The Future of Linear Ion Trap Mass Spectrometer Systems for Planetary Exploration

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The Mars Organic Molecule Analyzer (MOMA) onboard the 2020 Rosalind Franklin Rover incorporates the first linear ion trap (LIT) mass spectrometer that will be deployed into space. The fundamental technology developed for MOMA will enable a family of instruments employed in space exploration over the coming decades. Several key features of the LIT, as well as enabling portability developments, allow this mass analyzer to be applied to a variety of targets across the solar system.

The MOMA instrument suite is capable of Gas Chromatography Electron Ionization (GC-EI) as well as Laser Desorption Ionization (LDI), with the two ionization approaches enabling detection of molecular species across the volatility spectrum in support of the overarching mission science goals to seek evidence of past and/or present life at Mars. However, other planetary targets (i.e. Ocean Worlds such as Europa or Enceladus) likely require other modes of ionization in order to best suit the anticipated sample composition and target analytes. Very sensitive detection of trace amino acids has been demonstrated through the use of fluorescent tagging combined with capillary electrophoresis (CE) but coupling this to a mass spectrometer is desirable to maintain broad chemical analysis capability. As such the design of a nano-electrospray ionization (nESI) source, compatible with the requirements of operation on Europa will be discussed, specifically addressing the issues of gas load and consumption as it impacts a portable instrument.

Similarly to how the LIT is finding applications on multiple missions, the development of algorithms and techniques for one scenario can often be applied to many others. A common challenge for small, resource-constrained ion traps is the need to deal with samples that have a wide range of concentration of analytes. During MOMA development as well as during the development of a second-generation MOMA-like LIT instrument recently field-deployed to the Atacama Desert, a range of techniques such as SWIFT, selective accumulation, broad band isolation and high dynamic range lens gating have all been investigated to address the challenges of a complex sample. The application of these techniques to Mars analog samples, including those studied in the Atacama desert, as well as future expected ESI data will be presented and discussed.