Dosimetric Properties of Commercial Polycarbonate

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Abstract: A simple and inexpensive dosimeter whose special dosimetric properties can be determinated, quantified and related to absorbed dose was studied in this work. The ionizing radiation interacts with polymers, transferring energy to atoms of the polymer chain, causing permanent changes in their physical and chemical structure. Commercial polycarbonate (PC) is a new type of film detector that suffers yellowing upon radiation exposure. The color change was used as dosimetric property to measure the absorbed doses. The spectrophotometry was the investigation technique and the absorbance was measure on a spectrophotometer Shimadzu UV-2101PC. PC films were irradiated with gamma doses between 1 and 150 kGy from a ^{60}Co Gammacell source and with electrons from industrial accelerator with maximum energy of 1.5 MeV and absorbed doses between 1.88 and 150 kGy The dosimetric properties studied were: pre-and post-irradiation stability, dose – response, environmental conditions influence and electron energy and dose-rate dependence. The after irradiation environmental conditions effect was observed and must be corrected. The optical response presents linear behavior in the gamma dose range studied and until 40 kGy to electron radiation; good stability before irradiation. These results indicate that the dosimetric characteristics of polycarbonate dosimeters are suitable to determine high gamma doses and electron doses and can be used as a alternative high doses dosimeter.

1. Introduction

Some polymeric films present changes in their properties due to the interaction of ionizing radiation that can be related with the absorbed dose [1]. Radiation induced chemical reactions results in rearrangements and/or formation of new bonds and the main effects are scission of main chain (degradation) or cross-linking. To be applied in radiation dosimetry they must present preferentially linear response in the dose range to be measured. It is necessary to determine its dosimetric properties such as lower and upper limits of useful dose range; dose rate and energy dependence; stability before and after irradiation and environmental conditions effects [2,4,5]. Polycarbonates are usually applied in neutron and alpha particles detection using nuclear tracks detection technique now a days they has been studied as a dosimeter to measure gamma-rays doses [3]. The radiation induced main chain scission of PC and produces phenoxy radical responsible for the yellowing [4,5]. In this work samples of commercial polycarbonate were investigated to be applied as dosimetric material evaluating the radiation dose response to^{60}Co gamma radiation and electrons from accelerator with maximum energy of 1,5 MeV using spectrophotometric technique.

2. Experimental

Samples of commercially available polycarbonate manufactured by Policarbonatos do Brasil (3 x 1 x 0.3 cm^3) were irradiated free in air and under electronic equilibrium conditions with doses between 1 and 150 kGy and dose rate of 2.60 kGy/h in a ^{60}Co gamma radiation source. Electron irradiations were performed using a JOB-188 Dynamitron Inc. Electron Accelerator. The samples were irradiated with electron beams with energies between 1.25 and 1,499 MeV, dose rate between 4 and 34 kGy/s and absorbed doses between 1.88 and 150 kGy. Optical absorption measurements were taken in a Shimadzu spectrophotometer UV-2101PC at wavelength ranging between 190 and 900 nm.

3. Results

The typical PC spectrum presents after irradiation an absorption band centred in 412 nm, that was used to evaluate the optical response.

The optical response stability before irradiation is better than 95% when PC samples are exposed to normal ambient conditions, however, after irradiation the samples must be maintained at lower temperature to avoid losses of response, approximately 30% after 2 days at room temperature and 8 % if maintained at 5°C.

The absorption intensity of the 412 nm peak increase linearly as a function of absorbed dose as showed in the Fig 1 to gamma radiation in the dose range between 1 and 150 kGy and Fig. 2 to accelerated electrons.

The optical response of PC samples irradiated with electrons accelerated (absorbed dose 15 kGy) with energies between 1.25 and 1,499 MeV and current between 1 to 8 mA are showed in the Fig. 3. No significant energy dependence response was observed in the studied energy range; less than 3% on average. Only sample irradiated with 4 mA current present anomalous behaviour, with 8% to 1.25MeV electrons and 4mA.

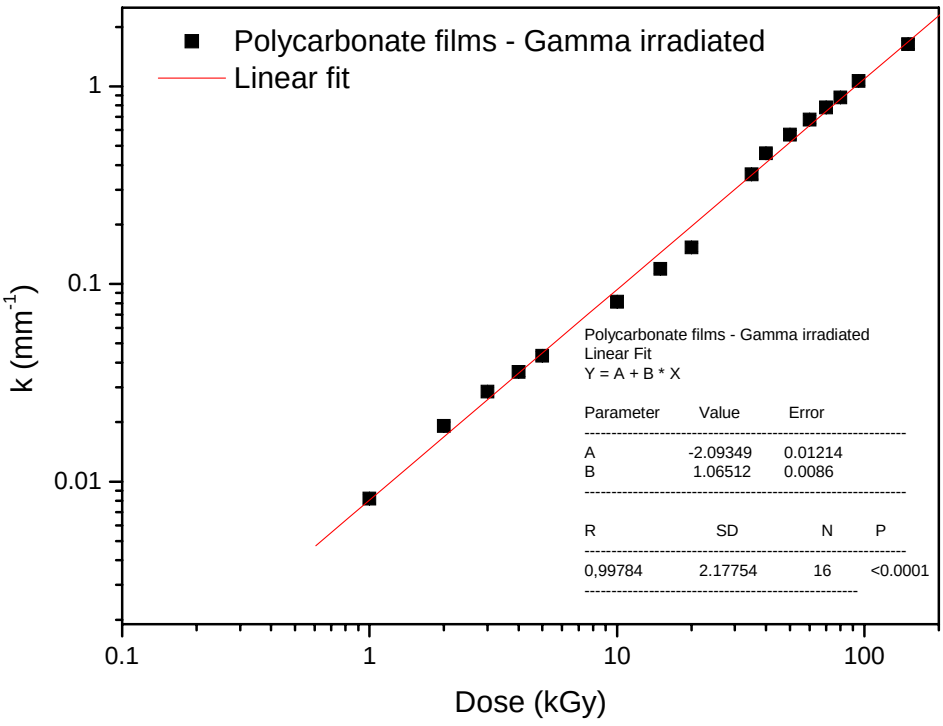

Figure1. Dose response curve of polycarbonate films irradiated with ^{60}Co gamma radiation, λ = 412 nm.

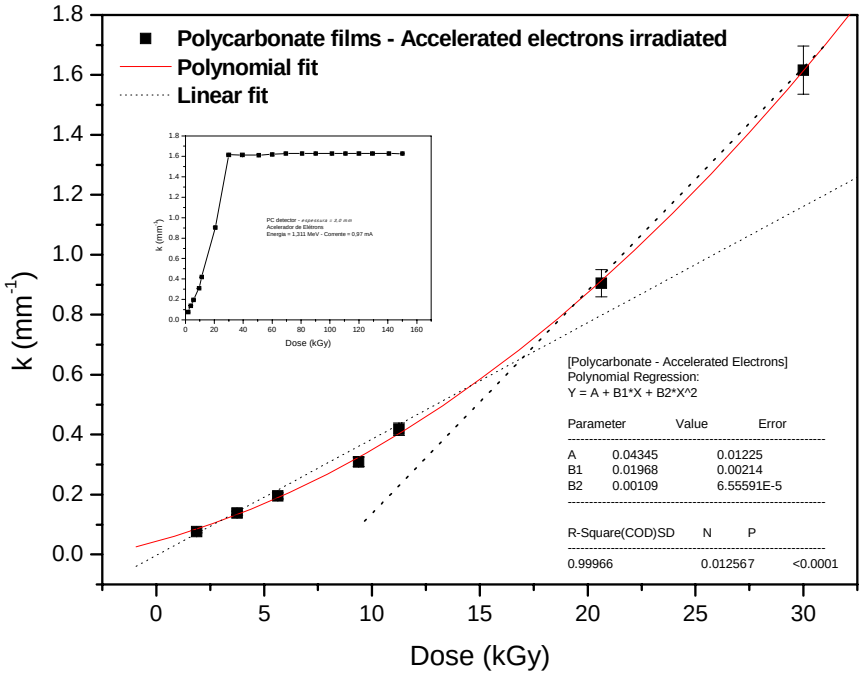

Figure 2. Dose response curve of polycarbonate (PC) films irradiated with accelerated electrons, E = 1,311 MeV and I = 0.970 mA; λ = 412 nm.

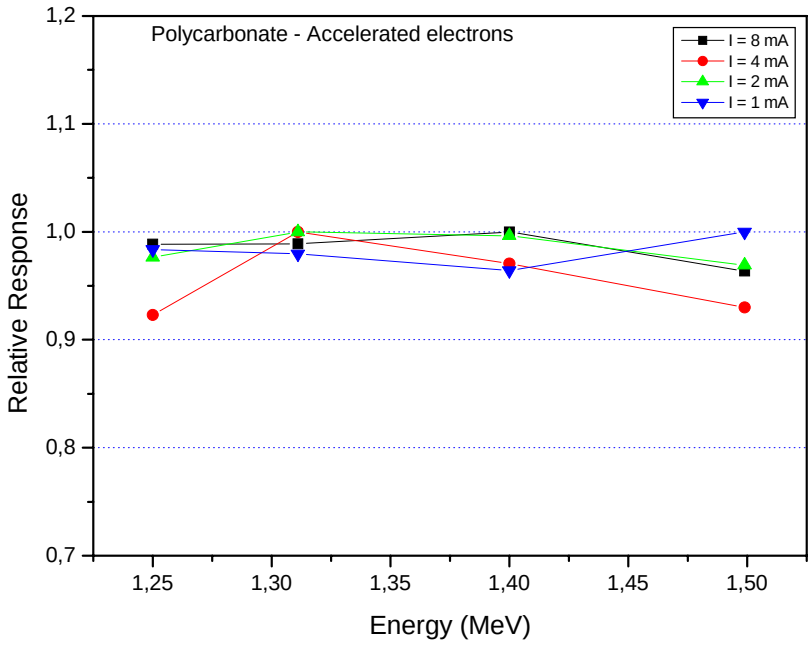

Figure 3. Energy dependence response for electron beam of Polycarbonate samples, dose 15 kGy.

4. Conclusions

The use of PC detectors for electron beam and gamma dosimetry is cheap and the absorbance analysis is very simple.

The PC detector can be used in a wide gamma dose range and a limited electron dose range.

The storage conditions doesn't affect the non-irradiated detector response, however, after irradiation the detector must be kept under refrigeration to preserve its optical response and reading must be done up to 24 hours after irradiation.

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