Surface science methodology reveals relaxation and failure mechanisms of energy storage devices

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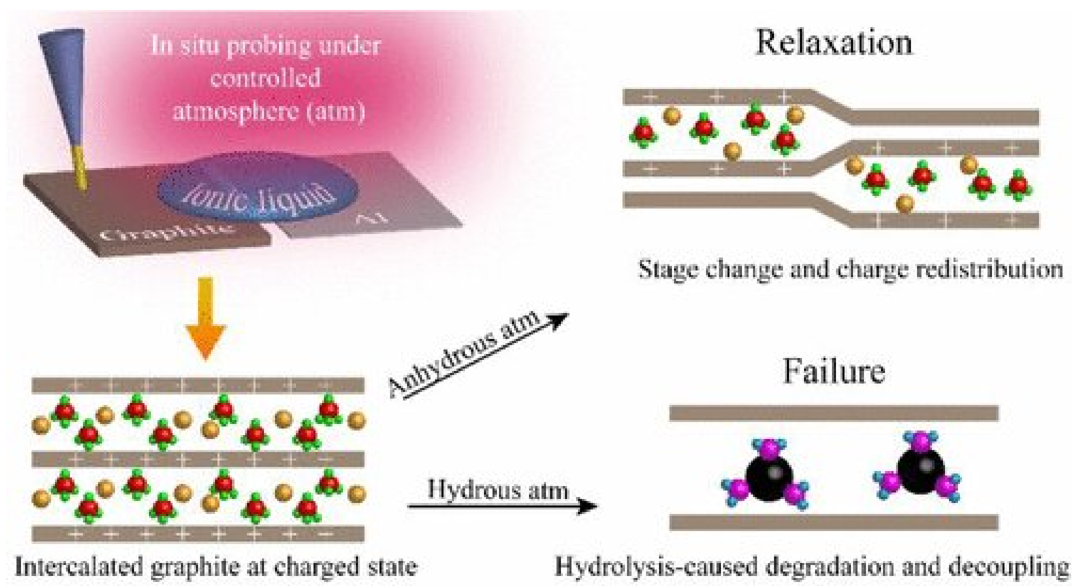

Graphical abstract. Credit: DOI: 10.1021/jacs.1c09429

Long cycle life and high safety are required for energy storage devices (ESDs) in their large-scale applications. Therefore, it's important to explore both the operating and failure mechanisms of ESDs.

Previous characterization techniques such as X-ray diffraction (XRD), transmission electron microscopy (TEM), X-ray spectroscopy and topography, and nuclear magnetic resonance (NMR) were based on bulk regions of electrodes or electrolytes, and they overlooked the critical surface/interface behaviors that govern the operation and failure in ESDs.

Recently, a research team led by Prof. Fu Qiang from the Dalian Institute of Chemical Physics (DICP) of the Chinese Academy of Sciences (CAS) revealed the atmosphere-dependent relaxation and failure mechanisms of ESDs by in situ surface science methodology.

The results were published in *Journal of the American Chemical Society* on Oct. 13.

The researchers visualized atmosphere-dependent relaxation and failure processes in ESDs by in situ Raman, X-Ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS).

They found that for aluminum ion battery (AIB), the relaxation effects of the graphite electrode in anhydrous atmospheres were manifested by recoverable stage-structure change and electronic relaxation. The mechanism could be described as the redistribution of the anion/cation pairs within graphite electrode by in situ XPS.

Once exposure to hydrous atmospheres, H_2O molecules from ambient could intercalate into the graphite electrode and hydrolysis reactions could be induced between newly intercalated H_2O and ions. After H_2O intercalation and hydrolysis, the failure behaviors of the graphite electrode happened as shown by the stage-structure degradation and electronic decoupling.

"We have developed the atmosphere-, temperature- and potential-controlled operando/in situ surface/interface techniques and well-defined model devices," said Prof. Fu. "Such methods can be extended to explore the relaxation and failure mechanisms of more ESDs, such as metal-ion secondary batteries/supercapacitors, and the interface reactions in metal-gas batteries."

More information: Chao Wang et al, In Situ Visualization of Atmosphere-Dependent Relaxation and Failure in Energy Storage Electrodes, *Journal of the American Chemical Society* (2021). DOI: 10.1021/jacs.1c09429

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