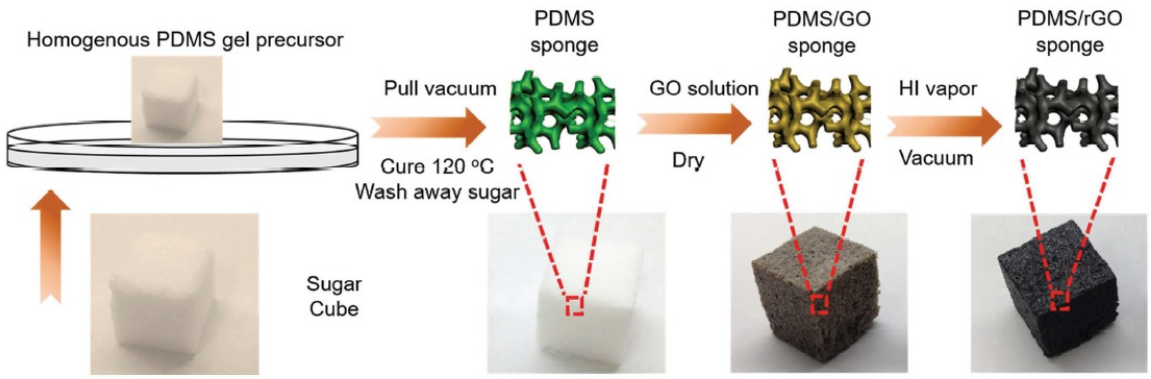
Stretchable sodium-ion battery electrodes made using sugar cubes

April 25 2017, by Lisa Zyga



A sugar cube serves as a template for new stretchable, sponge-like, graphene-based battery electrodes. Credit: Li et al. ©2017 WILEY-VCH

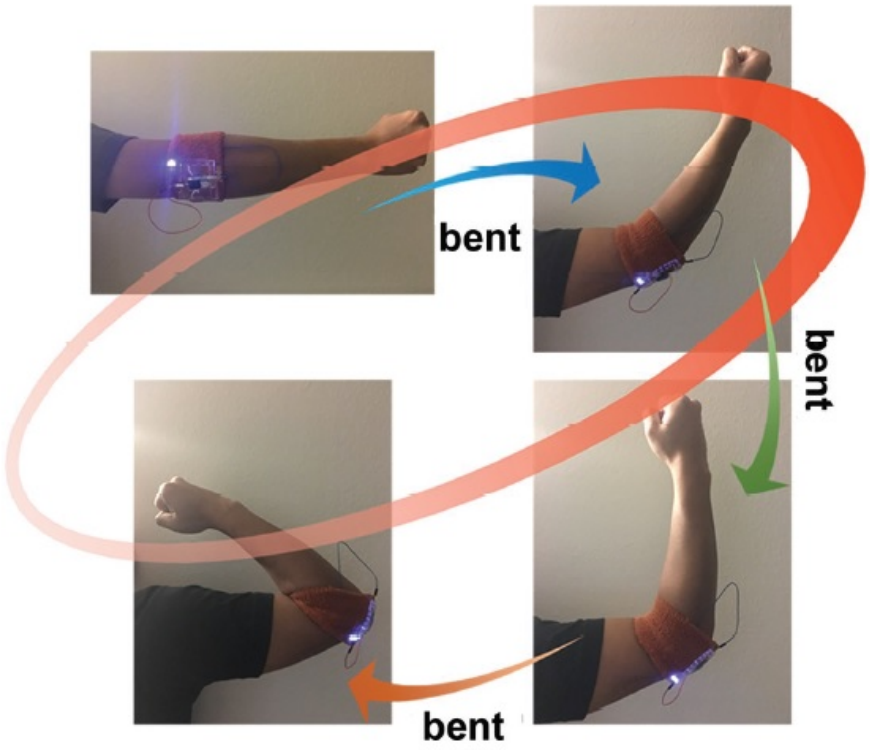
(Phys.org)—Scientists have used sugar cubes as a template for synthesizing stretchable battery electrodes, which serve as a key component in newly designed stretchable yet mechanically robust sodium-ion batteries. Although there has recently been a great deal of research on stretchable batteries, usually these devices still contain some rigid components. By using electrodes templated on sugar cubes, the new

battery is one of the first sodium-ion batteries whose components are all fully stretchable.

The scientists, led by Guihua Yu at the University of Texas at Austin, have published a paper on the new stretchable batteries in a recent issue of *Advanced Materials*.

By starting with sugar cubes, the researchers were able to obtain the size, shape, and porosity needed for high-performance battery electrodes. The researchers first placed ordinary sugar cubes on top of a polymer gel in a dish. After the dish was placed in a vacuum, heated in an oven, and washed, the sugar was dissolved away and the polymer gel took its place, resulting in stretchable polymer sponges. The pores of the polymer sponges were then filled with a conductive graphene-based solution to create "sponge electrodes," which the researchers achieved by immersing the sponges in the solution and squeezing them several times to soak it up.

As the researchers explained, the sponge's porous architecture provides a combination of stretchability, mechanical strength, fast sodium-ion transport, and large storage capacity. Tests showed that the full battery can be stretched to 50% beyond its original length, and that the strain is limited by the intrinsic properties of the polymer material. The researchers expect that modifying the polymer or developing a new nanoarchitectured elastomer could further increase the stretchability of the battery.



The stretchable sodium-ion full battery is attached to an athletic elbow brace under different bending states, where it continuously powers a commercial LED light. Credit: Li et al. ©2017 WILEY-VCH

"This first-of-its-kind battery design maintains better mechanical properties compared with most reported designs using one or more rigid components that fail to meet the stretchability requirement for the entire device," Yu told Phys.org. "Moreover, the demonstrated electrochemical performance rivals most previously reported stretchable energy systems. This novel stretchable sodium-ion battery represents a promising alternative for the next generation of energy-storage technologies in a broad range of applications."

In its current form, the battery retains nearly 90% of its capacity after 100 cycles of stretching to 50% strain. This performance is sufficient to enable the researchers to mount the stretchable battery on an elbow brace, and demonstrate that the battery continues to power an LED when the user's arm is bent at different angles. The stretchable battery has potential applications in conformable health monitoring skin sensors, wearable communication devices, roll-up displays, and implantable medical devices.

In the future, the researchers plan to make further improvements to the battery, such as extending the lifetime and scaling up the design to larger-sized batteries. They anticipate that the sponge design can also be extended to other types of devices, such as energy-harvesting devices.

"Future directions will be focused on further improving the mechanical properties and electrochemical performance, along with lowering the manufacturing cost," Yu said.

More information: Hongsen Li et al. "An All-Stretchable-Component Sodium-Ion Full Battery." *Advanced Materials*. DOI: 10.1002/adma.201700898