Product information

ANCAMINE® 2410

Curing Agent

DESCRIPTION

Ancamine 2410 curing agent is a highly monodispersed adduct of ethylene diamine (EDA) designed for use in coatings and related applications.

TYPICAL PROPERTIES

Property	Value	Unit	Method
Appearance	Light Yellow Liquid		
Color	2	Gardner	
Viscosity @ 25°C			ASTM D 445-83, Brookfield, RVTD, Spindle 4
@ 122°F	200,500	mPa.s	
@ 212 °F	890	mPa.s	
Specific Gravity @ 77°F	1.17		ASTM D 1475-85
Weight per Gallon	9.72		
Amine Value	364	mg KOH/g	Perchloric Acid Titration
Flash Point	>400	°F	Seta Flash Closed Cup
Equivalent Wt/{H}	85.5		
Recommended Use Level	45	phr	EEW=190

ADVANTAGES

- Excellent chemical resistance
- Can be used in compliance with FDA 21 CFR 175.300 and 21 CFR 175.105
  - Low residual EDA
  - Sharp reduction in viscosity with increased temperature or solvent addition for easier handling and reduced VOC

APPLICATIONS

- Chemically-resistant, high-solids tank and FDA-compliant coatings

STORAGE 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.

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STORAGE AND HANDLING

Refer to the Safety Data Sheet for Ancamine 2410 curing agent.

TYPICAL CURE SCHEDULE

2–7 days at ambient temperature.

TYPICAL PERFORMANCE*

Property	Value	Unit
Glass Transition Temperature	109	°F

* Ancamide 2410 curing agent formulated with standard Bisphenol-A based (DGEBA, EEW=190) epoxy resin.

SUPPLEMENTARY INFORMATION

Ancamine 2410 curing agent is an amine curing agent for use in high-performance epoxy barrier coating systems for the protection of steel from water in addition to a variety of chemicals including strong alkalis, oils and a wide range of solvents. Ancamine 2410 curing agent offers excellent resistance to long-term immersion in ketones, esters, aromatics, glycol ethers, alcohols and many other organic solvents. The product also provides excellent resistance to bases, most mineral acids and certain organic acids. Starting point formulations have been developed and are shown in Appendix 1.

Ancamine 2410 curing agent is compliant with FDA 21 CFR 175.300 and can be used as a component of barrier coatings which offer excellent resistance to immersion in products such as wine, orange juice and cola.

Ancamine 2410 exhibits rapid cure speed. When used with liquid epoxy resin, pigmented coatings generally reach a dry to touch state in less than one hour with dry hard in approximately 4 hours. With proper formulation, pot lives in the order of 3 to 5 hours can be obtained with VOCs of less than 2.8 pounds per gallon. When used at levels of 10 to 20% of the weight of the hardener based on solids, Ancamine 2410 is also an effective modifier to increase the cure speed of other hardeners, particularly in high-solids coatings applications.

CHEMICAL STRUCTURE

Ancamine 2410 curing agent is an isolated adduct with a highly monodispersed molecular weight distribution.
Normally, adducts of polyamines and epoxy resin have very broad molecular weight distributions (polydispersed), with significant amounts of unreacted polyamine. Whereas the normal polydispersed adducts are generally prone to blush and exudation of amine to the surface of films, Ancamine 2410 is relatively blush-resistant. When properly formulated with epoxy resins, the high functionality of the adduct and its monodispersed molecular weight distribution leads to a uniformly crosslinked matrix with a high crosslink density. This accounts for the outstanding chemical resistance properties of the product.

VISCOSITY REDUCTION

Ancamine 2410 curing agent has a higher viscosity at ambient temperature than many amine adducts; the neat viscosity of the product at room temperature is about 1,000,000 poise. This high viscosity is the result of the very low levels of unreacted amine within the product, as described above. While the presence of unreacted polyamine in most amine adducts acts as a solvent for the curing agent, it is not without negative consequences, such as a strong tendency to blush and exude to the surface. Also, due to their low molecular weight and high vapor pressure, unreacted polyamines tend to cause greater problems with odor and toxicity than is the case with Ancamine 2410 curing agent. The addition of solvents or heat to Ancamine 2410 will reduce the viscosity rapidly and efficiently due to the monodispersed nature of the adduct. Exhibit 1 shows the viscosity reduction profile from the application of heat.

EXHIBIT 1: ANCAMINE 2410 VISCOSITY

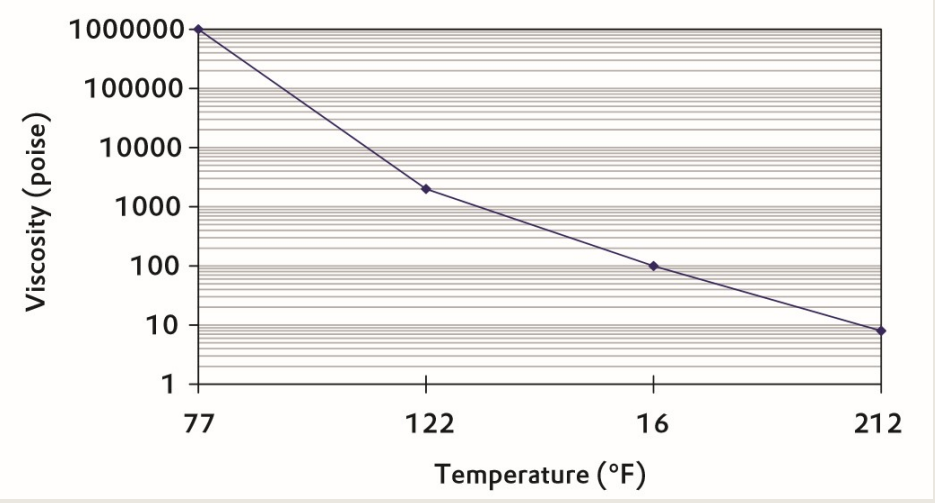
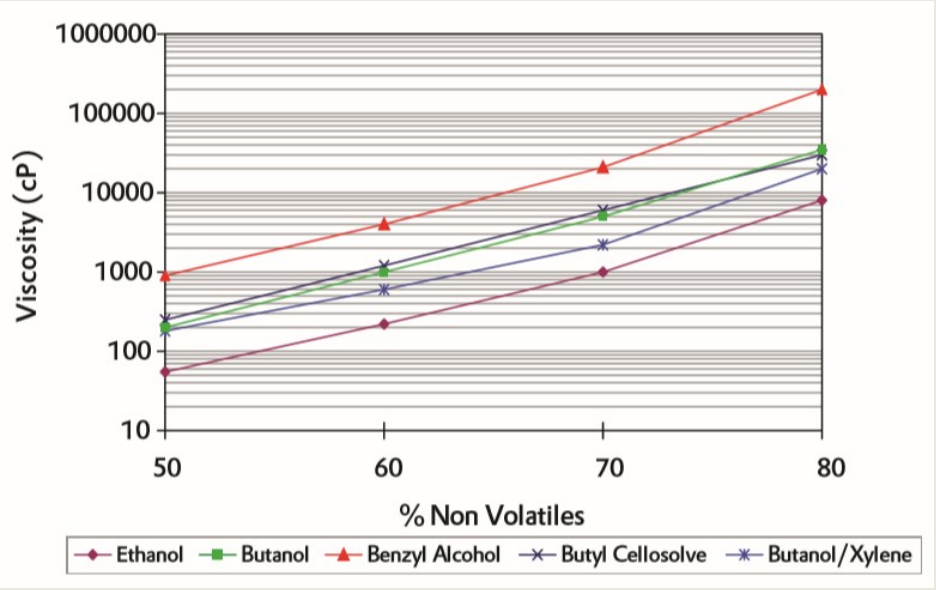


Exhibit 2 shows the effect of various solvents on viscosity. Ethanol, butanol, benzyl alcohol, butyl cellosolve and a 60%/40% butanol/xylene blend have been evaluated. Ethanol has the greatest viscosity reduction performance with Ancamine 2410 curing agent. The butanol/xylene blend and butanol alone showed comparable viscosity reductions. As shown in the graph, viscosity was significantly reduced resulting in easier handling at a 20-30% solvent addition level.

EXHIBIT 2: VISCOSITY OF ANCAMINE 2410 IN SOLVENTS



STARTING POINT FORMULATIONS

Ancamine 2410 curing agent can be used to develop highperformance barrier coatings that provide excellent humidity and chemical resistance. Formulations developed using flat, platy pigments for aluminized epoxy mastic or stainless steel barrier finishes are detailed in Formulations 2410HS01, 2410HS02 and 2410HS03. In Formulation 2410HS01, the B side of the coating formulation was modified with an amidoamine, Ancamide® 500 curing agent, to reduce the initial mix viscosity and increase the flexibility of the cured coating. In developing high-performance coatings, extender pigments such as talc and wollastonite can be used to improve performance properties. Ancamine 2410 is also compatible with a variety of silicone and fluorocarbon flow and leveling aids, including Byk 320, Beetle 216-8 and FC430.

The solvent blends in these formulations are designed to yield a good balance of pot life and cure speed, with environmentally acceptable VOC. The use of ketones, such as MEK, is very helpful in extending the pot life of formulations based on Ancamine 2410 curing agent. Ethanol and butanol, as noted above, are excellent solvents for achieving low-VOC formulations with Ancamine 2410 curing agent. Using these solvent blends, pot lives of 3 to 5 hours can be obtained, with dry to touch of less than one hour, and dry hard of only 4 hours.

PERFORMANCE EVALUATION

All coatings were evaluated in 5% salt spray and in continuous humidity at 122°F. They were also evaluated after immersion in wine, orange juice and cola following a 7 day ambient cure. Ancamine 2410-based formulations were also tested for chemical and solvent resistance using both spot tests and by immersion with more volatile reagents.

Coatings were applied to grit blasted, hot rolled steel (2.5-4.0 mil profile) using conventional spray equipment in both single and double coats to give 2.0-4.0 DFT. For salt spray evaluation (ASTM B-117), panels were scribed and evaluated for field blisters using the Federal Standard Test Method # 141a, Method 6461, and the scribe creep was rated in accordance with ASTM D-1654. Panels exposed to humidity were not scribed and the coatings were assessed for blistering only. Similar evaluations were made for panels immersed in wine, orange juice and cola. These tests also included evaluations for changes in visual appearance.
Chemical and solvent resistance evaluations were carried out by immersing test panels in beakers half-filled with reagents. The beakers were sealed to prevent evaporation of the test solution. In certain cases, resistance was determined using the watch glass methodology (ASTM D-1308), where the test solution was replenished on a daily basis.

CORROSION RESISTANCE

All of the following formulations were evaluated for salt spray and constant humidity resistance. The results obtained are presented in Tables 3 and 4. Formulation 2410HS03 was shown to have the best all around performance. No field blistering was observed and there was only a minimal amount of scribe creep detectable following 1350 hours of salt fog exposure. All three formulations gave excellent humidity resistance, with no signs of field blistering after 5 months continuous testing.

TABLE 3: SALT SPRAY RESISTANCE — ANCAMINE 2410

Formulation	Scribe Creep	Field Blistering	Blister Size
2410HS01	5.5	10	10
2410HS02	7	7	5
2410HS03	8	10	10

5% salt spray, cabinet temperature 95°F – ASTM B-117, film thickness 2.0-2.5 mils

Rating: 10 = Best, 0 = Worst

TABLE 4: CLEVELAND HUMIDITY EXPOSURE — ANCAMINE 2410

Formulation	Scribe Creep	Field Blistering	Blister Size
2410HS01	10	10	10
2410HS02	10	10	10
2410HS03	10	10	10

Continuous 100% humidity exposure – ASTM D-2247, cabinet temperature 122°F

Film thickness 2.0 mils. Rating: 10 = Best, 0 = Worst

For blister size, rating 10 = no blisters observed

CHEMICAL RESISTANCE

Formulation 2410HS02 is a starting point formulation using Ancamine 2410 curing agent in a stainless steel barrier application. This formulation has also been evaluated for immersion in a wide variety of acids, alkalis and organic solvents. The results of the chemical resistance trials are outlined in Tables 5 and 6.

TABLE 5: ANCAMINE 2410 CHEMICAL RESISTANCE: ACIDS & ALKALIS

Acids*	
Sulfuric Acid (98%)	Dissolves in 4 hours
Sulfuric Acid (10%)	Slight loss of gloss after 2 weeks
Hydrochloric Acid (37%)	Blistering after 1 week
Nitric Acid (6 molar)	Yellowing after 18 hours, no further effect after 1 week
Glacial Acetic Acid	Film disintegrates after 16 hours
0.5 N Acetic Acid	Loss of gloss after 24 hours, no further effect after 2 weeks
Lactic Acid	Surface attack after 72 hours
Pelargonic AcidDDSA	No effect in 2 weeks
Acetic Anhydride	No effect in 1 week
Phosphoric Acid	Loss of gloss after 18 hours, no further effect after 2 week

Alkalis*	
50% Sodium Hydroxide	No effect in 3 weeks
10% Sodium Hydroxide	No effect in 3 weeks
Ammonium Hydroxide (28%)	No effect in 2 weeks

Amines*	
Morpholine	No effect in 4 months
Amino methyl piperazine	No effect in 4 months
Tributylamine	No effect in 4 weeks
Monoethanolamine	No effect in 4 months
Diethylene amine	Blistering in 16 hours

* Watch glass exposure, ASTM D 1308

TABLE 6: ANCAMINE 2410 CHEMICAL RESISTANCE: SOLVENTS AND OTHER ORGANICS

Solvents	
Acetone	No effect in 5 weeks
Cyclohexanone	No effect in 3 weeks
Ethyl acetate	No effect in 2 months
Ethylene glycol*	No effect in 4 weeks
Ethylene glycol monopropyl ether	No effect in 5 months
Ethylene glycol monomethyl ether*	No effect in 4 weeks
Propylene glycol monomethyl acetate	No effect in 5 months
Ethanol	No effect in 5 months
Propanol	No effect in 3 weeks
Toluene	No effect in 3 months
Hexane	No effect in 3 months
Aromatic 100*	No effect in 3 weeks
Tetrahydrofuran	Softening after 3 weeks
Dimethyl formamide	Softening after 3 weeks
1,1,1 trichloroethane	No effect in 5 months

Other Organics	
Motor oil	No effect in 5 months
Skydrol LD-4	No effect in 5 months
Mineral oil	No effect in 3 months
Glycerine*	No effect in 4 weeks
50% phenol in xylene*	Film disintegrates after 1 week

Inorganic Salts	
10% Cobalt chloride	No effect in 3 weeks
1% Potassium ferrocyanide	No effect in 3 weeks
51% Manganese nitrate	No effect in 3 weeks
23% Ammonium sulfide	No effect in 3 weeks

* Watch glass exposure

The solvent resistance of Formulation 2410HS02 is extremely high. Films (2-4 mil DFT) were found to be extremely resistant to attack from a wide variety of solvents, including ketones, esters, aromatic, aliphatic and chlorinated hydrocarbons, alcohols and glycol ethers. Resistance to Skydrol and mineral oil was also excellent. Few solvents produced any visible signs of attack other than a slight softening after up to 5 months immersion. Even very aggressive solvents such as ethanol, tetrahydrofuran, dimethylformamide and 1,1,1-trichloroethane had little or no effect. Resistance to alkalis was also very good. Neither 10% nor 50% sodium hydroxide produced any effect over 3 weeks.
In general, the resistance of room temperature, amine cured epoxy coatings toward acidic reagents is not as good as their resistance toward neutral and basic materials. However, because of the tightly crosslinked network it forms, Ancamine 2410 curing agent appears to be suitable for immersion in some organic and mineral acids and would be acceptable for splash and spill service with many others. It has poor resistance to glacial acetic acid, but holds up well to more dilute solutions. Resistance to concentrated sulfuric acid is poor, but this is the case with all bisphenol A-based epoxy resin films. It would be anticipated that higher acid resistance would be obtained with bisphenol F based epoxy resins. Resistance to more dilute sulfuric acid was quite good. Formulation 2410HS03 has also been subjected to the same tests. It gave similar results and offers the same high level of chemical and solvent resistance.

FOOD STUFF EXPOSURE

Coatings were also evaluated for continuous immersion in wine, orange juice and cola. No blister formation in the immersed region or the vapor space was observed following 5 months continuous testing. The only effect noted during this test was a change in the visual appearance of the coating. Formulation 2410HS01 tended to show some slight discoloration in all three solutions, whereas Formulation 2410HS02 only showed slight discoloration upon immersion in red wine. In all cases, the stains were easily removed by washing. Formulation 2410HS03 also showed some discoloration after immersion in red wine. In this case the stain could not be removed by washing. The results of the immersion tests are outlined in Table 7.

TABLE 7: RESISTANCE TO FOOD STUFF - ANCAMINE 2410

	Visual Change	Field Blisters	Blister Size
Cola			
2410HS01	Loss of Gloss	10	10
2410HS02	No Change	10	10
2410HS03	No Change	10	10
Red Wine			
2410HS01	Moderate Discoloration*	10	10
2410HS02	Slight Discoloration*	10	10
2410HS03	Heavy Discoloration**	10	10
Orange Juice			
2410HS01	Loss of Gloss33	10	10
2410HS02	No Change	10	10
2410HS03	No Change	10	10

Film thickness 2.5-3.0 mils over grit blasted steel. Rating: 10 = Best, 0 = Worst

* Discoloration largely removed by washing

** Discoloration not removed by washing

APPENDIX 1:

ANCAMINE 2410 STARTING POINT FORMULATIONS
(Note: These formulations have not been submitted for approval under FDA 21 CFR 175.300)

TABLE 8: FORMULATION 2410HS01

A Side	Pounds	Gallons	Supplier
Epon 828	284.6	29.34	Shell Chemical Co.
Cabosil TS-610*	7.6	0.43	Cabot Corp.
Disperse at high speed, reduce speed then add			
Aluminum L243	106.0	8.59	Silberline Ltd.
When uniformly mixed add			
Epodil® 759 reactive diluent	86.3	11.64	Evonik
SF 69	0.4	0.05	G.E.
Total (A Side)	**484.9**	**50.05**	
B Side			
Ancamine 2410	77.7	8.00	Evonik
Beetle 216-8	22.7	2.61	American Cyanamid Co.
Ancamide 500	81.8	10.34	Evonik
Ethyl Alcohol	38.9	5.94	Shell Chemical Co.
Methyl Ethyl Ketone	73.9	11.01	Eastman Chemical Co.
n Butyl Alcohol	81.7	12.10	Ashland Chemical Co.
Total (B Side)	**376.7**	**50.00**	
TOTAL	**861.6**	**100.05**	

* Evonik's Aerosil R972

TABLE 9: TYPICAL PROPERTIES

Non Volatile(wt)	72.0%	Weight/Gallon Comp A	9.68
Non Volatile (vol)	64.0%	Weight/Gallon Comp B	7.53
PVC	5.0%	Weight per Gallon	8.61
Pigment Content	9.0%	Initial Viscosity (cps)	270
Mix Ratio (vol)	1:1	Pot Life (h)	3
VOC (lbs/gal)	2.43	Dry to Touch (h)	1.5
VOC (g/l)	290.5	Dry Hard (h)	4.0
		Direct Impact Resistance* (inch lb)	56

*ASTM D 2794-90

TABLE 10: FORMULATION 2410HS02 HIGH SOLIDS COATING — STAINLESS STEEL BARRIER FINISH

A Side	Pounds	Gallons	Supplier
DER 331	334.9	34.52	Dow Chemical Co.
Cabosil TS-610*	7.1	0.40	Cabot Corp.
Disperse at high speed, reduce speed then add			
Stainless Steel Flake	178.2	3.27	Novamet Specialty Products Inc.
Beetle 216-8	32.2	2.73	American Cyanamid Co.
BYK 320	3.6	0.50	Byk Chemie GmbH
n Butyl Alcohol	58.5	8.67	Ashland Chemical Co.
Total (A Side)	**605.5**	**50.11**	
B Side			
Ancamine 2410	152.3	15.70	Evonik
Ethyl Alcohol	39.3	6.00	Shell Chemical Co.
Dissolve then add			
Cabosil TS-720**	8.9	0.56	Cabot Corp.
LVT 325	130.0	5.58	Specialty Minerals
Disperse to 4-5 nsu			
Methyl Ethyl Ketone	149.3	22.25	Eastman Chemical Co.
Total (B Side)	**479.8**	**50.10**	
TOTAL	**1085.3**	**100.21**	

* Evonik's Aerosil R972

** Evonik Aerosil R202 may also be used

TABLE 11: TYPICAL PROPERTIES

Non Volatile(wt)	76.0%	Weight/Gallon Comp A	12.08
Non Volatile (vol)	62.0%	Weight/Gallon Comp B	9.58
PVC	16.0%	Weight per Gallon	10.83
Pigment Content	30.0%	Initial Viscosity (cps)	900
Mix Ratio (vol)	1:1	Pot Life (h)	3
VOC (lbs/gal)	2.60	Dry to Touch (h)	0.75
VOC (g/l)	311.0	Dry Hard (h)	4.0
		Pencil Hardness*	H

*ASTM D 3363-74

TABLE 12: FORMULATION 2410HS03 HIGH SOLIDS COATING — STAINLESS STEEL BARRIER FINISH

A Side	Pounds	Gallons	Supplier
Epon 828	330.9	34.13	Dow Chemical Co.
Cabosil TS-610*	7.0	0.40	Cabot Corp.
50% FC430 in Xylene	3.5	0.43	3M Specialty Chemicals Div.
Disperse at high speed, reduce speed then add			
Stainless Steel Flake	176.0	3.24	Novamet Specialty Products Inc.
BYK 320	7.1	0.50	Byk Chemie GmbH
Aromatic 100	79.0	8.67	Ashland Chemical Co.
Total (A Side)	**603.5**	**50.11**	
B Side			
Ancamine 2410	150.5	15.70	Evonik
Ethyl Alcohol	37.7	5.76 S	Shell Chemical Co.
Dissolve, then add			
Cabosil TS-720**	8.8	0.56	Cabot Corp.
Wollastocoat 10ES	133.3	5.51	NYCO Minerals, Inc.
Disperse to 6 nsu			
Methyl Ethyl Ketone	152.3	22.69	Eastman Chemical Co.
Total (B Side)	**482.6**	**50.03**	
TOTAL	**1086.1**	**100.08**	

* Evonik's Aerosil R972

** Evonik Aerosil R202 may also be used

TABLE 13: TYPICAL PROPERTIES

Non Volatile(wt)	74.0%	Weight/Gallon Comp A	12.05
Non Volatile (vol)	60.0%	Weight/Gallon Comp B	9.64
PVC	16.0%	Weight per Gallon	10.85
Pigment Content	30.0%	Initial Viscosity (cps)	580
Mix Ratio (vol)	1:1	Pot Life (h)	4.5
VOC (lbs/gal)	2.74	Dry to Touch (h)	0.75
VOC (g/l)	327.9	Dry Hard (h)	4.0
		Pencil Hardness	3H

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