PROJECT SUMMARY

Purpose of the research

The purpose of this Phase 1 development was to determine the feasibility of non-thermal sanitation by atmospheric pressure plasma (NTSAPP) of foods and surfaces contacted during food processing stages. The ultimate objective of this research is to develop a non-thermal food sanitation system, using atmospheric pressure air plasma, to sterilize foods and food processing related surfaces for ISS and other space exploration applications.

Brief description of the research carried out

The Phase 1 research included development of functional requirements for a spaceflight NTSAPP food sanitation system. Multiple iterations of plasma jet reactor designs that treat surfaces in direct contact with the plasma plume were developed, built, and tested. A plasma reaction chamber that incorporates several jet reactors and treats three dimensional surfaces within the chamber volume was designed, built, and tested. Antimicrobial testing was performed with a standalone jet reactor and with the plasma reaction chamber. The antimicrobial performance of each hardware item was tested with Salmonella on Teflon, lettuce, and tomato. Designs and test results were evaluated and a conceptual design of a spaceflight NTSAPP plasma reaction chamber was developed.

Research findings or results

All Phase 1 objectives were achieved:

- System requirements and test protocols were developed.
- Two NTSAPP concepts were designed, fabricated, and tested
- Both designs were tested to determine antimicrobial performance on a variety of food and non-food substrates.
- Both designs were evaluated and a conceptual design for a spaceflight plasma reaction food processing chamber was developed.

Tests with the jet reactor showed a 2 $\log_{10}$ reduction in *Salmonella* on Teflon disks and a nearly 1 $\log_{10}$ reduction on lettuce. he plasma chamber tests on both lettuce and tomato substrates using argon for a process gas yielded greater than a 2 $\log_{10}$ reduction in *Salmonella*. Some tests with nitrogen as the process gas showed complete reduction of *Salmonella* on all lettuce and tomato samples, with no *Salmonella* detected on any treated samples. In addition, tests with lab air as the process gas showed nearly 1 $\log_{10}$ reduction in *Salmonella* on tomato, compared to control samples. Thermal tests showed that temperature inside the plasma chamber reached a maximum temperature of 6°C above ambient during processing, which indicates that food quality will not be affected. A conceptual design of a flight NTSAPP system showed that a plasma reaction chamber design can fit within the mass, power, and volume constraints of an ISS EXPRESS Rack single locker and include all necessary shielding and grounding to satisfy safety and EMI requirements.

Do the results justify Phase II continuation?

In general, the results of the Phase 1 development were very encouraging and show that food sanitation with non-thermal atmospheric pressure plasma is definitely feasible. Greater than 2 $\log_{10}$ reduction in *Salmonella* was achieved on lettuce and tomatoes on the Phase 1 plasma reaction chamber prototype, with some test samples showing complete reduction of *Salmonella*. Of course, further refinement of the NTSAPP power supply, jet reactor design, and integrated plasma reaction chamber design would improve efficiency and antimicrobial performance, and much more testing with different fruit and vegetable substrates, different inoculums, and different process gases would more truly demonstrate NTSAPP capabilities.