Multiphysics modeling of stimuli-responsive gels with applications to biological systems, shape morphing and micro-motility

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ABSTRACT

Polymer gels are soft materials that swell and shrink in response to changes in solvent content. These materials are widespread in nature and play an important role in all forms of life. Hence, the study of polymer gels provides insight on natural systems, further suggesting effective strategies for the realization of nature-inspired materials and devices. In particular, syntetic polymer gels have been employed in biomechanics and biomedicine, as tissue replacements, tissue scaffolds and drug delivery systems, due to their biocompatibility and biomimetic mechanical properties [1].

Here, we present a computational multiphysics model to characterize the coupled non-linear elasticity and solvent transport in the swelling of polymer gels. The model is based on the formulation introduced in [2] and is implemented in a finite element code. Simulations regarding some gel-based biological systems are discussed.

Moreover, we are interested in certain polymer gels, called stimuli-responsive gels, that react to environmental triggers (such as temperature or pH) by altering their swelling behavior. Specifically, temperature-responsive gels have been employed as soft micro-actuators [3], *smart* drug delivery systems [4] and shape programmable materials [5]. Motivated by these applications, we extend our model to include the effects of thermal activation on swelling and perform several numerical simulations of micro-robots and shape-morphing devices.

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