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Biofilms and planktonic cells of *Deinococcus geothermalis* in extreme environments

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Abstract

In addition to the several extreme environments on Earth, Space can be considered as just another exceptional environment with a unique mixture of stress factors comprising UV radiation, vacuum, desiccation, temperature, ionizing radiation and microgravity. Life that processes in these environments can depend on the life forms and their state of living. The question is whether there are different strategies for individual microorganisms compared to communities of the same organisms to cope with the different factors of their surroundings. Comparative studies of the survival of these communities called biofilms and planktonic cell samples of *Deinococcus geothermalis* stand at the focal point of the presented investigations.

1. Introduction

A biofilm is a structured community of microorganisms that live encapsulated in a matrix of extracellular polymeric substances on a surface. Microorganisms living in a biofilm usually have significantly different properties to cooperate than individually living microorganisms of the same species. An advantage of the biofilm is increased resistance to various chemical and physical effects, while the dense extracellular matrix and the outer layer of the cells protect the interior of the microbial consortium.

2. The Space Experiment

The space experiment BOSS (Biofilm organisms surfing Space) as part the ESA experimental unit EXPOSE R-2 with a planned launch date in July 2014 will be subsequently mounted on the Russian Svesda module outside the ISS. An international team of scientists coordinated by Dr. P. Rettberg will investigate the hypothesis whether microorganisms organized as biofilm outmatch the same microorganisms exposed individually in the long-term survival of the harsh environmental conditions as they occur in space and on Mars. Another protective function in the samples could be dust particles for instance Mars regolith simulant contained inside the biofilms or mixed with the planktonic cells, as additional shelter especially against the extraterrestrial UV radiation. *D. geothermalis* besides others, like co-cultures of *Halomonas muralis* and *Halococcus morrhuae*, *Bacillus horneckiae*, *Chroococcidiopsis* and *Gloeocapsa*, was involved in the several preparatory test runs at the Planetary and Space Simulation facilities at the German Aerospace Center in Cologne.

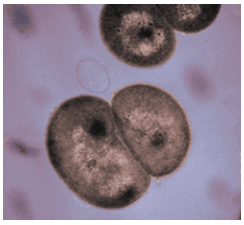

Figure 1: *Deinococcus geothermalis*

3. Methods

Results of the already carried out EVTs (Experiment Verification Test) and the SVT (Science verification test) as EXPOSE-R2 mission preparation tests, where investigated parameters like dehydration, temperature extremes, extraterrestrial UV radiation, simulated Martian atmosphere, and a Mars-like UV climate were tested individually as well as in combination will be presented. Following exposure to the parameters listed above, 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.

4. Results and Conclusions

So far, the results suggest that *D. geothermalis* remains viable in the desiccated state over weeks to months, whereas culturability, 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 will contribute to the fundamental understanding of the opportunities and limitations of viability of microorganisms organized in biofilms or as planktonic cells under the extreme environmental conditions of space or other planets.

References

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