A Fully Integrated Microfluidic Device for Blood Plasma Separation and Biomarker Detection

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Human blood plasma contains biomarkers associated with many diseases. Separation of plasma from blood cells is crucial for many disease diagnostics. The current centrifugation separation technology suffers from its bulky design and inability to be integrated with downstream detection. A microfluidic device for blood plasma separation, antigen/antibody binding, biomarker capture, and fluorescence detection was successfully developed. The device uses the principle of bubble-induced acoustic microstreaming to capture and separate the blood cells from the blood sample, resulting in a pure plasma solution. Bubble-induced microstreaming results from an acoustic field on oscillating air bubbles causing the viscous dissipation of the surrounding liquid in the microchannel. This device successfully demonstrated plasma separation, with a 31.8% yield and 99.9% plasma purity, comparable to a traditional centrifuge. The blood was spiked with a fluorescent P24 antibody, which was then mixed with 7-μm diameter beads conjugated with P24 antigens in a micromixing chamber. The bound proteins were then captured by acoustic microstreaming and detected using a fluorescence microscope. The fluorescent detection of HIV1 P24 antibody from a whole blood control demonstrated a detection limit of 17 pg/μL. This device shows the potential of immunoassay-based disease diagnostics with high sensitivity and quantification.

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