Versatile fibers offer improved energy storage capacity for wearable devices

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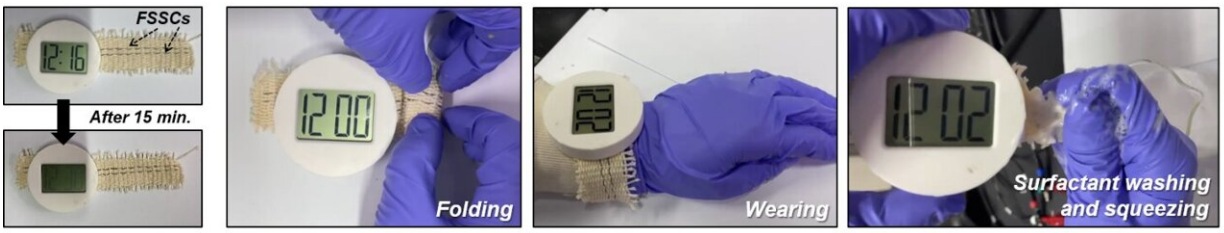


Carbon nanotube fibers fabricated into fiber-like supercapacitors (FSSCs) demonstrate their energy storage capabilities and wearable properties in a commercially available digital watch. Credit: Korea Institute of Science and Technology

The latest wearable devices, such as Samsung's Galaxy Ring and Apple's Vision Pro, are taking health care a step further and even enabling people to work virtually. Given the characteristics of wearable devices that require them to be small and lightweight, there is an inevitable limitation on battery capacity, still presenting a technical barrier to incorporating a variety of functions. In order for wearable devices to fully realize their potential, it is necessary to develop a lighter and 'more from less' energy storage method.

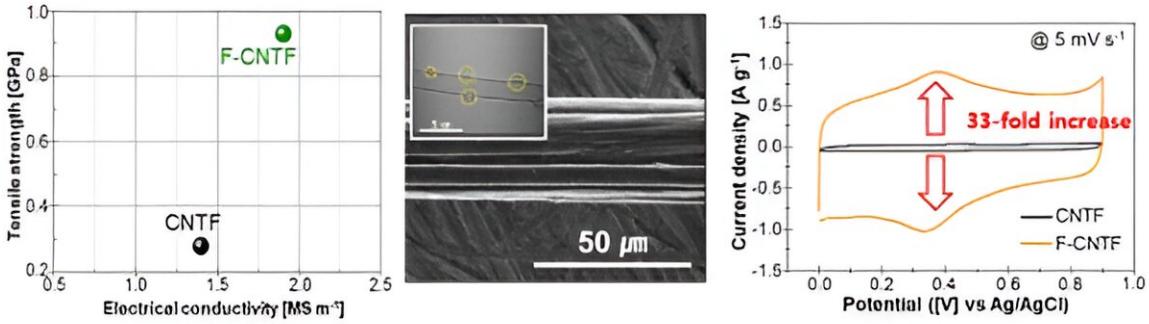
A joint research team led by Dr. Hyeonsu Jeong and Namdong Kim of the Center for Functional Composite Materials, Jeonbuk Branch, and Dr. Seungmin Kim of the Center for Carbon Fusion Materials has developed

a fiber-like electrode material that can store energy. The research is published in the journal *Advanced Energy Materials*.

The fibers are strong, lightweight, and highly flexible, enabling greater freedom in wearable device form factors and the ability to be made into various shapes and applications.

Carbon nanotube fibers are flexible, lightweight, and possess excellent mechanical and electrical properties, making them a promising material for wearable devices. However, due to their small specific surface area and lack of electrochemical activity, previous studies have mainly used them as a current collector and coated their surface with active materials.

However, this approach is not only uneconomical due to the high cost of additional materials and processes, but also has a high probability of separation of the active material from the fiber during long-term use or physical deformation.



A comparison of the mechanical and electrical conductivity property enhancement of functionalized carbon nanotube fiber compared to raw fiber, showing a 33-fold increase in electrochemical activity despite a clean surface with no active material. Credit: Korea Institute of Science and Technology

To solve this problem, the Korea Institute of Science and Technology (KIST) research team developed a fibrous electrode material with high energy storage capacity without the need for active materials. The team developed carbon nanotube fibers with both electrochemical activity and excellent physical properties by acid-treating and modifying powder-form carbon nanotubes, followed by spinning them into fibers.

The modified carbon nanotube fiber has 33 times more energy storage capacity, 3.3 times more mechanical strength, and more than 1.3 times more electrical conductivity than ordinary carbon nanotube fibers. Moreover, since the energy storage electrode material was developed using only pure carbon nanotube fibers, it can be mass-produced using wet spinning technology.

When tested with fiber-shaped supercapacitors, they retained nearly 100% of their performance when knotted and 95% of their performance after 5,000 bending tests. They also performed well when woven into the wrist straps of digital watches using a combination of regular and carbon nanotube fibers, after being bent, folded, and washed.

Dr. Kim Seung-min of KIST said, "We have confirmed that carbon nanotubes, which have recently started to attract attention again as a conductive material for secondary batteries, can be used in a much wider range of fields."

"Carbon nanotube fiber is a competitive field because we have the original technology and there is not much of a technology gap with advanced countries," said Dr. Hyeon Su Jeong, a co-researcher, adding, "We will continue our research to apply it as a core material for atypical energy storage."

Another co-researcher, Dr. Nam-dong Kim, said, " We are currently conducting research to apply this technology to fiber-type batteries with

higher energy density, going beyond supercapacitors. ."

More information: Hayoung Yu et al, Active Material-Free Continuous Carbon Nanotube Fibers with Unprecedented Enhancement of Physicochemical Properties for Fiber-Type Solid-State Supercapacitors, *Advanced Energy Materials* (2023). DOI: 10.1002/aenm.202303003

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