New process to describe radiation damage at the molecular level. Application to ^{125}I seeds in water

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Sinopsis We present the first step of a general study on induced damage by ^{125}I in water at the molecular level. Requirements for such a study are introduced and preliminary results on the emission spectra of ^{125}I seeds are presented.

The main goal of this work is to study the biological damage induced by the radiation in a nanometric target volume (nanodosimetry), which is related to molecular dissociation.

The Monte Carlo codes used in this study includes all relevant interactions (LEPTS, Low Energy Particle Track Simulation [1], for energies < 10 keV with GEANT4 for >10keV) to obtain not just absorbed doses but also the number of dissociations in any nanovolume (~nm^3). According to the nanodosimetry concept, the MC code should track the particles with low energy, in order to take into account some interactions which are very efficient in this energy range. The input parameters for the MC are the cross sections (elastic and inelastic) and the electron energy loss spectra which have been previously measured experimentally or calculated depending on the energy range [2].The final goal is to improve the calculations used in clinical dosimetry based on these new concepts, or at least to define where the absorbed dose is low but some molecular damage is actually calculated by our model during treatment.

The first case to be studied are the low dose rate prostate treatments with ^{125}I seeds. The first measurements are based on quantifying the ionization generated by the ^{125}I seeds (Figure 1) in liquid water and comparing the experimental results with those obtained by the MC code. In addition, the absorbed dose calculated by MC will be checked by clinical planning system based on the TG43 protocol (using a water medium).

For this purpose, the ^{125}I seed is placed in a water phantom with dimensions of 50cmx50cmx50cm. The ionization chamber (model CC 01 of IBA) with an active volume of 0,01 cm^3 is used. The electrometer MAX-4001 of Standart Imaging is connected to the chamber and operated in Low Range module with a resolution of 0,01 pC. The main difficulty of these measurements consist in the determination of the reference point between the chamber and the irradiation source, as other variables are well controlled. This uncertainty was kept below 1 mm.

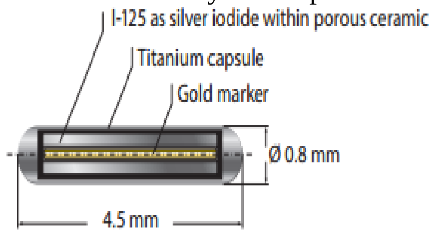

Figure1. IsoSeed®I25.S061-1

All the measurements are corrected for radioactive decay (S_k=2.483 U, $T_{1/2}$ = 59.41 d), pressure and temperature to the standard conditions of normalised radioactive activity, 20ºC, and 1013 mbar.

In the Table 1 the ionization data obtained at different geometries is showed.

z(mm)	x(mm)	y(mm)	Mean (pC)	sd (pC)	v.i (%)
2	0	0	19.84	0.36	1.8
4	0	0	10.31	1.67	16.2
7	0	0	4.30	0.54	12.6
10	0	0	2.97	0.32	10.9
20	0	0	1.04	0.12	11.2
30	0	0	0.63	0.08	12.3
10	0	5	2.65	0.17	6.3
10	0	10	2.02	0.22	11.1
10	0	20	1.28	0.10	7.7
10	0	30	0.45	0.05	11.6
10	14	0	1.11	0.11	9.5

x: coordinate on longitudinal axis on the seed; sd: standard deviation; i.v.: variation index.

The spectrum of the ^{125}I seeds was measured with a Si(Li) detector and so all the required information is available to begin MC simulations as future work.

Aknowlegments

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