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Characterizing organic-phyllosilicate samples with Raman spectroscopy: hints for planetary exploration

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The presence of organic compounds identified on the surface of Mars[1,2] brings us closer to the potential finding of signs of extinct life. Smectites, widespread in Noachian terrains, are good indicators of past aqueous environments on Mars. In addition, they have demonstrated their ability to preserve organic compounds under present-day surface conditions[3].

Raman spectroscopy is a powerful tool to detect organic compounds (e.g.,[2]) and to characterize phyllosilicate mineralogy (e.g.,[4]). The following sample return missions will allow the possibility of studying Mars samples on Earth using laboratory equipment with much higher resolution than the field equipment onboard the rovers. Keeping this in mind, we used confocal Raman spectroscopy with excitation wavelengths of 488, 532, 688, and 783 nm to analyze the effect of organic compounds matrix-linked with clay minerals. We analyze several clay minerals (i.e., nontronite, saponite, and interstratified clay minerals) in presence of organics (i.e., glycine, alanine, urea) at different concentrations. Figure 1a shows a comparison between the urea-nontronite (NAu1) spectra at two different organic concentrations (%TOC=7.6 and 0.4, respectively). While the presence of urea in NAu1 is easily measurable at high concentrations, its detection is difficult at low concentrations. However, we can find some diagnostic features by comparing them with the spectrum of NAu1 pristine sample (i) an increase of the integrated intensity ratio between the peaks at 246 and 3576 cm^{-1} (from ∼ 3 in NAu1 to ∼ 2 in NAu1-urea samples) and (ii) a shift towards low wavenumbers of OH stretching (figure 1b). Accordingly, these characteristics could track the presence of urea intercalated in the smectite.

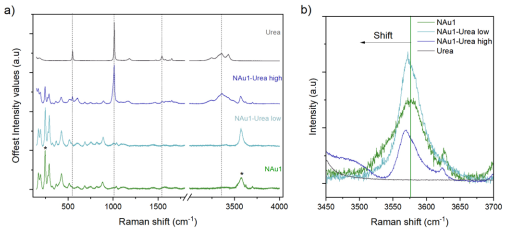

Figure 1. a) Raman spectra (532nm) of urea, NAu1-urea high, Nau1-urea low, and NAu-1 pristine. Dashed lines mark the main peaks of urea, whereas the asterisk highlights the NAu1 peaks used to estimate the intensity ratio. b)Enlargement of the 3450-3700 cm^{-1} region, showing a shift towards low wavenumbers when urea is adsorbed on nontronite.

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