Name(s)

Stanley Liu

Project Number

S0316

Project Title

An Integrated Microfluidic System for Blood Plasma Separation and Immunoassay Detection

Abstract

Objectives

Human blood plasma is critical for disease diagnostics since plasma contains biomarkers associated with many diseases, including those associated with viral or other pathogenic infections. The current rapid tests (lateral flow strips) are inexpensive and fast but suffer from low accuracy and manual preparation as they rely on colorimetric detection and the separation of plasma through centrifugation. The benchtop standard for plasma separation is centrifugation, which suffers from its bulky and expensive design, and inability to be integrated with detection. The objective of this project was to develop an inexpensive and efficient integrated device based on acoustic microstreaming for plasma separation and biomarker detection.

Methods

The device was completely designed by myself using the AutoCAD software. The device was fabricated on PDMS, an inexpensive polymer, at UCI lab with the help of the mentor. The device was first tested using food dyed water by myself at home. Biological tests were done at the microfluidics lab at UCI under proper safety protection using control blood and inactivated P24 antigens and antibodies (all commercially available). Any work handling the P24 antigens and antibodies was done by the mentor. The data analysis was performed by myself. A commercial software ImageJ was used to analyze fluorescent images.

Results

An integrated microfluidic device for blood plasma separation, antigen/antibody binding, biomarker capture, and fluorescence detection was successfully developed. Bubble-induced acoustic microstreaming allowed plasma to be separated from blood cells resulting in a pure plasma at the end of the separation channel. Plasma separation was demonstrated at a separation efficiency of 99.9% and a yield of 31.8%. Microstreaming was used as a micropump to achieve 6 µL/min and also a micromixer to enhance antigen/antibody mixing and binding. The fluorescent detection of P24 antibody from a whole blood control was demonstrated with a detection limit of 17 pg/µL.

Conclusions

A microfluidic device for blood plasma separation, antigen/antibody binding, biomarker capture, and fluorescence detection was successfully demonstrated. Acoustic microstreaming showed advantages over the other plasma separation techniques: 1) no cell clogging issue; 2) no moving part; 3) simple in design; 4) easy to integrate and fabricate; 5) low cost. The micropump and micromixer based on acoustic microstreaming are low-cost and efficient. The integration of plasma separation and biomarker detection could serve as a faster and more effective alternative to the current rapid diagnostic tests.

Summary Statement

An integrated microfluidic device based on acoustic microstreaming was successfully developed for blood plasma separation, antigen/antibody binding, biomarker capture, and fluorescence detection.

Help Received

I designed the entire device by myself, led a majority of the experiments, and did all data analysis. Neha Garg at UCI helped fabricate my device, supervise me during experiments, and provide advice on how to modify experimental procedures. Professor Rasheed at USC offered advice on biomarker detection.