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MIT engineers designed a battery made from inexpensive, abundant materials, ...

As the world builds out ever larger installations of wind and solar power systems, the need is growing fast for economical, large-scale backup systems to provide power when the sun is down and the air is calm. Today''s lithium-ion batteries are still too expensive for most such applications, and other options such as pumped hydro require specific topography that''s not always available.

Now, researchers at MIT and elsewhere have developed a new kind of battery, made entirely from abundant and inexpensive materials, that could help to fill that gap.

The new battery architecture, which uses aluminum and sulfur as its two electrode materials, with a molten salt electrolyte in between, is described today in the journal Nature, in a paper by MIT Professor Donald Sadoway, along with 15 others at MIT and in China, Canada, Kentucky, and Tennessee.

"I wanted to invent something that was better, much better, than lithium-ion batteries for small-scale stationary storage, and ultimately for automotive [uses]," explains Sadoway, who is the John F. Elliott Professor Emeritus of Materials Chemistry.

In addition to being expensive, lithium-ion batteries contain a flammable electrolyte, making them less than ideal for transportation. So, Sadoway started studying the periodic table, looking for cheap, Earth-abundant metals that might be able to substitute for lithium. The commercially dominant metal, iron, doesn''t have the right electrochemical properties for an efficient battery, he says. But the second-most-abundant metal in the marketplace -- and actually the most abundant metal on Earth -- is aluminum. "So, I said, well, let''s just make that a bookend. It''s gonna be aluminum," he says.

The three ingredients they ended up with are cheap and readily available -- aluminum, no different from the foil at the supermarket; sulfur, which is often a waste product from processes such as petroleum refining; and widely available salts. "The ingredients are cheap, and the thing is safe -- it cannot burn," Sadoway says.

In their experiments, the team showed that the battery cells could endure hundreds of cycles at exceptionally high charging rates, with a projected cost per cell of about one-sixth that of comparable lithium-ion cells. They showed that the charging rate was highly dependent on the working temperature, with 110 degrees Celsius

(230 degrees Fahrenheit) showing 25 times faster rates than 25 C (77 F).

Surprisingly, the molten salt the team chose as an electrolyte simply because of its low melting point turned out to have a fortuitous advantage. One of the biggest problems in battery reliability is the formation of dendrites, which are narrow spikes of metal that build up on one electrode and eventually grow across to contact the other electrode, causing a short-circuit and hampering efficiency. But this particular salt, it happens, is very good at preventing that malfunction.

The chloro-aluminate salt they chose "essentially retired these runaway dendrites, while also allowing for very rapid charging," Sadoway says. "We did experiments at very high charging rates, charging in less than a minute, and we never lost cells due to dendrite shorting."

"It"s funny," he says, because the whole focus was on finding a salt with the lowest melting point, but the catenated chloro-aluminates they ended up with turned out to be resistant to the shorting problem. "If we had started off with trying to prevent dendritic shorting, I"m not sure I would"ve known how to pursue that," Sadoway says. "I guess it was serendipity for us."