Special Issue

ज्ञान-विज्ञानं विमुक्तये
UNIVERSITY GRANT COMMISSION

International Innovative Journal Impact Factor (IIJIF)

ISSN 2319-8648

Impact Factor - 2.143

Indexed

Prereviewed

UGC Approved Sr. No. : 64310

Contact:

Editor in Chief
Mr.Arun B. Godam
Mob..8149668999
9881182275

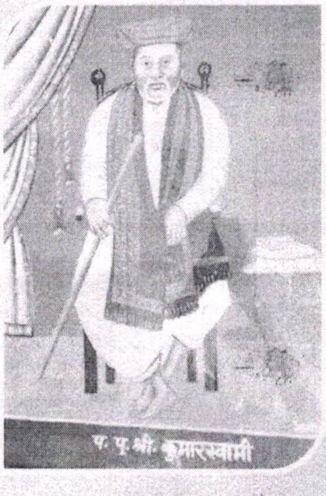
Special Editor
prof. B.B. Jadhav

SHAURYA PUBLICATION
Latur

International Conference on Applied Science (ICAS-17)

(26th- 27th December, 2017)

ICAS-17



Shri Mahantswami Sikshan Prasarak Mandal's

Shri Kumrswami Mahavidyalaya,

Ausa

Dist. Latur.MS, India

09421769537

www.sksmausa.org.in

1 Preface

This volume contains all papers presented at **ICAS-17**: **International Conference on Applied Science** held on December 26-27, 2017 at Kumarswami College, Ausa, Distt. Latur.

International Conference on **Applied Science (ICAS-17),** is being organized by Shri Kumarswami Mahavidyalaya, Ausa, Dist. Latur, MS, India. The theme of the conference is an innovative approach of Science, which provides a valuable opportunity for all over world developers, researchers to engage in scientific discussion about the current research and latest advancement that help the world going forward. Applied science is a discipline of science that applies existing scientific knowledge to develop more practical applications, like technology or inventions.

The objective of **ICAS-17** is to provide an opportunity to discuss on advances in Science and technology in the fields of **Physics, Chemistry, Biology, Computer Science & Mathematics.** The conference is aimed to provide an opportunity for exchange of ideas and dissemination of knowledge among Academia, Industry, Research Scholars, and Scientists for the growth of the society. Researchers are invited by prospective authors from their subject specialization.

Our main objective is to promote scientific and educational activities towards the advancement of common man's life by improving the theory and practice of various disciplines and sectors of Research Challenges in Science Technology. Shri Kunarswami Mahavidyalaya being one of the affiliated colleges of Swami Ramanand Teerth Marathwada University, Nanded, MS, India, organizes conferences, workshop, seminars and/or awareness programs by providing the supports to improve research and development activities.

There were 248 submissions. Each submission was reviewed by 07, and on the average 05, program committee members. The committee decided to accept 193 papers. The program also includes 18 invited talks.

Our affiliated Swami Ramanand Teerth Marathwada University is kind enough to grant for organizing such academically important event for the first time in our college **Shri Kumarswami Mahavidyalaya, Ausa.**

We are thankful to **Mahatma Basweshwar Shikshan Sanstha, Latur,** for their kind support as always.

EasyChair really helped us to publish worldwide and to manage all tedious activities of the conference. **Team ICAS-17** is sincerely thankful to EasyChair.

And lastly, we are thankful to all participants, reviewers, and guests. This would not have been possible without your support.

Wish you a very Happy New Year !!!

December 26, 2017
LATUR

Maheshwar M. Betkar

ICAS - 2017
SKSM, AUSA

Supercapacitive Properties of Cobalt-Nickel Hydroxide Composite Electrode

Janardhan H. Shendkar[a] and Rajaram S. Mane[b]

[a]S. S. J. E S. Arts, Comm. and Sci. College, Gangakhed, Dist. Parbhani, India

[b]School of Physical Sciences, Swami Ramanand Teerth Marathwada University, Nanded, India

Abstract

The structural, morphological and electrochemical studies of electrochemically deposited composite of cobalt-nickel hydroxide composite ($Co-Ni(OH)_2$) electrode are attempted wherein as developed composite electrode is amorphous in structure and of platelet-type in surface morphology. The composite electrode has demonstrated 398.5F/g, 19.9Wh/kg and 1195.5W/kg electrochemical supercapacitance, energy density and power density, respectively; obtained by taking an average anodic cathodic current value of CV curve and further compared with values obtained using galvanostatic charge-discharge measurements.

Keywords: Electrochemical Supercapacitor; Supercapacitance; Nanoplatelets

1. Introduction

The global issues of alarming environment lead to exploring clean energies where production, storage and transportation of electrical energy has prime are needed. Production is achieved via wind, nuclear, bio-fuel and solar cell devices where has batteries or/and supercapacitors are used for storing purpose. An on today transportation through either copper or aluminium wires has not found an alternative. As far as storage concern, electrochemical supercapacitors are electronic components that can be quickly charged and discharged [1] and have relatively higher energy and lower power densities than traditional capacitors and lower energy and higher power densities than batteries thereby, acting as the bridging function for energy storage between traditional capacitors and batteries [2]. They are nowadays widely used in consumer electronic products like memory backup systems and hybrid electrical vehicles [3]. Basic mechanism of charge storage is classified into two; i) electric double layer capacitor wherein the charge is stored at the interface of surface of electrode/electrolyte electrostatically without any chemical reaction (hence has long cycle life), and ii) pseudocapacitor or faradaic capacitor or redox capacitor [4] wherein reversible redox chemical reaction between electrode material and electrolyte is responsible for charge storage and has less cycle life than previous one.

The most important goal of synthesis is to develop the required structure, shape and size of inorganic materials used which in fact have considerable attention due to their high charge storage potential used in applications like batteries and electrochemical supercapacitors [5]. The high-cost, and toxic nature of RuO_2 has created serious issue on its commercial use though it corroborates higher performance [6, 7] thereby there is need to introduce new alternatives like conducting polymers, transition metal oxide/hydroxide, carbon materials and composite of them etc., that fulfil both requisitions. Among all transition metal hydroxides $Ni(OH)_2$, $Co(OH)_2$ and $Mn(OH)_2$ have showed remarkable performance supercapacitor application.

These hydroxides/oxides can be synthesized using by electrochemical method on conducting substrates for higher supercapacitance. The low-cycle life of nickel hydroxide ($Ni(OH)_2$) is due to weak adhesion of nickel based materials with the substrate used [8] which can be overcome by making its composition with other electrode material like cobalt, manganese etc. As an effort, in the present case, we have synthesized a composite electrode of $Ni\text{-}CO(OH)_2$ using electrodeposition method, characterized for its structure and morphology and finally applied in electrochemical supercapacitive properties using cyclic-voltammetry (CV) and galvanostatic charge-discharge measurements.

2. Experimental Section

The analytical reagent grade chemicals, nickel nitrate, cobalt nitrate, sodium hydroxide and acetone were purchased from Merck and used without further purification. The composite $Ni\text{-}CO(OH)_2$ electrode was electro-deposited on polished stainless-steel (SS) substrate by applying a constant potential of -1.0 V for 10 min. in presence of Ag/AgCl reference electrode and platinum wire counter electrode. Equal concentration of Ni and CO nitrate solutions i.e. 0.5 M were mixed together for forming $Ni\text{-}CO(OH)_2$ electrode. The prepared composite electrode was dried in air at room temperature before its next use. Rigaku 2500 diffractomerter was used for X-ray diffraction in the range of 10° - 80° and Hitachi S – 4800 field-emission scanning electron microscope (FESEM) plane-view image and energy dispersive X-ray (EDX) analysis measurements were used for morphology and phase purity i.e. stoichiometry confirmations. The potentiostatic electrodeposition and CV measurements were performed on WPG 100 Potentiostat/ Galvanostat WonAtech electrochemical workstation, while galvanostatic charge-discharge was studied by IVIUM workstation. These electrochemical characterisations were studied in 1.0M NaOH electrolyte.

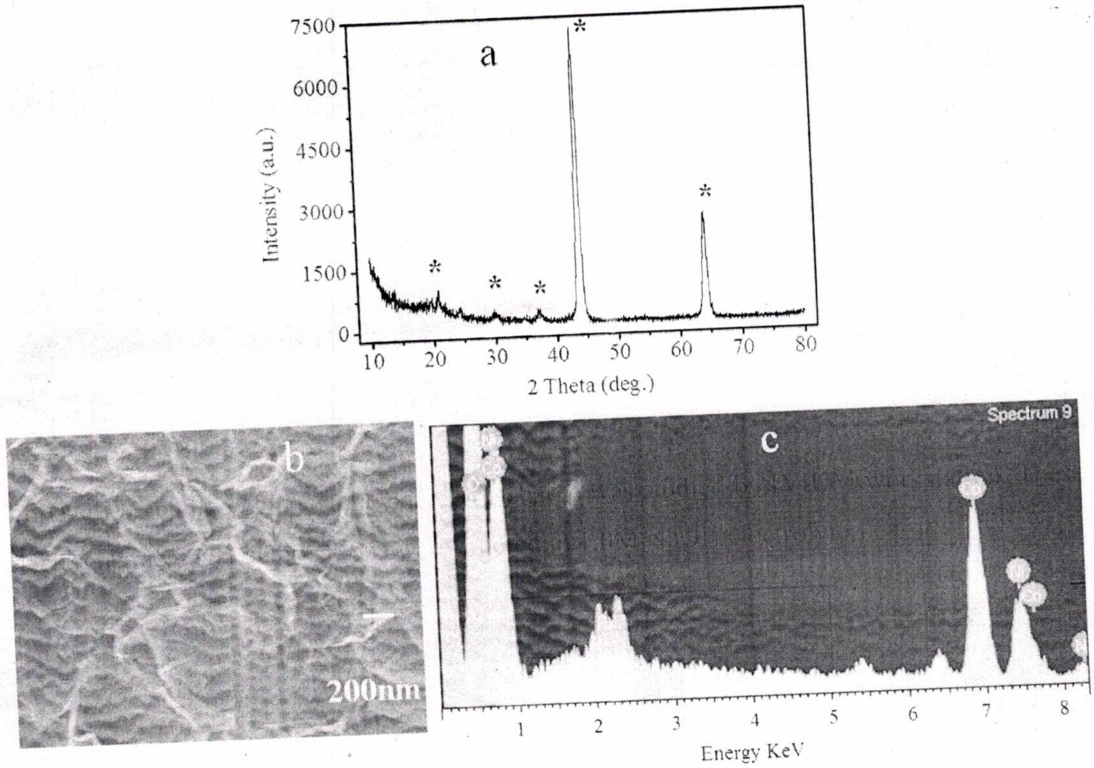


Fig. 1: a) XRD, b) FESEM, c) EDX, of Ni-Co(OH)$_2$ composite.

3. Results and discussion

In the electrodeposition of Ni-Co(OH)$_2$ process, a constant potential of -1.0V was applied for 30 min. The cations of cobalt and nickel move towards negative electrode i.e. stainless steel and start to deposit on it under applied potential, at the same time nitrate ions gets reduced to form hydroxide ions. These hydroxide ions react with cobalt and nickel ions at negative electrode to deposit composite of cobalt and nickel hydroxide as follows [9, 10].

$$NO_3^{-} + 7H_2O + 8e^{-} \rightarrow NH_4^{-} + 10\,OH^{-} \quad (1)$$

$$Ni^{2+} + Co^{2+} + 2OH^{-} \rightarrow Ni\text{-}Co(OH)_2 \quad (2)$$

The XRD pattern of the Ni-Co(OH)$_2$ composite electrode is given in Fig 1a. In the XRD pattern, the peaks with '*' notations were of SS. As there was no peak other than SS we confirmed that as-deposited Ni-Co(OH)$_2$ was amorphous in nature, which not surprising one. The FESEM image of Ni-Co(OH)$_2$ composite electrode is shown in Fig 1b. The surface of electrode material was composed of 2D platelet-type surface architecture which on account of higher voids causing excess diffusion of the electrolyte ions would be the best for supercapacitor application. The EDX spectrum of Ni-Co$(OH)_2$ composite electrode is shown in the Fig 1c which is a plot of the energy of characteristic X-rays along the X-axis and the number of counts of the characteristic X-rays along the Y-axis. The characteristic energy dispersive X-ray spectrum showed the existence of the cobalt, nickel and oxygen in 0.5-0.5:1 proportion, supporting for the formation of Ni-Co$(OH)_2$ composite.

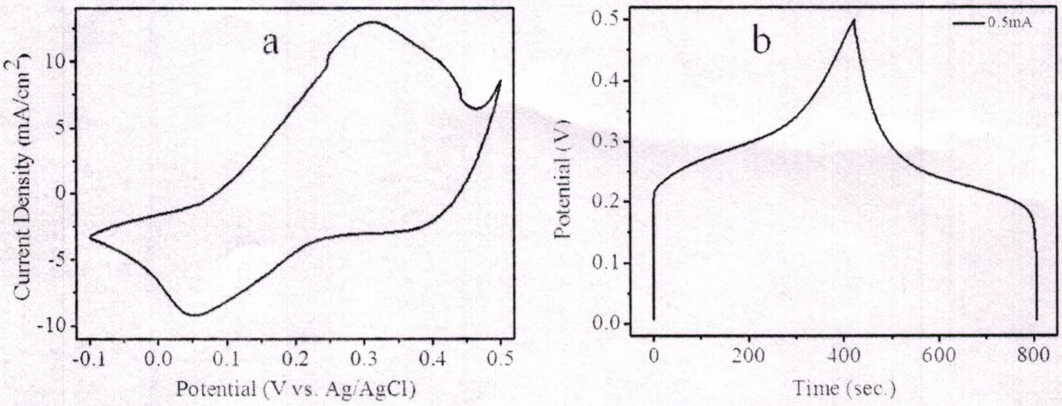


Fig. 2: a) CV and b) Galvanostatic charge-discharge curve of Ni-Co$(OH)_2$ composite.

The cyclic voltammery (CV) of the composite material electrode for 10mV/s in the potential window of – 0.1V to 0.5V was studied in 1.0M NaOH electrolyte (Fig 2a). The CV curve exhibited the redox reaction peaks, which was a sign of the contribution to the capacitance due to Faradaic capacitance. The surface Faradaic reactions in alkaline medium are as follow [11, 12].

$$Co(OH)_2 + OH^- \leftrightarrow CoOOH + H_2O + e^- \quad (3)$$

$$CoOOH + OH^- \leftrightarrow CoO_2 + H_2O + e^- \quad (4)$$

$$Ni(OH)_2 + OH^- \leftrightarrow NiOOH + H_2O + e^- \quad (5)$$

The anodic peak current was more dominant than the cathodic peak current suggesting the limited reversibility of the redox reaction. In such situation the conversion of CoOOH to $Co(OH)_2$, CoO_2 to CoOOH and NiOOH to $Ni(OH)_2$ was not complete during the cathodic cycle of CV. The SC value of the composite was calculated from CV curve by;

$$C_S = \frac{I}{m\frac{dV}{dt}} \quad (6)$$

where, I is the average of anodic and cathodic currents (mA), m is the mass of the active material of electrode (g) and dV/dt is the sweep rate or scan rate (mV/s). The obtained SC value was 389.5F/g and the energy density and power density, obtained by equations (8) and (9) were 19.9Wh/kg and 1195.5W/kg, respectively. These values were higher because of calculation of supercapacitance at anodic and cathode potentials (certain maximum values of the currents at electrode potentials) of electrode material, while in other method the current is generally considered as continuous function of voltage in calculation by determining overall area of the CV curve or galvanostatic charge-discharge curve.

The SC value was calculated from CV curve by [13]

$$C_s = \frac{1}{m\Delta V\frac{dV}{dt}} \int I(V)dV \qquad (7)$$

The energy density and power density of the Ni-Co(OH)$_2$ composite electrode were calculated from CV curve by

$$E = \frac{C_s(\Delta V)^2}{2} \qquad (8)$$

$$P = \frac{C_s\Delta V\frac{dV}{dt}}{2} \qquad (9)$$

where, Cs is specific capacitance (F/g), m is the mass of the active material of electrode (g), ΔV is the potential window of CV (V), $\int I(V)dV$ is the area of the closed CV curve (mW), *dV/dt* is the scan rate (mV/s). The SC value of obtained by equation (7) was 312 F/g. The energy density and power density values were 15.6Wh/kg and 937.5W/kg, respectively. The galvanostatic charge-discharge of the Ni-Co(OH)$_2$ composite electrode was studied and is shown in Fig 2b. The SC value was calculated by equation (10) [14].

$$C_s = \frac{It}{m\Delta V} \qquad (10)$$

The energy density and power density can also be calculated from charge-discharge curve by (11, 12) [15].

$$E = \frac{C_s(\Delta V)^2}{2} = \frac{It\Delta V}{2m} \qquad (11)$$

$$P = \frac{E}{t} = \frac{I\Delta V}{2m} \qquad (12)$$

where, I is galvanostatic current (mA), t is discharge time (s), m is mass of active material of electrode (g), ΔV is the potential window in the charge-discharge curve. The SC value, obtained using equation (10) for Ni-Co(OH)$_2$ composite electrode was 137.5F/g. The energy density and power density, calculated by equation (11, 12) were 4.77Wh/kg and 44.64W/kg, respectively.

4. Conclusions

Using cobalt nitrate and nickel nitrate solutions and potentiostatic electrodeposition method amorphous and nanoplate-type surface morphology Ni-Co(OH)$_2$ composite electrode on SS substrate was synthesized and applied for electrochemical supercapacitor application. Specific capacitance, energy and power densities of Ni-Co(OH)$_2$ composite electrode were measured by using two methods one from CV and other from charge-discharge. Using CV measurement, the composite electrode material demonstrated 398.5F/g, 19.9Wh/kg and 1195.5W/kg electrochemical supercapacitance, energy density and power density, respectively, whereas, as using charge-discharge measurement these values were 137.5F/g 4.77Wh/kg and 44.64W/kg, respectively.

References

[1] G. Wang, L. Zhang, J. Zhang, Chem. Soc. Rev., 2012, 41, 797.

[2] C. Largeot, C. Portet, J. Chmiola, P. Taberna, Y. Gogotsi and P. Simon, J. Am. Chem. Soc., 2008, 130, 2730.

[3] Y. Zhai, Y. Dou, D. Zhao, P. F. Fulvio, R. T. Mayes, S. Dai, Adv. Mater., 2011, 22, 4828.

[4] F. Shi, L. Li, X.- L, Wang, C.- D. Gu and J.- P. Tu, RSC Adv., 2014, 4, 41910.

[5] X. Wang, W. Tian, T. Zhai, C. Zhi, Y. Bando and D. Golberg, J. Mater. Chem., 2012, 22, 23310.

[6] S. Trasatti and G. Buzzanca, J. Electroana. Chem. and Interfa. Electrochem., 1971, 29, A1.

[7] W. Deng, X. Ji, Q. Chen and C. E. Banks, RSC Adv., 2011, 1, 1171.

[8] F. Shi, L. Li, X. L. Wang, C. D. Gu and J. P. Tu, RSC Adv., 2014, 4, 41910.

[9] C. Polatides, G. Kyriacou, J. Appl. Electrochem., 2005, 35, 421.

[10] D. A. Corrigan, R. M. Bendert, J. Electrochem. Soc., 1989, 136, 723.

[11] V. Gupta, S. Gupta, N. Miura, J. Power Sources, 2008, 177, 685.

[12] H. Wang, H. S. Casalongue, Y. Liang, H. Dai, J. Am. Chem. Soc., 2010, 132, 7472.

[13] S. H. Aboutalebi, A. T. Chidembo, M. Salari, K. Konstantinov, D. Wexler, H. K. Liua and S. X. Doua, Energy Environ. Sci., 2011, 4, 1855.

[14] F. Chen, W. Zhou, H. Yao, P. Fan, J. Yang, Z. Fei and M. Zhong, Green Chem., 2013, 15, 3057.

[15] Y.-S. Li, I-W. Sun, J.-K. Chang, C.-J. Sua and M.-T. Lee, J. Mater. Chem., 2012, 22, 6274.