Supplementary Material

Biosignature Preparation for Ocean Worlds (BioPOW) Instrument Prototype

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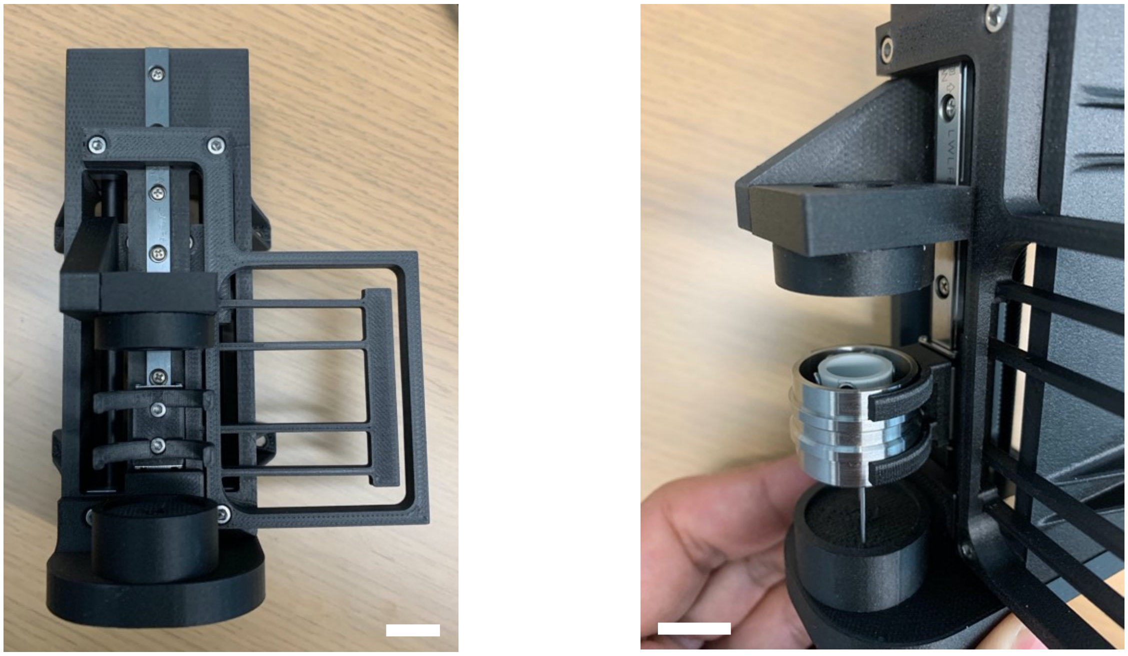
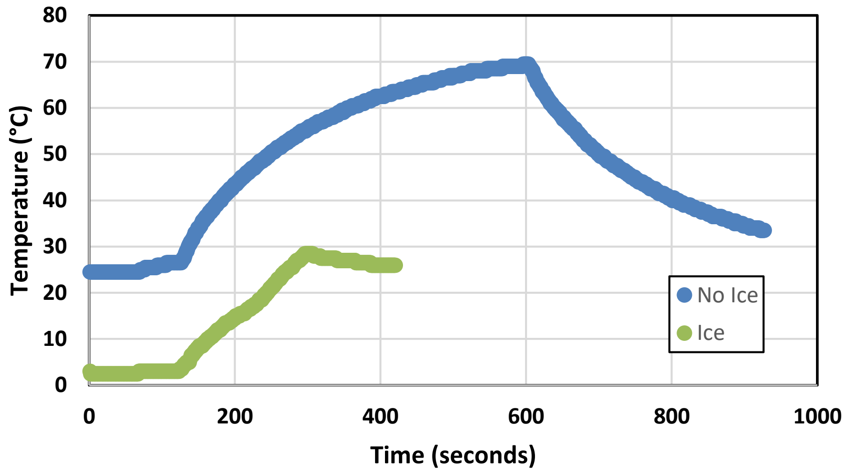
We designed and built a prototype of the sample cup sealing mechanism for melting the ice sample. The prototype was 3D printed with Onyx filament from Markforged. The receiving clips for the sample cup are mounted to a bearing block that slides on a linear rail. A four-bar linkage flexure, which is intended to represent an alternative to the linear rail in the flight-worthy design, centers the sample cup receiving clips along the rail in the neutral position while waiting for a new cup. The flexure would eliminate the need for lubrication, which is desirable in the space environment. It would provide both precision alignment and the spring force necessary to return the sample cup receiving clips to the default position during each test cycle. In our prototype however, it is only serving as a spring while the linear rail provides alignment. A linear actuator system is mounted to the reverse side of the receiving clip. The linear actuator will move the upper section of the receiving chamber downward, applying a compressive load to seal the upper and lower sections while making electrical contact on the base to drive the heating element, which is embedded within the sample cup. The upper section has a gas inlet for helium and outlet port for transferring evolved gases to a downstream mass spectrometer and to vent. A Haydon Kerk stepper motor and encoder enabled precise control of the cup and lid position. The electronics breadboard included control of the sealing mechanism.

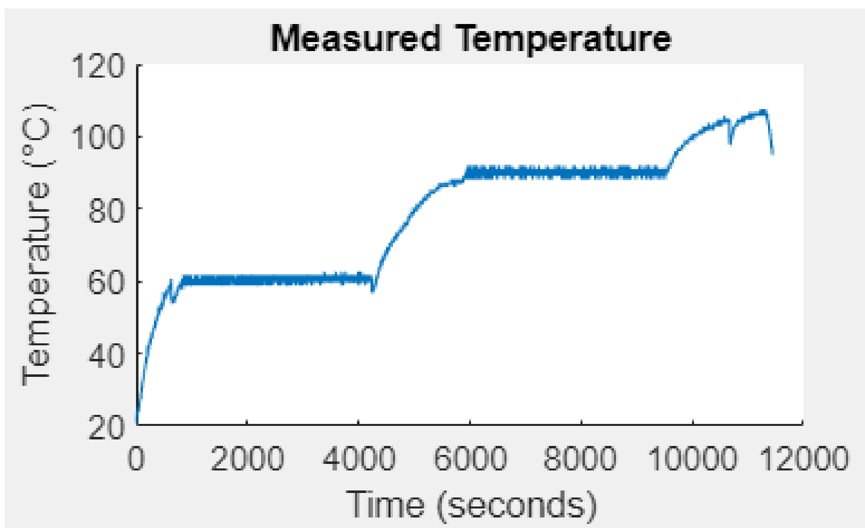


Supplementary Figure 1. Two images of the sealing mechanism: a front view (left) and a side view (right) shows the position of the sample cup. Scale bars are 2 cm.

We performed preliminary heating tests with the sample cup and derivatization tank to ensure heaters were sized appropriately and the designs could reach the desired temperatures in reasonable times.



Supplementary Figure 2. Time needed to heat the sample cup with and without ice. The thermocouple was placed on the inside wall of the Shapal (thermal conductivity 92 W/m-K, wall thickness 1.27 mm) and a nichrome heater coil on the exterior of the sample cup was heated with an external power source (5 W) attached to two resistors.



Supplementary Figure 3. Time needed to heat the derivatization tank to 60 °C for amino acid concentration and 90 °C for derivatization. The thermocouple was mounted to the bottom of the derivatization tank and a Minco resistive strip was heated with an external power source (5 W) attached to two resistors. The tank was empty during this heating profile.