

Electronic Supplementary Information

Bimetallic nickel cobalt selenides: a new kind of electroactive materials for high-power energy storage

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Experimental sections

Synthesis of $\text{Ni}_x\text{Co}_{1-x}(\text{CO}_3)_{0.5}\text{OH}$ precursor: The Ni–Co precursors are synthesized via a facile urea-assisted hydrothermal method. In the typical procedure, $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ and $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ with different ratios were firstly dissolved into 60 ml of deionized water (the total mass of $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ and $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ is 1 mmol); then 5 mmol of urea was added to the solution under vigorous stirring to form a homogeneous solution. The solution was transferred into a Teflon-lined stainless-steel autoclave and heated at 120 °C for 12h. After cooling down to room temperature, the precipitate was collected by three deionized water and ethanol washing cycles.

Synthesis of the Ni–Co selenides: The $\text{Ni}_x\text{Co}_{1-x}(\text{CO}_3)_{0.5}\text{OH}$ precursors were converted to Ni–Co selenides by hydrothermal treating of the precursor in selenide solution. Typically, 70 mg of the precursor was dispersed into 50 ml of the ethanol under ultrasonic treatment. Then, 200 mg of Na_2SeO_3 and 10 ml of hydrazine hydrate were added into the solution under vigorous stirring. The solution was transferred into a Teflon-lined stainless-steel autoclave and heated at 140 °C for 12h. The Ni–Co selenides were collected by repeated washing with deionized water and ethanol.

Materials characterizations: The crystalline structures of Ni–Co selenides were characterized by XRD (AXS D2 Phaser; Cu $K\alpha$, $\lambda=0.1542$ nm) test. The morphology of the samples was characterized by SEM (HITACHI SU8010) and HRTEM (JEOL JEM-2100F) measurements. The

surface elements and their chemical valance in Ni_{0.5}Co_{0.5}Se sample was determined by the XPS (Kratos, AXIS-ULTRA DLD-600W) test.

Electrochemical measurments: Electrochemical performances of the Ni–Co selenides were evaluated in a three-electrode glass configuration. 6 M KOH is used as the electrolyte, a platinum foil (1cm×1cm) was used as the counter electrode, and a Hg/HgO electrode was used as reference electrode. For preparation of working electrode, the active material, acetylene black and poly(tetrafluoroethylene) in a mass ratio of 80:10:10 is mixed with a small amount of ethanol. The mixture was drop dried into a circular Ni foam ($d=1.2$ cm) and pressed at 10 MPa. The mass of active material in each electrode is 3~4 mg. The electrodes were first activated by several CV cycles and then used for CV and GCD measurements. The specific capacity (in C g⁻¹) is calculated from GCD curves following equation $C=Q/m=It/m$. All of the electrochemical measurements were performed by a CHI 660E electrochemical workstation.

The Ni_{0.67}Co_{0.33}Se//RGO hybrid supercapacitor is assembled using Ni_{0.67}Co_{0.33}Se as positive electrode material and RGO electrode as the negative electrode material. To balance the charge storage in positive and negative electrodes, the charge storage in positive electrode (Q_+) and negative electrode (Q_-) should follow the equation: $Q_+=Q_-$, where $Q_{\pm}=C_{\pm}\times m_{\pm}$. So the mass ratio of electroactive in positive electrode and negative electrode is $m_+/m_-=C_-/C_+$. The specific capacity values of Ni_{0.67}Co_{0.33}Se and RGO electrodes are both calculated by the CV curves at 5 mV s⁻¹. The specific capacity of each electrode is calculated according to CV curves following the equation: $C=\int(I dV)/(vm)=S/(2vm)$, where S is the integral area of the CV curve, v is the scan rate.