Standoff Time-Resolved Fast Fluorescence of Organics and Amino Acids


In the March 2020 revision, the SuperCam instrument will be able to uniquely overcome challenges targeting Raman spectroscopy, Laser-Induced Breakdown Spectroscopy (LIBS), and Time-Resolved Fluorescence Spectroscopy (SERS), without the need for sample manipulation or treatment. Among the three techniques, the Raman spectroscopy process comprises the identification of organic molecules and biological components [6]. Both LIBS and fluorescence spectroscopy have much higher sensitivity for detecting very low concentrations of biological components. Raman and fluorescence spectroscopies provide now distinct detection of bi-modalities in comparison to LIBS. Laser-induced Raman spectroscopy (LIFS) spectroscopy could help in measuring the optical emission of molecules that have been excited to higher electronic states through absorption of characteristic pollutants; from a non-resonant and pulsed laser source. Fluorescence signals are several orders of magnitude higher than Raman signals, which makes the LIFS technique suitable for detecting a minute amount of the molecule in a large search area. Planetary missions containing xenon metal and rare earths will produce fluorescence spectra when excited with UV and visible lasers. These fluorescence can be in their case overlap with the fluorescence output at 440-460 nm range as a consequence of the presence of fluorescence dye. The potential is exploited in the time resolved fluorescence spectroscopy to detect bi-modalities. Here, we present data on various amino acids and proteins, and bi-modalities using the current time resolved fluorescence spectroscopy.

In this study, a combined organic Raman (LIBS-LIFS) system utilizing a 512 nm Nd:YAG pulsed laser and a high-speed collection telescope was used. Remote LIBS spectra were measured in an air volume over a range from a distance of 9 m to 90 m pulse of laser power for excitation. For planetary exploration, a compact, portable remote Raman 0.3-1.5 V laser source using 22K telescopes has been developed under the Mars Instrument Development Program [7]. The potential of LIBS is capable of measuring material up to 50 meters away using Raman and fluorescence spectroscopy and has a LIBS collection microscope, which includes adjacent and several other geometries. Good quality data can be obtained at shorter distances of 10 m or less, for bi-modalities. The LIBS offers time-gating capabilities for analyzing the Raman lines, enabling Raman line by line modalities that are capable of distinguishing between organic and inorganic fractions, as well as identify atmospheric gases between the system and target.

Samples and Methodology:
We measured all of the protogenic amino acids (GLU, amino acids, and glycine) in each of the samples obtained from glass containers in the same container and Raman lines from glass allowed the sample analysis without interference from the background lines. The LIBS and Raman lines were recorded from 9 m distance with a detection time equal to 15 hours, making the analysis of the Raman lines, and wider fluorescence band-passes covering a time of 100 m and sufficient signal-to-noise ratio. In protogenic, amino acids (proteins, proteins, carbohydrates, and proteins) in each sample, the laser power was increased to a range of 50-150 mW. The samples were collected at ambient conditions and the 1 mW laser power was used at the spectral range of 300-1700 cm⁻¹.

Conclusions:
We have demonstrated that time resolved fluorescence can be used to detect amino acids, quantitative identification of organic acids, and proteins. The instrument possesses the necessary characteristics to successfully distinguish between fluorescent organic and inorganic materials on planetary surfaces. Additional evidence of combining fluorescence spectroscopy with Raman is necessary to improve the identification of structures in complex organic mixtures and to distinguish natural organic materials from inorganic. Fluorescence spectroscopy of water, volatile gas, and hydrogen-sodium-containing organic compounds will enable the detection of optically active amino acids and proteins, which can be used for the determination of amino acid and protein abundances from a distance of 10-50 m. This allows for the determination of fluorescence spectra that is suitable for planetary exploration applications, requiring no sample preparation or collection, and provides new diagnostic techniques of the SuperCam instrument on MARSIS mission will be able to locate biological and organic materials using its fast fluorescence mode and identify the chemical structure using remote Raman spectroscopy.

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References: