Paper-and-scissors technique rocks the nano world

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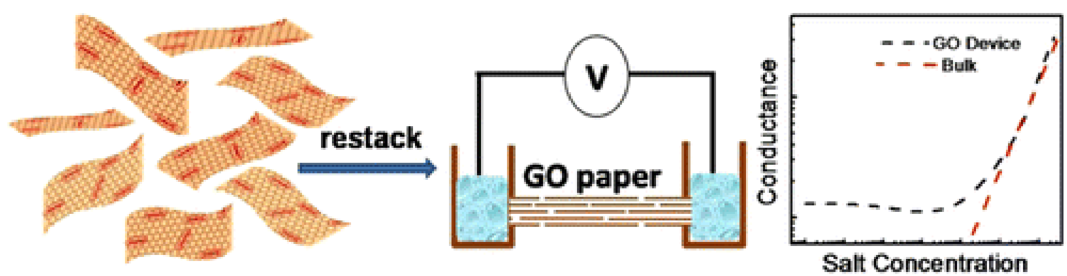

Credit: JACS

Sometimes simplicity is best. Two Northwestern University researchers have discovered a remarkably easy way to make nanofluidic devices: using paper and scissors. And they can cut a device into any shape and size they want, adding to the method's versatility.

Nanofluidic devices are attractive because their thin channels can transport ions—and with them a higher than normal electric current—making the devices promising for use in batteries and new systems for water purification, harvesting energy and DNA sorting.

The "paper-and-scissors" method one day could be used to manufacture large-scale nanofluidic devices without relying on expensive lithography techniques.

The Northwestern duo found that simply stacking up sheets of the inexpensive material graphene oxide creates flexible "paper" with tens of thousands of very useful channels. A tiny gap forms naturally between neighboring sheets, and each gap is a channel through which ions can flow.

Using a pair of regular scissors, the researchers simply cut the paper into a desired shape, which, in the case of their experiments, was a rectangle.

"In a way, we were surprised that these nanochannels actually worked, because creating the device was so easy," said Jiaxing Huang, who conducted the research with postdoctoral fellow Kalyan Raidongia. "No one had thought about the space between sheet-like materials before. Using the space as a flow channel was a wild idea. We ran our experiment at least 10 times to be sure we were right."

Huang is an assistant professor of materials science and engineering and the Morris E. Fine Junior Professor in Materials and Manufacturing in the McCormick School of Engineering and Applied Science.

"Many people have studied graphene oxide papers but mainly for their mechanical properties or for making graphene," Huang said. "Here we show that graphene oxide paper naturally generates numerous nanofluidic ion channels when layered."

The findings are published in the *Journal of the American Chemical Society*.

To create a working device, the researchers took a pair of scissors and cut a piece of their graphene oxide paper into a centimeter-long rectangle. They then encased the paper in a polymer, drilled holes to expose the ends of the rectangular piece and filled up the holes with an electrolyte solution (a liquid containing ions) to complete the device.

Next they put electrodes at both ends and tested the electrical conductivity of the device. Huang and Raidongia observed higher than normal current, and the device worked whether flat or bent.

The nanochannels have significantly different—and desirable—properties from their bulk channel counterparts, Huang said. The nanochannels have a concentrating effect, resulting in an electric current much higher than those in bulk solutions.

Graphene oxide is basically graphene sheets decorated with oxygen-containing groups. It is made from inexpensive graphite powders by chemical reactions known for more than a century.

Scaling up the size of the device is simple. Tens of thousands of sheets or layers create tens of thousands of nanochannels, each channel approximately one nanometer high. There is no limit to the number of layers—and thus channels—one can have in a piece of paper.

To manufacture very massive arrays of channels, one only needs to put more graphene oxide sheets in the paper or to stack up many pieces of paper. A larger device, of course, can handle larger quantities of electrolyte.

More information: The paper is titled "Nanofluidic Ion Transport through Reconstructed Layered Materials."
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