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Recyclable aqueous-based polymeric energy storage device

The decarbonization of the energy industry and digitalization of society will accelerate the production of energy storage devices. To ensure long-term sustainable usage of finite resources, it is imperative to design intrinsic circularity into energy storage devices, in particular the recyclability of their constituent materials. However, the recovery and extraction of most electrode materials reported to date are complex and energy intensive as they are multi-phased. Here, we demonstrate polymeric energy storage electrodes that are operated in aqueous electrolytes, are simultaneously redox-active, ionically and electronically conductive, as well as solution processible. These characteristics enable the implementation of electrochemically stable single-phased electrodes that can be deposited using simple solution processing techniques and subsequently be solvent extracted at the device's end-of-life, recycled, and redeposited for new devices. In this work, we demonstrate the recyclability of a pair of single-phased electron- and hole-transporting conjugated polymers that retain high electrochemical stability and capacity over multiple recycling cycles. By demonstrating the design criteria for achieving multifunctional, single-phased, and solution processible materials as energy storage electrodes, this work provides a framework of design strategies for more sustainable energy storage technologies.