Carbon Nanotube-Coated Electrodes Improve Brain Readouts

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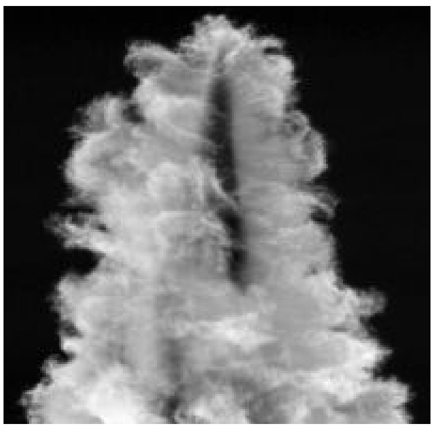

A scanning electron microscope image of a metal electrode (dark region in center of image) coated with carbon nanotubes.

A research group has significantly improved the quality of brain-function measurements by coating metal neural electrodes with carbon nanotubes. Their work could potentially allow scientists to learn more about brain diseases that are based on electrical impulse malfunctions, such as Parkinson's and epilepsy.

One limitation of current machines used to record brain signals are the electrodes: They have a natural resistance to electric current, called impedance, which compromises their ability to produce sensitive readouts. The impedance also makes the machines less effective at putting out charge when they are being used to simulate brain-cell activity via neurons in culture.

Coating the electrodes with carbon nanotubes, which have excellent electrical properties, offers a solution to both problems, discovered Edward Keefer, of the University of Texas Southwestern Medical School, and colleagues from the Texas Scottish Rite Hospital for Children, Vanderbilt University, and the University of North Texas.

“Modulation of brain activity to provide symptomatic relief from growing number of diseases such as Parkinson’s, depression, and epilepsy has become the treatment of choice when all other options fail," Keefer told *PhysOrg.com*. "The interface between the cells of the brain and the surface of the implanted electrode determines whether these treatments work or not. By coating electrode surfaces with carbon nanotubes, we can improve the efficiency of this cell-electrode interface by one-thousand times or even more.”

Keefer compared the improvement in nanotube-coated electrodes over standard electrodes to the difference between watching your favorite show on a 13-inch black-and-white television with a broken antenna or a brand-new 60-inch, high-definition, satellite-fed model.

"For an electrophysiologist, that is the difference the nanotube-coated electrodes make in what we can see on our oscilloscopes," he said.

The electrodes they tested were commercial varieties made of tungsten and stainless steel wire, which are thin and sharp. In two animal samples—the motor cortex of rats under anaesthesia and the visual cortex of awake rhesus macaque monkeys—the group took readouts with a nanotube-coated electrode and a non-coated electrode, and compared the results.

In both cases, the coated electrodes produced much better readings. The performance was further enhanced when the group used a coating made of a combination of carbon nanotubes and a conducting polymer material.

Additionally, scanning electron microscope images showed that the coating on the electrodes used for the monkeys had not been damaged by the tough outer brain layer, called the dura mater.

Besides performance, the coated electrodes have other advantages. Scientists have already documented the properties and performance of metal-coated electrodes used in other applications, such as electronics, and nanotubes appear to be nicely biocompatible. For example, scientists have had success using carbon nanotube substrates as supports for the growth of neurons.

Nanotube-coated electrodes are compatible with existing brain-machine devices, so that new equipment wouldn't need to be developed to use them.

While the group's tests were a success, nanotube-coated electrodes are not yet ready for humans. There is much more to learn, including how the coated electrodes hold up over long exposure to neural tissue.

Citation: Keefer, E. W., Botterman, B. R., Romero, M. I., Rossi, A. F. & Gross, G. W. *Nature Nanotech.* 3, 434-439 (2008).