Utilization of Microscopic Techniques in Determining Microbial Contamination as it Relates to Planetary Protection

K. Venkateswaran

Biotechnology and Planetary Protection Group, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109

Background: An increasing number of in situ life detection and sample return missions to other planetary bodies where life may be present are envisioned. As enabling technologies for these robotic missions emerge, awareness of the need to control the microbial contamination aboard spacecraft is growing. Knowledge of the microbial diversity of spacecraft assembly areas, as well as any exceptional characteristics that contaminant microbes might possess, are critical to the development of useful cleaning and sterilization technologies. Utilization of various modern molecular methods, including microscopy techniques, is obligatory to measure the cleanliness of spacecraft associated components. As structure and chemistry are integral parts of biology, application of microscopic techniques coupled with in situ chemical analysis is invaluable in assessing microbial contamination.

Results and Discussion: Qualitative and quantitative assessments of microbial burden in the spacecraft- associated environment were carried out using conventional microscopic approaches. Morphological characterization of unusual microorganisms isolated in the assembly facilities was studied using electron microscopy. Cleanliness of spacecraft qualified materials was assessed using environmental scanning electron microscopy (ESEM). The morphological changes of various microbes following hydrogen peroxide, desiccation, UV and γ-radiation treatments were validated using various microscopic techniques. In particular, the formation of "dome-like" structures by *Bacillus* spores on aluminum due to desiccating conditions was characterized using ESEM, atomic force microscopy, and FIB-SEM analyses. Specific probes were used to discriminate particles from microbes by combining both nucleic acid hybridization and microscopic visualization.

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