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Exploring supercapacitors to improve their structure

No matter how intimidating their name, supercapacitors are part of our daily lives. Take buses for example: supercapacitors are charged during braking and supply electricity to open the doors when the vehicle stops! Yet the molecular organization and functioning of these electricity storage devices had never previously been observed. For the first time, researchers from CNRS and the Université d'Orléans have explored the molecular rearrangements at play in commercially available supercapacitors while in operation. The technique devised by the scientists provides a new tool for optimizing and improving tomorrow's supercapacitors. The results are published on-line on *Nature Materials's* website on 17 February 2013.

Supercapacitors are electricity storage devices that are quite different to batteries. Unlike these, they are charged much faster (usually in seconds) and they do not suffer such rapid wear due to charging/discharging. On the other hand, at equivalent size and although they offer greater power, they cannot store as much electrical energy as batteries (carbon-based supercapacitors supply an energy density of around 5 Wh/kg compared to around 100 Wh/kg for lithium-ion batteries). Supercapacitors are used in the recovery of braking energy in numerous vehicles (cars, buses, trains, etc.) and to open the emergency exits of the Airbus A380.

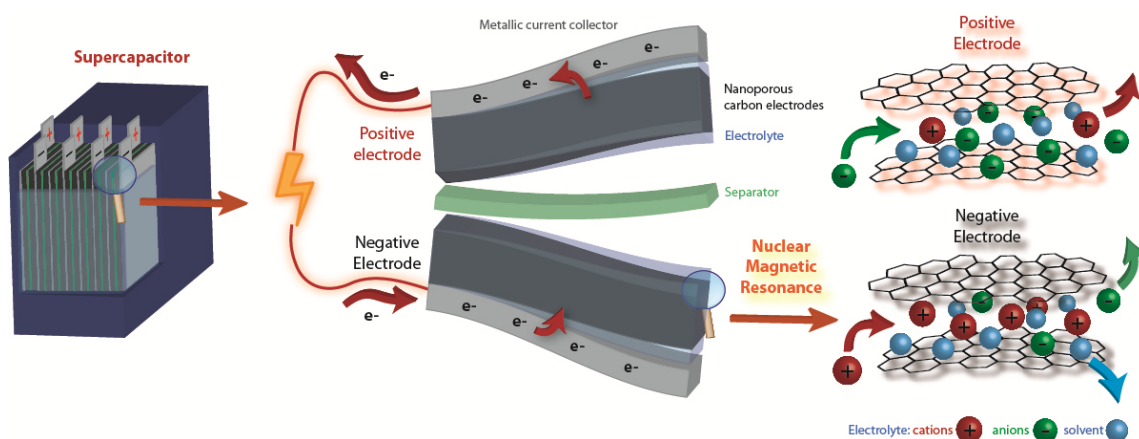
A supercapacitor stores electricity through the interaction between nanoporous carbon electrodes and ions, which carry positive and negative charges, and move about in a liquid known as an electrolyte (see diagram below). When charging, the anions (negatively charged ions) are replaced by cations (positively charged ions) in the negative electrode and vice versa. The greater this exchange and the higher the available carbon surface area, the greater the capacity of the supercapacitor.

Using Nuclear Magnetic Resonance (NMR) spectroscopy, the researchers delved deeper into this phenomenon and were able, for the first time, to quantify the proportion in which charge exchanges take place in two supercapacitors using commercially available carbons. By comparing two nanoporous carbon materials, they were able to show that the supercapacitor containing the carbon with the most disordered structure had greater capacitance and improved high-voltage tolerance. This could be due to better electronic charge distribution upon contact with the electrolyte molecules.

These results stem from a collaboration between two Orleans-based teams: one from the CNRS CEMHTI⁽¹⁾, specialized in NMR and a member of the Réseau Français sur le Stockage Electrochimique de l'Energie (www.energie-rs2e.com), the other at the Centre de Recherche sur la Matière Divisée (CNRS/Université d'Orléans), which focuses on the study of new carbon materials for supercapacitors.

This complementarity has made it possible to develop a technique that gives research laboratories and industry a genuine tool for optimizing supercapacitors' materials.

(1) CNRS Laboratoire "Conditions Extrêmes et Matériaux : Haute Température et Irradiation"



Simplified diagram of a supercapacitor and how it works from the macroscopic scale to the molecular level. ©Cehmti-Michael Deschamps

Bibliography

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