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ENHANCED CAPACITIVE CHARACTERISTICS OF TiO_2 NANOFLAKES BASED ELECTRODE MATERIAL FOR SUPERCAPACITOR

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Abstract

This paper presents an experimental investigation of the enhanced capacitive characteristics of newly fabricated TiO_2 based electrode material for supercapacitor. TiO_2 particles have been synthesized by means of sol-gel method. The size, morphology and structural properties of TiO_2 particles have been studied with the help of high resolution transmission electron microscope, field emission scanning electron microscopy and X-ray diffraction, respectively. The electrochemical properties of the TiO_2 based electrode were determined by using cyclic voltammetry and galvanostatic charge-discharge tests. The results obtained from cyclic voltammetry test show that maximum specific capacitance for TiO_2 based electrodes has been evaluated as 164 F g^{-1} at the scan rate of 5 mV s^{-1} in 1M Na_2SO_4 electrolyte. The cycle stability of the TiO_2 based electrodes has been probed with the help of the cyclic voltammetry and galvanostatic charge-discharge measurements.

Keywords: *nanoflakes, electrode material, Specific capacitance, charge-discharge, cycle stability.*

1. Introduction

In last two decades, Supercapacitors (also called as electric double layer capacitor or ultracapacitor) have been drawing more attention from the researchers and engineers as they have some significant features such as higher power density, longer life cycle, short response time and high durability [1]. Due to these salient features, a new concept of the hybrid charge storage devices where in, supercapacitor integrated with a fuel cell or a battery has been developed [2, 3]. Some of their applications can be found in portable electronic devices, backup power supply, low-emission hybrid cars, instant switches, regenerative braking system, motor starter, industrial power and renewable energy systems [4-9]. An immense potential of the supercapacitor can be explored further in many power source sectors provided the energy density is increased to a desired level [10, 11]. Therefore, more research works are currently carried out to address this low energy density issue through by enhancing the specific capacitance values to a greater extent.

Based on the past literatures, they are reported that if the transition metal oxides are used as active materials for the electrodes, the electro sorption or redox processes would increase the specific capacitance values [12-15]. Metal oxides including ruthenium oxide (RuO_2), manganese oxides (MnO_2), nickel oxide (NiO), tin oxide (SnO_2), vanadium oxide (V_2O_5), iron oxide (Fe_3O_4), etc., were investigated in the past for supercapacitor applications. Amongst transition metal oxides, RuO_2 is reckoned to be a most attractive electrode material due to significant features like, greatly reversible redox reactions, broad potential window, good thermal stability, proton-electron mixed conductive behavior, high rate capability and high theoretical specific capacitance (up to 2200 F g^{-1}) [16]. In spite of these significant features, applications of RuO_2 are limited due to toxicity and high cost.

Manganese oxides (MnO_2) are environmentally friendly feature, abundance, non-toxicity, low cost and have high theoretical specific capacitance. From the past literatures, it is observed that MnO_2 based electrodes have moderate cycle stability up to 1000 charge-discharge cyclic operations and if number of charge-discharge cycles are increased more than 1000 then, specific capacitance values of MnO_2 based electrodes would be expected to be retain less than 80% while comparing to that of initial value [7]. To improve the cycle stability and