Radiation quality discrimination by continuous and pulse ESR techniques

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The biological damages produced by ionizing radiations in tissues and cells depend on the radiation quality, besides on the dose. The discrimination of the radiation quality, which is related to the linear energy transfer (LET), interests various fields such as radiobiology, astronautic space research, radiotherapy research and accidental dosimetry.

In this work we have applied continuous wave ESR (cw-ESR) and pulse ESR techniques to ammonium tartrate samples with the aim of developing procedures able to discriminate radiation quality whose knowledge is fundamental for rabiobiological considerations. We have chosen the ammonium tartrate because it is a promising compound for the measurement of the absorbed ionizing radiation dose [1, 2, 3]. The compound is particularly competitive to standard alanine in the detection of ionizing radiation other than high energy gamma photons, such as low energy X photons, electrons, protons, thermal neutrons.

At the same time cw-ESR and the Electron Spin Echo (ESE) decay techniques and Double Electron-Electron Resonance (DEER) can be used to obtain from average to local distributions of spins. CW-ESR is particular suited for the determination of total spin (macroscopic) concentration, whereas ESE is suited for the determination of local concentration. A new insight into the knowledge of the complex distribution of free radicals inside the dosimeters can be obtained by DEER. This technique is very useful for our purpose because it is able to measure distance between radicals in solids in the range of approximately 1.5-8 nm by analyzing the dipolar coupling between two electron spins.

In this work we analyze the spatial distributions of the free radicals produced after exposure of ammonium tartrate dosimeters to various radiation beams (21 MeV protons, ^{60}Co γ-photons, thermal neutrons).

By measuring the differences between the local radical concentrations and the macroscopic one, and the distributions of radical-radical distances obtained with DEER, this study has given details on the differences between the distributions of radicals created by the radiation-matter energy transfer for the different ionizing radiations.

Differences and analogies are discussed in terms of differences and analogies in the LET and type of particles involved.

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