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Truly green paper battery is algae-powered

(*Nanowerk Spotlight*) The batteries that power our everyday devices, from laptop computers, to mobile phones, watches, toys and flashlights, are a major source of pollution. The average household in the Western world uses about 20 batteries a year, resulting in hundreds of thousands of tons of discarded batteries that end up in landfills. When the battery casing corrodes, toxic heavy metals like mercury and cadmium can leak out and pollute soil and ground water.

Researchers have been working on non-metal batteries but so far the performance of the used materials – polypyrrole for instance, a conducting polymer – has not been good enough for commercial applications.

"One way to improve the performance of nonmetal-based energy storage devices would be to use composite electrode materials of conductive polymers, deposited as thin layers on a suitable large surface area substrate," Maria Strømme tells Nanowerk. "Cellulose is in this case an appealing substrate material because of its abundance in nature and its well-established industrial use. Furthermore, cellulose fibers have been found to be well wetted by polypyrrole, which makes the homogeneous coating of individual cellulose fibers possible. Thus, composites of cellulose with conductive polymers are particularly attractive as these are fully recyclable, lightweight, mechanically robust, and can be manufactured at low costs."

Strømme, a professor of nanotechnology at the Ångström Laboratory at Uppsala University, together with Leif Nyholm, professor of chemistry, and their groups, have developed a novel polypyrrole-cellulose composite electrode material that is mechanically robust, lightweight, and flexible. The material owes its high-surface area to the the distinctive cellulose nanostructure – entirely different from that of terrestrial plants – to *Cladophora*, a filamentous green algae that the researchers collected from the Baltic Sea.

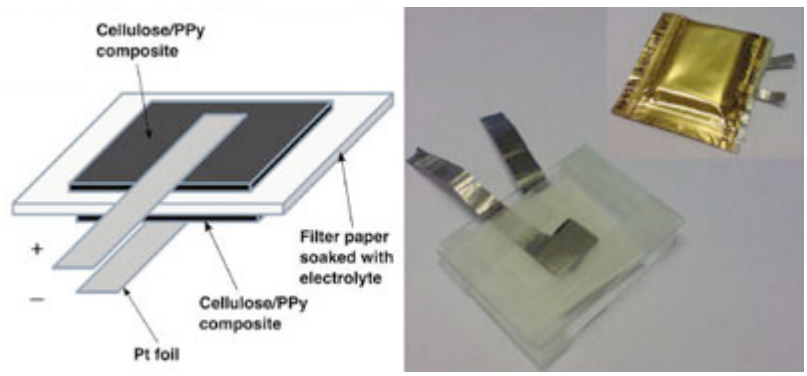
Cladophora algae.

While the cellulose from wood pulp and cotton that is typically used in the paper industry has a rather small specific surface area of about 1 square meter per gram, the surface area of cellulose from *Cladophora* can be up to 100 times larger.

By coating the highly porous *Cladophora* cellulose substrates with a homogeneous, 50 nm thick layer of polypyrrole, the Swedish researchers have produced a battery that weighs almost nothing and that has set new charge-time and capacity records for polymer-cellulose-based batteries.

The team have reported their findings in the September 9, 2009 online edition of *Nano Letters* ("Ultrafast All-Polymer Paper-Based Batteries").

To stress-test their new electrode material, the team performed 100 consecutive galvanostatic charge-discharge cycles using a current of 600 mA per square centimeter. They found that over the 100 cycles the capacity loss was only 6%. While these tests were initially run with an entirely un-optimized packaging, a newer design has allowed them to already run 1000 cycles (but at a lower rate).



The Cladophora cellulose-polypyrrole conductive paper composite. Left: schematic image, and right: photograph of the composite paper battery cell before and after sealing it into an polymer coated aluminum pouch. (Reprinted with permission from American Chemical Society)

"We anticipate that these batteries may open up entirely new possibilities when it comes to battery applications" says Strømme. "With the technique fully developed I believe that we may see applications that we cannot really dream of today. Try to imagine what you can create when a battery can be integrated into wallpapers, textiles, consumer packaging, diagnostic devices, etc."

She adds that while it is difficult to say something about the ecological benefits of these (literally) green energy storage devices, we are talking about a battery that mainly consists of paper and salt water and that can theoretically be made in your own kitchen (if you have a strong mixer) without the major resources input needed to create today's conventional batteries.

On a commercial scale, the algae battery would probably be inexpensive to manufacture based on an easy all chemical batch fabrication process using inexpensive and abundant materials.