Epoxy Curing Agents and Modifiers

ANCAMINE® 2280 Curing Agent

DESCRIPTION

Ancamine 2280 curing agent is a low-viscosity modified cycloaliphatic amine designed for use with liquid epoxy resins in two-package formulations. It yields formulations with excellent chemical resistance, waterspot resistance and resistance to amine blush. These properties make Ancamine 2280 ideal for formulating flooring, coatings and linings.

ADVANTAGES

- Excellent resistance to amine blush and waterspotting at ambient and low temperatures
- Excellent chemical resistance
- Good low-temperature cure
- Low skin irritation — DOT noncorrosive

APPLICATIONS

- Industrial flooring
- High-solids coatings
- Chemically resistance linings and mortars
- Secondary containment linings

SHELF LIFE

At least 24 months from the date of manufacture in the original sealed container at ambient temperature. Store away from excessive heat and humidity in tightly closed containers.

STORAGE AND HANDLING

Refer to the Material Safety Data Sheet for Ancamine 2280 curing agent.

TYPICAL CURE SCHEDULE

7 days at ambient temperature.

TABLE 1: TYPICAL PROPERTIES

Appearance	Amber Liquid
Color[1] (Gardner)	8
Viscosity[2] @ 77°F (cP)	450
Amine Value[3] (mg KOH/g)	250
Specific Gravity[4] @ 70°F	1.06
Flash Point[5] (closed cup), °F	>200
Equivalent Wt/{H}	110
Recommended Use Level, (phr, EEW=182)	58

TABLE 2: TYPICAL HANDLING PROPERTIES*

	A*	B*
Use Level (phr)	58	55.9
Mixed Viscosity[2] @ 77°F (cP)	2,860	1,240
Gel Time[6] (min) (150g mix @ 77°F)	50	79
(150g mix @ 50°F)	113	235
Thin Film Set Time[7] @ 77°F (h)	6.0	8.8
@ 50°F	13	22.5
@ 40°F	19	29
Peak Exotherm[(8)] (150g mix @ 77°F)	250	—

TABLE 3: TYPICAL PERFORMANCE*

7 day cure @ 77°F	A*	B*
Glass Transition Temperature[9] (°F)	122	—
Compressive Strength @ yield[10] (psi)	10,400	6,900
Compressive Modulus[10] (thousand psi)	307	231
Tensile Strength[11] (psi)	7,600	4,900
Tensile Modulus[11] (thousand psi)	390	218
Tensile Elongation[11] @ break (%)	3.2	12
Flexural Strength[12] (psi)	13,600	9,700
Flexural Modulus[12] (thousand psi)	500	303
Hardness[13] (Shore D)	78	78
60° Specular Gloss[14]	104	—
Abrasion Resistance[15] Weight Loss (@ 1,000 cycles with wheel no. 10)(grams)	—	0.052
Mar Resistance[16] (kg)	—	1.05

A* Ancamine 2280 formulated with standard Bisphenol-A based (DGEBA, EEW=190) epoxy resin.

B* Ancamine 2280 with 90% DGEBA resin (EEW=190) and 10% Epodil® 748 diluent (C_{12}-C_{14} alkyl glycidyl ether).

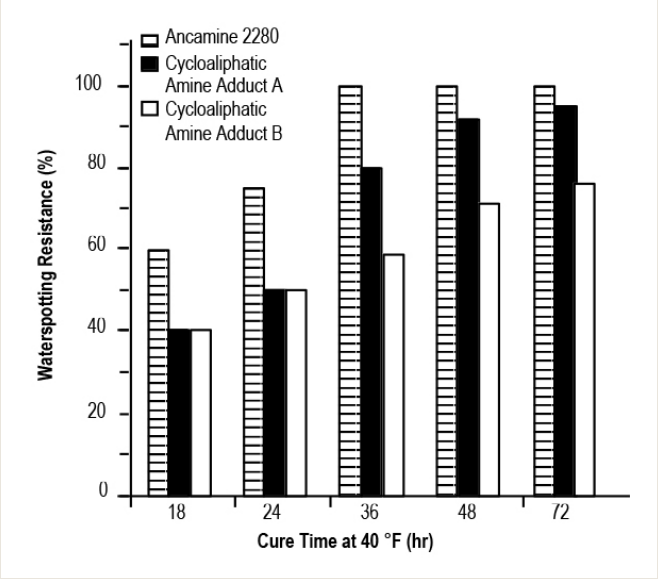
NOTE: Please see last page for footnotes

SUPPLEMENTARY DATA

EXCELLENT WATERSPOTTING RESISTANCE: Curing agents were combined at recommended mix ratios with standard liquid epoxy resin (EEW=190). 10 mil films were applied to steel Q panels and cured at 40°F, 90% RH. After 18, 24, 36, 48 and 72 hours, water saturated cotton was placed on each film for 24 hours. The coatings were then evaluated for waterspotting resistance.

As shown in Figure 1, Ancamine 2280 curing agent provides excellent waterspotting resistance, superior to standard cycloaliphatic amine curing agents. It rapidly develops resistance to amine blush and exudation, even when cured at reduced temperature (40°F) and high humidity (90% RH).

FIGURE 1:
WATERSPOTTING RESISTANCE OF CYCLOALIPHATIC AMINE CURING AGENTS



EXCELLENT CHEMICAL RESISTANCE—IMMERSION RESISTANCE: Chemical immersion studies following ASTM D543 were performed on coupons using standard bisphenol-A (EEW=190) resin and bisphenol-F (EEW=170) resin. Ancamine 2280 and three industry standard curing agents were mixed with the resins at recommended use levels and cured for 7 days at 77°F. The coupons were then immersed in the reagents at 77°F and percent weight gain was measured after specified time periods. A lower weight gain generally indicates better chemical resistance.

As shown in Table 4, Ancamine 2280 curing agent, when combined with bisphenol-A epoxy, provides excellent chemical resistance to many typical solvents, acids and bases. And, data in Table 5 shows chemical resistance of Ancamine 2280 curing agent can be enhanced with the use of bisphenol-F epoxy in applications requiring improved chemical resistance.

Chemical resistance of Ancamine 2280-cured formulations can be further optimized for specific chemicals using different resin blends. Table 6 shows immersion data for Ancamine 2280 with a bisphenol-F/multifunctional epoxy novolac resin blend.

Ancamine 2280 curing agent imparts outstanding chemical resistance with this resin blend to all of the reagents except MEK.

Another advantage of Ancamine 2280 curing agent is that it offers formulating flexibility for chemical resistance depending on the specific chemical environment. To demonstrate this, Ancamine 2280 was mixed with bisphenol-A epoxy (EEW=190) at 53, 58 and 63 phr. Samples were cured for 7 days at ambient temperature before immersion.

As shown in Figure 2, higher use of Ancamine 2280 improves hydrocarbon resistance, while lower use levels improve aqueous acid resistance. At all use levels, resistance to water is good.

TABLE 4: COMPARATIVE CHEMICAL RESISTANCE[17] WITH BISPHENOL-A EPOXY RESIN—PERCENT WEIGHT GAIN

Reagent	Immersion Time	Ancamine 2280	Cycloaliphatic Mannich Base	Cycloaliphatic Amine Adduct C	Cycloaliphatic Amine Adduct D
Xylene	3 Week	0.1	0.4	1.0	2.3
	3 Month	0.01	0.9	-1.0	10.1
Toluene	3 Week	2.3	3.3	6.6	29.2
	3 Month	6.5	11.8	17.3	Destroyed
Trichloroethane	3 Week	0.1	0.0	0.3	1.2
	3 Month	0.1	0.0	0.5	4.5
Ethylene Glycol Monobutyl Ether	3 Week	2.4	6.5	2.5	6.2
	3 Month	5.1	13.5	5.5	10.5
Methyl Ethyl Ketone	3 Week	Destroyed	Destroyed	Destroyed	Destroyed
	3 Month	Destroyed	Destroyed	Destroyed	Destroyed
Ethanol	3 Week	6.98	10.7	5.0	5.2
	3 Month	3.5	5.8	3.2	9.7
Skydrol	3 Week	-0.3	-0.1	-0.3	—
	3 Month	-0.7	-0.3	-0.8	—
D. I. Water	3 Week	1.2	0.9	1.1	0.8
	3 Month	1.7	1.7	1.6	1.7
10% Acetic Acid	3 Week	5.4	5.0	4.6	12.2
	3 Month	9.6	9.1	8.2	22.0
5% Acetic Acid	3 Week	2.6	2.1	2.8	4.0
	3 Month	4.4	3.6	4.8	7.6
10% Lactic Acid	3 Week	1.9	2.5	1.7	8.7
	3 Month	3.4	4.6	2.9	16.4
70% Sulfuric Acid	3 Week	0.2	0.2	0.0	1.0
	3 Month	0.2	0.1	-0.1	1.9
50% NaOH	3 Week	-0.2	-0.2	-0.2	-0.1
	3 Month	-0.2	-0.3	-0.3	-0.1

TABLE 5: COMPARATIVE CHEMICAL RESISTANCE[17] WITH BISPHENOL-F EPOXY RESIN—PERCENT WEIGHT GAIN

Reagent	Immersion Time	Ancamine 2280	Cycloaliphatic Mannich Base	Aliphatic Amine Mannich Base
98% Sulfuric Acid	1 Day	1.2	1.5	-0.5
	1 Week	1.3	-0.2	-7.1
	3 Week	-0.1	-1.8	-16.4
	3 Month	-2.0	-3.8	-48.5
Toluene	1 Day	0	—	0.0
	1 Week	0.6	—	0.0
	3 Week	1.3	—	0.1
	3 Month	2.4	—	0.4
Ethanol	1 Day	1.4	—	0.5
	1 Week	3.5	—	1.3
	3 Week	6.0	—	2.5
	3 Month	2.4	—	4.9
25% Acetic Acid	1 Day	3.1	3.1	10.1
	1 Week	8.7	9.3	29.6
	3 Week	16.2	16.0	Destroyed
	3 Month	25.6	24.7	Destroyed

SPILLAGE RESISTANCE: Spillage resistance studies were conducted on Ancamine 2280 curing agent formulated with a 90% bisphenol-A resin (EEW=190) and 10% Epodil 748 diluent (C_{12}-C_{14} alkyl glycidyl ether) blend cured for 7 days at 77°F. Table 7 shows the immersion/recovery schedule for the testing. Percentage weight change and Shore D hardness were measured after each of the immersion periods. The samples were then allowed to recover before reimmersion for the next time period. Hardness retention is relevant in flooring applications where it indicates the ability of the floor to support traffic after exposure to chemical spills. Results of this study are presented in Table 8. These results show that Ancamine 2280 is very suitable for flooring systems that require high resistance to a variety of chemicals.

For information on chemical resistance of many other Evonik curing agents, please refer to our bulletin "Chemical Resistance for Ambient Cure Epoxy Formulations."

TABLE 6:
CHEMICAL RESISTANCE FOR ANCAMINE 2280 WITH BISPHENOL-F/NOVOLAC RESIN BLEND—% WEIGHT CHANGE AS A FUNCTION OF TIME—CONTINUOUS IMMERSION

Reagent	3 day % Weight Change	28 day % Weight Change
Deionized Water	0.55	1.61
Methanol	8.94	8.76
Ethanol	1.92	5.19
Toluene	0.05	0.56
Xylene	0.00	0.09
Butyl Cellosolve	0.25	0.97
MEK	15.70	D@5
10% Lactic Acid	1.06	3.35
10% Acetic Acid	2.25	6.64
70% Sulfuric Acid	0.03	0.08
98% Sulfuric Acid	0.46	-1.63
50% Sodium Hydroxide	-0.01	-0.04
10% Sodium Hypochlorite	0.55	1.24
1,1,1 Trichloroethane	0.07	0.35

NOTE: Samples were cured for 7 days at 77°F before testing. Tested in accordance with ASTM D543-84. Bisphenol-F / Novolac Resin blend tested is 60 wt.% Epon 862 (EEW=172) and 40 wt.% D.E.N. 431 (EEW=176).

FIGURE 2:
CHEMICAL RESISTANCE CAN BE IMPROVED BY ADJUSTING MIX RATIO

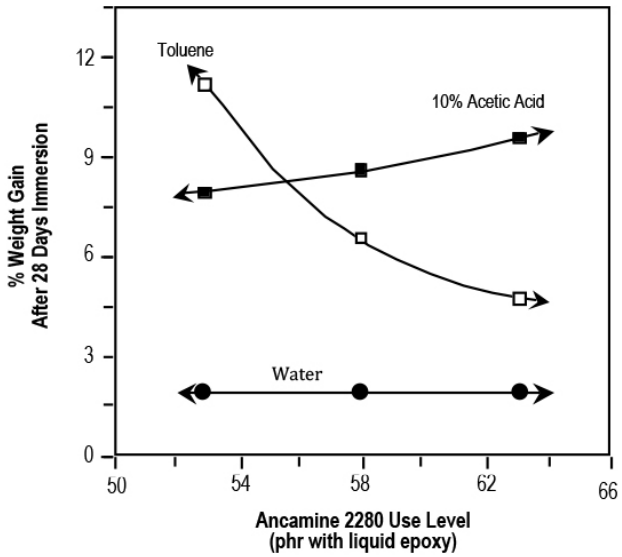


TABLE 7:
SPILLAGE RESISTANCE TEST METHOD SCHEDULE

- Castings of 1/8" thickness are immersed for specified time period.
- Sample is then removed, weighed, and hardness tested immediately.
- Sample is then allowed to recover for specified time before re-immersion.

3 hr imm → test → 24 hr recover →
24 hr imm → test → 24 hr recover →
3 day imm → test → 3 day recover →
7 day imm → test → 7 day recover →
28 day imm → test → 7 day recover →
90 day imm → test

TABLE 8:
SPILLAGE RESISTANCE FOR ANCAMINE 2280 WITH 90% DGEBA / 10% EPODIL 748
% WEIGHT CHANGE AND SHORE D HARDNESS AS A FUNCTION OF TIME

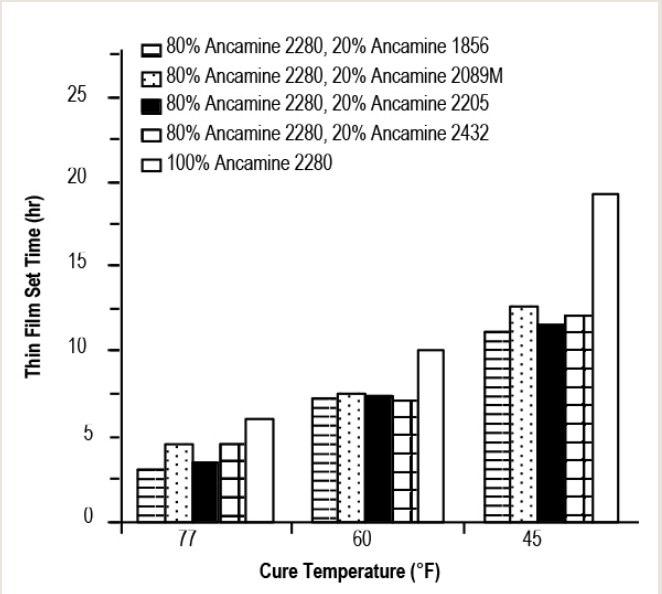
Reagent	Initial Hard.	After 3 hr		After 24 hr		After 3 days		After 7 days		After 28 days		After 90 days	
		% wt.	Hard	% wt.	Hard	% wt.	Hard	% wt.	Hard	% wt.	Hard	% wt.	Hard
10% Acetic Acid	78	0.64	77	1.47	76	2.68	74	4.10	73	6.86	68	10.9	65
10% Lactic Acid	78	0.16	78	0.47	79	1.05	77	1.66	78	2.72	76	4.00	65
Toluene	78	0.09	75	2.62	69	8.79	65	11.48	57	13.39	50	18.09	50
Xylene	78	-0.02	75	-0.01	74	0.69	70	1.92	64	6.50	62	8.51	62
Trichloroethane	78	0.09	75	1.43	74	6.03	69	10.04	67	18.83	63	29.61	60
Methanol	78	2.38	62	6.66	33	5.25	28	DESTROYED					
Ethanol	78	0.63	76	1.89	70	3.62	65	5.79	61	2.91	56	-1.04	68
Butyl Cellosolve	78	0.17	75	0.85	71	2.20	64	3.41	63	6.78	60	14.42	60
Methyl Ethyl Ketone	78	5.77	58	19.67	19	12.57	20	DESTROYED					
Skydrol	78	0.04	75	-0.06	75	-0.14	75	-0.23	74	-0.39	76	-0.55	53
70% Sulfuric Acid	78	0.13	80	0.04	80	0.03	80	0.03	81	-0.01	80	0.0	80
98% Sulfuric Acid	78	-19.33	72	DESTROYED									
Deionized Water	78	0.14	78	0.35	78	0.63	78	1.00	78	1.46	77	1.31	77
50% Sodium Hydroxide	78	0.03	80	-0.05	78	-0.12	78	-0.16	78	-0.30	80	-0.44	63
Bleach	78	0.08	79	0.31	78	0.57	79	0.81	78	0.82	79	0.26	64

NOTE: Samples were cured for 7 days at 77°F before testing.

CURE SPEED: Thin film set times are shown in Figure 3 for Ancamine 2280 accelerated with Ancamine 1856, 2089M, 2205, or 2432 curing agents. 80% by weight Ancamine 2280 and 20% of the accelerating curing agents were mixed with standard bisphenol-A (DGEBA, EEW=190) resin at recommended use ratios. Three mil films were applied to glass plates and measured with a B K dry time recorder. At 77˚F, accelerating Ancamine 2280 decreases thin film set time from 6 hours to 4.5 hours or less with all four products. These accelerators offer the capability to formulate Ancamine 2280 to the desired set time and still obtain good chemical resistance and waterspot resistance. Ancamine 2432 should be used as the accelerator for maximum chemical resistance.

As temperature decreases, use of the accelerators improves cure speed by about 40% compared to straight Ancamine 2280. Although all four accelerators will not severely impact blush resistance at a 20% use level, Ancamine 2089M or Ancamine 2432 should be used to maintain excellent blush resistance at low temperatures

FIGURE 3:
CURE SPEEDS OF ACCELERATED ANCAMINE 2280 SYSTEMS



ANCAMINE® 2280 Curing Agent

TABLE 9:
HIGH-BUILD GRAY ENAMEL STARTING POINT FORMULATION

Component A	Parts by Weight
Liquid DGEBA (EEW=190)*	450 lb
Cresyl Glycidyl Ether (Epodil 742-Evonik)	100 lb
Titanium Dioxide (DuPont)	150 lb
Black Iron Oxide (Bayer)	2.0 lb
Nuoperse 657 (Elementu)	1.5 lb
Byk 320 (Byk Chemie)	1.0 lb
FC 430 (3M Company)	0.6 lb
	705.1 lb
Component B	
Ancamine 2280	303 lb

Mixed Properties	
Mixed Viscosity[18] (KU)	110
Pot Life[6] (min) (150 g mass)	75
Thin Film Set Time[7] @ 77°F (hr)	6.5
Pounds per Gallon[4]	9.9
PVC (%)	4.5
Hegman Grind[19]	6+

CURED FILM PROPERTIES – 7 DAY AMBIENT CURE	
Pencil Hardness[20]	HB
Gloss[14] 60°	105
Cross Hatch Adhesion[21]	5B
MEK Double Rubs	200+

* Liquid Resin Suppliers: Epon 828 Resin™: Shell Chemical Company. Epon 862 Resin™, Shell Chemical Company. D.E.R. 331 Resin™, Dow Chemical Company. D.E.N. 431 Resin™, Dow Chemical Company.

STARTING FORMULATION: Table 9 shows a high-build gray enamel formulation using Ancamine 2280 curing agent.

Footnotes:

(1) ASTM D 1544-80
(2) ASTM D-445-83, Brookfield RVTD, Spindle 4
(3) Perchloric Acid Titration
(4) ASTM D 1475-85
(5) Seta Flash Closed Cup
(6) Techne GT-4 Gelation Timer
(7) BK Drying Recorder
(8) ASTM D 2471-71
(9) ASTM D 3418-82
(10) ASTM D 695-85
(11) ASTM D 638-86
(12) ASTM D 790-86
(13) ASTM D 2240-86
(14) ASTM D 523-85
(15) ASTM D 4060-90
(16) ASTM D 5178-91
(17) ASTM D 543
(18) ASTM D 562-81
(19) ASTM D 1210-79
(20) ASTM D 6633
(21) ASTM D 3359-87

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