Pulsating gels could power tiny robots

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As a kid, did you ever put those little capsules into warm water and watch them grow into dinosaurs? When certain gels are put into a solution, they will not only expand, but also contract again, repeatedly, as if the little dinosaur grew and shrank over and over.

The way those gels change shape had never been theoretically examined, until now. Anna Balazs, Distinguished Professor and Robert von der Luft Professor in the Department of Chemical and Petroleum Engineering at the University of Pittsburgh, and Victor Yashin, a postdoctoral researcher in the department, have formulated the first general model to study large-scale shape changes in responsive gels. Their results are published today in the prestigious journal *Science*.

Balazs and Yashin studied a unique class of polymer gels called Belousov-Zhabotinsky (BZ) gels. "They don't need any external control, you put them in a bath of solution with some reagents, and they beat spontaneously like a heart," said Balazs, who also is a researcher in Pitt's Gertrude E. and John M. Petersen Institute of NanoScience and Engineering. The oscillation occurs because the gels contain a metal catalyst linked to the backbone of their polymer chain. The movement results in beautiful patterns that can be seen by the naked eye.

Such gels have potential as synthetic muscles materials that can do active work. "You could make little autonomous devices for a couple hours and, when they stop running, add more reagent," said Balazs. For example, the gels could be the artificial muscle for a micro-sized robot, or they could be used to deliver pulses of drugs to a patient.

All previous calculations involving how such responsive gels reacted were only one-dimensional: They assumed that the material was spherically uniform and that waves moved along only in one direction. Those models can only predict how the material's volume will change how it will swell and shrink. To capture changes in the shape of the material requires two-dimensional calculations, which Balazs and Yashin used to create their computer model.

Their model, called the gel lattice spring model, captures large-scale, two-dimensional deformations and chemical reactions within a swollen network of polymers. The model represents gel material as a lattice of springs, like hooked-together Slinky toys: When the material is deformed, it springs back.

When Balazs and Yashin applied their new technique to gels undergoing the BZ reaction, they observed traveling waves of local swelling that formed a rich variety of dynamic patterns and gave rise to distinctive oscillations in the gel's shape.

"This will open up a whole new field for studying morphological transformations in this soft material," said Balazs. "It is a nice computational tool for starting to investigate shape changes in gels."

In future studies, Balazs plans to take advantage of the 2D network construct to examine chemically or physically heterogeneous gels.

Source: University of Pittsburgh