Researchers overcome critical challenges in developing fire-risk-free aqueous zinc batteries

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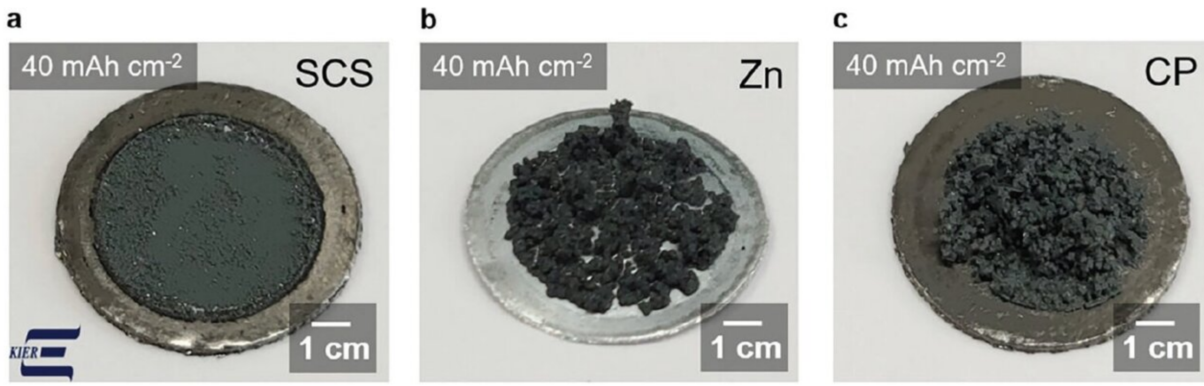

The developed electrode (a) shows more uniform deposition compared to the zinc (b) and carbon (c) electrode. Credit: Korea Institute of Energy Research (KIER)

Researchers have developed a key electrode manufacturing technology that can control dendrite formation in aqueous zinc batteries. The team includes Dr. Jung-Je Woo from the Gwangju Clean Energy Research Center at the Korea Institute of Energy Research (KIER), along with Professor Jaephil Cho's research team from Ulsan National Institute of Science and Technology (UNIST).

The technology developed by the research team was published as a cover article in the August issue of the journal *Advanced Energy Materials* in the field of energy and materials.

Aqueous zinc batteries are secondary batteries that use water as the electrolyte, making them free from fire risks and environmentally friendly compared to lithium-ion batteries, which use volatile liquid electrolytes. Additionally, since aqueous zinc batteries use two electrons per ion, they can theoretically offer more than twice the capacity of lithium-ion batteries, which use only one electron per ion.

However, there is a problem with the dendrite phenomenon, where zinc is deposited in elongated forms on the surface of the anode during the charging process, leading to a shorter lifespan. The formed dendrites can pierce the separator between the anode and cathode, causing electrical short circuits and severely impacting the battery's performance. Particularly, dendrites form more actively in aqueous zinc batteries than in lithium-ion batteries, making this a significant obstacle to the commercialization of the technology.

The research team successfully used copper oxide to promote uniform zinc deposition and control dendrite formation. When electrodes made using this method were applied to batteries, they demonstrated a lifespan more than ten times longer than conventional batteries.

In the past, the primary method used to suppress dendrite formation involved adding promoters like copper to accelerate the initial growth of zinc and guide uniform deposition. However, a problem with this approach was that dendrite formation would recur with repeated charging and discharging cycles of the battery.

In response, the research team devised a method to control dendrite formation step-by-step using copper oxide. Like regular copper, copper oxide promotes the initial growth of zinc and guides its deposition.

Additionally, copper oxide has optimized conductivity for depositing zinc in a uniform distribution, allowing for more efficient deposition compared to regular copper.

After distributing zinc uniformly, copper oxide self-transforms into a scaffold. The scaffold acts like a fence, suppressing disordered zinc deposition and growth. This allows for the continuous prevention of dendrite formation, even with repeated charging and discharging cycles.

The batteries using the research team's technology demonstrated a lifespan more than ten times longer than conventional aqueous zinc batteries, increasing the potential for commercialization.

By suppressing dendrite formation, the battery maintains 80% of its capacity even after 3,000 charge-discharge cycles.

The research team successfully controlled zinc deposition to achieve a world-leading capacity of 60 mAh/cm^2. They also demonstrated durability through more than 3,000 battery performance tests and confirmed that the technology could be applied to large-area electrodes of 64 cm^2.

Dr. Jung-Je Woo, the lead researcher, stated, "The significance of this research is that it provides a solution to the challenge of dendrite formation in metal batteries such as aqueous zinc batteries using low-cost processes and materials like copper oxide."

He added, "We aim to contribute to the commercialization of aqueous batteries through follow-up research that standardizes and systematizes the developed electrodes."

More information: Jihun Kim et al, Self-Converted Scaffold Enables Dendrite-Free and Long-Life Zn-Ion Batteries, *Advanced Energy*

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