New design for a rechargeable hydrogen-chlorine battery in a wide temperature range

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A research team led by Prof. Chen Wei from the University of Science and Technology of China (USTC) of the Chinese Academy of Sciences (CAS) designed a rechargeable hydrogen-chlorine (H₂-Cl₂) battery that can operate in temperatures ranging from -70°C to 40°C. The study was
published in *Journal of the American Chemical Society* as the cover article.

Hydrogen fuel cells are a promising technology valuable for their sustainability and the abundance of hydrogen, among which H₂-Cl₂ fuel cells stand out due to fast electrochemical kinetics, high redox potential and high specific capacity of Cl₂/Cl⁻ redox couple. However, the volatile chlorine gas cannot be retained during the charging process, resulting in poor Coulombic efficiency (CE) and reversibility. There is an urgent need to develop aqueous chlorine batteries with high performance and applicability at different temperatures.

The research team first discovered that due to the lack of binding sites with strong affinity to Cl₂, traditional adsorptive cathodes have difficulty immobilizing Cl₂, causing low reversibility. To tackle this problem, the team designed a hierarchically porous carbon cathode composed of highly micro-/mesoporous carbon (HPC) and macroporous carbon felt (CF), effectively confining the Cl₂ on the cathode and improving the reversibility.

The team showed that the H₂-Cl₂ cells maintained a high CE and stability, operating steadily for 500 cycles at a discharge capacity of 3 mAh cm⁻². In addition, the cells operate well at ultralow temperatures, maintaining a discharge plateau of 1.1 V and a high specific capacity of 282 mAh g⁻¹ at -70°C.

To further understand the mechanism of reversibility improvement, the team combined X-ray photoelectron spectroscopy (XPS) with theoretical calculations and revealed that the Cl₂/Cl⁻ reaction occurs along with the reversible formation and breakage of C-Cl bonds, which enhances the reversibility of the Cl₂/Cl⁻ cathodes.

This work provides a new direction for the design of aqueous chlorine
batteries and high-energy-density hydrogen batteries in a wide temperature range.

**More information:** Zehui Xie et al, Rechargeable Hydrogen–Chlorine Battery Operates in a Wide Temperature Range, *Journal of the American Chemical Society* (2023). [DOI: 10.1021/jacs.3c09819](https://doi.org/10.1021/jacs.3c09819)

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