Search for Organic Molecules at Oxia Planum with the Mars Organic Molecule Analyzer (MOMA) Investigation Onboard the ExoMars Rosalind Franklin Rover

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Introduction:

The Mars Organic Molecule Analyzer (MOMA) is one on the nine scientific instruments onboard ESA's Rosalind Franklin rover to be launched in July, 2020 to explore the *Oxia Planum* region of Mars as part of the ExoMars program [1]. MOMA is a novel chemical analysis laboratory devoted to the search for organic molecules in the subsurface sediments collected by the rover's two-meter deep drill. The clay-rich surface at *Oxia Planum* will provide ancient material, well-known on Earth to trap and stabilize organic molecules for very long periods (Gyrs), thus increasing the potential to detect ancient organic materials from early Mars.

The MOMA experiment :

MOMA is designed to analyze solid samples that have been collected by the drill and crushed into particulate form by the rover's sample processing and distribution system (SPDS), using both gas chromatography mass spectrometry (GCMS) and laser desorption mass spectrometry (LDMS) modes. GCMS and LDMS provide complementary views of the sample's organic composition over a range of volatility and molecular weight. The MOMA instrument is composed of four main subsystems [2]: (i) a pulsed UV laser for performing laser desorption/ionization (LDI) of samples loaded into a refillable container – the "front end" of LDMS mode. LDI is relatively "soft" compared to pyrolysis and electron impact (EI) in that it is capable of producing large, intact ions from the sample. However, it is primarily a surficial analysis technique; (ii) a set of ovens able to pyrolyze bulk samples directly, up to 850°C, or to apply chemical derivatization at lower temperatures, to enhance the broad gas chromatograph mass spectrometry (GCMS) analysis of key organic species, such as amino acids, the patterns of which could indicate biotic or prebiotic chemistry; (iii) a GC devoted to separate the many volatile and semi-volatile chemical species, including organic enantiomers, that may be released from sample in the ovens; and (iv) an ion trap mass spectrometer (ITMS) that will characterize the ions produced from either direct LDI of samples, or EI of the molecules eluting from the GC. The MS is able to characterize the ions in the m/z 50-500 range in the GCMS mode, and the m/z 100-1000 range in the LDMS mode, thereby focusing on the expected mass ranges produced by each ionization technique.

Now the flight model of the instrument is completed and integrated in the rover. The performance of the instrument, and its capability to detect organic bioindicators and biomarkers has been assessed under operating conditions representative of those at the Mars surface.

Experiments and results:

To assess the performance of MOMA and to prepare for the interpretation of future data collected on Mars, our team performed different tests and studies using laboratory subsystem modules, and an engineering test unit, all representative of a part or the whole instrument. These experiments were run under operating conditions representative of those that will be experienced during the operations of the rover on Mars. When it was not possible to carry out analytical experiments with the flight model, to prevent its aging and contamination with organic molecules from Earth, functional tests have been performed during thermal vacuum testing to baseline its performance for reference to the flight spare performance. Despite the absence of a sample to analyze, useful results were obtained that can be used to confirm the operational relationship between the flight and flight spare models.

For most of the tests, analytical standards, both organic and inorganic, were used to facilitate the interpretation of the measurements. But samples more representative of the materials that will be collected by the drill were also used. For instance, organic molecules were adsorbed on phyllosilicates in the laboratory [3]to assess the influence of the mineral matrix on the extraction and detection of organic molecules. Earth natural samples, as Atacama desert soil samples, analogues to Mars surface materials were also used to perform tests on more complex and realistic samples.

In this contribution, we present an overview of MOMA and of its performance demonstrated during the various experiments carried. We show the capability for this instrument to detect organic materials in relation to biotic and prebiotic processes on Mars.

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References:

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