Chemiluminescence-based biosensors for life science applications in space

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Introduction

Portable diagnostic devices are ideal tools for performing analyses outside of a laboratory environment. There is a strong demand for simple portable analytical devices suitable for space applications, that astronauts can use to perform clinical monitoring (e.g. detection of biomarker in blood, urine, saliva samples) during space missions, or that can be used for astrobiology investigations (e.g. detection of specific molecules outside of the Earth). Our research group is taking part in some projects involving the use of portable chemiluminescence (CL) biosensors for space applications.

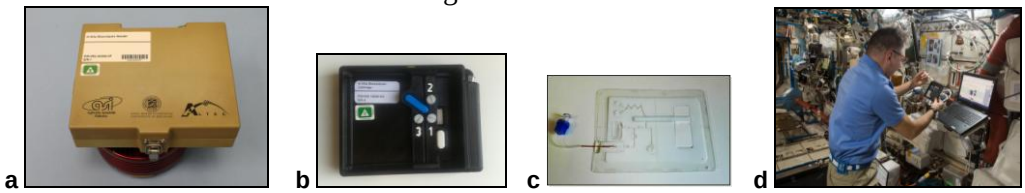
Materials and Methods

The developed biosensors are based on different approaches. As part of the IN SITU Bioanalysis project, we developed a portable analytical device which relies on the Lateral Flow Immunoassay (LFIA) technique, in which the immunological reaction is performed on a nitrocellulose membrane, employing immunoreagents immobilized in specific areas. The payload comprised a 3D-printed plastic cartridge (Fig.1b) containing a sealed fluidic element (Fig.1c) with the LFIA strip, a port for sample loading, pressure-activated reagent reservoirs and valves. The analysis required a simple manual procedure, and the flow of sample and reagents was obtained by pressing buttons on the cartridge or (across the LFIA strip) by exploiting capillary forces. Detection was performed by CL imaging, using a CL reader based on an ultrasensitive, thermoelectrically cooled charge-coupled device (CCD) camera (Fig.1a). The results were collected on an ISS laptop, then sent to ground personnel for processing and evaluation by medical experts. Another CL-based approach was selected in the frame of PLEIADES project involving in a microfluidic cartridge integrated with an array of thin-film hydrogenated amorphous silicon (a-Si:H) photosensors for acquiring the CL signal for the detection of bio-organic molecules in extra-terrestrial environments, exploiting immunoassays of DNA-based switch biosensors.

Results and Discussion

The CL-LFIA biosensor was successfully used on board the ISS by the Italian astronaut Paolo Nespoli during the VITA mission (July-December 2017) (Fig.1d). As a technological proof-of-concept, the device demonstrated the feasibility of performing sensitive (nanomolar level) immunological clinical chemistry analyses directly on board the ISS. As concern the PLEIADES microfluidic platform for life biomarker detection, a preliminary study was conducted for selecting the most suitable bioanalytical approach (e.g. immunoassay, gene probe assay).

Figure 1: CL-based biosensor for monitoring the health status of the crew members aboard the ISS.



Conclusion

The developed biosensors can find a variety of applications in space, for early detection of physiological changes that astronauts often experience during spaceflight, such as inflammation, infection, bone loss, muscle atrophy and cardiovascular disorders. In addition, they may applied on Earth for health monitoring, food safety, environment control, bio-terrorism.