Cobalt Ferrite Nanoparticles for Supercapacitor Application

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Abstract. Cobalt ferrite nanoparticles were synthesized by sol-gel method and used for supercapacitor application. Structural and morphological properties were studied by X-ray diffraction and field emission scanning electron microscopy, respectively. The potential use of these nanoparticles as an electrode for supercapacitors was investigated by the electrochemical behavior using cyclic voltammetry (CV) and galvanostatic charge-discharge tests. The CV curves of the cobalt ferrite nanoparticle modified electrode showed a typical pseudocapacitive behavior.

1. INTRODUCTION

Due to depleting fossil fuel reserves, and escalating environmental problems, there is urgent demand for environment-friendly energy storage and conversion system, which includes batteries, fuel cells, capacitors, and supercapacitors [1]. Research interest in the electrochemical supercapacitors has been greatly stimulated due to their high power density, reversibility, and cyclability [2]. In pseudo supercapacitors, capacitance arises from the faradic reactions occurring at the electrode interface [3]. Various transition-metal oxides which show pseudocapacitance have been widely studied for supercapacitor applications [4]. Due to its easy redox reaction, natural abundance, and environmental friendliness oxides of iron and its composites could be a potential candidate for such applications [5]. The charge storage capacity of the iron oxide can be improved by increasing its active surface area through nanostructuring. The sol-gel method is one of the best methods to prepare iron oxide nanoparticles due to its advantages like low processing temperature, high purity, better homogeneity, and single-phase products [6, 7]. In this work, $CoFe_2O_4$ nanoparticles prepared by the sol-gel technique were investigated for supercapacitor application.

2. EXPERIMENTAL

Cobalt ferrite nanoparticles were synthesized by sol-gel method. $Fe(NO_3)_3.9H_2O$ (AR grade) and $Co(NO_3)_2.6H_2O$ (AR grade) in 2:1 ratio were dissolved in 50 ml ethylene glycol ($C_2H_6O_2$). This solution was heated to 200 °C under constant stirring for solvent evaporation, and further heating at the same temperature resulted in self-ignition. After this, the powder was cooled down to room temperature. The powder was then annealed for two hours at 350 °C in air and was cooled inside the furnace. $CoFe_2O_4$ nanoparticles thus prepared were used for characterization and supercapacitor application. The X-ray diffraction (XRD) pattern was recorded by a Rigaku Miniflex 600 X-ray diffractometer with Cu-Kα radiation (λ=1.5406 Å). Particle size and shape was observed by the field emission scanning electron microscope (FE-SEM) JEOL JSM-7100F. The electrochemical measurements were carried out in 1 M KOH electrolyte with a three-electrode system using Metrohm-autolab's potentiostat PGSTAT302N. Glassy carbon electrode (GCE) modified by $CoFe_2O_4$ nanoparticles, platinum wire, and Ag/AgCl electrode were used as working electrode, counter electrode, and reference electrode, respectively. The working electrode was prepared by mixing active material $CoFe_2O_4$ nanoparticles (5 mg) with 1 ml ethanol and 15 µl Nafion binder. 10 µL of black suspension, thus prepared was dropped on the polished GCE and dried in air for 1 h at room

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