

Scientists Engineer 'Pumped-Up' Materials

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Robots with 'roid rage? Responsive prosthetics leading to the Six Million Dollar Man or the Bionic Woman? North Carolina State University scientists have devised new materials that aim to put some serious muscle behind robots or biomedical devices.

The artificial muscle materials are activated by an external electrical field and then change dimensions in specific directions. Besides a pumped-up robot or smart prosthetics, other uses for these materials could be small vehicles that fly or slither into a cave, responsive textiles, steerable catheters, microfluidic or haptic devices such as continuous-action micropumps and refreshable Braille pads and other biomedical applications.

In a paper published in the most recent edition of *Advanced Materials*, the NC State researchers, Dr. Richard Spontak, professor of chemical and biomolecular engineering and materials science and engineering, Dr. Tushar Ghosh, professor of textile and apparel technology and management, and Ravi Shankar, a doctoral student in fiber and polymer science and materials science and engineering, show that their materials produce a great deal of stretch - or actuation strain - with a greatly reduced electrical field.

"That's important," Spontak says, "because a reduced electric field and high field-induced displacement constitute the holy grail for electrically responsive organic materials targeted for advanced engineering and biomedical applications.

"Our material is a type of electroactive polymer called a dielectric elastomer. There are many different dielectric elastomers currently available, but ours is a blend of a molecularly self-organized polymer - called a block copolymer - and a block-selective oligomer such as mineral oil," Spontak says. "It is attractive because of its low cost, light weight, robust mechanical properties and potential to emulate biological muscle."

"The NC State material also shows a higher electromechanical coupling efficiency - the ability to turn electrical energy into mechanical work - and significantly fewer property changes due to either actuation or mechanical cycling than other tested materials," Ghosh added.

"When an external electric field is applied across the material from compliant electrodes on opposing sides of a film," Ghosh explains, "the active region of the elastomer squeezes together while enlarging laterally. The compression is due to the development of a 'Maxwell stress,' and is the underlying principle by which dielectric elastomers function."

In the paper, results demonstrate that the NC State materials attain actuation strains of about 250 percent on an area basis, and coupling efficiencies greater than 90 percent, which are the highest reported to date in this growing field of smart materials.

"The scientific literature is filled with numerous candidate materials tested for efficacy as artificial muscles. But since the NC State materials are a carefully chosen mixture of different components with specific functions, they can be physically tailored to achieve broadly different performance, giving them remarkable versatility that other, more conventional, electroresponsive materials are not able to match," Spontak adds.

And when the first robotic arm pins a human arm in an arm-wrestling match - it hasn't happened yet, but to some engineers it's akin to computer scientists developing a machine able to defeat a human in chess - the Spontak-Ghosh team wouldn't be surprised if their nanostructured dielectric elastomers provide the muscle behind the victory.

Citation: "Electroactive Nanostructured Polymers as Tunable Actuators", Ravi Shankar, Tushar K. Ghosh and Richard J. Spontak, NC State University, Published: 19, 2218, Sept. 2007, in *Advanced Materials*

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