Europan Molecular Indicators of Life Investigation (EMILI)

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The Europa Lander mission, studied by NASA, offers the opportunity to search for signs of extant life on a planetary body with a subsurface ocean that could host utterly alien biology. An Organic Composition Analyzer (OCA) on the Lander would identify key compounds, such as amino and fatty acids, organic structural/isomeric patterns and biases, and other potential biosignatures, while remaining fully prepared to analyze molecular evidence unfamiliar from terrestrial biology and/or strongly modified by the Europan environment (e.g., due to exposure to intense cosmic radiation). The OCA should be sensitive to compounds with a wide range of characteristics, including water solubility and volatility, molecular weight and structure, and chemical complexity, with nM limits of detection (LoD). The Europan Molecular Indicators of Life Investigation (EMILI), that received support under the ICEE-2 program, is designed to meet the scientific and engineering requirements of the OCA. EMILI couples two complementary analytical separation techniques: capillary electrophoresis and gas chromatography with an ion trap mass spectrometer, which can robustly detect, structurally characterize, and quantify the broadest range of analytes.

OCEANS: The Organic Capillary Electrophoresis Analysis System (OCEANS) of EMILI analyzes water soluble, low-volatility organics, and inorganic salts using capillary electrophoresis (CE) coupled to multiple detectors. Organics released from as-received samples via subcritical water extraction are subsequently prepared for CE analysis using a microfluidic sample processor. A laser-induced fluorescence (LIF) detector provides high sensitivity to amino acids while a broad range of ionizable organics can be detected by electrospray mass spectrometry (CE-ESI-MS).

GAPS: EMILI's Gas Analysis Processing System (GAPS) broadly analyzes less-soluble, more-volatile organics (e.g., fatty acids, alkanes) and gases using pyrolysis/derivatization and gas chromatography coupled to the same mass spectrometer through an electron ionization source.

ITMS: The ion trap mass spectrometer (ITMS), adapted from the Mars Organic Molecule Analyzer (MOMA) on ExoMars, provides wide mass range compound identification from both OCEANS and GAPS sources, with extremely low limits of detection. The ITMS includes tandem mass spectrometry (MS/MS) to investigate molecular structure, potentially enabling detection of key species such as hetero-oligomers.

Using flight-like OCEANS and ITMS prototypes we have demonstrated CE-ESI-MS analysis of a range of amino acids, small peptides, and reference compounds at concentration limits of detection in the nM range.

We present details on the development of EMILI and the latest results from prototype testing.