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Research Article

Bacterial Cellulose Retains Robustness but Its Synthesis Declines After Exposure to a Mars-Like Environment Simulated Outside the International Space Station

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Abstract

Cellulose is a widespread macromolecule in terrestrial environments and a major architectural component of microbial biofilm. Therefore, cellulose might be considered a biosignature that indicates the presence of microbial life. We present, for the first time, characteristics of bacterial cellulose after long-term spaceflight and exposure to simuled Mars-like stressors. The pristine cellulose-based pellicle membranes from a kombucha microbial community (KMC) were exposed outside the International Space Station, and after their return to Earth, the samples were reactivated and cultured for 2.5 years to discern whether the KMC could be restored. Analyses of cellulose polymer integrity and mechanical properties of cellulose-based pellicle films, as well as the cellulose biosynthesis-related genes' structure and expression, were performed. We observed that (i) the cellulose polymer integrity was not significantly changed under Mars-like conditions; (ii) *de novo* cellulose production was 1.5 times decreased in exposed KMC samples; (iii) the dry cellulose yield from the reisolated *Komagataeibacter oboediens* was 1.7 times lower than by wild type; (iv) there was no significant change in mechanical properties of the *de novo* synthesized cellulose-based pellicles produced by the exposed KMCs and *K. oboediens;* and (v) the gene, encoding biosynthesis of cellulose (*bcsA*) of the *K. oboediens,* was down-regulated, and no topological change or mutation was observed in any of the *bcs* operon genes, indicating that the decreased cellulose production by the space-exposed samples was probably due to epigenetic regulation. Our results suggest that the cellulose-based pellicle could be a good material with which to protect microbial communities during space journeys, and the cellulose produced by KMC members could be suitable in the fabrication of consumer goods for extraterrestrial locations. Key Words: Bacterial cellulose—Extraterrestrial stressors—Microbial biosignature—Kombucha multimicrobial community—*Komagataeibacter oboediens*—The *bcs* operon. Astrobiology 21, xxx–xxx.

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