# Survival of lichens on the ISS-II: ultrastructural and morphological changes of Circinaria gyrosa after space and Mars-like conditions

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Lichens are extremophile organisms, they live in the most extreme conditions, colonizing areas with extreme temperatures, high aridity condition and high UV-radiation. Therefore they have been by far the most successful settlers of the Antarctic continent. Also in the laboratory they survive temperatures near the absolute cero and absolute dryness without difficulty. Lichen species have distinct likes and dislikes when it come to the physico-chemical properties of the substrate while the group of lichens as a whole is pretty adaptable to various substrata (from rocks to glass). The main feature/aspect of their evolutionary/ecological success of this capacity is the close symbiotic relation between two organisms, a fungi and a cyanobacteria or an algae [1], allowing them to survive at real space [2] and at Mars conditions [3, 4, 5], such as that on the ISS. At the exposure platform EXPOSE-R2 on ISS (2014-2016), samples of the lichen species Circinaria gyrosa belonging to the BIOMEX experiment (Biology and Mars Experiment, ESA) [5], were exposed during 18 months to real space and to a Mars simulated environment to study Mars habitability and resistance to real space conditions. Also the identification of biomarkers was done to include them as reference for future space missions to Mars (Exo Mars). After the return of the mission at June 2016, the first preliminary analysis were performed, showing the metabolic activity a quick and complete recovery of the dark space control samples exposed to space vacuum and Mars-like atmosphere. In contrast, the samples directly exposed to space radiation showed slow recovery in reference to their observed original activity. Electron and fluorescence microscopy techniques also revealed that the viability of C. gyrosa exposed to space conditions decreased in comparison to those exposed to Mars-like environment. Moreover, differences were observed between samples positioned at level 1 and level 2. In general, TEM and FESEM observations showed that samples at level 2 (basal samples) were slightly affected in their morphology/ultrastructure by the exposure conditions. In contrast, cellular ultrastructure alterations were clearly evident for samples exposed to space radiation, which led to a shrinkage process. The cell walls were irregularly shaped and debris of the major organelles were visible. Now, the biomolecular changes of the DNA are in study by PCR and sequencing techniques. In contrast to these studies, the biogeochemical variations will be examined with spectroscopic analyses (Raman) to look for possible degradation of cell surfaces and pigments which were in contact with terrestrial rocks, and Martian analogue regolith. These experiments will contribute to answer questions on the habitability of Mars, on the likelihood of the Lithopanspermia HYPOTHESIS y [8] and will be of relevance for planetary protection issues.