PROJECT SUMMARY

Purpose of the research

The purpose of this Phase 1 development was to determine the feasibility of using RNA amplification technology to rapidly detect specific microbes in spacecraft water systems. The ultimate objective of this research is to develop a Rapid Multiplex Microbial Detector (RMMD) that is capable of rapidly detecting and roughly quantifying multiple species of microbes in ISS and other space exploration water applications, with minimal mass, power, volume, and crew time.

Brief description of the research carried out

The Phase 1 research included evaluation of the microbes that should be detected for the Phase 1 development and for the final spaceflight application. Lyophilized formulations of isothermal genetic amplification chemistry were developed and tested. Detection chemistries for four different bacterial strains were developed and tested. A benchtop prototype amplification cartridge and process controller was designed, fabricated, and tested. Designs and test results were evaluated and a conceptual design of a spaceflight RMMD was developed.

Research findings or results

The primary objective of the Phase 1 activity was to develop the chemistry and hardware designs for the Rapid Multiplex Microbial Detector and demonstrate prototype hardware functionality in a laboratory setting.

All Phase 1 objectives were achieved.

- We selected four microbes to be detected in Phase 1 and fourteen microbes to be detected in Phase 2 based on inputs from NASA.
- We developed isothermal amplification chemistry for the four bacteria selected for evaluation in Phase 1. Lyophilized chemistry was shown to be stable over 13 weeks.
- We developed detection chemistry for the four bacteria selected for evaluation in Phase 1. Laboratory tests of the four reagents show capability to detect RNA in quantities much less than one cell. Specificity testing with all target microbes showed no false positive results.
- We designed and fabricated a benchtop prototype cartridge and processing chamber.
- We tested the prototype cartridge to show proper filling, sample isolation, and liquid containment.
- We tested the processing chamber to show rapid sample heating, accurate and uniform temperature control, and successful illumination and fluorescence detection.

Do the results justify Phase 2 continuation?

The results of the Phase 1 development were very encouraging and show that rapid genetic amplification and detection of multiple water-borne microbes in space is definitely feasible. Laboratory tests of amplification and detection chemistry for four microbial species showed excellent sensitivity and specificity. The lyophilized formulations showed shelf stability over 13 weeks with no decrease in performance, but these test data are limited by the duration of a Phase 1 project. Prototype hardware generated rapid, consistent heating of all reaction chambers in the cartridge, and the prototype processing chamber is capable of generating and detecting fluorescence in a sample. Of course, further refinement of the RMMD optics, electronics, and thermal insulation would improve detection accuracy, and development of chemistry for detection of more bacteria and viruses is needed to truly meet NASA's needs. These tasks are planned for Phase 2.