Food for thought—edible soft robotic candy actuators

By **Lori A. Wilson**

One of the goals of soft robotics is the ability to interface with the human body. Traditionally, silicone materials have dominated the field of soft robotics. In order to shift to materials that are more compatible with the body, developments are being made with biodegradable and biocompatible soft robotics.

The Soft Robotics Team at The Haverford School in Pennsylvania has developed gummy actuators that are biodegradable and edible. The idea emerged because it was a unique way to put robots in or on the body. The result is a combination of robotics and candy. They experimented with mold synthesis and formulating different chemical compositions of gummy material and documented their steps. The team is led by the director of robotics at The Haverford School, Holly Golecki, who has a background in bioengineering and materials science, and is supervised by Marion Jacob, a middle-school science teacher at Haverford. Contributors are Kyle Wagner, Richard "Cal" Buonocore, Xavier Segel, Matthew Baumholtz, Aditya Sardesai, Ruhao Sun, Bram Schork, and Yiheng "Intel" Chen.

They presented a poster titled "Design and Characterization of Edible Soft Robotic 'Candy' Actuators" at the 2018 Materials Research Society (MRS) Spring Meeting within Symposium SM01—Soft Materials, Sensors, Electronics, Displays and Actuators—Functional Components of Soft Machines and Robots. The poster won an honorable mention at the Thursday session. They also gave demonstrations of their actuators during coffee breaks .

The students were originally inspired after reading a paper on the soft robotics heart sleeve (Roche et al. 2017). They thought that using a biodegradable version of the actuators in this device could remove the need for implanting the device and subsequent surgery to remove it. The device could be implanted and then it would eventually degrade away.

This past fall, the students entered and won the High School Division of the Soft Robotics Toolkit Design competition hosted by Harvard University for their creation of an edible soft robotic actuator. To further explain their creation, first, commercially available gelatin-based candies were recast into pneumatic actuators utilizing molds found on Harvard's Soft Robotic Toolkit (https://softroboticstoolkit.com). Edible robotic devices were actuated repeatedly using a 150-psi power inflator. A novel gelatin-based formula, FORDmula, was later developed and used to create functional actuators. To investigate the mechanics and functionality of the FORDmula, students performed compression testing and biodegradation studies. The tests showed that at low strains, the material had similar behavior to traditional silicon materials. Degradation studies showed that actuation was possible within the first 15 minutes in a biologically relevant solution followed by complete dissolution of the actuator afterward. A taste test with elementary-aged peers proved the fun, edible nature of the actuators.

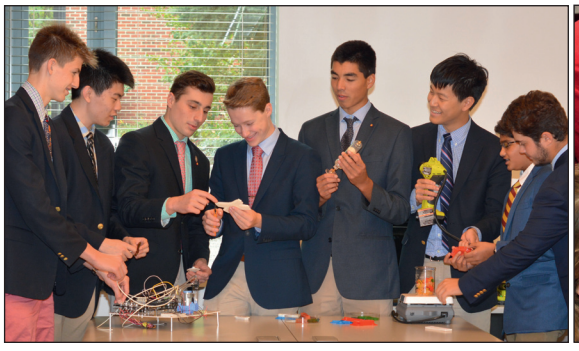
"From my perspective," Golecki says, "I see a lot of value in the creativity and exploration that the Soft Robotics Toolkit competition promotes for high-school students. It presents an authentic opportunity for students to contribute to this relatively new field. This group's enthusiasm has attracted more students to our soft robotics effort at Haverford, and students are working on both materials-based projects as well as adapting the control system to new applications."

"We wanted to find something that would taste good and was edible," Segel says. "And, more importantly, it would have the properties of a normal silicon polymer using the FORDmula," which consists of water, corn syrup, and gelatin.

This edible soft actuator was also designed to be a teaching tool for K–12 school teachers to encourage studies in robotics and materials science and engineering. The soft robots were brought to lower schools as part of the curriculum. "Imagine being six years old, and you walk into a science class, and your teacher says, 'today we are going to make robots out of gummy bears,' " Buonocore says.

The students are able to make the candy "move" by using a fluidic control board that inflates and deflates individual chambers with air. The mimicked motion allows for fun ways to deliver medication (e.g., dentistry purposes). "How cool would it be if a gummy actuator could just crawl into your mouth," Baumholtz says.

"The opportunity to present at the MRS 2018 Spring Meeting and interact with leaders from this field has invigorated the students' passion for this work and will likely have a profound impact on them going forward," Golecki says. To view the students' submission, visit https://vimeo.com/220906510 or https://softroboticstoolkit.com/edible-actuators. □



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