delivering high quality products and services across the globe.

Cardolite manufactures all products at production plants in Newark, New Jersey (USA) and Zhuhai, Guangdong (China). With well over 35,000 T/yr of total capacity for the coatings product line, these facilities are the largest and most advanced CNSL technology manufacturing facilities in the world. They are designed to support the most demanding customers and provide reliable supply of high quality products. Both Cardolite facilities are ISO 9000 registered and adhere strictly to local and best practice health, safety, environmental, and security standards.

To further advance CNSL technology, Cardolite also operates two advanced research facilities in the USA and China. By using CNSL as a primary building block, these labs are able to develop coating materials that have unique advantages over some traditional coating chemistries. In addition, Cardolite runs a full coating application laboratory in Beijing, China to help customers accelerate time to market and assure product quality and performance.

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

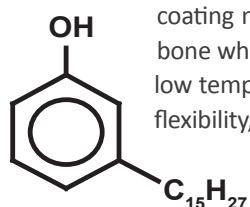


Epoxy Curing Agents

Cardolite offers a full line of epoxy amine curing agents based on CNSL technology for use in the formulation of a wide range of high performance coatings. Applications requiring fast cure, low temperature cure, low VOC, surface tolerance and excellent anti-corrosive protection, such as formulations for marine, protective, industrial, and floor coatings or pipe and tank linings, are especially suitable for Cardolite technology.

CNSL Technology

Cardanol is a unique natural phenolic material obtained by distilling CNSL and serves as the primary building block for Cardolite curing agents. The molecule is composed of an aromatic ring with an OH group and a long aliphatic side chain, which bring valuable intrinsic benefits to



coating materials. The aromatic ring provides a strong chemical resistant backbone while the OH group gives strong adhesion and good reactivity for fast and low temperature cure. The side chain provides excellent water resistance, good flexibility, low viscosity, extended pot life, and excellent corrosion protection.

Green

From the beginning, Cardolite products have been based on cashew nutshell liquid, a natural, non-food chain, and annually renewable biomaterial. The technology has been widely adopted because there are inherent performance benefits gained from using this starting raw material without sacrificing performance or cost. The relatively low viscosity of Cardolite products brings good workability to formulations as coatings trend towards higher solids and solvent free systems for the protection of applicators and the environment.



Phenalkamine Technology

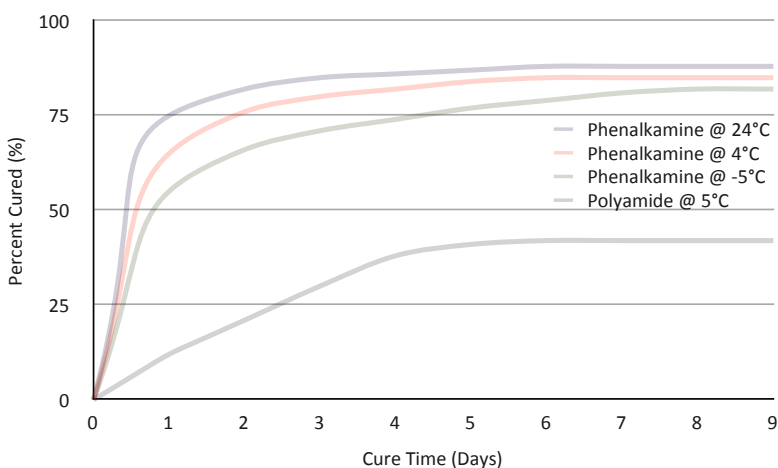
The Mannich reaction of CNSL, formaldehyde, and certain amines is called a phenalkamine. Phenalkamines share some similar advantages to other Mannich base curing agents, such as: extremely fast cure, low temperature cure (even below 0°C), good chemical resistance, good surface appearance, good moisture tolerance, and non-blushing properties. However, due to the long aliphatic side chain of cardanol, phenalkamines also have very good pot life, good flexibility, surface tolerance, and excellent water and salt water resistance. Many Cardolite phenalkamines are also approved for use in food contact and potable water coatings.

The fast and low temperature cure properties of phenalkamines have a number of benefits for coating formulations. Application productivity can be significantly improved and the ability to apply a coating in low temperatures allows for a longer or even year round painting season. Faster cure also means protected surfaces can be re-coated or returned to service more rapidly, including solvent free formulations that will continue to cure when immersed in water and solvent based coatings that will continue to cure in poorly ventilated conditions. In forced cure industrial coating applications, phenalkamines can help save energy by lowering oven cure temperatures, or improving process efficiency via increased production line speeds. Finally, fast cure can also help protect coating manufacturers from coating failures. By reaching a high level of crosslinking very quickly, coatings develop their stability early and avoid problems when the environmental conditions change after application.

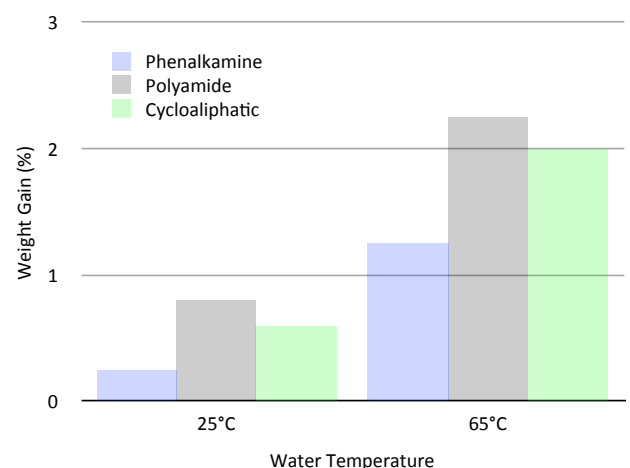
The high hydrophobicity of phenalkamines provided by the long linear side chain also brings many benefits to coating formulations compared with some other technologies. Water sensitivity of the phenolic hydroxyl and other formulation components can be counteracted, which reduces the chance the resin binder barrier will be broken and increases corrosion protection. Adhesion to poorly prepared or tough wet surfaces, such as water saturated concrete is especially good with phenalkamines because this hydrophobic effect ensures surrounding water does not influence the surface resin bond.

With over two decades of research, Cardolite has pioneered new developments in phenalkamine technology such as innovative low viscosity, light colored, and faster curing products. The property and application selection charts to follow can help determine which phenalkamine is appropriate for different formulation and application requirements. In addition, Cardolite has broad expertise and experience supporting, developing, and manufacturing curing agent solutions to fit specific customer needs. If a standard Cardolite product does not function as desired for a specific application, Cardolite can provide formulation technical support and custom modifications from as simple as a solvent cut to as complex as altering the curing agent's fundamental properties.

Phenalkamine Low Temperature Cure Data and Comparison



Comparative Water Resistance of Phenalkamines



Phenalkamine Curing Agent Property Selection Chart

Product	Appearance	Phenalkamine Type	Color (Gardner)	Viscosity @ 25°C (cPs)	Solids (%)	Amine Value (mg KOH/g)
NC-541	Reddish brown	Unmodified	16	28,000	100	330
LITE 2001	Light yellow	Unmodified	10	28,000	100	330
NC-541X90	Reddish brown	Solvent cut	16	4,000	90	300
LITE 2001X90	Light yellow	Solvent cut	10	3,800	90	300
NC-541LV	Reddish brown	Unmodified	15	2,300	100	340
LITE 2001LV	Light yellow	Unmodified	10	2,500	100	340
LITE 2010LV	Orange brown	Unmodified	10	4,100	100	247
NC-562	Orange brown	Adduct	14	1,300	65	185
LITE 2562	Yellow	Adduct	9	1,500	65	180
NC-556x80	Reddish brown	Adduct	14	4,500	80	330
NX-2016	Orange brown	Adduct	15	12,000	75	208
NX-2018	Orange brown	Adduct	16	8,400	75	218
NX-5459	Yellow brown	Adduct	15	1,650	70	205
NX-5050	Dark amber	Adduct	18	770	80	165
NX-5444	Yellow brown	Adduct	8	4,300	80	218
NX-5445	Dark Amber	Adduct	18	1,800	78	155
NX-5406	Yellow brown	Adduct	10	2,600	76	200
NC-540	Reddish brown	Unmodified	15	2,000	>97	535
NC-558	Amber	Unmodified	17	900	100	340
NC-557	Yellow brown	Unmodified	14	1,100	100	355
NC-566	Amber	Unmodified	14	1,800	100	380
NX-2003	Light yellow	Unmodified	10	620	100	360
NX-2003D	Yellow brown	Unmodified	13	700	100	357
NX-5454	Yellow	Unmodified	11	1,080	100	275
NX-5198	Orange	Unmodified	11	140	95	300
LITE 2002	Light yellow	Unmodified	10	450	100	360
LITE 2002LP	Light yellow	Unmodified	10	700	100	360
NX-2007	Light yellow	Unmodified	4	265	100	310
NX-2009	Light yellow	Unmodified	7	370	100	310
NX-4943	Orange Red	Unmodified	14	1,800	100	488
NX-5567	Orange brown	Specially modified	15	770	85	561

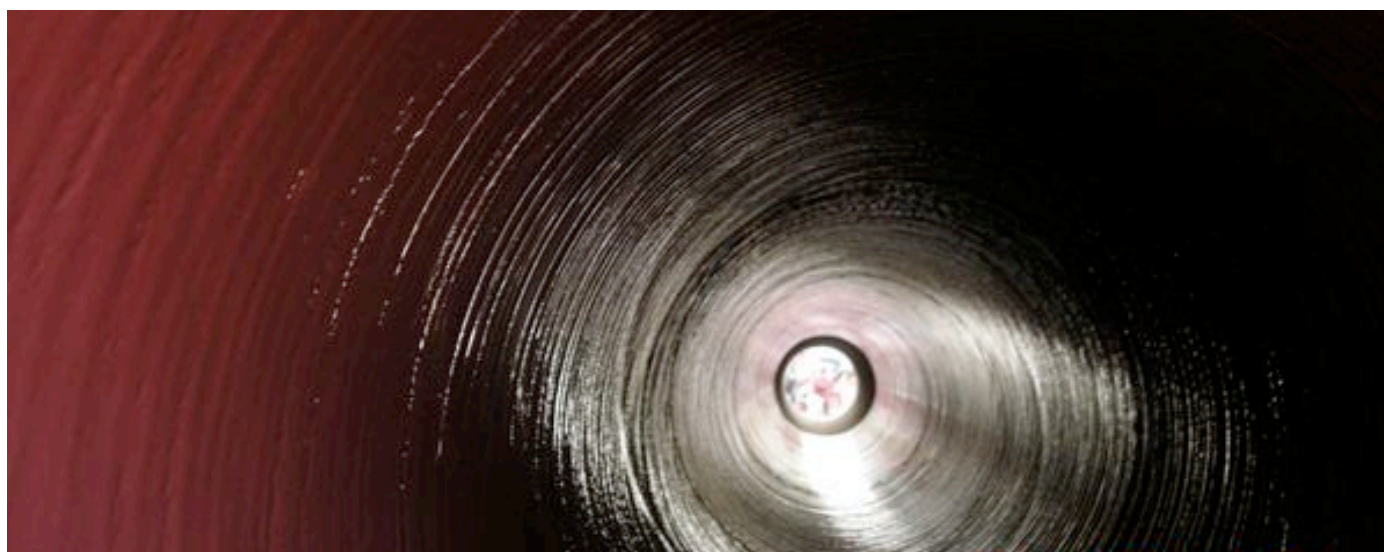
* 200 micron

AHEW	Thin Film* Dry Hard Times (hours)			Key Properties
	25°C	5°C	0°C	
130	4.5	11	20.5	Low temperature cure, surface tolerant, excellent anticorrosion
132	3	12.5	19	Light color
144	5	13	21	Solvent cut for good handling
144	9	17	31	Light color, solvent cut for good handling
125	7	24+	36	Low viscosity for high solids
125	7	17	29	Low viscosity, light color
125	3	13.5	19	Low viscosity, light color, excellent film at extreme conditions
174	3	5	11	Fast cure, good blush resistance and adhesion
174	2.5	7.5	11.5	Light color, fast cure, good blush resistance and adhesion
135	3.5	12	19.5	Fast cure, high solids, good handling viscosity
151	2	6.5	11	Fast cure, high solids
151	3	9	14	Fast cure, cost effective
164	4	12	18	Fast cure, high solids, FDA 175.300
190	2	7.5	11	Very fast cure, high solids, low viscosity
190	1.5	6	6	Fast hardness development, good flexibility, high solids
256	2	6.5	14.5	Very fast cure, high solids, low viscosity
300	2	6	13.5	Very fast cure, high solids
81	3.5	13	19	Low viscosity, surface tolerant, solvent free, good chemical resistance
95	10	22	32	Good film, excellent adhesion, potable water safe
95	7	16.5	27.5	Fast cure, excellent adhesion
95	3.5	9	14	Very fast cure, excellent adhesion
95	4.5	18.5	22	Fast cure, excellent adhesion, light color, solvent free
95	4.5	15	24	Fast cure, excellent adhesion, solvent free
133	2	7.5	10	Very fast cure, excellent film appearance, solvent free
179	2.4	13	-	Fast cure, low viscosity, cost effective
104	6	20	30.5	Low viscosity, light color, excellent anticorrosion
104	7	21	39	LITE 2002 with Improved pot life
113	2	16	23.5	Fast cure, low temperature cure, good flow
95	4	12	20.5	Good film appearance, fast cure, cost effective
82	4	14	23	Excellent chemical resistance, solvent free
66	3	10	15	Excellent chemical resistance, fast cure

Phenalkamine Curing Agent Application Selection Chart

	NC-541 NC-541X90	LITE 2001 LITE 2001X90	NC-541LV	LITE 2001LV LITE 2010LV	NC-562 LITE 2562 NX-2016	NX-5459	NX-2018
Heavy Duty Marine, Protective, and General Industrial Coatings							
Medium Solids (≥65%)	✓	✓	✓		✓	✓	✓
High Solids (≥80%)			✓	✓		✓	
Solvent Free							
Transportation Primers							
Medium Solids (≥65%)					✓		
High Solids (≥80%)						✓	
Potable Water Pipe/Tank Linings*							
Solvent Based	✓		✓	✓			
Solvent Free			✓	✓			
Concrete Coatings							
Solvent Based Primer	✓		✓		✓	✓	✓
Solvent Free Primer				✓			
Topcoat							
Speciality Coatings							
FDA 175.300	✓		✓			✓	
Chemical Resistance							

* Dependent on individual country regulations



NC-556X80	LITE 2002 LITE 2002LP	NX-5406 NX-5050 NX-5445	NX-5444	NC-540 NC-557 NC-566	NC-558 NX-2003(D)	NX-5198 NX-5454	NX-2007 NX-2009	NX-4943 NX-5567
		✓						
✓		✓	✓					
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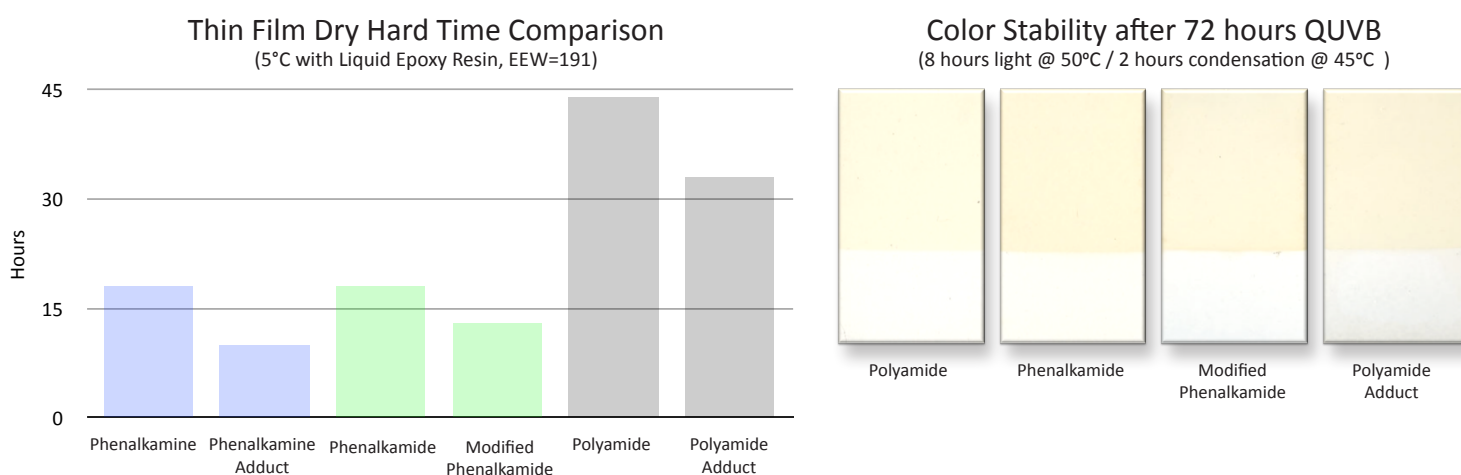


Phenalkamide Technology

Cardolite phenalkamide technology is a new category of epoxy curing agent that fills a gap between polyamide and phenalkamine technology. By chemically combining the two technologies, phenalkamide curing agents offer the benefits of both while mitigating their limitations. The end result is a series of surface tolerant, fast and low temperature curing, light colored epoxy curing agents with excellent anti-corrosion properties, good color stability, and extended overcoatability.

Phenalkamide technology can be used in many applications where polyamide technology currently prevails to bring a new level of performance, reliability, application latitude, and cost savings. General protective coatings, for example, that require good color stability and long overcoatability can avoid having separate summer and winter versions by using a phenalkamide based converter package. The overall system will have fast cure, low temperature cure, and excellent corrosion protection without the need for tertiary amines or anticorrosive pigments. A single formula's broader application latitude gives coating manufacturers protection from summer converter packages being used erroneously in low temperature conditions, and simplifies finished product and raw material inventory management.

The selection chart below can be used to choose the appropriate phenalkamide for different application and formulation requirements.



Phenalkamide Curing Agent Property Selection Chart

Product	Type	Color ¹ (Gardner)	Viscosity ² (cPs)	Solids ³ (%)	AHEW	Dry Speed ⁴ (hours)	Description
LITE 3000	Phenalkamide	9	2,400	70	256	3.5/18	First generation phenalkamide combining and balancing the benefits of phenalkamine and polyamide technologies.
LITE 3000NH	Phenalkamide	9	1,800	70	256	3.5/17	LITE 3000 cut in non-HAPs solvent
LITE 3000BA70	Phenalkamide	10	6,000	100 ⁵	256	4/14	100% solids version of LITE 3000 cut in benzyl alcohol
LITE 3100	Modified Phenalkamide	9	4,500	80	150	2.5/13	Modified version of LITE 3000 with increased cure speed, higher solids, and lower use level
LITE 3100NH	Modified Phenalkamide	9	4,200	80	150	4/8	LITE 3100 cut in non-HAPs solvent
LITE 3005	Phenalkamide	11	1,700	70	256	8/18	NX-5052 is the undiluted version. Cost effective alternative to traditional polyamides with drop-in compatibility and improved performance.
LITE 3040	Phenalkamide	9	5,000	100	118	7.25/29	Low viscosity, solvent free phenalkamide for very high solids coatings. Excellent alternative to 100% solids polyamides.

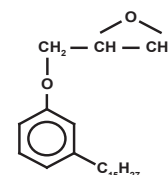
¹ ASTM D1544, ² ASTM D2196 at 25°C, ³ ASTM D2369-98, ⁴ ASTM D5895 dry hard at 25°C/5°C, ⁵ ASTM D2369-98 at 85°C for 30 minutes

Epoxy Resins, Diluents, and Modifiers

In addition to phenalkamine and phenalkamide curing agents, Cardolite offers a line of CNSL derived epoxy resins, diluents, and modifiers that provide tools to formulators looking to add unique properties to their coatings.

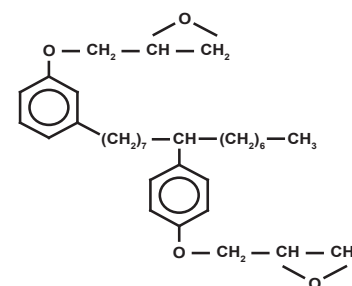
Cardolite NC-513/Ultra LITE 513

Cardolite NC-513 and Ultra LITE 513 are monofunctional reactive epoxy diluents that can be used to increase the flexibility, impact resistance, chemical resistance, and water resistance of epoxy coatings. These reactive diluents have very low viscosity and low volatility, which make them ideal for helping formulate high solids and solvent free coatings. Good reactivity means these diluents react completely into the coating network, and offer low migration levels for the resulting coating. Ultra LITE 513 is a lower viscosity, higher purity, and very low color version of NC-513; they are both identical in chemical make-up.



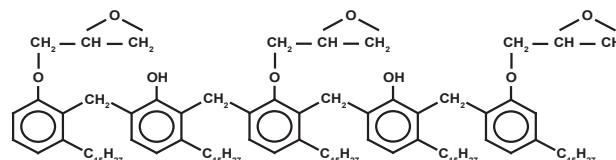
Cardolite NC-514

Cardolite NC-514 is a flexible difunctional glycidyl ether epoxy resin exhibiting the reactivity and chemical characteristics of a traditional bisphenol A type resin. The chain of 8 carbons separating the aromatic groups allows this resin to be used in conjunction with traditional epoxy resins or as a sole resin to increase coating flexibility, abrasion resistance, water resistance, and chemical resistance without adversely affecting other properties.



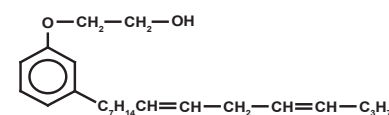
Cardolite NC-547

Cardolite NC-547 is a polyglycidyl ether epoxy novolac resin derived from cardanol. This resin can be used in conjunction with standard epoxy resins to bring additional flexibility and longer pot life to coatings without adversely affecting chemical and water resistance.



Cardolite LITE 2020*

Cardolite LITE 2020 is a low viscosity multi-purpose resin modifier. This resin is 100% non-volatile and is therefore useful for formulating environmentally friendly high solids 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 corrosion resistance and early water resistance.

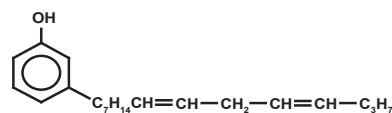


Cardolite LITE 2100*

Cardolite LITE 2100 is a low color and low viscosity cashew nutshell liquid modified hydrocarbon resin. LITE 2100 is recommended as an epoxy modifier for use in protective and industrial coatings, and tar replacement. LITE 2100 is 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 and protective performance. In addition, LITE 2100 shows less effect on dry time than competitive chemistries and it can increase hardness development of the coating while providing improved flexibility and impact resistance. The high hydrophobicity of this product results in excellent water and moisture resistance, and more importantly, excellent corrosion protection on immersed and vapor exposed surfaces. Moreover, LITE 2100 shows very good UV resistance with excellent gloss retention for use in lighter color coatings.

Cardolite NX-202x Product Family

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.



Used as epoxy diluents and accelerators, high viscosity solvent or solvent free formula-

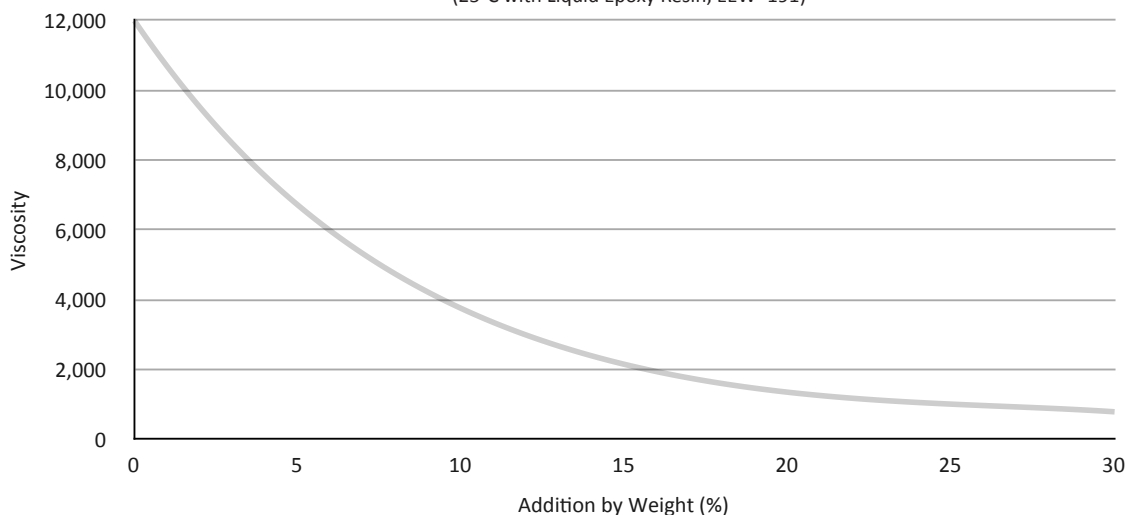
tions can achieve enhanced workability, higher solids, and faster cure without sacrificing other performance properties. NX-2021 is the standard modifier grade while NX-2022 is higher in purity. NX-2024 and NX-2025 are the lower odor and lighter initial color versions of NX-2021 and NX-2022 respectively.

Ultra LITE 2023, NX-2023, and NX-2023D are the wet color stable versions of the NX-202x product family for longer shelf-life at lower colors. Ultra LITE 2023 has the lowest viscosity and typical initial color (Gardner 1) of the three, followed by NX-2023 and NX-2023D as indicated in the selection table.

The graphs below show some examples of dilution efficiency for Cardolite's resin modifiers and reactive diluents, and a selection chart for all resins, diluents, and modifiers follows.

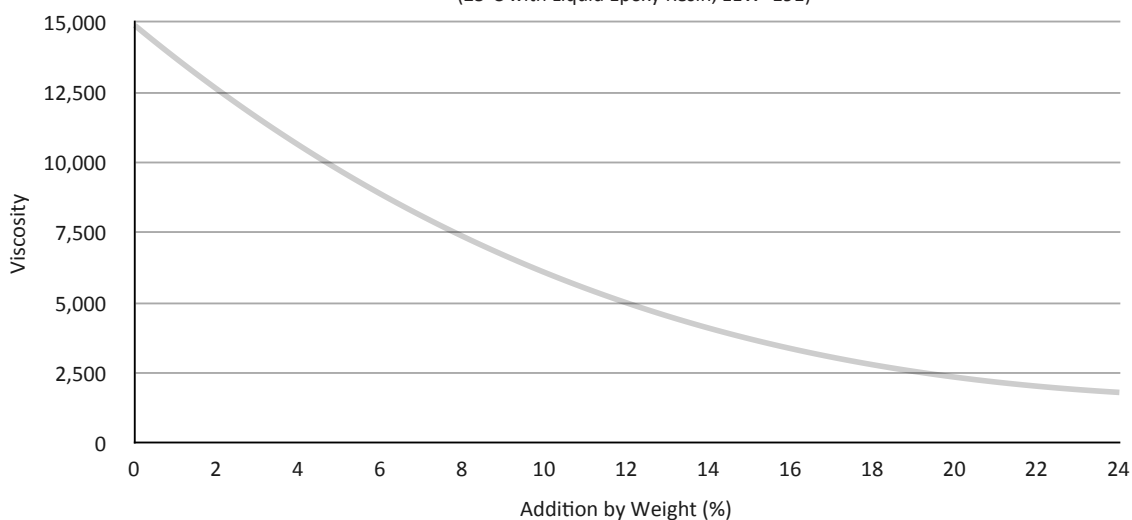
NX-202x and LITE 2020 Dilution Curve

(25°C with Liquid Epoxy Resin, EEW=191)



NC-513 and Ultra LITE 513 Dilution Curve

(25°C with Liquid Epoxy Resin, EEW=191)



Epoxy Resin, Diluent, and Modifier Property Selection Chart

Product	Type	Typical Color ¹ (Gardner)	Typical Viscosity ² (cPs)	Typical Volatile Loss ³ or Solids (%)	EEW	Hydrolyzable Chlorine (%)
NC-513	Reactive diluent	11	50	≤ 0.5	425 - 575	≤ 2
Ultra LITE 513	Reactive diluent	1	24	≤ 0.5	≤ 450	≤ 1
NC-514	Epoxy resin	17	25,000	≤ 3	350 - 500	≤ 2
NC-547	Epoxy novolac resin	18	28,000	≤ 2	550 - 850	≤ 2.5
LITE 2020	Nonreactive resin modifier	12	90	≥ 97 (solids)	-	-
LITE 2100	Hydrocarbon resin modifier	4	450 - 750	≤ 1	-	-
NX-2021	Nonreactive resin modifier	12	60	≤ 0.5	-	-
NX-2022	Nonreactive resin modifier	8	50	≤ 0.5	-	-
Ultra LITE 2023	Nonreactive resin modifier	1	50	≥ 99.5 (solids)	-	-
NX-2023	Nonreactive resin modifier	5	60	≥ 99.5 (solids)	-	-
NX-2023D	Nonreactive resin modifier	10	100	≥ 99.5 (solids)	-	-
NX-2024	Nonreactive resin modifier	4 - 9	50	≤ 0.5	-	-
NX-2025	Nonreactive resin modifier	≤ 5	50	≤ 0.5	-	-

¹ ASTM D1544, ² ASTM D2196 at 25°C, ³ ASTM D2369-98, * LITE 2020 and LITE 2100 not approved for sale in Europe

CNSL Polyols

In addition to epoxy curing agents, resins and modifiers, Cardolite offers a line of renewable, CNSL based polyols that have unique qualities compared to other polyester or polyether polyols. CNSL polyols have improved water resistance because of their long aliphatic chain, the absence of ester bonds (hydrolysable), and fewer ether oxygen atoms compared to typical polyether polyols (less hydrophilic). Cardolite polyols designed for polyurethane coatings applications have shown excellent resistance to salt water, acid, and alkali solutions. This allows polyurethanes to withstand unfavorable conditions such as those encountered by pipes buried in soils of varied pH around the world. In addition, CNSL polyols provide very fast cure for quick return to service. The following table contains CNSL polyols currently available from Cardolite.

Product	Type	Color ¹ (Gardner)	Viscosity ² (cPs)	Hydroxyl Value ³ (mg KOH/g)	Hydroxyl Eq. Weight ³ (g/mole)	Solids ⁴ (%)
NX-9001	CNSL Polyol	18	2,000	175	320	98
NX-9001LV	Low Viscosity CNSL Polyol	18	1,000	175	320	98

¹ ASTM D1544, ² ASTM D2196 at 25°C, ³ GPC, ⁴ ASTM D2369-98





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