Protection of cyanobacterial carotenoids' Raman signatures by Martian mineral analogues after high dose gamma irradiation

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The future search-for-life missions to Mars - ESA/Roscosmos's ExoMars2020 and NASA's Mars2020 rovers - will carry Raman spectrometers for *in situ* analysis of extraterrestrial material for the first time[1,2]. The question remains whether signs of extinct or extant life could be detected by this method. From our terrestrial examples, carotenoids (e.g. serving in cyanobacteria as accessory and photoprotective pigments) have been extensively used as biosignature models due to their stability and easy identification by Raman spectroscopy with a 532nm excitation wavelength[3]. Evaluating the detection limit of pigments under simulated extraterrestrial conditions is beneficial for the success of future life-detection missions. Ionizing radiation can be considered the most deleterious factor for the long term preservation of potential biomarkers on Mars[4]. Here, we report on the preservation potential of Raman signatures in the Antarctic cyanobacterium *Nostoc* sp. strain CCCryo 231–06 after high doses of gamma irradiation performed in the frame of the STARLIFE project[5]. The carotenoids' signals usually dominate the Raman spectra at 532nm excitation wavelength due to resonance effects. But comparing their distribution and quantifying their preservation is still problematic in natural samples. To standardize the analyses, we successfully applied Raman mapping and signal-to-noise ratios (SNR) masks to quantify the effects of irradiation. The typical *in vivo* Raman signatures of carotenoids could be detected even after exposure to up to 56 kGy with significant deterioration in terms of signal coverage and SNR. However, for colonies embedded in two different Martian mineral analogues (phyllosilicatic and sulfatic Mars regolith simulants), the carotenoids' signatures remained detectable even after the highest dose of γ-rays (117kGy) tested in this study, with no significant effect on signal coverage or SNRs. Carotenoids proved again their scientific value as model biosignatures for future life detection missions on Mars. Data gathered during these ground-based irradiation experiments contribute to interpret results from space experiments (such as BIOMEX[6]) and will guide our search for life on Mars and other bodies of interest.

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