Product information

ANCAMIDE® 2386

Curing Agent

DESCRIPTION

Ancamide 2386 curing agent is a low-viscosity modified amidoamine. It is designed for use with liquid epoxy resin or combination blends of liquid and solid epoxy resins to deliver highperformance coatings. It can be used to formulate both high-solids and solvent-free coatings for airless spray application.

TYPICAL PROPERTIES

Property	Value	Unit	Method
Appearance	Amber liquid		
Color	8	Gardner	ASTM D 1544
Viscosity @ 77°F	340	cP	ASTM D 445-83, Brookfield, RVTD, Spindle 4
Amine Value	364	mg KOH/g	Perchloric Acid Titration
Specific Gravity @ 77°F	1.000		ASTM D 1475-85
Flash Point	>200	°F	Seta Flash Closed Cup
Equivalent Wt/{H}	93		
Recommended use Level	49	PHR	EEW=190

ADVANTAGES

- Long pot life with short thin film set time
- Excellent film formation and blush resistance
- Low viscosity
- Excellent corrosion resistance
- Very good low temperature cure
- Very good solvent resistance
- Good gloss

APPLICATIONS

- High-solids and 100% solids anticorrosive primers and basecoat enamels for industrial maintenance and marine applications
- Topcoats for interior floor and wall paints

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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 Safety Data Sheet for Ancamide 2386 curing agent.

TYPICAL CURE SCHEDULE

7 days at ambient temperature

TYPICAL HANDLING PROPERTIES*

Property	Value	Unit	Method
Mixed Viscosity at 77°F	3,020	cP	BK Drying Recorder
Gel Time (150g mix @ 77°F)	135	min	Techne GT-4 Gelation Timer
Thin Film Set Time @ 77°F	8.5	h	BK Drying Recorder

* Ancamide 2386 curing agent formulated with standard Bisphenol-A based (DGEBA, EEW=190) epoxy resin.

SUPPLEMENTARY DATA

Ancamide 2386 curing agent can be readily formulated into high-performance, low-VOC anticorrosive primers. The 40% PVC primer with liquid epoxy resin shown in Exhibit 1 was formulated to airless spray viscosity using only 2.1 lb/gal VOC. This primer delivered excellent long term protection for steel with good pot life and fast dry time.

EXHIBIT 1: STARTING FORMULATION ANCAMIDE 2386 ANTICORROSIVE PRIMER

A Side	Pounds	Gallons	Supplier
Liquid Epoxy Resin	267.9	27.67	Dow, Resolution
MPA 1078	4.6	0.62	Rheox
TiPure R-900	26.8	0.82	DuPont
Wollastokup 10AS	281.4	11.60	Nyco
Xylene	36.7	5.08	
Diacetone Alcohol	33.2	4.24	
	650.6	50.0	
B Side			
Ancamide 2386	132.7	15.89	Evonik
MPA 1078	4.6	0.62	Rheox
Beetle 216-8	17.2	2.04	Cytec
Red Iron Oxide	64.0	1.53	Mineral Tech
325 Mesh Talc	103.5	4.49	Cyprus
Zinc Phosphate	151.3	5.41	Mineral Tech
Wollastokup 10AS	114.6	4.73	Nyco
High Flash Naptha	111.2	15.26	
	698.1	50.0	

Properties			
VOC	2.08 lb/gal	Pot Life	2 hr[A]
Volume Solids	72.0%	Tack Free	2 hr
PVC	40%	Dust Free	3 hr
A Viscosity	1500 cP	Hard Dry	Overnight
B Viscosity	3000 cP	Mix Viscosity	1800 cP

(A) Time to have viscosity double

CORROSION TESTING

The primer was spray applied to shot blasted steel (2 mil profile) at 3-4 mil DFT then cured for 7 days at 25°C before testing. Testing included salt fog, prohesion, and Electrochemical Impedance Spectroscopy (EIS). The salt fog test was run in accordance with ASTM B 117. The prohesion test involved a one hour wet fog cycle at 25°C with a 0.35% ammonium sulfate / 0.05% sodium chloride solution followed by a one hour dry cycle at 35°C. The panels were rated in accordance with ASTM D 1654. Electrochemical Impedance Spectroscopy (EIS) was evaluated by immersing test panels in 1M NaCl for 24 hours and measuring the pore resistance. Pore resistance was re-measured after 1,000 hours of prohesion exposure.

ACCELERATED CORROSION TESTING RESULTS

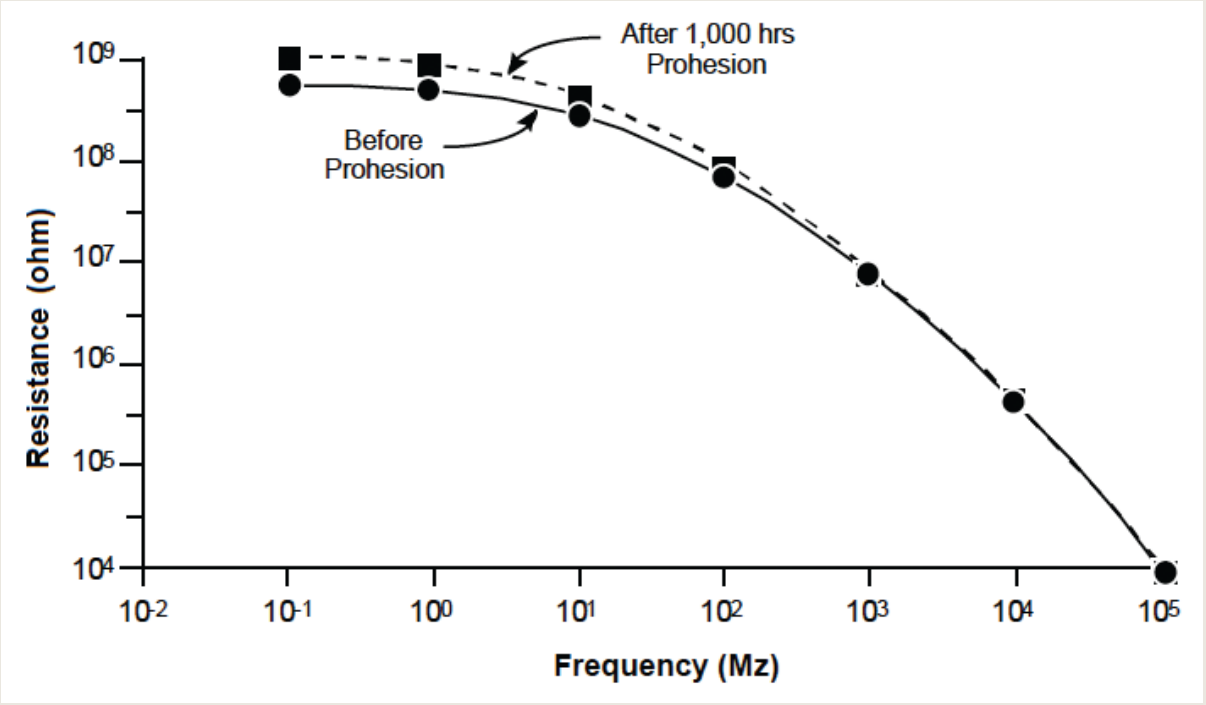
Salt Fog	3,000 hr	Field Rating	10
		Scribe Rating	8
Prohesion	3,000 hr	Field Rating	9
		Scribe Rating	7

Ancamide 2386 primer delivered excellent corrosion protection in salt fog and prohesion testing.

ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY RESULTS

EIS measures the resistance of a coating to ion penetration (pore resistance). Corrosion is initiated by ions diffusing through a coating to form an electrical circuit with the steel substrate. By measuring the coatings resistance to ion penetration, EIS is an excellent predictor of the anticorrosive properties of the coating. A good barrier coating should have a pore resistance of at least 10^7 ohms at a frequency of 10^{-1} Hz.
Coatings were tested before and after 1,000 hours of prohesion exposure by immersing them in a 1 M NaCl solution for 24 hours and measuring pore resistance. Initial pore resistance > 10^8 ohms indicated excellent barrier properties as shown in Figure 1. After 1,000 hours prohesion exposure, a slight increase in resistance was observed, perhaps due to post curing in the prohesion cabinet. These
results indicate that the Ancamide 2386 primer will provide excellent corrosion protection for steel.

FIGURE 1: EIS ANALYSIS OF ANCAMIDE 2386 PRIMER



FORMULATING GUIDELINES

PIGMENTATION

Good results have been obtained using a combination of talc, wollastonite and zinc phosphate. Conventional talcs may be used or low oil absorption talcs may be substituted to further reduce application viscosity. Surface-treated wollastonite, such as Wollastokup 10AS, offers superior corrosion resistance when compared with untreated wollastonite. A modest improvement in barrier properties can also be achieved by grinding amine-treated wollastonite (10AS) into the epoxy and by grinding epoxy treated wollastonite (10ES) into the curing agent. Fine particle size zinc phosphate has been an effective anticorrosive pigment at a recommended loading of 1.5 pounds per gallon. Excellent results may also be obtained using strontium zinc phosphosilicate (SZP 391) at 0.5 pounds per gallon. Red iron oxide and titanium dioxide are included as hiding pigments. PVC levels of 35-40% are recommended to provide maximum barrier properties while remaining safely below the CPVC.

SOLVENTS

Solvents were chosen to provide good solvating power while remaining HAPS-compliant. The principal solvents are xylene and high flash naptha. A ketone solvent such as methyl propyl ketone (MPK) may be added as 10% of the solvent mixture to speed solvent evaporation.

ANCAMIDE 2386 CURING AGENT REDUCES FORMULATION VOCS

Ancamide 2386 curing agent is very effective at modifying high-VOC formulations to reach compliance while maintaining handling and performance. Exhibit 2A shows a typical high-VOC primer based on high viscosity polyamide (Ancamide 220X70) and solid epoxy resin (DER 661). Features of this primer included long pot life, fast dry time and good flexibility. However, at airless spray viscosity, the VOC was greater than 3.1 lb/gal.

EXHIBIT 2A: HIGH VOC ANTICORROSIVE PRIMER

A Side	Pounds	Gallons	Supplier
DER 661X75	291.4	32.0	Dow
TiPure R 900	19.6	0.6	DuPont
Wollastokup 10AS	187.1	7.7	Nyco
PM Solvent	73.6	9.7	Dow
	571.6	50.0	
B Side			
Ancamide 220X70	168.7	21.5	Evonik
Wollastekup 10AS	104.8	4.3	Nyco
Red Iron Oxide	46.9	1.1	Bayer
Beaverwhite 325	75.6	3.3	Cyprus
Zinc Phosphate	110.6	4.0	Heubach
PM Solvent	41.4	5.4	Dow
Super High Flash Naphtha	75.7	10.4	Ashland
	623.7	50.0	

Properties			
VOC	3.14 lb/gal	Pot Life	5 hr
Volume Solids	58%	Set to Touch	20 min
PVC	36.5%	Dust Free	75 min
A Viscosity	1570 cP	Hard Dry	Overnight
B Viscosity	970 cP	Direct Impact	60 in lb
Mixed Viscosity	1300 cP	Reverse Impact	6 in lb

ANCAMIDE 2386 MODIFICATION

By replacing a portion of the high viscosity binder with Ancamide 2386 and liquid epoxy, the VOC can be reduced from > 3.1 lb/gal to < 2.7 lb/gal. In doing this, fast dry times are maintained. Pot life is actually longer due to the low mixed viscosity of Ancamide 2386 curing agent. Volume solids are slightly higher while PVC is held constant, and impact resistance indicates that much of the flexibility has been retained.

EXHIBIT 2B: STARTING FORMULATION ANCAMIDE 2386 MODIFIED ANTICORROSIVE PRIMER

A Side	Pounds	Gallons	Supplier
DER 661X75	179.6	19.7	Dow
DER 331	107.8	11.1	Dow
TiPure R 900	21.8	0.7	DuPont
Wollastokup 10AS	196.1	8.1	Nyco
PM Solvent	79.1	10.4	Dow
	584.3	50.0	
B Side			
Ancamide 2386	64.3	7.7	Evonik
Ancamide 220X70	64.3	8.2	Evonik
Wollastekup 10AS	125.9	5.2	Nyco
Red Iron Oxide	52.2	1.3	Bayer
Beaverwhite 325	84.2	3.7	Cyprus
Zinc Phosphate	123.1	4.4	Heubach
PM Solvent	43.0	5.7	Dow
Super High Flash Naphtha	72.9	10.0	Ashland
	623.7	50.0	

Properties			
VOC	2.67 lb/gal	Pot Life	7 hr
Volume Solids	64%	Set to Touch	55 min
PVC	36.3%	Dust Free	90 min
A Viscosity	990 cP	Hard Dry	Overnight
B Viscosity	1570 cP	Direct Impact	32 in lb
Mixed Viscosity	950 cP	Reverse Impact	2 in lb

ANCAMIDE 2386 IN GLOSS ENAMEL COATINGS

Ancamide 2386 curing agent exhibits excellent blush resistance, allowing the formulation of high gloss enamels with zero induction time at ambient temperature. In addition, the low viscosity of Ancamide 2386 curing agent provides the formulating freedom to design fast-dry enamels or even solvent-free enamels depending on the epoxy resin used. Exhibits 3 through 6 show a series of gloss enamels offering a range of dry times, pot lives and VOC levels.

Exhibits 3 and 4 had starting formulations which were both high gloss and VOC-compliant (2.8 lb/gal) with high solids and comparable fast dry times. The formulation in Exhibit 3 had a 1:1 mix ratio and utilized a combination of liquid and solid resin. Exhibit 4 was a 4:1 mix ratio formulation utilizing solid resin only.

EXHIBIT 3: STARTING FORMULATION ANCAMIDE 2386 FAST DRY GLOSS ENAMEL 1:1

A Side	Pounds	Gallons	Supplier
Liquid Epoxy Resin	198.4	20.49	Dow, Resolution
Solid Epoxy Resin	198.4	21.81	Dow, Resolution
PM Solvent	44.7	6.20	
Methyl Propyl Ketone	10.2	1.50	
	451.7	50.0	
B Side			
Ancamide 2386	130.4	15.62	Evonik
Beetle 216-8	1.3	0.15	Cytec
PM Solvent	35.3	4.58	
TiPure R 960	410.3	12.60	DuPont
n-Butanol	51.1	7.56	
High Flash Naphtha	69.7	9.49	
	698.1	50.0	

Properties			
VOC	2.8 lb/gal	Pot Life	3 hr
Weight Solids	75.9%	Set to Touch	2.4 hr
Volume Solids	62.4%	Dust Free	3 hr
A Viscosity	720 cP	Hard Dry	Overnight
B Viscosity	460 cP	60° Gloss	> 90
Mixed Viscosity	500 cP		

EXHIBIT 4: STARTING FORMULATION ANCAMIDE 2386 FAST DRY GLOSS ENAMEL 4:1

A Side	Pounds	Gallons	Supplier
DER 660PA80	480.4	52.32	Dow
Nuosperse 657	3.6	0.43	Hüls
Beetle 216-8	2.9	0.34	Cyanamid
TiPure R 960	336.3	10.32	DuPont
High Flash Naphtha	64.9	8.82	Ashland
Methyl Propyl Ketone	14.4	2.12	Eastman
	945.7	80.0	
B Side			
Ancamide 2386	110.1	13.20	Evonik
n-Butanol	45.6	6.80	Ashland
	155.7	20.0	

Properties			
VOC	2.8 lb/gal	Pot Life	3 hr
Weight Solids	75.7%	Set to Touch	2.4 hr
Volume Solids	62.3%	Dust Free	3 hr
A Viscosity	1420 cP	Hard Dry	Overnight
B Viscosity	70 cP	60° Gloss	> 90
Mixed Viscosity	700 cP		

Exhibits 5 and 6 were solvent-free formulations, one using liquid epoxy resin and the other using liquid epoxy resin modified with trimethylolpropane triacrylate. Both had a 1:1 mix ratio and high gloss. Gloss was enhanced in the solvent-free systems with the use of Epodil L diluent in combination with benzyl alcohol.

EXHIBIT 5: STARTING FORMULATION ANCAMIDE 2386 SOLVENT-FREE ENAMEL

A Side	Pounds	Gallons	Supplier
DER 331	464.3	47.3	Dow
Epodil L	17.2	2.05	Evonik
	481.5	50.00	
B Side			
Ancamide 2386	234.6	28.1	Evonik
Benzyl Alcohol	46.9	5.4	Kalama
Epodil L	39.1	4.5	Evonik
TiPure R 960	400.4	12.0	DuPont
	721.0	50.0	

Properties			
VOC	0.9 lb/gal[B]	Pot Life	60 min
Weight Solids	94%	Set to Touch	13 hr
Volume Solids	92%	Hard Dry	26 hr
A Viscosity	9000 cP	60° Gloss	> 90
B Viscosity	2000 cP		
Mixed Viscosity	2800 cP		

(B) Theoretical

EXHIBIT 6: STARTING FORMULATION ANCAMIDE 2386 SOLVENT-FREE GLOSS ENAMEL: ACRYLATE MODIFIED

A Side	Pounds	Gallons	Supplier
DER 331	336.9	34.8	Dow
Trimethylolpropane Triacrylate	84.2	9.1	Sartomer
Epodil L	50.9	6.1	Evonik
	472.0	50.00	
B Side			
Ancamide 2386	250.3	30.0	Evonik
Benzyl Alcohol	54.2	6.2	Kalama
Epodil L	15.9	1.8	Evonik
TiPure R 960	400.4	12.0	Ashland
	720.8	50.0	

Properties			
VOC	1.3 lb/gal[2]	Pot Life	45 min
Weight Solids	93%	Set to Touch	3 hr
Volume Solids	90%	Hard Dry	7 hr
A Viscosity	2700 cP	60° Gloss	> 90
B Viscosity	2500 cP		
Mixed Viscosity	1900 cP		

Table 1 shows some of the comparative properties of the unmodified formulation and the TMPTA modified formulation. The acrylate modification resulted in a slightly softer film with higher flexibility and a slight improvement in abrasion resistance at the expense of reduced corrosion resistance.

TABLE 1: ANCAMIDE 2386 SOLVENT-FREE ENAMELS: COMPARATIVE PROPERTIES

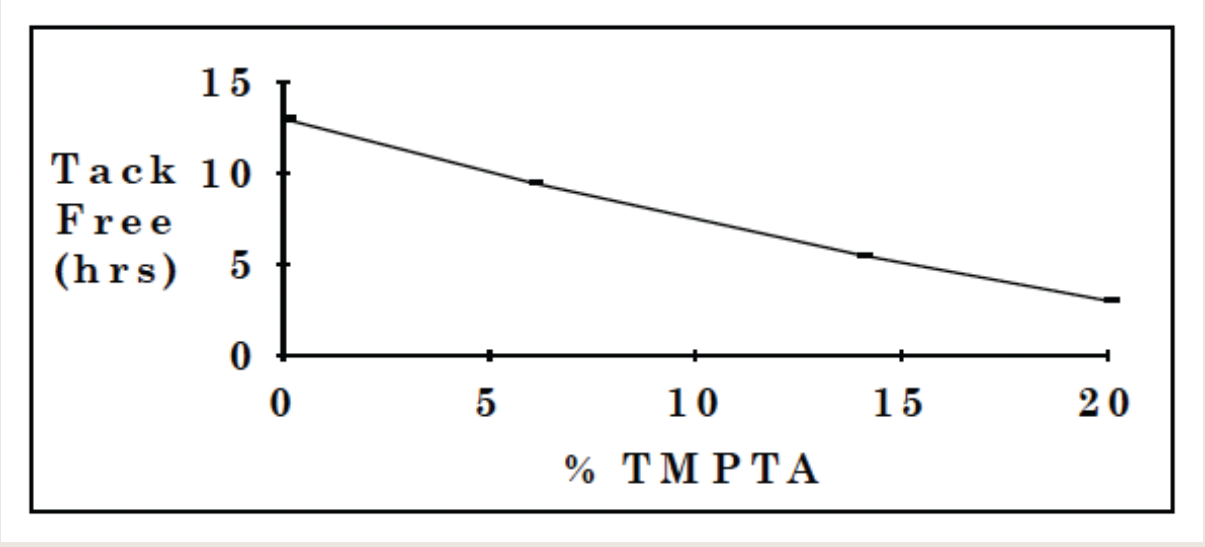
	Abrasion Resistance[a]	500 hr Humidity[b]	Köenig Hardness	Direct Impact
Unmodified	100 mg loss	No Effect	108	14 in lb
Acrylate Modified	90 mg loss	8 Few Blisters	87	20 in lb

(a) Taber Abrasion, CS 17, 1 Kg weight, 1,000 cycles
(b) Cleveland Humidity, constant humidity, 40°C

ACRYLATE MONOMER: EFFECT ON DRY TIME

The use of acrylate significantly decreased the dry time of the film, reducing the set-to-touch time from 13 hours to 3 hours and the hard dry time from 26 hours to 7 hours from the unmodified formulation while maintaining most of the pot life. Figure 2 shows the decrease in tack free time as the acrylate loading increases.

FIGURE 2:



% TMPTA is based on total weight of TMPTA + epoxy resin. Dry time can be accelerated by increasing the TMPTA level to a maximum of 20%. Higher loadings of TMPTA will result in reduced chemical resistance. TMPTA levels above 20% are not recommended.

CHEMICAL RESISTANCE OF SOLVENT-FREE COATINGS

Saturated cotton balls were placed on cured coatings and covered during exposure. Pencil hardness and appearance were noted at 0 time and after 1 hour, 6 hours and 24 hours exposure. As shown in the tables below, the unmodified formulation had excellent short term chemical resistance. Modification with trimethylolpropane triacrylate reduced resistance to both solvents and acids.

UNMODIFIED FORMULATION

	0 Time	1 Hr	6 Hr	24 Hr	Appearance
Toluene	2H	2H	2H	2H	No Effect
MIBK	2H	2H	6M Blisters	Cracking	Destroyed
10% Acetic	2H	2H	H	HB	Slight Softening
10% Lactic	2H	2H	2H	H	Very Slight Softening
70% Sulfuric	2H	2H	2H	2H	Discoloration
50% NaOH	2H	2H	2H	2H	No Effect

ACRYLATE MODIFIED FORMULATION

	0 Time	1 Hr	6 Hr	24 Hr	Appearance
Toluene	HB	2B	4D Blisters	Cracking	Destroyed
MIBK	HB	6B	4D Blisters	Cracking	Destroyed
10% Acetic	HB	2B	8F Blisters	6M Blisters	Destroyed
10% Lactic	HB	B	2B	3B	Slight Discoloration
70% Sulfuric	HB	HB	HB	HB	Discoloration
50% NaOH	HB	HB	HB	HB	No Effect

GENERAL CHEMICAL RESISTANCE

The liquid epoxy resin cured for 7 days with Ancamide 2386 curing agent showed excellent overall chemical resistance and significantly exceeded typical amidoamine curing agent results. Table 2 shows short and medium-term results for immersion testing in accordance with ASTM D543 where 1“ x 3“ of 1/8“ thick castings were immersed in the specified reagents and measured for weight gain.

TABLE 2: ANCAMIDE 2386 CHEMICAL RESISTANCE — % WEIGHT GAIN

Reagent	1 Day	3 Days	7 Days	28 Days	90 Days
10% sulfuric	0.36	0.60	0.89	1.78	2.83
70% sulfuric	0.14	0.32	0.46	0.84	1.28
Water	0.17	0.35	0.57	1.13	1.74
Butyl Cellosolve	0.20	0.45	0.96	4.75	6.32
MEK	12.41	D	D	D	D
10% Acetic Acid	1.43	2.49	3.75	6.83	10.39
10% Lactic Acid	0.53	0.98	1.53	2.88	4.52
Toluene	1.17	5.30	11.45	D	D
40% Nitric Acid	2.28	4.50	8.04	D	D
Ethanol	1.48	2.67	3.88	6.77	10.30
10% HCl	0.21	0.37	0.59	1.21	1.93
1,1,1 Trichloroethane	0.26	0.82	1.61	3.74	5.79

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