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Biofilm and Planktonic Lifestyles Differently Support the Resistance of the Desert Cyanobacterium *Chroococcidiopsis* Under Space and Martian Simulations

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Abstract When *Chroococcidiopsis* sp. strain CCMEE 057 from the Sinai Desert and strain CCMEE 029 from the Negev Desert were exposed to space and Martian simulations in the dried status as biofilms or multilayered planktonic samples, the biofilms exhibited an enhanced rate of survival. Compared to strain CCMEE 029, biofilms of strain CCME 057 better tolerated UV polychromatic radiation (5×10^5 kJ/m^2 attenuated with a 0.1 % neutral density filter) combined with space vacuum or Martian atmosphere of 780 Pa. CCMEE 029, on the other hand, failed to survive UV polychromatic doses higher than 1.5×10^3 kJ/m^2. The induced damage to genomic DNA, plasma membranes and photosynthetic apparatus was quantified and visualized by means of PCR-based assays and CLSM imaging. Planktonic samples of both strains accumulated a higher amount of damage than did the biofilms after exposure to each simulation; CLSM imaging showed that photosynthetic pigment bleaching, DNA fragmentation and damaged plasma membranes occurred in the top 3–4 cell layers of both biofilms and of multilayered planktonic samples. Differences in the EPS composition were revealed by molecular probe staining as contributing to the enhanced endurance of biofilms compared to that of planktonic samples. Our results suggest that compared to strain CCMEE 029, biofilms of strain CCMEE 057 might better tolerate 1 year's exposure in space during the next EXPOSE-R2 mission.

Keywords Space simulation · Mars simulation · Astrobiology · *Chroococcidiopsis* · Biofilm · DNA damage

Mickael Baqué and Giuliano Scalzi contributed equally to this work.

This manuscript is in memoriam of Imre E. Fridamm (1921–2007) and Roseli Ocampo-Friedamm (1937–2005)

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