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A microfluidic approach to the investigation of magnetotactic bacteria motility through viscoelastic fluids

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Abstract

Magnetotactic bacteria (MTB), a class of non-pathogenic bacteria that grow magnetic nanoparticles (MNPs) internally, have the potential to be used for targeted drug delivery. The MNPs inside MTB cause them to orient and move in response to magnetic field lines, a phenomenon called magnetotaxis. The self-propulsion capabilities of MTB can allow them to penetrate through tissue, and a magnetic field can be used to direct the MTB to the target tissue or organ. However, when MTB are used in the body, they may encounter fluids of different viscoelasticities, depending on the target location. Thus, an understanding of the capability of directing MTB using a magnetic field through viscoelastic fluids will be essential to their use for targeted drug delivery. In this work, we develop a microfluidic-focused experimental setup to evaluate the motility of MTB in viscoelastic fluids under the influence of different magnetic field strengths. We used polyacrylamide (PAM) dissolved in water as a model viscoelastic fluid. A microfluidic channel is filled with PAM solution for MTB studies. A Brookfield viscometer is used to determine the viscosity average molecular weight of three PAM samples and to obtain the shear rate vs. viscosity plots for various PAM concentrations. Custom 3D-printed Helmholtz coils are used to generate the magnetic field for MTB experiments. The coils are mounted on an Olympus BX51 microscope, and the magnetic field at the center of the coils was characterized through finite element analysis simulations and experimentally. Our microfluidic approach offers the advantage of generating precise magnetic fields along microchannels containing a viscoelastic fluid that can be used on the investigation of bacterial motility on-chip.

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