Study of the resistance, in the physical environment of the International Space Station, of a biochip-based instrument designed for astrobiological purposes.

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Introduction

Biochips present interesting potentialities for the search for life in the Solar System. Biochips are miniaturized devices composed of biological-sensitive systems (like antibodies and aptamers) fixed on a solid substrate allowing trace analysis of organic molecules from complex samples, with high sensitivity and specificity. Instruments based on this technology are under development. For example, the Life Marker Chip (LMC) (Sims et al., 2005; Martins, 2011), planned for the ESA ExoMars rover mission, and the Signs Of Life Detector (SOLID) (Parro et al., 2011) use antibodies as recognition molecules. Since 2005, thanks to CNES funding, the BiOMAS (Biochip for Organic Matter Analysis in Space) project has been aimed at demonstrating that it is possible to develop a biochip adapted to planetary exploration (Le Postollec et al. 2007). One of the main concerns of BiOMAS is to study the resistance of the biological components (antibodies and aptamers) under cosmic radiations. We have chosen to assess this key point with three complementary approaches: Monte Carlo simulations, laboratory irradiation experiments and a space mission aboard the ISS.

An experiment aboard the ISS is a relevant test to argue for the use of a biochip on new upcoming space missions. Irradiation conditions will be close to those that the biochip will face during a real mission. The biological components will be submitted to a combination of particles with a predominance of protons and ionizing doses accumulated will be in the same order of magnitude (several tens of mGy) as those simulated for a biochip aboard a typical mission to Mars. Exposure duration will be very long (~ 1 year) and therefore dose debits will be slower than those on beam facilities, which can influence the components behaviour. Moreover, samples will face, at the same time as irradiation, thermal cycles, launch constraints, vibrations, storage delays, and so on. This will be very representative of real space mission conditions and it will give crucial data to develop a future prototype of biochip for space purpose.

We present in this short paper, a description of our experiment aboard the ISS in the framework of the PSS (Photochemistry on the Space Station, P.I. H. Cottin).

Short description of the experiment

Different types of affinity receptors have been proposed for biochip-based instruments in the context of planetary exploration: antibodies, affibodies, molecular imprinted polymers and aptamers. During the future experiment aboard the ISS, we plan to test the resistance of antibodies and aptamers to space constraints in order to study the relevance of these receptors in this context. Thus, we have to design a model of biochip adapted to technical constraints of the EXPOSE-R2 carrier. New well shapes have been manufactured to suit closed cells to the EXPOSE-R2 carriers. 16 cells will contain a model of

biochip with different type of samples: grafted antibodies and aptamers (affinity receptors), free antibodies and fluorescent dye (to be used for the detection of targets). All samples will be freeze-dried. Half of the cells will be more protected from the cosmic rays that the other half, allowing us to test a possible shielding effect of the carriers. We plan to add dosimeters in the cells in order to estimate the dose of incident cosmic rays during the 15 months of the mission. ESA controls and laboratory controls will be available to discriminate the different possible sources of degradation. Finally, numerical simulation will be performed in parallel to estimate the types and the flux of particles that might interact with our samples.

The BiOMAS project

Prior to this experiment on board the ISS, we have conducted several experiments to test the effects of cosmic rays, thermal cycles, vibrations, freeze-drying procedures, etc. In particular, we have used beam facilities to test the effect of protons and neutrons on antibodies and aptamers recognition capabilities (Le Postollec et al. 2009a, 2009b, Baqué et al. 2011a, 2011b). We have also recently demonstrated that 25 MeV protons might have a deleterious effect on antibody performance (unpublished data). The aim of our studies is to propose relevant chemical environments and protections to insure the reliability of biochip-based instruments for space exploration.

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