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ORIGINAL PAPER

The effect of carbon black and HALS hybrid systems on the UV stability of high-density polyethylene (HDPE)

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Abstract In the present study, attempts were made to study the effect of a hybrid UV stabilizing system on high-density polyethylene (HDPE). For this purpose, high molecular weight PE was used to prepare samples containing different amounts of hindered amine light stabilizer (HALS), carbon black (CB) and HALS/CB systems as UV stabilizers. All samples were exposed to UV irradiation simulating 4 and 8 years of exposure to solar irradiation in central part of Iran (Yazd). FTIR results were used to estimate the carbonyl index (CI) of the samples. It showed that CI increased as UV exposure time increased. However, it was found out that in the samples having both stabilizers (HALS/CB), CI value was much less compared to other samples indicating that the presence of hybrid system would show a synergism effect on UV stabilization of HDPE. The gel content of all samples was measured and it confirmed the same results. The PECH sample (containing HALS and CB) showed the least gel content after equivalent time of 4 and 8 years of exposure (2 and 3.5 wt%, respectively) which was in accordance with CI result. Furthermore, the effect of different UV stabilizing systems on the mechanical properties of HDPE was studied. For this purpose, elastic modulus, elongation-at-break and yield stress of the samples were measured. It was found out that HALS/CB hybrid system preserved the mechanical properties of HDPE much better than the other systems, which was attributed to the synergistic effect of the simultaneous use of HALS and CB.

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Introduction

Polyolefins are the most used polymers with vast outdoor demands in urban and municipal, energy and industrial applications. Since there is a high probability of exposure to solar UV irradiation in outdoor uses, these materials should be stabilized against UV irradiation due to their vulnerability against this kind of radiation. UV irradiation can lead to degradation of polyethylene which generally initiates from the surface and continues by progression into the bulk of the material [1]. The mechanisms of photodegradation and stabilization of polyolefins have been studied comprehensively and it has been shown that their photodegradation in the presence of oxygen is an autocatalytic process [2–4]. Furthermore, different strategies of photostabilization of polymeric materials, particularly polyolefins, have been developed [5]. Rabello et al. [6] studied the effect of polymer chain structure on the photodegradation of polypropylene (PP). It was shown that increasing the crystallinity of PP, controlled by processing conditions, may notably increase its UV stability. Yang et al. [7] studied the effect of nano-ZnO, silica and alumina nano-particles on the photostability of linear low-density polyethylene (LLDPE). They showed that the presence of nano-ZnO induced a good UV stability while alumina nano-particles had the least effect. In addition to mineral micro- and nano-particles, organic compounds are also employed as UV stabilizing agents.

The influence of UV irradiation on the PE products such as PE pipes has received great attention and it is reported that UV radiation could cause the loss of antioxidant which results in lower oxidation induction time (OIT) [8].