Geophysical Research Abstracts
Vol. 18, EGU2016-17566, 2016
EGU General Assembly 2016

Resistance of lichens to simulated galactic cosmic radiation: limits of survival capacity and biosignature detection

Rosa de la Torre Noetzel (1), Ana Z. Miller (2), Beatriz Cubero (2), Marina Raguse (3), and Joachim Meessen (4)

(1) Instituto Nacional de Técnica Aeroespacial (INTA),Departamento de Observación de la Tierra, Madrid, Spain, (2) Instituto de Recursos Naturales y Agrobiología de Sevilla – CSIC, Sevilla, Spain, (3) Department of Radiation Biology, Institute of Aerospace Medicine, German Aerospace Center (DLR), Cologne, Germany, (4) Institute of Botany, Heinrich-Heine-University (HHU), Duesseldorf, Germany

Space constitutes an extremely harmful environment for survival of terrestrial organisms. Amongst extremophiles on Earth, lichens are one of the most resistant organisms to harsh terrestrial environments, as well as some species of microorganisms, such as bacteria (Moeller et al., 2010), criptoendolithic cyanobacteria and lithic fungi (de los Ríos et al. 2004).
To study the survival capacity of lichens to the harmful radiation environment of space, we have selected the lichen Circinaria gyrosa, an astrobiological model defined by its high capacity of resistance to space conditions (De la Torre et al. 2010) and to a simulated Mars environment (Sanchez et al., 2012). Samples were irradiated with four types of space-relevant ionizing radiation in the STARLIFE campaign: helium and iron ion doses (up to 2,000 Gy), X-ray doses (up to 5,000 Gy) and ultra-high γ-ray doses (from 6 to 113 kGy). Results on resistance of C. gyrosa to space-relevant ionizing radiation and its post-irradiation viability were obtained by: (i) chlorophyll a fluorescence of photosystem II (PS II); (ii) epifluorescence microscopy; (iii) confocal laser-scanning microscopy (CLSM), and (iv) field emission scanning electron microscopy (FESEM). Results of photosynthetic activity and epifluorescence showed no significant changes on the viability of C. gyrosa with increasing doses of helium and iron ions as well as X-rays. In contrast, γ-irradiation elicited significant dose-correlated effects as revealed by all applied techniques. Relevant is the presence of whewellite-like crystals, detected by FESEM on C. gyrosa thalli after high irradiation doses, which has been also identified in previous Mars simulation studies (Böttcher et al., 2014). These studies contribute to the better understanding of the adaptability of extremophile organisms to harsh environments, as well as to estimate the habitability of a planet's surface, like Mars; they will be important for planning experiments on the search of life in the universe, and as contribution of lithopanspermia, the theory that supports the interplanetary transfer of rock inhabiting life by means of meteorites (Mileikovsky et al., 2000).
Acknowledgements: AZ Miller acknowledges the support from the Marie Skłodowska-Curie actions (PIEF-GA-2012-328689).

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