Uncovering the key to safer energy storage devices that avoid thermal runaway

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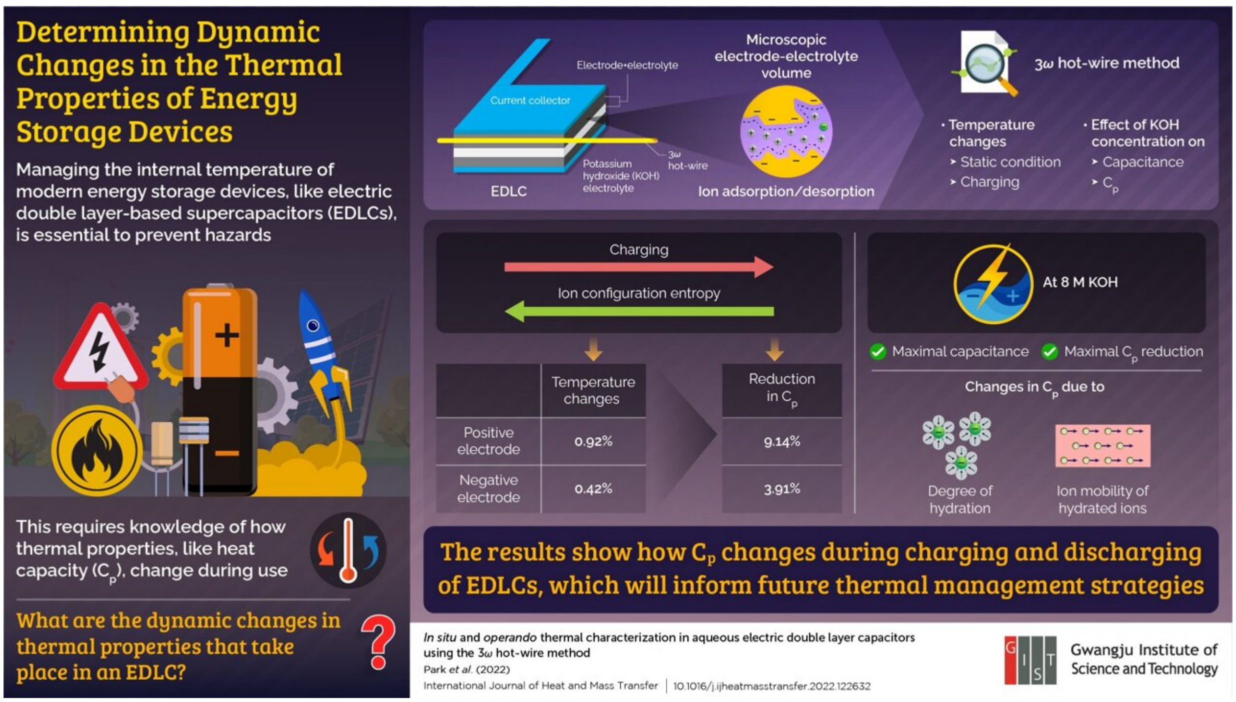

Effectively managing the thermal properties of energy storage devices is the key to avoiding thermal runaway and ensuring safety. Recently, scientists from the Gwangju Institute of Science and Technology uncovered key changes to the thermal properties of electric double-layer capacitors during charging and discharging, which will help inform future thermal management strategies. Credit: Gwangju Institute of Science and Technology (GIST)

Modern energy storage devices, such as supercapacitors and batteries, have highly temperature-dependent performance. If a device gets too hot, it become susceptible to "thermal runaway." Thermal runaway—or uncontrolled overheating—can ultimately result in explosions or fires. Adopting a well-informed thermal management strategy is necessary for the stable and safe operation of devices. To do this, it is important to understand how certain thermal properties, like heat capacity (C_p), dynamically change during charging and discharging.

Recently, researchers from the Gwangju Institute of Science and Technology investigated the thermal properties of electric double-layer capacitors (EDLCs)—a type of supercapacitor having high power and long life—for a technical foundation in thermal measurement and revealed significant information. "Using the 3ω hot-wire method, we were able to measure the change in heat capacity of EDLCs in real-time in a microscopic electrode-electrolyte volume, which is an active site for the adsorption and desorption of ions," explains Prof. Jae Hun Seol, who led the study. The study was made available online on 5 February 2022 and will be published in the *International Journal of Heat and Mass Transfer* on 1 June 2022.

The research team conducted experiments both in situ (under static conditions) and operando (during charging). They found that the temperatures of the positive and negative electrodes changed by 0.92% and 0.42% during charging, which corresponded to 9.14% and 3.91% reductions in their respective C_p. "According to thermodynamic theory, the ionic configuration entropy (a measure of randomness) of a system decreases during adsorption, i.e., charging. This also affects the free energy of the system. Together, this leads to a decrease in C_p," explains Prof. Seol.

The team also varied the concentration of the electrolyte, potassium hydroxide, to see how it affected EDLC performance. They found that the EDLC displayed maximum capacitance and Cp reduction when the electrolyte concentration was 8 M. They attributed this to variations in the degree of hydration of ions and their ionic mobility.

"An important aspect of this study is that charging and discharging also alters C_p of EDLCs," says Prof. Seol. "These findings will extend our understanding of the underlying thermal physics of EDLCs."

Indeed, these results can be considered a major step towards future effective thermal management strategies, which will create safer and more reliable energy storage devices.

More information: Yeongcheol Park et al, In situ and operando thermal characterization in aqueous electric double layer capacitors using the 3ω hot-wire method, *International Journal of Heat and Mass Transfer* (2022). DOI: 10.1016/j.ijheatmasstransfer.2022.122632

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