AUTOMATED IN-SITU SUBCRITICAL WATER EXTRACTION AND PRE-CHARACTERIZATION PLATFORM FOR MARTIAN REGOLITH

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Introduction: Here we present a compact, integrated sample extractor and analysis unit that could be used to support landed robotic missions seeking chemical signatures of life on Mars. In a first step, inorganic and putative organic compounds are automatically extracted from approximately 3 cm^3 of regolith or ice/soil mixtures by subcritical water extraction (SCWE) at 175 - 250°C and elevated pressures [1]. Following the extraction, miniaturized electrochemical probes quantify the eluate's pH and redox potential to better understand the sample chemistry and mineralogy. Colorimetric measurements by flow injection analysis (FIA) in a fully integrated microfluidic manifold (MicroFIA) furthermore allow additional assessment of the soil's ionic composition [2]. Besides the evaluation of the potential for habitability or past or present biology, this system can be employed as a front-end instrument for subsequent, more sophisticated organic analyzers such as capillary electrophoresis (CE) or mass spectrometer (MS) systems, to put these down-stream measurements in context [3].

Approach: The presented sensor platform consists of two sub-systems, comprising a SCWE and a MicroFIA unit. SCWE uses liquid water as extraction solvent at temperatures above the atmospheric boiling point of water (273 K, 0.1 MPa), but below the critical point of water (647 K, 22.1 MPa). At elevated temperatures, the permittivity, viscosity, ionization constant and surface tension of water are decreased, whereas its diffusion rate increases, making it a powerful solvent for extraction of both polar and non-polar compounds.

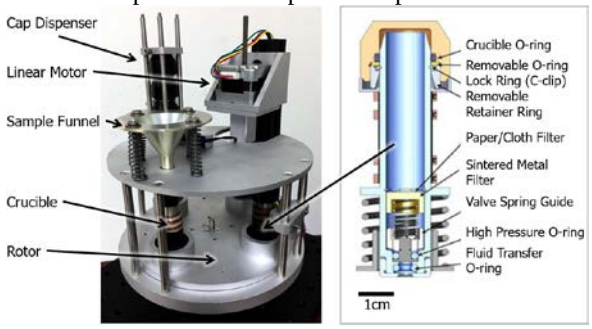

Figure 1: SCWE system core (left) and cross-section of a sealed extraction crucible developed together with *Ball Aerospace* (right) [4].

The presented automated SCWE system (Figure 1) allows for four independent extractions. The crucibles are mounted on a rotary holder and moved by a stepper motor to four positions, where: 1) the sample is filled into the extraction crucible, 2) the extraction crucible is capped and hermetically sealed by a linear motor and, 3) engaged with liquid interface to inject the extraction solution, and 4) the crucible is heated up to 250°C to initiate extraction. After concluding the extraction, the crucible engages again with the liquid interface to release the extract to the MicroFIA system (Figure 2) for downstream compositional analysis.

FIA is a technique where a liquid sample is injected into a moving carrier stream. The two liquids form a reaction plug, which is transported toward a detector that continuously measures changes in e.g. absorbance and electrode potential. FIA is a powerful but simple tool to measure ion concentrations, pH, ORP and electrical conductivity of a liquid sample, such as the extract from the SCWE unit.

Here, we are presenting the results of a fully integrated version that has been tested on a field trip in the Atacama Desert (Chile).

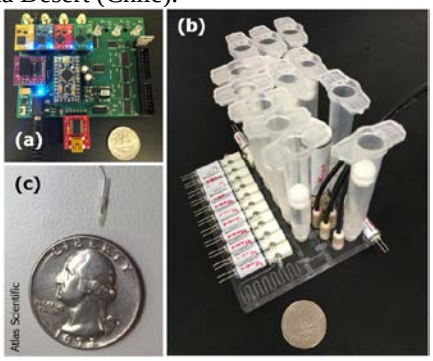

Figure 2: Photographs of (a) MicroFIA electronics, (b) assembled MicroFIA system, (c) mini pH probe.

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