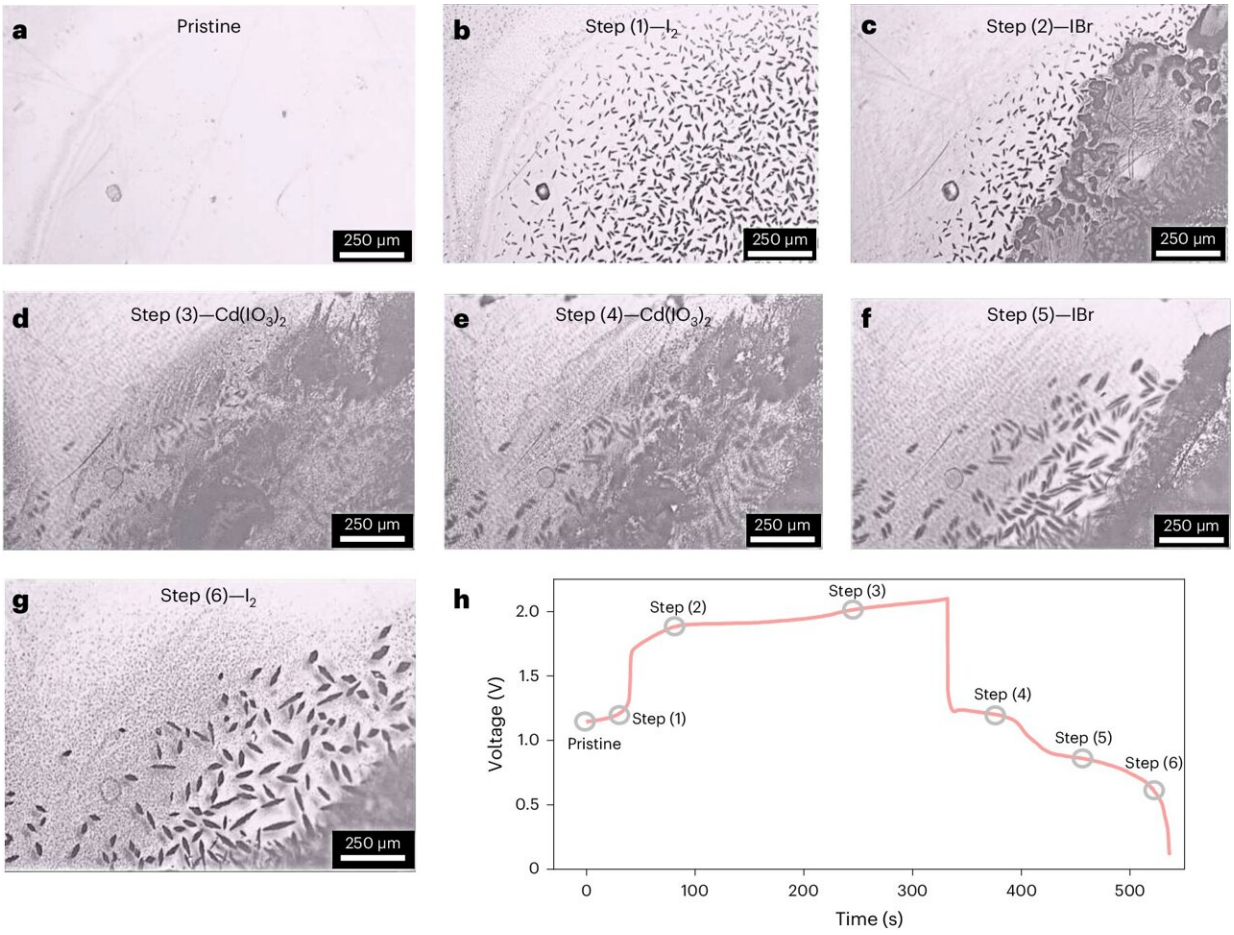
# Researchers develop high-energy-density aqueous battery based on halogen multi-electron transfer

April 23 2024, by Liu Jia




In situ observation of the charge-discharge process of IBA under an optical microscope. Credit: *Nature Energy* (2024). DOI: 10.1038/s41560-024-01515-9

Traditional non-aqueous lithium-ion batteries have a high energy density, but their safety is compromised due to the flammable organic electrolytes they utilize.

Aqueous batteries use water as the solvent for electrolytes, significantly enhancing the safety of the batteries. However, due to the limited solubility of the electrolyte and low battery voltage, aqueous batteries typically have a lower energy density. This means that the amount of electricity stored per unit volume of aqueous battery is relatively low.

In a study published in *Nature Energy*, a research group led by Prof. Li Xianfeng from the Dalian Institute of Chemical Physics (DICP) of the Chinese Academy of Sciences (CAS), in collaboration with Prof. Fu Qiang's group also from DICP, developed a multi-electron transfer cathode based on bromine and iodine, realizing a specific capacity of more than 840 Ah/L, achieving an energy density of up to 1,200 Wh/L based on catholyte in full battery testing.

To improve the energy density of aqueous batteries, researchers used a mixed halogen solution of iodide ions ($I^-$) and bromide ions ($Br^-$) as the electrolyte. They developed a multi-electron transfer reaction, transferring $I^-$ to iodine element ($I_2$) and then to iodate ($IO_3^-$).

During the charging process, $I^-$ were oxidized to $IO_3^-$ on the positive side, and the generated $H^+$ were conducted to the negative side in the form of supporting electrolyte. During the discharge process, $H^+$ were conducted from the positive side, and $IO_3^-$ were reduced to $I^-$.

The developed multi-electron transfer cathode had a specific capacity of 840 Ah/L. Combining the cathode with metallic Cd to form a full battery, researchers achieved an energy density up to 1,200 Wh/L based on the developed catholyte.

Researchers confirmed that $Br^-$ added to the electrolyte could generate polar iodine bromide (IBr) during the charging process, which facilitated the reaction with $H_2O$ to form $IO_3^-$. During the discharge, $IO_3^-$ could oxidize $Br^-$ to $Br_2$ and participated in the electrochemical reaction to realize reversible and rapid discharge of $IO_3^-$.

Therefore, the bromide intermediate formed during the charge and discharge process optimized the reaction process, effectively improving the kinetic and reversibility of the electrochemical reaction.

Prof. Fu's group proved the multi-electron transfer process through in-situ optical microscopy, Raman spectroscopy and so on.

"This study provides a new idea for the design of high-energy-density aqueous batteries, and may expand the aqueous batteries application in power batteries field," said Prof. Li.

**More information:** Xie, C., et al. Reversible multielectron transfer I−/IO3− cathode enabled by a hetero-halogen electrolyte for high-energy-density aqueous batteries. *Nature Energy* (2024). DOI: 10.1038/s41560-024-01515-9

Provided by Chinese Academy of Sciences