Proceedings of the ASME 2011 International Mechanical Engineering Congress & Exposition
IMECE2011
November 11-17, 2011, Denver, Colorado, USA

IMECE2011-62402

SEPARATION OF MAGNETIC BEADS IN A MICROFLUIDIC DEVICE – MODELING AND EXPERIMENTATION

Scott S. H. Tsai
School of Engineering and Applied Sciences
Harvard University
Cambridge, MA, U. S. A.
stsai@seas.harvard.edu

Jason S. Wexler
Mechanical and Aerospace Engineering
Princeton University
Princeton, NJ, U. S. A.
jwexler@princeton.edu

Ian M. Griffiths
Mathematical Institute
University of Oxford
Oxford, United Kingdom
ian.griffiths@maths.ox.ac.uk

Howard A. Stone
Mechanical and Aerospace Engineering
Princeton University
Princeton, NJ, U. S. A.
hastone@princeton.edu

ABSTRACT

We describe a microfluidic system that uses a magnetic field to deflect paramagnetic beads in the direction normal to the flow. Through modeling and experimentation, we study this system to separate beads by their magnetic properties and size. We also use a similar system to move the beads from one fluid stream to an adjacent miscible stream.

OVERVIEW

Magnetic fields applied to paramagnetic beads flowing in a microfluidic channel can deflect them normal to the flow.[1-2] Microfluidic devices that deflect beads this way have been used to separate specifically bound targets of cells, proteins and other biological components.[3-5] Beads are functionalized to bind to specific targets, flow through a microchannel, and are separated from the bulk flow.

We describe a system that separates beads by their size and magnetic properties. In our experiments, we systematically vary the paramagnetic beads' size and susceptibility, the average fluid speed, and the distance the permanent magnetic is placed away from the magnet. We also develop scaling and detailed mathematical models to predict the amount of deflection beads undergo as they move through the magnetic field. The beads are also made to go from one fluid stream to a parallel fluid stream by magnetic forces.

PROPOSED DEVICE

Figure 1 shows the region of the microchannel where the paramagnetic beads are deflected normal to the flow direction. The magnetic field gradient produces a force on the beads, pulling them toward the magnet. Larger beads or beads with higher magnetic susceptibility experience a larger force. When the fluid speed is low, the beads experience magnetic forces for a longer time. Thus, how much beads deflect will depend on their size and magnetic properties, as well as the flow speed.

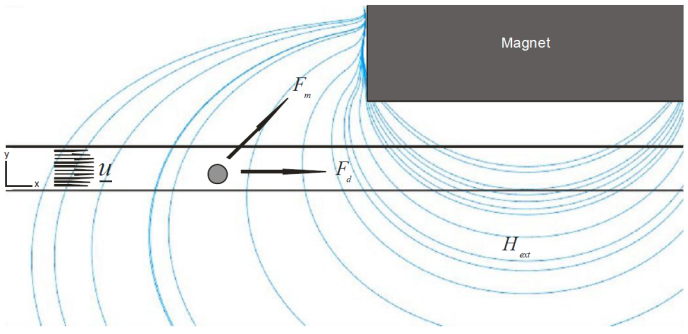

Figure 1 Magnetic and viscous forces act on paramagnetic beads traveling through the separation region of the microfluidic device, deflecting the beads in the direction normal to the flow.

REFERENCES

[1] D. W. Inglis, *et al.*, "Continuous microfluidic immunomagnetic cell separation," *Applied Physics Letters,* vol. 85, pp. 5093-5095, Nov 2004.

[2] D. W. Inglis, *et al.*, "Microfluidic high gradient magnetic cell separation," *Journal of Applied Physics,* vol. 99, Apr 2006.

[3] C. W. Yung, *et al.*, "Micromagnetic-microfluidic blood cleansing device," *Lab on a Chip,* vol. 9, pp. 1171-1177, 2009.

[4] L. Saias, *et al.*, "Microfluidic magnetic cell sorting system for cancer diagnosis," *Houille Blanche-Revue Internationale De L Eau,* pp. 105-111, 2009.

[5] A. E. Saliba, *et al.*, "Microfluidic Magnetic Cell Sorting System for Ctc Detection and Typing," *Anticancer Research,* vol. 28, pp. 3530-3531, Sep-Oct 2008.