Small-Scale Robots with Magnetoelectric Capabilities

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Over the past two decades researchers have been working to create synthetic small-scale machines ranging from molecular entities or miniaturized structures, to more complex assemblies of micro- and nanomaterials. These machines are able to navigate in complex environments by harvesting fuel from the surrounding media or from external power sources. One of the most sought-after applications for these miniaturized machines is to perform minimally invasive interventions, in which these devices will ultimately reduce risk, cost, and discomfort compared to conventional interventions. This has driven researchers to produce a myriad of small-scale robots loaded with therapeutic cargo.

One of the main aspects investigated has been the fabrication and optimization of the motility component of these small agents, and one of the most promising approaches is to use electromagnetic systems to wirelessly control and actuate magnetic micro and nanostructures. While many efforts have been dedicated to locomotion, there are many other challenges in small-scale robotics, for instance, the development of miniaturized mobile platforms capable of integrating multiple functionalities. We present here magnetoelectric-composite small-scale machines that, under the same source of energy, are able to perform two different functionalities depending on how magnetic fields are applied. The magnetostrictive component enables this machine to propel, while the magnetoelectric composite can be used to generate wirelessly a piezoelectric field [1]. The first part of this talk will focus on the concept of magnetically induced piezochemical potential, which can be exploited, for instance, to induce chemical processes such as electrodeposition [2]. In the second part of this talk, we will focus on the potential biomedical applications of these magnetoelectric small-scale robots. As an example, we will show how core-shell magnetoelectric nanowires are able to release *in vitro* anti-cancer drugs on-demand using the magnetoelectric approach [3].

1. J. Ma at al., Adv. Funct. Mater. 23 (2011), 1062
2. Chen et al., Mater. Horiz. 3 (2016), 199.
3. Chen et al., Adv. Mater. (Accepted manuscript): DOI: 10.1002/adma.201605458