Staged Inertial Microfluidic Focusing for Complex Fluid Enrichment

Amy E. Reece[1], Kaja Kaastrup[2], Hadley D. Sikes[2], John Oakey[1]

[1] University of Wyoming, Department of Chemical & Petroleum Engineering

[2] Massachusetts Institute of Technology, Department of Chemical Engineering

Abstract

Microfluidic inertial focusing induces the passive alignment of small particles without the need for external actuation or sheath fluid by predictably positioning particles to lateral and longitudinal equilibrium focusing positions. Equilibrium behavior of inertially focused particles has been extensively characterized and the constitutive phenomena described by geometric scaling relationships for straight channels of square and rectangular cross-section. We demonstrate that these geometric factors may be combined to produce a staged centrifugation device capable of high throughput and efficient single pass complex fluid enrichment. Straight and asymmetrically curved channels have been combined to accelerate focusing dynamics. We have investigated single and multiple pass concentration efficiency and results indicate that these devices are appropriate for routine cell handling operations, including media exchange. This is demonstrated with a routine fluorescence staining assay. The use of microfluidic inertial focusing to passively enrich particles with minimal sample loss and high efficiency is particularly useful for delicate samples that cannot tolerate centrifugation. The passive nature of inertial focusing allows for gentle cell handling that increases cell viability in biological sample processing. At the same time, microfluidic inertial focusing is inherently high throughput and therefore does not require a compromise in processing time relative to centrifugation. Staged centrifugation is particularly desirable for point of care settings where more conventional instrumentation is impractical or cost-prohibitive, and is especially useful in settings that work with delicate samples that are not sufficiently robust to survive centrifugation.