Numerical modelling for neural stem cell separation using dielectrophoresis

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Biography

I completed my bachelors in mechanical engineering from Sangli, India. Following my interest in fluid mechanics, I worked in Cummins Engine Filtration in India for a year. After coming to Clemson for my Graduate school, I decided to pursue research in microfluidics. My current work involves working and simulating microfluidic systems combined with electric forces for cell manipulation. My research interests include electrokinetics, microfabrication and microfluidics. I am a member of the Electrochemical Society (ECS) and AES Electrophoreis Society.

Overview:

Neural stem cells have received great interest in recent years due to their potential in treating spinal cord injuries, in promoting brain repair and other nervous disorders.[1,2] Currently, the most common methods used to quantitatively characterize stem cells is fluorescence activated cell sorting, (FACS) [3]. This technique is limited by the lack of antigens and labels that are specific enough to stem cells of interest. Dielectrophoresis which is a label free separation technique, has been recently demonstrated for the enrichment of neural stem/progenitor cells using the membrane capacitance of the cell as the distinguishing factor[4]. Here we use numerical simulation to investigate the use of streaming DEP for the continuous sorting of neural stem/progenitor cells. The aim is to understand how a select device and experimental variables affect the throughput and efficiency while continuously sorting SC27 stem cells, neurogenic progenitor, from SC23 cells, an astrogenic progenitor. The sorting is studied by characterizing the width of the stream obtained for these cells with a purity ≥98% for continuous separation. The variables studied here are electrode cross section shape (circle, lens and diamonds), height (10, 50 and 100% of the channel height), the flow rate (200-2000 µl/min) and the cell concentration (10^3 to 10^5 cells/ml). Based on the results of the simulation, a device is proposed to retrieve the streams.

Motivation:

In neural stem cell analysis, the early separation of neurogenic progenitor from astrogenic progenitor is of importance as these two cells differentiate into different neural cells during the process for genesis. Current methods normally use specific labels or formulation of certain probes for detection of the stem or differentiated cells. However, there is not a clear set of surface markers with sufficient specificity to identify promising cells, such as neural stem cells, from a background. This limits investigation of lineage-biased progenitors and their potential use as therapeutic agents. Alternatives to traditional techniques are thus needed.

State of the Art

Dielectrophoresis is a label free technique which is recently used for stem cell separation for stem cell separation from adipose tissue and peripheral blood stream.[4–6] Previous work by Labeed et al indicate separation of neural stem cells SC27 cells from SC23 is possible[7].

Intellectual Merit

The focus here is on studying how the device and experimental protocol can be optimized to increase the throughput and efficiency previously demonstrated using the advantage of high flow rate along with dielectrophoresis. The ultimate goal is an in-line module for cell sorting that could be incorporated in the bio manufacturing of therapeutic cells.

Broader Impact

The demonstration of numerical concept being extended to experiment will help separation of neural stem cells with high throughput and a high efficiency.

Research Approach

In this work numerical simulation is used to assess the potential for continuous separation of Human Neural Stem/Progenitor Cells (HuNPSC) using streaming DEP. Streaming DEP refers to the focusing of targeted cells into specific streams to facilitate their retrieval from the channel. The ideal scenario is that where wide streams of SC27 are well separated from SC23 streams. The width of the stream is maximized to increase throughput while the separation between streams of different cells must be widened to increase efficiency during retrieval. Here, we study the impact of different parameters on the width of such stream. The implemented model could be applied for different electrode materials and DEP technologies.

Conclusions

The results presented demonstrate the potential to continuously separate stem cells using streaming DEP with different electrode parameters and flow conditions. Separation is demonstrated using flow rate of around 1000 µl/min with the electrodes covering the entire height of the channel with an efficiency of 98%.

References

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