Extraterrestrial Molecular Indicators of Life Investigation (EMILI): Development of Flight-Like Prototype

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Abstract

Introduction: The Extraterrestrial Molecular Indicators of Life Investigation (EMILI) is an instrument concept under development for future potential astrobiology missions to Enceladus, Europa, Mars, and beyond. Alien molecular biosignatures may or may not share similarities to those of terrestrial life. In situ analyses must be prepared to detect and characterize a wide range of possible molecular species, structures, and patterns, typically with exquisite sensitivity and within a complex, unknown planetary environment. EMILI is designed to meet ambitious requirements for broad organic molecular analysis on future missions such as the conceptualized Enceladus Orbilander through chemical separation systems coupled to both optical and mass spectrometry detection. These are realized in an integrated, compact package compatible with anticipated flight environments.

Design: To detect and characterize *the broadest inventory* of organic molecules ranging over molecular weights to at least 1000 Da with varying volatilities and polarities spanning classes of potential biotic and abiotic structures, EMILI merges the complementary front-end separation techniques of liquid-based capillary electrophoresis (CE), including laser-induced fluorescence (LIF) and conductivity detection; and gas-based pyrolysis/ derivatization gas chromatography (GC), both coupled to a common highly sensitive ion trap mass spectrometer (ITMS). The Organic Capillary Electrophoresis Analysis System (OCEANS) incorporates liquid-based sample extraction and a CE-based subsystem for analysis of polar organics and inorganic salts. The Gas Analysis Processing System (GAPS) incorporates gas-based sample extraction and both GC and Evolved Gas Analysis (EGA) subsystems targeting non-polar organics, gases, and biominerals. OCEANS and GAPS both interface to an ion trap mass spectrometer (ITMS) derived and enhanced from the Mars Organic Molecule Analyzer (MOMA) and the Dragonfly Mass Spectrometer (DraMS) instruments, for sensitive molecular analysis. The EMILI ITMS also includes a novel electrospray

ionization interface, a wide mass range, and tandem mass spectrometry providing complete molecular characterization capabilities.

Development: EMILI has been integrated in various breadboard configurations to demonstrate feasibility of design elements and flight-like operations with adjustable and interchangeable components and assemblies. Testing has focused on the end-to-end performance of GAPS-ITMS (GC-MS) and OCEANS-ITMS (CE-MS) within flight constraints as these interfaces are key elements of the eventual flight concept. With the successful demonstration of breadboard performance, engineering test units (ETUs) of the subsystems have been designed and are under fabrication in a flight-like size and form factor for thermal-vacuum and vibration testing. Sample interface and electronics designs are also being adapted for the integrated EMILI configuration for various mission concepts and operational scenarios.

Biography - William Brinckerhoff

William Brinckerhoff is Senior Scientist for Life Detection in the Solar System Exploration Division of NASA's Goddard Space Flight Center, involved in the development of mass spectrometers and associated technologies for planetary missions to Mars, the Moon, Titan, and other bodies.

Keywords

Ion trap mass spectrometer, Astrobiology, Spaceflight mass spectrometry, CE-MS