Development of mass spectrometer for organic molecule detection in the future space life search missions

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The search for extraterrestrial life on planetary bodies, such as “Ocean worlds” and Mars, is a very challenging task. The ideal instrument for this task must be small in weight and size, but also very sensitive to detect very low concentrations of organic molecules. The quadrupole ion trap mass spectrometer (QITMS) satisfies these criteria.

In this study we will present the current level of development of our life detection system. QITMS instrument is a part of a larger instrument that has three subsystems: The ice Sample Handling and Distribution (SHaD); the Supercritical CO2 and Subcritical H2O Analysis (SCHAN) instrument for extraction, preconcentration, and chromatography; and the QITMS mass spectrometer. The full system will be used for organic molecule detection at sub-ppb level.

The interface between the SCHAN and QITMS consists of a combined electrospray ionization and atmospheric pressure ionization source, three differential pressure stages, and ion transfer optics. The ionization source operates at 2-4 kV and is a soft ionization technique that produce mainly quasi ions (M+H) + or cations with alkali metals. The pressure is reduced from atmospheric pressure to low pressure using three differential pressure stages: 1^{st} stage $8\cdot10^{-1}$ Torr; 2^{nd} stage $4\cdot10^{-4}$ Torr; and 3^{rd} stage $<5\cdot10^{-7}$ Torr. The ions are transferred from the inlet capillary to the ion trap with two quadrupoles and two orifices. We measured the total ion currents at different ion transfer elements in our instrument. The current measured at the inlet capillary was 80 nA while the current of ions that reaches the QITMS was around 3 pA, which is sufficient for detection of molecules. The QTMS is designed to measure masses up to 600 amu, which is sufficient for detection of most high priority organic molecules. The goal of our effort is to develop the fully integrated flight instrument that will be ready for the future Mars and Enceladus missions.