Detection of carotenoids of halophilic organisms in inclusions inside complex laboratory-grown chloride and sulfate crystals using a portable Raman spectrometer

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Abstract

Inclusions of organic material, either in the form of biomarkers derived from microorganisms or even original trapped ancient life in the form of preserved cells inside a mineral matrix are excellent diagnostic traces of life. They serve as direct proof of the presence of extinct life buried in the geological record of predominantly evaporitic origin. Raman spectroscopy is a powerful molecular spectroscopy technique capable of analyzing both organic and inorganic parts of studied samples. In the upcoming Martian missions (Exomars and Mars 2020), miniaturized Raman spectrometers will be among the instruments on board of the rovers and will perform in-situ analyses with the aim to find potential biosignatures of extinct or extant life [1]. A portable Raman spectrometer equipped with the convenient 532 nm laser excitation that enables the resonance-enhanced detection of carotenoids was previously used to determine the ability of such instrumentation for the detection of said biomarkers in artificially prepared inclusions in laboratory grown (Na, K- chloride and K, NH4+- sulfate) crystals [2].

To investigate the possibility to detect carotenoids in even more complex mineral aggregates, samples analyzed in the current study were prepared as follows: cultures of either halophilic archaea (Halorubrum sodomense) with bacterioruberin or halophilic bacteria (Salinibacter ruber) with salinixanthin were grown and subsequently their biomass inserted in solutions of salts with the above-mentioned cations. Primary crystals formed during evaporation of these solutions including the trapped microorganisms were then submerged into different saturated solutions of chlorides and sulfates, forming an outer layer over the primary crystals. The resulting samples were subjected to analysis using a portable Raman spectrometer.

The results illustrate that portable Raman spectrometers are consistently capable to detect the carotenoid signals even in these complex samples, where the biomass and its biomarkers are entrapped in two layers of inorganic crystals. Formation of similar complex mineral aggregates was previously observed in the frame of several evaporitic series. These complex substrates can contain biomarkers of extremophilic organisms. Therefore, investigation of the capabilities of detection of entrapped carotenoids is important both from the instrumental/practical point of view and for astrobiology in general.

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