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Radiation Effects on Mechanical Properties of LDPE/EVA blend

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1. Introduction

Restricted properties and a limited use of homo-polymers alone, have given rise to an exploration of composites, copolymers, blends, etc. Copolymers such as poly(ethylene-co-vinyl acetate) (EVA), poly(ethylene -co-butyl acrylate), poly(ethylene-co-ethyl acrylate) (EEA) have wide usages in different industry. Among the numerous ethylene copolymers, due to its wide range of properties depending on its vinyl acetate content, EVA has become one of the most useful copolymers in the electrical industry as a cable insulator, and in many other industries as a hot melt adhesive, a coating, etc. Several works looked at the influence of gamma rays on polymers [1]. Zhang *et al* have blended EVA with PE because crosslinked PE has a low flexibility for use as a cable insulation. It was reported that the blend showed have a better elongation, flexibility and heat aging effect than PE, but its hardness and softening point were lower [2].

In this study, the radiation degradation of LDPE/EVA blends as a function of the vinyl acetate contents was investigated by using TGA, gelation and elongation.

2. Experimental

2.1 Sample preparation

The investigated materials were LDPE/EVA blends. The LDPE of a density of 0.92 g/cm^3 was used, and the EVA component contained was 3.5 to 26 wt% of the vinyl acetate contents. The samples were prepared in proportions as shown in Table 1. The samples were irradiated using a ^{60}Co γ-ray and a ray up to 1,000 kGy at a dose rate of 5 kGy per hour in the presence of an air atmosphere.

Table 1. Formulation of LDPE/EVA blends

Sample	LDPE:EVA [phr]	EVA (VA content)
LDPE	100:0	-
LDPE-EVA_1	50:50	3.5 wt%
LDPE-EVA_2	50:50	9.5 wt%
LDPE-EVA_3	50:50	15 wt%
LDPE-EVA_4	50:50	19 wt%
LDPE-EVA_5	50:50	26 wt%

2.2 Thermogravimetric analysis (TGA)

Thermogravimetric analysis was performed by utilizing the TA Instruments-Model 2950. Thermogravi-metric studies were carried out under a nitrogen atmosphere; and a 10ºC/min heating rate was used. These results indicated the thermal stabilities of the virgin and irradiated samples.

2.3 Determination o f percentage gelation

For an investigation of the influence of gamma rays on the gelation of LDBE/EVA blends, the sol-gel analyses were performed. Xylene was used as a solvent in a soxhlet extractor and it was fluxed through each sample for 12 h. Gel percentages were calculated gravimetrically according to the following equation:

$$\%Gelation = \frac{m}{m_0} \times 100 \quad (1)$$

where m_0 and m are the masses of a sample before and after an extraction, separately.

2.4 Mechanical properties

The control and the irradiated samples were subject to a mechanical tensile testing following the ASTM standard D 638. The tensile properties of the sample at room temperature were evaluated using an universal mechanical tester (Model 1130), after a γ-ray irradiation during one week. A crosshead speed of 100 mm/min and a gauge length 50 mm were used. The specimen load was sensed by a 500 kg capacity Instron type-A load cell. This cell was mechanically calibrated by precision standard weights prior to the testing of each set of samples. From these experiments, elongation at break of all the samples was obtained. An average of 5 specimens was tested. All the tensile tests were run under a time mode.

3. Results and discussion

3.1 Thermogravimetric analysis

Figure 1 shows the TG thermograms of the non-irradiated and 1,000 kGy irradiated LDPE/EVA blends. TGA was used for a characterization of EVA and to quantify the vinyl acetate content. LDPE/EVA blends showed two decomposition stages, regardless of the vinyl acetate content. The first one is associated with a loss of acetic acid and components with a low molecular weight. Lately, a decomposition of the ethylenic fraction was obtained via carbonaceous residues due to a main chain degradation [3, 4]. As shown in figure 1, the loss of acetic acid in 1,000 kGy irradiated LDPE/EVA blends occurred more than in the non-irradiated samples. Radiation degradation in the

LDPE/ EVA blends occurred predominantly at the part of the vinyl acetate.

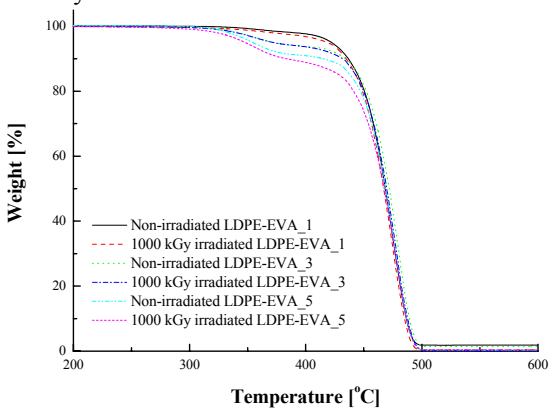

Figure 1. TG thermograms of γ-ray irradiated LDPE/EVA blends.

3.2 Gelation

Figure 2 shows the relationship between the gelation with a irradiation dose for the LDPE/EVA blends containing various vinyl acetate contents. Non-irradiated samples were found as soluble in hot xylene, however upon an irradiation they undergo crosslinking and as a result of the network formation in the polymer, the solubility of the samples was reduced significantly. It is shown in figure 2 that the gelation increased rapidly up to a dose of 200 kGy in all the samples then increase gradually up to a dose of 600 kGy. Increase in the gelation was enhanced by the LDPE/EVA blend. The reason for a superior crosslinking in the EVA than the LDPE is due to the increase of the amorphous phase in the polymer [5]. This was based on the consensus at ambient conditions where the radiation crosslinking occurs mainly within the amorphous regions of a polyethylene.

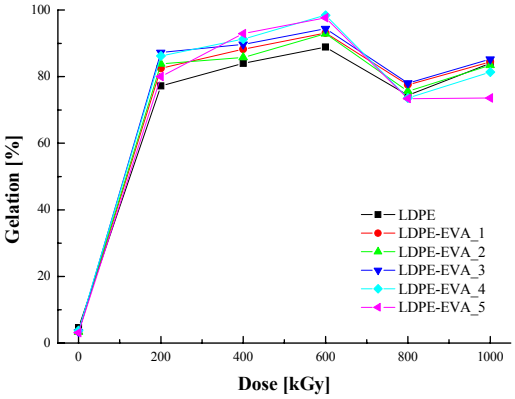

Figure 2. Percentage gelation of LDPE/EVA blends as a function of irradiation dose.

3.3 Mechanical properties

Figure 3 shows the relationship between the elongation at break and the irradiation dose of the samples. Generally an increasing irradiation dose results in a reduction in the elongation at break of the LDPE, EVA, and LDPE/EVA blends. As an irradiation dose increase, the values of the elongation at break were decreased gradually. However, LDPE/EVA blends showed a better flexibility than LDPE. As the dose increases more crosslinks are produced in the sample matrix which prevents a structural reorganization during a drawing. This ever increasing 3-dimensional gel-like structure brings about a decrease in the internal chain mobility and elongation [5].

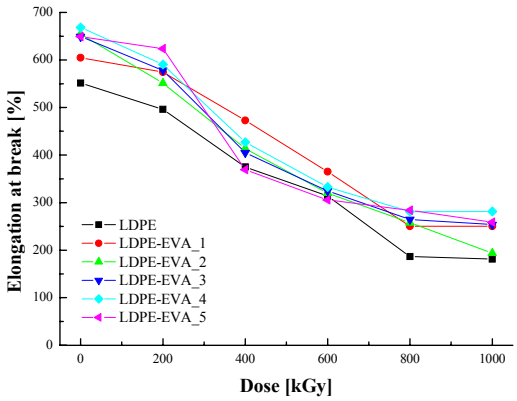

Figure 3. Elongation at break of LDPE/EVA blends as a function of irradiation dose.

4. Conclusion

In order to investigate the mechanical properties of gamma rays on the LDPE/EVA blends as a function of the vinyl acetate contents, samples were subject to gamma rays at ambient conditions up to 1,000 kGy. From the measurements, the proper content of the vinyl acetate in the LDPE/EVA blends was in the range of 9.5 ~ 15 wt% for the radiation resistance.

Acknowledgments

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