Multi-responsive gel cilia: bulk and actuating properties

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Polymer gels are privileged materials to interface the macroscopic world with living matter. These wet materials that allow for fluid flow in their bulk, can be easily made biocompatible and, therefore, envisaged as a support for living matter or body implants. Furthermore, due to their appropriate physico-chemical and mechanical properties they can be finely tuned either to mimic a biological function or to exert mechanical action on a living tissue. Their mechanical response can be driven by small perturbations of various natures and they are easy to deform when subject to small external mechanical or environmental changes. A wide range of actuating gel interfaces can be envisaged exhibiting various morphologies and trigged by different mechanisms of sensing or actuation. Within this framework, we report on large arrays of micro-fabricated gel cilia as a concrete example of a multi-responsive gel interface, that express sensing and motility (actuation) at the same time. First, we investigate in detail the magneto rheological response of highly swollen polymer gels that contain ferromagnetic particles under external homogeneous magnetic fields [1-2]. In a second moment, the micro-fabrication of a large array of gel cilia able to respond to pH changes and electric or magnetic fields is demonstrated [3-4]. The various limitations to miniaturization and response at (sub)micrometer length scales of such gel interfaces are also discussed. As a resume, we demonstrate how it is possible to integrate various types of stimuli into (potentially) biocompatible gels controlling gel morphology at micrometer scales.

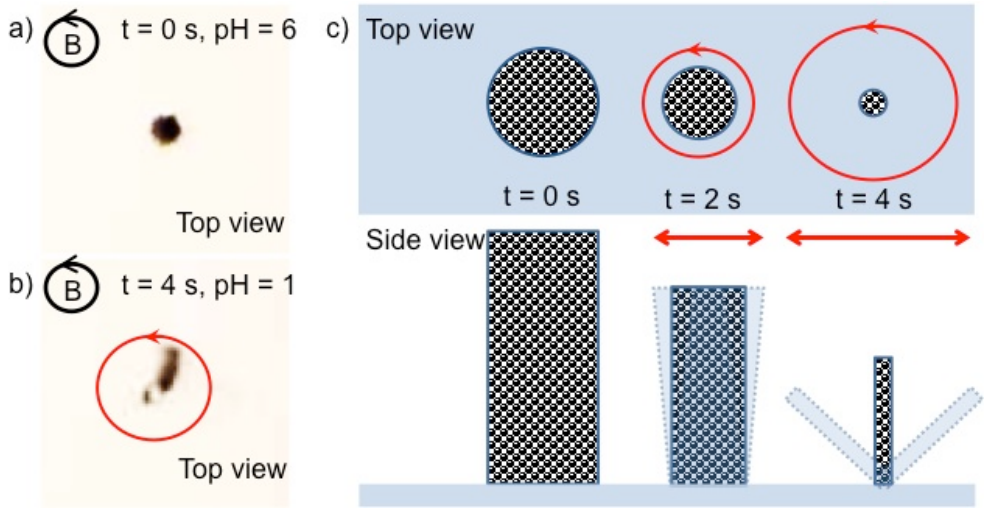

Figure 1 Top view of multi-responsive gel cilium under rotating magnetic field at a) pH6 (no movement) and b) pH1 (rotation). c) Representation of gel cilium change in size and bending during pH change and under rotating field.

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[2] H, An, B. Sun, S. J. Picken and E. Mendes "Long Time Response of Soft Magnetorheological Gels" *J. Phys. Chem.* 2012 116(15) 4702-11

[3] P.J. Glazer, M. van Erp, A. Embrechts, S.G. Lemay, E. Mendes "Role of pH gradients in the actuation of electro-responsive polyelectrolyte gels", *Soft Matter*, 2012, 8 (16), 4421 – 4426

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