New research improves conductive plastic for health, energy, other technologies

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Biological implants that communicate with the brain to control paralyzed limbs or provide vision to the blind are one step closer to reality thanks to research by Brian Collins, an assistant professor of physics at Washington State University.

Collins and an international team of scientists developed methods to improve the performance of a conductive plastic that can be used in devices that interface with the human body. Sensors based on the material are superior in detecting and recording signals used by neurons in the brain.

The material also could be used for better energy storage in the next generation of battery technology and might find its way into other flexible future applications.

The results are published in the April edition of *Nature Communications*.

"Because this material is biocompatible, it could be used in a wide array of medical implants and other on-the-body technologies," Collins said. "Circuits made with this polymer or another material like it could lead to clothing embedded with sensors, displays, even power sources, and might one day result in robotics that look, feel and even operate just like biological entities."

Optimizing conduction in plastic

Conductive plastic, or polymer, is a relatively new material. Its precursors are commonly seen in organic light-emitting diode (OLED)-based television sets and cell phones. Unlike metal-based devices and circuitry, polymers are flexible, easily mass-produced and biocompatible.

They are made from earth abundant elements (carbon, nitrogen and oxygen) and can be printed from inks. The materials studied by Collins have two additional important qualities: They can conduct both the electrical and ionic signals that neurons in the brain use to communicate. These qualities are also critical for materials in batteries.

To date, the problem with polymer-based electronics has been a lack of understanding in how their nanostructure affects performance, and therefore how to optimize that performance. Because they are made up of low-density carbon and other light elements, polymers are hard to study at the nanoscale.

"To have a device that can interface with the brain, it would need to be sensitive enough to detect faint ionic signals of neuronal activity and then capable of converting these to electrical signals that can be interpreted by a computer," Collins said. "Unfortunately, there are very few non-toxic commercial materials that can do this.

"With our research, it will be possible to achieve the critical capabilities of both types of conduction for polymer materials that can be used in the development of future devices," he said.

'Tuning' materials for best performance

Collins studies the relation between the physical nanostructure and electrical properties of conductive polymers. A novel resonant x-ray scattering technique he developed as a researcher at the National

Institute of Standards and Technology can uniquely probe molecular arrangements of polymer nanomaterials.

Using this technique, he was able to reveal how the arrangements can be controlled and tailored. His work was conducted using the Advanced Light Source at Lawrence Berkeley National Laboratory. His collaborators in the Department of Bioelectronics at the Ecole Nationale Supe´rieure des Mines in France then used a new method to separately measure electrical and ionic conductivity to determine which of the molecular configurations performed the best.

"Devices based on these materials could result in medical breakthroughs similar to the recent report of limb reanimation," Collins said, referring to Ian Burkhart of Ohio who, through a new experimental procedure involving neuron implants, can again articulate his fingers after being paralyzed for five years. "With our new ability to probe both polymer nanostructure and properties, it will be possible to tune materials for optimal performance in an array of novel technologies."

More information: Jonathan Rivnay et al. Structural control of mixed ionic and electronic transport in conducting polymers, *Nature Communications* (2016). DOI: 10.1038/ncomms11287

Provided by Washington State University

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