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Short Communication

Synthesis of Nickel Hydroxide and Its Electrochemical Performances

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The $Ni(OH)_2$ particles are synthesized by repeated immersion method. The as-prepared particles are $Ni(OH)_2$, which are well dispersed and have a fish-like shape. The electrochemical tests show that the particles have relatively high capacitance and excellent capacitive retention. The good structure and excellent performance suggest its promising application in supercapacitor.

Keywords: novel; nickel oxide; electrochemical

1. INTRODUCTION

In recent years, supercapacitors have attracted significant attention, mainly due to their high power density, long cycle life, and bridging function for the power/energy gap between traditional dielectric capacitors and batteries/fuel cells [1-4]. Transition metal oxides/hydroxides are a class of important mineral materials that have drawn extensive research attention as electrode materials and are qualified to be electrode materials for supercapacitors [5-9]. Among these materials, nickel hydroxide ($Ni(OH)_2$) attracts particular interest due to its high specific capacitance, practical availability, environmentally benign nature and possibility of enhanced performance through different preparative methods [10-13]. In particular, $Ni(OH)_2$ presents itself as a promising material for secondary battery and electrochemical capacitor application. However, only few papers are reported for the capacitive properties of the $Ni(OH)_2$. Accordingly, more and further studies on the synthetic approaches and capacitive properties are needed. Among the existing synthetic methods to the $Ni(OH)_2$ materials, the precipitation method is relatively easy, but difficult to get good surface microstructure[14-19].

In this work, we report a facile approach to synthesize $Ni(OH)_2$ by repeated immersion method. The $Ni(OH)_2$ particles have a wave-like shape which is believed to be very suitable for the electrode materials of supercapacitors. These particles were characterized by XRD, SEM. The supercapacitive behavior of $Ni(OH)_2$ was investigated by cyclic voltammetry in 3M KOH electrolyte. The effect of scan rate on the supercapacitor of nickel oxide thin film has been investigated.

2. EXPERIMENTAL

2.1 Materials preparation

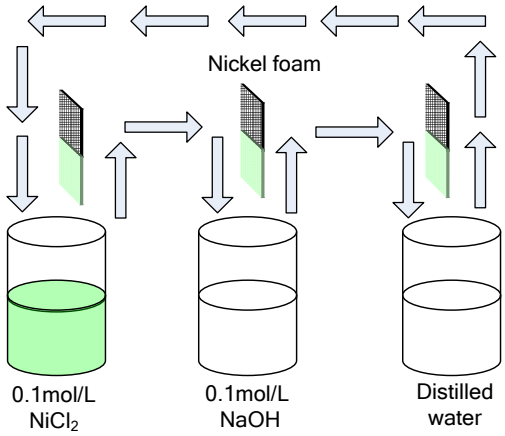

Figure 1. Schematic of apparatus for synthesis

The schematic representation of repeated immersion method chemical method is shown in Fig. 1. All the chemicals were of analytical reagent and used as received without further purification. Three breakers system is used for the deposition onto the nickel foam. In a typical preparation progress, the well cleaned nickel foam was dipped in 0.1 M $NiCl_2$ solution for 5 s. After that, we dipped the nickel foam in the 0.1 M NaOH solution for 5 s. Then, we dipped the nickel foam in the distill water for 5 s. Thus one cycle of immersion is completed. This cycle was repeated 50 times to increase the thickness of nickel hydroxide particles.

2.2 Materials characterization and measurement

Nickel oxide was characterized by X-ray diffraction (XRD), scanning electron microscopy and transmission electron microscopy. Powder x-ray diffraction (XRD) patterns of the sample was recorded on a Philips X'pert diffractometer with Cu Kα radiation (λ=1.5418 Å). The morphology and the structure of the sample were examined with a field-emission scanning electron microscopy (FESEM, JEOL JSM-6300F).

2.3 Electrochemical measurements

The working electrode was prepared by 85 wt% of the active material (Nickel oxide), 10 wt% of conducting agent (carbon black), and 5 wt% of binder (polyvinylidene difluride, PVDF). This mixture was pressed onto the glassy carbon electrode (Aida Hengsheng Technology co. td, Tianjin, China) and then dried at 60 °C. The electrolyte used was 3 M KOH aqueous solution. The capacitive performance of the sample was tested on the CHI660 electrochemical workstation (CHI, USA) with cyclic voltammetry and chronopotentiometry functions using three-electrode system (a saturated calomel electrode (SCE) as the reference electrode, a Pt electrode as the counter electrode). Experiments were carried out at room temperature. Powder x-ray diffraction (XRD) patterns of the sample was recorded on a Philips X'pert diffractometer with Cu Kα radiation (λ=1.5418 Å). The morphology and the structure of the sample were examined with a field-emission scanning electron microscopy (FESEM, JEOL JSM-6300F).

3. RESULTS AND DISCUSSION

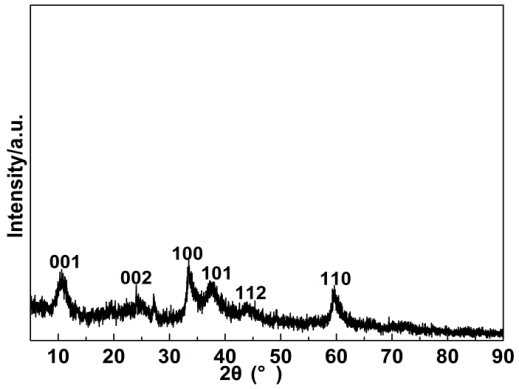

Figure 2. The XRD pattern of the sample $Ni(OH)_2$

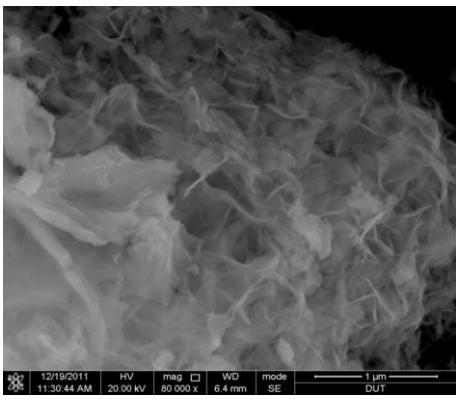

Figure 3. The SEM photograph of the sample $Ni(OH)_2$

Fig 3 shows the SEM image of the $Ni(OH)_2$. It reveals that the synthesized $Ni(OH)_2$ particles are well dispersed. The structure has a fish-like shape which consists of the aggregated flakes.

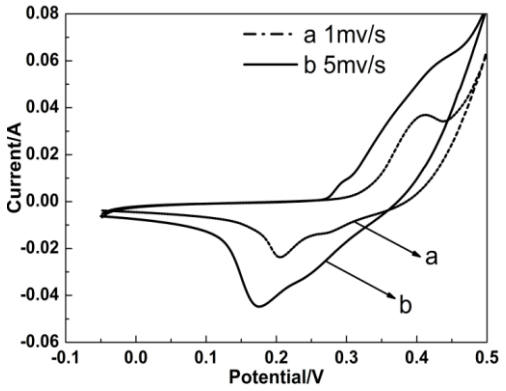

Figure 4. CV curves of the $Ni(OH)_2$ at different scan rates (a=1mV/s; b=5mV/s)

The phase and purity of the products were examined by XRD as shown in Fig. 2. The corresponding XRD pattern shows that it exhibits typical features of α-$Ni(OH)_2$ evidenced by the strong reflection of the low 2θ of 12.7° and all of the reflection peaks can be indexed to a pure hexagonal phase of α-$Ni(OH)_2$, which matches well with the standard pattern (JCPDS card 22–0752, a = 0.3131 nm, c = 0.6898 nm). Furthermore, two broad and asymmetric peaks are observed at about 33.7 and 60.0°, corresponding to nonbasal spacing and which are present in turbostratic materials. This turbostratic behavior has also been observed in other α-$Ni(OH)_2$.

Fig. 4 shows the CV curves of the $Ni(OH)_2$ electrode at different scan rates (a=1 mV/s; b=5 mV/s). The potential span is from 0 to 0.5 V (vs.SCE) in 3 M KOH aqueous solution. We can see that the CV curves have two intense peaks. One peak is anodic (positive current density) during the oxidizing reaction of Ni^{2+} to Ni^{3+}, and the other is cathodic (negative current density) during the reverse process.

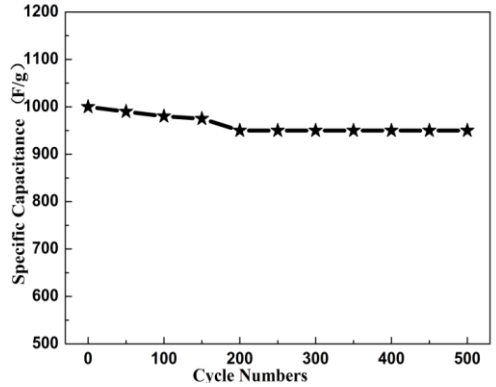

Figure 5. Cycle-life curves of $Ni(OH)_2$ samples electrode

These peaks come from fast and reversible redox processes that occur at the surface of the electrode, according to the following equation: $Ni(OH)_2 + OH^- \leftrightarrow NiOOH + e^-$. From the CV curves

at scan rates of 1 and 5 mV/s, the corresponding specific capacitances are 1300 and 888 F/g respectively. Therefore, at a slow scan rate, full utilization of the electroactive surface of $Ni(OH)_2$ particles enhances the specific capacitance.

Fig. 5 shows the profile of the specific capacitance versus charge/discharge cycle numbers at 10 mA. At the beginning, the specific capacitance of $Ni(OH)_2$ electrode is 1000 F/g. At the end of 200 cycles, the specific capacitance of $Ni(OH)_2$ electrode is 950 F/g which indicates that 95.0 % of their initial capacitance can be retained. The results suggest that these $Ni(OH)_2$ particles have relatively high capacitance and excellent capacitive retention. We report a facile approach to synthesize $Ni(OH)_2$ by repeated immersion method. The results suggest that these $Ni(OH)_2$ particles have relatively higher capacitance and more excellent capacitive retention than other articles [16-19].

4. CONCLUSIONS

In summary, with NaOH as precipitation agent and $NiCl_2$ as raw material, $Ni(OH)_2$ particles are synthesized by repeated immersion method. X-ray diffraction (XRD) shows that the material is cubic crystalling phase of $Ni(OH)_2$; scanning electron microscope (SEM) shows the $Ni(OH)_2$ particles present a fish-like shape. When evaluated for electrochemical performance, the $Ni(OH)_2$ particles demonstrate improved electrochemical properties with a high capacitance of 1000 F/g at the current of 10mA. With the increase of cycling times, the specific capacitance decreased; after 200 times it can be retained at 950 F/g (95.0 % of the initial capacitance).

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