Liquid Sample Extraction and Concentration for Potential Future In Situ Astrobiology Missions

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Program: FY21 R&TD Topics **Strategic Focus Area: Remote/In Situ/Life Detection Sensors and Instruments**

Background and Objective:

The Ocean Worlds Surveyor (OWLS) is an integrated, portable and autonomous life-detection instrument suite designed to identify and characterize life on ocean worlds such as Europa, Enceladus, Titan, and Ceres. The DCXM is the instrument that ingests, processes, and delivers samples to the other instruments within OWLS. The breadboard version of the DCXM (Fig. 1) was created to demonstrate these processes. Working off of this prototype, the brassboard instrument design is intended to handle multiple samples and provide semi-automation of the extraction and delivery processes.

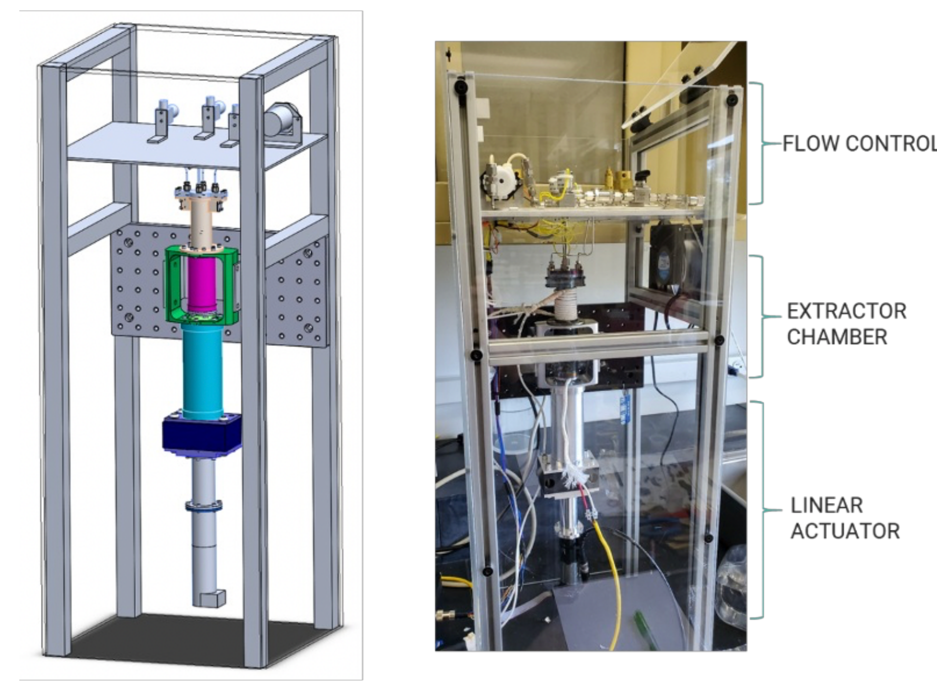
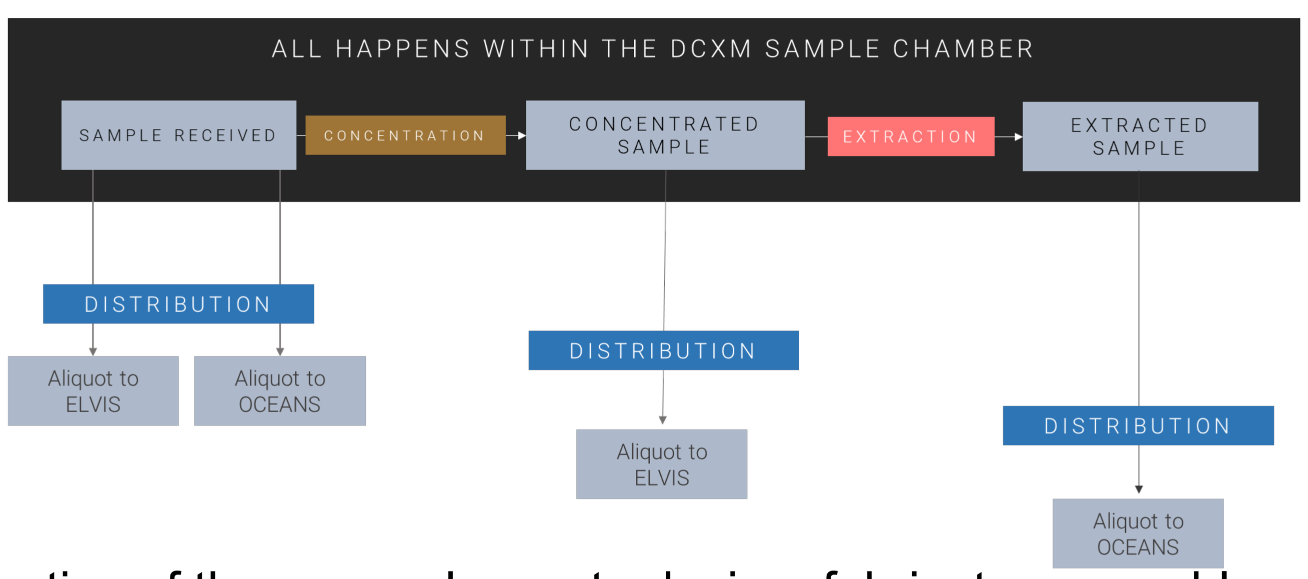


Figure 1. CAD (Computer Aided Design) drawing and current prototype of the OWLS DCXM breadboard. This version of DCXM only contained one sample chamber.

The DCXM performs the following processes:



1) **Accepts liquid/solid samples**
2) **Performs 10X concentration on ingested sample**
3) **Performs subcritical water extraction on ingested sample**
4) **Delivers samples to downstream instruments, to wit: OCEANS and ELVIS**

The objective of the research was to design, fabricate, assemble, and test a portable brassboard extraction/concentration system to support chemical analysis and life detection on potential future life detection missions. This subsystem, known by the acronym DCXM (Distribution, Concentration, and Extraction Module), is essential for future astrobiology missions because it provides a platform to prepare samples in-situ and direct them downstream to other instruments for life detection analysis. In particular, this system utilizes subcritical water treatment to extract organic matter from solid or liquid substrates [1-3]. The overall objective is to increase the TRL of this hardware to 4 and demonstrate end-to-end function. Initial validation of the system function will be performed in the laboratory using simulated samples. This work was a follow-on to the breadboard version of the Extractor Module in the OWLS project for extraction of organics for life detection.

Results:

In order to optimize sampling, the brassboard version of the DCXM includes a series of five extraction chamber assemblies in a carousel configuration (Fig. 2). The carousel includes linear and rotary stage assemblies which will allow sample chambers to alternate between being positioned beneath the sample inlet and chamber lid. Once chambers are positioned beneath the chamber lid via the rotary stage motors, the linear stage motors will position the chamber to seal against the chamber lid. After extraction/delivery, the rotary and linear stage motors will reposition the chambers to allow another chamber (containing a different sample) to be sealed against the lid.

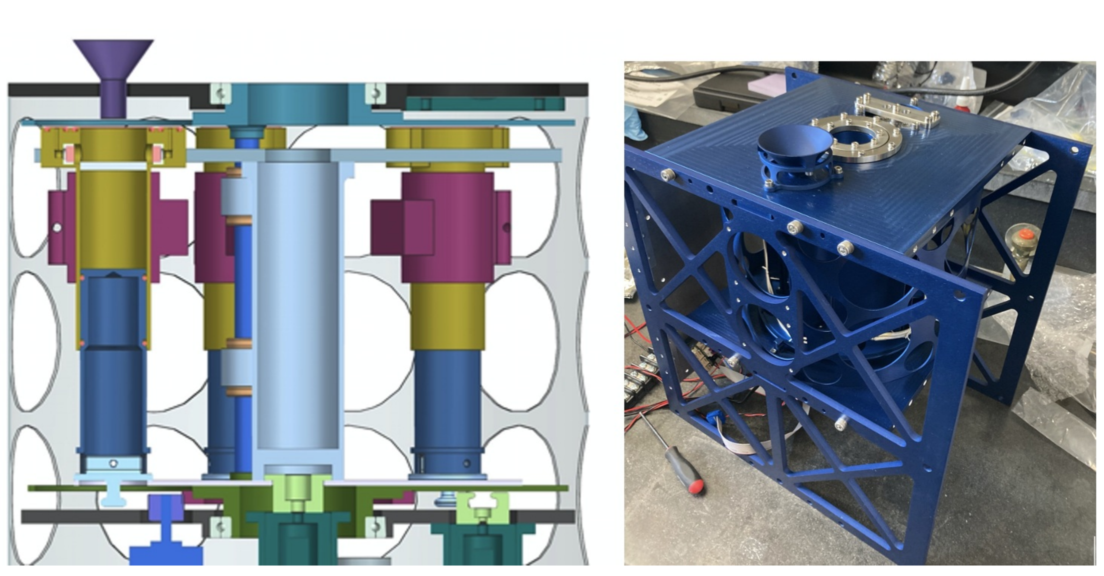


Figure 2. DCXM Brassboard carousel assembly in CAD view (left) with a photograph of prototype (right).

Mounted on top of the carousel is the flow control assembly (Fig. 3). The purpose of this assembly is to route samples once the sample chambers are positioned against the sample lid. This assembly contains the sample, water, and gas lines used during the extraction and delivery process.

Figure 3. DCXM Brassboard flow control assembly.

In addition, the flow control assembly contains a pressure regulator, flow control valves, a pressure sensor, and a variety of safety devices (i.e., one-way check valves, bleed valves, and purge valves).

All assemblies were created using Siemens NX CAD software. The fabrication and procurement of parts was performed at JPL and through outside companies. At present, the flow control and carousel assemblies are being integrated with electronics that will provide semi-automation to control the linear and rotary stages of the assembly. Once fully assembled and integrated, testing using various standards will take place to ensure that we are hitting our requirements for the filter concentration of cells, sonication for sample mixing, and the necessary heat and pressure profiles for subcritical water extraction. By examining and quantifying these metrics, the system developed will be compared to benchtop instruments, which represent the laboratory "gold standard" for instrumentation of this kind.

Significance/Benefits to JPL and NASA :

Prior to the development of the DXCM, the OWLS project did not possess a portable prototype instrument that could perform both extraction and concentration on natural samples. Performing extraction processes is essential for analyzing solid samples for biochemical traces of life. Additionally, following liquid treatment, the ability to concentrate organic materials and cells amplifies our ability to detect biosignatures. Therefore, advancing the development of the TRL of the DXCM has increased our ability to perform these analyses in situ and brings us closer to being able to fly OWLS as a flight project.

References :

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