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ORIGINAL PAPER

Co_3O_4/SiO_2 nanocomposites for supercapacitor application

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Abstract In this study, Co_3O_4/SiO_2 nanocomposites have been successfully synthesized by citrate–gel method by utilizing SiO_2 matrix for Co_3O_4 embedment. Spectroscopy analyses confirm the formation of high crystalline Co_3O_4 nanoparticles; meanwhile, microscopy findings reveal that the Co_3O_4 nanoparticles are embedded in SiO_2 matrix. Electrochemical properties of the Co_3O_4/SiO_2 nanocomposites were carried out using cyclic voltammetry (CV), galvanostatic charge–discharge, and electrochemical impedance spectroscopy (EIS) in 5 M KOH electrolyte. The findings show that the charge storage of Co_3O_4/SiO_2 nanocomposites is mainly due to the reversible redox reaction (pseudocapacitance). The highest specific capacitance of 1,143 F g^{-1} could be achieved at a scan rate of 2.5 mV s^{-1} in the potential region between 0 and 0.6 V. Furthermore, high-capacitance retention (>92 %) after 900 continuous charge–discharge tests reveals the excellent stability of the nanocomposites. It is worth noting from the EIS measurements that the nanocomposites have low ESR value of 0.33 Ω. The results manifest that Co_3O_4/SiO_2 nanocomposites are the promising electrode material for supercapacitor application.

Keywords Supercapacitor · Energy storage · Electrochemistry · Nanocomposites · Cobalt oxide

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Introduction

Supercapacitors, which are also known as ultracapacitors or electrochemical capacitors, are the energy storage devices that possess high power density (10 kW kg^{-1}), which can be fully charged or discharged in seconds [1]. In terms of their performance, they can strategically fill in the gap between conventional capacitors and batteries to give better energy and power performance. The potential applications of supercapacitors vary from household electronic products to emergency doors in Airbus A380 planes [2, 3] owing to their excellent energy and power performance. Nonetheless, the energy performance of supercapacitors is still far below as compared to that of batteries. Various research efforts have been attempted in order to enhance the energy performance of the supercapacitors. The energy density of a supercapacitor is given as 0.5 CV^2, where C is the capacitance and V is the operating voltage. Maximizing capacitance value in a supercapacitor is a key factor in enhancing energy performance. Electrode material plays a vital role in this context. The supercapacitors electrode material can be categorized into carbon-based materials (activated carbon, carbon nanotubes, graphene, fullerene, and etc.) [4–7], transition metal oxides (MnO_2, V_2O_5, Fe_2O_3, NiO, CuO, $Co(OH)_2$, Co_3O_4, and etc.) [8–14] and conductive polymers (polyaniline, polypyrrole,