Research aims to improve lithium-based batteries

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Research probing the complex science behind the formation of "dendrites" that cause lithium-ion batteries to fail could bring safer, longer-lasting batteries capable of being charged within minutes instead of hours.

The dendrites form on anode electrodes and may continue to grow until causing an internal short circuit, which results in battery failure and possible fire.

The batteries have two electrodes, called an anode and a cathode, separated by an insulating polymer (separator). Dendrites that grow in needlelike shapes may breach the separating barrier, destroying the battery. Researchers are using numerical modeling to find ways to understand the dendrites and to design better separators.

"We are trying to define the fundamental science behind these complex objects so that in collaboration with experimentalists we can make batteries that do not have this problem," said R. Edwin García, an associate professor of materials engineering at Purdue University.

Research findings show how groups of dendrites form and evolve and how individual dendrites interact with each other. The simulations also depict how dendrites sometimes detach from battery electrodes and become floating deposits, another potentially dangerous scenario that can cause a battery to catch on fire.

Findings are detailed in a research paper to appear on Feb. 1 in the *Journal of Power Sources*. The paper is authored by graduate student Aniruddha Jana; David R. Ely, a former postdoctoral researcher and now a professor at Ivy Tech Community College; and García.

The researchers have developed a modeling tool that helps battery makers design better separators. Pores exist between polymer fibers in the separator, and the researchers have modeled how pore size and morphology of the separator influence dendrite development.

"We found relationships between the geometry of the separator and its performance," García said. "We think it's the first step to improve the separator."

In some batteries, dendrites are lithium formations that grow while batteries are being recharged, adding layers that resemble tree rings, with each layer representing a single recharge. Because they grow faster when exposed to a high current needed for fast recharging, the dendrites limit recharging speed. Being able to control dendrites could lead to longer-lasting, safer, more compact batteries capable of charging within minutes.

One approach to potentially solve the problem is to induce lithium to grow uniformly and relatively flat instead of heterogeneously and pointed. The heterogeneous growth means the dendrites would sprout unevenly at various locations on the anode's surface. If they could be induced to grow uniformly and in a more controlled manner, the battery could be designed to accommodate this growth, preventing formations from reaching the cathode, Garcia said.

The work is ongoing and has been supported in part by the National Science Foundation.

"There are a lot of interesting challenges," Garcia said. "We want to put everything together: the separator and the particles of anode material so that we have a complete commercial system."

More information: Aniruddha Jana, David R. Ely, R. Edwin García, "Dendrite-separator interactions in lithium-based batteries," *Journal of Power Sources*, Volume 275, 1 February 2015, Pages 912-921, ISSN 0378-7753, dx.doi.org/10.1016/j.jpowsour.2014.11.056

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