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Assessment of Ethylene Vinyl-Acetato Copolymer (EVA) Samples Bombarded by Gamma Radiation via Linearity Analyses

L N de Oliveira[1,3], E O do Nascimento[1], F Schimidt[1], P L Antonio[3] and L V E Caldas[3]

[1]Instituto Federal de Educação, Ciência e Tecnologia de Goiás-IFG, Campus Goiânia, Goiânia-GO, Brazil
[2]Polícia Militar de Goiás, Goiânia-GO, Brazil
[3]Instituto de Pesquisas Energéticas e Nucleares-IPEN/CNEN, São Paulo-SP, Brazil

E-mail: lucas@ifg.edu.br, eriberto.on@gmail.com, schimidt99@gmail.com, patrilan@ipen.br and lcaldas@ipen.br

Abstract. Materials with the potential to become dosimeters are of interest in radiation physics. In this research, the materials were analyzed and compared in relation to their linearity ranges. Samples of ethylene vinyl-acetate copolymer (EVA) were irradiated with doses from 10 Gy to 10 kGy using a ^{60}Co Gamma-Cell system 220 and evaluated with the FTIR technique. The linearity analyses were applied through two methodologies, searching for linear regions in their response. The results show that both applied analyses indicate linear regions in defined dose interval. The radiation detectors EVA can be useful for radiation dosimetry in intermediate and high doses.

1. Introduction

EVA means Ethylene Vinyl Acetate. This product is in the form of a synthetic foam, and it is produced from its thermoplastic copolymer. It is a very flexible material, suitable for various purposes [1]. When this copolymer has more than 40% vinyl acetate in its composition it becomes very flexible, and it is called EVA rubber. This copolymer may be vulcanized and the rubber can increase the number of its applications in the industry. It can be used in the adhesive industry both associated with epoxy producing commercial hot-melt adhesives. It also may be used for traffic paints and marine paint applications [2]. The ethylene–vinyl acetate copolymers with ammonium polyphosphate are also used as enhanced flame-retardants, and their performance are related to the formation of a thermally stable phosphocarbonaceous structure in the char, and the blend even shows a slight improvement in mechanical behavior. Poly vinyl alcohol is widely used in connection with spray-drying of emulsions, in particular ethylene–vinyl acetate copolymer emulsions. The PVA is added both as a protective colloid during the polymerization and as a redisposing aid prior to the actual spray drying. Therefore, the objective of this research is to investigate EVA for its linearity after bombardment with gamma rays.

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2. Materials and Methods

The ethylene vinyl acetate (EVA) samples used in this work were composed by small cubic pieces, with dimensions of 1 x 1 x 0.5 mm^3 and of three colors: black, green and white. The EVAs were irradiated with absorbed doses between 10 Gy and 10 kGy using a ^{60}Co Gamma Cell-220 system (dose rate of 1.089 kGy/h); then each sample was evaluated, and it presented an absorbance spectrum acquired on a Fourier Transform Infrared (FTIR) Spectrometer (Frontier/Perkin Elmer). The spectra were acquired with the crude samples directly on the PIKE GladiATR accessory without any preparation. All spectra were obtained in triplicate for each sample, in the absorbance mode, in the region between 4000 and 450 cm^{-1}, with 16 acquisitions, 4 cm^{-1} resolutions and 1cm^{-1} spectral ranges.

3. Results

Figure 1 presents the spectra from black, green and white EVA samples. In these results it is possible to infer the characteristics of each sample along the associated wavenumbers, as well as the regions and peaks in which the irradiation was significant. The total area under the curves from 450 to 4000 cm^{-1} is presented in Figure 2. Linear and nonlinear regions from methods can be seen using the FTIR technique. A linear relationship between integrated area and the absorbed dose of the samples can be observed in Figure 3. The results obtained were R^2=0.30, R^2=0.46 and R^2=0.22 respectively for black, green and white EVA samples. In Figure 4, the dose-response curves of the ethylene vinyl acetate, using a ^{60}Co gamma radiation source in black color for a wavenumber of 2940 cm^{-1}; green color for a wavenumber of 430 cm^{-1}; and white color for a wavenumber of 2233 cm^{-1} are shown. The results obtained were R^2=0.51, R^2=0.89 and R^2=0.30 respectively for black, green and white EVA samples. In this way the green EVA shared a greater linearity than the other analyzed materials. In Figure 5 the cumulative probability as a function of linearity is shown. Specifically in the region of the zoom shown in the figure it is possible to infer that the material that presents greater linearity is the green one, in relation to the white and black ones. For green samples, the linearity begins around 0.5 and remains in the region cumulative probability larger than the other materials.

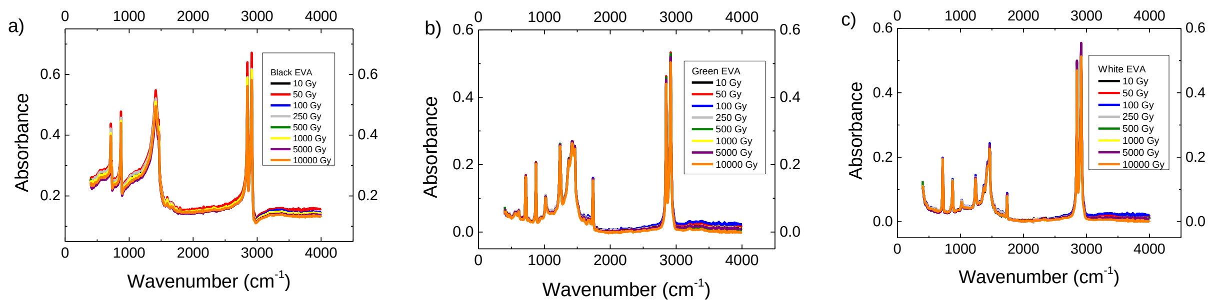

Figure 1. Spectra from black, green and white EVA samples. In these results it is possible to infer the characteristics of each sample along the associated wavenumbers, as well as the regions and peaks in which the irradiation was significant.

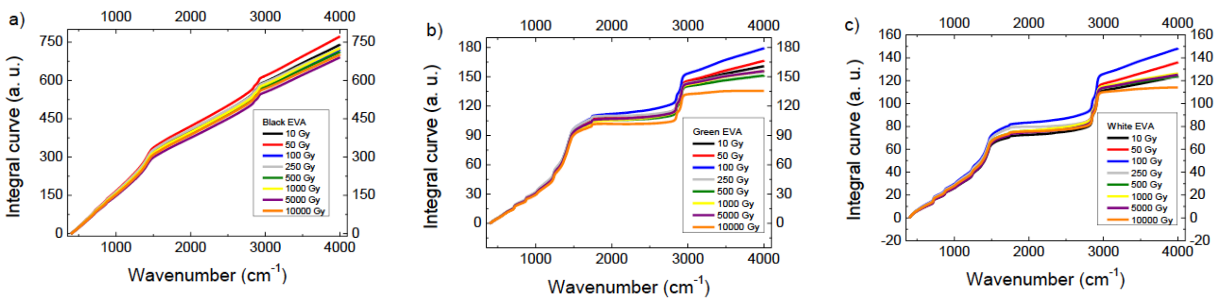

Figure 2. Integral area *versus* wavenumber, using the FTIR technique and irradiation from 10 Gy up to 10 kGy of absorbed doses. (a) Black; (b) Green; and (c) White samples.

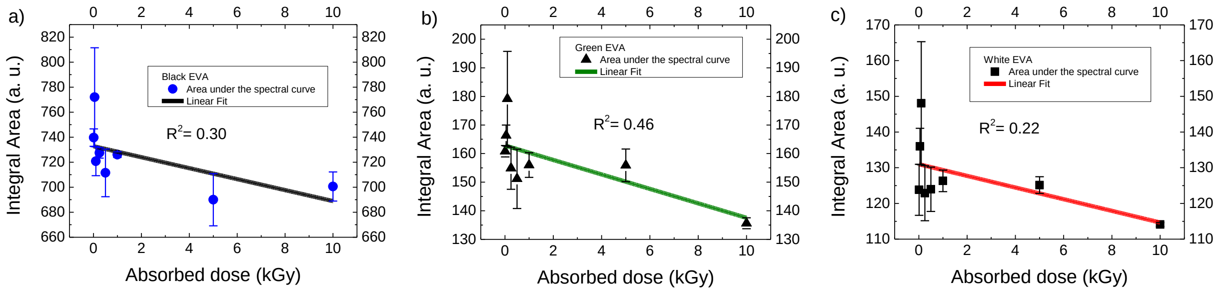

Figure 3. Linear relationship between integrated area and the absorbed dose of the EVA samples. The results obtained were R^2= 0.30, R^2 = 0.46 and R^2= 0.22 respectively for black, green and white EVA samples using the Integrated Area Under the Curve Method.

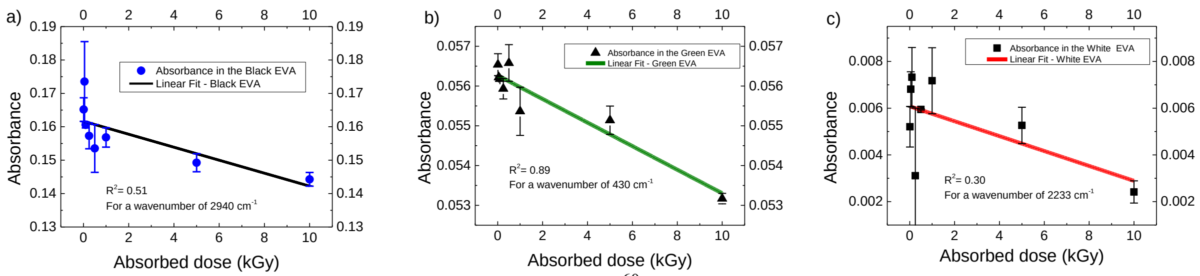

Figure 4. Dose-response curves of the EVA, using a ^{60}Co gamma radiation source in black color for a wavenumber of 2940 cm^{-1}; green color for a wavenumber of 430 cm^{-1}; and white color for a wavenumber of 2233 cm^{-1}. The linearity results obtained were R^2=0.51, R^2=0.89 and R^2=0.30 respectively for black, green and white EVA samples, using the Wavenumber Method.

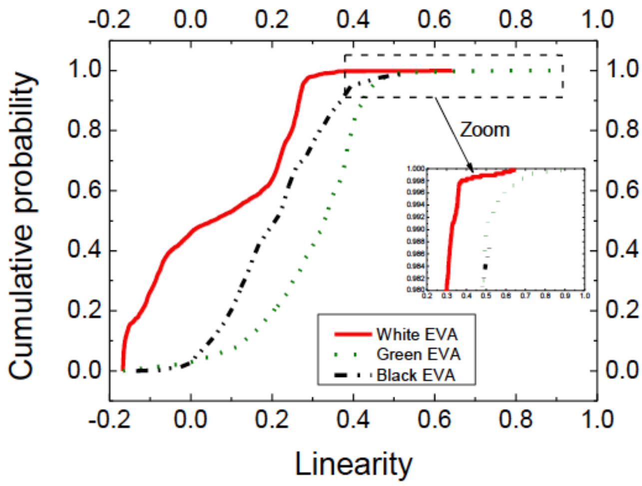

Figure 5. Cumulative probability *versus* linearity, for white, green and black EVA samples for wavenumber shown 400 up to 4000 cm^{-1}.

4. Conclusions

The FTIR measurements may be useful in dosimetry using the spectra of irradiated EVAs. The dose-response curves showed a non-linear relationship for all wavenumbers investigated. The highest linearity was in order respectively for green, white and black EVAs. The radiation detectors present potential use for radiation dosimetry in intermediate and high doses.

Acknowledgements

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