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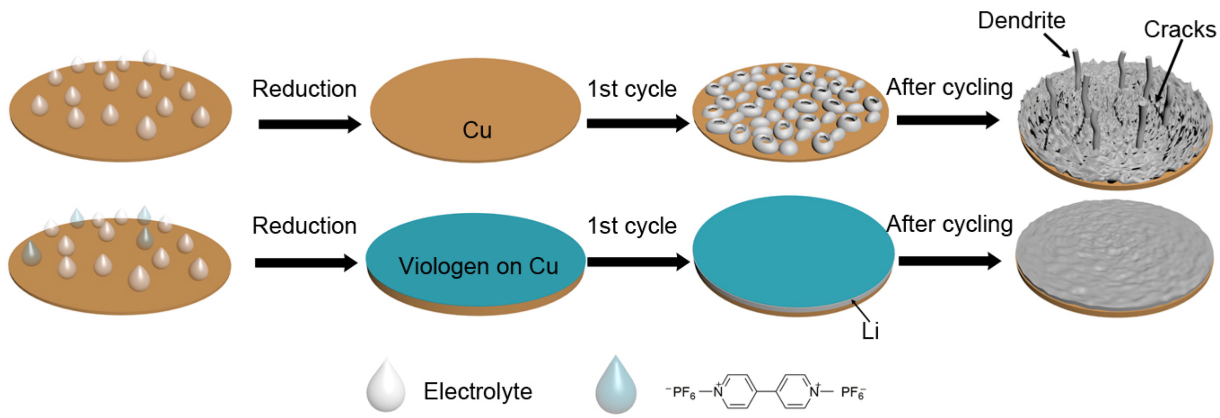

Illustrations of the design principles of using methyl viologen to form a stable coating to allow the stable cycling of lithium metal. Credit: UC Riverside

High performing lithium-ion batteries are a key component of laptops, smart phones, and electric vehicles. Currently, the anodes, or negative charged side of lithium ion batteries, are generally made with graphite or other carbon-based materials.

But, the performance of carbon based materials is limited because of the weight and energy density, which is the amount of energy that can be stored in a given space. As a result, a lot of research is focused on lithium-metal anodes.

The success of lithium metal anodes will enable many battery technologies, including lithium metal and lithium air, which can potentially increase the capacity of today's best lithium-ion batteries five to 10 times. That would mean five to 10 times more range for electric vehicles and smartphone batteries lasting five to 10 times more time. Lithium metal anodes are also lighter and less expensive.

The problem with lithium ion batteries made with metal is that during charge cycles they uncontrollably grow dendrites, which are microscopic fibers that look like tree sprouts. The dendrites degrade the performance of the battery and also present a safety issue because they can short circuit the battery and in some cases catch fire.

A team of researchers at the University of California, Riverside has made a significant advancement in solving the more than 40-year-old dendrite problem. Their findings were just published in the journal *Chemistry of Materials*.

The team discovered that by coating the battery with an organic compound called methyl viologen they are able to stabilize battery performance, eliminate dendrite growth and increase the lifetime of the battery by more than three times compared to the current standard electrolyte used with lithium metal anodes.

"This has the potential to change the future," said Chao Wang, an adjunct assistant professor of chemistry at UC Riverside who is the lead author of the paper. "It is low cost, easily manipulated and compatible with the current lithium ion battery industry."

The researchers designed a new strategy to form a stable coating to enhance the lifetime of lithium-metal anodes. They used methyl viologen, which has been used in other applications because of its ability to change color when reduced.

The methyl viologen molecule used by the researchers can be dissolved in the electrolytes in the charged states. Once the molecules meet the lithium metal, they are immediately reduced to form a stable coating on top of the metal electrode.

By adding only .5 percent of viologen into the electrolyte, the cycling lifetime can already be enhanced by three times. In addition, methyl viologen is very low in cost and can easily be scaled up.

The stable operation of lithium metal anodes, which the researchers have achieved with the addition of methyl viologen, could enable the development of next generation high-capacity batteries, including lithium metal batteries and lithium air batteries.

Wang cautioned that while the coating improves battery performance, it isn't a way to prevent batteries from catching fire.

The paper is called: "In Situ Formation of Stable Interfacial Coating for High Performance Lithium Metal Anodes."

More information: Haiping Wu et al. Formation of Stable Interfacial Coating for High Performance Lithium Metal Anodes, *Chemistry of Materials* (2017). DOI: 10.1021/acs.chemmater.6b05475

Provided by University of California - Riverside

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