Nanotube fibers being tested as a way to restore electrical health to hearts

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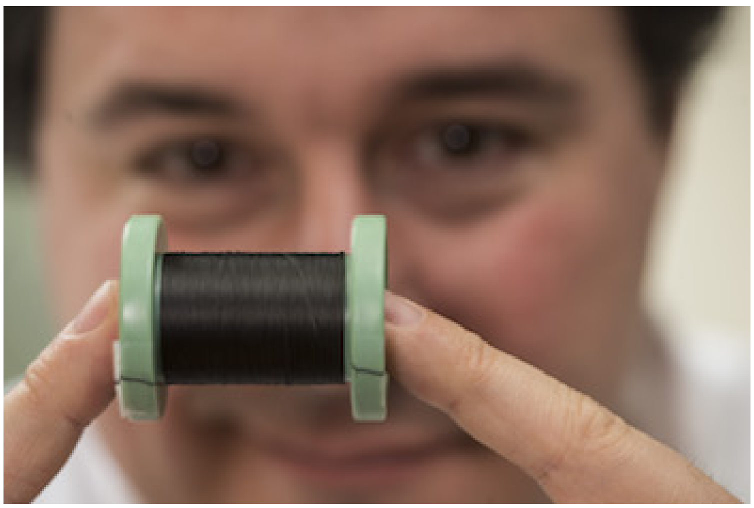

ice scientist Matteo Pasquali holds a spool of fiber made of pure carbon nanotubes. The fibers are being studied to bridge gaps in the conductivity in damaged heart tissues. Credit: Jeff Fitlow

Rice University and Texas Heart Institute researchers are studying the use of soft, flexible fibers made of carbon nanotubes to restore electrical conductivity to damaged heart tissue.

With support from the American Heart Association, these institutions will test the fibers' ability to bridge electrical gaps in tissue caused by cardiac arrhythmias that affect more than 4 million Americans each year.

A beating heart is controlled by electrical signals that prompt its tissues to contract and relax. Scars in heart tissue conduct little or no electricity. Soft, highly conductive fibers offer a way to work around those gaps.

"They're like extension cords," said Mehdi Razavi, the director of electrophysiology clinical research at the Texas Heart Institute and the project's lead investigator. "They allow us to pick up charge from one side of the scar and deliver it to the other side. Essentially, we're short-circuiting the short circuit."

The nanotube fibers developed at Rice by the lab of chemist and chemical engineer Matteo Pasquali are about a quarter of the thickness of a human hair. But even an inch-long piece of the material contains millions of nanotubes, microscopic cylinders of pure carbon discovered in the early 1990s.

Though the fibers were developed to replace the miles of cables in commercial airplanes to save weight, their potential for medical applications became quickly apparent, Pasquali said.

Rice research scientist Flavia Vitale is developing nanotube fiber applications. She is part of a collaboration with Texas Heart Institute to use the fibers as conductive bridges for damaged heart tissue. Credit: Jeff Fitlow

"We didn't design the fiber to be soft, but it turns out to be mechanically very similar to a suture," he said. "And it has all the electrical function necessary for an application like this."

Because the fibers are soft, flexible and extremely tough, they are expected to be far more suitable for biological applications than the metal wires used to deliver power to devices like pacemakers. They have already shown potential for helping people with Parkinson's disease who require brain implants to treat their neurological condition.

"People who progress to heart failure can have the formation of scar tissue over time," said Mark McCauley, a cardiac electrophysiologist at the Texas Heart Institute. "There are a lot of different ways scarring can affect conduction in the heart. Recently we've been most interested in the development of scarring after heart attacks, but we believe this fiber may help us treat all kinds of cardiac arrhythmias and electrical-conduction issues."

"Metal wires themselves can cause tissue to scar," said Flavia Vitale, a research scientist in Pasquali's lab who is developing nanotube fiber applications. "If you think about inserting a needle into your skin, eventually your skin will react and completely isolate it, because it's stiff. Scar will form around the needle.

"But these fibers are unique," she said. "They're smaller and more flexible than a human hair and so strong that they can resist flexural fatigue due to the constant beating of the heart."

Vitale noted the fibers' low impedance (its resistance to current) allows electricity to move from tissue to bridge and back with ease, far better than with metal wires.

The researchers are testing the fibers' biocompatibility but hope human trials are no more than a few years away.

Razavi said a safe, effective way to conduct electricity through scarred heart tissue will revolutionize treatment. "Should these more extensive studies confirm our initial findings, a paradigm shift in treatment of sudden cardiac death will be within reach, as for the first time the underlying cause for these events may be corrected on a permanent basis," he said.

Pasquali said he is gratified to see a new way in which nanotechnology, for which Rice is renowned, can help save lives. "We've been excited from the beginning to learn about each other's areas and come up with uses for the material," he said of his friendship – and now collaboration – with Razavi. "We're determined to find ways to treat rather than manage disease."

Provided by Rice University

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