The Organic Capillary Electrophoresis Analysis System (OCEANS) – A Wet Chemistry Biosignature Analyzer for Potential Future Ocean Worlds Missions

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Introduction: Searching for evidence of life elsewhere in the Solar System is one of the great challenges motivating NASA. There is a growing community consensus that multiple lines of evidence from coordinated instrument suites as part of in situ missions will be required to robustly meet this challenge [1, 2] The Organic Capillary Electrophoresis ANalysis System (OCEANS) is under development for chemical biosignature and context detection within larger life detection instrument suites such as the Europan/Enceladus Molecular Indicators of Life Instrument (EMILI) and the Ocean Worlds Life Surveyor (OWLS) [3, 4]. OCEANS performs liquid based separation of molecular biosignatures via capillary electrophoresis (CE) and can be coupled to an array of different detectors for coverage of the widest possible chemical phase space [5].

The OCEANS detection modes include laser induced fluorescence (LIF) for detection of chiral amino acids [6], capacitively coupled contactless conductivity (C^4D) for detection of inorganic ions and metabolically relevant organic acids [7, 8], and electrospray ionization mass spectrometry (MS) for detection of a broad range of positively ionizable compounds [9], as well as membrane relevant fatty acids [10].

OCEANS analyses have also been performed on cell samples after hot extraction to demonstrate the ability to convert cells into chemical biosignatures [11]. This hot extraction process is called, subcritical water extraction (SCWE), and both stand-alone and OWLS integrated SCWE systems have been built and coupled to OCEANS hardware for analysis [4, 12].

In order to prepare OCEANS for inclusion on a future life detection mission we have worked to systematically advance the technology readiness level of both the overall system and critical subsystems. Towards this, we have demonstrated the ability of the LIF detection system, including the fluorescent dye, to meet required performance at radiation levels relevant to a mission on Europa's surface [13, 14]. We have also shown that a C^4D detector can be designed using parts with flight analogs that are again suitable for use under the Europa relevant radiation levels [15]. Lastly, we have shown that the reagents critical to allow successful CE separation for LIF, C^4D, and MS methods can be stored for years without performance degradation [15, 16].

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