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Synthesis of graphene oxide/vanadium pentoxide composite nanofibers by electrospinning for supercapacitor applications

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ABSTRACT

Graphene oxide–V_2O_5 composite nanofibers were synthesized for potential application in supercapacitors. Graphene oxide was prepared by the modified Hummers method and the synthesized graphene oxide was washed with acid and base to reduce the agglomeration. The graphene oxide/vanadium pentoxide nanofibers were prepared by the electrospinning technique. The synthesized nanofibers were characterized with XRD, SEM, TGA and FTIR. The electrochemical characteristics of the nanofibers were investigated through electrochemical cyclic voltammetry test. The results showed that graphene oxide–V_2O_5 composite nanofibers exhibit the better capacitive behavior with better reversible charging/discharging ability and higher capacitance values, compared to pure V_2O_5 electrodes.

1. Introduction

In recent years, electrochemical capacitors (ECs) have attracted significant attention for their application in high-power energy storage devices for memory backup and, supplementarily used for hybrid cars etc. [1,2]. Electrochemical capacitors or supercapacitors have been considered as potential energy storage solutions due to their higher power density and long cycle life, compared to secondary batteries, and higher energy density than conventional capacitors [3,4]. In particular, electrochemical capacitors based on transition metal oxides (TMO) exhibit much higher specific capacitance than conventional carbon materials and better electrochemical stability than conducting polymers [5,6]. The amorphous-hydrated ruthenium oxide (RuO_2) is the most promising TMO candidate for supercapacitor electrodes owing to its high capacitance of over 700 F g^{-1} [7]. In general specific capacitance of metal oxide is not promising as expected, and thus it is notable that many researchers have turned to the incorporation and fabrication of graphene based hybrid materials in the pursuit for improved capacitance performance [8].

Metal oxide/graphene nanocomposites exhibit a high specific capacitance with enhanced rate capability and excellent electrochemical stability in addition to a high energy density at low operation rates [9,10]. The total specific capacitance of the composite material was higher than the sum of specific capacitances of pure graphene and pure metal oxide in their relative ratios, which was ascribed to be indicative of a positive synergistic effect of graphene and metal oxide on the improvement of the electrochemical performance.

Vanadium pentoxide (V_2O_5) has been used as an electrode material for ECs because of its layered structure, high capacity, and ease of preparation [11,12]. Because V_2O_5 exhibits a modest electronic conductivity, composites of V_2O_5 and carbonaceous materials have been prepared in an attempt to improve the electrode performance for EC applications [13,14].

Electrospinning is a very effective and versatile technique to produce single phase materials with controlled morphologies in industrial scale [15,16]. In the recent past, variety of electrospun materials have been developed and used for multifarious sectors particularly energy conversion and storage, dye sensitized solar cells, water splitting and purification etc. [15,17]. The present work deals with the preparation and characterization of electrospun graphene oxide/V_2O_5 nanofibers and performance of the material by CV characteristics.

2. Experimental

$V(C_5H_7O_2)_3$ vanadium acetylacetonate (0.174 g), graphene oxide and PVP (0.348 g) (polyvinyl pyrrolidone) were used as precursors for the preparation of graphene oxide/vanadium pentoxide(G-VO) nanofibers. The precursors were dissolved in mixture (1:4 volume ratios) of dimethylformamide (DMF) and ethanol with vigorous stirring. Graphene oxide powder was prepared by modified Hummers method. Different weight proportions of GO (0.2, 0.3, 0.4 and 0.5 wt.%) were added separately to the solution mixture and rigorously stirred to obtain uniform blend solutions. The mixed solution was taken in a

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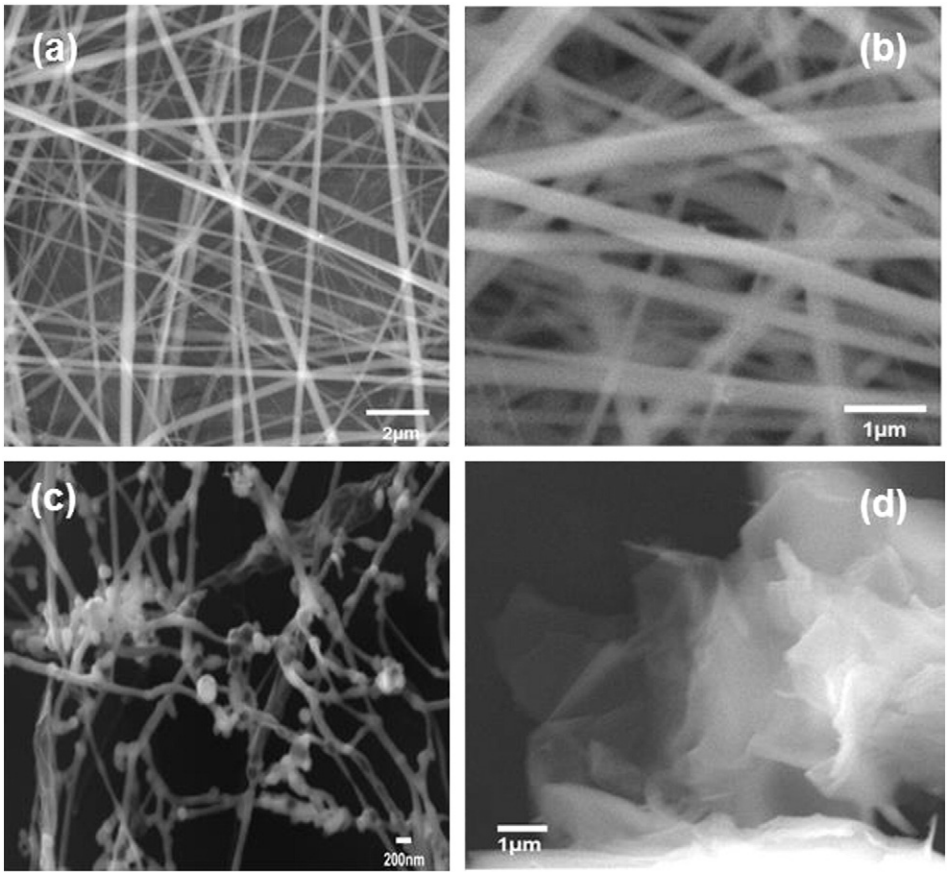

Fig. 1. Graphene oxide/vanadium oxide (a) as-prepared nanofibers, (b) annealed at 350 °C, (c) annealed at 550 °C, and (d) pure graphene oxide.

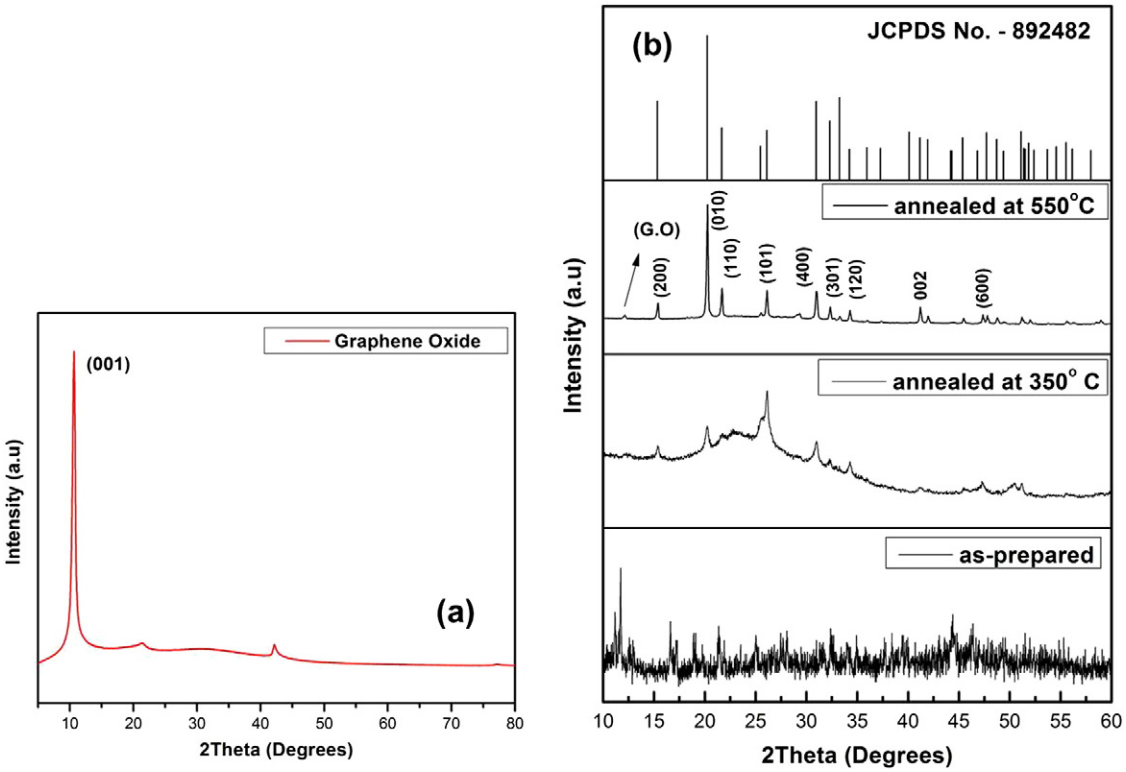

Fig. 2. XRD pattern of (a) graphene oxide and (b) fibers of graphene oxide/V_2O_5, as-prepared, annealed at 350 °C, annealed at 550 °C and JCPDS pattern for V_2O_5.