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# Acoustophoresis for on-chip screening of biomolecules and cells

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## Abstract

Even though, realm of personalized medicine has become more imminent owing to the increased cognizance of the shortcomings in the current treatment protocols, a better molecular understanding of biomolecules with novel specificities for drug selection and screening, to improve both innovation and productivity is still required. To keep abreast with these requirements the pharmaceutical drug & diagnostic industries have witnessed many new technological innovations in recent years.

Since past two decades, attempts are made to integrate basic unit operations on a microfluidic chip to unravel the Byzantine complexities of life sciences at a molecular level which forms the basis of numerous diseases. This integration has brought microfluidics to a state of evolving refinement and has led to the development of several integrated microanalytical systems. From the vast arsenal of microfluidic techniques, microchannel acoustophoresis has led to a paradigm shift for precise handling, manipulation and concentration of different biological targets (beads and cells).

This thesis intends on researching fundamental physical phenomena underlying acoustophoresis and attempts to explore its applications for screening and isolation of different biomolecules based on their affinities towards the target of interest. This is essentially achieved by exposing targets of interest to the transient acoustic fields which controls, displaces, and guides these microparticles present in the sample along the laminar flow profile within a microfluidic format.

The primary focus of this thesis is on improving efficiency in acoustophoretic washing of particle rich suspensions (greater than 1% concentration by volume). This was achieved by establishing a NOVEL HYPOTHESIS that requires tailoring of the acoustic properties of liquids enabling ultrasonic stabilization of the interface between the initial and final suspending medium. The acoustic force on the interface counteracts the transfer of contaminants due to hydrodynamic drag from the particles when they move between the two liquids. It is shown that liquids of high acoustic impedance (the product of density and speed of sound) tend to move towards acoustic pressure minima. Results show that by tuning the acoustic impedance in either the initial suspending liquid or the new liquid, we can reduce the drag associated carry–over of minute species. Furthermore it is demonstrated that acoustic relocation of liquids for impedance differences is sensitive for the impedance difference as low as 0.1%. This level of sensitivity indicates that acoustic radiation force on liquid interfaces is a key element to understand in these systems design for reliable operation and to develop new modalities.

Secondary focus of the thesis is to explore the applicability of the above proposed phenomenon for applications within life sciences. As an experimental application microbeads and cells were separated from dye molecules using two different approaches were evaluated namely, (1) acoustophoresis washing which was compared against (2) manual washing. Since, manual washing of biomolecules is a ubiquitous procedure within cell labs, it is desirable to understand if acoustic washing can yield equivalent or even better separation of biomolecules. Initial results of these experiments are in coherence with the finding that by altering the acoustic impedance of the initial suspending liquid, the drag associated carry–over of minute species can be substantially reduced resulting in a better separation (~ 100%) as compared to manual washing procedures even at higher particle concentration (4%).

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