Epoxy Curing Agents and Modifiers

SUNMIDE® CX-1151 Epoxy Curing Agent

DESCRIPTION

Sunmide CX-1151 curing agent is a phenalkamine based modified polyamine. This product can be used high-solids ambient-cure epoxy coatings by using liquid and semi-solid epoxy resin. Sunmide CX-1151 curative provides fast drying time at low temperature, high corrosion and chemical resistance. Sunmide CX-1151 curative is very well suited for use in the most demanding heavy-duty coatings applications at low temperatures.

ADVANTAGES

- Fast cure and drying time at low temperatures
- Good solvent resistance
- Good corrosion protection
- High gloss
- Good blush resistance

APPLICATIONS

- Marine coatings
- Industrial maintenance
- OEM primers
- High build and barrier coatings

SHELF LIFE

At least 24 months from the date of manufacture in the original sealed container at ambient temperature.

STORAGE AND HANDLING

Refer to the Safety Data Sheet on Sunmide CX-1151 curing agent.

TABLE 1: TYPICAL PROPERTIES

Appearance	Amber colored liquid
Color (Gardner)	18 max
Solids content [%]	80
Viscosity (at 77˚F), cP	2,620
Amine Value (mg/KOH/g)	175
Specific Gravity @ 77˚F	1.02
Flash Point (˚F), closed cup	60
Equivalent Wt/{H}	255
Recommended Use Level, [PHR]	112

TABLE 2: TYPICAL HANDLING PROPERTIES

Mixed Viscosity (cPs)*	3,350
Gel Time (150g mix) (min)	62.7
Thin Film Set Time (h) @ 77˚F[1]	1.75
Thin Film Set Time (h) @ 40˚F[1]	4.00
Thin Film Set Time (h) @ 5˚F[1]	> 24
Peak Exotherm (100g mass) ˚F	236
Peak Exotherm Time (min)	45

*Mix viscosity represents the viscosity after only mixing liquid epoxy resins and Sunmide CX-1151 curing agent.

TABLE 3: TYPICAL PERFORMANCE

Glass Transition Temp (˚F)	97
Hardness (Shore D)	52
Adhesion to steel (psi) 7 day cure @ 77˚F	100

Footnote:
(1) ASTM D 1544-80

SUPPLEMENTARY DATA

Fast Dry Time

Figure 1 shows the thin-film dry time of a modified polyamide and Sunmide CX-1151 curing agents mixed with liquid epoxy resins. Figure 1 also shows the thin film dry times of preliminary formulations based on a modified polyamide and Sunmide CX-1151 curative for anti-corrosive primers. The thin film dry time of Sunmide CX-1151 curing agent with liquid epoxy resin and of the primer based on Sunmide CX-1151 at room temperature and 40ºF was much faster than a modified polyamide. The thin film dry time at low temperatures (5ºF) of Sunmide CX-1151 and a modified polyamide curing agents with liquid epoxy resin was greater than 24 hours. The thin film dry time of the primer formulation based on Sunmide CX-1151 was about 19 hours and faster than the primer formulation based on a modified polyamide, which was over 24 hours.

Sunmide CX-1151 curing agent is designed to cure fast at temperatures as low as 5ºF when mixed with liquid epoxy resins. It produces hard, high-gloss coatings which are highly resistant to amine blush even when cured at very low temperatures.

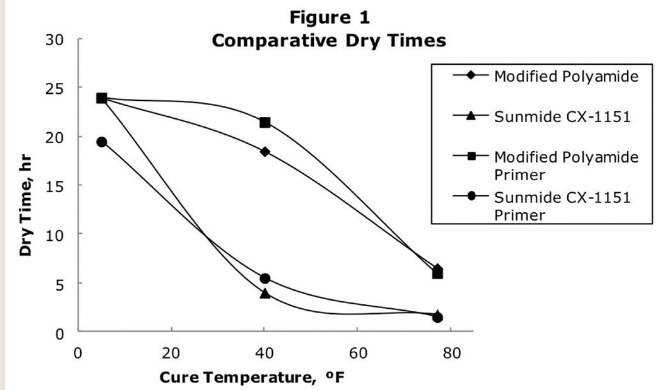
Hardness Development

Gel time and thin film set time are good indicators of cure, but often do not accurately predict the development of hardness. Table 4 contrasts the Shore D hardness development of a modified polyamide and Sunmide CX-1151 curing agents mixed with liquid epoxy resins with preliminary formulations based on a modified polyamide and Sunmide CX-1151 curing agents for anti-corrosion primers.

Viscosity And Gel Time

Viscosity (Figure 2) and gel time (Figure 3) measurements at room temperature of a modified polyamide and Sunmide CX-1151 curing agents mixed with liquid epoxy resins, as well as preliminary formulations based on a modified polyamide and Sunmide CX-1151 for anti-corrosive primers, were measured over time to determine the working time of the formulations. The reactivity of Sunmide CX-1151 at room temperature was higher than that of a modified polyamide.

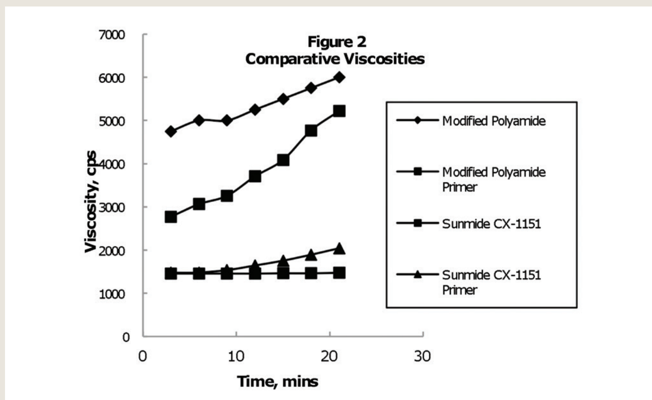
Similarly, the gel time of Sunmide CX-1151 curing agent mixed with liquid epoxy resin and primer formulation based on Sunmide CX-1151 curative at room temperature were shorter than a modified polyamide curing agent. This provides for a faster curing agent for low temperature applications.

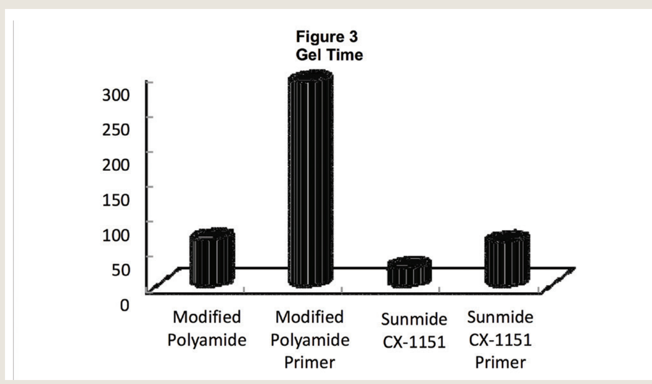


Note: Set to touch times were measured using a BK dry time recorder.

TABLE 4: SHORE D HARDNESS DEVELOPMENT OF A MODIFIED POLYAMIDE AND SUNMIDE CX-1151 AS A FUNCTION OF 77ºF CURE FOR A ¼ INCH THICK CASTING.

	Modified Polyamide	Sunmide CX-1151	Modified Polyamide Primer	Sunmide CX-1151 Primer
1 Day	75	28	40	35
7 Days	78	69	52	42
14 Days	80	70	55	45





Coating Properties

Table 5 shows the coating properties of a modified polyamide and Sunmide CX-1151 curing agents mixed with liquid epoxy resins as well as preliminary formulations based on a modified polyamide and Sunmide CX-1151 for anti-corrosive primers.

TABLE 5: COATING PROPERTIES

	Modified Polyamide	Modified Polyamide Primer	Sunmide CX-1151	Sunmide CX-1151 Primer
Cure Time	7 days	7 days	7 days	7 days
Appearance	Clear, tack- free	Red, tack- free	Clear, tack- free	Red, tack- free
Direct Impact (in/lb)²	20	36	112	28
Reverse Impact (in/lb)²	0	0	20	0
Persoz Hardness	280	323	181	230
Gloss, 60°	107	87	123	61

Note: Pigmented formulations based on epoxy resin (EEW = 214) were mixed with each curing agent applied to cold rolled steel panels (S) (~4 mils DFT) and cured for 7 days at room temperature before testing.

Sunmide CX-1151 Starting Formulations

TABLE 6: EPOXY AND CURING AGENT MIXTURE ONLY

Components		Weight %
PART A		
Epon 828 (Epoxy Resin Solution, EEW=190)	Momentive Performance Materials	36.29
DER 671 X75 (EEW=650)	Dow Chemical Company	7.72
Epodil® 742 Diluent (EEW=182)	Evonik	3.09
PART B		
Sunmide CX-1151	Evonik	52.89
	TOTAL	100.00

TABLE 7: PROPERTIES

Property	Value
Viscosity, cP	3,350
PVC, %	0
NVM, %	87.49
NVV, %	88.81
Density, g/mL	1.08
VOC, g/L	134.57

TABLE 8: PRIMER FORMULATION—PART A

Components		Weight %
Epon 828 (Epoxy Resin Solution, EEw=190)	Momentive Performance Materials	28.44
DER 671 X75 (EEW=650)	Dow Chemical Company	6.05
Epodil 742 Diluent (EEW=182)	Evonik	2.42
Talc (Nicron 503)	Luzenac America, Inc.	20.58
Titanium Dioxide	Dupont	6.05
Red Iron Oxide	Heubach	3.63
Mica WG-325	Kings Mountain Minerals, Inc.	6.05
Barium sulfate (barites)	Cimbar Performance Material	14.52
Xylene	Fisher Scientific	5.45
Methyl Ethyl Ketone	Fisher Scientific	1.21
1-butanol	Sigma-Aldrich	1.51
Dowanol PM Glycol Ether	Eastman Chemical Company	2.66
Disparlon 6650	King Industries	073
Silquest A 187	Momentive Performance Materials	0.69
	TOTAL	100.00

TABLE 9: PRIMER FORMULATION—PART B

Components		Weight %
Sunmide CX-1151	Evonik	94.79
Ancamine® K54	Evonik	0.64
Xylene	Fisher Scientific	2.29
1-butanol	Sigma-Aldrich	2.29
	TOTAL	100.00

Use Level, phr: 43.73

TABLE 10: PROPERTIES

Property	Value
Viscosity, cP	1,475
PVC, %	19.57
NVM, %	84.25
NVV, %	76.54
Density, g/mL	1.37
VOC, g/L	215.80

(1) Thin film Set Time in accordance with ASTM D5895 using a BYK drying time recorder, 77°F, 40°F and 5°F.

(2) Impact Resistance in accordance with ASTM D 2794

(3) Viscosity measurements - Brookfield viscometer LV, spindle 27, 77°F.

Modified Polyamide Starting Formulations

TABLE 11: EPOXY AND CURING AGENT MIXTURE ONLY

Components		Weight %
PART A		
Epon 828 (Epoxy Resin Solution, EEW=190)	Momentive Performance Materials	51.30
DER 671 X75 (EEW=650)	Dow Chemical Company	10.91
Epodil 742 Diluent (EEW=182)	Evonik	4.37
PART B		
Modified Polyamide	Evonik	33.42
	TOTAL	100.00

TABLE 12: PROPERTIES

Property	Value
Viscosity, cP	4,750
PVC, %	0
NVM, %	97.27
NVV, %	97.08
Density, g/mL	1.10
VOC, g/L	29.93

TABLE 13: PRIMER FORMULATION—PART A

Components		Weight %
Epon 828 (Epoxy Resin Solution, EEw=190)	Momentive Performance Materials	31.21
DER 671 X75 (EEW=650)	Dow Chemical Company	6.64
Epodil 742 Diluent (EEW=182)	Evonik	2.66
Talc (Nicron 503)	Luzenac America, Inc.	23.90
Titanium Dioxide	Dupont	3.98
Red Iron Oxide	Heubach	2.66
Mica WG-325	Kings Mountain Minerals, Inc.	5.31
Barium sulfate (barites)	Cimbar Performance Material	6.64
Xylene	Fisher Scientific	6.64
Methyl Ethyl Ketone	Fisher Scientific	2.66
1-butanol	Sigma-Aldrich	2.66
Dowanol PM Glycol Ether	Eastman Chemical Company	2.66
Disparlon 6650	King Industries Momentive	0.80
Silquest A 187	Performance Materials	1.59
	TOTAL	100.00

TABLE 14: PRIMER FORMULATION—PART B

Components		Weight %
Modified Polyamide	Evonik	89.92
Ancamine K54	Evonik	1.24
Xylene	Fisher Scientific	4.42
1-butanol	Sigma-Aldrich	4.42
	TOTAL	100.00

Use Level, phr: 22.61

TABLE 15: PROPERTIES

Property	Value
Viscosity, cPs	1456
PVC, %	20.16
NVM, %	85.10
NVV, %	76.75
Density, g/mL	1.34
VOC, g/L	200.16

(1) Thin film Set Time in accordance with ASTM D5895 using a BYK drying time recorder, 77°F, 40°F and 5°F.

(2) Impact Resistance in accordance with ASTM D 2794

(3) Viscosity measurements - Brookfield viscometer LV, spindle 27, 77°F.

CATHODIC DISBONDMENT

The increased use of cathodic protection in pipelines, ships, and other structures places additional demands on coating systems.

Cathodic protection prevents corrosion by converting the asset from an anode to a cathode using a connected sacrificial material to act as the anode. An electrical current may also be necessary.

Cathodic disbondment is a phenomenon during which a coating used in a cathodic protection service loses adhesion with the substrate metal. Cathodic disbondment can be affected by the coating formulation (including the curing agent), the extent of cure and coating thickness.

Evonik used industry standard ASTM G42 to challenge Sunmide CX-1151 in a primer formulation for cathodic disbondment. Designed to simulate pipeline coatings under elevated temperature, ASTM G42 calls for a standard coating formulation at 30-35 mil thickness to be immersed in an electrolyte solution for 28 days at 60ºC. During the test, the reference and applied voltages were recorded along with the impressed current. After immersion, the panels were then washed, visually inspected, and attempts were made to remove the coating. The extent of disbondment was measured.

The results were as follows, indicating suitability of formulations using Sunmide CX-1151 cathodic protection service.

Properties	Sunmide CX-1151
Delamination	<1.0mm
Blistering	None
Observed corrosion	None
Recommendation	Recommended for CD applications

Appendix 1

The formulation parameters were as follows:

- **Standard LER (EEW=190; DER 331 or Epon 828)**
- **PVC = 20%**

Part A	Weight (kg)	Volume (gal)
Epon 828	327.30	33.74
Nuosperse 657	5.24	0.68
Xylene	70.04	9.68
MIBK	32.73	4.89
Aromatic 100	72.01	9.88
TiO_2	130.92	3.93
Talcron MP 10-52	399.31	17.10
Part B	**Weight (kg)**	**Volume (gal)**
Sunmide CX-1151	425.0	50.0

TEST PARAMETERS

Test parameters included both formulation parameters and cathodic disbonding test parameters.

The cathodic disbonding test parameters:

- 28 days of immersion at a constant 60ºC
- Coating thickness of 30-35 mil
- Panel construction: hot rolled sand blasted steel
- Reference voltage: 1.5V
- 3% electrolyte solution comprised of 1 wt% each of: NaCl, Na_2SO_4, Na_2CO_3
- Reference electrode: Ag/Cl
- Holiday diameter: ¼ inch

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