

Global mixing in micro-channels and cavities by magnetically actuated particles

Citation for published version (APA):

Gao, Y., Hulsen, M. A., & Toonder, den, J. M. J. (2009). *Global mixing in micro-channels and cavities by magnetically actuated particles*. Poster session presented at Mate Poster Award 2009 : 14th Annual Poster Contest.

Document status and date:

Published: 01/01/2009

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

Global mixing in micro-channels and cavities by magnetically actuated particles

Y. Gao,
M. A. Hulsen,
J. M. J. den Toonder

Materials Technology Institute,
Department of Mechanical
Engineering,
Eindhoven University of
Technology,
The Netherlands

Introduction

A biosensor is an instrument that can rapidly measure the concentration of biological molecules or cells of interest in biofluids such as blood and saliva. The drive to realize such biosensors leads to the development of lab-on-a-chip systems. In these systems mass transport is dominated by diffusion, which is prohibitory slow. Two key processes that need to be mastered are: mixing (Fig. 1(b)) and target catching (Fig. 1(c)). Here, we propose the use of magnetic beads coated with an activated surface, and actuated by a magnetic field to control both process.

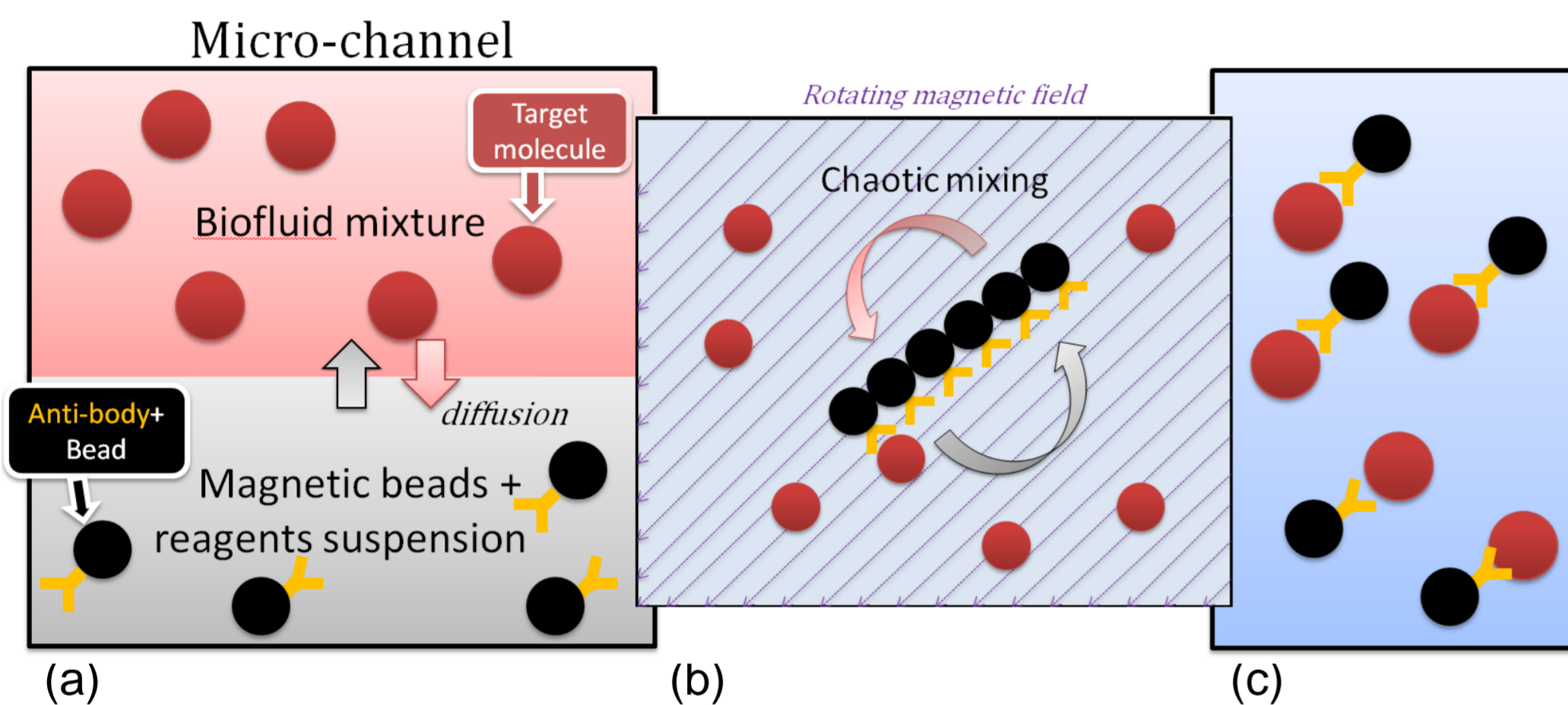


Fig. 1 Conceptual diagram of a magneto-active lab-on-a-chip system. (a) Laminar flow between the biofluid and reagents. (b) The mixing of fluid with reagents. (c) The catching and transportation of target material.

Objective

The development of optimized magnetic actuation protocols to achieve global mixing processes in micro-channels and sensor cavities.

Methods

Advanced numerical simulations and microfluidic experiments will be conducted to investigate the possibilities of achieving global mixing flows in micro-channels and cavities. To this end, a 3D finite element model will be set up and microfluidic experiments will be carried out to validate the numerical model.

Preliminary results

2D computer simulations of suspended super-paramagnetic beads, confined in a circular geometry with the presence of a rotating homogenous magnetic field have been done by Kang et al (Fig. 2) [1]. Kang concluded that the motion of the chain, fluid flow and mixing are significantly influenced by the Mason number, the ratio between the viscous and magnetic forces.

Specifically, the intermediate Mason numbers, which are characterized with the alternating topological changes of the chain (break-up and reformation, Fig. 2(b)), are the key mechanisms for chaotic mixing.

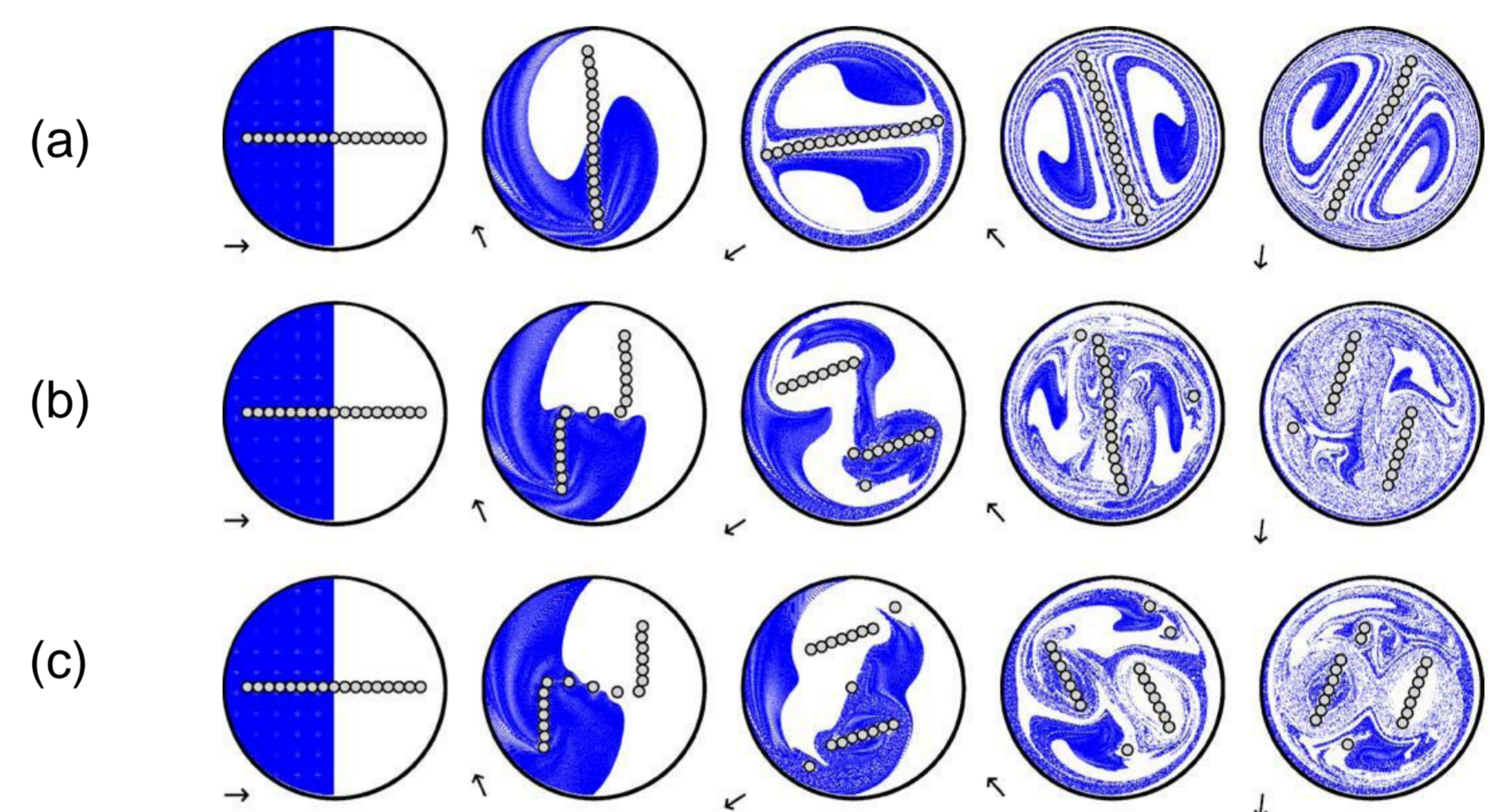


Fig. 2 Mixing, chain of beads with initial orientation perpendicular to the different fluid interface, visualized at different Mason numbers (a to c, $Ma = \{0.001, 0.002, 0.003\}$). Here, the black arrows indicate the direction of the applied magnetic field. Simulations by Kang et al. [1]

Microfluidic experiments with a suspension of super-paramagnetic beads in a cylindrical fluid chamber under influence of a rotating homogenous magnetic field (max. 3 mT) were carried out by Bokdam [2]. Fig. 3(b) shows the dynamics of the beads chain at intermediate Mason numbers: break-up and reforming chain rotation.

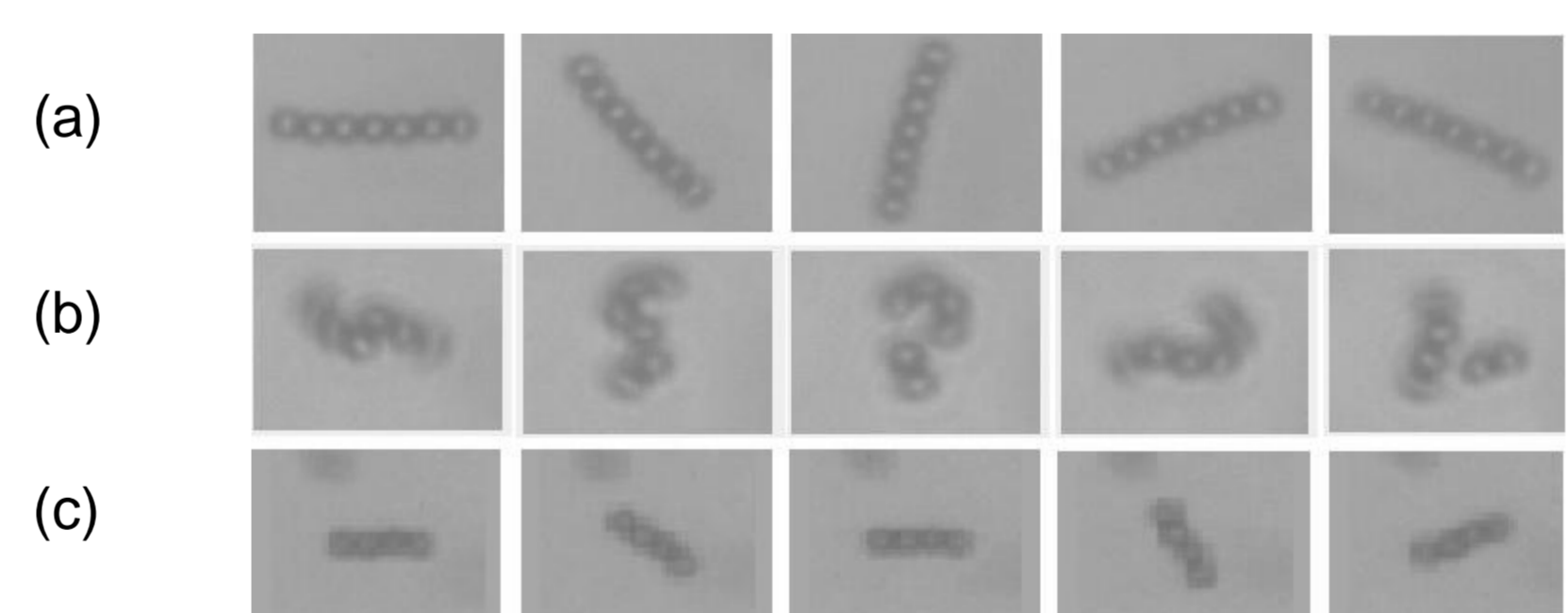


Fig. 3 Characteristic chain dynamics visualized at different Mason numbers (a to c, $Ma = \{0.25, 0.75, 6.8\}$). The displayed beads are $3 \mu\text{m}$ Sperotech beads. Results obtained by Bokdam [2].

Outlook

Experiments confirmed the simulated chain dynamics at different Mason numbers. Future experiments will consist of flow visualization (dyes) and flow quantification ($\mu\text{-PIV}$) to verify effective mixing in the intermediate Mason regime.

References:

- [1] Kang T. G. , Hulsen M. A. , Toonder J. M. J. DEN, Anderson P. D. , Meijer H. E. H. : Chaotic mixing induced by a magnetic chain in a rotating magnetic field (Phys. Rev. E, 2007)
- [2] Bokdam M. , Toonder J. M. J. DEN : super-paramagnetic beads in rotating magnetic fields (2008)