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Search for organic matter at Mars with combined measurements of the SAM and ChemCam instruments onboard the Curiosity rover

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Abstract

Since 2012, he Curiosity rover on Mars seeks clues of habitability in Gale crater. One of these clues is the presence of organic matter. For the moment, only a few traces of organic matter was recently found with the SAM experiment. We propose here to evaluate the capabilities for the ChemCam experiment to detect organic molecules from its elemental analysis of the Mars regolith or rocks. The first results obtained in laboratory with the ChemCam spare model and different samples show that it is possible to detect organic signatures with LIBS, focusing on atomic carbon, hydrogen and nitrogen peaks, and on a C-N molecular peak when the samples are enriched in organic molecules (100-10 wt%). We currently work with Mars representative samples to determine the instrument detection limit for organics, in order to determine if it can be used to guide Curiosity towards interesting outcrops.

1. Introductions

One of the priorities of the Mars Science Laboratory mission is the search for a past or present prebiotic chemistry. Among the possible indicators of such a chemistry, the **organic molecules** are key entities linked to the emergence and the development of life, as we know it on Earth. However, only rare evidences of the presence of such molecules (chlorobenzene and other chlorinated hydrocarbons) in the Mars sedimentary rocks[1] and regolith[2] were recently found[1] and at a very low concentration (150-300 ppm in the Cumberland mudstone). Thus, one of the most pressing questions is to follow the search and identification of molecules currently present at Mars, and their concentration.

Onboard the NASA Curiosity rover currently operating on Mars in Gale crater, the **ChemCam instrument**[3] (*Chemistry and Camera)* performs quasi-systematic analyses of the elementary composition of rocks and soils of the Mars surface

instrument is precious to determine the targets of interest to perform contact science and drills from a mineralogical point of view, it also gives chemical information that could be used to look for organics present in the soil.

2. Objectives

Curiosity has recently reached the base of Mount Sharp, a 5-km thick sedimentary formation where **phyllosilicates** were detected from the orbit by OMEGA and CRISM hyperspectral imagers[4]. Phyllosilicates are minerals known on Earth to concentrate organic molecules. We propose to determine the ChemCam instrument capabilities to detect organic molecules in the Martian rocks by evaluating the nature of the elemental signatures produced by the presence of organic in mineral samples, and the organic concentration detection threshold. If this work done at the laboratory with the ChemCam testbed reveals that ChemCam is able to detect organic matter at concentrations relevant to Mars, then Curiosity could be guided towards interesting outcrops potentially containing some organic matter to assess their presence. If a positive signature is obtained, then, the sample would have to be analyzed by the **SAM instrument**[5] (*Sample Analysis at Mars*) to indentify and quantify the present organic species.[6].

3. Method

Figure 1a shows the **ChemCam testbed** used to analyse various samples, using its infrared laser (1067 nm). The interaction between the laser and the target generates a plasma, which is analysed by three dispersive spectrometers to cover the ultraviolet (240-342 nm), purple (382-469 nm) and visible/near-infrared (479-906 nm) wavelength regions.

These test samples are composed of organic molecules and synthesized mineral mixtures. The first tests are realized on clay minerals like nontronite, which are formed in the presence of liquid water, and known to be present at the Mars surface and on Mount Sharp[7].

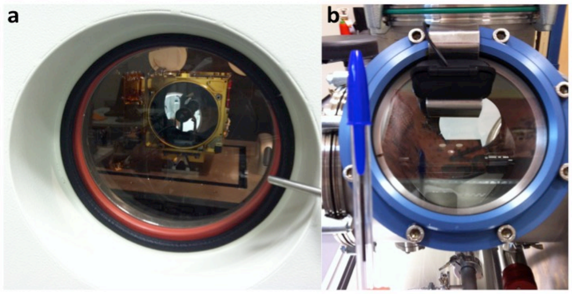

Figure 1: Close-up view of the ChemCam testbed located at IRAP (Toulouse) used for laboratory simulations of detection of organic matter in mineral matrixes (a). Low pressure chamber where the samples are placed. This system runs at Martian pressure (6 mbar) and Martian atmosphere analog composition (b).

The purpose is to determine the organic concentration threshold that ChemCam can detect in a sample. We selected glycine and adenine as the first test organic molecules because they are found in some micrometeorites and they are potentially present on Mars. These samples are placed in a low pressure chamber (**figure 1b**), reproducing the Martian environment (6 mbar of pressure and CO_2-rich atmospheric composition), to reproduce as closely as possible the spectra acquisition conditions encountered by ChemCam at Mars.

This first measurement campaign in the LIBS mode is aimed at determining if it is possible to detect organic matter through the elemental analysis and to proceed to a molecular identification.

Currently, samples of nontronite with different adenine concentrations are synthesized and they will be analysed to determine at best the concentration threshold in organic matter.

4. First Results

First tests were focused on reference samples (organic matter alone and mineral alone) in order to determine the characteristic emission lines of the different materials and to know if we are able to distinguish an organic molecule from inorganic ones

With these preliminary tests, we were able to highlight an enhancement of the carbon and hydrogen spectral signature, when the sample is enriched in organic matter. We also identified atomic nitrogen and a C-N vibrational molecular peak when introducing a nitrogen bearing molecules in the samples.

5. Present and future work

After the accurate characterization of the spectra of reference materials, samples will be synthetized with a gradually reduction of their organic content to determine the threshold below it appears impossible to trace the organics influence in the sample spectral signature. This study will be done with different "organic-clay" samples in an intimate mixing more representative of what it could be found on Mars, to see the influence of the nature of the samples on this detection threshold.

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