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ANTIMICROBIAL TESTING IN REDUCED GRAVITY ENVIRONMENTS

Abstract

NASA's human spaceflight program requires technologies that collect, store, recycle, and disinfect water for use and reuse in Environmental Control and Life Support Systems (ECLSS). Water is a critical life support element, representing 65% of the daily mass input for crew. In addition to maintaining water quality for crew use, ECLSS components must minimize mass, power and re-supply requirements. The technologies NASA currently employs for microbial control of spacecraft potable-water systems use a residual chemical biocide, such as iodine or either ionic or colloidal silver, and one or more physical disinfection devices (e.g. filters) to reduce the microbial burden at the point of use. None of these microbial control treatments are completely effective against all microorganisms and each have limitations for long-term use because they do not provide an absolute barrier to microbial growth, are inactivated over time by chemical degradation or interaction with material surfaces, require repeated application, or pose risks to human health with prolonged use. There remains a need to develop safe and effective technologies for microbial control and monitoring of potable-water systems in closed-loop life support systems. Our research goal was to perform short duration microgravity experiments with planktonic bacterial cells on commercially available antimicrobial surfaces. This study focused on the colonization stage of planktonic cells (i.e. measuring the adhesion onto surfaces). Specific research objectives were to: (1) evaluate the effectiveness of various antimicrobial materials in ground-based studies, (2) repeat the same efficacy tests in a reduced gravity environment, and (3) select an ideal in-flight microbial monitoring assay that would be both informative and practical for use in future NASA missions. Testing used a standard biofilm microorganism in defined ASTM test methods, Pseudomonas aeruginosa, added at a concentration of 1 x 10E5 cells per milliliter onto material surfaces. Several materials were effective at reducing microbial attachment in reduced gravity flight experiments, but none were capable of eliminating all bacteria. Lunar gravity experiments had an increased antimicrobial effect in 28 out of 36 test coupons compared to microgravity when provided otherwise identical conditions for growth, suggesting trace amounts of gravity may be required for maximum antimicrobial performance. Fixed bacteria exposed to lunar and microgravity had less adenosine triphosphate (ATP) production than controls in normal gravity, due either to the reduced fluid interaction of cells with antimicrobial surfaces or experimental limitations. An ATP luminescence assay was the method most amenable to development of an in-flight microbial monitoring assay.