

MEASUREMENT OF UV FLUORESCENCE AND RAMAN SIGNATURES OF SUBSURFACE ORGANICS IN MARS RELEVANT MINERALS TO CONSTRAIN DETECTION DEPTH FOR THE SHERLOC MARS 2020 INSTRUMENT. B. L. Carrier*, L. W. Beegle, R. Bhartia, W. J. Abbey, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA (*bcarrier@jpl.nasa.gov).

Introduction: SHERLOC is an instrument that is part of the Mars 2020 payload. It utilizes a deep UV laser (248.6 nm) to induce Raman and fluorescence in organics and minerals [1]. Samples of interest are spatially scanned with the laser to stimulate fluorescence emissions and Raman scattering from the sample. Specifically, fluorescence is generated from electronic transitions in aromatic organics and Raman scatter is generated from vibrational bonds in both organics and minerals [2]. SHERLOC will be used on Mars to identify, in situ, interesting samples for sample caching and potential subsequent return to Earth.

The mineral transparency at the wavelengths of interest (250-400 nm) for both the incident laser light and the sample specific photons from fluorescence emission or Raman scattering will affect the interrogation volume of analysis and thus constrain the limits of detection. To date the depth of penetration of UV photons into natural minerals has not been well characterized. Here we report on preliminary results using a SHERLOC-like laser to detect organics under thin layers of MMS basalt (Mojave Mars Simulant) [3], kaolinite and gypsum.

Methods:

Pellets consisted of three layers. The bottom layer consisted of the target mineral dust mixed with 10 wt.% cellulose (as a binder). A second layer consisted of the powdered organic to be analyzed. The top layer was a thin layer (~100-200 μm) of organic free mineral. The thickness of the top layer was measured using a Mitutoyo digital thickness indicator before being applied on top of the organic layer. Each pellet was analyzed at 58 micron spot size over 300 discrete points. Fluorescence spectra were obtained with 25 pulses and Raman spectra with 1200 pulses.

Results and Discussion: Preliminary results have been obtained for phenanthrene, phenylalanine and alanine under MMS, gypsum, and kaolinite. The aromatic compounds have been analyzed using fluorescence and Raman spectroscopy while the aliphatic alanine was analyzed using Raman only. In each case there was substantial variability from point to point, ranging from 0 to near 100% transmission. This is likely due to natural heterogeneity in the mineral matrices. Natural martian rocks will also show significant variability in their compositions, but these results indicate that the SHERLOC instrument should be able to detect aromatic and aliphatic organics with Raman and fluorescence spectroscopy to a depth of >100 μm in the minerals examined.

Preliminary results.

Figure 1 shows the averaged Raman spectrum for alanine, an aliphatic amino acid. Peak locations and relative intensities correlate well to the spectrum of pure alanine. The relative intensity between subsurface and surface samples of alanine was on the order of ~1.5%.

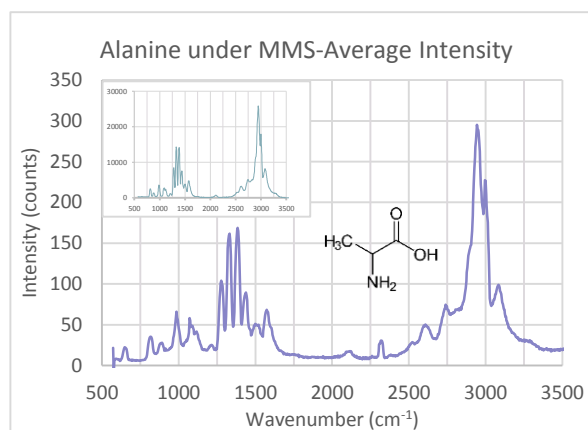


Figure 1. Averaged Raman spectrum of alanine under 99 ± 10 μm MMS. Inset-Raman spectrum of alanine on a surface.

Conclusions: Preliminary results show that organic molecules can be detected by the SHERLOC instrument at depths in excess of 100 μm in basaltic minerals. Aromatic compounds such as phenanthrene and phenylalanine can be detected via fluorescence spectroscopy to a depth of >160 μm . Aliphatic compounds such as alanine can be detected to a depth of >100 μm using Raman. The spectra of the subsurface organics investigated herein have been found to correlate well with the spectra of the pure organic. Further experiments will be performed to constrain the maximum depth and minimum concentrations at which organics can be detected using this method. The detection depth of these and other organics in various other Mars relevant minerals such as kaolinite and gypsum will also be investigated.

References:

- [1] Beegle et al. (2015) *IEEE*, 90, 1-11. [2] Bhartia, R., W.H. Hug, R. Reid, L. Beegle, (2015) Explosives Detection and Analysis by Fusing Deep UV Native Fluorescence and Resonance Raman Spectroscopy. P.M. Pellegrino, E.L. Holthoff, M.E. Ferrell (Eds.) *Laser-based Optical Detection methods of Explosives*, Boca Raton, FL: Taylor & Francis Group. [3] Peters et al. (2008) *Icarus*, 197.2, 470-479.