Analysis of Structural, Morphological and Electrochemical on Ni $(OH)_2$ Coated Carbon Sphere by Hydrothermal Method

R. Ranjithkumar, C. Sambathkumar, N.Nallamuthu, M. Krishna kumar, P. Devendran

Abstract: ***Nickel hydroxide Ni $(OH)_2$ nanoparticles (Nps) effectively embedded on carbon sphere ($Ni(OH)_2$@CS) by facile hydrothermal method. The prepared sample was characterized through powder XRD analysis which clearly shows the crystalline structure of the $Ni(OH)_2$@CS. FTIR spectra gave the functional group in the carbon sphere $Ni(OH)_2$@CS Ni-O, C-O, C-C, C=C, and OH vibration on the $Ni(OH)_2$@CS. The scanning electron microscope (SEM) shows the surface morphology of the sample. Energy dispersive analysis shows the elemental conformation of the prepared sample. The electrochemical performance analysis shows the Galvanostatic charge-discharge, cyclic voltammetry analysis gives the specific capacitance of the prepared sample. The impedance analysis shows the electrode-electrolyte interface on the electrode material.***

Keywords : ***$Ni(OH)_2$, carbon sphere, chemical reflux method, cyclic voltammetry, charge-discharge analysis.***

I. INTRODUCTION

The modern development of society depended with vitality and predominant widespread electric-vehicle, electronic gadgets and well known hybrid electric vehicle demand for energy source can be supplied using an unavoidable source such as electrochemical energy storage and sources[1-2]. The emergency need for effective energy storage devices was lead to in a prevalent and high concerned research exertion into the electrochemical energy storage devices too named as supercapacitors, ultracapacitors and Electrochemical double layer capacitor (EDLC) [3]. Carbon-based supercapacitors, additionally called EDLC, have pulled in extensive research interest as revolutionary control type vitality storage gadgets in the outlook of their remarkable properties, includ high-power densities, long cycle life and fast charging/releasing rate just as high safely[3-8].

The carbon-based materials with the permeable structure are one of the passionately debated issues in the region of materials science. The high explicit surface zone, enormous pore volume, well-requested and controllable permeable structure, unique morphologies of carbons and their outstanding chemical, mechanical and warm dependability make them fascinating for remarkable applications including catalysis, energy storage and change, water purification and sensing.[9-18]Varity of carbon material having excellent capacitance behaviour like carbon onion[19], carbide-derived carbon[20], carbon aerogels [21], carbon nanotube[22] outstanding retentivity of the electrode material[23]. Carbon sphere contains more advantages compare to exhausting material like spherical geometry, good liquidness, controllable porosity and ultra-tuneable size. Among, these innovative materials outstanding property and extraordinary application like catalysis, water purification as well as air purifications energy conversion and storage[10-14]. The synthesis strategies method of carbon spheres have been developing from multicomponent exclusively templating[24-27], hydrothermal carbonization (HyTC) [27], emulsion polymerization[28], self-assembly [29] and Stober method [30-33].

The electrochemical performance essential for electrode material like the metal oxides, hydroxide, nitrides and carbides and well-known electrode material for redox reactions. Closely, transitions metal oxides and hydroxides their electrochemical reactions in electrode material occurred extensively like $Co(OH)_2$ Fe_3O_4, MnO_2, V_2O_5, $NiCo_2O_4$, ZnO and $Ni(OH)_2$ enabling high reversible redox reaction from the electrode surface[34-36]. Moreover, The transition metal oxides (TMOxs) exhibit the good specific capacitance because the reason they possess many redox states as well as it contains a variety of hierarchical structure and pores nature of the material. Among, the hierarchical structure play a un avoids role in enhancing the energy density [37-38] The combines of metal hydroxides materials with carbon-based composite provide high perform of electrode material.

In present work, we coated the Nickel hydroxides to the carbon sphere surface. We found the electrochemical analysis of the prepared electrode material. The cyclic voltammetry analysis gives information about the oxidation and reduction reaction of the $Ni(OH)_2$ coated carbon sphere. The galvanostatic charge- discharge analysis gives the performance of the electrode material.

Revised Manuscript Received on December 16, 2019.

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II. MATERIAL SYNTHESIS

A. Materials

All the chemical reagents and were of AR grade and used without further purification. Nickel (II) nitrate hexahydrate $Ni(NO_3)_2 6H_2O$ and Glucose were acquired from Sigma Aldrich.

B. Carbon sphere synthesis method

In a typical synthesis of the carbon sphere from 1M glucose were added in 120ml deionized water Stirred in 10mins. The solution was transferred into the Teflon-lined autoclave (stainless steel) kept at 180 °C for 10hrs. Further, the product was collected by beaker kept in ultrasonic treatment for 10min to form the uniform sphere dispersion. Moreover, the products were centrifuged at 6000rpm and washed several times with deionized water and ethanol. Finally, the sample was dried at 80 °C for 12hrs in a vacuum oven.

C. Ni $(OH)_2$ coated on Carbon sphere

Separately, Nickel(II) nitrate hexahydrate $Ni(NO_3)_2 6H_2O$ was added 0.1M in 110ml deionized water. The solution was stirred in 20 min to make a light green solution. Further, the NaOH pellets 0.3g were added 15ml deionized water. The NaOH solution was added to Nickel nitrate solution into drop by dropwise then get precipitate. Moreover, added 0.5g carbon sphere in the nickel hydroxide solution stirred at 3hrs. That stirred solution was transferred to a Teflon lined autoclave (stainless steel) and kept at 100 °C for 10 hrs. Moreover, the products were centrifuged at 6000rpm and washed several times with deionized water and ethanol. Finally, the sample was dried at 80 °C for 12hrs in a vacuum oven.

III. RESULTS AND DISCUSSION

A. Structural characterization

The observed XRD pattern recorded at the 2θ range of 10 to 70. The crystalline peaks show the phase and hexagonal structure of $Ni(OH)_2$.

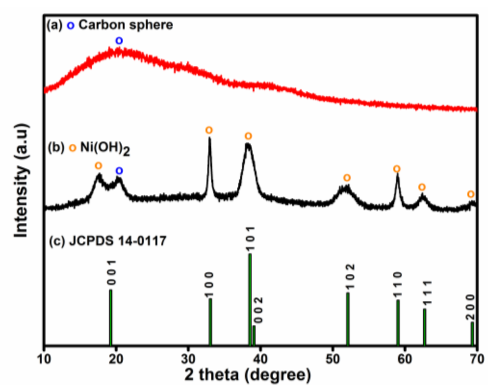

Fig. 1. XRD analysis of (a) carbon sphere and (b) $NiOH_2$ coated carbon sphere

Fig. 1(a) shows the XRD pattern of the carbon sphere and the broad peak appeared at 22°. The XRD pattern shows perfectly matched with the previous literature [39]. The Fig.1 (b) shows the crystalline peaks of Ni $(OH)_2$ coated on the carbon sphere exactly matched with JCPDS card No. 14-0117. The sharp peaks observed a range of 32.9°, 38.3°, 58.9°. The crystallite size was estimated theoretically by using Debye–Scherrer formula,

$$D = k\lambda/\beta \cos\theta \ldots\ldots\ldots(1)$$

The calculated average crystallite size was 30 nm.

B. FTIR analysis

The FTIR spectrum recorded at in the range of $400cm^{-1}$ to $4000cm^{-1}$. The FTIR spectrum shows the vibrations of intermolecular interactions of carbon sphere and $NiOH_2$ coated carbon sphere.

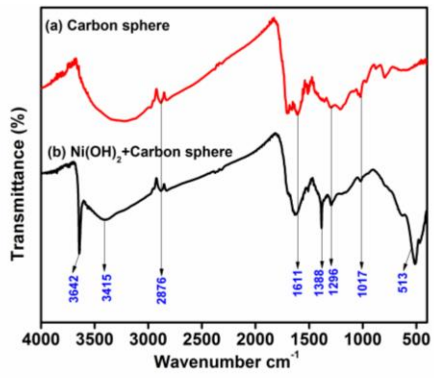

Fig. 2. FTIR spectrum of (a) carbon sphere and (b) $NiOH_2$ coated carbon sphere

Fig. 2(a) shows the spectrum of the carbon sphere. They observed some vibrations in the range at$3612cm^{-1}$, $3415cm^{-1}$ O-H vibrations[40]. The vibrations in the present peak at –C=O in $1611cm^{-1}$, $1388cm^{-1}$ [41-42]. stretching C-C vibrations. Fig. 2(b) shows the spectrum of $NiOH_2$ coated carbon sphere. The Vibration observed at the range in nearly $513cm^{-1}$ it's closely matched with the Ni-O stretching lattice vibration[43].

C. Surface and Elemental analysis

SEM images of $NiOH_2$ coated carbon sphere shown in Fig. 3 and the Elemental all are confirmed to EDXS analysis. The SEM images have different magnifications scanned of $NiOH_2$ coated carbon sphere. The Fig. 3(a) shows the images of $NiOH_2$ coated carbon sphere in the range of 20µm and as well as fig. 3(b) shows the same at the range of 1µm. The SEM images clearly reveal that the $NiOH_2$ was fully coated on the surface uniformly of carbon sphere.

The Fig. 3(d) shows the elementals are conforming through EDXS pattern analysis. The pattern of elementals is a presence in the $Ni(OH)_2$ coated carbon sphere. The percentage of elements also measured the carbon contains in the sharp peak of 38.1%. The oxygen contains 33.5% and also Ni contains 28.4%.

Retrieval Number: A11821291S419 /2019©BEIESP
DOI: 10.35940/ijeat.A1182.1291S42019

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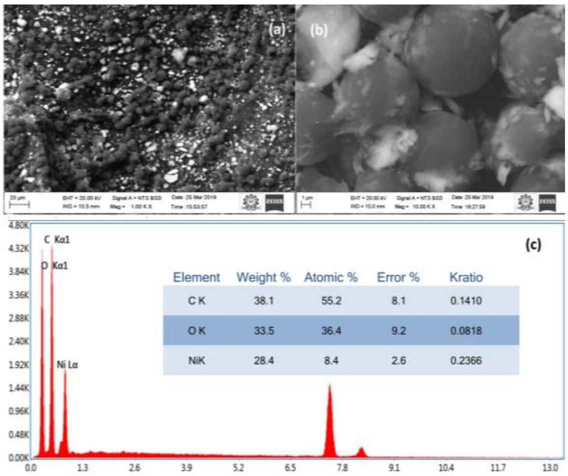

Fig. 3. Surface morphology of $NiOH_2$ coated carbon sphere with different magnifications

The fig 3(c) shows that the elemental composition of the prepared composite. The carbon contains the peak at the Kα radiation characteristic x-ray emits at the range of 0.277keV and the intensity was high. It shows the moreover the percentage of carbon was very high from the EDAX graph 38.1%. The Oxygen exhibits the range of radiation characteristic x-ray Kα 0.525keV and the oxygen contain 33.5%. Finally, the Ni peak contains in the range of 7.47keV in 28.4%.

D. Electrochemical analysis

1) Cyclic voltammetry

The electrochemical analysis of the prepared electrode material was observed from the range of 0 to 0.6V. The Electrochemical results show the oxidation and reduction states of the $NiOH_2$ coated carbon sphere. The oxidation takes place between the 0.33V and the reduction takes place the nearly 0.58V. The oxidation current occurs at the negative current then the reduction current observed at the positive range.

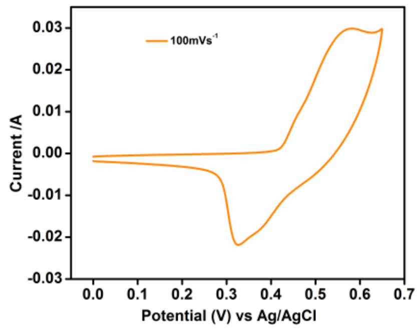

Fig. 4. Cyclic voltammetry curve of $NiOH_2$ coated carbon sphere working electrode

2) Galvanostatic charge-discharge

In Fig.5 shows the charge-discharge of the prepared $NiOH_2$ coated carbon sphere of the sample. The Charge-discharge curve gives information about the Internal resistance of the $NiOH_2$ coated electrode material and the specific capacitance of the prepared sample. In the fig shows the 1mA scan rate at the potential windows from the 0 to 0.55V. They have long charged and also discharge time.

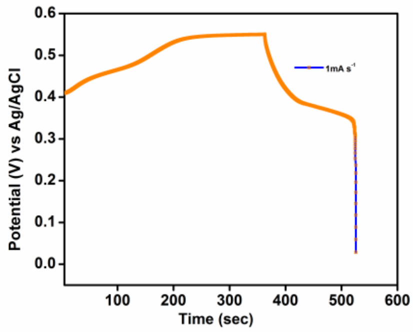

Fig. 5. The charge-discharge curve of $NiOH_2$ coated carbon sphere

IV. CONCLUSION

In conclusion, we prepare the $NiOH_2$ coated carbon sphere via the hydrothermal method. The crystalline structure was characterized through powder x-ray analysis. The presenting morphology was finder by the SEM images. The prepared elementals are predicted from the elemental analysis. The functional group vibrations are observed from the FTIR analysis. Here, we find the electrochemical studies showed that the material composite becomes a good material for electrochemical applications.

ACKNOWLEDGMENT

Author R.Ranjithkumar gratefully thanks to Kalasalingam Academy of Research and Education [KARE] to provide University Research Fellowship (URF) scheme and also thankful IRC provide characterisation facilities.

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