Europan Molecular Indicators of Life Investigation (EMILI) Technology Development

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The Europan Molecular Indicators of Life Investigation (EMILI), funded under the ICEE-2 program, is designed to meet and exceed the scientific and technical/resource requirements of the Organic Composition Analyzer (OCA) identified as a core instrument capability of the recently-studied Europa Lander mission [1]. EMILI tightly couples two complementary analytical techniques, based on (i) liquid processing with capillary electrophoresis and (ii) pyrolysis/derivatization with gas chromatography, to robustly detect, structurally characterize, and quantify the broadest range of organics and other chemicals that may be present over widely-varying concentrations.

The Organic Capillary Electrophoresis Analysis System (OCEANS) of EMILI analyzes water soluble, non-volatile organics and salts using capillary electrophoresis following liquid extraction from received ice/salt/mineral mixtures using a microfluidic sample processor. A laser-induced fluorescence (LIF) detector provides extremely high sensitivity identification and quantification of the abundance and chirality of organic acids traversing the capillary, which is additionally coupled to an electrospray ionizer for mass spectrometry (CESI-MS) analysis of the full complement of water-soluble compounds.

The Gas Analysis Processing System (GAPS) broadly analyzes less-soluble, more-volatile organics (e.g., fatty acids) and gases using pyrolysis/derivatization and gas chromatography which is then coupled to the same mass spectrometer through an electron ionization source. The ion trap mass spectrometer (ITMS) itself derives from the dual-source linear trap design of the Mars Organic Molecule Analyzer (MOMA) investigation on the upcoming ExoMars rover mission. Focused ion optical and detector development for enhanced and robust performance in the harsh Europan environment has been supported by the COLDTech and ICEE-2 programs.

The parallel OCEANS and GAPS analysis paths enable EMILI to perform a thorough analysis of potential molecular biosignatures and contextual organic and inorganic compounds, in samples received in specialized reaction cells that enable conversion of delivered cryogenic fines into the

required analytical streams. These cells and the associated sample receiving and processing subsystem have been developed to interface with, and are fully supported by, the current design of the Lander including the Collaborative Acceptance and Distribution for Measuring Europan Samples (CADMES) system under ICEE-2 development.

With ICEE-2 support EMILI prototypes will realize end-to-end functionality in all modes and examine performance metrics under realistic Europa Lander measurement conditions. Extensions of these capabilities to other potential astrobiology missions are also being considered by the team.

[1] Hand K. et al. JPL D-97677 Europa Lander Report (2017).