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EDITORIAL

Special issue on magnetic-based microfluidics

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Abstract This editorial summarises the significance of the contributions to the special issue on magnetic-based microfluidics. Magnetic-based microfluidics or micro magnetofluidics is a research area that combines the advantages of microfluidics and magnetism. The interaction between a flow field and a magnetic field leads to new functionalities that are useful for emerging applications such as lab-on-a-chip devices.

An year ago I was asked by the former editor of *Microfluidics Nanofluidics*, Prof. Dongqing Li, to edit a special issue on magnetic-based microfluidics. In a review published in *Microfluidics Nanofluidics* early this year, I have identified micro magnetofluidics as an emerging sub area of microfluidics (Nguyen 2012). The two-way interaction between magnetism and fluid flow on the micro scale has been used for various microfluidic applications. However, the recent trend shows increased activities in research works that combine magnetism with microfluidics to gain new functionalities. Due to the intuition of a weak magnetic body force based on the unfavourable scaling law in microscale, many of these functionalities have been neglected in the past. Since the field of micro magnetofluidics is expected to expand in the near future, I have made no attempt to cover all magnetic-based topics, but chose to focus on fundamental and applied works on magnetic fluids in microscale.

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Magnetic fluid consists of a carrier fluid and a suspension of magnetic particles. Depending on the size of the magnetic particles, the magnetic fluid behaves differently and has different applications. Magnetic particles of a size on the order of micrometer have been traditionally used for various lab-on-a-chip (LOC) applications due to the possibility of functionalizing the particle surface and easy manipulation using an external magnetic field. Ramandan and Gijs (2012) give a review on applications of magnetic particles for environmental monitoring and presents the basic usage of functionalized magnetic particles in such microfluidic systems. In an applied magnetic field, magnetic particles interact through dipole moments, aggregate and form superstructures such as chains. In the second review paper, Wittbracht et al. (2012) summarize recent developments of dipolar-coupled magnetic particles in microfluidics. Magnetic liquid marbles, liquid droplets coated with hydrophobic magnetic particles, represent a unique platform for magnetic-based digital microfluidics. In the third review paper of this issue, Zhao et al. (2012) report the recent progress in manipulation and detection of magnetic marbles.

Understanding the behaviour of magnetic particles in a magnetic field is important for design and development of these microfluidic devices. Hardt's group (Banerjee et al. 2012) investigates the aggregation dynamics and chain formation in a stationary uniform magnetic field. Chen's group (Li et al. 2012) reports the behaviour of a chain of super paramagnetic particles in an external oscillating field. Furlani and Xue (2012) provides a rapid analysis technique for modelling magnetic particle-based gene delivery.

Sorting and separation using magnetic fields are the basic tasks in a LOC platform. Traditionally, magnetic particles in a diamagnetic fluid are sorted and separated using an external magnet. The associated phenomenon is called magnetophoresis. Zahn's group (Sasso et al. 2012) reports the application of magnetophoresis for magnetic bead immunoassays. Oh's group (Lee et al. 2012) utilizes magnetophoresis to separate magnetic particles in a continuous droplet-based microfluidic platform. The same separation concept can apply to diamagnetic particles suspended in a magnetic fluid such as ferrofluid. This phenomenon is called diamagnetophoresis or negative magnetophoresis. Pamme's group (Vojtíšek et al. 2012) reports results of free-flow separation of diamagnetic particles using this phenomenon. Liang and Xuan (2012) utilize negative magnetophoresis to focus diamagnetic particles at the interface between magnetic and diamagnetic fluid streams. Mao's group (Zhu et al. 2012) reports the separation of biological particles such as live cells using negative magnetophoresis. Since diamagnetic particles can be focused on the magnetic/diamagnetic interface, controlling the position of this interface would allow active sorting of the focused particles. Zhu and Nguyen (2012) report experimental and numerical results of the spreading phenomenon of a ferrofluid stream in a uniform magnetic field.

Besides the aforementioned magnetofluidic applications, magnetism has versatile use for manipulation and actuation on various LOC platforms. Doyle's group (Suh et al. 2012) uses microfluidics to synthesise bar-coded magnetic hydrogel particles for bioassays. Ducree's group (Burger et al. 2012) utilized embedded permanent magnets as actuators for lab-on-a-sic platforms.

The contributions to this issue have each been rigorously reviewed and revised. The contribution of my research group (Zhu et al. 2012) was reviewed independently by the editor, Prof. Zengerle. I hope that readers find this special issue useful, and the issue may inspire you to join this exciting research field of micro magnetofluidics.

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