Researchers develop sodium battery capable of rapid charging in just a few seconds

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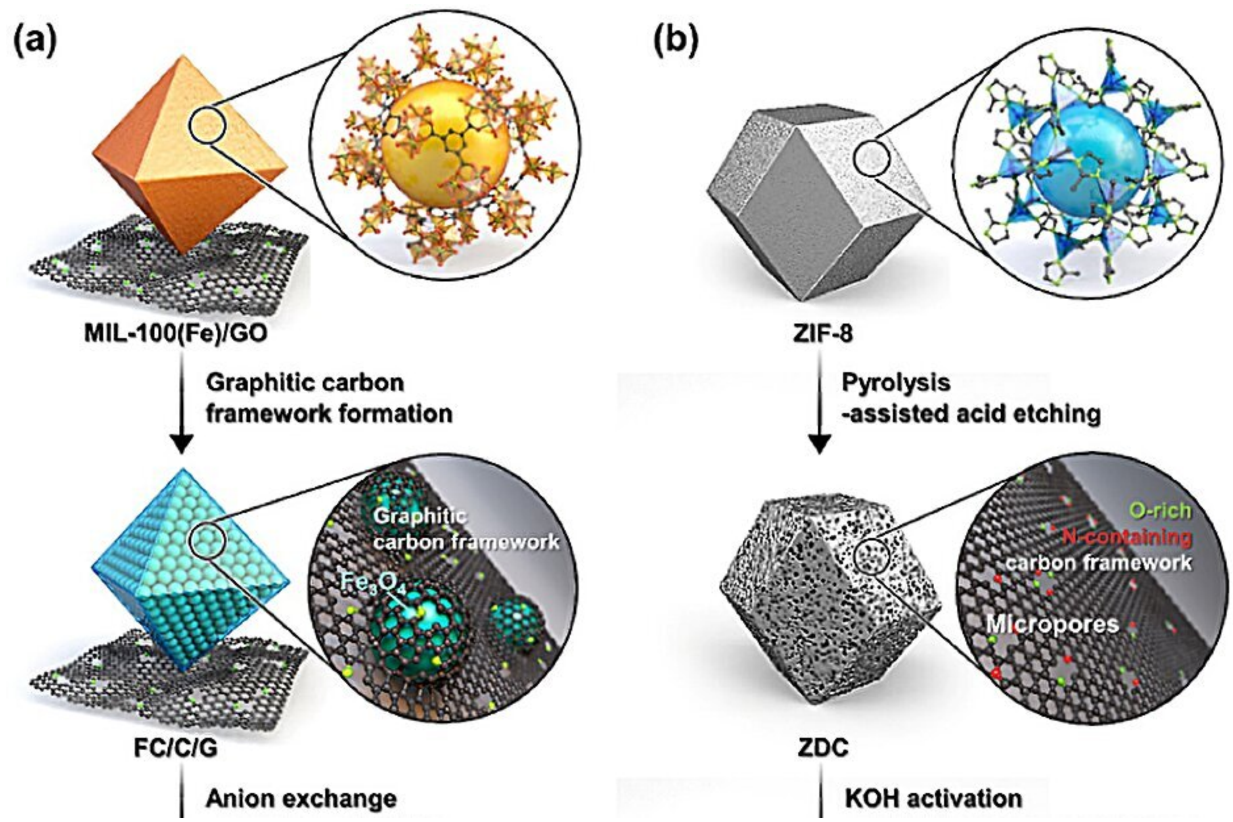


Schematic synthetic procedures of high-capacity/high-rate anode and cathode materials for a sodium-ion hybrid energy storages (SIHES) and their proposed energy storage mechanisms. Synthetic procedures for (a) ultrafine iron sulfide-embedded S-doped carbon/graphene (FS/C/G) anode and (b) zeolitic imidazolate framework-derived porous carbon (ZDPC) cathode materials. (c) Proposed energy storage mechanisms of Na+ ions in FS/C/G anode and ClO-4 ions in ZDPC cathode for an SIHES. Credit: KAIST Nano Materials Simulation and Fabrication Lab.

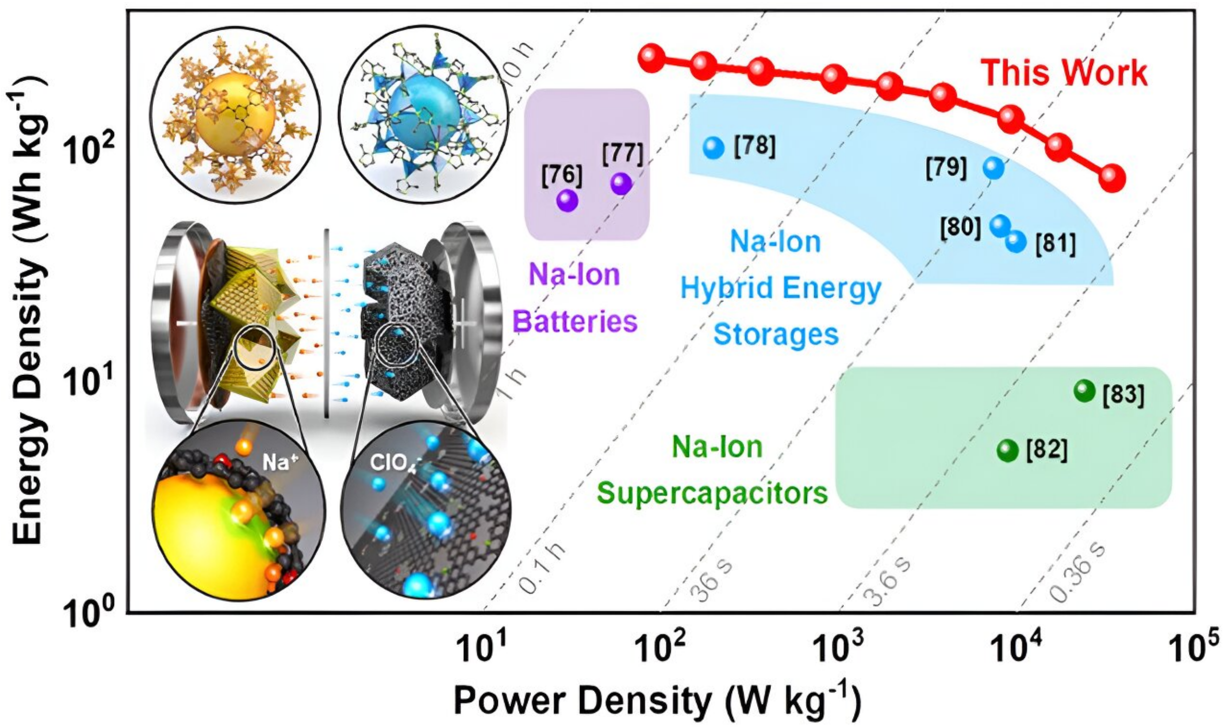
Sodium (Na), which is over 500 times more abundant than lithium (Li), has recently garnered significant attention for its potential in sodium-ion battery technologies. However, existing sodium-ion batteries face fundamental limitations, including lower power output, constrained storage properties, and longer charging times, necessitating the development of next-generation energy storage materials.

A research team led by Professor Jeung Ku Kang from the Department of Materials Science and Engineering has developed a high-energy, high-power hybrid sodium-ion battery capable of rapid charging.

This research, co-authored by KAIST doctoral candidates Jong Hui Choi and Dong Won Kim, was published in the journal *Energy Storage Materials* with the title "Low-crystallinity conductive multivalence iron sulfide-embedded S-doped anode and high-surface-area O-doped cathode of 3D porous N-rich graphitic carbon frameworks for high-performance sodium-ion hybrid energy storages."

The innovative hybrid energy storage system integrates anode materials typically used in batteries with cathodes suitable for supercapacitors. This combination allows the device to achieve both high storage capacities and rapid charge-discharge rates, positioning it as a viable next-generation alternative to lithium-ion batteries.

However, the development of a hybrid battery with high energy and high power density requires an improvement to the slow energy storage rate of battery-type anodes as well as the enhancement of the relatively low capacity of supercapacitor-type cathode materials.



Electrochemical characterizations of FS/C/G-20//ZDPC SIHES full cells (left). Ragone plots for FS/C/G-20//ZDPC (this work) and other previously reported sodium-ion electrochemical energy storage devices (right). Credit: KAIST Nano Materials Simulation and Fabrication Lab.

To account for this, Professor Kang's team utilized two distinct metal-organic frameworks for the optimized synthesis of hybrid batteries. This approach led to the development of an anode material with improved kinetics through the inclusion of fine active materials in porous carbon derived from metal-organic frameworks.

Additionally, a high-capacity cathode material was synthesized, and the combination of the cathode and anode materials allowed for the development of a sodium-ion storage system optimizing the balance and minimizing the disparities in energy storage rates between the electrodes.

The assembled full cell, comprising the newly developed anode and cathode, forms a high-performance hybrid sodium-ion energy storage device. This device surpasses the energy density of commercial lithium-ion batteries and exhibits the characteristics of supercapacitors' power density. It is expected to be suitable for rapid charging applications ranging from electric vehicles to smart electronic devices and aerospace technologies.

Professor Kang noted that the hybrid sodium-ion energy storage device, capable of rapid charging and achieving an energy density of 247 Wh/kg and a power density of 34,748 W/kg, represents a breakthrough in overcoming the current limitations of energy storage systems. He anticipates broader applications across various electronic devices, including electric vehicles.

More information: Jong Hui Choi et al, Low-crystallinity conductive multivalence iron sulfide-embedded S-doped anode and high-surface area O-doped cathode of 3D porous N-rich graphitic carbon frameworks for high-performance sodium-ion hybrid energy storages, *Energy Storage Materials* (2024). DOI: 10.1016/j.ensm.2024.103368

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