A smart color-changing flexible battery with ultra-high efficiency

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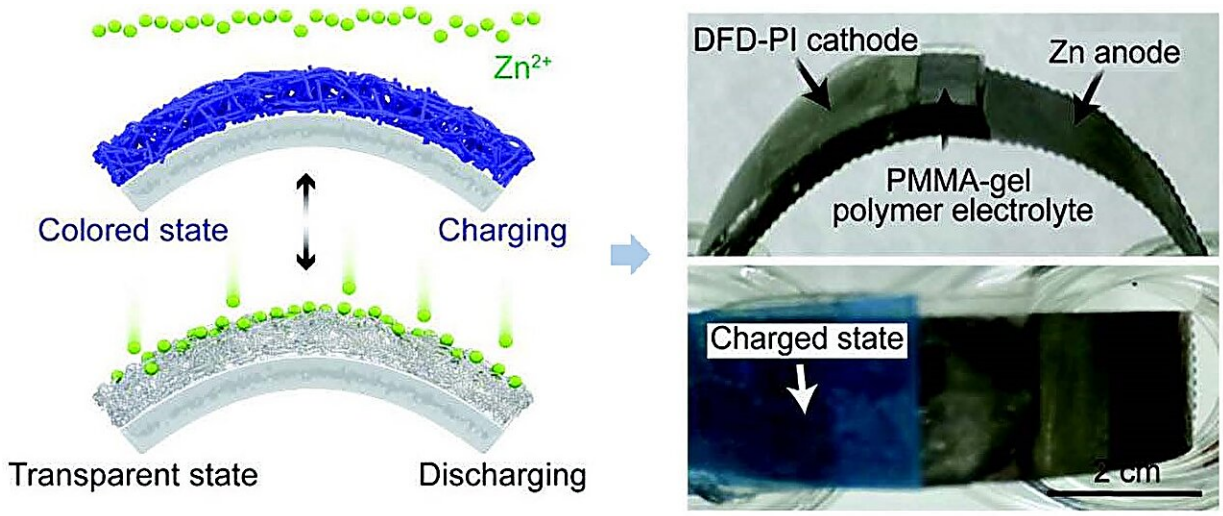

Electrochromic zinc ion battery whose anode is made of a polymer that turns dark blue when charged and transparent when discharged. Credit: *Advanced Materials* (2023). DOI: 10.1002/adma.202301141

With the rapid growth of the smart and wearable electronic devices market, smart next-generation energy storage systems that have energy storage functions as well as additional color-changing properties are receiving a great deal of attention. However, existing electrochromic devices have low electrical conductivity, leading to low efficiency in electron and ion mobility, and low storage capacities. Such batteries have therefore been limited to use in flexible and wearable devices.

On August 21, a joint research team led by Professor Il-Doo Kim from the KAIST Department of Materials Science and Engineering (DMSE) and Professor Tae Gwang Yun from the Myongji University Department of Materials Science and Engineering announced the development of a smart electrochromic Zn-ion battery that can visually represent its charging and discharging processes using an electrochromic polymer anode incorporated with a "π-bridge spacer," which increases electron and ion mobility efficiency.

Their research was published as an inside cover article for *Advanced Materials* on August 3 under the title, "A π-Bridge Spacer Embedded Electron Donor-Acceptor Polymer for Flexible Electrochromic Zn-Ion Batteries."

Batteries topped with electrochromic properties are groundbreaking inventions that can visually represent their charged and discharged states using colors, and can be used as display devices that cut down energy consumption for indoor cooling by controlling solar absorbance. The research team successfully built a flexible and electrochromic smart Zn-ion battery that can maintain its excellent electrochromic and electrochemical properties, even under long-term exposure to the atmosphere and mechanical deformations.

To maximize the efficiency of electron and ion mobility, the team modeled and synthesized the first π-bridge spacer-incorporated polymer anode in the world. π-bonds can improve the mobility of electrons within a structure to speed up ion movement and maximize ion adsorption efficiency, which improves its energy storage capacity.

In anode-based batteries with a π-bridge spacer, the spacer provides room for quicker ion movement. This allows fast charging, an improved zinc-ion discharging capacity of 110 mAh/g, which is 40% greater than previously reported, and a 30% increase in electrochromic function that

switches from dark blue to transparent when the device is charged/discharged.

In addition, should the transparent flexible battery technology be applied to smart windows, they would display darker colors during the day while they absorb solar energy, and function as a futuristic energy storage technique that can block out UV radiation and replace curtains.

Professor Il-Doo Kim said, "We have developed a polymer incorporated with a π-bridge spacer and successfully built a smart Zn-ion battery with excellent electrochromic efficiency and high energy storage capacity." He added, "This technique goes beyond the existing concept of batteries that are used simply as energy storage devices, and we expect this technology to be used as a futuristic energy storage system that accelerates innovation in smart batteries and wearable technologies."

More information: Tae Gwang Yun et al, A π-Bridge Spacer Embedded Electron Donor–Acceptor Polymer for Flexible Electrochromic Zn-Ion Batteries, *Advanced Materials* (2023). DOI: 10.1002/adma.202301141

Provided by KAIST