Engineers develop safe and long-cyclable lithium metal battery for high temperatures

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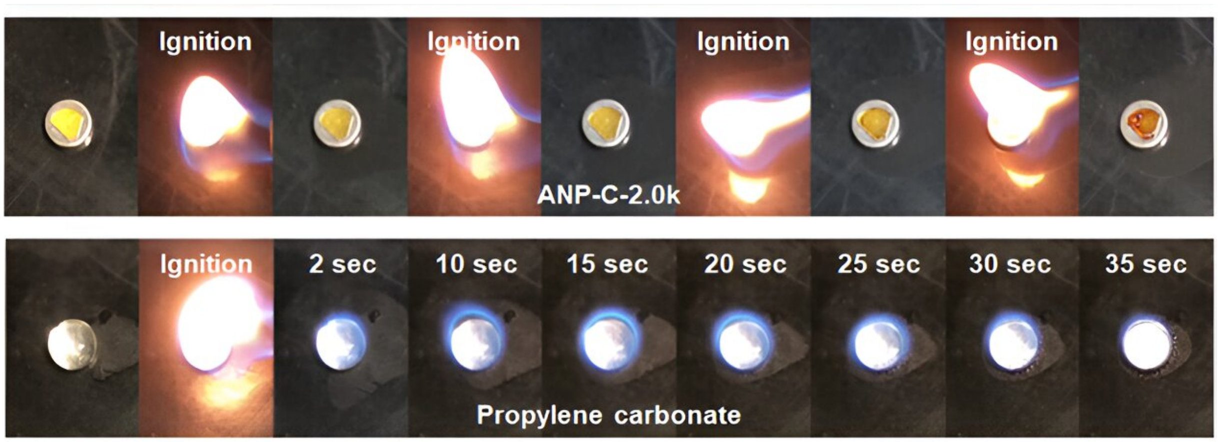


The flame tests depict that the new electrolyte membrane (above) is not ignited even with multiple applications of an open flame and resultingly simply turns into coal ash, in contrast with the highly flammable liquid organic solvent (below). Credit: The University of Hong Kong

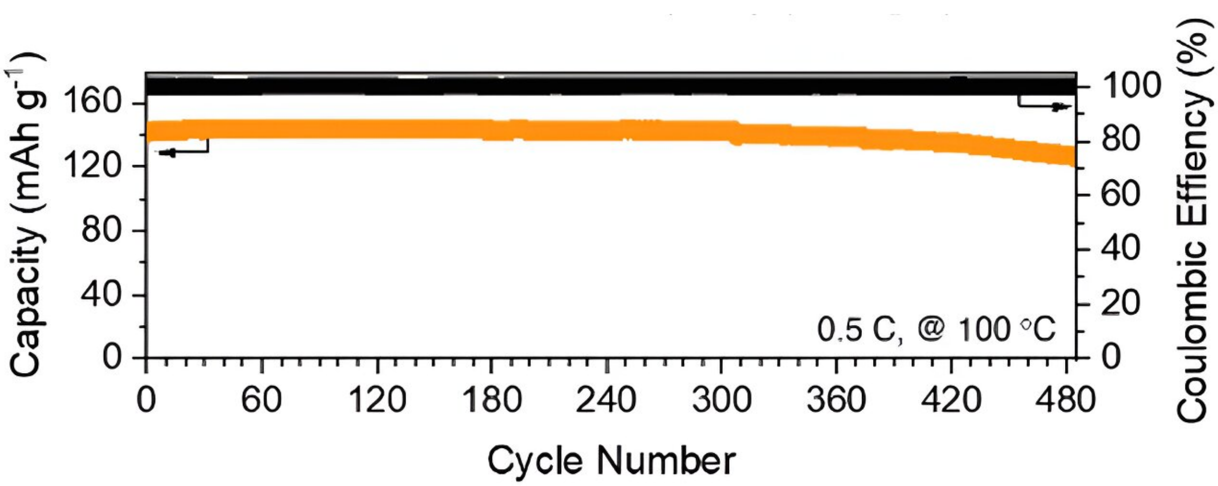
In recent years, batteries have become ubiquitous in consumers' daily lives. However, existing commercial battery technologies, which use liquid electrolytes and carbonaceous anodes, have certain drawbacks such as safety concerns, limited lifespan, and inadequate power density particularly at high temperatures.

Yet, there is an increasing need for batteries that can operate in extreme conditions, such as the high temperatures required in various industrial sectors, including medical device sterilization, subsurface exploration, and thermal reactors.

This has prompted researchers to search for solid electrolytes that are safe and compatible with lithium metal anodes, which are known for their high theoretical specific power capacity.

A research team led by Professor Dong-Myeong Shin of the Department of Mechanical Engineering at the University of Hong Kong (HKU) has developed a new generation of lithium metal batteries, representing a significant advancement in the field. Their innovation centers on microcrack-free polymer electrolytes, integral to these batteries, which promise extended lifespan and enhanced safety at elevated temperatures.

The findings have been published in the journal *Advanced Science* with the title "Accelerated Selective Li^+ Transports Assisted by Microcrack-Free Anionic Network Polymer Membranes for Long Cyclable Lithium Metal Batteries."



Cycle performance at 0.5 C and 100°C. Credit: The University of Hong Kong

The microcrack-free polymer electrolytes developed by Professor Shin's team are synthesized via a straightforward one-step click reaction, exhibiting notable attributes including resistance to dendrite growth and non-flammability, demonstrating a high electrochemical stability window up to 5 V, and an ionic conductivity of 3.1×10^{-5} S cm^{-1} at high temperatures.

These enhancements are attributed to tethered borate anions within the microcrack-free membranes, which facilitate accelerated selective transport of Li^+ ions and suppress dendrite formation. Ultimately, these anionic network polymer membranes enable lithium metal batteries to function as safe, long-cycling energy storage devices at high temperatures, maintaining 92.7% capacity retention and averaging 99.867% coulombic efficiency over 450 cycles at 100°C. Normally, the cycling performance of conventional liquid electrolyte Li metal batteries is fewer than 10 cycles at high temperatures.

The breakthrough by the research team potentially paves the way for future advancements in anionic polymer electrolyte design for next-generation lithium batteries.

"We believe this innovation opens doors for new battery chemistries that can revolutionize rechargeable batteries for high-temperature applications, emphasizing safety and longevity," said Dr. Jingyi Gao, the first author of the paper.

"Apart from applications in high-temperature scenarios, the microcrack-free electrolyte membranes also have the potential to enable fast charging due to low overpotential. This capability could allow electric vehicles to recharge in the time it takes to drink a cup of coffee, marking a significant advancement towards a clean energy future," Professor Shin added.

More information: Jingyi Gao et al, Accelerated Selective Li^+ Transports Assisted by Microcrack-Free Anionic Network Polymer Membranes for Long Cyclable Lithium Metal Batteries, *Advanced Science* (2024). [DOI: 10.1002/advs.202308530](https://doi.org/10.1002/advs.202308530)

Provided by The University of Hong Kong

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