Fungal spore resistance to space radiation

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Introduction: *Aspergillus* sp. was one of the predominant fungal genera detected aboard the Russian Space Station (Mir) as well as the International Space Station (ISS) (Checinska et al. 2015). As spore formers, filamentous fungi such as *Aspergillus* can pose a threat to astronauts' health and to planetary protection (Ramage et al. 2011). Experiments exposing *A. niger* to radiation have been performed to create and/or validate new biotechnology relevant strains (Meyer et al., 2007). Thus, it is still not well understood to what extent fungal spores can resist to the space environment, in particular to high radiation doses. In this study, the role of pigmentation and DNA repair in the resistance of *A. niger* spores towards space radiation was assessed, by exposing spores to UV-C and ionizing radiation (X-rays, Fe and He ions).

Methodology: The role of DNA repair and pigmentation in fungal spore resistance towards space radiation was assessed by testing different mutant strains of *A. niger*. These were exposed to the selected types radiation in saline solution suspensions containing 10^6 to 10^7 spores/ml. UV and X-rays exposure was conducted at the German Aerospace Center (DLR), Cologne, Germany, whereas heavy ion exposure (Fe and He) was conducted at the HIMAC (Heavy Ion Medial Accelerator) in Chiba, Japan. Spore survival was determined by the amount of colony forming units present upon revival after radiation. Spore resistance of mutant strains was compared with the wild-type.

Results: Wild-type spores of *Aspergillus niger* were able to withstand high doses of X-ray (1000 Gy) as well as helium and iron ion (500 Gy) irradiation, and UV-C radiation (3000 J/m2). Exposure to ionizing radiation of *A. niger* spores showed DNA repair defective strains being 10-1000 times more sensitive than the wild-type. As expected, a melanin deficiency was shown to decrease the LD_{90} value by a half, when exposed to in UV-C radiation. However, no significant differences were detected between the wild-type and the melanin mutant spores' resistance towards ionizing radiation (X-rays and heavy ions). Spores lacking in DNA repair by non-homologous end joining (NHEJ) are highly sensitive to radiation. This study shows that fungal spores are able to withstand higher doses than previously thought, which can have implications in future planetary protection policies. A 180 day trip to Mars yields a dose exposure of approx. 0.7 ± 0.1 Gy, and therefore, *A. niger* spores can are expected to survive, when considering the radiation factor alone (Zeitlin et al., 2013). Further studies are needed to assess the role of vacuum exposure in the resistance of *A. niger* spores to space radiation, since this condition might increase radiation resistance of *A. niger* spores (Silverman et al., 1967).

References:

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Acknowledgement:

M.C. and R.M. were supported by the DLR grant FuE-Projekt ISS LIFE, Programm RF-FuW, Teilprogramm 475. A.F., M.C. and R.M. were supported by the MEXT Grant-in-Aid for Scientific Research on Innovative Areas "Living in Space"-Grant (15H05935, 15K21745).