AN ANALYTICAL STUDY ON SUPERCAPACITIVE BEHAVIOUR OF NICO2O4 NANOPARTICLES

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Abstract
Successful production of nickel cobaltite (NiCo2O4) nano particles (NPs) using a straightforward hydrothermal technique. Scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FT-IR), and X-ray diffraction (XRD) are used to characterize the synthesized NPs (SEM). All of NiCo2O4's distinctive peaks in XRD and FT-IR are visible. By using cyclic voltammeter, the electrochemical performances are assessed (CV). These CV characteristics show that the synthetic NiCo2O4 NPs exhibit capacitive behavior consistent with a pseudo-super capacitor.
Keywords: NiCo2O4; Super capacitor; Cyclic voltametry

1. Introduction

Several semiconductor materials have been investigated recently for water-splitting and environmental remediation [1-4]. One of the significant metal oxides in the cobaltite family of minerals, which have a spinel structure, is NiCo2O4 among them. AB2O4 [5].

Excellent electrocatalytic activities have been demonstrated by NiCo2O4 materials for a variety of electrode processes, including O2 [6], Cl2 evolution [7], and O2 reduction [8], as well as their use as a negative electrode for lithium-ion batteries [9, 10].

In this paper, we present a straightforward procedure for producing NiCo2O4 nanoparticles. XRD, FTIR, and SEM were used to characterize the produced NiCo2O4 NPs. Following that, CV is employed to conduct more electrochemical research employing the synthesized g-NiCo2O4 NPs.

2. Experimental

2.1 Synthesis

The NiCo2O4 NPs have been synthesized by hydrothermal method. In a particular synthesis, Stiochiometric amount of Ni(NO3)2 & CO(NO3)2 were dissolved in 30 mL of DD Water and stirred for about 10 min to obtain a clear solution and then add 4M NaOH solution (50 mL) dropwise under stirring. Then the reaction mixture was stirred for about 30 min. The reaction mixture was then transferred into a Teflon-lined stainless steel autoclave, and hydrothermally treated at 160 °C for 24 h. Autoclave was cooled to room temperature and the reaction mixture was filtered, washed with distilled water and ethanol, followed by drying at 60 °C.

2.2 Characterization

XRD measurements were performed on a PAN Analytical Advance X-ray diffractometer using Ni-filtered Cu Kα (λ = 1.5406 Å) radiation in a 2θ scan range between 10° and 80°. FT-IR spectra were recorded using a PerkinElmer Spectrum 100 FT-IR spectrophotometer with a transmission method from 4000 to 400 cm^{-1} using a KBr pellet. The morphology is investigated by using SEM, VEGA3, Tescon, USA.

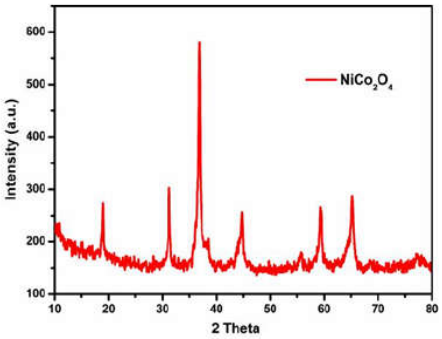
2.3 Electrochemical Measurements

Electrochemical measurements were evaluated on a CH Instruments electrochemical analyzer (Model CHI760E) with a conventional 3-electrode electrochemical system by using 0.2 M KCl as the electrolyte solution at different scanning rates. A glassy carbon electrode (GCE) modified with the synthesized samples served as working electrodes, while the Ag/AgCl (in saturated KCl) and Pt wire served as the reference and counter electrodes, respectively. The typical modified working GCE preparation was as follows: 2.5 mg of a synthesized NiCo2O4 NPs were dispersed in 2.5 mL of isopropanol−water solution and 20 μL of Nafion solution (5 wt %), which was then sonicated well at room temperature (RT) for 1 h to make a uniform slurry. The resultant slurry was deposited as a thin film onto the surface of the GCE by the drop-casting method. Finally, the modified GCE was dried at RT for 24 h.

3. Results and discussion

3.1 XRD studies

Fig.1 XRD pattern of synthesized NiCo2O4 nanoparticles.

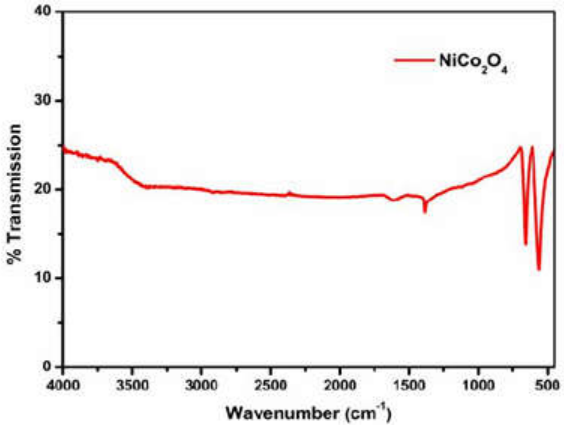


he XRD patterns of NiCo2O4 NPs are shown in Fig.1. According to the JCPDS standards (JCPDS card NO.73-1702), XRD pattern exhibits the pure cubic spinel phase of NiCo2O4 with fd3m space group [11]. Peaks from other crystallized phases are not observed, indicating the formation of pure NiCo2O4 NPs.

3.2 FT-IR studies

The FTIR Spectra of NiCo2O4 NPs is shown in Fig.2. In the FTIR spectrum of NiCo2O4, two strong absorption bands in the region 650-665 cm^{-1} and 550-560 cm^{-1} corresponding to the metal-oxygen stretching from tetrahedral and octahedral sites respectively, which are the characteristics of cobaltites. Only the Co–O and Ni–O vibrations of NiCo2O4 samples are detected, no signal corresponding to OH group is observed [12].

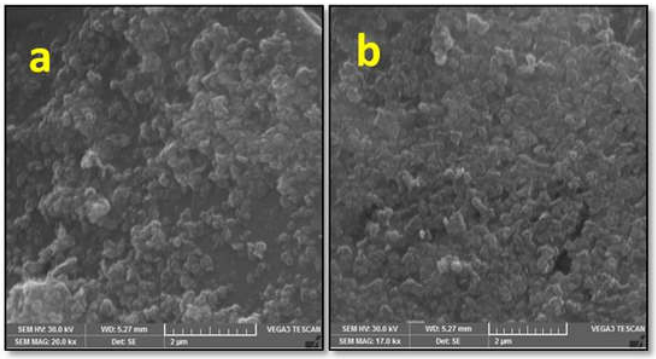
Fig.2 FTIR spectra of synthesized NiCo2O4 nanoparticles.



3.3 SEM Images

The SEM images of NiCo2O4 NPs are shown in Fig.3 (a-b). The synthesized NiCo2O4 is dispersed as small NPs and the distribution is homogeneous throughout the sample. But the shape of NPs cannot be differentiated easily.

Fig.3 SEM images of synthesized NiCo2O4 (a-b) nanoparticles**.**

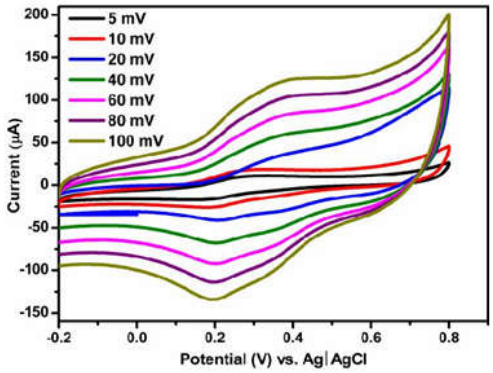


4. Super capacitor studies

4.1 Cyclic voltametry

The electrochemical performances of synthesized NiCo2O4 NPs are examined by CV. Fig. 4 shows the CV curves of NiCo2O4 NPs with various scan rates. All curves look similar, which significantly indicates an outstanding rate capability with an increase of scan rates. Besides these curves demonstrate improved conductivity and also had a nearly rectangular shape without apparent redox-current peaks, remarkably suggesting that a typical capacitive character of an electrical double-layer (EDL) capacitance of pseudo-super capacitor [13].

Fig.4 CV curves of synthesized NiCo2O4 nano particles at various scan rates.



Conclusions

In this summary, a simple hydrothermal approach has been used to successfully synthesis NiCo2O4 NPs. Several characterization approaches were used to characterize the synthesized NPs. XRD tests demonstrate that the produced NiCo2O4 is pure. In contrast, the conductivity has risen in the case of CV, and the form of the CV curves demonstrates the pseudo-capacitive behavior of produced NiCo2O4 NPs. These NiCo2O4 NPs may also be used to produce clean energy H2 from water splitting, build electrode materials for fuel cells, and photo catalytically degrade other priority pollutants including dyes, pesticides, and medicines.

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