ENERGY STORAGE

Electroplated batteries store more energy

A new process for making pure battery electrodes improves performance

Electroplated battery electrodes can store 30% more energy than today's best commercial models, according to a new study. The electroplating process is compatible with a range of high-performance cathode materials called lithium transition-metal oxides. And it could help make flexible batteries needed for wearable electronics.

Making electrodes from these oxide materials normally requires high temperatures, which constrains battery designs and performance, says Paul Braun, a materials scientist at the University of Illinois, Urbana-Champaign. The process starts by heating lithium and the transition metal of choice, such as cobalt, to 700–1,000 °C to form an oxide powder. The high-temperature process ensures the oxide has good crystallinity, which is necessary for high performance. The resulting powder then gets blended with binders and other additives to make an electrode. These additives don't store any energy, and they take up space and add weight, both of which are at a premium in portable electronics.

Braun's group avoided using these space-wasting additives by electroplating the material directly on an electrode support. Because electroplating is driven by electricity, the required temperature can be lower than that usually needed to form the desired oxides.

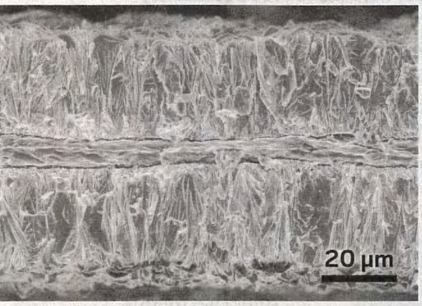
The researchers placed foam electrodes or aluminum battery foils in a molten salt made of a mixture of lithium hydroxide, potassium hydroxide, and cobalt oxide. This made good-quality films of lithium cobalt oxide on the foams and foils at 260 °C. Using this plating method, the group deposited three different cathode materials by switching out the cobalt oxide for manganese oxide and other compounds (*Sci. Adv.* 2017, DOI: 10.1126/sciadv.1602427). The process works well because this solution has a high ionic conductivity, and the transition-metal salts are highly soluble in it.

"It's exciting to see a new idea" for making batteries, says Yi Cui, a materials scientist at Stanford University who was not involved with the work. "They make lithium metal oxides with excellent crystallinity, and that shows up in the battery materials they've made."

Braun says the electroplated materials have higher energy densities than those of state-of-the-art batteries because of the purity—around 90%—of the lithium cobalt oxide or lithium manganese oxide. With no additives, the electroplated cathodes can store more energy in a given volume. And the process is compatible with unconventional electrodes, including flexible mats of carbon nanotubes.

The question is whether electroplating will work at manufacturing scales, says Sehee Lee, a materials scientist at the University of Colorado, Boulder. Typically, battery electrodes are made on large-volume, roll-to-roll systems that run 24 hours a day. "If they can do this electroplating process on a roll-to-roll system, that would be interesting," he says.

Xerion Advanced Battery is now developing the electroplated cathodes, Braun says. He thinks they will be most useful in portable electronics, possibly flexible ones for future smart watch bands or apparel.—KATHERINE BOURZAC, special to C&EN



Electroplating can grow films of lithium cobalt oxide on aluminum foil, as seen in this electron micrograph.

A flexible electroplated lithium cobalt oxide battery electrode can be rolled up.

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SOLAR ENERGY

Perovskite vulnerability uncovered

Methylammonium lead halide perovskites ($CH_3NH_3PbI_3$) show great promise for solar-cell materials because they are more efficient at converting sunlight into electricity than current commercial materials are. Perovskite efficiencies can reach 22%, while those of commercial materials are about 15%. However, these perovskites suffer from a serious drawback: They degrade rapidly upon exposure to oxygen and light.

A group including M. Saiful Islam at the University of Bath and Saif A. Haque of Imperial College London now reports experimental and theoretical evidence for the mechanism behind this degradation (*Nat. Commun.* 2017, DOI: 10.1038/ncomms15218). Their findings have led them to a way to protect these promising materials.

The team previously determined that when light excites these crystals, it creates electrons, which can react with O_2 to make reactive superoxide species. These superoxides then wreak havoc on the perovskite crystal structure, breaking it down to PbI_2, methylamine, and water.

In the new work, the group uses computational simulations and experiments to show that O_2 diffuses into iodide vacancies in perovskite crystal structures. These spaces were the most vulnerable and facilitated the superoxide degradation process.

With this mechanism in mind, the team tried to stabilize the material by coating it with a thin layer of iodide salts, which reduced the number of iodide vacancies. The protection was striking. Without the coating, the material began degrading within hours and became useless within days. However, crystals blanketed with the iodide salts remained stable for three weeks.—ELIZABETH WILSON