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SOLID (Signs Of Life Detector) Instrument: A Bioaffinity microarray-based instrument for life detection on Europa

V. Parro, L. A. Rivas, J. A. Rodríguez-Manfredi, Yolanda Blanco, J. Gómez-Elvira, and SOLID Team

Centro de Astrobiología (CSIC-INTA), Carretera de Ajalvir km 4, Torrejón de Ardoz, 28850, Madrid, Spain (parrogv@inta.es/ Fax: +34-915201074)

Abstract

It is generally accepted that the Astrobiological exploration of Europa is dependent on the possibility of sending a lander in a future mission. Since remote sensors are not definitive for detecting life, landers or contact probes, could bear instruments capable of performing in situ analytical techniques. Although the sampling of the Europa's subsurface ocean will not be feasible until the determination of its depth, the materials coming out from interior an located around fractures or diapires can be excellent targets for searching of molecular biosignatures. Biosensors based on the specificity of biological recognition (bio-affinity), like immunosensors, have been extensively developed for biomarker detection (nucleic acids, proteins, lipids, aminoacids, and other molecules). DNA and protein microarray technology allows covalent binding of thousands of probes (antibodies, other proteins, or organic polymers) in an small area (few square centimeters) on a solid support.

LDCHIP200, and antibody microarray for life detection

We have reported [1] a shotgun approach for antibody production for biomarker detection in astrobiology as well as environmental monitoring. We produced and tested 150 new polyclonal antibodies against microbial strains and environmental extracts, and constructed and validated an antibody microarray (LDCHIP200, for "Life Detector Chip") containing 200 different antibodies. We have successfully used the LDCHIP200 for the detection of biological polymers in extreme environments in different parts of the world (e.g., a deep South African mine, Antarctica's Dry valleys, Yellowstone, Iceland, and Río Tinto area). Clustering analysis associated similar immunopatterns to samples from apparently very different environments, indicating that they indeed share similar universal biomarkers. A redundancy in the number of antibodies against different target biomarkers allow us to obtain a sample-specific *immuno-profile* or *immnuno-fingerprint*, which may constitute by itself an indirect biosignature (Figure 1).

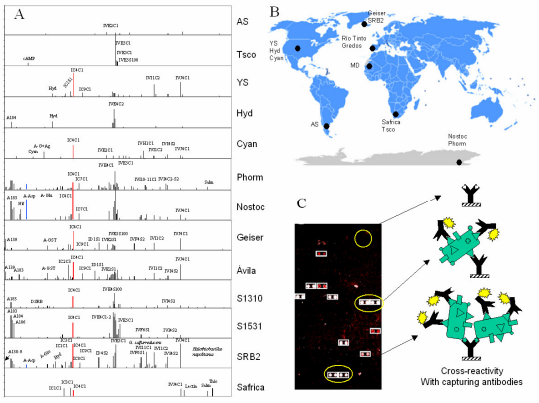

Figure 1. (A) immunoprofile obtained with LDCHIP200 with samples from different parts of the world (B). (C) example of a LDCHIP200 image with a duplicate spot pattern and the interpretation of the reaction taking place (*cartoons*). Modified from Rivas et al., (2008).

SOLID instrument concept

Based on protein microarray technology, we have designed and implemented the SOLID concept [2, 3]. We built and successfully tested a first SOLID prototype for the detection and identification of biochemical compounds and microorganisms [2]. Our system include all the mechanisms, detectors and electronics needed to automatically operate

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and collect results. A field prototype, SOLID2, was successfully tested for the analysis of 0.1 to 0.5 g of soil, sediments, grinded rocks, crushed ice, and liquid samples, and it was used as the key payload instruments for life detection in a Mars drilling simulation campaign in Río Tinto [4, 5].

The new version of the instrument (SOLID3) is able to perform both sandwich and competitive immunoassays. SOLID3 consists of two separate functional units: a Sample Preparation Unit (SPU), for ten different extractions by ultrasonication, and a Sample Analysis Unit (SAU), for fluorescent immunoassays. The SAU consists of different flow cells, each of them for an antibody microarray with a capacity of more than 1000 different probes. A unique and specially designed optical package allow fluorescent detection in a compact device.

The European Space Agency (ESA) initially selected the so called Life Marker Chip (LMC), an antibody array-based instrument for the search or life remains, as part of the Pasteur payload for ExoMars mission. SOLID-LMC like instruments should be also considered for a future missions to Europa.

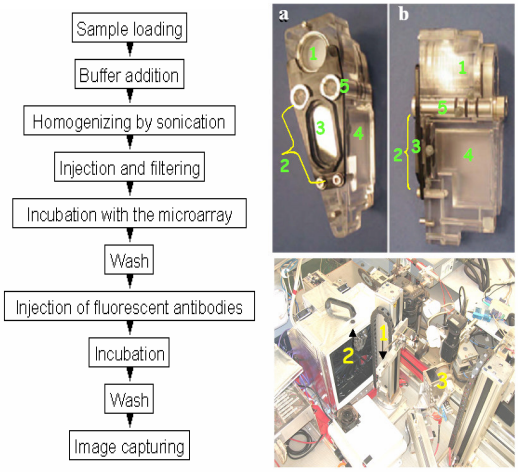

Figure 2. After sample loading, SOLID makes the whole process automatically (*left*). Front (a) and lateral (b) view of 1 out of 18 SOLID2 analysis module, being (1) the homogenizing chamber, (2) flow cell, (3) protein microarray support, (4) waste deposit, and (5) additional chambers for reactants and fluorescent antibodies. (*bottom right*) SOLID2 on the drilling platform during a Mars drilling simulation campaign (MARTE project 2005, http://marte.arc.nasa.gov/); (1) robotic arm for sample loading, (2) SOLID loading port, and (3) rock and soil crusher.

References

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Additional Information

SOLID Team
Víctor Parro (1), Luis A. Rivas (1), José A. Rodríguez-Manfredi (1), Yolanda Blanco (1), Graciela de Diego (1), Patricia Cruz-Gil (1), Mercedes Moreno-Paz (1), Miriam García-Villadangos (1), Carlos Compostizo (2), Pedro L. Herrero (2), Adolfo García-Marín (2), Eduardo Sebastián (1), Javier Martín-Soler (1), Julio Romeral (1), Olga Prieto Ballesteros (1), and Javier Gómez-Elvira (1).

(1) Centro de Astrobiología (INTA_CSIC), Carretera de Ajalvir km 4, Torrejón de Ardoz, 28850, Madrid, Spain.

(2) SENER Ingeniería y Sistemas S. A., Avda. Zugazarte 56, Las Arenas, 48930, Vizcaya, Spain.