SHRINKING PROPERTIES OF ELECTRON IRRADIATED POLYETHYLENE FILM

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ABSTRACT

This paper describes the evaluation of shrinkable properties of a commercial polyethylene film irradiated with accelerated electrons. The shrinking ratio, elongation ratio and the shrinking effect value were used to compare the shrinkable performance of the film at different irradiation absorbed doses. The cross-linking density evolution was determined by gel fraction determination.

INTRODUCTION

Industrial radiation applications of electron accelerators encompass a wide types of materials processing. One of the applications is the induction of a shrinking effect in polyethylene films. The shrinking effect depends on its morphology but when it is irradiated, the effect depends mainly on the cross-linking density induced by irradiation [1]. This work is based on the analysis of a commercial polyethylene film in which the maximum elongation ratio, obtained by the thermomechanical process, as well the heat-shrinking ratio and the shrinking effect value, were used to discriminate the irradiation doses that correspond to the maximum shrinking performance. The shrinking effect value is a relation between the shrinking ratio and the elongation ratio [2].

EXPERIMENTAL

A commercial quality polyethylene film analyzed in this work has a density of 0.94 g/cm^3 and an average thickness of 85±5 μm. For experimental purposes samples were cut in a rectangular shape namely 4.5 mm width by 12 mm length. Each film was wrapped in an aluminum foil to avoid the contact with the air of the irradiation chamber during its processing.

The irradiation parameters were fixed for an electron scanning width of 100 cm, electrons energy of 0.7 MeV and current of 0.9 mA that results in an absorbed dose rate of 5.61 kGy/s. These conditions were used to get a better irradiation homogeneity and to avoid a sample temperature variation during the multiple passes under the electron beam in dynamic process. The absorbed doses were fixed at 50, 100, 150, 200 and 300 kGy and the radiation dosimetry was evaluated by means of cellulose triacetate films.

To know the extension of the cross-linking effect, the gel fraction was determined by extraction with xylene, before and after the irradiation process. Thermomechanical measurements were carried out using a Shimatzu TMA-50 equipment, which permits a maximum deformation of the samples up to 50% under a tension of 1.8 MPa. During this measurements the samples were heated at 90 to 95 ^{0}C during 10 to 15 minutes.

RESULTS AND DISCUSSION

It can be seen in Figure 1 that the gel fraction increase with the absorbed dose, reaching about 65% for 300 kGy. This fact shows that the cross-linking is induced by radiation in the range of 100 to 300 kGy. Experimental results of the shrinking measurements and the calculated values of shrinking percentage and shrinking effect E, as a function of the absorbed dose, are given in Table I. The shrinking percentage reaches more than 80 % between 100 and 200 kGy. Greater shrinking percentage values could be reached with samples that could be deformed two, three or more times of its original length. In the present work it was not possible to verify this fact due to equipment limitations.

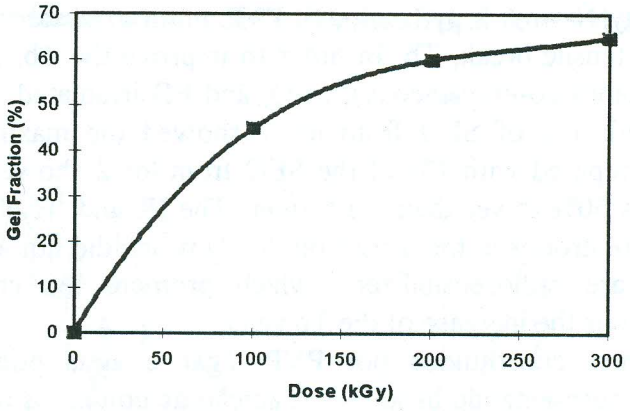

Figure 1. Gel fraction increase against the absorbed dose.

Table I. Experimental data and estimated values of the shrinking behavior of polyethylene film irradiated with electrons.

Dose (kGy)	Elongation (μm)	Shrinking (μm)	Shrinking Percentage (%)	Shrinking Effect
0	2767	1414	51.1	0.041
50	4836	3261	67.4	0.028
100	4717	3721	78.9	0.022
150	4125	3429	83.1	0.018
200	4995	4238	84.8	0.019
300	2907	1677	57.7	0.035

CONCLUSIONS

The best shrinking performance of the commercial polyethylene film occurs in the absorbed dose range between 100 and 300 kGy. The shrinking values of about **85 %** and the lower E value of 0.018, in the same dose range, strengthens this conclusion. Even though, with the limitations in stretching of the samples, the TMA-50 equipment has shown to be very useful to control the thermal parameters, which are very important in shrinking processes. The lower values of E confirms the shrinking behavior of the analyzed material, since E = 0 corresponds to the total length recovery of the stretched sample [2].

REFERENCES

[1] **M.A.López, G. Burillo and A. Charlesby**, *Radiat. Phys. Chem.*, **43**, 227, 1994.
[2] **W. Chen, K. Xing and L.Sun**, *Radiat. Phys. Chem.*, **22(3-5)**, 539, 1983.