Continuous-flow Ferrohydrodynamic Sorting of Cells in Microfluidic Devices with Permanent Magnets

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Technology description

Microfluidic devices for microparticle and cellular separation are becoming increasingly important in miniaturized biological applications. Existing separation methods, including techniques based on channel geometry and obstacle design, optical force, dielectrophoresis, and magnetic bead labeling, have their own shortcomings. Techniques based on geometries use appropriate channel and obstacle design to direct particles of different sizes into separate flow streamlines. The dimensions of the channels and obstacles have implications for the applicable separation size range, and a significant amount of fine-tuning is often necessary for the separation of small particles. The optical tweezer technique employs the forces exerted by a focused laser beam to manipulate nano- to micro-scale objects. This method is usually applied to move and trap a single object. The heating due to the focused laser beam can potentially damage living systems. Dielectrophoresis has the potential to realize integrated devices for high-throughput manipulation of microparticles or cells. However, its performance usually depends on the electrical properties of the specific liquid medium, particle shape, and its effective dielectric constant. The alternating electric fields may polarize the cell membranes and lead to cell death. The magnetic bead labeling technique, on the other hand, uses functionalized magnetic beads to label and separate target particles and cells. This approach takes long incubation time and is manually intensive. There is also the difficulty of removing the magnetic labels from the target particles or cells prior to further analysis.

In an attempt to address some of the aforementioned limitations, UGA researchers have developed a novel microfluidic device that can continuously separate non-magnetic microparticles (e.g., cells) based on their sizes inside water-based ferrofluids, with the use of a simple permanent magnet. Their ingenuous approach uses the ferrofluid as a uniform magnetic environment that surrounds the non-magnetic particles within the microfluidic channel. Non-magnetic microparticles mixed with water-based ferrofluids were introduced into the microfluidic channel and hydrodynamically focused by the ferrofluid sheath flow. Once entering the separation region, deflections of non-magnetic particles from their flow paths occurred because of the magnetic buoyancy forces on them . As a result, larger particles were deflected more than small ones. This phenomenon can be used to continuously separate non-magnetic particles inside ferrofluid based on their sizes. Size-based separation (1 μm and 9.9 μm, 1.9 μm and 9.9 μm, 3.1 μm and 9.9 μm, etc.) of microparticles close to 100% separation efficiency. Cell throughputs between 10^{6} and 10^{8} cells/h were achieved when the system was tested with a variety of

cells such asE. coli,S. cerevisiae,L. casei, HeLa and Jurkat cells, and cancer cells. The system is also applicable to other materials, such as - for instance—polymer beads, microparticulates in liquids– and waterborne contaminants.

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Advantages

· Inexpensive and of easy construction
· High throughput of analytes (cells, microparticles, etc.)
· Does not induce cell death or lysis
· Requires little or no sample preparation
· Requires no specialized training to operate, nor complex circuitry or additional equipment
· Water-based process

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