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Fabrication of $CoWO_4$/PANI composite as electrode material for energy storage applications

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ABSTRACT

The fabrication of novel electrochemical devices with salient structural features, morphology and porosity is necessary to enhance their efficiency and shelf life. The construction of electrodes using binary metal oxides (BMOs) with conducting polymers (CPs) is noted to be one of the promising strategies to enhance the electrochemical performance of supercapacitors (SCs). Herein, we reported an in-situ chemical oxidative polymerization synthetic route to prepare $CoWO_4$/PANI composite. The structure, crystalline phase, surface morphology and electrochemical (EC) attributes of the as-synthesized material were studied by different spectral and analytical techniques. The cloud-like $CoWO_4$/PANI electrode material exhibited a maximum specific capacitance (C_{sp}) of 653 Fg^{-1} at the scan rate of 5 mVs^{-1}. The prominent cycling stability of $CoWO_4$/PANI with 93.3% retention even after 5000 cycles at the current density of 1 Ag^{-1} was also observed. The study revealed cost-effective synthesis and fabrication of high-performance $CoWO_4$/PANI electrode material for energy storage devices.

1. Introduction

Nowadays, the scarcity of non-renewable energy sources, combined with environmental pollution, has resulted a significant increase in the design and development of novel flexible electrochemical devices [1]. Among the multiple categories of electrochemical energy storage devices, SCs, also known as electrochemical capacitors have received lot of attention because of their fast charging/discharging rate, high power density, long cycle life and simple operation principle and hence used as backup, auxiliary power sources for stand-by power systems as well as electric vehicles [2,3].

SCs are usually classified into Electrical double-layer capacitors (EDLCs), which store charges at electrode-electrolyte interface, Pseudocapacitors (PCs), which store charges through fast reversible Faradaic reactions and Hybrid capacitors, which operate by both electrical double layer and redox mechanisms. As a result, the physico-chemical characteristics of electrode materials are crucial with respect to the performance of SC [4–6].

Recent research advancement is focused on developing new Faradaic materials since they provide ultra-high capacitance and high energy density when compared to traditional carbon-based materials [2]. In general, Metal tungstates are considered as the most desirable transition-metal oxides owing to their abundance, low toxicity, rich polymorphism as well as stable multifunctional properties [7,8]. Recently, there has been pronounced research done on metal tungstates like $ZnWO_4$ [9], $MnWO_4$ [10], $FeWO_4$ [11], $CeWO_4$ [12], $CoWO_4$ [8] and $CuWO_4$ [13]. Among all these metal tungstates, $CoWO_4$ is an important p-type semiconductor with unique electrical and magnetic properties and has gained considerable attention in the field of catalysis, magnetism, sensors and photovoltaic electrochemical cells. However, reports related to cobalt tungstate as electrode material for high-performance supercapacitors are still scarce [8,14].

Among all conducting polymer (CPs) used in energy storage and conversion, PANI has received much focus, attention owing to its large theoretical capacitance, low-cost, facile synthesis, moderate electrochemical activities, variable oxidation states, good doing/de-doing characteristics and good environmental stability [15–18]. Impressively, the incorporation of conducting polymers into some inorganic materials is attempted to obtain composites with complementary behavior between the pristine polymer and the inorganic matrices, as a

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