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Previous Next

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Rational La-doped hematite as an anode and hydrous cobalt phosphate as a battery-type electrode for a hybrid supercapacitor†

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Abstract

In recent years, modern appliances require high energy density with a burst power supply. Hybrid supercapacitors show high performance based on high energy density without compromising power density and stability over thousands of charge–discharge cycles. In this work, the optimized hybrid electrodes using lanthanum-doped hematite (lanthanum-doped iron oxide) noted as 7.5%La-HMT as a negative electrode and hydrous cobalt phosphate (CoPO) as a battery-type positive electrode have been successfully fabricated *via* a simple hydrothermal method and a facile co-precipitation method, respectively. The 7.5%La-HMT showed excellent electrochemical performance due to doping of rare-earth La^{3+} metal ions, resulting in improvised active sites and reduction in the equivalent resistance. The 7.5%La-HMT operated at a high potential window (0 to −1.2 V) with an ultra-high specific capacitance (S_p) of 1226.7 F g^{-1} at 1 A g^{-1} with capacitance retention of 89.3% over 1000 cycles. CoPO could be operated at a high working window (0 to 0.45 V) with a specific capacity of 121.7 mA h g^{-1} at a current density of 2 A g^{-1} with capacitance retention of 85.4% over 1000 cycles. The configured CoPO//KOH//10%La-HMT aqueous hybrid capacitor device (Aq-HSC) could be operated at a potential window of 1.6 V and delivered a maximum energy density (E.D) of 83.6 W h kg^{-1} at a power density (P.D)