Rapid and Simple Sample Acquisition During Space Flight:

Simultaneous Extraction of Proteins and Nucleic Acids from Bodily Fluids and Cabin Water Using Free-Flow Bi-directional Isotachophoresis

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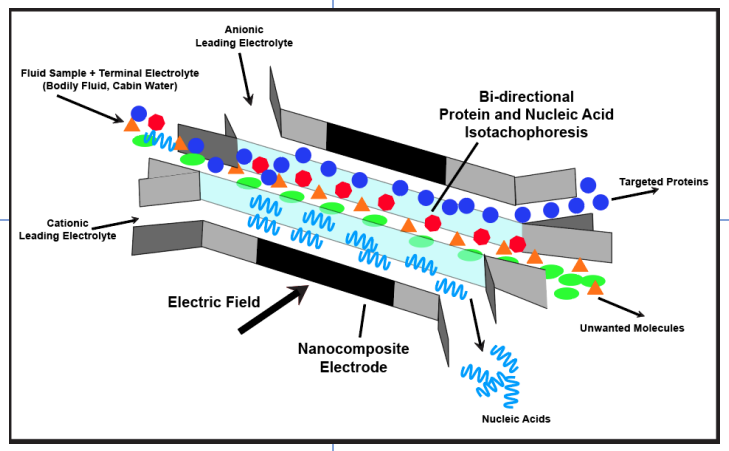
Research Objectives

- The overall goal of this proposal is to develop molecular pre-concentration, separation, extraction and amplification devices for proteins and nucleic acids for integration with in situ instrument systems in flight missions.
- We will develop an electrophoresis method for extracting both proteins and nucleic acids from a single fluid sample using a new type of free-flow bi-directional isotachophoresis (ITP).
- The innovation is an easy-to-use, portable, and lightweight fluidic platform capable of rapidly extracting, concentrating, and separating proteins and nucleic acids simultaneously from a liquid sample for integrated use with downstream in situ flight instruments.
- Current sample extraction methods are not ideal for space crew with limited time and resources, as they require long processing times, are labor intensive, and often use hazardous chemicals.
- The project is TRL 1. We have demonstrated that free-flow ITP in simple fluidic devices is possible. We have not initiated research to extract and separate proteins or nucleic acids. We plan on translating our work to extract target molecules from real world fluid samples. Funds for the proposed effort will be used to elevate this project to TRL 3.



Approach

My lab has developed small simple fluidic devices with nanocomposite electrodes that perform free-flow ITP separation and concentration of charged molecules and proteins. Further technical development is required to exploit our devices for sample acquisition during space flight missions.

Building on our previous microfluidic expertise, we will design and fabricate new free-flow ITP devices and investigate the electrophoresis behavior of nucleic acids and proteins in “clean” controlled mixtures of synthetic proteins and nucleic acids. The next step in our approach will be to investigate the ability to extract both nucleic acids and proteins simultaneously from a single sample using bi-directional ITP. We will combine mixtures of nucleic acids and proteins. Mixture of sample will driven into our ITP devices and we will investigate the separation and concentration efficiency for a given applied voltage, flow rate, sample pH, and buffer chemistry. With an improved understanding of how nucleic acid and protein mixtures impact ITP performance, we will then focus our efforts on developing the ability to extract target proteins and nucleic acids from real world fluids.

Potential Impact

- The success of the project will dramatically improve current sample acquisition capabilities with a molecular extraction and amplification method that is revolutionary in ease-of-use and flexibility.

Because separation, concentration and extraction of both nucleic acids and proteins will be accomplished in a single step, the proposed bidirectional ITP sample purification system offers an unprecedented level of operational simplicity. The system will require only small volumes of reagents and enable significant improvement in existing space science abilities as extracted samples will be capable of being used with downstream in situ instruments.
The proposed research will also dramatically improve sample purification and enrichment capabilities for existing meso- and microfluidic systems. The ITP hardware will be compatible with not only analytical instruments, but also with many existing microfluidic systems and devices. This project therefore has the potential to be crosscutting and serve as a valuable genetic and proteomic preparatory tool for fluidic applications in detection and prevention of disease in developing countries, biowarefare/anti-terrorism applications, environmental monitoring, point-of-care diagnostic testing and for basic biological research.