

**Economist.com** SEARCH

RESEARCH TOOLS

**Get 6 FREE issues >>** [Subscribe](#) | [Activate](#) | [RSS](#) | [Help](#)

Wednesday August 15th 2007

**EP** = requires subscription | LOG IN: E-mail address  Password   Remember me | [Register »](#)

PRINT EDITION



[Full contents](#) | [Subscribe](#)  
[Enlarge current cover](#)  
[Past issues/regional covers](#)

**NEWS ANALYSIS****POLITICS THIS WEEK****BUSINESS THIS WEEK****OPINION**

[Leaders](#)  
[Letters to the editor](#)  
[Blogs](#)  
[Columns](#)  
[Gallery](#)

**WORLD**

[United States](#)  
[The Americas](#)  
[Asia](#)  
[Middle East & Africa](#)  
[Europe](#)  
[Britain](#)  
[International](#)

[Country Briefings](#)   
[Cities Guide](#)

**SPECIAL REPORTS****BUSINESS**

[Management](#)  
[Business Education](#)

**FINANCE & ECONOMICS**

[Economics Focus](#)  
[Economics A-Z](#)

**SCIENCE & TECHNOLOGY**

[Technology Quarterly](#)

**BOOKS & ARTS**

[Style Guide](#)

**PEOPLE**

[Obituary](#)

**MARKETS & DATA**

[Weekly Indicators](#)  
[Currencies](#)  
[Rankings](#)  
[Big Mac Index](#)  
[Chart Gallery](#)

**DIVERSIONS**

[Correspondent's Diary](#)

**RESEARCH TOOLS****AUDIO****DELIVERY OPTIONS**

[E-mail Newsletters](#)  
[Mobile Edition](#)

**Technology Monitor****Storing electricity****It looks good on paper**

Aug 14th 2007  
 From Economist.com

**Cellulose and nanotubes combine to bring flexible batteries to the world**

ELECTRICITY-storage devices are getting more flexible, in a literal sense as well as in their design. This week sees the unveiling of the most robust but flexible battery ever. Pulickel Ajayan and his colleagues at Rensselaer Polytechnic Institute in New York made it by mixing carbon nanotubes (cylindrical, electrically conductive molecules made of carbon atoms) with cellulose, the stuff of paper. The result, which they report in this week's *Proceedings of the National Academy of Sciences*, is an energy store that is cheap, flexible and paper-thin.

Broadly speaking, devices for storing electricity come in two varieties: batteries and capacitors. Batteries contain lots of incipient electricity in the form of chemicals that, when they react, can be used to generate an electric current. Such "high energy density" devices, however, release their potential slowly. For a short, sharp shock a capacitor is better. This is a low energy-density device, which stores electricity directly by charging two conductive plates with static. One plate is positive, the other negative. When the plates are connected as part of a circuit, the charge flows rapidly between them and produces a far more powerful current than a battery. This is ideal for applications such as camera flashes.

The delightful thing about Dr Ajayan's device is that with suitable tweaking it can be used as a capacitor, a battery, or both. A sheet containing two layers of nanotubes acts as a capacitor (each layer is a plate). A sheet containing one layer, but with a coating of metallic lithium on the other side, acts as a lithium-ion battery. A sheet with two layers of nanotubes and a lithium coating can be switched from one application to the other as required.

The crucial component for making this material is an exotic solvent called 1-butyl, 3-methylimidazolium chloride. This molecular mouthful has the rare ability among solvents of being able both to dissolve cellulose and to act as an electrolyte—that is, a chemical that can carry charge between the electrodes of a battery in the form of charged molecules, or ions. It is thus integral both to the manufacturing process of the device and to its operation.

The result is a material that works at temperatures from  $-80^{\circ}\text{C}$  to  $180^{\circ}\text{C}$ , and can be rolled up, folded or cut like paper with no effect on its performance. It could be attached to folding solar panels of the sort used in space missions, and back on Earth it could provide portable power in deserts or at the poles.

The three-layer version, in particular, provides a unique hybrid power supply. It has the characteristics needed for applications that require both high-power pulses and steady, battery-like flow. Moreover, it provides them both while charging and while discharging. Hybrid cars are one such application. Many use dynamos to recover their energy of motion when they brake. The recovered energy is normally stored in a battery. However, such a car needs a burst of energy to get going again. Dr Ajayan's device could provide this more effectively than a conventional battery.

Like the cells of a conventional battery, layers of supercapacitor can be stacked together to increase output. Unlike conventional batteries, however, no poisonous chemicals are used to make Dr Ajayan's device. That makes it promising for medical

[Printable page](#)[E-mail this](#)[Get e-mail alerts](#)[RSS feed](#)[Bookmark](#)**Related Items****More...**[Technology monitor](#)**Websites**[Pulickel Ajayan discusses his work.](#)

Advertisement

**Economist Conferences**

**Fourth China Branding Roundtable**

**Winning moves for a changing game**

Sep 18th-19th 2007  
Beijing

RSS Feeds  
Screensaver

**CLASSIFIED ADS**

**The Economist Group**

Economist Intelligence Unit  
Economist Conferences  
The World In  
Intelligent Life  
CFO  
Roll Call  
European Voice  
EuroFinance Conferences  
Economist Diaries and  
Business Gifts

**EIU** [onlinestore](#) »

Advertisement



How would you characterise business conditions in the world today? Which countries have the best environments for investment? Take part in the inaugural **Global Business Barometer** survey, a quarterly benchmark of global business conditions for The Economist.



applications. Cellulose, which makes up more than 90% of the weight of the devices, is already used in implants. Carbon nanotubes are not fully tested in medical applications, but should be inert. And the researchers did some preliminary experiments using body fluids such as blood and sweat as electrolytes (having sweated the 1-butyl, 3-methylimidazolium chloride out first), and obtained encouraging results.

The next phase is to scale up the manufacturing process, with the aim of making the material rather as you would convert wood-pulp to newsprint. When you need more portable power, you may one day just pull some off a roll, and go.

[Back to top](#) »

Advertisement

**Blog: Free exchange**  
Real-life economics. No algebra

**Read more :**  
[How to save the environment: pri](#)  
[Put Mother Earth up for auction](#)  
Wed, 15 Aug 2007 17:34

**Economist.com**  
Global analysis. Daily

**Classified ads**

**Jobs**

VP, Global Program  
Job Title: Vice  
President, Global  
Program Reports To:  
President and CEO  
Location: Intern....

**Business / Consumer**

#1 rated internet  
business looking for  
professional  
consultants. No  
previous technical  
experience required.

**Tenders**

Supply of Laboratory  
equipment, Field  
equipment and Office  
and Library furniture  
for the Harry  
Oppenheimer  
Okavango Research  
Centre (HOORC).

**Property**

Waterfront Villa for  
Yacht & Golf lovers  
Waterfront Villa for  
Yacht & Golf lovers  
Island of Mallorca  
SW, S....

**Jobs**

Senior Programme  
Manager, Americas  
Economist  
Conferences, a  
division of the  
Economist  
Intelligence Unit  
(EIU), is a....

**Business / Consumer**

#1 rated internet  
business looking for  
professional  
consultants. No  
previous technical  
experience required.

**Sponsors' feature**

[About sponsorship](#) »

Sage advice ... with a twist  
Economist.com's weekly  
column covering the  
financial markets  
**Buttonwood**  
[Click here to read](#) »

**Don't let  
the  
information  
age**

[About Economist.com](#) | [About The Economist](#) | [Media Directory](#) | [Staff Books](#) | [Advertising info](#) | [Career opportunities](#) | [Contact us](#)

Copyright © The Economist Newspaper Limited 2007. All rights reserved. [Advertising Info](#) | [Legal disclaimer](#) | [Accessibility](#) | [Privacy policy](#) | [Terms & Conditions](#) | [Help](#)