LIQUID CRYSTAL ELASTOMERS

Selinger leads team evaluating new class of polymers

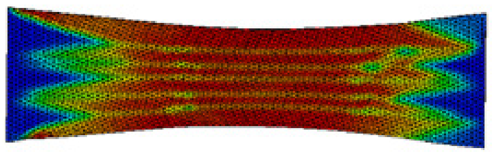
The emerging field of soft robotics requires mechanical components that grasp objects with the same delicacy as human hands. At present, most soft robots are powered by hard, sometimes bulky, actuators such as a servo motor, air compressor or hydraulic pump. However a new class of polymers, called "liquid crystal elastomers," may eventually find use as soft artificial muscles. A Kent State University research team led by Robin Selinger, Ph.D., leveraged Ohio Supercomputer Center's resources to analyze how these exciting new materials stretch, contract, curl or fold when heated, illuminated or exposed to an electric field.

"By modeling the co-evolution of a sample's microstructure and its strain field, we can predict its overall mechanical response and the sample's shape change," said Selinger, a professor of chemical physics. "My students and I wrote a finite element elastodynamics code from scratch and adapted it to model a variety of liquid crystal elastomers with different types of internal structure." The team collaborates with experimenters in Japan and the Netherlands.

A liquid crystal elastomer with uniform molecular alignment simply contracts and stretches when heated or cooled, but more complex types of actuation are also possible. Graduate student Vianney Gimenez-Pinto studied the way a liquid crystal elastomer with more complex internal microstructure behaves. She showed that a narrow liquid crystal elastomer ribbon can spontaneously twist and contract into a shape reminiscent of a rotini noodle when heated, while wider ribbons curl into the shape of a hollow cylinder. In both cases, she demonstrated that the twist direction reverses with change of temperature, in close agreement with experimental data.

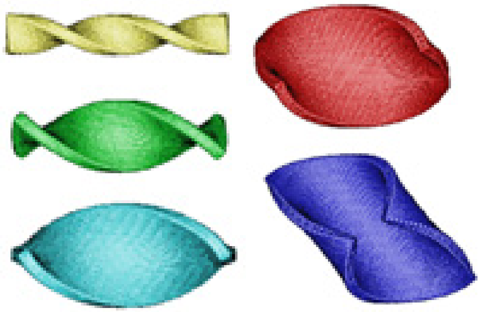
Even more complex structures produce contraction like a pleated window shade on heating. "In fact, by imposing a particular microstructure in a sample," Selinger suggested, "we can design a material that will spontaneously fold itself into any desired shape, a process known as auto-origami. The challenge here is to determine what internal microstructure will produce a particular desired shape or actuation behavior." Just for fun, Selinger also modeled how a liquid crystal elastomer "worm" could be actuated to crawl over hilly terrain.

Former graduate student Badel Mbanga, now a post-doctoral student at Tufts University, modeled how a liquid crystal elastomer's internal structure evolves when a sample is stretched. The resulting soft elastic response suggests that these materials may also find application as directional acoustic dampers.



(above) When a sample with uniform microstructure is stretched laterally, the microstructure evolves to form a pattern of stripes, giving rise to a remarkably soft elastic response.

(below) When heated, liquid crystal elastomer ribbons with twisted internal microstructure spontaneously deform from a flat initial state into a variety of curved shapes. The final shape depends on the ribbon's width-to-thickness ratio.



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