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Advanced Materials

AroCy® XU 366 Cyanate Ester

GENERAL

AroCy® 366 cyanate ester monomer is a viscous liquid at room temperature. The monomer form is preferred for RTM injection of catalyzed resin at pot temperatures of 65 - 75°C (150 -165°F). Blends with AroCy® cyanate ester prepolymers or thermoplastic tougheners develop excellent tack and drape as conformal prepreg.

The size and hydrocarbon character of the three-ring monomer backbone impart useful properties to homopolymers cured at temperatures as low as 121°C (250°F). Exceptionally low moisture absorption and dielectric loss properties are characteristic of AroCy® XU 366 matrices. Suggested applications include large (250 - 350°F cured) aircraft composite structures, microwave antennas, radomes, spaceware, and structural or electronic grade adhesives.

FEATURES

Semi-solid monomer form
Less volatile than liquid epoxy resin
Practical cure temperatures are ≥ 121°C (250°F)
Homopolymer ultimate Tg is 192°C
0.6% moisture absorption at 100°C saturation
2.6 - 2.8 dielectric constant
0.0004 dissipation factor at 1 MHz

TYPICAL PROPERTIES*

Visual Appearance	Amber viscous liquid
Brookfield Viscosity, cPs @ at 65°C	500
Density at 25°C	
G/cm^3	1.14
Lb/gal	9.50
Refractive Index at 110°C	1.5450
Reactivity at 107°C, %	
Trimerization per hour	<0.3
Nonvolatiles, weight %**	99.6

* Typical properties are based on Huntsman's test methods. Copies are available upon request.

** Measured on a 0.5 gram sample for 30 minutes on a 150°C hot plate.

CATALYSIS AND CURING

Uncatalyzed AroCy® XU 366 monomer, when heated under controlled conditions, progresses through several prepolymer physical states (determined at room temperature) prior to gelling at 61% conversion. With continued heating, uncatalyzed homopolymer slowly approaches its ultimate Tg of 192°C, reaching 172°C after 50 hours.

Preferred curing catalysts are nonvolatile liquid solutions of zinc, cobalt, copper or manganese octoates/naphthenates, or the more latent acetylacetonates, dissolved in nonylphenol. Cobalt acetylacetonates are the most latent (heat-triggered) catalysts. Copper and cobalt catalysts are advantageous in minimizing cyanate reaction with moisture evolving from undried hydrophilic substrates during thermal cure.

Achieving practical conversions, 83% in 3 hours at cure temperatures in the 121 - 177°C (250 - 350°F) range, requires nonylphenol concentrations of 2 to 6 phr in addition to the coordination metal catalyst (Table 1).

CURED STATE PROPERTIES

TABLE 1

Cure Temperature (Tc)
Achieving Ultimate Tg in Three Hours
as a Function of Nonylphenol Concentration

Nonylphenol Concentration, phr	Tc °C	Tg °C
1	220	192
2	200	178
4	185	170
6	177	168

Table 2 compares thermal, mechanical, electrical and moisture absorption properties as functions of maximum cure temperature (Tc MAX) for three cyanate ester resins. Data shown are with 2 phr nonylphenol. At 149°C (300°F) only AroCy® XU 366 achieves a useful combination of matrix properties. Higher conversions and improved properties are obtained using 4 and 6 phr nonylphenol.

Table 3 show that blends of AroCy® XU 366 with up to 50% AroCy B-30 prepolymer or AroCy® L-10 liquid monomer also develop useful matrix properties when cured at Tc MAX 177°C. With post-cure, such blends achieve Tg values well above 200°C and reflect the more hydrophobic nature of the AroCy® XU 366 component.

TABLE 2

Properties of Dicyanate Ester Homopolymers* as a Function of Maximum Cure Temperature (Tc Max)

Property	AroCy® XU 366	Homopolymer AroCy® L-10	AroCy B-10
Tc MAX 149°C			
Conversion, %	83.5	75.6	73.2
Tg, °C	128	119	123
Water Absorption, weight %[1]	1.0	9.8 [2]	5.9 [2]
Flexural Strength, KPa	80	63	6
Flexural Modulus, MPa	3.0	3.0	2.6
Flexural Strain, %	3.0	2.1	0.2
Dk, 1 MHz	2.80	NM	NM
Df, 1 MHz	1×10^{-3}	NM	NM
Tc MAX 177°C			
Conversion, %	89.3	83.6	74.8
Tg, °C	149	146	142
Water Absorption, weight % [1]	0.6	2.1	2.1
Flexural Strength, KPa	93	81	41
Flexural Modulus, MPa	3.0	3.3	2.9
Flexural Strain, %	3.7	2.5	0.5
Dk, 1 MHz	2.70	3.05	NM
Df, 1 MHz	4×10^{-4}	6×10^{-3}	NM
Tc MAX 204°C			
Conversion, %	99.1	87.5	81.8
Tg, °C	175	170	173
Water Absorption, weight % [1]	0.7	1.8	1.6
Flexural Strength, KPa	121	125	76
Flexural Modulus, MPa	2.8	3.1	3.4
Flexural Strain, %	5.1	4.3	2.3
Dk, 1 MHz	2.64	2.99	2.98
Df, 1 MHz	4×10^{-4}	5×10^{-3}	5×10^{-3}

* Catalyzed with 2 phr nonylphenol and 0.15 zinc naphthenate, 8% Zn grade. Cured 2 - 3 hours at Tc MAX.

[1] After 218 hours immersion in water at 100°C.

[2] Partially hydrolyzed.

NM = Not Measured

TABLE 3

PROPERTIES Of AroCy® XU 366 BLENDS

Composition (weight)	**A**	**B**	**C**	**D**
AroCy® XU 366	75	50	25	50
AroCy® B-30	25	50	75	-
AroCy® L-10	-	-	-	50
Nonylphenol	2	2	2	2
Zinc naphthenate [1]	0.15	0.15	0.15	0.15
Gel Time, minutes at 104°C	30	34	40	20
Cured State Properties [2]				
HDT, °C	150	142	139	154
Flexural Strength, ksi	20.0	20.6	12.4	23.8
Flexural Modulus, msi	0.54	0.56	0.56	0.52
Flexural Strain, %	3.9	4.2	2.8	5.0
% Water Absorption				
24 hours at 100°C	0.54	0.59	0.67	0.68
48 hours at 100°C	0.66	0.75	0.88	0.83
64 hours at 100°C	0.70	0.80	0.88	0.89
Post Cured [3]				
HDT, °C	197	211	226	215
Flexural Strength, ksi	20.2	20.9	19.1	22.5
Flexural Modulus, msi	0.47	0.48	0.49	0.45
Flexural Strain, %	5.7	4.7	4.0	7.0
% Water Absorption				
24 hours at 100°C	0.74	0.90	1.06	0.94
48 hours at 100°C	0.83	1.02	1.23	1.04
64 hours at 100°C	0.85	1.06	1.27	1.05

[1] 8% zinc grade.

[2] Cured 1 hour at 149°C plus 1 hour at 177°C.

[3] Post cured an additional 1 hour at 235°C.

STORAGE

AroCY® XU 366 is supplied in 40 pound pails. This product should be stored in a dry place, in the sealed original container, maintained between +5°C and +25°C (+41°F and 77°F). Under these storage conditions, the shelf life is 3 years. The product should not be exposed to direct sunlight.

Crystalline material can be melted in the closed containers by heating at a hot air temperature of 85°C (185°F). Application or compounding with other resinous components at temperatures of 65°C - 85°C (149°F and 185°F) is suggested to avoid unexpected crystallization of AroCy® XU 366 supercooled liquid. Electric resistance heating tapes, mantles or blankets should never be used for heating, as localized hot spots could initiate uncontrollable exothermic polymerization.

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First Aid!
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