443b Magnetophoretic Size-Based Trapping and Separation of Nonmagnetic, Submicronparticles in a Microsystem

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Magnetic particles have been widely used for biological separations. Most of these applications, particularly cell separations, involve attachment of the magnetic particles to the species of interest. In this work, we were able to separate submicron, nonmagnetic species based on size using magnetic fluids, but without attaching the magnetic particles to the species of interest. Instead, separation was achieved by a balance between magnetic-buoyancy effects and hydrodynamic drag on the nonmagnetic species. Separations were conducted in microdevices (chips) designed to generate sawtooth-like magnetic-field profiles and allow for real-time species-concentration measurements.

The chips were fabricated using standard micromachining techniques, including physical vapor deposition, photolithography, electroplating, and poly(dimethylsiloxane) (PDMS) bonding. Ferromagnetic (Ni) core elements on the chips produced a "sawtooth" magnetic field along a microfluidic channel when magnetized by external permanent magnets. The sawtooth field contained peaks of successively increasing magnetophoretic intensity (Mf„¤H), forming trapping points between peaks. Nonmagnetic particles were trapped against pressure-driven flow when the magnetophoretic force overcame the drag force. The particles of interest were 840 nm and 510 nm fluorescently-tagged polystyrene beads, suspended with equal concentrations in a water-based magnetic fluid (ferrofluid). The concentration profiles of both particle sizes were observed via optical fluorescence-intensity measurements. Experiments demonstrated size-based trapping, where 840 nm beads were trapped near the beginning of the channel, while 510 nm beads were trapped further downstream. Moreover, the location at which particles of a given size were trapped was shown to be a function of flow rate. The magnetophoretic trapping demonstrated in this work could form the basis of high-resolution, size-based separation methods for DNA, cellular organelles, viruses, and other like-sized biological and non-biological species.