ANALYTICAL FRACTIONATION TECHNIQUES APPLICATION IN THE POLYETHYLENE PHOTODEGRADATION PROCESS

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Abstract

The effects of ultraviolet (UV) source on polyethylene (PE) store bag were investigated in this study. The photodegradation activity on the PE bags was determined by monitoring its molecular weight loss through the Gel Permeation Chromatography (GPC). This degradation process has been analyzed using a novel solution technique, analytical Temperature Rising Elution Fractionation (TREF), which have allowed to isolate and quantify the evolution of the different families with dissimilar molecular weight after bag photodegradation. Finally, the chemical modifications were studied by Fourier Transform Infrared (FTIR) spectroscopy.

Keywords: *polyethylene bags, photodegradation, TREF*

1. Introduction

The wide use of polymers in many industrial and domestic fields causes ecological problems connected with their utilization. Some synthetic plastics including polyolefins, as low density polyethylene (LDPE), are characterized by relatively high stabilities under both photochemical and environmental conditions for tens of years. In the presence of sunlight LDPE undergoes a series of reactions such as photolytic, photo-oxidative and thermo-oxidative, leading to chemical degradation, and as consequence, its brittleness, loss of brightness, colour change, opacity and crack formation [1]. In the laboratory, this degradation might be accelerated by ultraviolet (UV) irradiation of LDPE. During irradiation activated molecules are formed, and then processes such as chain scission, cross-linking and oxidation take place [2]. The main process is the reduction in molecular weight, however, the formation of carbonyl, hydroxyl and vinyl groups also take place in the LDPE molecules [3]. The presence of chains with very low molecular weight and functional groups promote and accelerate the LDPE biodegradation.

2. Materials and Methods

In this study a LDPE film placed in both colored and white part of store bags has been analyzed. It is important to note that this film contains an additive pro-degradable, based on metal salts, which combines two degradation routes, allowing a shorter weathering degradation time (around three years) compared to other additives. These bags have been cut into small pieces. Then, LDPE is irradiated with a UV source in order to cause an accelerated aging. For evaluation of the samples before and after treatment different conventional techniques have been employed such as FTIR spectroscopy, to analyze the absorption peak of functional groups, and GPC to determine the molecular weigh and its distribution. As new, the analytical technique TREF applied to diluted solution, has also been used to study and quantify the number of chains with different molecular weight. Finally, standard biodegradation experiments have been carried out.

3. Results and Conclusions

Simultaneous exposure to UV light and oxygen led to the photo-oxidative degradation of LDPE films. As a consequence and it was expected, an increase of functional groups and a shift in molecular weight distribution to lower values were observed. TREF results show three crystallization peaks corresponding to three chain sets with molecular weights which differ in one or more order of magnitude. Beside this, the ratio among areas under crystallization peaks indicates the photo-oxidative degradation is a homogeneous and independent process of characteristic chain (Figure 1).

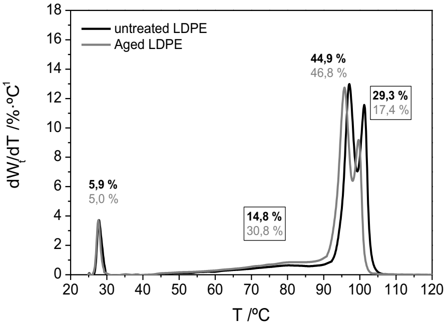

Fig 1. TREF profiles of LDPE film untreated (black color) and after accelerated aging (gray color). Areas under each crystallization peak are also indicated.

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