약물전달을 위한 미세합성입자의 거동

양재문, 박성배, 함승주*
연세대학교 화학공학과
(haam@yonsei.ac.kr*)

Microfluidic Visualization Study
- Motions of Synthetic Nanoparticles for Drug Delivery

Jaemoon Yang, Seong-Bae Park, Seungjoo Haam*
Yonsei University Department of Chemical Engineering
(haam@yonsei.ac.kr*)

Introduction

Most of drug delivery systems are release control system or absorption process control system up to date. However there is one of the remarkable system in recent years, the target intention system, drugs act to object target concentratedly. Particularly, the method, concerned on this study, is the synthesized products between drug and magnetic particle are injected in a blood vessel and magnets are added the target[1]. it can decrease the side effect

To design the target intention materials, the basic theories, pharmacological and physicochemistrical properties of drug as well genernal behavior, are understood certainly. Magnetic drugs, not confirmed experimently or theoreticaly, can act to animals without side effect. but it is wrong that the results are applied to human. So, the analysis about fluidmechanical and reaction engneeritical characteristic in vascular need.

In this study, similar vascular system are made up and the behavior mechnism in a vessel of the selected similar particle with drug carrier in the magnetic field using particle tracking velocimetry(PTV) method[2]. Because of it is not easy to observe in microscale and experiment has many variances, the commercial simulation program is used to confirm the data of experiment.

The results are applicable study for drug delivery system, though a research field of microfluidics, can be used for microscale spectrometer and micromachine[3].

Theory

Dominate forces

Magnetic nano particles under magnetic filed flow affected by various forces. However interrogation is in microscale, can reduce weak forces. Dominate terms are inertial and magnetic force[4].

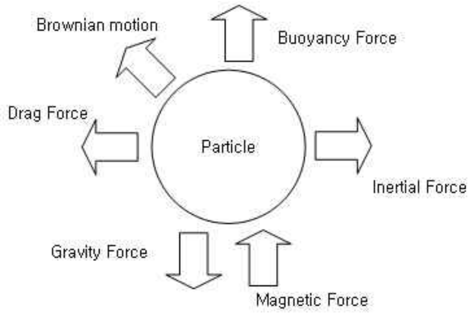


Fig.1 forces act on particle

Inertial force

$$F = A\rho u^2$$

Magnetic force

$$F_m = \frac{\chi_m V \nabla B^2}{2\mu_0}$$

So, we can obtain ratio(N) of between two forces. If it over critical point, effectiveness of magnetic force is nearly not visible, N value approch to zero.

$$N = \frac{magnetic\ force}{inertia\ force}$$

Particle Tracking Velocimetry method

PTV method, one of the visualization techniques, developed since last decade. This method has some merit rather than other methods[5]. PTV method use real images to obtain velocity vectors. Images by camera were captured in sequence. Analysis program developed at laboratory to calculate trace along the particle path. Calculated vectors are arranged through ensemble average.

Experiments

We experiment with PECA(poly(ethyl-2-cyanoacrylate)) magnetic nano particles (~500nm) that were synthesis in laboratory. And also proceed with similar size Fe3O4 particle.

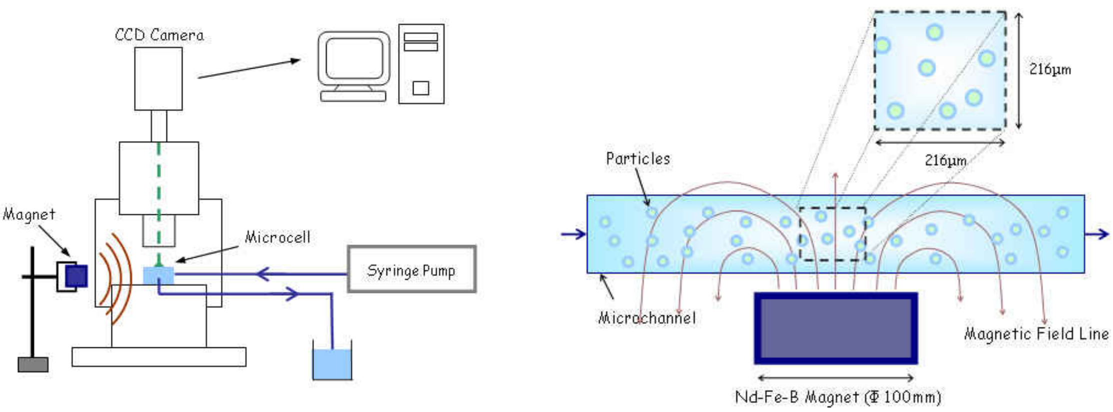


Fig.2 Experimental Setup

To set up vascular system(Fig.1), magnetic particles under water flow in sq I.D. 500 µm microchannel (VitroCom Inc.) that was affected by magnetic field with permanent magnet. Proper flow rate was controlled with syringe pump(HAMILTON KDS-100). Flow images were captured through epi-fluorescence microscope(Olympus BX51) with 80frames/s. And those were analyzed to obtain vector field using particle tracking velocimetry method.

Vector fields were acquired for various variances, flow rate(50µl/h~1000µl/h) and magnetic field strength(500G~5000G). Through magnitude of vector, seek the critical point for effective drug targeting.

Results & Discussions

To act with effective magnetic drug carier, prepared particle shoud to have some magnetic strength. It is suitable for drug delivery that can be cornfirmed by VSM graph(Fig.3).

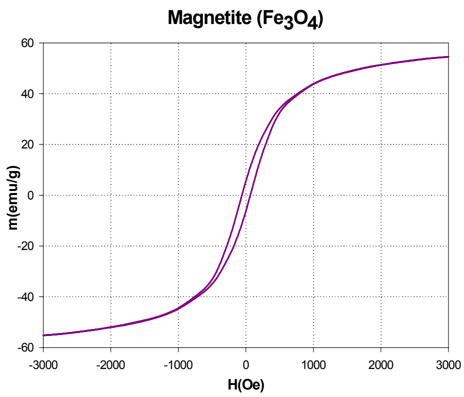
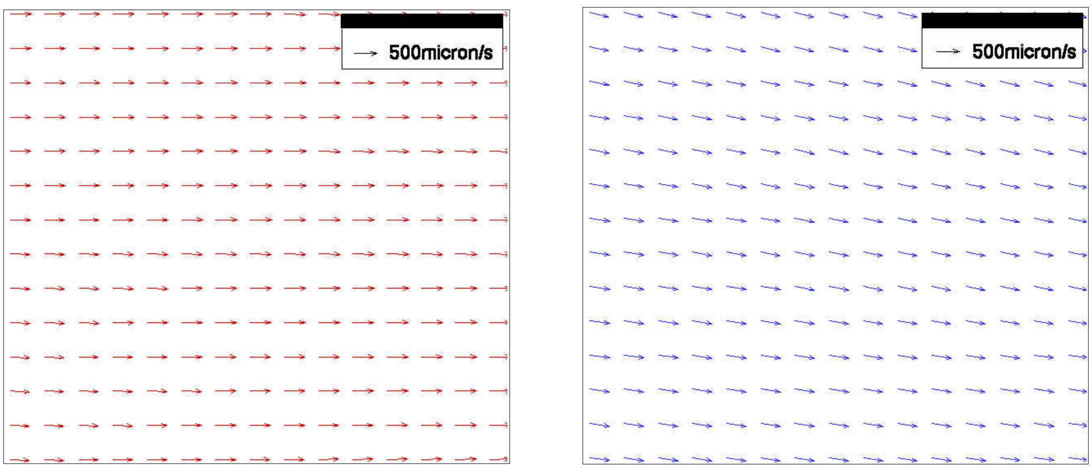


Fig.3 VSM data for magnetic particle

Fig.4 shows vector field(flow rate : 300µl/s) obtained using PTV method. When it has magnetic field, velocity vector incline to downward. Over the all variances, graphs are acquired(Fig.5). When difference of two results is decrease nearly to zero, that point is critical point.



(a) (b)

Fig. 4 Vector field (a) without magnetic field, (b) with 5000Gmagnetic field.

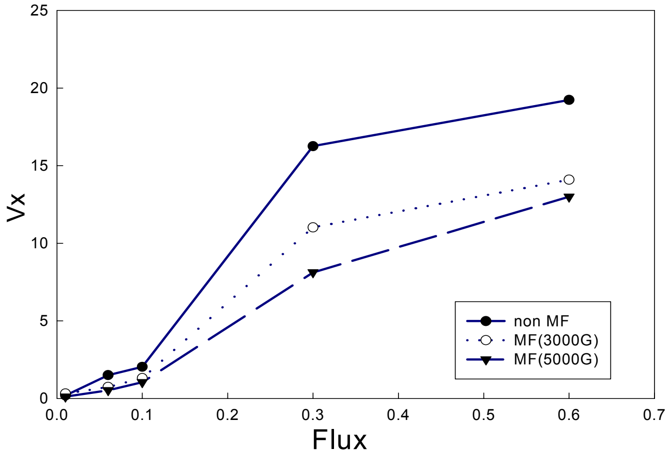


Fig.5 Graph to find critical point

In these results, we can obtain the effective point for drug delivery.

Reference

[1] Physiological aspects in magnetic drug-targeting,Andreas S. Lubbe, Christian Bergemann, Jeffery Brock, David G. McClure, Journal of Magnetism and Magnetic Materials 194 (1999) 149-155

[2] A. A. Adamczyk, and L. Rimai. "2Dimensional Particle Tracking Velocimetry(PTV) : Technique and Image Processing Algorithm", Experiments in Fluids, 6 : 373-380, 1988.

[3] The use of ferrofluids in micromechanics, R. Perez-Castillejos, J.A. Plaza, J. Esteve, P. Losantos, M.C. Acero, C. Cane, F. Serra-Mestres, Sensors and Actuators 84 2000 176-180

[4] Hydrodynamics of magnetic drug targeting, P.A. Voltairasa, D.I. Fotiadisa, L.K. Michalis, Journal of Biomechanics 35 (2002) 813 - 821

[5] A. Cenedese, A. Pococco, "Effects of image compression on PIV and PTV analysis", Optics & Laser Tech. 31 (1999) 141-149