Development of a Multi-Wavelength Ultraviolet Resonance Raman Spectrometer for Extraterrestrial Geobiology

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Autonomous in situ exploration and sample return selection on Mars will demand probes capable of providing fundamental geochemical information as well as high resolution nondestructive detection of biologically critical molecules. Laser Raman spectroscopy is a nondestructive technique producing significantly sharper spectral bands than infrared absorption and other reflectance/emission spectroscopies. Raman event efficiency increases in the ultraviolet (UV) since it is a function of the fourth power of frequency. In previous work we have demonstrated the ability of a UV Raman system to provide mineralogical signatures for diamond, calcium carbonate, kunzite, and tremolite. We have also demonstrated that the resonance characteristics of certain organic ring structures makes possible the in situ detection of biological signatures for aromatic amino acids, nucleic acids, proteins (cytochrome c3), tholins, polyaromatic hydrocarbons (PAHs), and bacteria (S. putrefaciens, E. coli, and a variety of cyanobacteria) against the mineral background.

We now describe the multi-wavelength ultraviolet Raman spectroscopic system we have developed to serve both as a laboratory instrument and as a prototype for a possible flight instrument. Most biological tissue is fluorescence-quiet between 200-260 nm, thus removing the major source of background noise from the Raman experiment. Our system employs light-weight hollow cathode lasers producing excitation at 224nm and 248nm. These choices provide specific resonance enhancement for amino and nucleic acids, respectively. These lasers require minimal warm-up time (milliseconds), no cooling, and low power consumption. The system provides us with coaxial visual microscopy, incoherent fluorescent microscopy, laser fluorescent microscopy, and laser Raman spectroscopy.