Development of a Low Power Gas Chromatograph-Mass Spectrometer for *In-Situ* Detection of Organics in Martian Soil

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Novel Aspect: Light weight, low power gas chromatography-mass spectrometry and in situ derivitization for the detection of organics in extraterrestrial soil samples.

Introduction

The Mars Organic Molecule Analyzer (MOMA) is a joint venture by NASA and the European Space Agency (ESA) to develop a sensitive, light-weight, low-power mass spectrometer for chemical analysis on Mars. MOMA is a key analytical instrument aboard the 2018 ExoMars rover mission seeking signs of past or present life. The current prototype was built to demonstrate operation of gas chromatography (GC) and laser desorption (LD) mass spectrometry under martian ambient conditions (5-7 Torr of CO2-rich atmosphere). Recent reports have discussed the MOMA concept, design and performance. Here, we update the current prototype performance, focusing specifically on the GCMS mode.

Methods

The MOMA instrument utilizes two modes of operation, laser desorption and gas chromatography, on the same 3-D ion trap sensor. When the analyte is a solid sample, (e.g. soil) sample treatment (pyrolysis, derivatization or thermochemolysis) is needed prior to gas chromatographic analysis. These pretreatments occur in a custom-built oven which allows volatilized and/or refractory analytes to be separated, ionized by an internal electron impact ionization source, and analyzed by the ITMS. When analytes or standards are in the gas phase, they are directly introduced into the ITMS for analysis. For reference, four different configurations were compared using commercial and prototype mass spectrometers and gas chromatographs.

Preliminary Data

In order to reduce both size and power requirements, the prototype ITMS has reduced geometry ($r0 = 0.5$ cm) and is operated in a lower voltage configuration, where the fundamental RF is ramped 100-900 V0-p. The ion trap is controlled by custom-written LabVIEW software which allows for sequence manipulation (i.e. user defined ionization times, ion cooling times, scan rates, etc.) while maintaining the ability to collect and record scans in fast repetition. To evaluate GCMS mode, we first coupled the prototype ITMS with a commercial GC (Shimadzu 2010). A simple form of AGC was implemented within our custom software allowing gain control to operate within the time frame of very sharp GC peaks (rise times of a few seconds). Total ion currents are maintained to within 30% of the setpoint for all spectra while modulating the ionization time over an order of magnitude. This allows the entire dynamic range of the ion trap to be accessed in a single GC run while maintaining constant trap loading and therefore stable mass calibration. In a parallel effort, we coupled a prototype GC developed at LATMOS (Paris) with a

commercial MS (DSQ II, ThermoElectron). These configurations were measured against a commercial GCMS (GCQ, ThermoElectron) using a variety of samples. One set contained low organic compounds (alkanes, alcohols and aromatics) which are of interest in exobiology. The second set contained heavier organic compounds such as amino acids. For each compound, detection limits were determined and compared for each GCMS configuration, where experimental conditions were constant (e.g. column, flow rate, etc.). Initial results using the combined GC and MS prototype have demonstrated the capability to detect alcohols (butanol), alkanes (heptane, decane), and cyclic compounds (benzene, toluene) at low ppm concentrations (~twice the sensitivity of the TCD alone).