"Designing Bio-Inspired, Adaptive Gels with Controllable 3D Structures"

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Refreshments at 3:30, 116 Upson Hall

ABSTRACT
Biological systems exhibit a remarkable ability to dynamically respond to external cues and adapt their behavior to environmental changes. We focus on two ubiquitous structural motifs in biology—loops and fibers—that both play a crucial role in enabling and supporting the dynamic and beneficial structural changes in living organisms. Namely, the loops in biomolecules (DNA and proteins) give these molecules the necessary flexibility to perform functions that affect behavior across a range of length scales. The fibers in soft tissue (or bone in muscle) provide a level of stiffness that improves the mechanical performance of the system. Inspired by the utility of these biological motifs, we use computational modeling to incorporate these structural elements into thermo-responsive gels and thereby introduce new dynamic behavior and functionality into the system. With the introduction of loops, we use temperature to release the stored length contained in these loops and thereby modulate the structural and mechanical characteristics of the material “on demand”. We also pattern the structure of the sample so that only specified regions contain the temperature-sensitive loops. In this manner, we design soft materials that can produce anisotropic actuation, as well as actuation in just specified regions of the sample. This development can lead to materials that act as pumps or exhibit novel forms of mobility in solution. With the introduction of fibers in the outer layers of the gels, we design structures that could not be stabilized in other ways. Namely, stiff fibers on the surface of the gels significantly inhibit certain regions from swelling or shrinking as the external stimuli are varied. We exploit this behavior to determine how to organize the fibers on the outer layer(s) to achieve unprecedented forms of dynamic architectural changes. The common feature of these loop- and fiber-containing gels is that the application of heat leads to the novel forms of three-dimensional (3D) self-organization, spontaneously transforming uniform structures into functional shapes or converting 2D layers into 3D forms. Moreover, the transformations are reversible, allowing one sample of material to provide useful service in different environments. Furthermore, the synergistic interactions of the different components in these systems lead to novel dynamic, adaptive behavior. Overall, the studies can provide effective design rules for creating tunable dynamic materials that provide a route to new properties and performance.

BIOGRAPHICAL SKETCH
Anna C. Balazs is the Distinguished Professor of Chemical Engineering and the Robert von der Luft Professor at the University of Pittsburgh. She received her B.A. in physics from Bryn Mawr College and her Ph.D. in materials science from the Massachusetts Institute of Technology. After postdoctoral work in the Polymer Science Department at the University of Massachusetts, Amherst, she joined the faculty at the University of Pittsburgh. Her research involves developing theoretical and computational models to capture the behavior of polymeric materials, nanocomposites and multi-component fluids. Balazs is a Fellow of the American Physical Society, the Royal Society of Chemistry, and the Materials Research Society. She was a Visiting Fellow at Corpus Christi College, Oxford University in 2000-2001 and 2007-2008. She has served on a number of editorial boards, including: Macromolecules, Langmuir, Accounts of Chemical Research, and Soft Matter. She was Chair of the American Physical Society Division of Polymer Physics in 1999-2000. She received a Special Creativity Award from the National Science Foundation. In 2003, she received the Maurice Huggins Memorial Award of the Gordon Research Conference for outstanding contributions to Polymer Science. Recently, she received the American Physical Society Polymer Physics Prize (2016), Royal Society of Chemistry S F Boys-A Rahman Award (2015), American Chemical Society Langmuir Lecture Award (2014) and the Mines Medal from the South Dakota School of Mines (2013).