MECHANICAL PROPERTIES OF ELECTRON IRRADIATED POLYAMIDE 6,6.

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Abstract

The tensile, impact and hardness properties of the electron irradiated Polyamide 6,6 were evaluated. Samples for the mechanical tests were injection-molded. These samples were irradiated at different doses at a dose rate of 22.42kGy/s and the doses were 70, 100, 150, and 200kGy. The tensile strength, impact and hardness measurements were performed according to the standards ASTM D 680, ASTM D 256 and ASTM D-2240 respectively. The experimental results have shown that the yield stress increases continuously with radiation dose as result of the stiffness of the bulk molecular chains that grow up with the amount of crosslinking. The values of hardness increases very fast up to about 100 kGy, after that, the values remain almost constant showing that the rigidity at the surface reaches a saturation state independent of further increase of crosslinking. On the other hand, the impact values decrease drastically with radiation dose. This behavior can be explained by the growing of fragility and brittleness produced by the rigidity of the crosslinked molecular structure that leaves the material weak to withstand impact loads.

Introduction

Radiation crosslinking, from all the radiation induced reactions, is one of the most important process from an industrial point of view for its applications and economical benefits. Crosslinking induces, on macromolecular materials, bondings between the long chain moleculas increasing the average molecular weight and forming, in this way, a network structure. These molecular modifications are proportional to radiation dose, over a wide range, and this process can be carried out on solid state without geometrical changes of the irradiated polymer. The chemical changes induced by crosslinking, produce improvements in the physical and mechanical properties of the irradiated polymer [1,2]. Polyamide 6,6, for its excellent mechanical, thermal, and electrical properties and its great performance in multiple technical applications is considered one of the most important engineering polymer [3], but sometimes, in specific applications some of its properties have to be improved by adding additives or fillers to get the required property. By these considerations, the aim of the present work was to utilize the ionizing radiation to improve the natural mechanical properties of polyamide 6,6 and to evaluate the irradiation parameters, mechanical behavior of the irradiated polymer and looking for the possibility to use radiation crosslinking instead of additives and fillers.

Experimental

The materials used in this work were polyamide 6,6 (A216). Samples for tensile strength, impact and hardness were injection-molded using a Battenfeld injector, taking special care with the row material that has a high rate of moisture absorption. The samples were irradiated with high energy electrons, at the IPEN-CTR irradiation facilities, using the Dynamitron JOB 188 accelerator with energy of 1.322 MeV, current of 5.2 mA and a doses rate of 22.42kGy/s. The radiation dose were 70, 100, 150, and 200kGy. These irradiated specimens were conditioned at 23°C and 50% humidity for 40 hours before being mechanically tested. The tensile strength, impact and hardness measurements were performed according with the standards ASTM D-680, ASTM D-256 and ASTM D-2240 respectively.

The tensile properties were determined using an Instron Universal Testing Machine (Model EMIC MEM-10000) with crosshead speed of 50mm/min, and a load cell of 2000N. The Izod Zwick Impact measurements were made with notched samples, and the harness were determined using a Shore D-Zwick equipment with a load of 1kgf for 10 seconds. All measurements were carried out in air and at room temperature,

Results and Discussion

The experimental results of tensile, impact and hardness measurements as a function of dose are given in Table 1.
The Yield Stress and Impact, and the Yield Stress and Hardness behavior are reported graphically in Fig. 1 and 2 respectively.
In fig. 1, the yield stress, of the tensile measurements, increases continuously up to about 24% of the value of the non-irradiated samples in the dose range analyzed. In this same dose range the impact values decreases

Table 1. Yield Stress, Impact and Hardness behavior Of electron irradiated Polyamide 6,6.

Dose [kGy]	Yield Stress [Mpa]	Impact [kJ/m^2]	Hardness [Shore D]
0	55	15	80
70	58	12	82
100	60	8	90
150	65	5	90
200	68	3.5	90

Relatively fast from 15 to about 8 kJ/m^2 in a doses range from 0 to about 100 kGy and then the decay is almost slowly up to 3.5 kJ/m^2 at 200kGy;

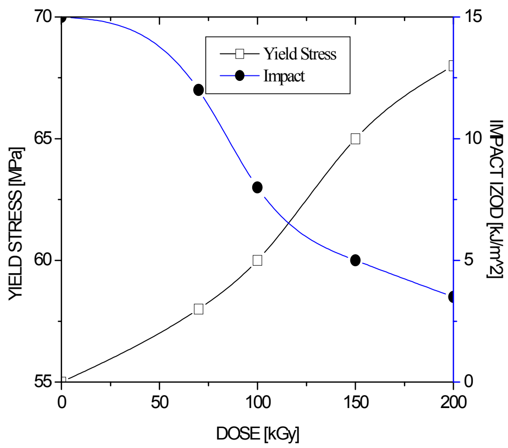

Figure 1. Yield Stress and Impact behavior of Polyamide 6,6 as a function of radiation dose.

The total decrease is about 77%. The increase of yield stress follows the increase of crosslinking density which contributed for the tenacity of the PA 6,6. On the other hand, the increase of crosslinking above 100kGy leaves the material brittle and fragile so that it can not withstand efficiently impact loads.

In Fig. 2, The hardness shore values increase only 13% as compared with the values of the non-irradiated samples, in this dose range.
Beside that, above 100kGy these values remain stable at about 90. The increase of the crosslinking density reaches its maximum value about 120kGy [2] and it is at this dose that the hardness also reaches its maximum value, remaining constant up to 200kGy.

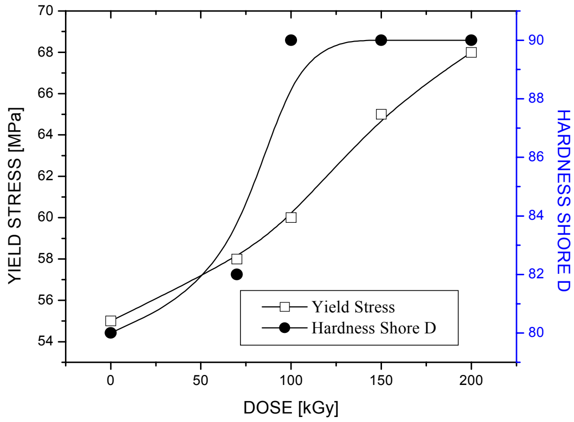

Figure 2. Yield Stress and Hardness behavior of Polyamide 6,6 as a function of radiation Dose.

Conclusions

The experimental results of this work shows that the Ionizing radiation, in the range from 0 to 200kGy, improves the tensile strength and the hardness properties of Polyamide 6,6. Unfortunately, the radiation induced crosslinking, has a negative effect on the impact properties of this polymer.

References

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