

**THE IMPORTANCE OF SAMPLE RETURN IN ESTABLISHING CHEMICAL EVIDENCE FOR LIFE ON MARS OR OTHER SOLAR SYSTEM BODIES.** D. P. Glavin<sup>1</sup>, P. Conrad<sup>1</sup>, J. P. Dworkin<sup>1</sup>, J. Eigenbrode<sup>1</sup>, and P. R. Mahaffy<sup>1</sup>, <sup>1</sup> NASA Goddard Space Flight Center, Greenbelt, MD 20771, [daniel.p.glavin@nasa.gov](mailto:daniel.p.glavin@nasa.gov).

**Introduction:** The search for evidence of life on Mars and elsewhere will continue to be one of the primary goals of NASA's robotic exploration program over the next decade. NASA and ESA are currently planning a series of robotic missions to Mars with the goal of understanding its climate, resources, and potential for harboring past or present life. One key goal will be the search for chemical biomarkers including complex organic compounds important in life on Earth. These include amino acids, the monomer building blocks of proteins and enzymes, nucleobases and sugars which form the backbone of DNA and RNA, and lipids, the structural components of cell membranes. Many of these organic compounds can also be formed abiotically as demonstrated by their prevalence in carbonaceous meteorites [1], though, their molecular characteristics may distinguish a biological source [2]. It is possible that *in situ* instruments may reveal such characteristics, however, return of the right sample (i.e. one with biosignatures or having a high probability of biosignatures) to Earth would allow for more intensive laboratory studies using a broad array of powerful instrumentation for bulk characterization, molecular detection, isotopic and enantiomeric compositions, and spatially resolved chemistry that may be required for confirmation of extant or extinct Martian life.

Here we will discuss the current analytical capabilities and strategies for the detection of organics on the Mars Science Laboratory (MSL) using the Sample Analysis at Mars (SAM) instrument suite and how sample return missions from Mars and other targets of astrobiological interest will help advance our understanding of chemical biosignatures in the solar system.

**Sample Analysis at Mars (SAM):** SAM consists of 3 instruments (gas chromatograph, quadrupole mass spectrometer, and tunable laser spectrometer) used to measure volatile species in the atmosphere and released from rock powders heated to temperatures up to 1000°C under He gas flow [3]. For the atmospheric measurements, the presence of volatile hydrocarbons such as methane can be detected directly by the tunable laser spectrometer above the part per billion level and the <sup>13</sup>C/<sup>12</sup>C ratio of CH<sub>4</sub> can also be determined. The measurement of more complex hydrocarbons in solid samples will be accomplished by three different experiments: (1) pyrolysis QMS analysis mode will enable the identification of characteristic alkane fragments and simple aromatic compounds such as benzene and methylbenzene; (2) pyrolysis GCMS mode will be used to separate and identify complex mixtures of larger al-

kanes and up to 4-ring aromatic hydrocarbons; and (3) chemical derivatization and GCMS analysis mode enables the extraction and identification of non-volatile molecular species such as amino acids and carboxylic acids that are not detected by the other two modes.

**Biosignature Detection:** The SAM instrument suite on MSL will provide the most sensitive measurements of the organic composition of rocks and regolith samples ever carried out *in situ* on Mars. MSL is not a life detection mission. However, if MSL stumbles upon biosignatures, the search for non-disputable chemical evidence of life on Mars may require measurements that go beyond *in situ* instrument capabilities including an analysis of chiral organic molecules, compound-specific isotopic measurements, as well as, isotopic and molecular spatial resolution of organic materials. Currently these measurements require more complex sample preparation and state-of-the-art laboratory instruments such as ultra performance liquid chromatography time of flight mass spectrometry, gas chromatography combustion isotope ratio mass spectrometry (GC-IRMS) [4,5], confocal Raman spectroscopy, and secondary ion mass spectrometry.

One of the current challenges with *in situ* measurements of organic compounds is that a robust analysis of soluble and insoluble organic matter requires a series of chemical extraction steps from the mineral matrix prior to analysis of the extracts that is extremely difficult to implement on flight missions. For example, one-pot, single-step chemical derivatization experiments have been developed for SAM [6] and COSAC [7] on the ESA Rosetta comet lander mission due to their simplicity, however in some cases derivatization efficiency of organics could be inhibited due to reactions between the derivatization agents themselves and the minerals. These *in situ* flight experiments will have limited time and resources and changes to experiments in response to discoveries are not always possible. This is not the case for laboratory studies where time and resources are more plentiful. Ultimately return of a carefully selected sample from Mars will be required for a robust screening of chemical biosignatures.

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