Lithium-ion battery with new chemistry could power electric vehicles

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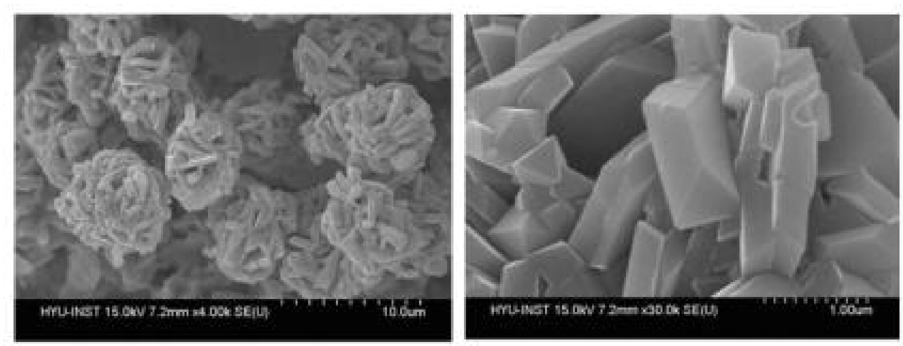

Images of the cathode, which is made of lithium manganese oxide doped with nickel and cobalt, as seen under a field emission scanning electron microscope. Image credit: Jusef Hassoun, et al. ©2011 American Chemical Society.

(PhysOrg.com) -- While car companies race to develop electric and hybrid electric vehicles, one of the biggest challenges they face is finding a suitable energy storage system. Lithium-ion batteries, which currently power a variety of smaller consumer electronics devices, could ideally fill this role. But at the moment, they require further improvements in terms of energy density and power density in order to be used effectively in electric vehicles. Now in a new study, researchers have developed a novel type of lithium-ion battery with an anode and cathode that involve new, advanced battery chemistries, greatly improving the battery's performance and likely making it suitable for electric vehicles.

The researchers, Jusef Hassoun, Ki-Soo Lee, Yang-Kook Sun, and Bruno Scrosati, from the University of Rome Sapienza in Rome, Italy, and Hanyang University in Seoul, South Korea, have published their study on the advanced lithium-ion battery in a recent issue of the *Journal of the American Chemical Society*.

Their study builds on the team's previous research involving the development of novel, advanced lithium-ion battery chemistries. The key to the high performance lies in the battery's electrode materials. Here, the scientists use a tin-carbon anode and a cathode made of lithium manganese oxide doped with nickel and cobalt. As far as the researchers know, a lithium-ion battery with this unique electrode combination has never been reported before.

"The battery is based on a new combination between a high-voltage cathode and a nanostructured anode material," Scrosati told *PhysOrg.com*. "The battery operates with a very stable capacity at high discharge rates with no significant capacity losses throughout the entire cycling test."

The new electrode materials provide certain advantages for the overall battery. As the researchers previously demonstrated, the tin-carbon anode has a high cycling life of several hundred cycles without a reduction in capacity, as well as discharge-charge efficiency approaching 100%. By applying a surface treatment to the anode, the researchers could further improve the capacity.

As for the new manganese-based cathode materials, they are more abundant, less expensive, more environmentally friendly, and have a higher stability at low temperatures compared to the lithium cobalt oxide cathode used in conventional lithium-ion batteries. Also, in designing the new cathode, the researchers carefully optimized the composition, particle size, shape, morphology, and tap density.

“The battery has: 1) a high volumetric and gravimetric energy density; 2) a high rate capability due to the nano-structured characteristics of the electrode materials; 3) an excellent cycle life; and 4) low cost, due to the use of electrode materials based on abundant elements,” Scrosati said.

The cathode’s high voltage and high capacity provides the new battery with a higher energy density (170 Wh/kg at average discharge voltage of 4.2 volts) than conventional lithium-ion batteries.

“The conventional lithium-ion batteries have an energy density of about 120-150 Wh/kg, depending on the used cathode material,” Scrosati said. “Generally, commercial lithium battery cells using layer structure cathode materials, for instance, NCA and NMC, deliver from 100 to 150 Wh/kg.”

Altogether, the high energy density, stable cycle life, and high rate capacity suggest that the battery looks very promising for powering electric vehicles.

“In summary, with respect to those using conventional lithium-ion batteries, electric vehicles using our battery may assure: 1) a longer driving range (210 km/charge vs. 150 km/charge due to the higher energy density; 2) a higher top speed; 3) a lower cost; and 4) better overall performance especially at low temperatures,” Scrosati said.

More information: Jusef Hassoun, et al. “An Advanced Lithium Ion Battery Based on High Performance Electrode Materials.” *Journal of the American Chemical Society*. DOI:10.1021/ja110522x

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