Positron Annihilation Spectroscopy for fundamental studies of living cells

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Purpose: We are going to present a feasibility study of the cytoplasmic changes in living cells by means of Positron Annihilation Spectroscopy (PAS) using a positron beam. This technique has been widely used for the study of defects in solids (metals, alloys, semiconductors, polymers): its main merit is to be a non-destructive technique, as opposed to many microscopic techniques (like TEM, APFIM). There are some different types of techniques based on PAS: lifetime measurement (LT), Doppler Broadening measurement (DB) and Coincidence Doppler Measurement (CDB), all of them implemented in our laboratory.
Until today, very few has been done in the application of PAS to biology. We plan to start with the study of some set of living cells, with the final target of studying single cell behavior.
The study we are going to present is a multidisciplinary approach, that needs the collaboration of scientists from different disciplines: physicists, medical physicists, molecular biologists, experts in radiation damage.

Materials and Method:
Experimental apparatus: For the present studies, one needs: (i) A positron beam; (ii) An interface between the vacuum chamber and the cell environment; (iii) A mosaic of cells on a suitable support; (iv) Lifetime and CDB spectrometers. Our laboratory is already equipped with all these tools, besides the vacuum/air interface that is in preparation. As to the lifetime spectrometer we still have to improve some details of the apparatus to get a better resolution.

Results: The sensitivity of the CDB to the chemical environment of the annihilation site may allow, for instance, the analysis of cell differentiation in staminal cells: we may think, for instance, to perform this analysis by combining LT and CDB techniques. Another field of study could be the analysis of the behavior of tumor cells and healthy cells. There are probably other processes taking place both in cytoplasm and in nucleus that we may hope to investigate with positrons in a future.

Conclusions: We want to point out that the lifetime technique is very sensitive to the analysis of sub-nano and nanovoids, but offers also a very important tool for studying the kinetics of cytoplasmic changes, and this, together with CDB, may make light on some yet ununderstood mechanisms taking place in cellular processes.

Keywords: Positron Annihilation Spectroscopy, living cells, Positron beam.