Out Of The Labs

Boosting Batteries For Electric Cars

Jonathan Fahey, 04.29.10, 6:00 AM ET

Gasoline beat out electricity as the prime power source for cars in the early 1900s. The problem was the battery. Electric cars are trying to make a comeback in the early 2000s. The problem is the battery.

Sure, batteries have gotten a lot better. Electric cars are here--but they are very expensive, like the Tesla Roadster, and they have a limited driving range, like the coming Nissan Leaf, which aims to last 100 miles before recharge. If batteries' improvements are compared with, say, the improvement in transistors, it looks like batteries have gone nowhere, fast.

One excuse: "In energy storage, we have a much bigger problem," says Claus Daniel, a research scientist and project director in the materials science and technology division at Oak Ridge National Laboratory. "Our first [automotive] batteries developed in the 1870s were pretty good."

Another problem is that even with huge advantages in the understanding of the materials, chemistry and physics that govern the storage and production of electricity in a cell, it is very hard to tell what is going on inside a battery when it is working. Batteries are inscrutable contraptions; manufacturers layer slurries of solvents, binders and active electrode materials under tightly controlled environments. Then the cell is quickly wrapped up--much of it reacts immediately with oxygen--never to be opened again.

But Daniel and Oak Ridge have some nifty tools not usually applied to things like batteries that will allow them to see what is going on inside a battery like never before. They will use these tools over the next year and a half as part of a recently announced advanced battery research program. The $6.2 million program is a collaboration between the Department of Energy (which runs Oak Ridge) and four U.S.-based battery companies, A123 Systems, Dow Kokam (a joint venture between Dow Chemical and Townsend Kokam LLC), Porous Power Technologies and Planar Energy.

The aim is to boost the prospects of U.S. battery makers as they try to establish large-scale manufacturing of automotive-sized batteries in the U.S. Batteries now account for as much as a third of the cost of building an electric car. That cost has to fall for electric cars to attract lots of customers, and the U.S. would do well to try to make such a valuable part of a car domestically. A123 is already using a $249 million grant from the Department of Energy to expand manufacturing capacity in Michigan. (See Nine More Myths About Electric Cars)

There are a couple of mysteries the researchers are especially curious about. A big one is degradation. In a typical lithium-ion battery, the negative electrode stores lithium ions in honeycomb-like lattices. When the ions are tucked in there, the lattice expands. When they leave and head over to the positive electrode (producing electricity), the lattice shrinks. This cycle of expansion and contraction slowly breaks down the lattice.

Oak Ridge happens to have a contraption that can see where others can't. It's the world's brightest source of neutrons, called the Spallation Neutron Source. It speeds protons to 90% of the speed of light and smashes mercury atoms to break off neutrons. Beams of neutrons can then be directed at materials, including whole working batteries, where they penetrate deep into their targets. The way the neutrons bounce off atoms inside tells researchers what is going on in there. As they understand better, they may be able to tweak the chemistry to make the battery last longer.

"It will give us totally new insight into what's going on in the inside of a battery," says Daniel. "The level of detail you can see is eye-opening."

For example, there is something called the "solid-electrolyte interface layer." Where the solid electrode meets a liquid electrolyte (the layer that separates the two electrodes in a battery), a thin film forms within a millisecond. It gums up the works--researchers call it "irreversible capacity loss"--but because it breaks down immediately in air, it has never been seen before. "We hope to see it very soon," says Daniel.

Oak Ridge is also developing a way to examine the molecular structure of liquids with a common technique called electron microscopy. This has to work in a vacuum, so it is usually impossible to keep liquids in place. But Oak Ridge is developing a microchamber that can hold liquids like the ones that are often used as electrodes in batteries.

Yet another technique is called acoustic emission spectroscopy. This will allow researchers to listen very, very carefully to what's happening inside a battery as the lattice stretches and changes. This could lead to entirely new materials for batteries. For example, silicon alloys can hold 12 times as many lithium ions as carbon formulations that are usually used. But silicon goes through a huge change in volume--it grows by 400%--leading to quick degradation. "The problem is how do I keep brittle material like silicon from breaking like that?" asks Daniel. "There are a huge variety of possibilities out there."

If the researchers can find and develop them, batteries may yet catch up with their old energy storage nemesis, gasoline.

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