The effect of antioxidant 1010 on the thermo-oxidative aging properties of polycarbonate/acrylonitrile–butadiene–styrene blends

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Abstract. In this research, the thermo-oxidative aging properties of PC/ABS with different content of antioxidant 1010 were studied. The ΔE value of the sample with 1wt% antioxidant 1010 was 35.3% lower than that without antioxidant before and after 500h aging. After aging for 500h, the elongation at break and impact strength of sample with 1wt% antioxidant 1010 decreased by about 76% and 42% respectively, which were 8% and 5% higher than those without antioxidant. The results of ATR-FTIR spectrum shown that antioxidant 1010 reduced the degradation of rubber phase (PB) in ABS caused by thermo-oxidative aging.

1. Introduction
Polycarbonate(PC)/acrylonitrile-butadiene-styrene(ABS) blends are widely used in automobile and electronic products due to their excellent mechanical properties and good processability. The PC/ABS blends properties are affected by many factors, such as composition, processing conditions, environmental conditions, thermo-oxidative and so on [1-4]. Li J et al investigate the infrared spectrum of polycarbonate/acrylonitrile-butadiene-styrene after UV radiation and the results show that polycarbonate can restrain the photo-oxidation of the acrylonitrile-butadiene-styrene because of the aromatic ketone taken place in polycarbonate [5]. Some researchers have studied the thermal degradation mechanism of polycarbonate [6-9] and acrylonitrile-butadiene-styrene [1]. Huang J et al found that the weakest bond in polycarbonate is the single bond between the methylic carbon and carbon atom. Jang B N and Wilkie C A [7] studied the thermal decomposition mechanism and products of polycarbonate by TGA, FTIR, GC and MS and found that chain scission and hydrolysis/alcoholysis are the main degradation pathways. Motaung T E and Feng Y et al [8, 9] studied the effect of nano TiO2 and silica on the thermal stability of polycarbonate. In this paper, the effect of antioxidant 1010 on the thermo-oxidative aging properties of polycarbonate/acrylonitrile-butadiene-styrene blends at 100°C was studied.

2. Experimental
2.1. Materials
Polycarbonate pellets (Makrolon 2807 supplied by Bayer Material Science Company, Germany) with a melt mass flow rate of 10 g/10 min (1.20 kg/300°C) and a density of 1.2g/cm³. Acrylonitrile-
butadiene-styrene (PA-758, was obtained from ChiMei Corporation, Taiwan) with a melt mass flow rate of 3.0 g/10 min (5 kg/200°C) and a density of 1.08 g/cm³. Antioxidant 1010 was provided by Shanghai Macklin Biochemical Co., Ltd (China). Polycarbonate and acrylonitrile-butadiene-styrene were dried in an air circulating oven at 120°C and 80°C for 6 h respectively before using.

2.2. Sample preparation
PC and ABS were dried in an air circulating oven at 120°C and 80°C for 6 h, respectively. PC and ABS were mixed physically with the weight ratio of 50:50 in a high speed mixing machine. And antioxidant 1010 was added with 0, 0.1, 0.5 and 1wt%. The blends have been obtained by melt compounding in a co-rotating twin-screw extruder (KTE-20-6, Kerke Extrusion Equipment Co., Ltd., Nanjing, China). The extruded pellets were dried at 90°C for 6h and then injection moulded (MH-35T, Dongguan Min-hui Plastic Machinery Co., Ltd., Dongguan, China) for tests.

2.3. Thermo-oxidative aging
Impact and tensile specimens were aged in an air circulating oven (SETH-Z-032L, Shanghai Espec Environment Equipment Co., Ltd, Shanghai, China) at 100°C for 100, 200, 300, 400 and 500h. The specimens used for ATR-FTIR test were also aged at the same time.

2.4. Optical characterization
The color measurement was obtained by a colorimeter CD-6834 made by BYK Additives & Instruments (Germany). This instrument was used to test the color changes of samples before and after aging in this research. The color change value ΔE was used to represent the color change of the samples before and after aging.

2.5. Mechanical properties
The tensile tests were performed in a universal testing machine (ETM104C, Shenzhen Wance Test Instruments Co., Ltd., Shenzhen, China) according to ASTM D-638 with a crosshead speeds 5mm/min. Notched Izod impact tests were done according to ASTM D 256A by a plastic impact testing machine (GT-7045-MDH, Gotech Testing Machines Co., Ltd., China). For each blend, the data reported was the average of ten specimens.

2.6. FTIR analysis
ATR-FTIR spectra were obtained on these samples by using a Fourier Transform Infrared instrument (Spectrum Two, PerkinElmer). The wavenumber range was from 4000cm⁻¹ to 550cm⁻¹.

3. Results and discussion

3.1. Optical characterization
The ΔE values of samples before and after aging were tested by CD-6834 colorimeter. The effect of antioxidant 1010 content on optical characterization during aging was shown in Figure 1. With the increasing of aging time, the ΔE values also increases. At the same time, the introduction of antioxidant 1010 reduced the ΔE value, and with the increase of antioxidant content, the effect was more obvious. The ΔE value of the sample with 1wt% antioxidant 1010 was 35.3% lower than that without antioxidant before and after 500h aging.
Figure 1. The $\Delta E$ values of PC/ABS with 0, 0.1, 0.5 and 1 wt% antioxidant 1010 before and after thermo-oxidative aging for different hours.

3.2. Mechanical Properties

Figure 2 showed the variation in mechanical properties for PC/ABS blend specimens with different content of antioxidant 1010 after thermo-oxidative aging at 100°C. As shown in Figure 2(a) and 2(b), due to the thermo-oxidative degradation in the rubbery phase (PB) at the surface causes an increase in polymer density, both tensile strength and modulus increased after thermo-oxidative aging, and the degradation in turn promotes brittle failure [10]. Figure 2(c) showed the relationship between elongation at break and aging time. The elongation at break decreases dramatically at the beginning of aging and then decreases slowly. The increase of surface density caused by thermo-oxidative aging makes the sample brittle [4, 10]. Figure 2(d) showed the relationship between impact strength and aging time for specimens which were notched after thermo-oxidative aging at 100°C. Figure 2(c) and 2(d) shown the introduction of antioxidant 1010 can effectively alleviate the decline of elongation at break and impact strength. After aging for 500h, the elongation and impact strength of samples with 1wt% antioxidant 1010 decreased by about 76% and 42% respectively, which were 8% and 5% higher than those without antioxidant.
3.3. FTIR analysis
To investigate thermo-oxidative aging effects on polymer microstructure, ATR-FTIR spectra were obtained on these samples before and after 500h aging. It has been reported that the presence of oxygen can effectively reduce the degradation activation energy of ABS [11]. It can be seen from Figure 3, the absorbance of C=O caused by aging is significantly higher than that of unaged samples. The increased absorption intensity of C=O can be attributed to the degradation of butadiene [3]. It can be seen from Figure 3 (b) that the introduction of antioxidant 1010 can effectively reduce the formation of C=O, which indicates that the introduction of antioxidant 1010 can reduce the degradation of PB phase.

4. Conclusion
The effect of antioxidant 1010 on the thermo-oxidative aging properties of PC/ABS was studied. The introduction of antioxidant 1010 can effectively alleviate the color change of samples during the aging process, and effectively alleviate the decline of elongation at break and impact strength. The results of ATR-FTIR spectrum showed that the introduction of antioxidant 1010 reduced the degradation of rubber phase (PB) in ABS caused by thermo-oxidative aging.
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