ANTEC® 2021

2021 PROCEEDINGS

NEXT GENERATION CARBON BLACK FOR ULTRA-HIGH JETNESS IN PLASTICS APPLICATIONS

Zhenpeng Li, Natalie Harris and Zhaokang Hu, Birla Carbon U.S.A., Inc., Marietta, GA

Abstract

A new carbon black product was developed at Birla Carbon with ultra-high jetness and bluish undertone for high color applications in plastics. The new product was demonstrated with improved jetness in various polymer systems over the existing high color products, especially achieving a 40% improvement in polyamide 6. The new product shows great potential for ultra-high jetness plastics applications including automotive, household appliances, and consumer electronics.

Introduction

Carbon black has been extensively used as a colorant in engineering plastics materials for a variety of different applications. Market forecasts an over 4% increase on demand in those plastics systems in next few years. Especially for automotive industry, major Auto OEM's have been vigorously seeking alternative solutions to achieve lighter weight resulting in higher fuel efficiency. In the past decade, more and more metal components have been replaced with engineering plastics parts for exterior and interior applications. One of the challenges with such material replacement is to match the color performance. Conventionally, color appearance such as high quality black has been realized by applying multiple-layer coating structure on the top of metal pieces. It is efficient but costly, multiple-step process. Similarly, with the rapid development of consumer electronics industry, surface aesthetics has been evolving as one of the most critical parameters to attract consumer's interest. As one of the most common and popular colors, a piano black like surface with ultra-high jetness, high gloss, and attractive undertone is highly welcomed. Unfortunately, there are not many commercially available carbon black products, which are able to meet such stringent color performance requirements. Numerous efforts have been made including the hybrid solution by mixing conventional carbon blacks with organic dye for smooth molded surface and blueish undertone. It functions well in some applications. However, when high temperature extrusion and injection molding involved for the final applications, many of those organic molecules may not survive and start to degrade. As a result, instead of an ultra-high jetness black, the injection molded parts suffer an undesired greenish black appearance.

At Birla Carbon, we have developed the next generation carbon black product, which demonstrates superior jetness to the existing products in multiple engineering thermoplastics systems including polyamide (PA), polycarbonate (PC), ABS, SAN, and polypropylene. It shows great potential to be used in those demanding applications when ultra-high jetness is required.

Experimental Section

Materials

Carbon blacks studied in this proceeding were Raven 2350 Ultra (Black A), Raven 2500 Ultra (Black B), Raven 2800 Ultra (Black C), and a new product under the development from Birla Carbon U.S.A., Inc. All carbon blacks were in bead form and were thoroughly dried at 125 ℃ for 12 hours before compounding. Polyamide 6 (PA 6) resin, Aegis H8202NLB, was purchased as pellet from M. Holland Company. The PA 6 resin was dried under vacuum at 80 ℃ for 48 hours.

Compounding of plastics/carbon black

A co-rotating twin-screw extruder (PRISM Twin-Screw Extruder; Model TSE-16-TC; D = 16 mm; L/D = 25:1) was used to compound the carbon blacks in PA 6 through a typical multi-stage compounding process. First, a masterbatch was produced with a 30 wt.% carbon black loading which was then let down into various carbon black concentrations (0.1, 0.5, and 1.0 wt.%, respectively) with 0.3 wt.% ethylene bis-stearamide (EBS) as a mold release agent. The processing conditions are summarized in Table 1.

Table 1. Compounding conditions by twin-screw extruder.

Melt Temp. Profile [℃] Die-Hopper	Screw Speed [rpm]	Total Feed Rate [g / min]
240 - 210	250	30

Injection molding of color plaques

The pelletized polyamide compounds with 0.1, 0.5, and 1 wt.% of carbon black were molded into flat color plaques (90 mm × 60 mm × 3 mm) by using an injection molder (Arburg Injection Molder, Model 270C, Clamping force = 400 kN). All compounds were pre-dried under vacuum at 80 ℃ for 48 hours. The injection molding conditions are summarized in Table 2.

Table 2. Injection molding conditions for color plaques.

Melt Temp. Profile [°C] Nozzle-Hopper	Mold Temp. [°C]	Injection Pressure [bar]	Holding Pressure [bar]
255 - 235	100	1500	800

Characterization

The color performance was instrumentally measured by using a Color-Eye 2145 reflectance spectrometer (GretagMacbeth, New Windsor, NY) with a D65 illuminant, 10° observer in a 45/0 geometry per ASTM D2244. The color coordinate readings were automatically converted into Hunter Lab color-scale values based on the average measurement of eight samples.

The dispersion of carbon black in polyamide compounds was characterized by optical microscopy. A small piece around 5 mg of each sample was cut off from a color plaque. It was then placed between two cleaned glass microscope slides and hot pressed into a thin film for direct observation under an Olympus BX51 Light Microscope (Olympus Corporation, Center Valley, PA). A transmission mode was used to evaluate the carbon black dispersion in polyamide after compounding. The photographic images of the color plaques were taken by using a Nikon D3200 digital camera for visual appearance comparison.

Results and Discussion

The color performance of all studied carbon blacks in polyamide 6 was scaled per Hunter Lab dimensional color space, in which L denotes the jetness ranging from 0 (black) to 100 (white), and b the undertone with a negative value for more bluish while a positive value is indicative of a more brown tonal response [1]. As shown in Figure 1, the L values decrease as the carbon black concentration increasing from 0.1 to 1 wt. % for all tested samples. At the same carbon black concentration, the new carbon black product demonstrates a much lower L value, indicating an approximately 40% improvement in jetness. This can be visually detected from the photographic images of injection molded plaques as shown in Figure 2. The light microscopic graphs in Figure 3 demonstrates the high dispersion level of the new carbon black product in PA 6 that is similar to other Raven blacks with very few observable undispersed carbon blacks by using the same compounding conditions.

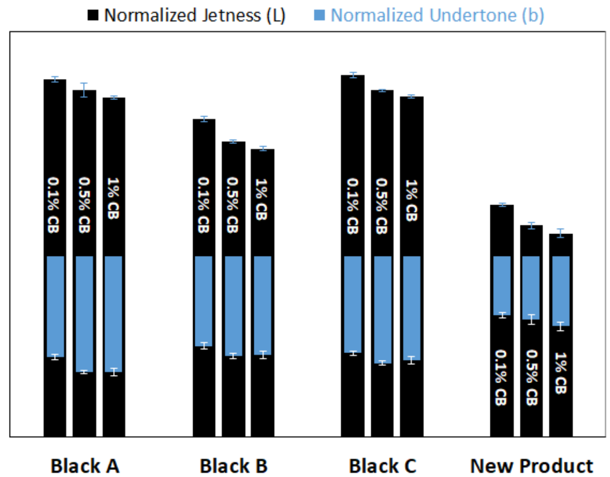

Figure 1. Color performance (Hunter Lab) of PA 6/carbon black color plaques. Black A: Raven 2350 Ultra; Black B: Raven 2500 Ultra; Black C: Raven 2800 Ultra.

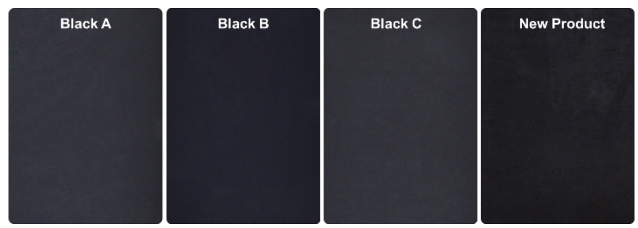

Figure 2. Visual appearance of PA 6/carbon black color plaques with 0.1 wt. % carbon black concentration. Black A: Raven 2350 Ultra; Black B: Raven 2500 Ultra; Black C: Raven 2800 Ultra.

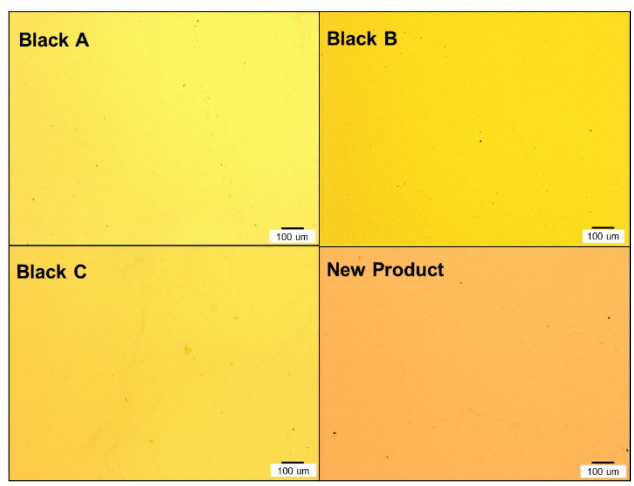

Figure 3. Light microscopic images of PA 6/carbon black compounds with 0.5 wt.% carbon black concentration. Black A: Raven 2350 Ultra; Black B: Raven 2500 Ultra; Black C: Raven 2800 Ultra.

Conclusions

Birla Carbon has successfully developed a next generation Raven product with ultra-high jetness and bluish undertone for high color applications in plastics. The new product surpasses the existing high color Raven products with improved jetness in various polymer systems, especially a 40% improvement being achieved in polyamide 6. With the demonstrated color improvement, this new product can be potentially used for a variety of different applications including automotive, household appliances, and consumer electronics when ultra-high jetness color performance is required with a good balance of blue tone.

References

1. N. Whetzel, "Measuring color using Hunter L, a, b versus CIE 1976 L* a* b*." Application notes. Retrieved from Hunterlab website: https://support.hunterlab.com/hc/en-us/articles/204137825-Measuring-Color-using-Hunter-L-a-b-versus-CIE-1976-L-a-b-AN-1005b (2016).