New cathode coating extends lithium-ion battery life, boosts safety

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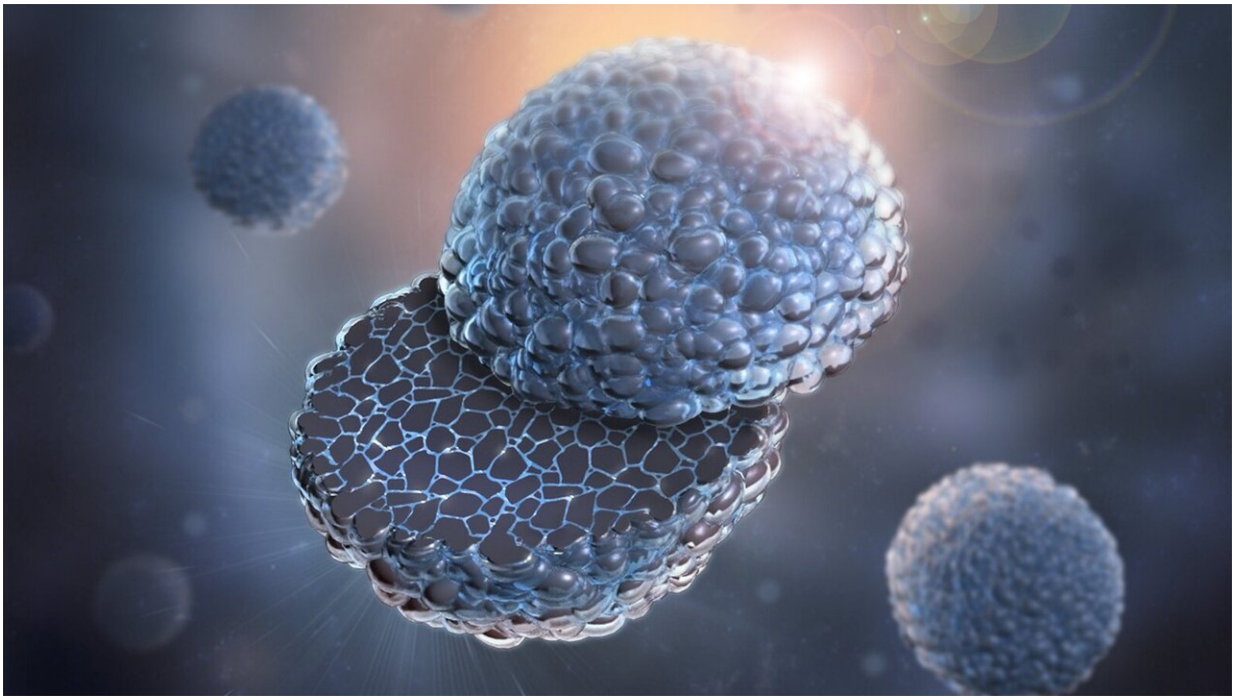

PEDOT is coated on both primary and secondary particles of NMC cathode used in EVs. This coating protects the cathode against reactivity with electrolyte and extends the life of the battery. Credit: Argonne National Laboratory

The U.S. Department of Energy's (DOE) Argonne National Laboratory, in collaboration with Hong Kong University of Science and Technology (HKUST), has developed a new particle-level cathode coating for lithium-ion batteries meant to increase their life and safety.

The idea, three years in the making, was developed at Argonne in collaboration with HKUST. It was funded by the DOE's Office of Renewable Energy and Energy Efficiency, Vehicle Technologies Office.

"This is an incredibly exciting advancement," said Khalil Amine, Argonne distinguished fellow and head of the Technology Development group in the Electrochemical Energy Storage department within Argonne's Chemical Sciences and Engineering division. "This could significantly improve our experience with the devices we've come to rely on."

The initial experiment was conducted in Hong Kong: HKUST had the ideal set-up and was able to carry out the work under the laboratory's specifications.

Lithium batteries, used to power everything from electric cars to cell phones and computers, have been using a cathode coating technology for more than 15 years.

But it is not without limitations: It is only a partial coating, one that covers just a small part of the outside of the cathode particle and does not protect the cathode when operating at a high voltage or at high temperature.

The cathodes researchers were studying are metal oxides made of nickel, manganese and cobalt. A cathode charged at high voltage generates oxygen, oxidizing the electrolyte, creating an unwanted film on the cathode and causing energy loss. High temperatures increase the speed of these reactions, compromising the electro-chemical performance of the battery itself.

The new coating, made with a conducting polymer called

poly(3,4-ethylenedioxythiophene) (PEDOT), marks a breakthrough in lithium-ion battery technology since it fully and completely protects each particle of the cathode—inside and out—from reactivity with the electrolyte.

PEDOT is applied using Argonne's oxidative chemical vapor deposition technique, which uses gas to ensure the coating is applied to every particle of the cathode, forming a robust skin.

The conventional coating slows down lithium diffusion in and out of the cathode particle, decreasing battery efficiency because of poor electronic and ionic conductivity.

By contrast, the new Argonne coating facilitates the transport of lithium ions and electrons in and out of the cathode, boosting battery energy.

Argonne's Center for Nanoscale Materials (CNM), a DOE Office of Science User Facility, has played a significant role in the experimentation. Researchers used CNM's Zeiss NVision 40 focused ion beam-scanning electron microscopy dual-beam system and FEI Talos F200X (S)TEM equipped with a SuperX energy-dispersive X-ray spectrometer to confirm the coating of PEDOT on both primary and secondary particles of layered cathodes and their stability after battery cycling.

Argonne assistant chemist Gui-Liang Xu of the Chemical Sciences and Engineering Division (CSE), scientist Yuzi Liu (CNM), postdoctoral appointee Xiang Liu (CSE), postdoctoral research scholar Han Gao (CSE), visiting graduate student Xinwei Zhou (CNM), physicist Yang Ren of the Advanced Photon Source, another DOE Office of Science User Facility at Argonne, and Zonghai Chen (CSE) also contributed to the project, Amine said.

Currently, lithium-ion batteries operate at 4.2 V at the cell level. The new coating can help increase the voltage to 4.6 V. This 15 percent difference can lead to a significant cost reduction of the overall battery pack.

"This would increase the driving range of electric cars and boost the battery life of cell phones and laptops, ultimately changing the way we live," Amine said.

A paper on the topic was published in *Advanced Energy Materials* in December 2019, and another published in the journal *Nature* in May 2019.

More information: Bing-Qing Xiong et al. Boosting Superior Lithium Storage Performance of Alloy-Based Anode Materials via Ultraconformal Sb Coating–Derived Favorable Solid-Electrolyte Interphase, *Advanced Energy Materials* (2019). DOI: 10.1002/aenm.201903186

Gui-Liang Xu et al. Building ultraconformal protective layers on both secondary and primary particles of layered lithium transition metal oxide cathodes, *Nature Energy* (2019). DOI: 10.1038/s41560-019-0387-1

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