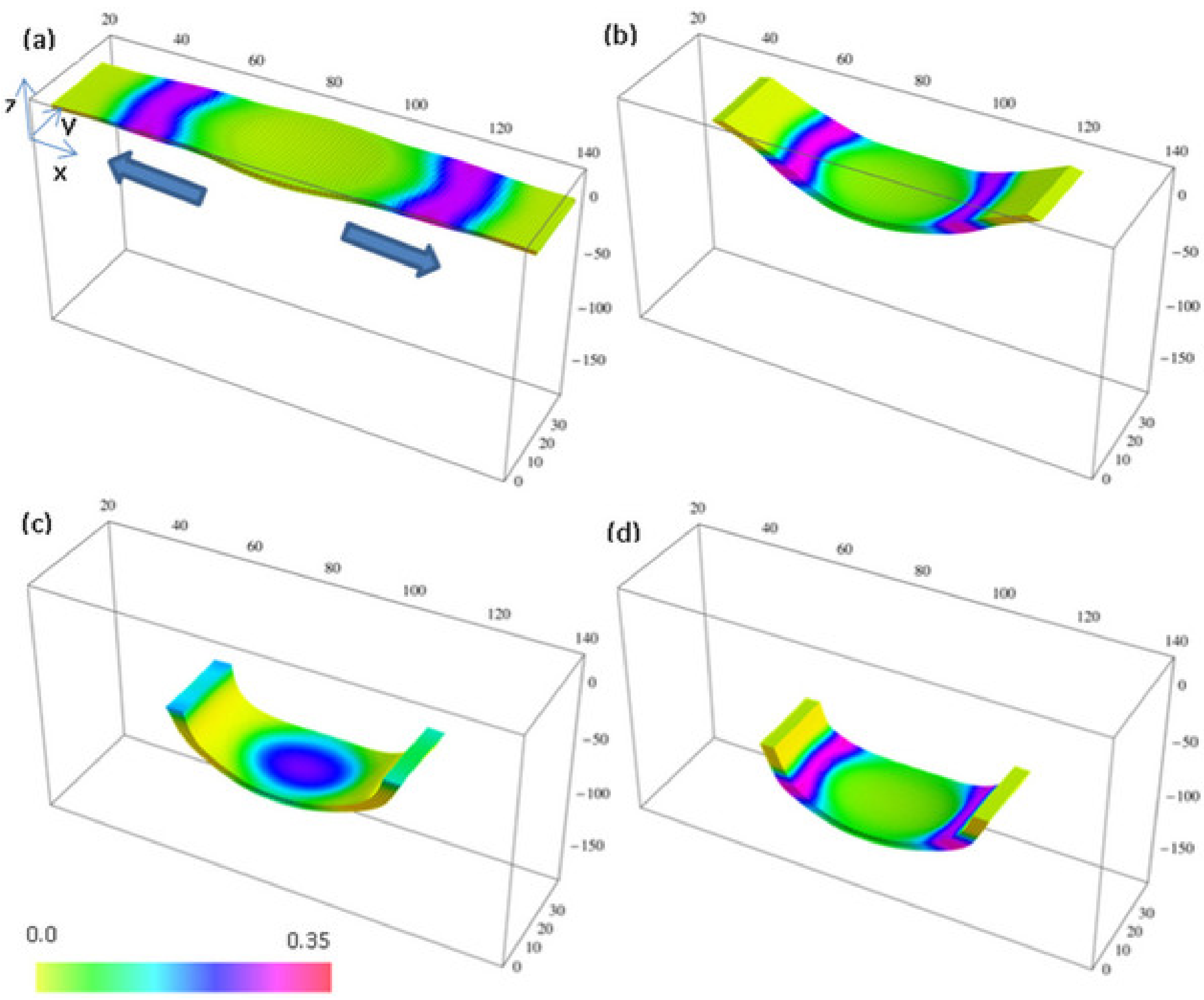
# Toward a squishier robot: Engineers design synthetic gel that changes shape and moves via its own internal energy

May 5 2015




Dynamics of a SP-BZ gel with total concentration of chromophores Ctsp=0.2. Credit: *Scientific Reports*, DOI: 10.1038/srep09569

For decades, robots have advanced the efficiency of human activity. Typically, however, robots are formed from bulky, stiff materials and require connections to external power sources; these features limit their dexterity and mobility. But what if a new material would allow for development of a "soft robot" that could reconfigure its own shape and move using its own internally generated power?

By developing a new computational model, researchers at the University of Pittsburgh's Swanson School of Engineering have designed a synthetic polymer gel that can utilize internally generated chemical energy to undergo shape-shifting and self-sustained propulsion. Their research, " Designing Dual-functionalized Gels for Self-reconfiguration and Autonomous Motion ", was published April 30th in the journal *Scientific Reports*, published by Nature.

The authors are Anna C. Balazs, PhD, the Swanson School's Distinguished Professor of Chemical and Petroleum Engineering and the Robert v. d. Luft Professor; and Olga Kuksenok, PhD, Research Associate Professor.

"Movement is a fundamental biological behavior, exhibited by the simplest cell to human beings. It allows organisms to forage for food or flee from prey. But synthetic materials typically don't have the capability for spontaneous mechanical action or the ability to store and use their own energy, factors that enable directed motion" Dr. Balazs said. "Moreover in biology, directed movement involves some form of shape changes, such as the expansion and contraction of muscles. So we asked whether we could mimic these basic interconnected functions in a synthetic system so that it could simultaneously change its shape and move."

As a simple example in nature, Drs. Balazs and Kuksenok use the single-celled organism euglena mutabilis, which processes energy to expand and contract its shape in order to move. To mimic the euglena's mobility, Drs. Balazs and Kuksenok looked to polymer gels containing spirobenzopyran (SP) since these materials can be morphed into different shapes with the use of light, and to Belousov-Zhabotinsky (BZ) gels, a material first fabricated in the late 1990s that not only undergoes periodic pulsations, but also can be driven to move in the presence of light.

"The BZ gel encompasses an internalized chemical reaction so that when you supply reagents, this gel can undergo self-sustained motion," Dr. Kuksenok explains. "Although researchers have previously created polymer chains with both the SP and BZ functionality, this is the first time they were combined to explore the ability of "SP-BZ" gels to change shape and move in response to light."

As Balazs and Kuksenok noted, these systems are distinctive because they not only undergo self-bending or folding, but also self-propelled motion. Namely, the material integrates the powerful attributes of each of the components-the ability of SP-functionalized gels to be "molded" with light and the autonomous mechanical actions of the BZ gels.

According to Dr. Balazs, there were unexpected results during their research. "Uniform light exposure won't work. We had to place the light at the right place in order for the gel to move. And if we change the pattern of the light, the gel displays a tumbling motion.

"We also found that if we placed the SP in certain regions of the BZ gel and exposed this material to light, we could create new types of self-folding behavior." The next phase of the research will be to combine the patterning of the SP and BZ functionality in the gels with the patterning of the light to expand the polymer's repertoire of motion.

Dr. Balazs adds that these SP-BZ gels could enable the creation of small-scale soft robotics for microfluidic devices that can help carry out multi-stage chemical reactions.

"Scientists are interested in designing biomimetic systems that are dissipative - they use energy to perform a function, much like our metabolism allows us to carry out different functions," she explained. "The next push in materials science is to mimic these internal metabolic processes in synthetic materials, and thereby, create man-made materials that take in energy, transform this energy and autonomously perform work, just as in biological systems."

The benefit of using polymer gels instead of metals and alloys to build a robot is that it greatly reduces its mass, improves its potential range of motion and allows for a more "graceful" device.

"To put it simply, in order for a robot to be able to move more autonomously in a more biomimetic way, it's better if it's soft and squishy," Dr. Kuksenok says. "It's ability to grab and carry something isn't impeded by non-flexible, hard edges. You'd also like its energy source incorporated into the design so that it's not carrying that as extra baggage. The SP-BZ gel is pointing us in that direction."

**More information:** Designing Dual-functionalized Gels for Self-reconfiguration and Autonomous Motion, *Scientific Reports*, DOI: 10.1038/srep09569

Provided by University of Pittsburgh

https://phys.org/news/2015-05-squishier-robot-synthetic-gel-internal.html