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Rational design of 2D manganese phosphate hydrate nanosheets as pseudocapacitive electrodes

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Abstract

A new class of 2D nanosheets of nitrogen-integrated phosphate-rich ammonium manganese phosphate hydrate, ($NH_4MnPO_4 \cdot H_2O$) (AMP), has been developed as pseudocapacitive electrode materials. The optimized electrodes exhibited device capacitances of 48.4 and 65.4 F/g for symmetric and asymmetric configurations, respectively. The devices showed excellent energy and power (e.g., 29.4 Wh/kg and 133 kW/kg for asymmetric cells) with extraordinary capacitance retention (e.g., >93%, 100 000 cycles at 5 A/g for asymmetric cells) that surpass those of most of the reported values. The huge pseudocapacitance of AMP is attributed to several factors, including the electroactive sites containing NH_4^+ ions, the conductive inorganic layers, intercalated water interactions of $Mn^{2+}\cdots H_2O$, redox-active phosphate ions, and the 2D nanosheets. AMP-based all-solid-state flexible asymmetric devices exhibited >95% capacitance retention upon 1000 repetitive charge–discharge cycles. This study opens doors to elegant strategies of unlocking the rich physicoelectrochemical properties of 2D AMP for next-generation pseudocapacitors.