Radiation induced damage by secondary electrons in condensed water molecules

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Synopsis A newly designed experimental setup for the study of induced damage from different radiations is presented. A narrow electron beam collides with a gold surface, generating secondary electrons. In order to cover a wide range of energies, several detectors are placed surrounding the sample, providing also angular resolution. Being biological molecules our priority, the same procedure is applied to condensed water molecules. Afterward, experimental results are used to validate our Monte-Carlo simulation, LEPTS. This code is able to combine primary and secondary electron tracks to provide accurate energy procedure and induced damage information.

During the last decades, many investigations have been devoted to the understanding of how radiation affects biological systems and the magnitude of its consequences. Traditional conception of this physical process makes primary radiation the main cause of biological damage. However, it has been verified recently that two-thirds of the damages caused by ionizing radiation are linked to the generated secondary species [1], mainly secondary electrons. Therefore, accurate radiation damage studies must take into consideration these electrons, following them from the highest energies to the subionization levels, where they can still lead to genotoxic or mutagenic lesions, via dissociative process [2].

Water is one of the most abundant molecule in the Universe, and also the main component in cells (60-70%). Understanding electron interactions with this molecule is essential to analyze radiation damage on any biological system. Important biomedical applications require scattering data in the condensed phase. However, due to experimental difficulties, most available measurements to date are in the gas phase. Also, Shyn and co-workers have reported strong backward scattering, but experimental results are scarce [3]. Both issues have motivated the construction of a newly portable experimental unit, designed to analyze interaction of different radiations (photons, e−, ions...) with any biological target.

The experimental setup consists on a high vacuum chamber adaptable to the electron gun exit, provided with an appropriate set of spectrometers (Silicon, Silicon (Lithium) and electrostatic hemispherical analyzer with microchannel plate detector) mounted on a rotatory plate which can be controlled from the outside. The sample holder has an external temperature control system. Molecular vapours are condensed through an injection needle in combination with a oven on the highly hydrophilic gold (111) surface layer. A scheme of the experimental setup can be seen in the figure below.

Experimental results, i.e., interaction probabilities, secondary electrons energy loss spectra and its angular distribution, are used to validate our Monte-Carlo simulation, LEPTS, which have been presented in previous works [4] and already validated for one sample.

Figure 1. Schematic diagram of the experimental arrangement

References

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