

Fabrication and Characterization of MagnetoSperms

Targeted therapy using MagnetoSperms have the potential to mitigate the negative side-effects associated with conventional treatment. We fabricate MagnetoSperms by an electrospinning technique using polystyrene, dimethylformamide and iron oxide nanoparticles. An empirical model of the size of the magnetic microparticles and the parameters (electric potential, concentration of the solutions and nanoparticles, and dynamic viscosity of the fluid) of the electrospraying technique is developed. The magnetic dipole moment of the microparticles is characterized using a an electromagnetic system and a force sensor at the microscale. In addition, we experimentally demonstrate closed-loop motion control of the microparticles under the influence of the controlled magnetic field gradient in three-dimensional space.

Objective

This work aims at the fabrication and characterization of a biologically-inspired microrobot, which we refer to as MagnetoSperm (Fig. 1). The fabrication is done using the electrospinning workstation of MNRLab, whereas the locomotion is achieved under the influence of oscillating magnetic fields. These fields are produced using an electromagnetic system.

Tasks

- Fabrication of MagnetoSperms using electrospinning;
- Characterization of the propulsive force, frequency response, and the magnetization.

Materials

- The electrospinning workstation in MNRLab;
- The electromagnetic system will be fabricated;
- MagnetoSperms have to be fabricated.

PREREQUISITES

Students are expected to have a working knowledge of control theory, differential equations, linear systems, statics, kinematic and dynamics. Familiarity with programming, especially with Matlab and C++.

OTHER NOTES

This project will involve a weekly meeting with the instructors and progress reports have to be prepared. All reports should be written in academic paper format.

1. References

- [1] I. S. M. Khalil, H. C. Dijkslag, L. Abelmann, and S. Misra, "MagnetoSperm: A microrobot that navigates using weak magnetic fields," *Applied Physics Letters*, vol. 104 (223701), June 2014.
- [2] I. S. M. Khalil, A. F. Tabak, A. Klingner, and M. Sitti, "Magnetic propulsion of robotic sperms at low-Reynolds number," *Applied Physics Letters*, vol. 109 (033701), July 2016.

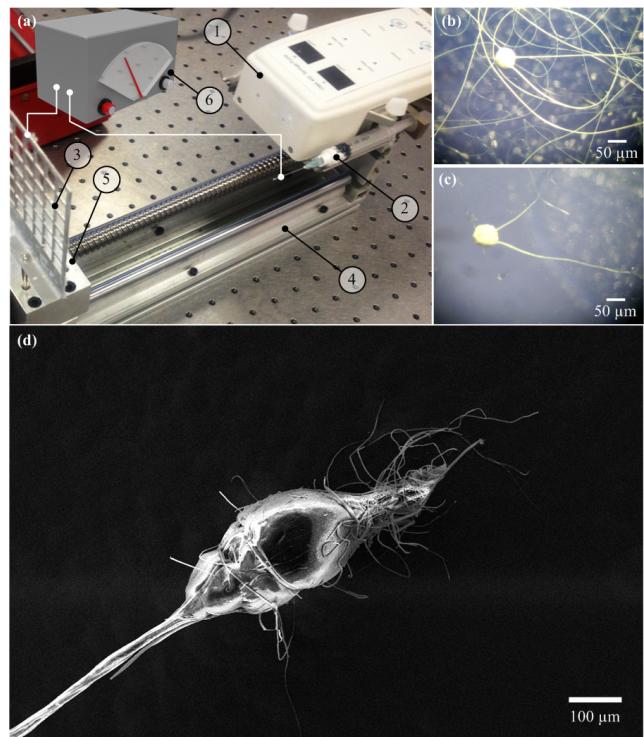


Figure 1. Fabrication of sperm-shaped magnetic microrobots using electrospinning. (a) The electrospinning workstation consists of a syringe pump (1), a syringe needle (2), and a collector (3). The distance between the collector and the syringe needle is controlled using a linear motion stage (4) and a cartesian robotic system (5). The syringe needle and the collector are connected to a high-voltage power supply (6). (b) Beaded fibers are formed when electrical potential is increased to a few kilovolts. (c) The sperm-shaped microrobots are cut and separated from the fibers. The magnetic head provides directional control under the influence of the external magnetic fields, whereas the flexible tail provides propulsive force using a flagellated swim. (d) Scanning Electron Microscopy image of the sperm-shaped microrobot.