IMPRS on Multiscale Biosystems

Project description

Title: Acceleration and amplification of biomimetic actuation: the empty pore matters
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Project description: Nature has evolved many materials solutions that enable organisms to grow and move in a physical world, despite the limitations of chemical availability and synthesis temperatures. These biomaterials are produced with exquisite control of the underlying architecture. A well-known example can be found in the ability of some tissues to move upon external stimuli, such as seen in the pine-cone, or wheat awn. In many cases the manipulative and locomotive capabilities of biological systems are even more precise and robust than the most advanced ones man ever made. Learning from Nature how materials architecture controls actuation can provide direction for technical development. Biomimetic actuators can transfer external stimuli into shape and structure change, thus important for applications in soft robotic systems, artificial muscles, self-healing designs, sensors, just to name a few.

We recently observed an ultrafast and sensitive porous polymer film folding in different solvents and vapors (Fig. 1). This project aims to understand why the pores improve dramatically the kinetics and sensitivity of the polymer actuator. Fundamentally the pores were believed to accelerate the mass transport and in addition may also control swelling strains during actuation. Despite these ideas, many questions remain open: 1) How do pore characteristics (pore size, geometry, etc.) control folding. 2) What is the mechanism by which the pore material interacts with solvents molecules to give rise to local volume changes? (role of hydrophilicity, crosslinking density, etc.), 3) What internal stresses are produced inside these polymers. A good understanding of these factors, will lead to design rules for optimal porous actuators with instant response and large extent of folding.

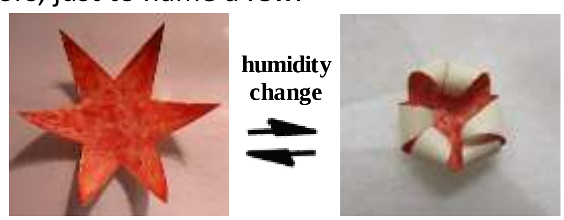

Figure 1. Fast and reversible folding of star-like film in different humidity.

Required background: Candidates with a background in physical chemistry and material science are highly encouraged to apply. A background knowledge in polymer science will be an additional advantage.

Paper to read before the interview: 1). Harrington, M. J., et al. (2011). Origami-like unfolding of hydro-actuated ice plant seed capsules. ***Nat. Commun.***, 2, 337–7. 2). Zhao, Q.; et al. (2012) Poly(ionic liquid) Complex with Spontaneous Micro-/Mesoporosity: Template-Free Synthesis and Application as Catalyst Support. ***JACS*** 134 11852 3). Stoychev, G., et al. (2013). Hierarchical multi-step folding of polymer bilayers. ***Adv. Func. Mater.,*** DOI: 10.1002/adfm.201203245.

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