PRESS RELEASE

GIST Researchers Develop Novel Electrode for Improving Flowless Zinc-Bromine Battery

Researchers developed a novel electrode that effectively suppresses the harmful self-discharge phenomenon in flowless zinc-bromine batteries

The flowless zinc-bromine battery (FLZBB) is a promising alternative to flammable lithium-ion batteries due to its use of non-flammable electrolytes. However, it suffers from self-discharge due to the crossover of active materials, generated at the positive graphite felt (GF) electrode, to the negative electrode, significantly affecting performance. Now, researchers have developed a novel nitrogen-doped mesoporous carbon-coated GF electrode that effectively suppresses self-discharge. This breakthrough can lead to practical applications of FLZBB in energy storage systems.

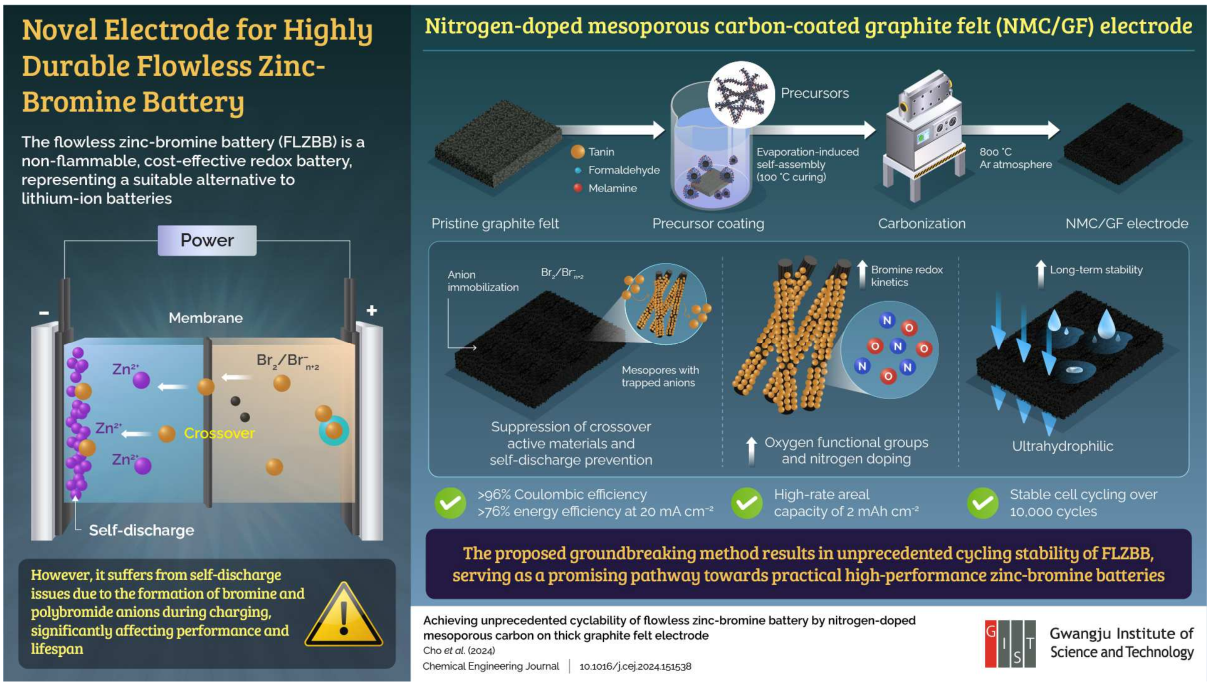

Image title: Nitrogen-Doped Mesoporous Carbon-Coated Graphite Felt Electrodes
Image caption: The novel electrodes effectively suppress the crossover of bromine and bromine complexes, thus preventing self-discharge and enhancing the electrochemical performance and cycling stability of flowless zinc-bromine batteries.
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Due to rising environmental concerns, global energy production is shifting from fossil fuels to sustainable and renewable energy systems such as solar and wind power. Despite their advantages, they have two significant weaknesses: volatile power production and irregular supply. Hence, they are augmented with energy storage systems (ESSs). Lithium-ion batteries are at the forefront of ESSs but are prone to fires due to flammable electrolytes and lithiumbased materials. The flowless zinc-bromine battery (FLZBB), which uses non-flammable electrolytes, is a promising alternative, offering cost-effectiveness and a simple battery platform.

A FLZBB consists of a positive electrode, a negative electrode, an electrolyte, and a separator to keep the electrodes apart. Unlike conventional zinc-bromine batteries, the electrolyte in FLZBB does not need to be pumped and is instead held in a gel-like container. Graphite felt (GF) is widely used as an electrode in many redox batteries due to its stability in acidic electrolytes. However, in FLZBBs, bromine and polybromide ions are formed within the GF-positive electrode during charging. These active materials can escape and diffuse uncontrollably to the negative electrode, causing self-discharge, which severely affects performance and lifespan. Many studies have explored approaches to suppress this crossover phenomenon, however, self-discharge remains a major issue for FLZBBs.

To address this issue, a team of researchers led by Professor Chanho Pak and including integrated M.S. and Ph.D. student Youngin Cho (first author) from the Graduate School of Energy Convergence, Institute of Integrated Technology at Gwangju Institute of Science and Technology, Korea, developed a novel nitrogen-doped mesoporous carbon-coated thick GF (NMC/GF) electrode. Their study was made available online on April 22, 2024, and published in Volume 490 of the *Chemical Engineering Journal* on June 15, 2024.

The researchers fabricated the NMC/GF electrodes using a simple, cost-effective evaporation-induced self-assembly method. In this method, a pristine GF felt was coated with precursor materials and mixed in a solvent, followed by drying and curing. When applied to an FLZBB, the new electrodes effectively suppressed the crossover of the active materials and prevented self-discharge. This success was attributed to the mesopores present on the GF fibers in the NMC/GF electrodes.

Prof. Pak explains, "*The NMC coating on the GF electrodes introduced mesopores with strategically embedded nitrogen sites, which served as a stronghold, capturing the bromine and bromine complexes in the positive electrode, suppressing bromine crossover and self-discharge phenomena*. *Moreover, this coating made the originally hydrophobic pristine GF electrodes ultrahydrophilic, improving interfacial contact with the electrolyte in the aqueous electrolyte and enhancing electrochemical performance. Additionally, it allowed the incorporation of abundant oxygen and nitrogen species, which improved bromine reaction speeds, further boosting performance*."

The FLZBB with NMC/GF electrodes demonstrated excellent Coulombic and energy efficiencies of 96% and 76%, respectively, at a current density of 20 mA cm^{-2}, as well as a high-rate areal capacity of 2 mAh cm^{-2}. Furthermore, the battery exhibited unprecedented durability, with charge/discharge cycling stability extended to over 10,000 cycles. Also, the thick GF electrode used can potentially reduce the overall price of the battery.

Highlighting the significance of this achievement, Prof. Pak says, "*The development of FLZBB positive electrode, which maintains long-term operation over 10,000 cycles with high efficiencies, will accelerate the development of stable ESSs and eco-friendly energy conversion* *in the long term. Moreover, NMC/GF positive electrode can also be used for other aqueous batteries.*"

This groundbreaking technology can enable practical applications of FLZBB, leading to safer ESSs and more stable renewable energy systems.

Reference

Title of original paper:	Achieving unprecedented cyclability of flowless zinc-bromine battery by nitrogen-doped mesoporous carbon on thick graphite felt electrode
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About the Gwangju Institute of Science and Technology (GIST)
The Gwangju Institute of Science and Technology (GIST) was founded in 1993 by the Korean government as a research-oriented graduate school to help ensure Korea's continued economic growth and prosperity by developing advanced science and technology with an emphasis on collaboration with the international community. Since that time, GIST has pioneered a highly regarded undergraduate science curriculum in 2010 that has become a model for other science universities in Korea. To learn more about GIST and its exciting opportunities for researchers and students alike, please visit http://www.gist.ac.kr/.

About the authors
Dr. Chanho Pak has been a full professor at Gwangju Institute of Science and Technology (GIST) since August 2016. Before moving to GIST, he worked as the vice president of the Battery Research Center of Samsung SDI, directing the development of MEA for fuel-cell electric vehicles. He also worked for the Samsung Advanced Institute of Technology of Samsung Electronics from 1995 to 2013. He received his B.S. (1990), M.S. (1992), and Ph. D. (1995) degrees from the Department of Chemistry at the Korea Advanced Institute of Science and Technology. He conducted postdoctoral research at the Department of Chemical Engineering at Yale University in 1999 and the College of Chemistry at the University of California, Berkeley in 2000. He has over 130 research publications and 228 granted patents in the field of fuel cell and nanostructured materials.

Youngin Cho is an integrated M.S. and Ph.D. student at Gwangju Institute of Science and Technology since 2022.