Ultra-Low Emission Epoxy Protective Coating – A Solution towards Sustainable Future

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Outline

- ❑ Coating Market Requirements
- ❑ Evolution of epoxy coatings and the technical challenges involved
- ❑ Effect of Plasticizers in Epoxy Coating
- ❑ Ultra-low emission epoxy curing agents Ancamine® 2712M, Ancamine® 2739 and Ancamide® 2769 Performance
- ❑ Summary & Questions

Market Trend & Drivers in the Epoxy Coatings Industry

Better EH&S Profile

- Ultra-low or zero emission
- Improved EH&S profile & Sustainable solution
- Elimination of harmful raw materials

Improved Efficiency

- Wider application window
- Reduced downtime
- Fast through cure at applied temperature

Enhanced Performance

- Improved Corrosion resistance
- Enhanced durability over time
- Blush resistance under humid conditions

Epoxy Coating Systems Development 1970 - Today

1970

Solventborne Epoxy Coating

VOC content > 450 g/l

+ High flexibility
+ Fast lacquer dry & long pot life
+ Long overcoatability

- Moderate chemical resistance
- Poor low temperature cure
- High VOC

Polyamides Curing Agents predominantly used with solid epoxy resins

Epoxy Coating Systems Development 1970 - Today

1970

2000

Solventborne Epoxy Coating

VOC content > 450 g/l

High Solid Epoxy Coating

VOC content < 250 g/l

+ High flexibility
+ Fast lacquer dry & long pot life
+ Long overcoatability

\- Moderate chemical resistance
\- Poor low temperature cure
\- High VOC

\+ Low VOC
\+ Low temp. cure with good apperance
\+ High chemical resistance

\- Long dry time & short pot life
\- Needs plasticizer for full cure
\- Moderate flexibility

Emerging Environmental Regulations Drive Innovation

1970

Solvent Born Epoxy Coating

VOC content > 450 g/l

+ High flexibility
+ Fast lacquer dry & long pot life
+ Long overcoatability

- Moderate chemical resistance
- Poor low temperature cure
- High VOC

2000

High Solid Epoxy Coating

VOC content < 250 g/l

+ Low VOC
+ Low temp. cure with good apperance
+ High chemical resistance

- Long dry time & short pot life
- Needs plasticizer for full cure
- Moderate flexibility

2015

Ultra Low / Zero Emission Epoxy Coating

VOC content < 100 g/l

+ Ultra low or no VOC
+ Low temperature cure with good appearance
+ Long Pot life faster cure
+ Does not need plasticizer for full cure
+ Good flexibility
+ Excellent corrosion resistance

2025

New Evonik offerings bring traditional Epoxy Coating Systems to the Next Level

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Example of Property Loss in Systems with Fugitive Plasticizers…

	VOC	Plasticizer
▪ Release during…	Application	Service Life

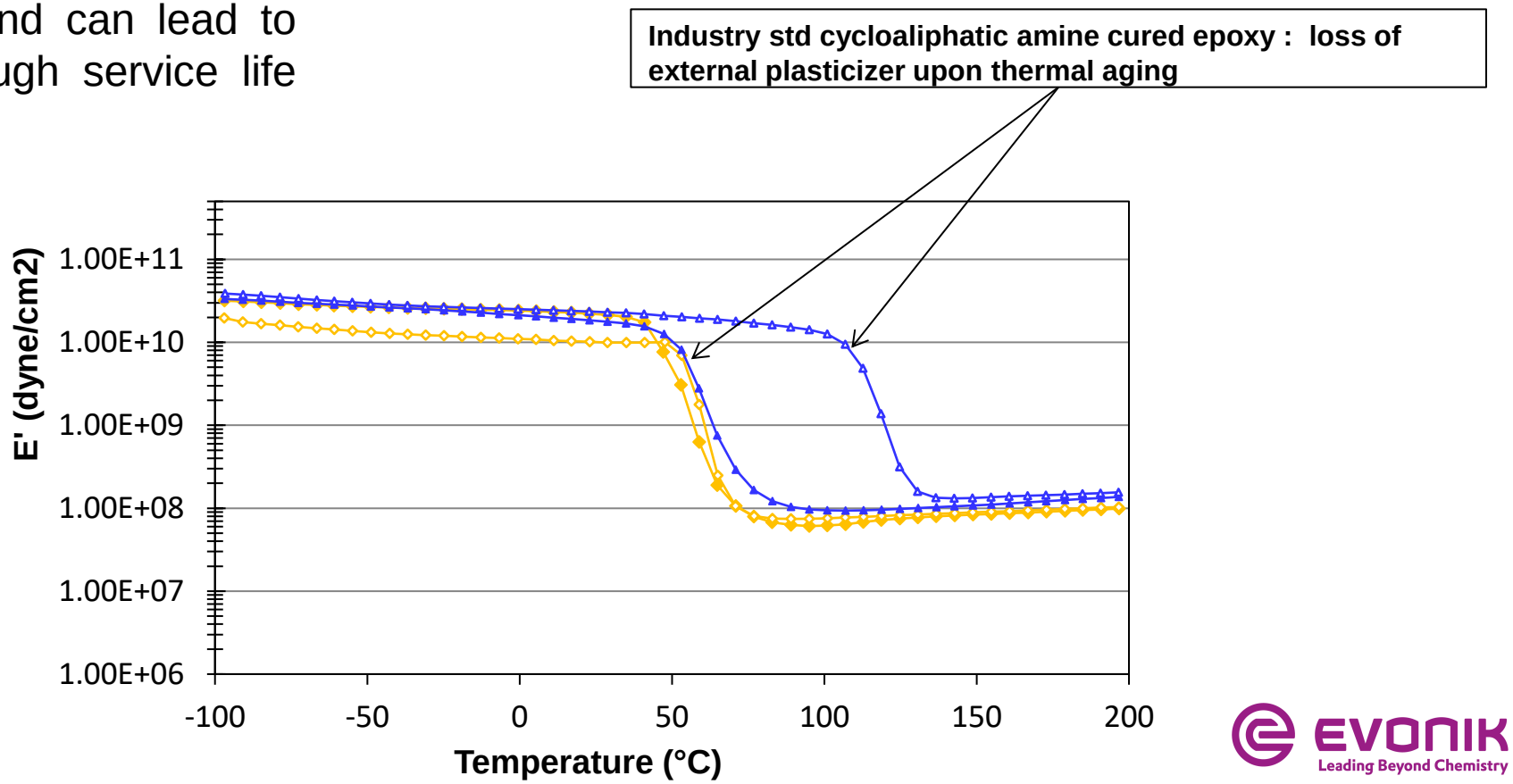
Emission of "fugitive" plasticizer over time may lead to brittle films & loss of adhesion over time.

Typical failure in HS/Low VOC Epoxy Coatings

DMA Analysis of Epoxy Systems

- Plasticization is required for high degree of cure under ambient and sub-ambient conditions in epoxy amine systems

- Use of fugitive plasticizers and can lead to loss of coating integrity through service life and reduce indoor air quality



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Ultra-Low Emission Products Designed to Support Low VOC Coatings

Alternative to conventional Mannich Base better EH&S profile

Ancamine® 2712M

Low Viscosity / Solvent Free

Good corrosion protection

High Aesthetics

Cyclo-type performance

Ancamine® 2739

Excellent Carbamation resistance

Long pot-life / Summer Grade

Low viscosity

Polyamide type performance

Ancamide® 2769

Designed for epoxy polyamide coatings with Ultra High Solids

Excellent Compatibility with LER

Adheres well at poorly prepared substrates

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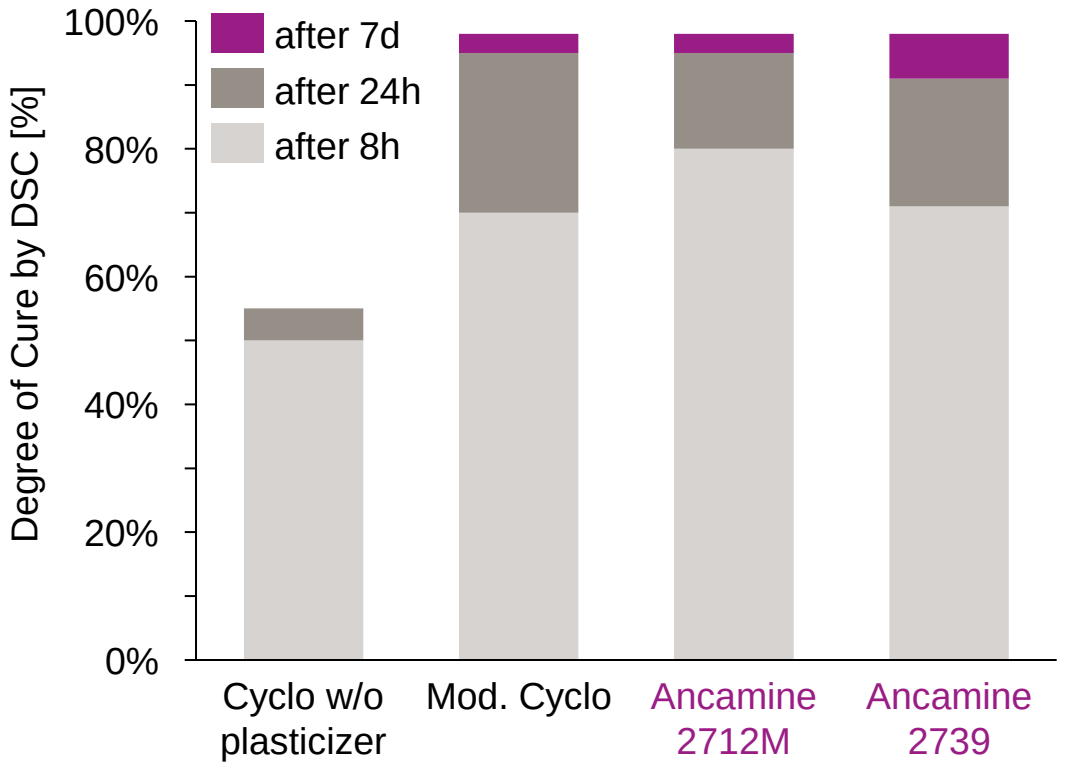
Ancamine® 2712M and Ancamine® 2739
Handling Properties vs High Solid Systems

Properties	Unit	Ancamine 2739	Ancamine 2712M	Modified Cycloaliphatic
AHEW	g/eqv	95	95	95
Viscosity @ 23°C	mPas	400	300	500
Mixed Viscosity @ 23°C	mPas	630	850	800
Gel time 150g mix, @ 23°C	min	75	35	40
TFST, phase III, 23˚C	h	9.5	7	8
TFST, phase III, 10˚C	h	17	14	20
Persoz hardness, 23˚C [1d/7d]		185/300	240/360	175/315
Carbamation resistance 23˚C,24h / 10˚C,2d		5/4	5/4	5/3
EIS (Rp)	Ω 24h	$1.0x10^{10}$	$2.3x10^{10}$	$9.3x10^{8}$
VOC for system	g/l	10	0	160

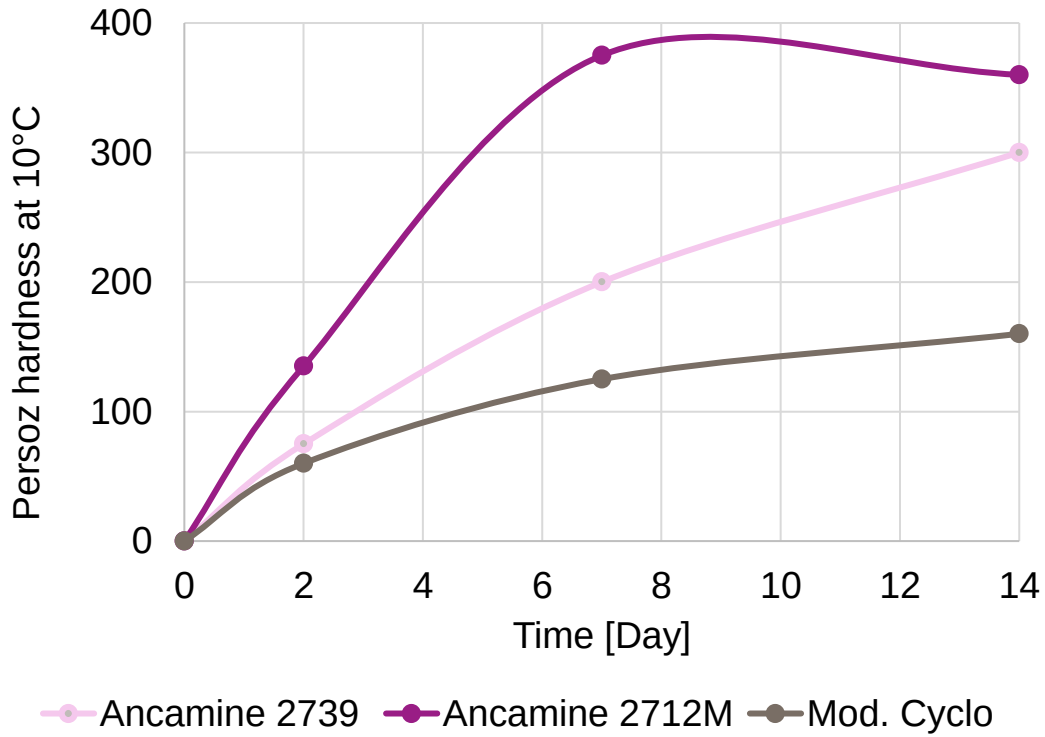
All formulations tested with Bisphenol A/F resin, C12-C14-glycidyl ether diluted, EEW=190, η=900 mPa.s

Ancamine 2739 and 2712M improve VOC level and provide excellent handling properties

Ancamine® 2739 & 2712M Deliver High Degree of Through Cure at Ambient and Low Temperatures



All formulations tested with Bisphenol A/F resin, C12-C14-glycidyl ether diluted, EEW=190, η=900 mPa.s
Cured at room temperature



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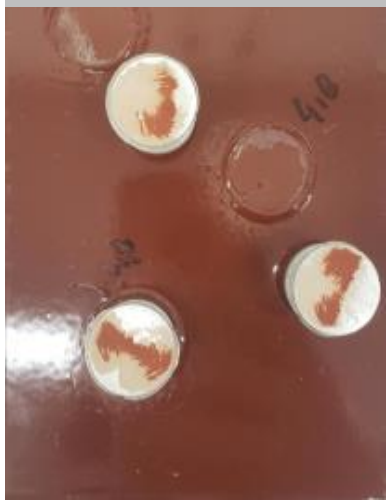
Anti-Corrosive Primers Based on Ancamine® 2739 and 2712M Provide a Balance of Cure Properties and Excellent Corrosion Protection

	Unit	Ancamine 2739	Ancamine 2712M	Modified Cycloaliphatic
VOC	g/l	88	60	220
Persoz hardness d7	s	230	290	170
Gloss	-	90	103	102
Thin film set time (BK) Ph III	h	8.0	6.5	7.5
Thumb twist drying time DTT / DH	h	5.0 / 9.5	4.0 / 8.0	4.8 / 9.0
Cross Hatch Adhesion[1] d7	D3359	5B	5B	5B
Salt Spray[2] 2000h		10	10	10
		No scribe creep or field blisters		
Cleveland Humidity 1000 h		10	10	10

Pull off Adhesion Test
Ancamine 2739



2000h Salt Spray
Ancamine 2739

[1]ASTM D3359 – rating 5= excellent no loss of adhesion

[2]Panels were scribed and evaluated for field blisters using ASTM B117. Evaluation of scribe creep was rated in accordance with ASTM D1654.

[3]Spray applies on sandblasted steel with a DFT of 150µm

Emission Test Results

DGEBA/F, Epodil® 748 Reactive Diluent diluted, EEW197, η 900mPa.s

Thermal Extraction/Desorption		
Thermal Extraction	T = 30°C Carrier gas flow: 75 ml/min Extraction time: 6 h Adsorbent: Tenax TA	
Thermal Desorption	Initial Temp: 20°C Desorption rate: 60°C/min End Temp: 300°C (30min)	
Analysis	GC/MS	
	Ancamine 2712M	**Cycloaliphatic Amine**
3 days testing	Few emissions; ppb level Zero BZA	BZA 30 µg/g sample
7 days testing	Few emissions; ppb level Zero BZA	BZA 20 µg/g sample

Product Summary of Ancamide® 2769

Benefits of this technology

Description

- Ultra Low Emission Amine Curing Agent showing excellent compatibility with LER

Target mkt segments

- Protective & Maintenance Coatings
- Marine Coatings
- **Corrosion Protection**

Benefit(s)

- 100% Solid formulations
- **Significantly reduce emissions and VOC**

Portfolio overview

Handling Properties

- Viscosity: 100 – 160 cPs
- AHEW: 150
- Phr: 65
- Gel Time, (150g mix at 77°F) (23°C)
  - 120 minutes

Advantages

- 100% solids showing polyamide like properties with no plasticizers.
- Excellent adhesion to poorly prepared substrates
- No Induction time required

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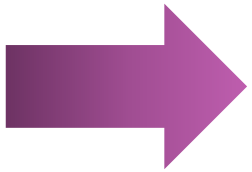
Ancamide 2769 Polyamide Curing Agent

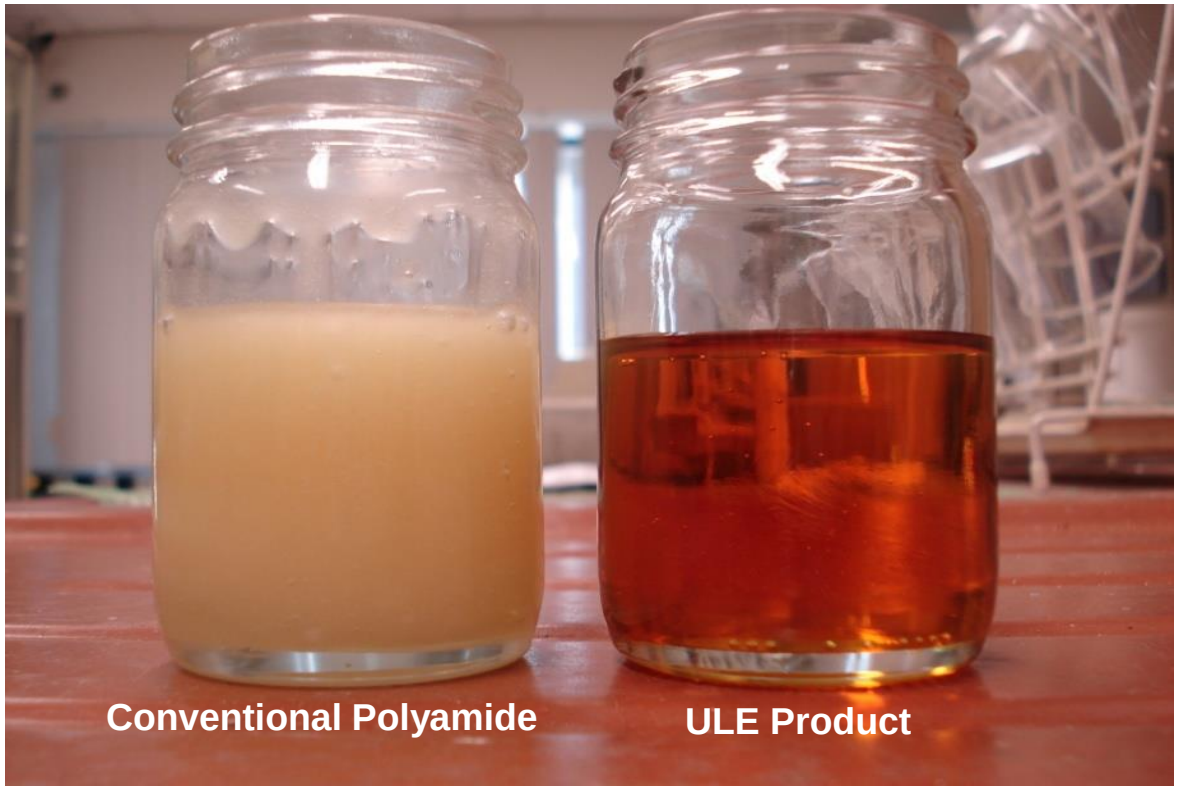
Conventional Polyamides
Solvent containing polyamides and adducts High VOC >250 g/l
Plasticizer-containing (benzyl alcohol) polyamides
High viscosity polyamides and adducts
Induction time requirements
Good corrosion protection and adhesion

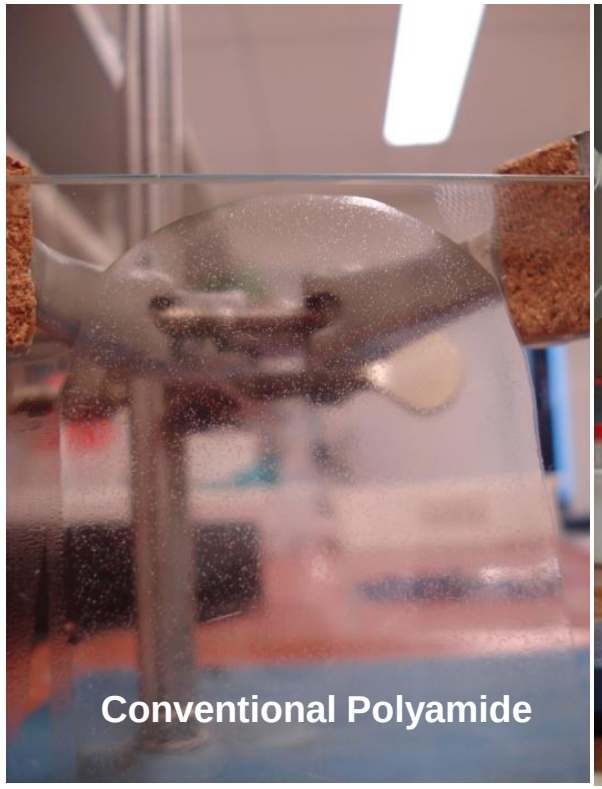


Ancamide 2769
Solvent free→ *Ability to formulate to 0 g/l VOC*
Plasticizer free→ *Improved mechanical properties*
Very low viscosity→ *Higher PVC, improved wetting*
Improved resin compatibility→ *No induction time, better productivity*
Maintain expected performance for corrosion and adhesion

Resin compatibility

Immediately after mixing with standard LER





No induction time required. Clear films immediately after mixing.

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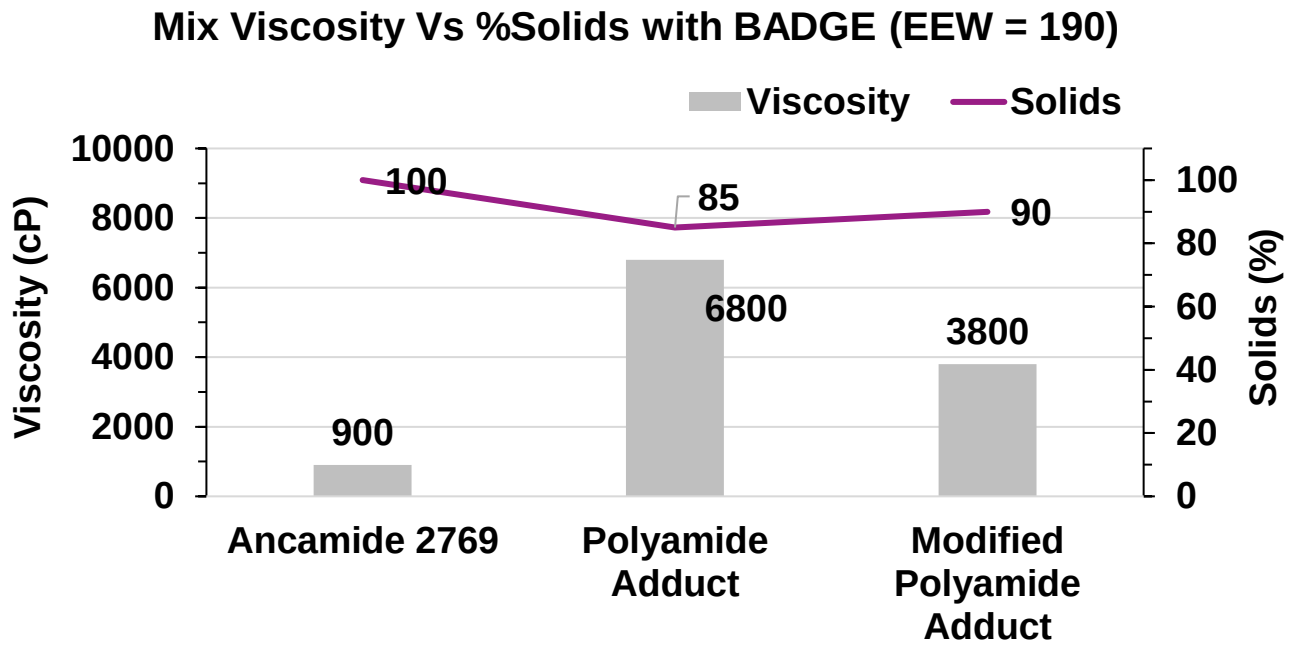
Ancamide® 2769 – Formulation Flexibility

Curing Agent Details	Neat Hardener Viscosity @ 25ºC	% Solids
Ancamide® 2769	150 cP	100%
Polyamide Adduct	3000 cP	70%
Modified Polyamide Adduct	1000 cP	75%



Ancamide 2769 enables high solids coatings and formulation flexibility due to its inherent low viscosity in turn Low VOC.

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Ancamide® 2769 - Excellent Adhesion

- **Adheres well on poorly prepared substrates**
  - Use in surface tolerant primers on metal Panel
  - Panels prepared by immersing in water for 3-4 weeks until rust build was significant
  - They were then coated and cured at RT for 7 days and then subjected to Adhesion test
  - It showed adhesion strength of 899 PSI

All tests performed on sandblasted steel SA2 ½ panels.

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Ancamide® 2769 – Performance Summary

Properties		Ancamide 2769
Potlife (min. to double viscosity)	@ 23°C (in min.)	120
TFST, 74F (23°C), 150µm wft	Phase 3 (in hours)	13.0
TFST, 50F (10°C), 150µm wft	Phase 3 (in hours)	27.0
Salt Spray 2000 hrs	Field/Scribe	10/9
Prohesion 2000 hrs	Field/Scribe	10/9

After 2000h Prohesion Test

After 2000h Salt Spray Test

Ancamide 2769 is capable of being formulated to ultra low VOC primers

DFT ~ 200-250 µm (8-10 mils)

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Ultra-low Emission Technology for Sustainable Future…

- ✓ Ultra-low viscosity enabling true VOC emissions
- ✓ Provides excellent surface appearance
- ✓ Workable Pot-life enabling better spray application process
- ✓ Excellent adhesion to metal substrates
- ✓ Improved resin compatibility with LER
- ✓ Exhibits good corrosion protection with Primer formulations

Our Regional Technical Team

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