ORIGINAL RESEARCH PAPER

Physics

STRUCTURAL AND ELECTROCHEMICAL PROPERTIES OF CHEMICALLY DEPOSITED COPPER DOPED NICKEL HYDROXIDE

KEY WORDS: CBD, marigold, microflower, supercapacitor, nickel hydroxide.

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ABSTRACT

Present work reported, copper doped $Ni(OH)_2$ deposited successfully by chemical bath deposition method on economical stainless steel electrode. The XRD analysis represent hexagonal crystal structure and presence of Ni and Cu confirm by FT-IR study. The surface morphology studied by SEM indicates nanopetals linked marigold like microflowers. The 0.2% Cu doped Ni(OH)2 shows specific capacitance 715 Fg^{-1} at scan rate 10 mV s^{-1}. EIS study interprets that electrode N-0.2% have least charge transfer resistance which improve value of specific capacitance. All results revels cupper is good dopant for improve the specific capacitance.

INTRODUCTION

Conventional energy sources like coal, mineral oils and natural gas have many fatal issues regarding to health and environment. Pollution, global warming, greenhouse effect, diseases related air are serious problems caused by combustion of non-renewable energy sources. These sources of energy are limited. Solar energy, wind energy, ocean energy are nonconventional energy sources possess some advantages and some drawbacks like availability, affected by atmospheric condition[1,2]. It urgent to search for a energy storage device which have high power density, cyclic stability and high specific capacitance. Supercapacitor is better option for these search. Recently many researcher work on electrode material and transition metal oxides and hydroxide give impressive results. Ruthenium oxide, cobalt oxide, iron oxide, vanadium oxide, nickel oxide and nickel hydroxide are many transition metal oxide and hydroxide materials are used in supercapacitor[3][4].Nickel hydroxide used as in nickel hybrid batteries ,in fuel cell and in many electrochemical sensor. Ni(OH)2 have high theoretical specific capacitance 2055F g-1 and cheap[5]. Electrochemical properties of material depends on morphology and Many type of morphology observed by Ni(OH)2 material. These different nanostructure produced by simple chemical methods [6].

Lokhande et al. synthesise Ni(OH)2 microflower successfully with higher specific capacitance 562 F g-1 at scan rate 10 mV s-1. They also archives α phase of Ni(OH)2[7].Liu et al. reported 3D self-assemble porous structure have higher specific capacitance 2110 F g-1 for current density 1 A g-1 can deposited by CBD method[8]. Doping of transition elements improve electrochemical properties of supercapacitor. Liu et al. doped cobalt in Ni(OH)2 improve specific capacitance 2879 Fg-1 at current density 1 Ag-1.They also reported doping majorly affected by size of element and electronegativity majorly affect[9].

EXPERIMENTAL

The copper doped nickel hydroxide thin films were deposited by chemical bath deposition method by on cost-effective stainless-steel substrate as a current collector. 1M $NiSO_4 6H_2O$ and 1M $CuSO_4 6H_2O$ was used as nickel source and copper source in double distilled water (DDW). The different concentration of (0.1%, 0.2% and 0.3%) $CuSO_4 6H_2O$ was added into 1M $NiSO_4 6H_2O$ with constant stirring in a beaker. 0.25 M $K_2S_2O_8$ and aq. NH_3 was added into the solution. The precleaned substrates were dipped in the above beaker and kept at room temperature for 2h. After that substrate heated at temp 100°C for 2 hr. For 0.1%, 0.2% and 0.3% Cu doping the obtained films were named as N-0.1%, N-0.2% and N-0.3% respectively.

RESULT AND DISCUSSION

STRUCTURAL AND MORPHOLOGICAL PROPERTIES:

X-ray diffraction analysis and FT-IR study are used to determine structural properties of electrode.

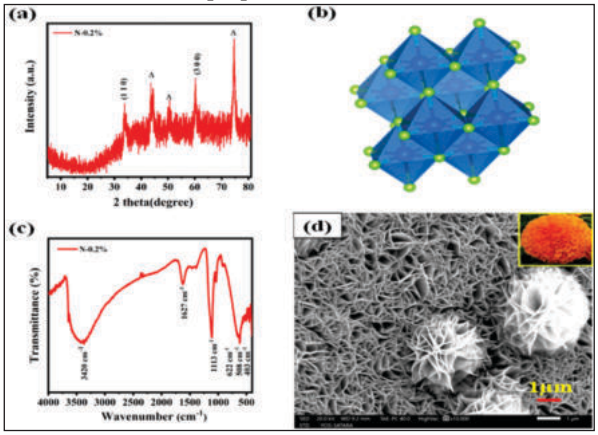

Fig. 1 a represent XRD pattern of N-0.2% optimize electrode. Spectrum shows peaks at 33.81 and 60.24° corresponding to (1 1 0) and (3 0 0) plane. Ni(OH)2 XRD data matches with JCPDS card 022-0444 which indicate hexagonal crystal structure.

Fig. 1 (b) shows crystal structure of Ni(OH)2. Lattice parameter are lattice parameter are a = b = 5.34 Å, c =7.5 Å and α = β = 90°, = 120°.

Fig.1 c shows FT-IR analysis of N-0.2% electrode. This analysis studied at range 400 to 4000 cm-1 wavenumber. Peak at 508 cm^{-1} indicates presence of $Cu(OH)_2$ and 403 cm^{-1} indicate Ni-O stretching mode [10][11]. Presence of O-H molecule represent by peak values of 3420 and 1627 cm^{-1}. The S=O bond represent by wavenumber 1113cm^{-1}.

Fig.1 d shows SEM image of N-0.2% electrode. SEM image shows Marigold like flowers form on surface of electrode. This microstructure increases effective surface area so improvement of electrochemical properties occurs.

Electrochemical Properties And Electrochemical Impedance Spectroscopy

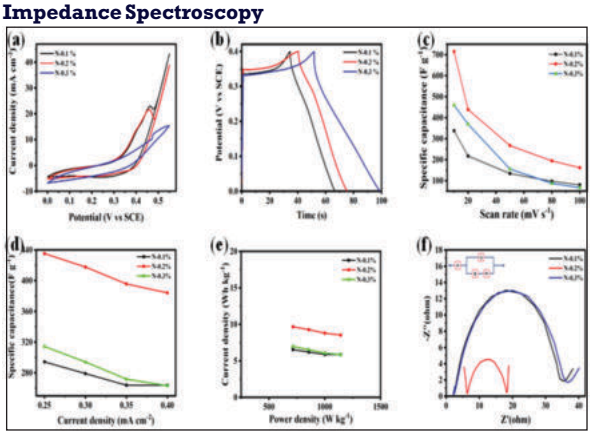

Fig. 2 Supercapacitor study of copper doped nickel hydroxide (a) Cyclic voltammograms of different electrode at scan rate 1mV s-1. (b)Galvanostatic charge-discharge study of different electrodes at current density 2.5 mA cm-2. (c)Variation of scan rate vs. specific capacitance of different electrodes. (d)Current density vs. specific capacitance of different electrodes. (e)Rogene plot of different electrode. (f) Nyquist plot for different electrode.

Fig.2 a indicate CV of N-0.1%, N-0.2% and N-0.3% electrode. Area under CV graph increases as scan rate increases which improve rate of interaction between electrode and electrolyte[12]. Specific capacitance calculated from CV are 338,715 and 360 Fg-1 at scan rate 10 mV s-1.

Fig 2 b shows GCD of N-0.1%, N-0.2% and N-0.3% electrode. Electrode N-0.2% have maximum discharge time. Specific capacitance calculated from GCD are 314,435 and 230 Fg-1 at current density 2.5 mA cm-2.

Fig 2 c shows Variation of scan rate vs. specific capacitance of different electrodes. Current density vs. specific capacitance of different electrodes shown in

fig 2 d. Rogene plot represented in fig 2 e. Fig 2 f shows Nyquist plot for different electrode. All electrode have approximately same solution resistance but electrode N-0.2% smaller charge transfer resistance. After the interpretation of electrochemical analysis, electrode N-0.2% have higher specific capacitance. Improved value of specific capacitance prove Ni^{+2} ions successfully replace by Cu^{+2} ions. Marigold like morphology increases effective surface area of electrode-electrolyte interaction so rate of faradic reaction increases which result increase in specific capacitance of electrode.

CONCLUSIONS

The copper doped $Ni(OH)_2$ successfully deposited by chemical bath deposition method. The structural study reveals that $Ni(OH)_2$ deposited with hexagonal crystal structure. FT-IR study confirm doping of copper in $Ni(OH)_2$ with Cu-O peak. The SEM study shows marigold flower like microstructure deposited on surface which improve electrochemical properties. After study of supercapacitive properties 0.2% doping copper in $Ni(OH)_2$ electrode have greater specific capacitance 715 Fg^{-1} for scan rate 10 mV s^{-1}. Present work conclude that copper is good option for doping which is ecofriendly, cheap and easily deposited by chemical method.

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