NEW TRANSPARENT COPOLYCARBONATE COMPOSITIONS WITH LOW OSU HEAT RELEASE VALUES

Jianbo Di, Gary Davis, Katherine Jackson*, Ahmed El Kassmi, Brian Mullen, Laura Schultz, Moitreyee Sinha*, Paul D. Sybert and Jenny Zhang*
GE Plastics
1 Lexan Lane
Mt. Vernon, IN 47620

**GE Global Research*
1 Research Circle
Niskayuna, NY 12309

Abstract

New polyester carbonate copolymers afford the first resins with low color, high transmission and low haze combined with low OSU Heat Release values. In addition, the fabricated articles can be hard coated to provide improved levels of scratch resistance. These compositions can be varied to maximize the various mechanical properties depending on the needs of the application. The excellent clarity combined with OSU 65/65 compliance allow for applications such as interior transportation windows/dust covers, partitions, mirrors and lighting lenses. The excellent colorability also allows for the fabrication of interior opaque components for the transportation industry.

Introduction

Safety concerns have prompted more stringent regulations for fire resistance of materials used in interior applications on commercial aircraft with the intention of reducing the rate of flame spread, heat release rate, smoke generation and toxic gases of combustions during an incident. In the 1980's Federal Aviation Administration (FAA) established a test method – Ohio State University (OSU) Heat Release test - that measures heat release rate from materials exposed to radiant heat [1]. The FAA established a maximum acceptable 2 minutes Heat Release (HR) and Peak Heat Release (PHR) of 65 KW min/m2 and 65 KW/m2 respectively, more commonly known as OSU 65/65. This became law for various interior materials in commercial aircraft manufactured after 1988. Traditionally some polyetherimide and polyphenylsulfone [2-8] grades meet the OSU 65/65 standards, but to date no transparent low color materials meet the requirements.

Transparent materials are needed and used as covers for windows, lighting and signage. The transparent dust covers for windows currently in use on commercial aircrafts are typically made of a transparent polycarbonate material having a scratch resistant hard coat. These dust covers do not meet the OSU 65/65 requirement. The FAA has provided exemptions to allow the use of such materials because to date no commercial materials are available which meet the necessary requirements. In addition to dust covers, such a transparent materials meeting the OSU 65/65 standards will greatly increase design freedom for aircrafts interiors.

A class of new polyester carbonate copolymers has been developed by GE Plastics that has low OSU heat release values (<55/55) while maintaining low color, high transmission and low haze. This resin complies with FAA requirements on flame, smoke and toxicity and will be hereto referred to as OSU resin. To our knowledge these are the first polymers that have the combination of OSU 65/65 compliance, high clarity and low color. This paper will explore the optical, physical, thermal and FAR properties of the new resins. Hard coated sheets made of OSU resin have been shown to meet OSU 65/65 standards and offer improved scratch resistance. Opaque formulations can be prepared by the addition of dyes and pigments and the properties thereof are also discussed.

Results and Discussion

Optical and FAR Properties

The light transmission and haze of OSU resin, measured on plaques of 0.125 inch thickness per ASTM D 1003, are >86% and <1.5, respectively. A transparent color chip and an opaque color chip in white color are shown in Figure 1. The excellent optical properties of OSU resin make possible transparent (tinted or untinted) and opaque white resins, which have not been accessible by existing OSU 65/65 compliant materials.

FAA regulations on the flammability of materials cover the following burning behavior: heat release (OSU Heat Release Test), smoke generation (NBS Smoke

Density Test) and toxic gas emission (Draeger Tube Toxic Gas Test). For certain parts of the aircraft, FAA also requires the materials to pass either a 12 second or a 60 second vertical burn test. In addition, aircraft manufactures may have additional requirements on the flammability of the materials. Table 1 summarizes the performance of OSU resin against typical FAA requirements. Especially noteworthy are the OSU heat release values that not only meet, but also exceed OSU 65/65 standards (<55/55). At the same time, OSU resin generates a very low amount of smoke and toxic gases during burning.

Like polycarbonate, OSU resin shows an excellent balance in physical and thermal properties (Table 2). The T_g of OSU resin is 140 ºC while both polyetherimide and polyphenylsulfone have much higher T_g. The lower T_g of OSU resin allows better thermoforming for sheet applications. OSU resin also shows excellent toughness as measured by notched izod impact strength of 170 to 800J/m, depending on the compositions and color packages.

Weatherability of OSU Resin

The weatherability of transparent resin formulations is mainly related to their ability to retain color, transparency and good mechanical properties. In this study, a transparent, hard coated and UV stabilized OSU sheet sample and a commercial aircraft dust cover sample (also hard coated and UV stabilized) were tested side by side in accelerated weathering which was accomplished using a CIRA/ soda lime-filtered xenon arc, a more rain-like water spray, and an occasional sponge-wiping of the samples [9]. Figure 2 shows the changes in yellowness index (YI, ASTM E313-73, D1925) as a function of exposure energy for the two samples. The OSU sheet sample showed a trend of bleaching to the blue side while commercial sample became more yellow with time. While the data are not included in this report, both samples had minimal changes in both %T and %H at 1500 kJ.

Chemical Resistance of OSU Resin

The chemical resistance of OSU resin against common cleaning solutions used in aircraft was evaluated and summarized in Table 3. The results showed that OSU resin offers good chemical resistance for aircraft interior applications.

Hard Coated OSU Sheet

In some interior parts of transportation devices, the plastic parts are silicone hard coated in order to improve the scratch resistance. Articles made of OSU resin have been shown to process well in existing coating procedures with commonly used hard coatings. The coating showed satisfactory surface and adhesion performance, without sacrificing either optical or FAR performance. Typical FAR properties of OSU parts coated with a silicone based coating are shown in Table 4.

Conclusion

New polyester carbonate copolymers afford the first resins with low color, high transmission and low haze combined with low OSU Heat Release values. In addition, the fabricated articles can be hard coated to provide improved levels of scratch resistance. These compositions can be varied to maximize the various mechanical properties depending on the needs of the application. The excellent clarity combined with OSU 65/65 compliance allow for applications such as interior transportation windows/dust covers, partitions, mirrors and lighting lenses. The excellent colorability also allows for the fabrication of interior opaque components for the transportation industry.

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Figures and tables are provided for general information and are not for the purpose of warranty or specification. Any flame or ignition resistant rating presented herein is NOT intended to reflect hazards presented by this or any other material under actual fire conditions. All resins and mixtures discussed herein should be thoroughly tested in actual parts under end use conditions before incorporation into any device.

Keywords

OSU, polyester carbonate copolymer, heat release.

Figure 1
Transparent and white opaque color chips of OSU resin

Table 1
FAR Properties of OSU resin

OSU Heat Release Test		FAA Requirements [1]	Transparent OSU Resin
2 minutes	kw-min/m^2	65	<55
Peak Rate	kw/m^2	65	<55
NBS Smoke Density - Flaming Mode			
D_s @ 1.5 minutes			3
Dm @ 4.0 minutes		200	33
Draeger Tube Toxicity			
Carbon Monoxide	ppm	3,500	75
Hydrogen Cyanide	ppm	150	<1
Nitrous Gases	ppm	100	<1
Sulfur Oxides	ppm	100	<1
Hydrogen Chloride	ppm	150	20
Hydrogen Fluoride	ppm	100	20

[1] Per 14CFR 25.853 Appendix F. Results shown above were tested on parts with thickness of 0.080 inches (2.0 millimeters).

Table 2
Physical properties of transparent and opaque OSU formulations

PROPERTY	Units	Method	PC	Transparent OSU Resin	Opaque OSU Resin
MECHANICAL					
Tensile Stress at Yield, 50 mm/min	MPa	ASTM D 638	62	74.2	73.9
Tensile Stress at Break, 50 mm/min	MPa	ASTM D 638	66	72.8	60.7
Tensile Elongation at Yield, 50 mm/min	%	ASTM D 638	7	6.9	6.8
Tensile Elongation at Break, 50 mm/min	%	ASTM D 638	110	99	52
Tensile Modulus, 50 mm/min	MPa	ASTM D 638	2,351	2,510	2,420
Flexural Modulus 1.27 mm/min	MPa	ASTM D 790	2,344	2,480	2,470
Flexural Stress@Yield, 1.27mm/min	MPa	ASTM D 790	93	116	114
IMPACT					
Notch Izod Impact, 23°C	J/m	ASTM D 256	801	719	540
THERMAL					
HDT, 0.455MPa	°C	ASTM D 648	138	131	130
HDT, 1.82MPa	°C	ASTM D 648	127	120	117
Tg	°C	DSC	150	140	140
PHYSICAL					
Melt Flow Rate, 300°C/1.2 kgf	g/10 min	ASTM D 1238	10.5	6	6

All test specimens were molded at 0.125”. The tensile properties were obtained on Type 1 bars.

Figure 2
Color change during Xenon Arc weathering of transparent OSU formulations

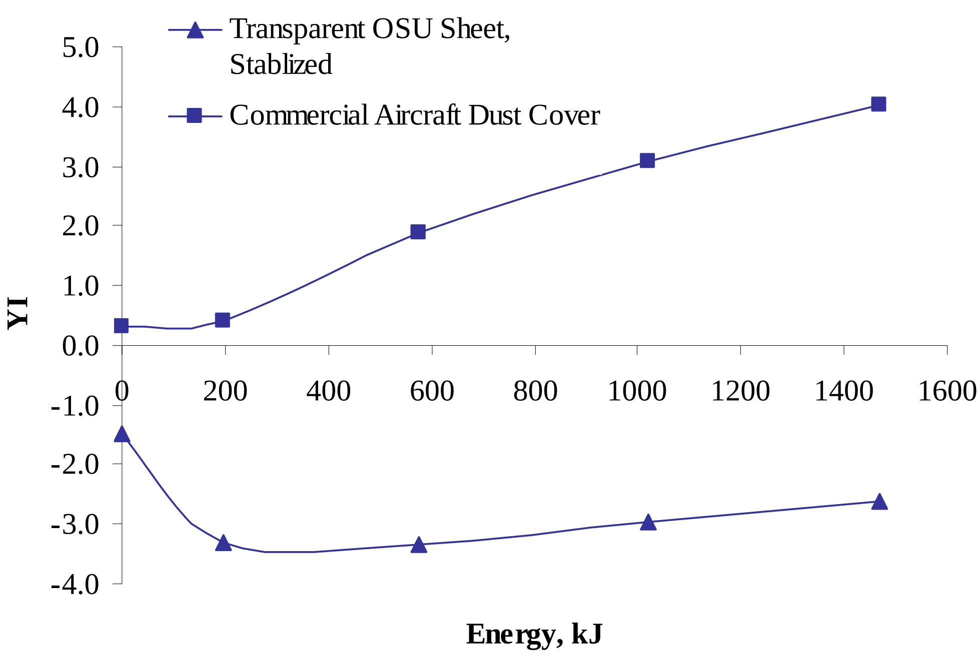

Table 3
Chemical resistance of OSU resin against solutions commonly used in aircrafts

Chem. ID	OSU Resin
SD-20	Pass
479C cleaner	Pass
Dish soap	Pass
Novus polish	Pass
100% TCE	Fail
Naphtha	Pass
2006A clean	Pass
Albright clean	Pass
Downy	Pass
C1102 clean	Pass
BUC	Pass
Form. 409	Pass

Chemical Resistance: 1Hr. Exposure, @74F, with 2000PSI fixtures

Table 4
FAR properties of OSU sheet with hard coating

OSU Heat Release Test		FAA Requirements [1]	OSU Sheet Transparent
2 minutes	kw-min/m^2	65	<55
Peak Rate	kw/m^2	65	<55
NBS Smoke Density - Flaming Mode			
D_S @ 1.5 minutes			5
Dm @ 4.0 minutes		200	37
Draeger Tube Toxicity			
Carbon Monoxide	ppm	3,500	100
Hydrogen Cyanide	ppm	150	<1
Nitrous Gases	ppm	100	<1
Sulfur Oxides	ppm	100	<1
Hydrogen Chloride	ppm	150	1
Hydrogen Fluoride	ppm	100	1

[1] Per 14CFR 25.853 Appendix F. Results shown above were tested on parts with thickness of 0.080 inches (2.0 millimeters).