IAF SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Science, Instruments and Technologies (3B)

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BESIDES (BIOMOLECULAR SIGNATURE DETECTION SYSTEM): A LAB-ON-CHIP-BASED ANALYTICAL PLATFORM FOR LIFE BIOMARKERS DETECTION IN ASTROBIOLOGY INVESTIGATIONS

Abstract

The search for biomolecules believed to be life biomarkers is a topic of increasing scientific interest in the field of astrobiology, especially now that the exploration of the Solar System has gained further momentum. At present, significant ambiguities remain in the identification of specific organic chemical species with currently widely used in situ detection methods (i.e., mass spectrometry). The goal of the BESIDES (BiomolEcular SIgnature DEtection System) project, funded by the Italian Space Agency (ASI), is to develop a highly integrated miniaturized multi-parameter platform for use in future planetary exploration missions. BESIDES proposes in situ analysis of organic molecules using state-of-the-art analytical techniques for specific detection of target molecules. BESIDES exploits Lab-on-Chip technology and uses immunological, enzymatic, and synthetic-artificial recognition element-based assays to detect, identify, and evaluate biogenic compounds. The project proposes to integrate into a single Lab-on-Chip 1) a microfluidic network for handling analytes and reagents; 2) a set of detection sites dedicated to immunoassays, enzyme assays, and assays based on Molecular Imprinted Polymers nanoparticles (nanoMIP), with bioluminescence/chemiluminescence (BL/CL) detection, exploiting magnetic microspheres as the solid phase; 3) an array of hydrogenated amorphous silicon thin-film photosensors (a-Si: H) for BL/CL analytical signal detection. The proposed instrument includes (i) a high signal-to-noise ratio signal readout subsystem, (ii) a control subsystem and auxiliary subsystems for sample and reagent dispensing, and (iii) a user interface for system control and programming, and data management. All the components will be designed and assembled in order to satisfy all the requirements for space missions. The proposed analytical technique has a unique ability to exploit specific antibodies, enzymes, and nanoMIPs to selectively recognize structurally related target molecules extracted from the samples of interest to provide a powerful tool for the detection of organic molecules of biological origin (e.g., nucleotides, proteins, alkaloids, lipids, and pigments), which are of fundamental importance for the confirmation of present or past life on a planet (or planetary body). In addition, BL/CL is considered a very advantageous detection technique for lab-on-chip devices, offering high detectability in small volumes, high specificity, and simple instrumental requirements. Finally, the approach of exploiting magnetic microspheres as a solid phase to perform the analyses provides, compared to the more conventional approach of immobilizing the detection elements in microfluidic channels, the enormous advantage of making the system reusable to be able to perform more analysis runs.