

AMICURE® PACM Curing Agent**DESCRIPTION**

Amicure® PACM curing agent is a liquid unmodified cycloaliphatic amine; bis-(p-aminocyclohexyl) methane. It has been designed for use as an alternative to aromatic amines in the elevated temperature cure of liquid epoxy resins.

APPLICATIONS

- Structural Composites
 - High Temperature Pipes and Fittings
 - Wind Blades
 - Tanks
 - Casting and Tooling
- Adhesives

RECOMMENDED PROCESSING

- Resin Infusion
- Filament Winding
- Wet lay-up Laminates
- Resin Transfer Molding

ADVANTAGES

- Excellent fracture toughness and fatigue properties
- Fast cure enables increased throughput
- Long pot life at moderate temperatures
- Excellent mechanical properties following elevated temperature cure
- Good resistance against acids, alkali, water, and hydrocarbon solvents when heat cured

TYPICAL CURE SCHEDULE

- 1 hour at 176°F, then 2 hours at 302°F
- 1 hour at 80°C, then 2 hours at 150°C

STORAGE AND HANDLING

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.

Material may crystallize or solidify upon exposure to low temperatures. Crystallized or solidified material can be utilized after melting at elevated temperatures without impacting handling or physical properties. It is recommended that the material be heated to 50-70°C while mixing continuously for 1 hour. Once the solidified material has fully homogenized, it can be cooled to room temperature and utilized under normal conditions.

Refer to the Safety Data Sheet for Amicure PACM curing agent.

TABLE 1: TYPICAL PROPERTIES

Appearance	Clear Liquid
Color (Gardner)	1
Viscosity @ 77°F / 25°C	80 cPs
Specific Gravity @ 77°F / 25°C	0.96
Amine Value (mg KOH/g)	526
Flash Point (closed cup)	90°C >194°F
Equivalent Wt/{H}	52.5
Use Level (1) (PHR)	29.0

TABLE 2: TYPICAL HANDLING PROPERTIES¹

Mixed Viscosity 77°F / 25°C	1,720 cPs
Gel Time (150g mix @ 77°F / 25°C)	220 min
Time to 10,000 cPs @ 104°F / 40°C	93 min

TABLE 3: TEMPERATURE RESISTANCE¹

Heat Deflection Temperature (ASTM D658-264)	160°C	320°F
Glass Transition Temperature (DSC second scan)	166°C	331°F

TABLE 4: MECHANICAL PERFORMANCE – CAST PANEL¹

Flexural Strength	162 MPa	23.5 ksi
Flexural Modulus	3.5 GPa	0.51 Msi
Tensile Strength	72 MPa	10.4 ksi
Tensile Modulus 2	2.3 GPa	.33 Msi
Tensile Elongation @ Break	5.5%	
Compressive Strength	106 MPa	15.4 ksi
Compressive Modulus	2.0 GPa	0.29 Msi
Fracture Toughness K1C	0.86 MPa*m ^{1/2}	783 psi*in ^{1/2}
Fracture Toughness G1C	275 J/m ²	1.53 in-lb/in ²
Izod Impact Strength	44.0 J/m	0.8 ft-lb/in

TABLE 5: MECHANICAL PERFORMANCE – COMPOSITE PANEL¹

ILSS 0° Longitude	68.0 MPa	9,863 psi
ILSS 90° Transverse	21.0 MPa	3,046 psi
Flexural Strength - Composite 0° Longitude	1158 MPa	167.9 ksi
Flexural Modulus - Composite 0° Longitude	51.0 GPa	7.40 Msi

(1) Amicure PACM curing agent formulated with standard Bisphenol-A based (DGEBA, EEW=180) epoxy resin

VISCOSITY PROFILE

Amicure PACM curative offers low inherent viscosity and moderate pot life which is advantageous in many processes for the fabrication of composite components. Figure 1 shows the viscosity build of the Amicure PACM with both EEW=180 and EEW=190 DGEBA resin at two different processing temperatures (25°C and 50°C). Lower initial viscosity can be achieved at 50°C, allowing for better infusion and a pot life (2X initial viscosity) of approximately 35 minutes. The pot life increases to approximately 1.5 hours with a processing temperature of 25°C. Pot life can also be increased by using EEW=180 DGEBA resin at either processing temperature.

MECHANICAL PROPERTIES

In addition to the cure cycle and processing conditions used, the selection of an epoxy curing agent is a critical factor in determining the structural integrity of a composite part. Evonik offers a wide selection of amine based curing agents which can be used to maximize load-bearing capabilities, fatigue resistance, and fracture toughness in a fully formulated system. Amicure PACM curing agent can provide the highest fracture toughness of any commercially available cycloal-

iphatic amine when cured with epoxy resin. This intrinsic feature comes from the methylene linkage between the two cycloaliphatic rings that enables the free rotation of the amine during cure.

FIGURE 1: AMICURE PACM / DGEBA MIX VISCOSITY AT 77°F (25°C) AND 122°F (50°C)

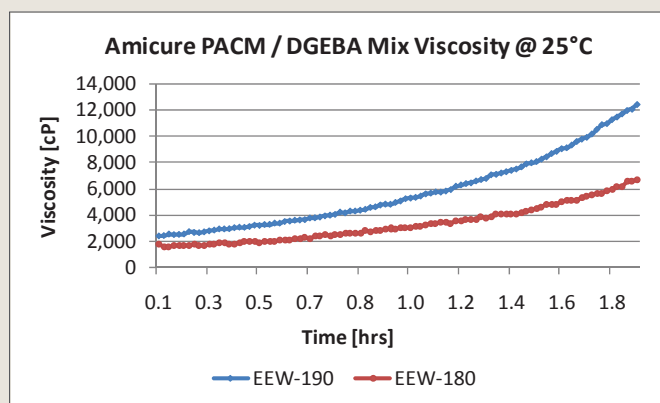
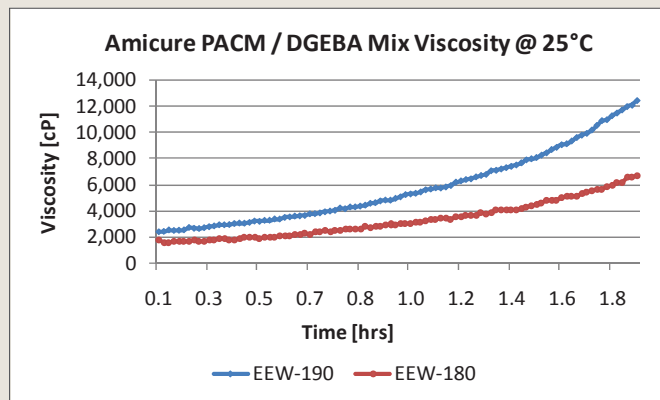


TABLE 6: COMPOSITE PANEL FABRICATION

Method: Vacuum Assisted Resin Transfer Molding (VARTM)
Fiber Type: E-glass (275g/m ²) unidirectional
Fiber Volume: 60 ± 3%
Cure Schedule: 1 hr at 80°C, then 3 hrs at 150°C

TABLE 7: MECHANICAL PERFORMANCE - COMPOSITE PANEL

	SI	English
Flexural Strength 0° Longitude (ASTM D790)	1158 MPa	168.0 ksi
Flexural Modulus 0° Longitude (ASTM D790)	51.0 GPa	7.40 Msi
Flexural Ultimate Strain (ASTM D790)	2.6%	
ILSS 0° Longitude (ASTM D2344)	68.00 MPa	9.9 ksi
ILSS 90° Transverse (ASTM D2344)	21.00 MPa	3.0 ksi
Compressive Strength 0° Longitude (ASTM D695)	324 MPa	47.0 ksi
Compressive Modulus 0° Longitude (ASTM D695)	13.0 GPa	1.89 Msi

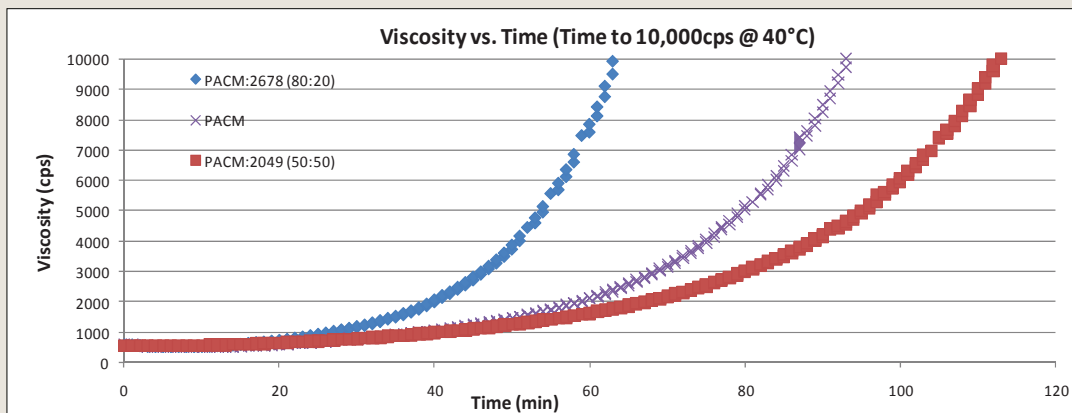
FORMULATING TIPS

The performance of formulations containing Amicure PACM curative can be modified by including other Evonik amines. Ancamine® 2678 and Ancamine® 2049 amines can be used with Amicure PACM to tailor the system's reactivity profile while maintaining key mechanical properties. A comparison of faster and slower cure amine formulations is shown below, including the DGEBA (EEW=180) mix viscosity build at 40°C.

TABLE 8: PROPERTIES COMPARISON BETWEEN FAST, MEDIUM AND SLOW CYCLOALIPHATIC AMINE FORMULATIONS

Formulation (using EEW=180 DGEBA)	Fast	Medium	Slow
Amicure PACM, pbw	20	28	15
Ancamine 2678, pbw	5		
Ancamine 2049, pbw			15
Total phr	25	28	30
AHEW	46	52.5	55
Handling Properties			
Viscosity at 77°F / 25°C	55 cPs	80 cPs	90 cPs
Mixed Viscosity at 77°F / 25°C	1,430 cPs	1,720 cPs	1,800 cPs
Gel Time (150g mix at 77°F / 25°C)	72 min	220 min	300 min
Time to 10,000 cPs at 104°F / 40°C	60 min	93 min	115 min
Tg (DSC second scan)	150°C	166°C	164°C
Mechanical Properties			
Flexural Strength	150 MPa	162 MPa	145 MPa
Flexural Modulus	3.0 GPa	3.5 GPa	3.0 GPa
Tensile Strength	60 MPa	72 MPa	65 MPa
Tensile Modulus	2.5 GPa	2.3 GPa	3.1 GPa
Tensile Elongation at Break	4.0%	5.5%	4.7%
Compressive Strength	105 MPa	106 MPa	120 MPa
Compressive Modulus	1.6 GPa	2.0 GPa	2.2 GPa
Fracture Toughness (SENB)			
Fracture Toughness K_{1C}	0.65 MPa*m ^{1/2}	0.86 MPa*m ^{1/2}	0.78 MPa*m ^{1/2}
Fracture Toughness G_{1C}	220 J/m ²	275 J/m ²	245 J/m ²

FIGURE 2: MIX VISCOSITY BUILDS OF FAST, MEDIUM, AND SLOW CYCLOALIPHATIC AMINE FORMULATIONS WITH DGEBA RESIN



CHEMICAL RESISTANCE

DGEBA epoxy resin cured with Amicure PACM curative can exhibit excellent chemical resistance in various reagents when cured at higher temperatures. Chemical resistance can be further improved by using a blend of Bis-F or multifunctional resin with DGEBA resin.

TABLE 9: CHEMICAL RESISTANCE TEST

Formulation: DGEBA Epoxy Resin Mix (EEW=180)	
Cure Schedule: 2 hrs at 80°C, then 3 hrs at 150°C	
Specimen: 1" X 3" X 1/8" Bar	
Test: % Weight gain after 120 days immersion at 73°F / 24°C	
Reagent	% Weight Gain
Water (Distilled)	2.0%
Toluene	0.7%
Acetone	8.5%
Ethanol	1.2%
Methanol	8.0%
HNO ₃ (10%)	3.8%
Acetic Acid (25%)	16.6%
NH ₄ OH (10%)	1.5%

Epoxy Curing Agents and Modifiers

AMICURE® PACM Curing Agent

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