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Research paper

Facile synthesis of NiO nanoflakes via hydrothermal route: Effect of urea concentration

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ABSTRACT

In the current investigation, NiO nanoflakes were developed using a simple and cost-effective technique known as hydrothermal method. Effect of variation of Ni precursor with concentration of urea on electrochemical properties was studied. Increased urea concentration in Ni nitrate precursor causes agglomeration of nanoparticles with morphological distortion of nanoflakes. For electrochemical experiments, samples were prepared with Ni:urea precursor ratio such as 1:2, 1:4, 1:6, 1:8, and 1:10 were used. The ratio of Ni (1):urea (2) precursor indicates the maximum capacitance value 128F g^{-1} in 1 M KOH electrolytes at a scan rate of at 10 mV s^{-1}.

1. Introduction

Recently, population growth and depletion of natural resources have contributed to the energy crisis as a modern global issue [1]. As a result of these issues, researchers are interested in researching various forms of energy storage devices such as batteries, supercapacitors, condensers, etc. Due to its high quality of power density, energy density, and long cycle lifespan [2,3], the supercapacitor made up of electrochemical reaction is one of the excellent electric energy storage device.

There are three types of supercapacitors such as pseudocapacitors (PCs), electrochemical double-layer condensers (EDLCs), and hybrid superconductors [4]. In the case of pseudocapacitors, the faradic electron charge-transfer takes place with the redox reaction while in EDLCs, electric double layers are formed at the boundary of the electrode-electrolytic solution. Mostly, conducting polymers, various metal oxides, and composite materials are mainly used as pseudocapacitors [5].

These pseudocapacitor materials are being mostly utilized in supercapacitors than EDLCs. It is well known that RuO_2 has a high theoretical specific capacitance of 1400-2000Fg^{-1} [6] and is one of the best supercapacitor material. But because of its rarity, high cost, it is a very difficult job to utilize it on a commercial scale. Researchers are therefore trying to substitute inexpensive earth-abundant and suitable metal oxides such as MnO_2, Fe_2O_3, NiO, Co_3O_4, etc.

Among these materials, NiO is a flexible low cast transition metal oxide with good pseudocapacitive behavior. Nickel Oxide is a semiconductor possessing holes as majority charge carriers. The energy band gap of NiO is lying in the ranges of 3.6–4.0 eV [7]. Such outstanding features showing NiO material have a plethora of applications such as transparent electrodes in display and photovoltaic devices [8], photocatalysis [9], dye-sensitized solar cells [10], electrochromic devices [11], chemical sensors [12] and supercapacitors [13]. For the synthesis of a nickel oxide material various techniques were used like are spray pyrolysis [14], electrodeposition [15], chemical bath deposition [16], and SILAR [17], hydrothermal method [18,19], etc.

A hydrothermal method is cost-effective among these various methods easily carried out under controlled conditions above the room temperature to obtain NiO with precise morphology. The size, growth, and morphology of electrode material are very easy to control in hydrothermal route by changing the different parameters such as time of reaction, temperature retention, and precursor concentration of the reactants. The pH of growth solution was controlled by the concentration of the reactant [20]. By choosing suitable precipitants such as urea, oxalic acid, ammonium hydroxide, ammonium carbonate, and others the pH of growth solution can be easily controlled in hydrothermal route. [21].

Various morphologies of the NiO films such as nanofiber [22], flowerlike [23], nanocubes [24], nanospheres [25], nanowires [26], nanoflakes [27], etc have been obtained. It is well recognized that NiO's physicochemical properties are of highly depend on structure, morphology, and size. Therefore from the point of researcher's view the preparation of porous materials with various morphologies and hierarchical structures is illustrated. NiO nanoflowers showing 47.6 Fg-

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