Membrane Inlet Mass Spectrometry for Ocean Worlds

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Detection of extant life and habitability assessment on Ocean Worlds is a high scientific priority for NASA. Gases, including light hydrocarbons and volatile organic compounds, are a relevant set of analyte species that can be occluded in water and ice as products of metabolism and indicators of habitability, and are expected to be present in a variety of planetary environments. Future missions to icy moons such as Europa and Enceladus may be engineered to penetrate ice and send autonomous payloads to oceans below, although initial missions to Ocean Worlds likely will only access the surface and near-surface ice. On Mars, recent discovery of liquid water ~1.5 km below the surface of the South Polar Layered Deposits may provide a more near-term opportunity to study liquid water and overlying ice on another planet. Consequently, we are investigating ways to employ variations of membrane inlet mass spectrometry (MIMS) for extraction of volatile analytes that have relevance to advancing the search for life and assessment of habitability on Ocean Worlds.

We are developing a low-power static (i.e., non-flowing sample) MIMS interface that obviates the need for power-hungry sample pumps and requires only limited volumes of water. The static MIMS interface is intended ultimately for in-situ analyses of gaseous, semivolatile, and water-soluble biosignatures from liquid or melted ice samples in lander missions with limited power budgets on Ocean Worlds. The MIMS interface receives small volumes (e.g., 1 mL) of liquid samples from which a large fraction of the volatile species are extracted and delivered to a linear quadrupole mass spectrometer. The interface will be coupled with a Goddard Space Flight Center (GSFC) gas processing system (GPS), which is based on the GPS incorporated into the Sample Analysis at Mars instrument currently operating on the Curiosity Rover on Mars. The GPS includes enrichment cells to concentrate volatiles of interest for analysis, and a scrubber cell to trap unwanted water vapor. We will present progress to date on individual work on the static MIMS probe at SRI International (SRI) and the GPS at GSFC and our initial integration of the two systems.

We will also present a concept to integrate two techniques, a Honeybee Robotics thermal ice probe and an SRI underwater MIMS system, to create MeltMIMS, a novel instrument for in-situ analyses of dissolved gases and volatile organics in ice and ice-covered lakes. The GSFC team is providing expertise on in-situ planetary habitability and biosignature measurements for development of the concept. The MeltMIMS is proposed to ultimately allow us to determine concentrations of volatile analytes of biological relevance in the melt water with high spatial resolution as the thermal ice probe melts through, e.g., a Europa or Mars ice layer, and when it reaches a subglacial ocean or lake below.