Breakthrough enables safer alternative to lithium-ion batteries

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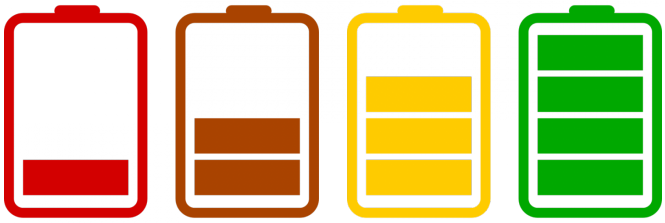

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Researchers at the U.S. Naval Research Laboratory's (NRL) Chemistry Division have developed a safer alternative to fire-prone lithium-ion batteries, which were recently banned for some applications on Navy ships and other military platforms.

Joseph Parker, Jeffrey Long, and Debra Rolison from NRL's Advanced Electrochemical Materials group are leading an effort to create an entire family of safer, water-based, zinc batteries. They have demonstrated a breakthrough for nickel-zinc (Ni-Zn) batteries in which a three-dimensional (3-D) Zn "sponge" replaces the powdered zinc anode traditionally used. With 3-D Zn, the battery provides an energy content and rechargeability that rival lithium-ion batteries while avoiding the safety issues that continue to plague lithium.

Their research appears in the April 28th, 2017 issue of *Science*, the premiere journal of the American Association for the Advancement of Science. Additional contributors to this research article include former NRL staff scientist, Christopher Chervin, National Research Council postdoctoral associate, Irina Pala, as well as industry partners Meinrad Machler and CEO of EnZinc, Inc., Michael Burz.

"Our team at the NRL pioneered the architectural approach to the redesign of electrodes for next-generation energy storage," said Dr. Rolison, senior scientist and principal investigator on the project. "The 3-D sponge form factor allows us to reimagine zinc, a well-known battery material, for the 21st century."

Zinc-based batteries are the go-to global battery for single-use applications, but are not considered rechargeable in practice due to their tendency to grow conductive whiskers (dendrites) inside the battery, which can grow long enough to cause short circuits.

"The key to realizing rechargeable zinc-based batteries lies in controlling the behavior of the zinc during cycling," said Parker, lead author on the paper. "Electric currents are more uniformly distributed within the sponge, making it physically difficult to form dendrites."

The NRL team demonstrated Ni-3-D Zn performance in three ways: extending lifetime in single-use cells; cycling cells more than 100 times at an energy content competitive with lithium-ion batteries; and cycling cells more than 50,000 times in short duty-cycles with intermittent power bursts, similar to how batteries are used in some hybrid vehicles.

With the benefits of rechargeability, the 3-D Zn sponge is ready to be deployed within the entire family of Zn-based alkaline batteries across the civilian and military sectors. "We can now offer an energy-relevant alternative, from drop-in replacements for lithium-ion to new opportunities in portable and wearable power, and manned and unmanned electric vehicles," said Dr. Long, "while reducing safety hazards, easing transportation restrictions, and using earth-abundant materials."

More information: Joseph F. Parker et al, Rechargeable nickel–3D zinc batteries: An energy-

dense, safer alternative to lithium-ion, *Science* (2017). DOI: 10.1126/science.aak9991

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