Fungi in space: Implications for astronaut health and planetary protection

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Abstract:

Aspergillus and Penicillium were the predominant fungal genera detected aboard the Russian Space Station (Mir) as well as the International Space Station (ISS), and fungal growth has been shown to promote biodegradation of spacecraft materials which might compromise life-support systems [1-2]. Moreover, as spore formers, filamentous fungi are a threat to astronauts' health, and their resistant spores may pose a threat to planetary protection. This, together with their ability to form biofilms, makes monitoring and controlling fungal populations a challenge when it comes to meeting the medical and operation requirements for the current and future space missions [3-5]. The doctoral study work here presented focuses on i) understanding fungal growth and biofilm formation in the space environment, ii) searching for spaceflight-relevant antimicrobial surfaces; iii) assessing fungal radiation resistance, and iv) identifying the potential of these fungi in space biotechnology.

In order to characterize fungal growth under simulated microgravity, the 2-D Clinostat was used, and Aspergillus niger, a model fungus, was selected due to its significance in the medical and biotechnology applications. Colony morphology and sporulation of the fungus were studied after 3 days in minimum medium at 30°C. In addition, 5-day colonies were analyzed by scanning electron microscopy (SEM) techniques revealing changes in structure due to simulated microgravity. Moreover, studies on the survivability and morphology of A. niger towards space radiation indicate high spore resistance to X-rays, with LD90 dose for the wild-type strain N402 being 250 Gy. Interestingly, exposure to Fe and He ion radiation showed that the spore's ability to germinate was still intact after exposure to 1000 Gy of Fe ions. Further work with fungal strains isolated from the ISS are being carried out to identify differences in radiation resistance and growth under microgravity.

To assess growth, gene expression and biofilm formation in real microgravity, the NASA-funded project "Biofilm in Space (BFS)" will comprise a spaceflight experiment aboard the ISS, planned to be launched early 2019. This experiment is also testing coupons of different materials (such as quartz, aluminum, silicone, and polycarbonate), in the search for antimicrobial surfaces. For the experimental design to be spaceflight ready, several pre-flight tests have been performed defining and optimizing the culture conditions for the fungus Penicillium rubens on BioServe's space hardware [6]. As of today, P. rubens cells were grown in the 12-well BioCells for 2 and 4 days, both in simulated microgravity (provided by clinorotation) and in 1 x g static controls in order to measure its adherence to two different materials – cellulose membrane and aluminum. Transport and stowage conditions were also tested, assessing viability and biofilm formation after 10 day and 20 day stowage at - 20°C.

Overall, this work marks an important step in the establishment of new methodologies to study filamentous fungi biofilms under simulated and real space conditions, and will help to develop the appropriate contamination, control and potential biotechnology measures, both on Earth and in Space.

References

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