Concentrating Bacterial Spores from Milk and Juices Using Dielectrophoresis Based Microfluidic Capture Systems

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Project Scope: The goal of this project is to design and develop a prototype device that can be ultimately scaled up for concentrating spores from large volumes of milk and apple juice. We designed, developed and optimized a single channel prototype device, and demonstrated the utility of dielectrophoresis (DEP) to concentrate Clostridium sporogenes (as surrogates of B. anthracis and Clostridium botulinum spores) from milk and apple juice.

Recent Progress: Despite the urgent need for sample concentration for food-safety applications, direct DEP trapping of biological species from high conductivity buffers is limited. In this project, we utilized negative DEP to concentrate bacterial spores from high conductivity food sample matrices. The effectiveness of DEP as functions of the applied electric field frequency, amplitude and the conductivity of the ionic solution was validated both experimentally and theoretically. The correlation between experimental results and scaling analysis provided us with fundamental understandings of DEP characteristics, especially in high conductivity media. Using electrode designs that amplify the negative DEP, we successfully demonstrated the utilization of DEP for concentrating spores from milk and apple juice. As a result, we have shown that the proposed device will potentially allow microfluidic systems that can concentrate bacterial spores from large volumes of media with a practical range of conductivity.

Future Plans: Future studies are planned to include integration of the DEP capture unit with diagnostic devices and sample feeding components, enabling the development of a micro total analysis system for rapid detection of pathogens and other microorganisms in high conductivity food matrices as well as physiological buffer solutions.

Relevance to listed research areas: The possibility of deliberate contamination of vulnerable foods such as fruit juices and milk with infectious spores or their associated toxins is an unfortunate reality. A key limitation of current bio-threat agent detection and characterization technologies is linked to the small sample volumes that can be analyzed by the current methods. For food defense purposes, there is a critical need to develop technologies that can rapidly and efficiently separate and concentrate bio-threat agents from food matrices, thereby rendering them available for detection. The current detection technologies, without an efficient bio-threat agent separation and concentration technologies are unfortunately of very limited value for food defense purposes. This project addresses the critical issue of low-cost and rapid sample concentration techniques that would maximize the probability of detecting intentional contamination of milk and apple juice.

Publications: Two journal papers are currently in review, which were prepared on the results of DEP scaling analysis and negative DEP trapping device development.