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Simulation of the Magnetic Particle Trajectory in a Vein for MDDS Application

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Magnetic drug delivery system (MDDS) can deliver the magnetic drug to a specific area and reduce the side effect on healthy tissues. To improve its delivery efficacy, the high magnetic field strength and gradient are required. In order to understand the motion of the magnetic drugs under high magnetic field, this study established a multi-physics simulation model (including: magnetic force, drag force, and buoyancy-gravity), and the flow trajectory of ferromagnetic particles in the microfluidic channel were validated by microscopic observation. The main assumption was that the permanent magnet attracted the magnetic drug in the vein. The Nd-Fe-B permanent magnet was used as the magnetic source with a surface magnetic field of 0.35T. The strength of the magnetic field can be changed by controlling the distance from the microfluidic setup. In addition, both static and laminar flow conditions were studied. In the microfluidic validation experiment, the flow rate (1-15 mm/sec), channel width (˜ 2 mm), density (˜1060 kg/mˆ3), and viscosity (˜0.0032 kg/m*sec) referred to the vein conditions were considered. Our preliminary flow simulation results were validated with the microfluidic experimental observations that magnetic particles larger than ˜ 8 um will be captured on the wall of channel under 1 mm/sec flow rate and magnet distance ˜ 20 mm. And the particle trajectory shown error less than 0.012 mm over 1.5 mm flow distance. In addition to the fluid mechanism, effect of the distance from a particle to a magnetic source, flow rates, viscosity, and particle sizes will also be discussed. Moreover, the simulation results will be used to predict the minimum captured particle size under a specific flow and magnetic strength characteristics for MDDS applications.

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