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EPR Characterization of a Medical Grade Polyethylene for High Dose Dosimetry

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Background of the study

The Quality Control of radiation processing of polymers and composites by electron beam (0.1-10 MeV), gamma and X-ray (0.6-7.5 MeV) can often be achieved by full knowledge of the irradiation parameters and by periodic analysis product. In such cases where the product itself is used for the quantitative control efficiency process other radiation dosimeters are not necessary. The main changes induced upon irradiation on the structure of the polymers are the creation of free radicals and the modification of the electronic configuration of these materials. The electronic paramagnetic resonance of the ionizing radiation induced free radicals in polyethylene has been extensively investigated by many authors. However, in the best of our knowledge, there is no data in the literature available regarding EPR dosimetric properties of the polyethylene.
In this work we are interested in the free radicals induced by gamma and electron beam irradiation in a polyethylene in order to investigate its use as high dose dosimeter.

Methodology

The polyethylene samples were obtained from commercial medical grade polyethylene sheets of 28 microns thick and were cut into pieces of 30 mm x 4 mm dimensions for EPR measurements. The PE samples were subjected to different doses irradiation in air and in nitrogen at room temperature of Cobalt-60 gamma rays (5-118 kGy) and 2.2 MeV electrons beam (25-1000 kGy). The EPR measurements were recorded at room temperature by means of X-band Bruker EMX machine with a microwave frequency of about 9.5 GHz.

Results and conclusion

The EPR spectrum obtained immediately after irradiation consists of six lines with a small amount of an asymmetric component, the six-line spectrum is attributed to alkyl radicals (AR) and the unbalanced line spectrum is attributed to the peroxide radical (PR). The effect of increasing the dose of PE films was studied in the range 5-50 kGy. The intensity of EPR spectra increase with increasing dose. The dose response curve of AR follows a linear model, while the curve of evolution of PR follows a first order kinetics model. We observed a strong decrease of ARs during the first three days after irradiation followed by a slow decrease until their total disappearance after 9 days. The concentration of PRs increased significantly after irradiation to stabilize after 31 days. The PRs thus formed are interesting for dosimetry because there exist alone without overlapping with other radicals and it is stable. However, the very long time to stabilize at a disadvantage. We found that the PR is completely separable after annealing for 20 minutes at 100 ℃. The repeatability of measurements for the two radicals has been proven. The coefficients of variation were found to be less than 1 %.

Country/Organization invited to participate

Tunisia

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