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EFFECTS OF GAMMA RADIATION ON MECHANICAL BEHAVIOR OF FLUORPOLYMERS/CARBON NANOTUBES NANOCOMPOSITES

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ABSTRACT

Fluoroelastomers are a elastomers group, which have excellent thermal and mechanical properties and high chemical resistance. They are used in environments to degrade most another polymers. Multiple polymers/carbon nanotubes nanocomposites are related in literature. The aim of this study was process and evaluates the changes in the mechanical properties due to the incorporation of functionalized carbon nanotubes in fluorinated rubbers. The nanocomposite was prepared from an open mill (Copê), with two rolls, with addition of carbon nanotubes of 1%, and Viton® from Dupont. The samples were subjected to gamma radiation using a ^{60}Co source with doses 5 kGy, 10 kGy, 20 kGy at room temperature and air atmosphere. The effects of incorporation were compared and evaluated. The characterization was made by tensile strength and elongation at break.

1. INTRODUCTION

The fluoroelastomers stand out at many applications by excellent chemical and mechanical properties. These elastomers can be used in many temperature ranges, and generate a high assembled value to the manufactured materials. This type of polymer is present mainly in the areas of transport, chemical processing and electrical engineering [1].

Fluoroelastomers are synthesized from a variety of fluorinated monomers. The amount and type of each monomer, determine the type of fluoropolymer obtained. Fluorinated rubbers, known as FKM, contains vinylidene fluoride as a monomer [2].

Formulations most commercially found are those that combine hexaflourpolipropylene and tetrafluoroethylene to vinylidene fluoride, resulting in a chain like is shown in Figure 1.

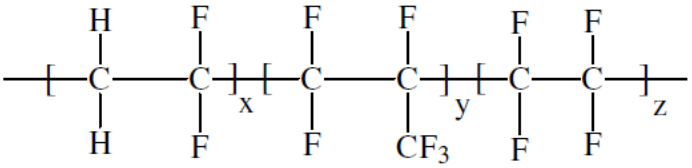

Figure 1 – Molecular chain of FKM. [3]

Polymeric composites are multicomponent materials that consist of two or more phases. The matrix is the phase of largest volumetric quantity, at which to cause changes such as, for example, increased mechanical and thermal properties. The dispersive phase is smaller volumetric amount, and is composed of a material capable of changing the matrix.

The polymers are generally used as matrix nanocomposites because the combinations of matrices and reinforcements are endless and can be modeled for a specific property is reached.

Nanoparticles based on carbon, such as graphene, carbon nanotubes and fullerenes are extensively studied as reinforcements because they are capable of causing considerable changes in polymer matrices.

The objective of this paper is show as fluorelastomeric matrix is affected by the incorporation of multi walled carbon nanotubes. After the incorporation of nanotubes, the nanocomposite was subjected to gamma irradiation, in order to assess the improvement in compatibility and the degradation of the nanocomposite.

2. MATERIALS AND METHODS

2.1. Materials

The nanocomposite was formulated, like is shown in Table 1.

Table 1 - Nanocomposite formulation

Components	Amounts (phr)
Viton F 605-C	100
Magnesium Oxide	3
Calcium Hydroxide	6
Carbon Black	30
Carbon nanotubes	1

Carbon nanotubes were provided by the Federal University of Minas Gerais, UFMG. They are obtained by chemical deposition from the vapor phase, CVD, with purity higher than 93%. The external diameter variation is 08-25 nm and the tube length from 5-30 μm.

2.2. Processing

Samples were prepared in open mill (Copê), with two rolls, 40 Kg capacity, according to ASTM D-3182 [4], temperature 50 ° C to 60 ° C.

Then, the compound was cured in a hydraulic press HIDRAUL-MAQ with 5 MPa of pressure, prepared according to the same standard, at 195 ° C for 5 minutes, and irradiated at dose rate of 5 kGy/h at 5, 10 and 20 kGy with γ-irradiation source of the laboratory is a ^{60}Co.

2.3. Characterizations

To obtain tensile and strenght at break values, mechanical tensile test was realized in a TA.XT texturometer of Stable Micro System, with load of 50 kN and speed of 500 mm.min -1.

The samples were prepared from thermopressed films, consisting of rectangles with 8 x 1 cm and thickness averaging 0.4 mm. The test pieces were used according to ASTM standard D 412 [5].

3. RESULTS AND DISCUSSIONS

The results indicated that there was no significant variation in the doses 5 and 10 kGy compared to non-irradiated nanocomposite. This suggests that the degradation and crosslinking reactions occurred in the same ratio [6]. At a dose of 20 kGy, however, the tensile strenght was reduced by approximately 17%, indicating that the degradation reaction was predominant.

The data show that the addition of multi walled carbon nanotubes did not interfere with the radioestability of fluorinated matrix, so that radiation typically acted, degrading it in a relatively low dose for polymers.

Tensile strength at break is shown in Figure 2.

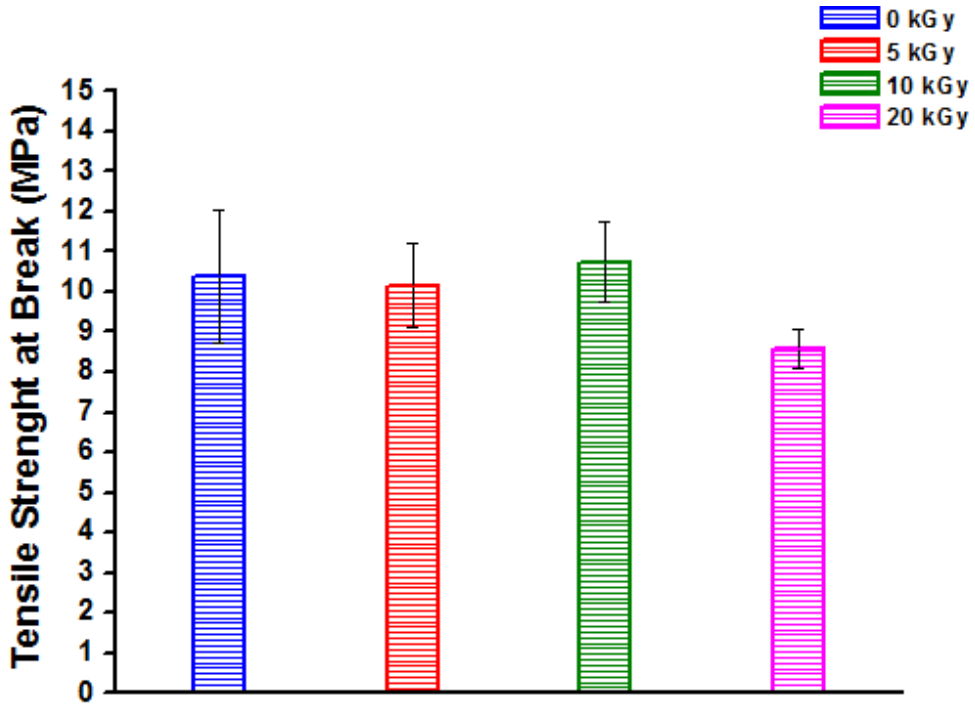

Figure 2 - Gamma radiation effect on fluorpolymers/carbon nanotubes nanocomposites tensile strength at break

Elongation at break are shown in Figure 3.

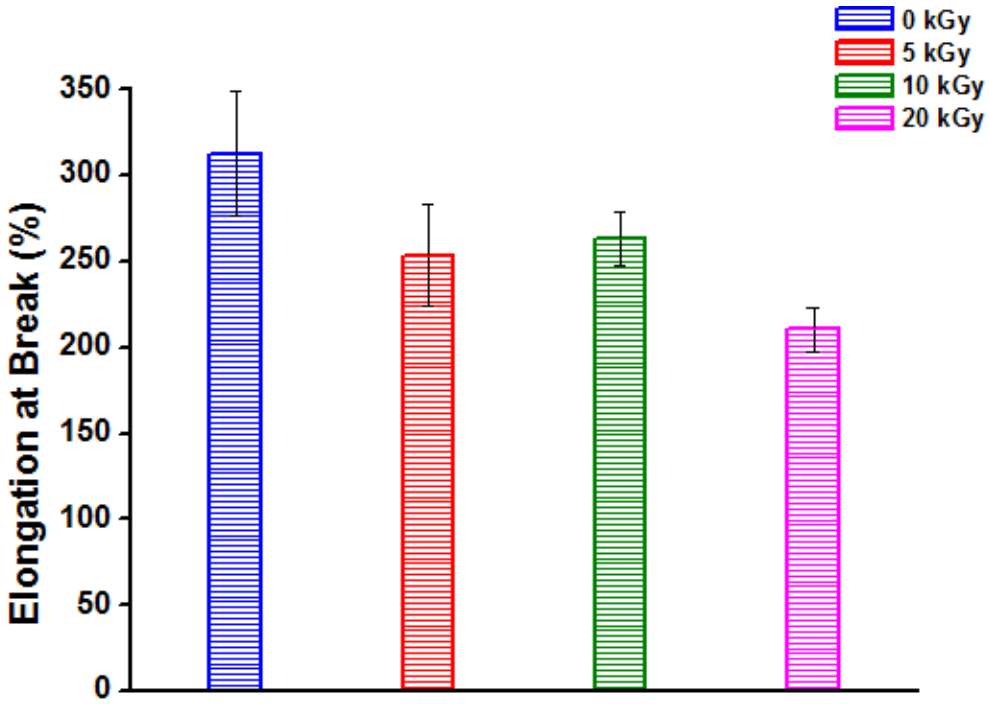

Figure 3 - Gamma radiation effect on fluorpolymers/carbon nanotubes nanocomposites elongation at break

The data obtained from the elongation at break are similar to those obtained for the tensile strenght at break, it shows that at doses 5 and 10 kGy, there crosslinking and degradation reactions occurring at the same rate, while at the dose of 20 kGy, the degradation reaction is most frequent [6].

But it is possible to observe that the presence of carbon nanotubes becomes nanocomposite more resistant to elongation, indicating that the chains are transferring load to the nanotubes in the matrix-reinforce interface [7].

For cases where the charge transfer does not occur, the stretching tends to vary little from the non-irradiated nanocomposite, as shown by Zen, in her research [6].

4. CONCLUSIONS

The effect of gamma radiation on fluorinated rubber tends to degradation of the material for high doses. For doses up to 20 kGy, it was demonstrated that there may be a balance between the degradation and crosslinking reactions, keeping the mechanical properties of the material balance.

Likewise, the incorporation of carbon nanotubes did not change the direct effects of radiation on polymer and only reinforced the polymeric matrix.

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