Optimization of Multiple Frequency Waveforms for Ion Isolation and Ion Ejection from a Linear Ion Trap Mass Spectrometer for Planetary Exploration

D. A. Kaplan[1], A. Grubisic[2,3], R. M. Danell[4], D. T. Snyder[5], F. H. W. van Amerom[6], V. T. Pinnick[2], R. D. Arevalo, Jr.[7], X. Li [8,2], S. S. Larson[2], S. A. Getty[2], R. G. Cooks[5], W. B. Brinckerhoff[2]

[1]KapScience, Tewksbury, MA, desmond@kapscience.com
[2]NASA Goddard Space Flight Center, Greenbelt, MD
[3]University of Maryland, College Park, MD
[4]Danell Consulting, Inc, Winterville, NC,
[5]Purdue University, W. Lafayette IA
[6]Mini-Mass Consulting, Inc, Hyattsville, MD
[7]Department of Geology, University of Maryland, College Park, MD
[8]University of Maryland, Baltimore County, Baltimore, MD

The Mars Organic Molecule Analyzer (MOMA) is an instrument under development by teams in Europe and the U.S. for the 2020 ExoMars rover mission. The instrument contains a lightweight, low power, dual source mass spectrometer intended to detect and identify martian organics, including non-volatile and high-molecular weight species by laser desorption/ionization (LDI). During LDI experiments, to meet the challenges of operating in Mars ambient conditions, both ion isolation and ion fragmentation are done at relatively high pressures. Because of these higher pressures, unintended ion fragmentation is possible. New operational methods that can mitigate these effects have been explored. A new mode to rapidly eject a wide range of ions above a certain m/z can aid in charge control and minimizing ion fragmentation. Operating on Mars also sets a practical limit on maximum RF voltage for the ion trap, and new methods for ion isolation at these higher pressures provide the ability to mitigate unwanted ion fragmentation and to address issues with ion secular frequency amplification not being consistent across the desired operating range.

As an extension to the isolation and fragmentation schemes being developed, an alternative mode of mass analysis, termed secular frequency scanning, has been explored. This scheme produces a mass spectrum by fixing the RF at a given voltage and scanning the frequency of the resonance ejection voltage. Secular frequency scanning can have several benefits including lower RF power consumption and increased mass range. The advantages and disadvantages of the secular frequency scanning compared to conventional resonance ejection will be covered.

Through the use of advanced ion manipulation and excitation techniques it is possible to overcome some of the compromises in performance imposed by the unique MOMA operating environment. These unique modes of operation can improve performance of MS and MS/MS analysis of complex molecules on Mars' surface.