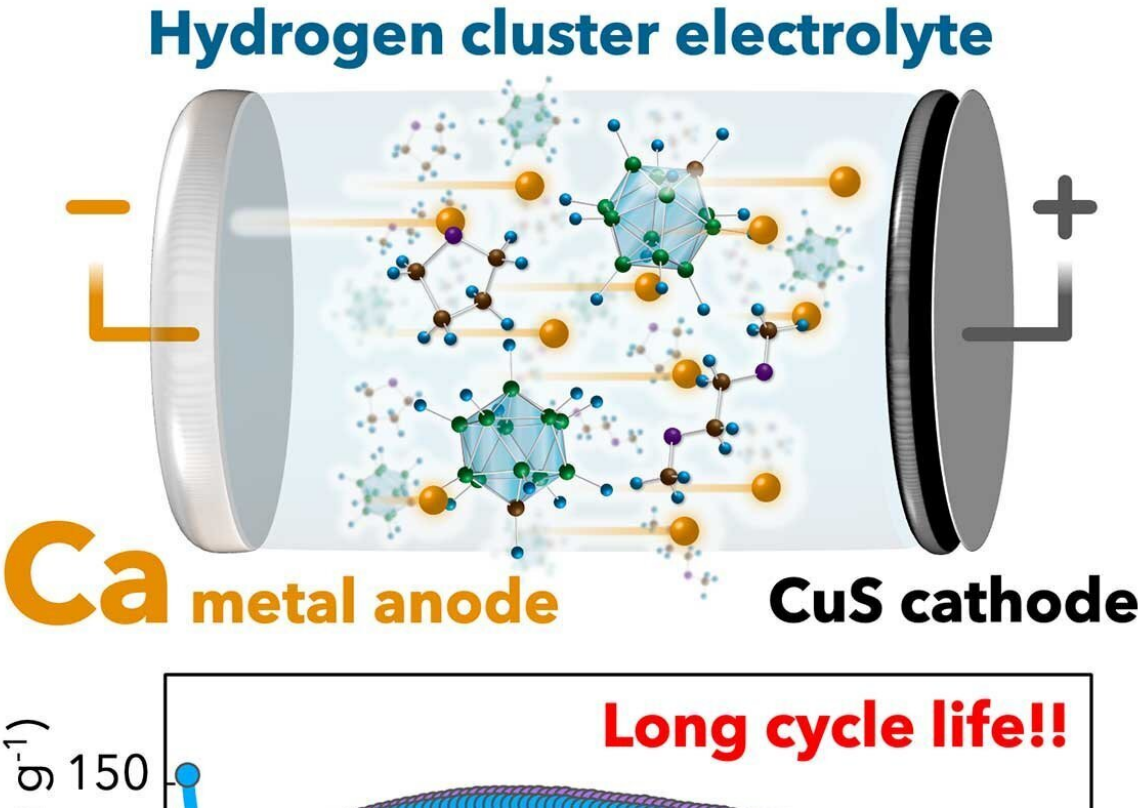


# Researchers develop calcium rechargeable battery with long cycle life

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Schematic of a prototype Ca metal battery. The battery comprises a  $\text{Ca}^{2+}$  storing positive electrode containing the CuS cathode and Ca metal anode with a hydrogen cluster electrolyte. Cycling performance of the Ca-CuS battery. Credit: Kazuaki Kisu

A research group has developed a prototype calcium (Ca) metal

rechargeable battery capable of 500 cycles of repeated charge-discharge—the benchmark for practical use.

The breakthrough was reported in the journal *Advanced Science* on May 19, 2023.

With the use of electric vehicles and grid-scale energy storage systems on the rise, the need to explore alternatives to [lithium-ion batteries](#) (LIBs) has never been greater. One such replacement is Ca metal batteries. As the fifth most [abundant element](#) in the Earth's crust, calcium is widely available and inexpensive and has higher energy density potential than LIBs. Its properties are also thought to help accelerate ion transport and diffusion in [electrolytes](#) and [cathode materials](#), giving it an edge over other LIB-alternatives such as magnesium and zinc.

But many hurdles remain in the way of Ca metal batteries' commercial viability. The lack of an efficient electrolyte and the absence of [cathode](#) materials with sufficient  $\text{Ca}^{2+}$  storage capabilities have proved to be the main stumbling blocks.

In 2021, some members of the current research group provided a solution to the former problem when they realized a new fluorine-free calcium (Ca) electrolyte based on a hydrogen (monocarborane) cluster. The electrolyte demonstrated markedly improved electrochemical performances such as high conductivity and high electrochemical stabilities.

"For our current research, we tested the long-term operation of a Ca metal battery with a [copper sulfide](#) (CuS) nanoparticle/carbon composite cathode and a hydride-based electrolyte," says Kazuaki Kisu, assistant professor at Tohoku University's Institute for Materials Research (IMR).

Also a natural mineral, CuS has favorable electrochemical properties. Its layered structure enables it to store a variety of cations, including lithium, sodium and magnesium. It has a large theoretical capacity of  $560 \text{ mAh g}^{-1}$ —two to three times higher than present cathode materials for lithium-ion batteries.

Through nanoparticulation and compositing with carbon materials, Kisu and his colleagues were able to create a cathode capable of storing large amounts of calcium ions. When employed with the hydride-type electrolyte, they produce a battery with a highly stable cycling performance. The prototype battery maintained 92% capacity retention over 500 cycles based on the capacity of the 10th cycle.

The group is confident that their breakthrough will help advance research into cathode materials for Ca-based batteries. "Our study confirms the feasibility of Ca metal anodes for long-term operations, and we are hopeful the results will expedite the development of Ca metal batteries," says Kisu.

**More information:** Kazuaki Kisu et al, Calcium Metal Batteries with Long Cycle Life Using a Hydride-Based Electrolyte and Copper Sulfide Electrode, *Advanced Science* (2023). [DOI: 10.1002/adv.202301178](https://doi.org/10.1002/adv.202301178)

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