Paper-thin supercapacitor has higher capacitance when twisted than any non-twisted supercapacitor

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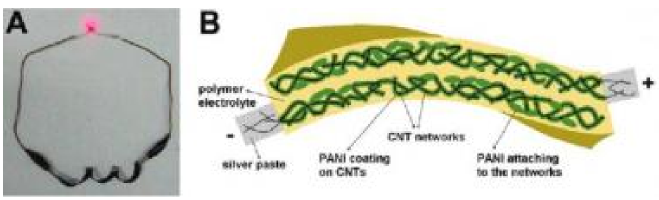

(A) Using three of the new highly flexible supercapacitors arranged in series, the researchers demonstrated lighting a red LED. (B) An illustration of the flexible, all-solid-state paper-like polymer supercapacitors. Image credit: Chuizhou Meng, et al. © 2010 American Chemical Society.

(PhysOrg.com) -- In an effort to develop wearable electronics, researchers have designed a new ultra-thin supercapacitor that has a capacitance that is six times higher than that of any current commercial supercapacitor. What's more, the new supercapacitor was tested in a twisted state to demonstrate its good electrochemical properties with high flexibility.

The researchers, Chuizhou Meng, et al., from the Tsinghua-Foxconn Nanotechnology Research Center at Tsinghua University in Beijing have published their results in a recent issue of Nano Letters.

As the researchers explain, portable electronic devices are becoming increasingly small and flexible. However, the energy management components - e.g. batteries and supercapacitors - tend to lag behind the other components when it comes to small size and flexibility. Specifically, supercapacitors are limited by their conventional configuration, which is a separator sandwiched between two electrodes sealed in liquid electrolyte. The two major drawbacks with this configuration are that the liquid electrolyte requires safety encapsulation materials to prevent leakage, and the multiple parts of the system that move relative to each other decrease the performance and cycle life of the device.

In an attempt to design an energy-storage device that is smaller and more flexible than previous devices, the researchers turned to carbon-based materials. By using two slightly separated electrodes made of polyaniline (a conductive polymer) and carbon nanotubes, and solidifying them in a gel polymer solid-state electrolyte (acting simultaneously as a separator), the researchers could fabricate a highly flexible supercapacitor that was as thin as a standard piece of paper. The novel materials and no moving parts enabled the researchers to overcome the problems with the conventional configuration, and further decrease the size and increase the flexibility of the device.

“We innovatively designed the microstructure and optimized the configuration of our supercapacitors so as to effectively make full use of each necessary component,” coauthor Changhong Liu told PhysOrg.com. “We omitted the heavy metal current collectors and bulky encapsulation of conventional supercapacitors. Here, carbon nanotubes formed a good electric conducting network, polyaniline provided extremely large pseudocapacitance, and the ultra-thin middle gel polymer electrolyte layer acted simultaneously as a separator. Overall, the devices are very flexible and paper-like.”

In tests, the researchers demonstrated that the new supercapacitor has a capacitance of 31.4 F/g when twisted, compared to 5.2 F/g for current commercial supercapacitors. The new supercapacitor also showed superior characteristics in other areas, such as a high power density, low leakage current, and long cycle life. The researchers predict that these properties could be further improved by optimizing the device's materials and structure, such as by shortening the distance between electrodes.

“To the best of our knowledge, this flexible paper-like supercapacitor has much higher specific capacitance than current high-level conventional commercial ones,” Liu said, adding that the researchers could not guarantee that they were aware of every commercial device.

The researchers also showed how three twisted supercapacitors connected in series could be used to light a red LED. After 15 minutes of charging at 2.5 V, the rolled-up supercapacitors lit the LED for almost 30 minutes. Given its high capacitance and flexibility that surpass current commercial supercapacitors, the new supercapacitor should be attractive for use in wearable electronics, an area which is still only beginning to be explored.

“We think that this lightweight and flexible energy storage device will have great application potential in future wearable electronics,” Liu said. “For example, incorporated with flexible display technology, it will make a flexible electronic book truly paper-like, by saving much weight and space. And in the future, when flexible large-scale integrated circuits come true, a lightweight and flexible notebook computer is much expected.”

More information: Chuizhou Meng, et al. “Highly Flexible and All-Solid-State Paperlike Polymer Supercapacitors.” *Nano Lett*. ASAP. DOI:10.1021/nl1019672

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