MAGNETIC MICROROBOTS: TOWARDS CLINICAL APPLICATIONS

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Abstract: Untethered magnetic micro- and nanorobots are tiny vehicles that are propelled and steered by externally applied magnetic fields. One of the ultimate goals of small-scale robotics is to develop machines that can deliver drugs or perform other medical tasks in the confined spaces of the human body [1]. Other envisioned applications include water remediation and "on-the-fly" chemistry [2]. Recent progress in this field has been closely linked to advances in materials science and manufacturing. However, despite many impressive demonstrations, aspects such as complex locomotion, multifunctionality, biocompatibility, and biodegradability must be further investigated to enable successful translation of these devices to real applications. To this end, new material-based concepts and novel fabrication schemes are urgently required.

In this talk, I will present several of our recent advances in small-scale robotics. First, I will show how 3D-printed microtemplates can be used to fabricate complex robotic microstructures composed of rigid metals, soft polymers, and their hybrids [3]. This approach enables the realization of topologically complex metal–organic architectures with micrometric resolution. I will then turn to multiferroic small-scale robots [4]. These robots are based on magnetoelectric composite materials that generate electric fields when subjected to external magnetic fields. Micro- and nanorobots capable of wirelessly delivering such electric fields can be employed for the electrostimulation of cells, with potential applications in the central nervous system and in bone tissue engineering. Finally, I will present our recent clinically ready magnetic microrobot platform for targeted drug delivery [5], which integrates a clinical electromagnetic navigation system, catheter-based deployment, and a dissolvable capsule to enable precise, image-guided navigation and local therapeutic release under physiological conditions in anatomically realistic in vitro models and large-animal studies.

Key words: *microrobotics, biomedicine, targeted drug delivery, magnetism, magnetoelectricity*

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