Dec. 12, 2012 — **A NEW STUDY OF THE BATTERIES COMMONLY USED IN HYBRID AND ELECTRIC-ONLY CARS HAS REVEALED AN UNEXPECTED FACTOR THAT COULD LIMIT THE PERFORMANCE OF BATTERIES CURRENTLY ON THE ROAD.**

Researchers led by Ohio State University engineers examined used car batteries and discovered that over time lithium accumulates beyond the battery electrodes -- in the "current collector," a sheet of copper which facilitates electron transfer between the electrodes and the car's electrical system.

This knowledge could aid in improving design and performance of batteries, explained Bharat Bhushan, Ohio Eminent Scholar and Howard D. Winbigler Professor of Mechanical Engineering.

"Our study shows that the copper current collector plays a role in the performance of the battery," he said.

The study, which appears in a recent issue of the journal *Scripta Materialia*, reflects an ongoing collaboration between Bhushan and Suresh Babu, professor of materials science and engineering and director of the National Science Foundation Center for Integrative Materials Joining for Energy Applications, headquartered at the university. The team is trying to determine the factors that limit battery life.

Lithium-ion batteries are the rechargeable batteries used in most hybrid-electric cars and all-electric cars as well. Inside, lithium ions shuttle back and forth between the anode and cathode of the battery -- to the anode when the battery is charging, and back to the cathode when the battery is discharging.

Previously, the researchers determined that, during aging of the battery, cyclable lithium permanently builds up on the surface of the anode, and the battery loses charge capacity.

This latest study revealed that lithium migrates through the anode to build up on the copper current collector as well.

"We didn't set out to find lithium in the current collector, so you could say we accidentally discovered it, and how it got there is a bit of a mystery. As far as we know, nobody has ever expected active lithium to migrate inside the current collector," Bhushan said.

Shrikant Nagpure, now postdoctoral researcher at Ohio State, carried out this research as a part of his doctoral degree. He examined batteries that were aged in collaboration with the university's Center for Automotive Research, where colleagues Yann Guezennec and Giorgio Rizzoni have studied battery aging for several years, in collaboration with the automotive industry.

Key to the discovery of lithium in the current collector was collaboration between the Ohio State team and Gregory Downing, a research chemist at the National Institute of Standards and Technology and an expert on a technique called neutron depth profiling (NDP), a tool for impurity analysis in materials.

Previously, the researchers used NDP to study the cathodes and anodes of six off-the-shelf lithium-ion car batteries -- one new battery and five batteries which they aged themselves in the laboratory -- and found that lithium builds up on the anode surface over time.

To understand more about how these batteries degrade, Bhushan and his colleagues have been studying the batteries further, at various scales ranging from the millimeter (millionths of a meter) down to the nanometer (billionths of a meter) with different techniques.

In the NDP technique, researchers pass neutrons through a material and capture the charged particles that emerge from the fission reaction between neutrons and lithium in the electrodes. Since different chemical elements emit a certain signature set of particles with specific energies, NDP can reveal the presence of impurities in a material.

In this latest study, NDP detected the presence of lithium in the copper current collector from one of the aged batteries. The detection was measured as a ratio of the number of copper atoms in the collector to the number of lithium atoms that had collected there. The test yielded a ratio of up to 0.08 percent, or approximately one lithium atom per 1250 copper atoms in the collector.

That's a small number, but high enough that it could conceivably affect the electrical performance of the current collector -- and, in turn, the performance of a battery, Bhushan said. He hopes that battery makers will further investigate this phenomenon and use the information to design new materials that might prevent lithium from escaping the electrode material.

Next, he and his colleagues will study the impedance, or internal electrical resistance, of lithium-ion batteries on the nanoscale.

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