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Structural and morphological changes in binder-free $MnCo_2O_4$ electrodes for supercapacitor applications: effect of deposition parameters

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Abstract

In the present work, binder-free $MnCo_2O_4$ nanoflakes were prepared using a cost-effective potentiostatic mode of electrodeposition. Structural and microstructural features of the prepared $MnCo_2O_4$ samples were examined by different characterization techniques including X-ray diffraction, Raman, field emission scanning electron microscopy, energy-dispersive X-ray spectroscopy and supercapacitive testing. The morphological investigation revealed that a unique nanoflake-like structure with uniform morphology. The electrochemical properties of $MnCo_2O_4$ nanoflakes were investigated by cyclic voltammetry, galvanostatic charge discharge and electrochemical impedance spectroscopy. The maximum specific capacitance observed for the $MnCo_2O_4$ thin films was 585 F g^{-1} for a current density of 0.2 mA cm^{-2}. Our results indicate that the $MnCo_2O_4$ electrode has potential for application in supercapacitors.

1 Introduction

The growing use of non-conventional energy sources in recent years has led to an urgent need for energy storage applications, such as battery, capacitors and supercapacitors. Supercapacitors are promising devices for energy storage, such as in hybrid vehicles, backup energy systems, and portable electronics [1, 2]. Supercapacitors have the ability to charge and discharge quickly, having high power densities, which are favorable characteristics required in these types of applications. They store energy in the form of a double layer or in the form of a redox reaction, involving a change in the oxidation state during the charging and discharging process [3]. For both mechanisms, the electrode materials play a crucial role in the electrochemical conversion and energy accumulation for supercapacitor devices.

Several physical and chemical methods are available for the synthesis of electrode materials, such as evaporation [4], sputtering [5], chemical vapor deposition (CVD) [6], electrochemical deposition [7], etc. Among these methods, electrodeposition is the simplest, binder-free, low-cost method for facile synthesis of nanomaterials. In electrodeposition, the structures, nanostructures, and their composition are controlled by various parameters such as the deposition potential, time, electrolyte ingredients, etc. [8].

Transition metal oxides such as Co_3O_4 [9–11], NiO [12, 13], MnO_2 [14, 15], and RuO_2 [16] are promising materials for supercapacitor applications. Of these, electrodes based on Co_3O_4 have been studied extensively. Previous studies have reported that oxides with two different cations enhance the electrochemical performance relative to that of individual oxides [17–19]. Thus, most research in this regard is focused on the synthesis of efficient ternary transition metal oxide materials for supercapacitor applications. Various ternary transition metal oxides such as $MnCo_2O_4$ [18, 20–22],

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