Making sodium-ion batteries that are worth their salt

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(PhysOrg.com) -- Although lithium-ion technology dominates headlines in battery research and development, a new element is making its presence known as a potentially powerful alternative: sodium.

Sodium-ion technology possesses a number of benefits that lithium-based energy storage cannot capture, explained Argonne chemist Christopher Johnson, who is leading an effort to improve the performance of ambient-temperature sodium-based batteries.

Perhaps most importantly, sodium is far more naturally abundant than lithium, which makes sodium lower in cost and less susceptible to extreme price fluctuations as the battery market rapidly expands.

"Our research into sodium-ion technology came about because one of the things we wanted to do was to cover all of our bases in the battery world," Johnson said. "We knew going in that the energy density of sodium would be lower, but these other factors helped us decide that these systems could be worth pursuing."

Sodium ions are roughly three times as heavy as their lithium cousins, however, and their added heft makes it more difficult for them to shuttle back and forth between a battery's electrodes. As a result, scientists have to be more particular about choosing proper battery chemistries that work well with sodium on the atomic level.

While some previous experiments have investigated the potential of high-temperature sodium-sulfur batteries, Johnson explained that room-temperature sodium-ion batteries have only begun to be explored. "It's technologically more difficult and more expensive to go down the road of sodium-sulfur; we wanted to leverage the knowledge in lithium-ion batteries that we've collected over more than 15 years," he said.

Because of their reduced energy density, sodium-ion batteries will not work as effectively for the transportation industry, as it would take a far heavier battery to provide the same amount of energy to power a car. However, in areas like stationary energy storage, weight is less of an issue, and sodium-ion batteries could find a wide range of applications.

"The big concerns for stationary energy storage are cost, performance and safety, and sodium-ion batteries would theoretically perform well on all of those measures," Johnson explained.

All batteries are composed of three distinct materials—a cathode, an anode and an electrolyte. Just as in lithium-ion batteries, each of these materials has to be tailored to accommodate the specific chemical reactions that will make the battery perform at its highest capacity. "You have to pick the right materials for each component to get the entire system to work the way it's designed," Johnson said.

To that end, Johnson has partnered with a group led by Argonne nanoscientist Tijana Rajh to investigate how sodium ions are taken up by anodes made from titanium dioxide nanotubes. "The way that those nanotubes are made is very scalable—if you had large sheets of titanium metal, you can form the tubes in a large array," Johnson said. "That would then enable you to create a larger battery."

The next stage of the research, according to Johnson, would involve the exploration of aqueous, or water-based, sodium-ion batteries, which would have the advantage of being even safer and less expensive.

Provided by Argonne National Laboratory

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