In situ/operando synchrotron-based X-ray studies on batteries and supercapacitors

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Abstract

Energy storage technology is the key challenge for power generation and renewable energy sources transporting. Various types of energy storage systems have been developed to store renewable energies. Electrochemical energy storage devices, such as batteries and supercapacitors, have been developed tremendously because of their potential applications such as portable electronics, electro mobility, and large-scale stationary energy storage. Lithium ion batteries (LIBs) which possess high energy density have been widely utilized in portable electronic devices, and they are also a promising energy storage system for electric vehicles recently. Although LIBs are the leading energy storage technology nowadays, the limited resources of lithium and the high cost are the major challenges.[2-5] Na-ion batteries (NIBs) and Zn-ion batteries (ZIBs) are promising candidates for large-scale energy storage due to high abundance of sodium and zinc.[5] Thus, NIBs and ZIBs have attracted significant attention recently because of their low-cost advantages.

Here we synthesized various advanced metal oxides such as polyoxometalates (POMs) and high-entropy oxides (HEOs) and evaluate their electrochemical performance in LIBs and NIBs. They exhibit different behaviors from the traditional binary or ternary metal oxides. POMs are transition metal oxide clusters which can provide multiple redox reactions during charging/discharging processes. HEOs are a new class of metal oxides which consist of at least five cations in the crystal structure and exhibits high entropy of the system. High capacity (> 1000 mA h g^{-1}) and well cycling stability (without significant capacity fading up to 100 cycles) can be obtained with those metal oxide electrodes. To understand the charge storage mechanism of those advanced metal oxides, several *in operando* synchrotron X-ray techniques including X-ray diffraction, X-ray absorption spectroscopy, as well as transmission X-ray microscopy were conducted.

Keywords – batteries, supercapacitors, in operando X-ray diffraction, in operando X-ray absorption spectroscopy, in operando transmission X-ray microscopy