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A Salt and Paper Battery

The simple, non-polluting battery could be used in compact devices.

By Prachi Patel

Researchers at Uppsala University in Sweden have made a flexible battery using two common, cheap ingredients: cellulose and salt. The lightweight, rechargeable battery uses thin pieces of paper--pressed mats of tangled cellulose fibers--for electrodes, while a salt solution acts as the electrolyte.

The new battery should be cheap, easy to manufacture, and environmentally benign, says lead researcher Maria Stromme (http://personal.teknik.uu.se/Teknikvetenskaper/nfm/staff/maria/maria.html) . She suggests that it might be used to power cheap medical diagnostics devices (http://www.technologyreview.com/biomedicine/23110/) or sensors on packaging materials or embedded into fabric. "You don't need advanced equipment to make the batteries," Stromme says, "so they could be made on site in developing countries."

The new battery uses a type of rechargeable thin-film design (http://www.technologyreview.com/energy/17513/) that many other researchers and companies have been working on for several years.

Thin-film batteries typically use solid electrolytes instead of liquid or gel, and their electrodes are typically made of lithium combined with metals such as nickel, cobalt, or manganese. The salt-and-paper battery is an ideal replacement for the lithium ones used in many low-power portable devices, such as wireless sensors, smart cards, medical implants, and RFID tags. "For these applications, the thinner and smaller the battery, the better," says Sara Bradford, an energy and power consultant at Frost & Sullivan.

Thin-film batteries have other attractive features. They have a long shelf life, retaining their charge after being stored for many years, and they can be charged and discharged tens of thousands of times, says Raghu Das, CEO of research company IDTechEX and an expert on printed electronics, "enabling wireless sensors that can last for decades with an appropriate energy harvester attached."

However, only a handful of startups, such as Infinite Power Solutions

(http://www.infinitepowersolutions.com/) in Littleton, CO, and Solicore (http://www.solicore.com/) in Lakeland, FL, have generated enough venture backing to bring their batteries to market. Cymbet (http://www.cymbet.com/) in Elk River, MN, and Excellatron (http://www.excellatron.com/) in Atlanta, GA, are other strong contenders with market-ready technologies. More than four million thin-film batteries will ship this year, according to a May 2009 report (http://www.nanomarkets.net/news/pr_detail.cfm?PRID=352) by market research firm NanoMarkets.

The new paper battery, described in a paper published online in the journal *Nano Letters (http://pubs.acs.org/doi/abs/10.1021/nl901852h)* , has some catching up to do. Lithium batteries can deliver 4 volts and have energy densities of 200 to 300 milliwatt-hours per gram. In comparison, a single paper battery cell delivers 1 volt and can store up to 25 milliwatt-hours of energy per gram. When providing maximum current, it loses 6 percent of its storage capacity after 100 recharging cycles. However, Stromme says that her team has already run the battery for 1,000 recharging cycles at lower current. She also points out that these are numbers from an initial laboratory prototype.

The researchers are now working on optimizing the battery. Eventually, stacking multiple cells together and connecting them in series will increase the voltage. Meanwhile, depending on the application, she says, "we can tune the size and the current we draw to fulfill those requirements."

The paper battery can furthermore be recharged much faster than a lithium battery. The cellulose that Stromme and her colleagues use comes from a type of polluting algae found in seas and lakes. Although the algae's cell walls contain cellulose, it has a very different nanostructure, which gives it 100 times the surface area. The researchers coat the paper made from this cellulose with a conducting polymer and then sandwich a salt-solution-soaked filter paper between the paper electrodes.

Chlorine ions flow from the positive electrode to the negative one, while electrons travel through the external circuit, providing current. The paper electrode stores charge while recharging in tens of seconds because ions flow through the thin electrode quickly. In contrast, lithium batteries take 20 minutes to recharge. "The combination of large capacity and small charging time is very unique," Stromme says.

Bradford says that the new paper battery is at a relatively early research stage compared to other thin-film technologies. "For a battery to succeed, you need to have a good cost and manufacturing process in place, but performance is the key aspect," she says. "If it's not a several-degrees improvement on existing technology, it's very hard to make the battery profitable."

Stromme, meanwhile, is confident that the environmentally friendly design will find

niche applications. She says that it could be produced commercially within three years.

Upcoming Events

Lab to Market Workshop (http://www.technologyreview.com/emtech/09/workshop.aspx)
Cambridge, MA
Tuesday, September 22, 2009
http://www.technologyreview.com/emtech/09/workshop.aspx (http://www.technologyreview.com/emtech/09/workshop.aspx)

EmTech 09 (http://www.technologyreview.com/emtech)
Cambridge, MA
Tuesday, September 22, 2009 - Thursday, September 24, 2009
http://www.technologyreview.com/emtech (http://www.technologyreview.com/emtech)

Nanotech Europe 2009 (http://www.nanotech.net)
Berlin, Germany
Monday, September 28, 2009 - Wednesday, September 30, 2009
http://www.nanotech.net (http://www.nanotech.net)

2009 Medical Innovation Summit (http://www.ClevelandClinic.org/innovations/summit)
Cleveland, OH
Monday, October 05, 2009 - Wednesday, October 07, 2009
http://www.ClevelandClinic.org/innovations/summit (http://www.ClevelandClinic.org/innovations/summit)

Optimizing Innovation 2009 (http://www.connecting-group.com/Web/EventOverview.aspx?Identificador=6)
New York, NY
Wednesday, October 21, 2009 - Thursday, October 22, 2009
http://www.connecting-group.com/Web/EventOverview.aspx?Identificador=6 (http://www.connecting-group.com/Web/EventOverview.aspx?Identificador=6)