FAST BREAKING PAPERS - 2009

December 2009

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Patrice Simon & Yury Gogotsi talk with *ScienceWatch.com* and answer a few questions about this month's Fast Breaking Paper in the field of Materials Science. The authors have also sent along images of their work.

Article Title: Materials for electrochemical capacitors
Authors: Simon, P;Gogotsi, Y
Journal: NAT MATER, Volume: 7, Issue: 11, Page: 845-854, Year: NOV 2008
* Univ Toulouse 3, CIRIMAT, CNRS, UMR 5085, F-31062 Toulouse 4, France.
* Univ Toulouse 3, CIRIMAT, CNRS, UMR 5085, F-31062 Toulouse 4, France.
* Inst Univ France, F-75005 Paris, France.
* Drexel Univ, Dept Mat Sci & Engn, Philadelphia, PA 19104 USA.

Top: Patrice Simon, bottom: Yury Gogotsi

SW: Why do you think your paper is highly cited? Does it describe a new discovery, methodology, or synthesis of knowledge?

This paper describes the current state-of-the-art in the field of electrochemical capacitors (ECs) or "supercapacitors," from both the scientific and applications points of view. Many new discoveries have been made and new applications have appeared since publication of the last major review article dedicated to supercapacitors in 2001 (R. Kötz, *et al*.). Those recent developments have brought ECs to the front edge of the energy storage area. Thus, a review of the latest discoveries within the entire field was timely and quite important for facilitating further advances. It represents a synthesis of knowledge which provides an overall summary while outlining future research directions.

SW: Would you summarize the significance of your paper in layman's terms?

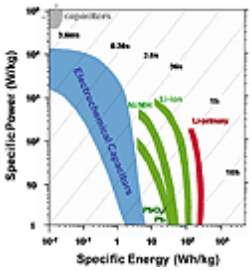
ECs are high-power energy storage devices which can complement or even replace batteries in those applications where fast-charge delivery or uptake is needed for several seconds. Thanks to these unique properties, the use of ECs has dramatically increased in the past three years in areas ranging from backup power to cars, aircrafts, cranes, trams, electric tools, etc.

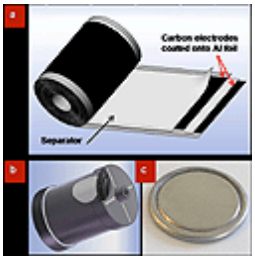
Today, the transition from gasoline to hybrid and electric engines in the automotive industry offers tremendous opportunities to ECs in the recovery of braking energy or in boosting the acceleration of cars powered by small engines or batteries. This paper also presents the latest scientific discoveries in the EC area, describing the future challenges and new strategies developed to improve the energy and

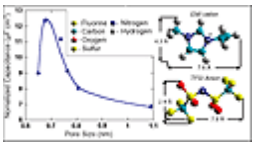
power densities of these systems.

SW: How did you become involved in this research, and were there any problems along the way?

This paper resulted from cooperation between our two research groups at Drexel University (Philadelphia, PA, USA) and Paul Sabatier University (Toulouse, France). Professor Yury Gogotsi, a material scientist from Drexel University and an expert in nanostructured carbon materials, designed porous carbon with a narrow and tunable pore size distribution in the sub-nanometer range. Together with Professor Patrice Simon, who is an expert in capacitive energy storage, these two research groups achieved a scientific breakthrough by showing that, in defying conventional wisdom, carbon pores smaller than the size of the solvated ions of the electrolyte (< 1 nm) were accessible to ions, opening new opportunities for the design of a new generation of high-energy density supercapacitors. This work was published in *Science* magazine in 2006 (J. Chmiola, *et al.*) and ultimately led to the *Nature Materials* paper, which presented a broader picture of the mechanisms of capacitive energy storage and described new materials that enable the development of electrochemical capacitors with an improved power and energy density.







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SW: Where do you see your research leading in the future?

Our research is focused on understanding the mechanism of ion adsorption in pores smaller than the solvated ion size. We will try to understand the ion transport in nanopores, as well as to elucidate the increase of the charge stored in the pores of the carbon electrodes when the pore size closely matches the ion size. This research will have potential application not only in the energy storage area (supercapacitors) but more generally in any field dealing with ion transport through porous membranes such as water desalination or the function of ion channels in cells.

We also will develop new materials for electrochemical energy storage with the goal being to significantly increase the power and energy stored per unit of weight and volume and to make supercapacitors as common as batteries in energy storage applications.

SW: Do you foresee any social or political implications for your research?

There are many good economical reasons to switch to renewable resources such as the sun, wind, ocean waves, geothermal, hydropower, etc. Another reason for switching to renewables—even if you don't believe in global warming—is the environment.

We breathe pollution coming from cars, buses, and coal-burning power plants. Thus, few people doubt nowadays that renewable resources and nuclear power generation will largely replace fossil fuels within the next decade or two.

However, the energy produced from renewable resources is primarily electrical energy. Therefore, solving the problem of electrical energy storage is the critical issue in the transition to a renewable energy economy. It will be impossible to become independent of gasoline, coal, and natural gas if we don't develop much better and more efficient solutions for the storage of electrical energy.

Supercapacitors are projected to be as important as batteries in moving from "chemical" to "physical" energy, because they have a higher power and lower losses (less energy is wasted in each storage cycle) compared to all other electrical energy storage systems. Therefore, our research helps to make this planet cleaner and healthier and our countries less dependent on supplies of foreign oil.

Patrice Simon, Ph.D.
Professor of Material Science
Université Paul Sabatier
CIRIMAT Laboratory (UMR CNRS 5085)
Toulouse, France
Web

Yury Gogotsi, Ph.D.

Trustee Chair Professor of Materials Science and Engineering
Drexel University
Philadelphia, PA, USA
Web

KEYWORDS: DOUBLE-LAYER CAPACITORS; CARBIDE-DERIVED CARBON; ACTIVATED CARBONS; NANOPOROUS CARBON; PORE-SIZE; ION SIZE; SUPERCAPACITOR ELECTRODES; MESOPOROUS CARBONS; LITHIUM BATTERIES; ENERGY MANAGEMENT.

PDF

back to top

2009 : December 2009 - Fast Breaking Papers : Patrice Simon & Yury Gogotsi on Electrochemical Capacitors (ECs)

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