Facile synthesis and superior supercapacitor performances of

Ni$_2$P/rGO Nanoparticles

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Experimental Section

Synthesis

All chemicals were of analytical grade and used without further purification. Graphene oxide (GO) was made via a modified Hummers method.[1, 2] The Ni$_2$P/rGO composites were synthesized via two steps. Step 1, the synthesis of the precursor was reported in the previous literatures.[3-7] Step 2, in a typical synthesis of Ni$_2$P/rGO composites, 5 mg GO and 0.3 g the precursor were dispersed in 20ml distilled water and subjected to ultrasonic vibration to form a homogeneous suspension, respectively. The two former suspensions were homogeneously mixed with each other and subjected to ultrasonic vibration for a while, named as M1. The 1.03 g NaH$_2$PO$_2$ ·H$_2$O was dispersed in 20 ml distilled water and mixed with M1. Then, the mixture was calcined at 500 ℃ for 1 h and cooled to room temperature under a flow of Ar (99.999%). The solid obtained was washed thoroughly with distilled water and absolute ethyl alcohol to remove the by-products. After that, the wet products were dried at 80℃ for 12h in a vacuum oven.

Pure Ni$_2$P nanoparticles were synthesized by the same method as described above to make Ni$_2$P/rGO composite, except that there was no GO involved.
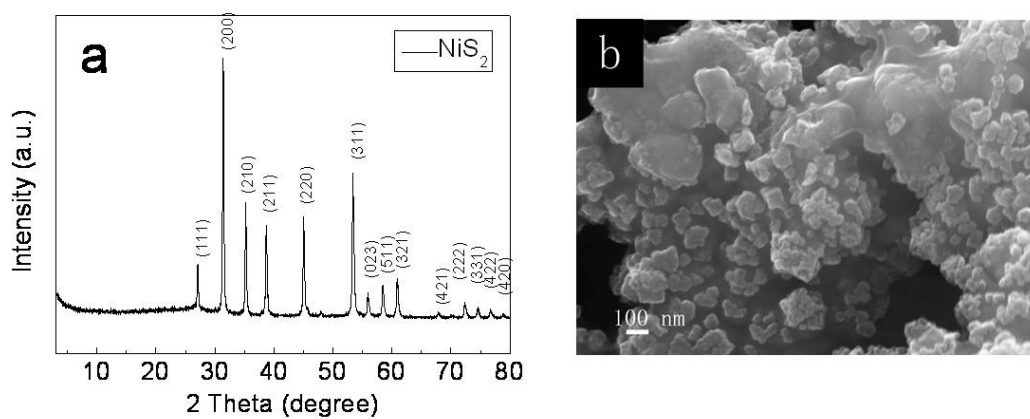
Characterization

The crystal structure and surface configuration of samples was determined by powder X-ray diffraction (XRD，Rigaku D/Max-2500，Cu Kα radiation)，scanning

electron microscope (SEM，JEOL JSM-6700F Field Emission) , transmission electron microscope (TEM) and high-resolution transmission electron microscope (HR-TEM) on a JEOL JEM-2100 TEM. The electronic states of the as-prepared products were investigated by X-ray photoelectron spectroscopy (XPS, PHI5000VersaProbe).

Electrochemical measurements

For electrochemical measurements, the working electrodes were constructed by mixing the active material, acetylene black，graphite and Polyvinylidene Fluoride (PVDF) binder in a weight ratio of 70:20:5:5. This mixture was then pressed onto the nickel foam electrode (1.0 cm×1.0 cm), and dried under vacuum at 80℃ for 10 h. Then, electrochemical measurements were conducted in a three compartment cell using a LAND battery test instrument (CT2001A). A nickel foam and saturated calomel electrode (SCE) electrode were used as a counter electrode and reference electrode, respectively. The electrolyte was a 2 M KOH aqueous solution. Cyclic voltammetry (CV) was conducted by a Zahner IM6e electrochemical workstation with voltage scan rates of 1 mV s^{-1}, 5 mV s^{-1}, 10 mV s^{-1}, 20 mV s^{-1} and 50 mV s^{-1}. The galvanostatic charge-discharge tests were conducted at the current of 1 mA cm^{-2}, 5 mA cm^{-2}, 10 mA cm^{-2}, 20 mA cm^{-2} and 50 mA cm^{-2}.

Fig.S1.   XRD pattern (a) and SEM image (b) of the precursor NiS$_2$.
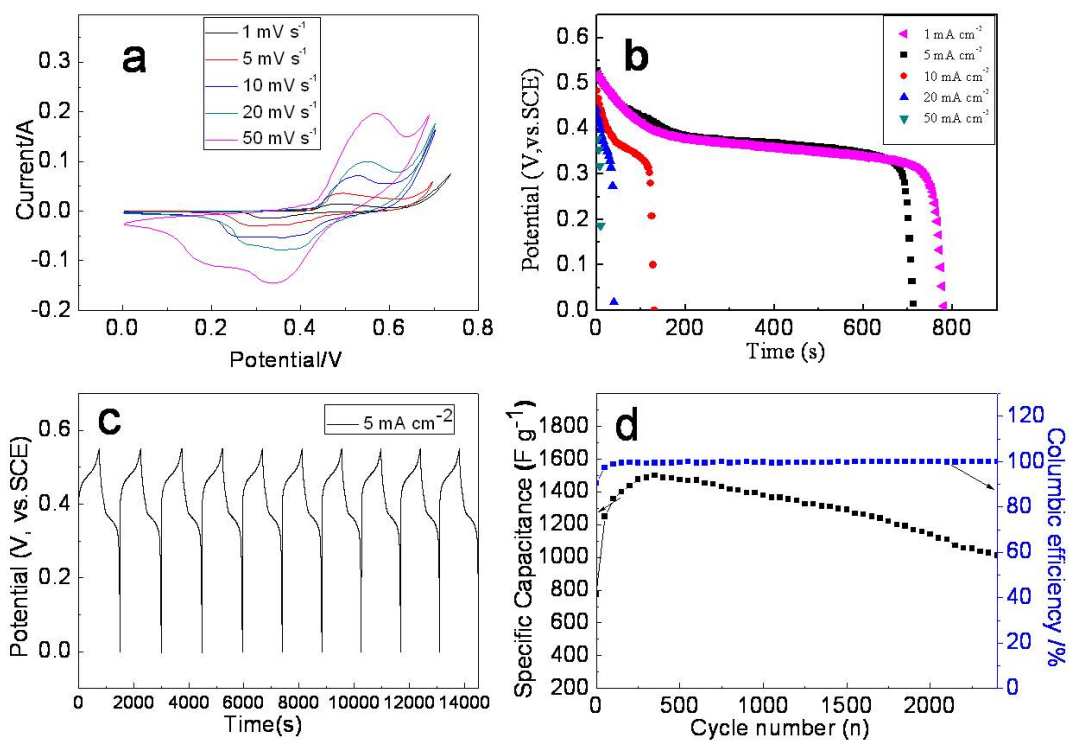
Fig.S2. Electrochemical characterizations of Ni_2P electrode. (a) CV curves of Ni_2P electrode at various scan rates. (b) Galvanostatic discharge curves of Ni_2P electrode at various discharge current densities. (c) Galvanostatic charge and discharge curves of Ni_2P electrode at a current density of 5 mA cm^{-2}. (d) Dependences of the discharge specific capacitance and the coulombic efficiency on the charge-discharge cycle numbers. The charge-discharge tests were performed at 5 mA cm^{-2} in 2 M KOH solution.
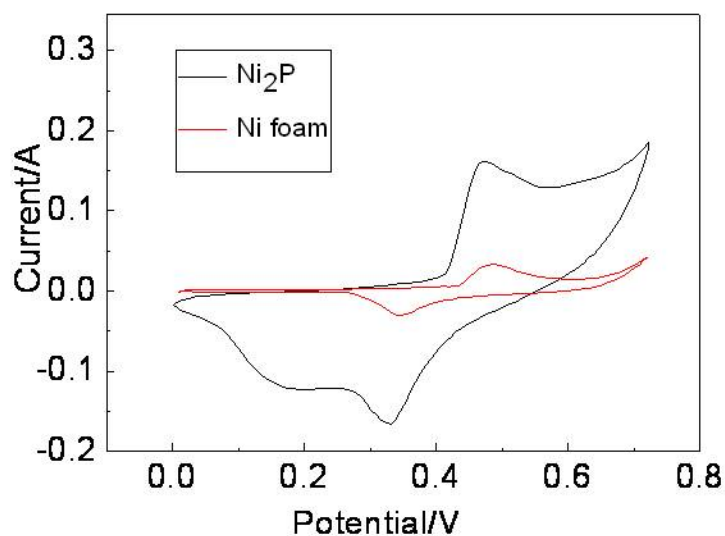
Fig.S3. The curves of Ni foam with and without loading of Ni$_2$P nanoparticles, 50 mV s^{-1}.

Reference

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