Portable Blood Plasma Separation for Point of Care Diagnostics

by

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Technical Summary

Point of care testing is expanding the healthcare field towards personalized and early-detection medicine. Microfluidic platforms present an opportunity for low cost, portable diagnostic sensors through manipulation of small volumes of fluids on isolated, compact devices. One of the challenges of microfluidic sensors is the biological sample pretreatment steps that are manually performed prior to on-chip loading and sensing. This issue is especially prominent for human blood, which contains about 50% cells by volume. These blood cells can rupture, clog devices, block optical readouts, and foul electrodes. At the same time, the liquid portion of human blood, plasma, is rich in a variety of disease indicators, many of which have not yet been identified, and thus is an essential part in the diagnostic field.

This thesis work presents a portable, hand-driven blood plasma separation construct that could replace centrifugation for point of care applications, where large equipment or proper user training is very limited. The study focused on a temporary expansion of the cell free layer, which develops near the microfluidic channel walls, through a range of constriction-expansion designs. The investigation of channel dimensions, expansion angles, and resistance ratios has allowed us to further improve plasma separation without requiring an external field or equipment. This device provides 1,000-10,000 times reduction in cell concentration, for 5-10% plasma yield, even in undiluted blood. At the same time, the system setup was optimized for flow profile reproducibility, and shows minimal clogging or fouling of the microfluidic device. The plasma collection rate allows for incorporation with bench-scale sensing, as well as with portable diagnostic components. A few low-power sensor constructs were pursued in collaboration with other researchers. Most notably, this separation system was applied to a low-power, colorimetric malaria protein sensor that produced an amplified color change in the presence of a malaria protein at a concentration well below clinical relevancy for undiluted whole blood.

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