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Simultaneously Ion- and Electron-Conducting Block Copolymer Binders for Battery Electrodes[1]

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Lithium-ion batteries provide a portable, on-demand source of electrical energy and are comprised of multiple components for storing and releasing ions, transporting charges, and maintaining mechanical integrity. Polymeric binders, although representing only a fraction of the battery, are an important component for maintaining adhesion between different parts. Polymers that are simultaneously ion- and electron-conducting and redox-active are potentially ideal materials for use in electrodes, and here we show that such polymers can improve both mechanical and electrochemical properties of electrodes. First, flexible, carbon-free hybrid battery cathodes are prepared using poly(3-hexylthiophene)-*block*-poly(ethyleneoxide) (P3HT-*b*-PEO) as a binder. Only 5_wt % polymer was required to triple the flexibility of V_2O_5, and electrodes comprised of 10_wt % polymer had unusually high toughness (293_kJ/m^3) and specific energy (530_Wh/kg), both higher than reduced graphene oxide paper electrodes. Next, we present work on self-doped conjugated polymeric binders, which provide stable conductivities and are fully water-processable. These materials are incorporated into V_2O_5 cathodes and suppress the crystallization of V2O5, even at thermal annealing temperatures above 400 C, maintaining the more favorable aerogel structure. Finally, we discuss the design and development of conjugated and redox-active polymers in Silicon anodes. These results highlight the importance of tradeoffs between mechanical and electrochemical performance in the design of conjugated polymeric binders.

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