2007 International Nuclear Atlantic Conference - INAC 2007
Santos, SP, Brazil, September 30 to October 5, 2007
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: 978-85-99141-02-1

MECHANICAL PROPERTIES OF POLYAMIDE 6,6 / LOW DENSITY POLYETHYLENE BLEND BY IONIZING RADIATION

Eddy S. Pino and Marcos A. F. Feitosa

Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
eddypino132@yahoo.com.br

ABSTRACT

Polymer blending is a growing scientific and commercial development activity. In most of the cases, polymeric blends are formed by thermodynamically immiscible components. Such blends require the use of compatibilizers that, often, are copolymers, graft copolymers or any mean that improves the dispersion and adhesion of the blend phases. Compatibility of a polymer blend plays an important role in determining the blend properties for its end use. In this work, the improvement of mechanical properties of PA 6,6/LDPE 75/25% wt/wt composition blend, using electron radiation, was studied. Samples for mechanical test were melt-mixed in an extruder and then injection-molded. These samples were electron irradiated to overall doses of 50, 100, 150, 200 and 250 kGy. Tensile measurements have shown that the strength at break increases with an increase of radiation dose. Hardness Shore D measurements show that this property also increases as a function of radiation dose. On the other hand, Impact Izod tests show that the resistance to impact decreases with the increase of radiation dose. The behavior of these bulk and surface properties implies that ionizing radiation produces changes in the mechanical performance of the irradiated blend due to a combined radiation inducing effects, cross-linking and the compatibility of blend components.

1. INTRODUCTION

The main objective of polymer blending is to obtain new materials having a good range of properties with a low cost/benefit ratio and to allow the recycling of degraded polymeric materials [1]. In most of the cases the major problem in polymer blending is the immiscibility of its components due to their extremely different chemical structure, which sets thermodynamically unfavorable conditions for miscibility. Considerable efforts have been made to improve the miscibility among the blend components. The improvement of miscibility between the polymer components and the enhancement of blend performance is denominated of blend compatibility. This compatibility can be achieved using copolymers, graft copolymers or any other techniques, like ionizing radiation, that will improve the dispersion and the adhesion of the blend phases [2, 3]. The compatibility processes depends on the physical and chemical interactions across the phase boundaries, which, at the end, will determine the blend properties.

Blends based on expensive engineering thermoplastic, such as polyamides, and low cost polyolefins are very important polymeric systems in order to obtain materials with a wide range of physical and mechanical properties at low cost and also allowing the recycling of wasted raw materials. Polyolefins improve the mechanical properties of the polyamide, and the polyamide increases the resistance to oxygen permeability, resulting in an adequate

material for packaging industry. Unfortunately, polyamides and polyolefins form highly incompatible blends due to its extremely different chemical structures, thus many efforts have been devoted to compatibilize such blends [4]. In this work, the compatibility of the PA 6,6/LDPE blend, using ionizing radiation, and the evaluation of their mechanical performance were studied.

2. EXPERIMENTAL

The materials used in this work were polyamide 6,6 (Technyl A-216-Rhodia) and low-density polyethylene (PB-208-Politeno) with composition PA6,6 / LLDPE 75/25% wt/wt.. The samples were prepared by melt mixing at 260°C and 15 minutes of mixing time, using a Refenhauser extruder. The dumbbell-shaped for tensile tests and parallelepiped specimens for hardness and impact tests were injection-molded using a Battenfeld injector. These specimens were electron irradiated at the IPEN-CTR irradiation facilities, up to overall doses of 50, 100, 150, 200 and 250kGy. After irradiation, these specimens were kept at 23°C and 50% humidity for 40 hours before being mechanically tested. The tensile strength properties were measured according to ASTM D-638, using an Instron Universal Testing Machine (Model 5565). All measurements were carried out at room temperature, crosshead speed of 50 mm min^{-1}, and with a load cell of 10 kN. Hardness measurements were carried out using a Shore D durometer model Microtest-ASTM-2240, and the impact test with an Impact Izod tester ISO-180, model-Zwick using notched samples.

3. RESULTS AND DISCUSSION

The experimental data of mechanical properties for the blend, as a function of radiation doses, are reported in Table 1.

Table 1. Stress at Break, Hardness Shore D and Impact Izod for PA 6,6 / LDPE Blend.

Dose [kGy]	Stress at Break [MPa]	Hardness Shore D	Impact [kJ m^{-2}]
0	11.3	63.3	4.8
50	13.0	66.8	4.6
100	14.0	67.3	4.5
150	16.0	68.5	4.3
200	16.5	68.2	4.2
250	16.6	69.3	4.2

In Table 1, it is shown that the tensile strength at break increases in a continuous way as the radiation dose increases from 0 to 250 kGy and the improvement of the tensile strength at break is about 47% of the value for non-irradiated sample. The Hardness Shore D increases from the value of the non-irradiated sample, up to about 9.5% when the radiation dose reaches 250 kGy. On the other hand, the values of the Impact Izod decrease continuously

from 4.85 to 4.21 kJ m^{-2} in a range from 0 to 250 kGy reaching a reduction of about 13.2 %.

The irradiated blend mechanical properties behavior can be attributed to chemical induced reactions during the electron irradiation, mainly due to the interaction of the carboxylic groups formed in the polyethylene chains and the amine groups of the polyamide [4] enhancing, in this way, the adhesion between the blend continuous phases. Another effect that also contributes to the mechanical behavior of the irradiated blend is the amount of cross-linking induced by radiation in each blend component, which increases with the doses, producing more rigidity to the blend, improving the tensile and hardness performance but, in the other hand, this rigidity reduces the strength to impact of the blend. In immiscible polymer blends such as PA/PE, the effect of the ionizing radiation has been used to improve the mechanical properties through overall cross-linking [5]. Another aspect to be taken in account for the improvement of the mechanical performance of blends is related to the polymer-polymer compatibility of blend components. The effect of ionizing radiation at the interface improve the interfacial adhesion of the two-phase blend increasing the bulk properties of the blend [6].Under these considerations, the mechanical behavior of the PA 6,6/LDPE blend is due to the combine radiation induce effect, cross-linking and compatibility of the bled components.

4. CONCLUSIONS

The improvement of the tensile and hardness and the reduction of the impact properties of the irradiated blend confirm the possibility of the use of electron irradiation to enhance the low compatibility between polyamide and polyethylene. This compatibility effect is generally attributed to the chemical interactions of the oxidized functional groups, mainly carboxylic groups, induced in the irradiated polyethylene chains and the amine end groups of the polyamide, producing a graft copolymer, which enhances the adhesion between the polymer phases. Another effect of the ionizing radiation is the increase of cross-link degree, induced in each blend component during irradiation, which result in an increase of the blend rigidity, improving the tensile and hardness properties and reducing the strength to impact for the irradiated blend.

5. REFERENCES

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