Pumping iron: A hydrogel actuator with mussel tone

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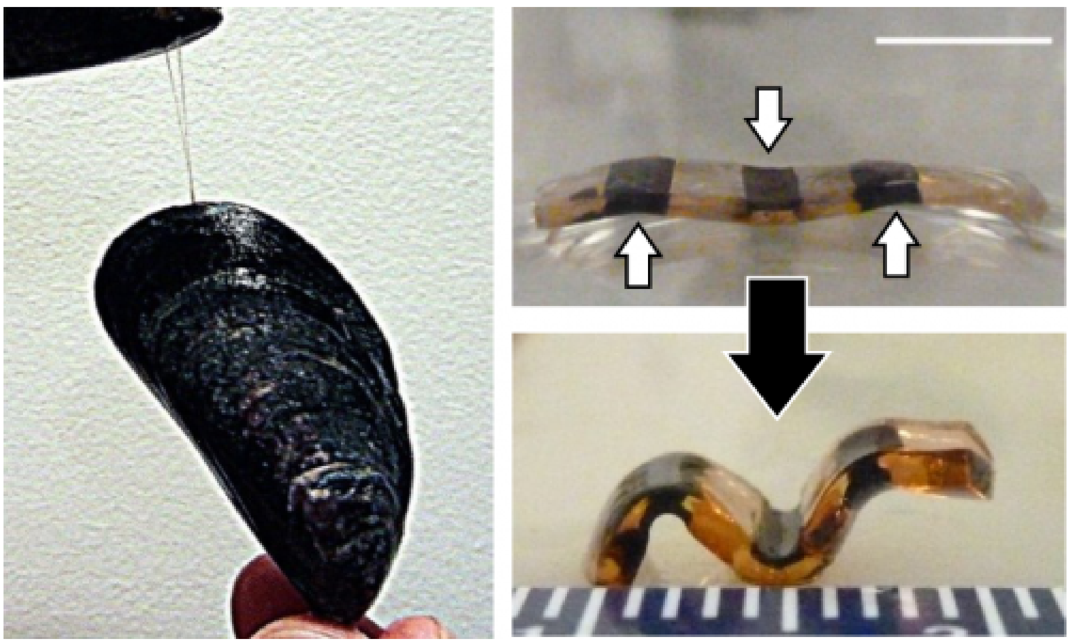

A hydrogel treated with dopamine and iron ions is flat under neutral conditions (top photo) and bends in an alkaline state. Michigan Tech's Bruce P. Lee borrowed chemistry found in the adhesive proteins of mussels, left, to make his hydrogel actuator. Credit: Bruce P. Lee

(Phys.org) —Protein from a small, tasty mollusk inspired Michigan Technological University's Bruce P. Lee to invent a new type of hydrogel actuator.

Hydrogels are soft networks of polymers with high water content, like jello. Because of their soft, gentle texture, they have the potential to interact safely with living tissues and have applications in a number of medical areas, including tissue engineering. Lee, an assistant professor of biomedical engineering, wanted to make a hydrogel that wouldn't just sit there.

"Hydrogels that can change shape on command could be used to deliver pharmaceuticals," he said. "We've taken a hydrogel and made it into an actuator: something that can change shape or move, maybe by opening the door for a drug and letting it out."

To make his movable hydrogel, Lee borrowed chemistry from proteins that mussels use to anchor themselves to wet rocks. A component in that protein, DOPA (for 3,4-dihydroxyphenylalanine), has unusual properties shared by its chemical cousin, dopamine, and it was dopamine that Lee incorporated into their hydrogel.

He started with a dopamine-suffused hydrogel shaped like a thick, short stick of gum. Next, he laid an iron rod across it in three places, each time running a charge through the rod to release iron ions onto the hydrogel's surface. Finally, he raised the hydrogel's pH.

The hydrogel moved on its own, bending like an inchworm where the ions had been deposited.

Lee explains: At an acid pH, only one side chain on the dopamine molecules attaches to the iron ions. "But if you raise the pH, three dopamine side chains converge to grab the one ion," he said. "That makes all the molecules come together, so the hydrogel shrinks in that spot, causing it to bend where the ions are."

A hydrogel could be programmed to adopt all manner of shapes by changing the placement of the ions, the composition of the hydrogel and the voltage. You can also remove the ions and reintroduce them in a different pattern, so that the same hydrogel can be reprogrammed to transform into a different shape.

"You can make it almost like a claw, so at some point it might even be able to pick things up," Lee said. "The body is slightly alkaline, so perhaps it could be loaded with a drug and introduced into the body, where it could release the drug. And maybe it could be designed to respond to other stimuli, like temperature."

Other scientists have used metal ions to make hydrogel actuators, but no one has used chemistry found in mussel adhesive proteins. Lee hopes to follow up on his initial discovery.

"Right now, our hydrogel actuator is slow and takes some time to bend," he said. "We need to study it more, and we also want to try it with other ions, like titanium and copper."

More information: A paper describing the work, "Novel Hydrogel Actuator Inspired by Reversible Mussel Adhesive Protein Chemistry," coauthored by Lee and undergraduate Shari Konst, was published online March 4 in *Advanced Materials*: onlinelibrary.wiley.com/doi/10 … a.201306137/abstract

Provided by Michigan Technological University

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