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Some Physical Chemical Aspects of Non-Woven Fabric Polypropylene Exposed to Electron-Beams

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1. Introduction

Polyolefins as polyethylene and polypropylene (PP) are widely used in industry because of their low cost, ease of processing, good mechanical properties, and excellent chemical resistance.

However, these polymers have low surface tension, poor adhesion and insufficient chemical functionality which limit their use in certain applications. Polypropylene (PP) is a biocompatible polymer widely used medical area. Among several applications, PP can be found in a non-resorptive sutures and implants [1]. In some applications, the hydrophobic properties of PP are very useful because bacteria cannot bind easily to this polymeric surface. However, tissue integration and cell adhesion may be hindered due to this inert characteristic.

Polypropylene non-woven fabric have been widely used in biomedical separation fields owing to their random network of overlapped fibers [2], multiple connected pores, high thermal and chemical stability. For example, when blood comes into contact on this kind of polymer surface, it is generally accepted that adsorption of plasma proteins occurred in the initial step, followed by platelet adhesion, activation of the coagulation pathways and the final thrombus formation owing to its poor biocompatibility and strong hydrophobicity.

In this work, PP (sheet and non-woven fabric) samples were irradiated by electron beam radiation and their post-irradiation characteristics were analysed. The effects of radiation were evaluated by physical chemical analysis, thermogravimetry and infrared spectrometry and its results were discussed.

2. Methodology

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Sheet and non-woven fabric (NWF) polypropylene were the polymer samples used in this work. Sheet thickness was 0.15 mm and its density was 0,978 g.mm $^{-3}$ and NWF thickness was 0.025 mm and its area density was 40 g.m^{-2}, that is the kind of NWF-PP currently used in medical stuffs.

2.1 irradiation process:

Electron beam irradiation was evaluated in Job 188 Dynamitron accelerator, at room temperature and atmosphere air, at absorbed doses: 30 kGy, 50 kGy, 70 kGy and 100 kGy. The dose rate applied was 2.2 kGy.s-1. Polymeric samples of 100 mm x 150 mm were weighted before and after irradiation process.

2.2 Polymer substrates characterization

Mass percent changes were determined gravimetrically, from relation of pre-irradiation polymer mass (m_0) and post-irradiation polymer mass (m_f), as following relation in Eq. 1:

$$\%\, Mass = \left[\left(m_f - m_0 \right) m_0 \right] \times 100 \qquad (1)$$

Stress-strain analysis were evaluated from ASTM D5034-09 in a universal assay machine Instron model 5567. NWF PP irradiated and non-irradiated samples were cutted in retangular shape of 100 mm x 150 mm. Stress-strain behavior was obtained at strain rate of 100 mm. Min -1 and using a 1 kN load cell.

Contact angle measurements were obtained from static drop method. A 20 µL of distilled water was applied on polymer surface of both Sheet-PP and NW-F-PP irradiated and non-irradiated samples. The contact angle was measured from virtual goniometer in the interface drop/polymer surface. The work temperature was 25 ºC.

Hydroperoxides determination by iodometry of both Sheet-PP and NW-F-PP non-irradiated and 30 kGy irradiated samples. About 10 mg of each polymer sample was mixtured with 10 ml of isopropanol, 1 ml potassium iodide 20%, 0.5 ml H_2SO_4 1M and 5 ml of distilled water. This mixture was refluxed by 30 minutes and titrated with standard sodium tiosulfate 0,01M.

3. Results and Discussion

Fig. 1 shows the mass percent changes in function of absorbed dose. Both sheet-PP and NWF-PP present increasing in mass percent, but NWF-P sample shows a greater mass gain than sheet-PP sample. This behavior must be linked to the larger surface of NWF-PP sample, since it appears as a fiber network, compared to sheet-PP sample, that shows a continous surface, disregarding morphological imperfections and discontinuities. In this sense, NWF-PP sample is more affected by the oxidation during irradiation process under atmosphere air.

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The values described in Table 1 present the decrease of tensile stress at yield with increase of absorbed dose, where from 50 kGy minimum values are shown. It suggests NWF-PP samples are susceptible to irradiation process.

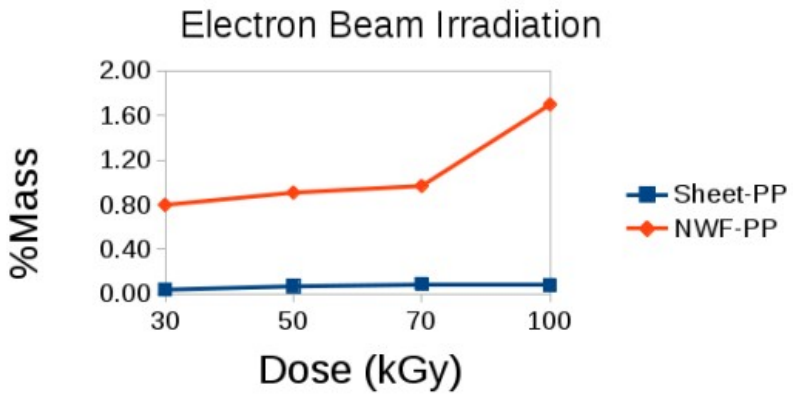

Figure 1. Mass percent changes for PP samples inf function of absorbed dose.

Table 1. Mechanical parameters from stress-strain tests.

NWF-PP	**Extension at yield (mm)**	**Tensile stress at yield (MPa)**	**Load at yield (N)**	**Estension at break (mm)**
Original	46.5 ± 10.1	13.4 ± 1.2	134.0 ± 12.0	85.3 ± 36.0
30 kGy	28.9 ± 9.6	6.4 ± 0.7	63.7 ± 7.2	71.0 ± 13.6
50 kGy	11.5 ± 8.5	2.6 ± 0.8	26.1 ± 7.9	60.3 ± 8.1
70 kGy	7.2 ± 0.4	1.9 ± 0.4	18.7 ± 4.8	45.5 ± 2.1
100 kGy	5.2 ± 0.3	1.3 ± 0.4	13.4 ± 3.2	21.0 ± 0.4

Contact angle measurements is show in Table 2 and the values of this parameter to both kind of samples do not present significative changes in function of absorbed dose until 70 kGy; from 100 kGy is observed a greater change in contact angle value to NWF-PP sample. These results suggest irradiation process was not enough to make the surface more hydrophilic for both PP sample types.

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Table 2. Contact angle measurements.

Sample	Original	30 kGy	50 kGy	70 kGy	100 kGy
Sheet-PP	68.2°	68.9°	68.8°	66.0°	61.1°
NWF-PP	120.0°	118.0°	117.0°	116.6°	65.9°

The values of hydroperoxides by iodometry showed absence of these chemical specie to non-irradiated samples and values about 0.86 mmol/g and 0.44 mmol/g respectively to Sheet-PP and N-WF-PP irradiated samples at 30 kGy, suggesting Sheet-PP samples are more oxidized than N-WF-PP samples, although these latter samples have a larger area to provide the oxidation process. However degradation is great in these conditions for N-WF-PP and this deterioration is related to chain scission mechanism where peroxides and hydroperoxides decompose to give rise to other oxygenated species (carbonyls, esters and alcohols) [3].

4. Conclusions

The EB irradiation process allows PP substrates to develop two reaction ways: oxidation and degradation. It was evidenced N-WF-PP samples are more susceptible to the radiation effects than sheet-PP samples, where degradation process is highly important. In this case, N-WF-PP samples are more sensible to the radiation effects where degradation is high in low absorbed doses. NWF-PP samples and in these experimental conditions the hydrophilicity surface is not reached. To perform surface oxidation on PP samples, should be given some change in irradiation process; perhaps considering carrying out the process under an oxidizing atmosphere or increasing the temperature during irradiation or applying these two conditions together. Although, there is peroxide-hydroperoxide formation and these species are decomposed in a fast chain-scission mechanism in the polymeric substrate.

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