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Facile synthesis of $Ni(OH)_2$ nanowires on nickel foam via one step low-temperature hydrothermal route for non-enzymatic glucose sensor

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ABSTRACT

$Ni(OH)_2$ nanowires were successfully fabricated on nickel foam via one step low-temperature hydrothermal route without nickel salts added. The results revealed that the prepared $Ni(OH)_2$ nanowires with average diameter of about 200 nm are arranged on porous sponge-shape nickel foam. The $Ni(OH)_2$ nanowires modified Nickel foam electrode can be used as non-enzymatic glucose sensor with a high sensitivity of 1598 $\mu A \cdot mM^{-1} \cdot cm^{-2}$, a linear range covering from 0.1 mM to 6 mM and a short response time within 3 s at an applied bias of 0.55 V vs. Ag/AgCl. Furthermore, The $Ni(OH)_2$ nanowires modified nickel foam electrode exhibited a good ability of selectivity and stability.

1. Introduction

Nickel based functional materials (NiO, NiS and Ni_3S_2, et al.) have been widely used as non-enzymatic glucose sensors [1–3]. In recent years, nickel hydroxide for non-enzymatic glucose detection has aroused increasing attention due to its excellent electrochemical performance [4,5]. There are two strategies to fabricate nickel hydroxide electrodes in the field of non-enzymatic glucose catalysis. Typically, the sensor electrode is obtained by casting the mixture of active material and binder onto the conductive substrate [6,7]. But it is obviously that the traditional casting strategy affects the contact of active substances with glucose [8] and increases the interfacial resistance. Another strategy to obtain electrodes is to directly grow active materials on the matrix. For example, Zhan et al. [9] fabricated of $Ni(OH)_2$ on Three-dimensional graphene foam using high-temperature hydrothermal method with nickel salts added. Zhao et al. [10] reported the deposition of $Ni(OH)_2$ on Ni foam with nickel salts added via a low-temperature hydrothermal route. Nevertheless, it is undesirable to prepare nickel hydroxide by adding nickel salt [11,12] and as a result of massive residual nickel ions in the water and energy consumption. So it is urgent to develop green synthesis method of nickel hydroxide.

Herein, we report one-step low-temperature hydrothermal route to fabricate the $Ni(OH)_2$ nanowires on nickel foam without nickel salts added for non-enzymatic glucose sensor. In our design, the $Ni(OH)_2$ nanowires in-situ grown directly on the nickel foam are beneficial to increase the contact area between active substances and glucose.

2. Experimental

In a typical procedure, nickel foam (1 × 1 cm) was firstly cleaned using acetone, absolute ethanol and deionized water. Then, nickel foam was put into a beaker filled with 4 mol/L NaOH solution. The beaker was sealed and maintained at 60 °C for 12 h. Finally, the product was rinsed with deionized water and dried at 45 °C in air. The formation mechanism of $Ni(OH)_2$ nanowires on nickel foam, the characterization and electrochemical measurements of samples are provided in supporting Supplementary information Section 1.

3. Results and discussion

The morphology of the Ni $(OH)_2$ nanowires/Nickel foam electrode was characterized by the scanning electron microscope (SEM). The as-prepared $Ni(OH)_2$ nanowires are arranged on the Ni foam like the soaring spring grass (Fig. 1a and b), and the as-synthesized $Ni(OH)_2$ nanowires revealed an average diameter of 200 nm and a length of 5–10 μm (Fig. 1c). The EDAX pattern

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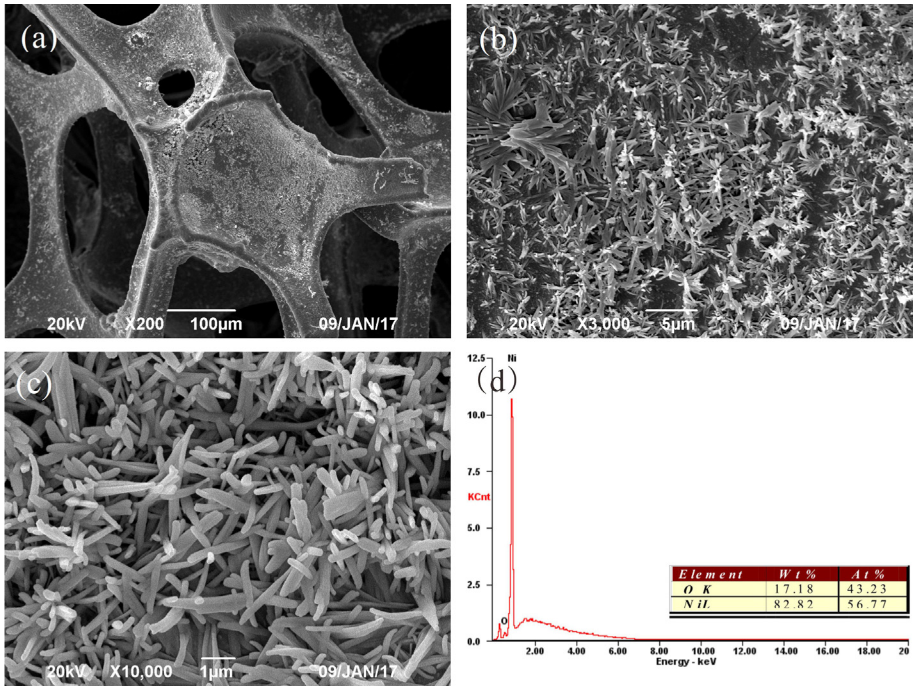

Fig. 1. SEM images and corresponding EDAX spectrum of the $Ni(OH)_2$ nanowires prepared by hydrothermal treatment of nickel foam.

(Fig. 1d) provides the typical signal of Ni and O, and the atomic percent of nickel and oxygen are 56.77% and 43.23%, respectively. Furthermore, TEM studies show that the $Ni(OH)_2$ nanowire with diameter of 200 nm is indeed composed of many nanoparticles with diameter of about 10 nm (Fig. S1a), and the EDAX pattern from TEM (Fig. S1b) are well in good agreement with the SEM-EDAX results (Fig. 1d). The corresponding selected area electron diffraction (SAED) pattern (Fig. S1c) shows several well-defined disperse rings, suggesting good polycrystalline nature of β-Ni$(OH)_2$. The high-resolution TEM image (Fig. S1d) shows that the interplanar spacing of 0.47 nm, which corresponds to the (001) plane of β-$Ni(OH)_2$.

The full surveys scan spectrum of XPS indicates the presence of C, Ni, O and residual Na from NaOH (Fig. 2a). Elemental analysis showed that the atom concentrations of C, Ni and O in the as-prepared electrode were determined as 19.98%, 20.74% and

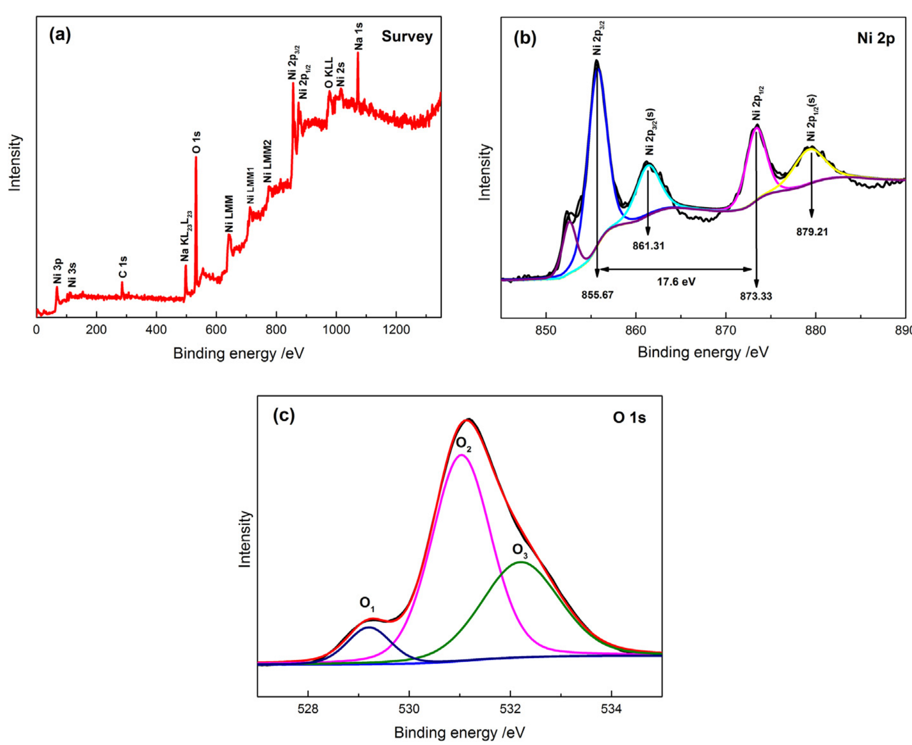

Fig. 2. XPS spectra of the as-prepared electrode: (a) the full surveys scan spectrum; (b) the spectra of Ni 2p; (c) the spectra of O 1s.