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Technical Paper

New Low Styrene, Isophthalic Fire Retardant Resin

Abstract

A new isophthalic fire retardant resin has been developed that meets ASTM E 84 Class I without the use of synergists. A significant added advantage is that it contains less than 40% styrene. A second version is available that meets ASTM E 84 Class I with 1.5 % antimony trioxide or ASTM E 84 Class II without the use of synergists. This paper will provide information on cast mechanical properties, standard liquid property values, projected corrosion resistance capability and the ASTM E 84 test results on composites made with the two versions. Comparative data for non-fire retardant resins will also be provided.

Introduction

The industrial need for low styrene content resins also applies to isophthalic fire retardant resins. In order to service this market, two new isophthalic resins with less than 40% styrene were developed. One meets ASTM E 84 Class I without the use of synergists and the other requires the use of 1.5% antimony trioxide to meet ASTM E 84 Class I. For the purposes of this paper, the one that meets ASTM E 84 Class I will be coded F1 and the one that needs the 1.5% antimony trioxide will be coded F2. Liquid properties, cure rate and cast mechanical properties of a standard non fire retardant isophthalic resin will be included for comparative purposes. The information on the non fire retardant isophthalic resin will be coded NFR.

The heat distortion temperature of standard non fire retardant isophthalic resins 1:1(isophthalic acid: maleic) is normally about 220°F. A heat distortion temperature minimum of 190°F was imposed on the newly developed resin. (Some heat distortion properties were traded for lower styrene content and fire resistance.)

ASTM E 84 fire resistant standard was chosen because it is a required test that must be passed in order for products to be considered in many fire retardant applications. The title for the ASTM E 84 standard is “Surface Burning Characteristics of Building Materials”. Laminates that are a minimum of 18 inches wide by 24 feet long are compared in burning characteristics to a mineral fiber cement board, which is rated 0, and a red oak board that is rated 100. To meet an ASTM E 84 Class I rating, the laminate in question must have an ASTM E 84 rating of 25 or less. There is a need to provide products that will meet ASTM E 84 Class I with and without synergists. A resin that fulfills Class I rating without synergists is usually high in halogen content. This type of resin is more expensive than a non-halogenated product and is also higher in specific gravity. The higher specific gravity is a major concern to some fabricators because of the need to purchase more pounds of resin to make a specific fiberglass reinforced plastic part. Halogens that are commonly used are bromine and chlorine. Because halogens are an integral part of the polymer they do not pose any health concerns or fabrication problems. Synergists such as antimony trioxide and dispersions of antimony pentoxide/antimony trioxide are often used. When using bromine, an ASTM E 84 Class I rating can be obtained by using approximately one half the amount of halogen and adding a synergist to the resin. In the case of antimony trioxide, 1.5 to 3.0% is usually added. The dispersions of antimony trioxide/antimony pentoxide are usually supplied in a carrier and thus more must be added to allow for the carrier dilution.

Experimental

Some of the key requirements that were imposed in resin development were:

1) Styrene content must be <40%
2) Resin cast heat distortion must be >180°F
3) Resin must meet ASTM E 84 Class I with and without synergists

Liquid properties were tested with standard equipment and methods that are typically used in the industry. Composites were also prepared to determine the rate of cure. The cast and composite preparation are found in figures 1 and 2 respectively. The castings were tested for mechanical properties. Fire testing was run on composites at an outside lab.

Results

a) Two resins with less than 40% styrene and with standard gel, cure and viscosity properties were successfully developed. See figure 3 for the detailed resin liquid properties.
b) F1 and F2 were tested for rate of cure in a 2-ply composite and the results are typical to those of several other isophthalic resins. See figure 4.
c) A heat distortion of greater than 180°F was obtained on both F1 and F2. Other mechanical properties are tabulated in figure 5.
d) The ASTM E 84 values are in figure 6. An ASTM E 84 Class I composite with and without synergists was obtained. Note that the F2 can be converted into an ASTM E 84 Class I product with the addition of only 1.5% antimony trioxide.

Applications

These newly developed products can be used for many hood and duct applications where mild chemical resistance is required. Other applications are partitions, guards over belts, motors, covers for water treatment plants, architectural structures and structural laminates for gel coated water-cooling towers, etc.

Conclusions

a) Two fire retardant resins have been developed, F1 and F2, which meet specific ASTM E 84 require-ments and contain less than 40% styrene.
b) F1 meets ASTM E 84 Class I without synergists.
c) F2 meets ASTM E 84 Class I with 1.5% antimony trioxide.
d) F1 meets ASTM E 84 Class II without synergists.
e) Viscosity, thixotrope ratio, gel, cure properties and cast properties of both F1 and F2 are similar to those of NFR resins. (The cure of F1 and F2 is slightly slower than NFR and the heat distortion of F1 and F2 is slightly lower than NFR resins.
f) The heat distortion temperature of both F1 and F2 is greater than 190°F.
g) Both F1 and F2 are significantly more fire retardant than NFR.

Figure 1 - **CASTING PREPARATION**

CATALYST AND CURE SCHEDULE	QUANTITY AND TIME
Catalyst system	
Benzoyl Peroxide (BPO), %	1.0
Cure schedule	
60°C/160°F, hours	4
93°C/200°F, hours	1
116°C/240°F, hours	1
138°C/280°F, hours	2

Figure 2 - COMPOSITE PREPARATION

PREPARATION	DETAILS
Promoter system	None (Resins are prepromoted)
Catalyst system	1.25 % MEKP (9% active oxygen)
Composite Construction	2 plies of 2.0 ounce chopped strand glass mat
Glass content, %	30
Thickness, inches	0.08
Posture	3 hrs at 100°C/212°F

Figure 3 –RESIN LIQUID PROPERTIES

PROPERTY	F1	F2	NFR
25°C BROOKFIELD VISCOSITY SPINDLE #2 @ 20 rpm, cps	500	500	500
THIX RATIO 2/20	2	2	2
GEL TIME WITH 1.25% MEKP, minutes	20	20	20
TOTAL TIME, minutes	27	26	32
PEAK EXOTHERM, °F	340	360	380
SPECIFIC GRAVITY	1.26	1.21	1.08

Figure 4 –COMPOSITE CURE RATE

DETAILS	F1	F2	NFR
PLIES OF 1.5 oz CHOPPED STRAND MAT	2	2	2
GLASS CONTENT, %	35	35	35
MEKP CONTENT ON THE RESIN, %	1.25	1.25	1.25
GEL TIME, minutes	26	25	25
TIME TO TACK FREE, minutes	90	80	70
SHORE D HARDNESS AFTER 2 HOURS	55	65	75
BARCOL HARDNESS AFTER 3 HOURS	10	20	25
BARCOL HARDNESS AFTER 24 HOURS	25	35	38

Figure 5 -**CAST MECHANICAL PROPERTIES**

PROPERTY	F1	F2	NFR
TENSILE STRENGTH, psi	9,400	11,000	12,000
TENSILE MODULUS, psi	560,000	550,000	550,000
ELONGATION, %	1.9	2.4	2.8
FLEXURAL STRENGTH, psi	17,400	18,000	18,400
FLEXURAL MODULUS, psi	600,000	580,000	610,000
HEAT DISTORTION TEMPERATURE, °F	194	205	224
BARCOL HARDNESS (934)	40	44	43
SPECIFIC GRAVITY	1.33	1.28	1.16

Figure 6 **- ASTM E 84 RESULTS**

TEST	RESULTS		
	F1	F2	NFR
ASTM E 84 test with no synergist			
Flame spread	20	35	280
Smoke development	600	650	1000
ASTM E 84 test with 1.5% Antimony Trioxide			
Flame spread	-	15	-
Smoke development	-	650	-