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BIOFILMS IN SPACE

Abstract

Fossil biofilms and microbial mats are the earliest signs of life on Earth that we can find today and might also be the first forms of life to be detected on other planets. Microorganisms living in a biofilm usually have significantly different properties from planctonic microorganisms of the same species, as the dense and protected environment of the film allows them to cooperate and interact in various ways. In the space experiment BOSS (Biofilm Organisms Surfing Space) to be accommodated in the ESA facility EXPOSE R-2 on the ISS in July 2014 and in the corresponding lab experiments the hypothesis will be tested that bacteria forming a biofilm, where they are embedded and aggregated in their EPS matrix, are more resistant than the same bacteria in form of planktonic cultures to the harsh environmental conditions as they exist in space and on Mars. For flight experiment optimization, D. geothermalis besides others, like co-cultures of Halomonas muralis and Halococcus morrhuae, Bacillus horneckiae, Chroococcidiopsis CCMEE 029 and Streptomyces, Polaromonas and Arthrobacter strains from volcanic rocks, was exposed in the Planetary and Space Simulation facilities at DLR in Cologne in the EXPOSE-R2 mission preparation tests. Investigated parameters such as dehydration, temperature extremes, extraterrestrial UV radiation, simulated Martian atmosphere, and a Mars-like UV climate and were applied individually as well as in combination. Following exposure the survival of both biofilms and planktonic cells of D. geothermalis was assessed in terms of (i) culturability by colony counts on R2A medium, (ii) membrane integrity by using the Live/Dead differential staining kit, (iii) ATP content by using a commercial luminometric assay, and (iv) the presence of 16S rRNA by fluorescence in situ hybridization. So far, the results demonstated that D. geothermalis remains viable in the desiccated state over weeks to months, whereas cultivability, intracellular ATP levels, and membrane integrity were preserved in biofilm cells at a significantly higher level than in planktonic cells. Furthermore, cells of both sample types were able to survive simulated space and Martian conditions and showed high resistance after irradiation with monochromatic and polychromatic UV light. The results support the hypothesis that bacteria can survive space travelling when embedded in biofilms, eg., attached on or included into mineral particles.