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New Battery Resembles Paper

By Veronica Raymond
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A battery that resembles a small sheet of paper could pave the way for a new generation of extremely flexible, cheap, and environmentally friendly energy sources.

A traditional battery has three key elements: an electrolyte solution made up of positive and negative ions, two electrodes made of different materials between which the ions flow, and a separator membrane through which positive and negative ions pass in opposite directions. Attempts to make batteries less bulky and more flexible have met with limited success, largely because of the challenges of combining these elements into thinner materials. A team of scientists headed by chemist Robert Linhardt, materials scientist Pulickel Ajayan, and engineer Omkaram Nalamasu of Rensselaer Polytechnic Institute in Troy, New York, wondered whether paper might be the answer.

To make the new battery, the researchers dissolved cellulose, a plant material used to make paper, in a liquid salt solution. They then added microscopic carbon nanotubes and let the mixture dry. Those steps yielded a thin film that resembled a piece of paper, which was white on one side and black with nanotubes on the other. To complete the battery, the team soaked the cellulose with a lithium hexafluorophosphate solution and covered the white side of the film with lithium metal. The carbon nanotubes served as one electrode and the lithium metal the other. The solution provided the electrolyte, and the cellulose worked as the spacer.

Each gram of paper produces about 10 milliamps of current at 2 volts, and the researchers were able to use the batteries to power a fan and LED light. Stacking multiple sheets increases the power, the team reports online this week in the *Proceedings of the National Academy of Sciences*. Unlike other flexible batteries, the paper battery is completely integrated, says Linhardt.

The battery has other advantages. It works in temperatures as high as 150 °C and as low as -70 °C, it retains the flexibility of paper, and, because it's made from 90% cellulose, it's cheap to manufacture. Its low toxicity also makes it an attractive power source for medical devices such as pacemakers and insulin pumps, Linhardt says.

The initial results are "very encouraging," says electrical engineer Sandipan Pramanik of the University of Alberta in Edmonton, Canada. In addition to medical applications, he thinks the technology will provide a better way to charge cell phones and laptops. Before that happens, however, Pramanik says engineers will have to find a way to manufacture the paper batteries on a large scale.

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