FLAME RETARDANT PC/ABS BLENDS FOR NOVEL LOW GLOSS MEDICAL APPLICATIONS

Amit S. Kulkarni, Srinivas Siripurapu, Todd M. Loehr, Parminder Agarwal, SABIC Innovative Plastics, Mt. Vernon, IN 47712

B. Parthipan, Pooja M.K., GE Global Research, John F. Welch Technology Center, Bangalore, Karnataka, India 560066

Abstract

Flame retardant (FR) PC/ABS blends find applications in the medical housings market owing to their superior processability and a fine balance between the primary requirements of flammability performance, mechanical properties and chemical resistance to hospital cleaners. In recent times, low part-surface gloss is emerging as an important requirement for such applications. This manuscript showcases a new chlorine-bromine free FR PC/ABS blend which meets these demanding requirements for extrusion and thermoforming applications.

Introduction

Blending polycarbonate (PC) with poly(acrylonitrile-butadiene-styrene) (ABS) is an effective route of synergistically combining the physical properties afforded by PC such as excellent room temperature impact, heat-resistance, and weatherability with the inherent superior processability, low temperature impact, and chemical resistance of ABS [1-3]. Flame retardant PC/ABS blends find multitude of applications in the computer and business equipment markets, as well as construction and furniture industry. Delivering the excellent physical property-processability balance, along with non-chlorinated/ non-brominated flame retardant packages poses a fascinating challenge.

A Low-Gloss flame-retardant PC/ABS (LG FR PC/ABS) is the latest in the CX-series [1-3] of flame retardant PC/ABS grades from SABIC Innovative Plastics. Table 1 outlines typical properties of this grade. It has a UL 94V flame rating of V-0 at 1.5 mm, a 5VB rating at 2.3 mm and is designed for sheet extrusion applications to meet stringent requirements in the medical housings, construction and furniture industries. In addition to chlorine/bromine-free flame retardant package, resistance to chemical cleaners and disinfectants, the Low-Gloss FR PC/ABS is designed specifically for low-gloss applications.

Table 1. Typical physical and flammability properties of flame retardant, extrudable PC/ABS blend, for low gloss applications.

Property	Test	Value
Melt Flow Rate, 260^{o}C/5kgf	ASTM D 1238	11 g/10min
Tensile Modulus	ASTM D 638	2870 MPa
Izod Impact, 23^{o}C	ASTM D 256	590 J/m
Heat Deflection 1.82 MPa, 3.2mm	ASTM D 648	88 ^{o}C
UL 94V-0	UL 94	1.5 mm
UL 94-5VB	UL 94	2.3 mm
Specific Gravity	ASTM D 792	1.2

The appearance of surface gloss is primarily a function of the reflective nature of an object's surface [4]. This is schematically represented in Figure 1, where the difference in specular reflection of an incident beam of light from a glossy surface (a) and a matt surface (b) is shown. Gloss of any surface depends on factors like the nature of the incident beam of light, and the surface finish of the object, and can be perceived by an observer as the appearance of distinct reflections, lack of haze, or in the case of fabrics as the presence of contrast [4]. In case of articles fabricated from engineering thermoplastics like PC/ABC resins, the manifestation of gloss, or the lack thereof, is primarily dictated by the surface finish of the article. The Low-Gloss FR PC/ABS blend, through proprietary additive technology can attain inherent low-gloss levels native to special matt surface finishes.

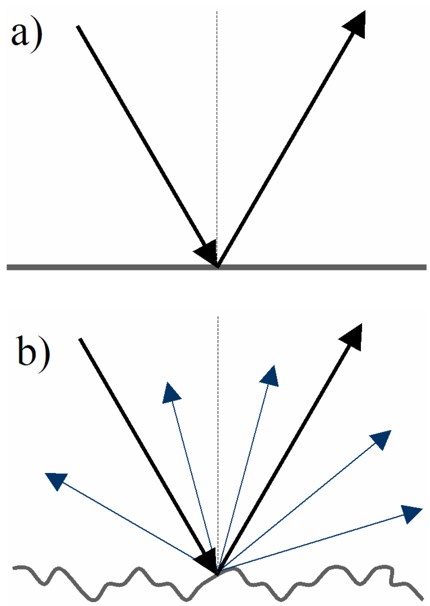

Figure 1. Difference in the reflection [4] of an incident beam of light resulting in a) glossy appearance and b) matt surface appearance.

Results and Discussion

The appearance of low gloss as stated in the previous section is a function of the surface finish as well as a material property. Figure 2 shows details of the 60° Gardner gloss measurements on a series of injection molded plaques using six different surface textures. These textures include standard leather type and stipple grain surface finishes routinely used in automotive interior applications. As can be seen from the data in Figure 2, a 60° Gardner gloss value of 6 and lower can be achieved for this flame retardant PC/ABS grade.

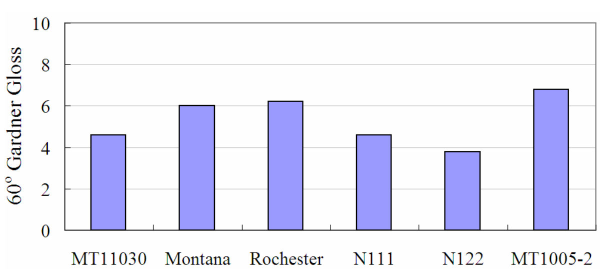

Figure 2. 60° Gardner Gloss measurement on six textured surfaces for the Low-Gloss FR PC/ABS blend, the textures represent different leather and stipple grain surface finishes typical of automotive interior applications.

The incorporation of surface micro-roughness, to alter the reflective nature of a molded surface (Figure 1) will typically result in the appearance of low gloss. But this Low-Gloss FR PC/ABS blend also incorporates low gloss through the use of novel additive technology, where the gloss of a profile-extruded or injection-molded part is a result of the resin property along with the tool surface finish and processing conditions. This is shown in Figure 3, where a side-by-side comparison with a high-gloss FR PC/ABS is shown. The 60° Gardner values in Figure 3 were measured on different injection molding tools, all with a smooth surface finish. As indicated by the data in Figure 3, the Low-Gloss FR PC/ABS blend has an inherently low gloss, irrespective of the surface finish of the final part (Figure 2).

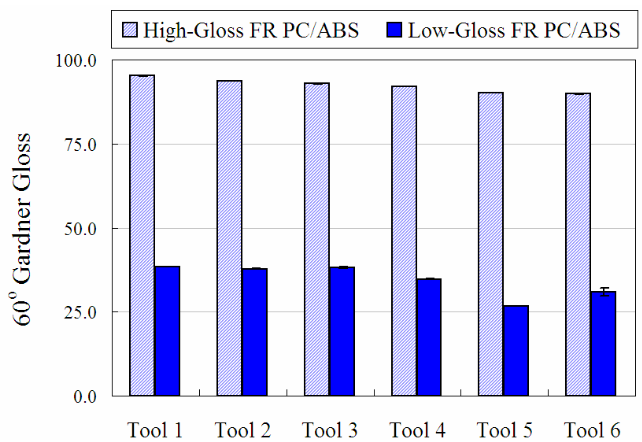

Figure 3. 60° Gardner Gloss measurement on untextured (smooth) surfaces for the Low-Gloss FR PC/ABS blend and a high gloss product on parts injection-molded on different molding tools.

Low-Gloss FR PC/ABS blend contains a non-chlorinated and non-brominated PC/ABS flame retardant package. The potential toxicity of fumes generated in a fire is sometimes a concern along with the flame retardant rating of the material. Table 2 outlines the performance of this PC/ABS blend in a Draeger tube fume analysis measurement. The limits on the concentration of different gases as set by Airbus Directive ABD0031/AITM3.0005 [5] are given in Table 2. The concentration was measured under flaming conditions on two samples, 2.95" by 2.95", and 65 mil in thickness. A side-by-side testing of PVC based competitor material was also performed using the same sample dimensions. The 4 minute test shows that the Low-Gloss FR PC/ABS blend, results in concentrations of potentially toxic gases below the limits set by the directive, whereas the PVC based material results in much higher concentrations. In the case of HF and HCl, the PVC based material fails to meet the concentration limits as stipulated by the directive as can be seen from the values tabulated below. The smoke corrosivity [6] of these liberated noxious gases could be of particular interest in the computer and business equipment manufacturing industry. Acidic fumes like HCl and HF could damage sensitive electronic equipment with the potential loss of stored data.

Table 2. Draeger tube fume analysis values for Low-Gloss FR PC/ABS blend versus traditional PVC based resin for 65 mil thickness. Limits for noxious gases set as per Airbus Directive ABD0031 AITM 3.005 [5].

Gases	Limits ppm	Low-Gloss FR PC/ABS	PVC based material
HCN	150	5	1
CO	1000	300	300
NO/NO_2	100	10	2
SO_2/H_2S	150	<1	<1
HF	100	40	500
HCl	150	20	2000

One of the primary application areas for FR PC/ABS grades is in the field of medical housings. Apart from FR performance, and the inherently superior mechanical properties of FR PC/ABS, resistance to a variety of chemicals and disinfectants is a critical feature for these applications. An exposure study was conducted to check the effects of continuous chemical exposure on the appearance of injection molded Low-Gloss FR PC/ABS plaques. A variety of different chemicals/ disinfectants/ detergents were chosen for this study. The injection-molded plaques were immersed in the chemicals for duration of 3 days. The chemicals chosen for this experiment included 2% solution of hydrogen peroxide (2% H_2O_2), 70% isopropyl alcohol, Formula 409®, a general purpose cleaner by the Clorox Company, 3% solution of ammonia, and 2% solution of liquid cleaner Joy®, a dish cleaning soap by Procter & Gamble. The initial color of the plaques was measured using a GretagMacbeth COLOR-EYE 7000A Spectrophotometer following the ASTM D2244 protocol. The L^*, a^*, and b^* values, also known as Hunter's co-ordinates [7] were used to quantify the color, where L^* is the lightness/darkness, b^* is the representation of blue /yellowness and a^* is the representation of green/redness. The change in the color (Delta E) was documented at the end of each 24-hour period. The quantitative color change was calculated from the following expression [7],

$$Delta\,E = \sqrt{(L_1 - L_0)^2 + (a_1 - a_0)^2 + (b_1 - b_0)^2} \quad (1)$$

where subscripts 1 and 0 refer to measurements on consecutive days. A D65 illuminant was used for making these measurements. This data is shown graphically in Figure 4. As can be seen there is a negligible change in the color of the injection-molded plaques of the Low-Gloss FR PC/ABS blend following this chemical exposure. The maximum value of Delta E seen in this data set is about 0.27.

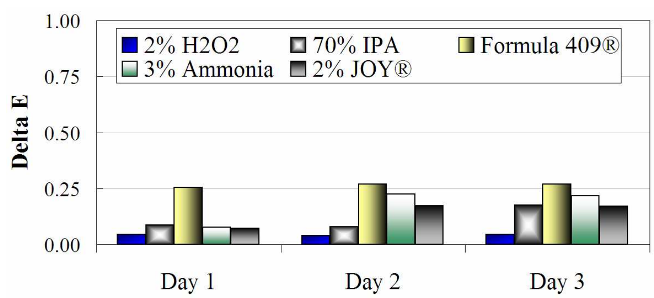

Figure 4. Change in the color value of injection molded plaques of Low-Gloss FR PC/ABS blend following exposure to different chemicals, disinfectants and detergents.

The effect of exposing high performance engineering thermoplastics materials to different chemicals for an extended duration could be purely aesthetic. A more severe effect of such exposure could be the physical degradation leading to a loss in the physical properties of the material. Environmental stress cracking resistance (ESCR) [8] of a material can be used to study the effect of chemical species on the physical properties of different thermoplastics. A series of chemicals and disinfectant solutions were chosen and are listed in Table 4. Following the ISO 4599 protocol[4] for ESCR testing, tensile bars were exposed to these chemicals for a duration of 7 days at 23 °C. The tensile bars were kept strained at 0.5%. Following the exposure, uniaxial tensile testing was conducted on the samples, and appropriate controls, which had not been exposed to these chemicals. The percent retention of uniaxial tensile properties (ISO 527) for Low-Gloss FR PC/ABS blend following the test are listed in Table 3. As can be seen, there is no significant change in the yield strength after the chemical exposure. The data from Figure 4 and the ESCR test results from Table 3, indicate the performance of this PC/ABS blend in aesthetic as well as physical property testing following chemical exposure.

Table 3. Percent retention of uniaxial tensile properties following exposure to different cleaners and disinfectants for 7 days at 0.5% strain following ISO 4599 ESCR protocol [8].

	Chemical	Yield Strength (%)	Strain at Break (%)
1	IPA (70%)	101	101
2	H_2O_2	101	95
3	Virex 256	93	37
4	Cidex Plus	100	73
5	Ethanol	99	97
6	Betadiene	102	89
7	Bleach (50%)	100	82

The weathering performance of materials chosen in applications for medical housing as well as in the generic building and construction industry is often as critical as the other physical and processing characteristics of the material. ISO 4892-2B [9] is a weathering protocol using exposure to xenon-arc light source, in a controlled humidity environment, to replicate actual end use conditions. ASTM D4459 [10] is a similar protocol to test the effects of exposure of the parts to xenon-arc radiation. There are some differences in these two testing protocols. The irradiance level used in the two tests is 0.3 W/m^2 for ASTM D 4459 at 340 nm, and 1.5 W/m^2 for ISO 4892-2B at 420 nm. The relative humidity is maintained at 55% and 50% in the ASTM and ISO test respectively. The tests use similar inner (S. Boro) and outer (sodalime) filters on the xenon lamps.

Weatherability testing on injection molded plaques of the Low-Gloss FR PC/ABS grade was performed using the two protocols described in the previous paragraph. The starting color values (L^*, a^* and b^* values) of these plaques were measured using a GretagMacbeth COLOR-EYE 7000A Spectrophotometer. Figure 5 shows the Delta E values measured for these plaques at an interval of 100 hours, up to 500 hours exposure. As can be seen from the plot, the change in the color as measured using the spectrophotometer was negligible at around 300 hours of exposure. This data set along with the previous information presented in this paper on the retention of physical and aesthetic properties on exposure to chemicals encompass the potential for use of this FR PC/ABS blends in a multitude of applications.

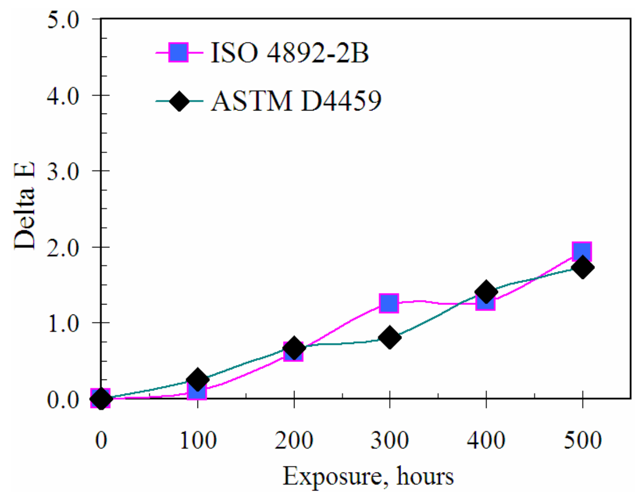

Figure 5. Change in color as measured by Delta E values for injection-molded plaques in xenon arc weathering tests following ISO 4892-2B [9] and ASTM D 4459 protocol [10], measured at 100-hour intervals up to 500 hours.

Conclusions

PC/ABS blends are a unique class of engineering thermoplastic materials, and are the material of choice in a variety of applications [11]. The superior melt processability, as well as the excellent mechanical properties of the constituent PC phase, the advantages of an impact modified system, as well as the non-chlorinated and non-brominated FR systems, has lead to growth in the use of PC/ABS blends. For applications in medical, computer and business equipment housings; chemical resistance to generic chemicals/cleaners, as well as weathering performance is very useful.

Designing PC/ABS blend products has a long history of meeting new challenges. Meeting new application space requirements, and offering more product features is the goal of any new product. The low gloss flame retardant PC/ABS blend described in this paper, commercially available as CYCLOY* CX3222ME, not only offers a non-chlorinated and non-brominated FR system; it also is specifically designed to meet low gloss aesthetic applications typically seen in automotive applications. The resistance to different chemicals, disinfectants, and cleaners makes it a viable choice for thermoforming applications in the medical housings market.

References

1. S. Siripurapu, A. Chakravorty, and N. Singh, "Novel polycarbonate blends with improved environmental stress cracking resistance (ESCR) to hospital cleaners and household disinfectants," *SPE-ANTEC Tech. Papers*, **2**, 799 (2007).
2. S. Siripurapu, "Flame resistance of PC/ABS blends with low smoke generation," *SPE-ANTEC Tech. Papers* Manuscript #0233 (2008).
3. S. Siripurapu, "Improving weld line strength of PC/ABS blends with tailored silicone copolymers," *SPE-ANTEC Tech. Papers* Manuscript #103334, **4**, 2137 (2006).
4. R. S. Hunter, *The Measurement of Appearance*, John Wiley & Sons, New York (1975).
5. ABD0031 Issue E, AITM 3.0005, *Fireworthiness Requirements Pressurized Section of Fuselage*.
6. M. A. Barnes, P. J. Briggs, M. M. Hirschler, A. F. Matheson, and T. J. O'Neill, "A comparative study of the fine performance of halogenated and non-halogenated materials for cable applications. Part I Tests on materials and insulated wires," *Fire and Materials*, **20**, 1 (1996).
7. F. W. Billmeyer, and M. Saltzman, *Principles of Color Technology*, Interscience Publishers, New York (1966).
8. ISO Standards Handbook, Vol. 1, ISO 4599, *Determination of Resistance to Environmental Stress Cracking-Bent Strip Method*.
9. ISO Standards Handbook, Vol. 1, ISO 4892, *Methods of Exposure to Laboratory Light Sources*.
10. ASTM Standards, ASTM D4459-06, *Standard Practice for Xenon-Arc Exposure of Plastics Intended for Indoor Applications*.
11. B. Hager, D. Wittmann, and E. Wenz, "Thirty years of PC/ABS blends in the plastics industry," *Technical Papers, Regional Technical Conference, SPE*, **3**, 1301 (2008).

Key Words: PC/ABS, Low-Gloss, flame retardant, extrudable.

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. Solvent resistance data is supplied for comparative purpose only. Resistance to solvents will depend on many molding, design, and end use features. All resins and mixtures discussed herein should be thoroughly tested in actual parts under end use conditions before incorporation into any device.