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To bolster lithium battery life, add a little salt

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(Phys.org) —Cornell chemical engineers have achieved a breakthrough in the race to achieve safer, longer-lasting batteries to power the world's automobiles, cell phones, computers and autonomous robots.

Adding certain halide salts to liquid electrolytes spontaneously creates nanostructured surface coatings on a lithium battery anode that hinder the development of detrimental dendritic structures that grow within the battery cell. The discovery opens the way potentially to extend the daily cycle life of a rechargeable lithium battery by up to a factor of 10.

The so-called dendrite problem has been troubling lithium battery technology for years. Over several charge/discharge cycles, microscopic particles called dendrites form on the electrode surface and spread, causing short circuits and rapid overheating.

"We had conflicting insight from two theories under development in the group and by theorists in the Cornell physics department, which suggested that a nanostructured metal halide coating on the anode could help a little – or a lot – in controlling the formation of dendrites. As it turns out, they work spectacularly well in solving what is widely considered a grand-challenge problem in the field," said Lynden Archer, the William C. Hooey Director and Professor of Chemical and Biomolecular Engineering.

Archer is senior author on the paper, "Stable Lithium Electrodeposition in Liquid and Nanoporous Solid Electrolytes," published in *Nature Materials* Aug. 10. The other authors are Cornell graduate students

Yingying Lu in chemical and biomolecular engineering and Zhengyuan Tu in materials science and engineering.

Rechargeable lithium-based batteries are among the most versatile platforms for high-energy, cost-effective electrochemical energy storage. Consumers use these batteries every day for computers, cell phones, tablets and automobiles.

Computer makers and car manufacturers (who are striving for better batteries in electric cars) have battled metal deposition and dendrite formation on the anodes during repeated charge/discharge cycles, particularly at high rates and low temperature. A common theme that frames these efforts is that dendrites are an inherent challenge for all batteries based on lithium, sodium, aluminum and other metals, and can at best only be managed through careful design of the electrolyte and battery operating condition.

The Cornell team had a different idea. They went to "density functional theory" and "continuum analysis" – forms of chemical modeling – to examine the stability of metal electrodeposition for answers. This effort led to the conclusion that infusing simple liquid electrolytes reinforced with halogenated salt blends in a nanoporous host material holds the long-sought solution. The result: Lithium metal based batteries that exhibit stable long-term charge/recharge cycling at room temperature, with no symptoms of instability over hundreds of cycles and thousands of operating hours, the researchers reported.

Improving the efficiency of lithium in batteries couldn't be happening at a better time; demand for the metal is expected to boom. Early in 2014, Tesla Motors, which makes a fully electric car, announced it would build a lithium battery "gigafactory."

Concurrently, Archer says, safer batteries will also result. Dendritic structures not only lead to safety challenges through the internal shorts they can cause over time, which may lead to overheating, but they also lower a battery's efficiency.

Archer and his team have spent two years conducting this research, which was supported by the Energy Materials Center at Cornell, an Energy Frontier Research Center funded by the U.S. Department of Energy.

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