A breakthrough in calcium ion batteries could replace lithium in clean energy storage.

Scientists at HKUST have developed high-performance calcium ion batteries using a semi-solid electrolyte, opening up the possibility of replacing lithium-ion batteries in electric vehicles and renewable energy.

A research team at the Hong Kong University of Science and Technology (HKUST) has announced a significant breakthrough in the field of calcium-ion batteries (CIBs), opening up the possibility of changing how we store energy for technological devices and systems.

By integrating quasi-solid-state electrolytes (QSSE), the research team created a new generation of calcium ion batteries with higher efficiency and greater environmental friendliness. The research results were published in the journal Advanced Science under the title: 'High-Performance Quasi-Solid-State Calcium-Ion Batteries from Redox-Active Covalent Organic Framework Electrolytes'.

This technology can support renewable energy storage, electric vehicles, and many other high-energy consumption applications.

The urgent need for lithium alternatives.

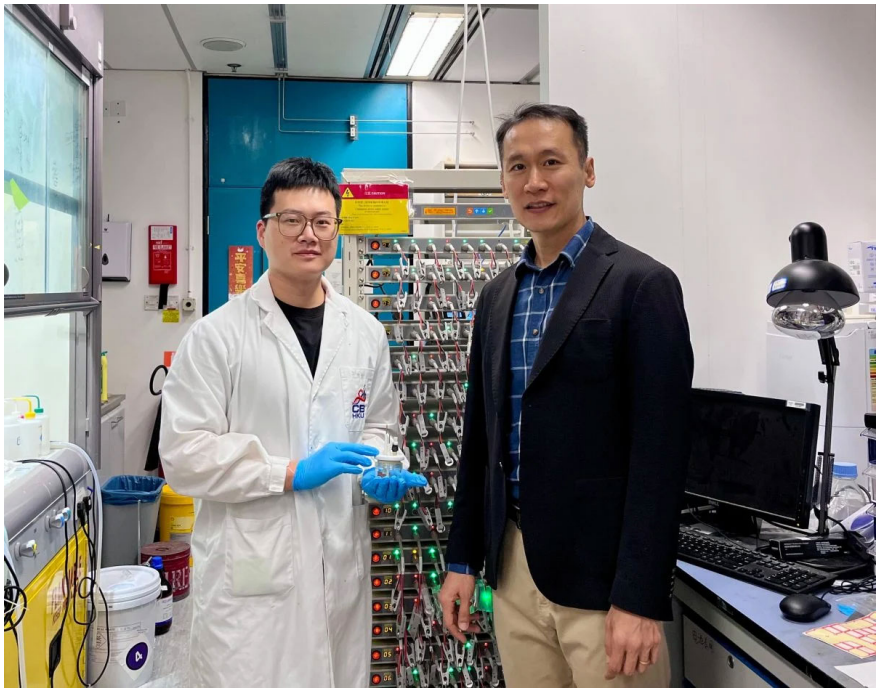
As global investment in renewable energy accelerates, the demand for high-capacity and stable batteries is also growing. Currently, lithium-ion batteries (LIBs) still dominate the market, but limited lithium supply and energy density approaching optimal levels are forcing scientists to seek new approaches.

In this context, calcium ion batteries (CIBs) have emerged as a promising option. Calcium is abundant in nature, and CIBs operate within an electrochemical range comparable to lithium-ion batteries. However, technical challenges have slowed the development of this technology. Ensuring efficient movement of Ca^{2+} ions within the battery and maintaining stability across multiple charge-discharge cycles remains a difficult problem, preventing CIBs from directly competing with commercial lithium-ion batteries.

To overcome the technical hurdles, Professor Yoonseob Kim's team – Associate Professor in the Department of Chemical and Biological Engineering, HKUST – developed redox covalent organic frameworks that act as semi-solid electrolytes.

These carbonyl-rich QSSEs exhibit strong ionic conductivity (0.46 mS/cm) and high Ca^{2+} ion transport capacity (above 0.53) at room temperature.

Combining practical experiments and computational simulations, the research team discovered that Ca2+ ions can move rapidly along the linearly arranged carbonyl groups within the ordered pores of the organic framework. This 'directed pathway' mechanism accelerates ion transport and improves battery stability.



Impressive performance after 1,000 cycles.

Based on the new platform, the team successfully fabricated a complete calcium ion battery cell with a specific recovery capacity of 155.9 mAh/g at a current density of 0.15 A/g.

Notably, even at a high current density of 1 A/g, the battery maintained over 74.6% of its capacity after 1,000 charge and discharge cycles. This result demonstrates the great potential of redox organic framework materials in upgrading calcium ion battery technology, bringing it closer to practical applications.

Professor Kim shared that this research highlights the transformative potential of calcium ion batteries as a sustainable alternative to lithium-ion technology. By exploiting the unique properties of the redox covalent organic framework, the team has taken a significant step towards high-performance energy storage systems that meet the demands of a green future.