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Synthesis and Characterization of GO/V_2O_5 Thin Film Supercapacitor

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ABSTRACT

For potential applications in supercapacitors, Graphene oxide - Vanadium oxide structures exhibit high capacitance performance. In this study, GO was synthesized by Hummers Method and coated on substrate materials. Then, thin film supercapacitors glass/GO/VO, PMMA/GO/VO, FTO/ GO/VO and ITO/ GO/VO were fabricated successfully by chemical bath deposition method (CBD). Structural characterizations were investigated by SEM, XRD, FTIR, UV-VIS and AFM. I-V and C_S-V characteristics were investigated and energy densities were calculated at voltage range (from -0.2 to 1.2 V) at scanning potential 25, 50, 75 and 100 mV/s. At the scanning rate of 25 mV/s, the maximum capacitance values for glass/GO/VO, PMMA/GO/VO, FTO/GO/VO and ITO/GO/VO thin film supercapacitors structures were 880 F/g, 806.6 F/g, 949.6 F/g and 563.2 F/g; and the energy intensities were calculated as 85.4 W h/kg, 44.8 W h/kg, 15.78 W h/kg, 23.4 W h/kg, respectively.

1. Introduction

Recently, producing fossil fuels as much as producing energy because of the harmful effects they have on the consumption and environment has a separate precaution. Therefore, alternative energy storage devices with high energy and power capacities are needed and intensive studies are being made to develop these devices [1]. Supercapacitors (SC), also referred to as electrochemical capacitors, appear as promising energy storage system because of their higher power density compared to other devices, their ability to be used repeatedly without any distortion, power consumption or large scale repeated charge cycles and higher energy density than conventional capacitors [2–4]. However, in order to meet the demand for increased energy storage, the energy densities of supercapacitors must be improved. Supercapacitors, which exhibit significantly higher power density compared to batteries, are very good candidates for countless industrial applications and electronic devices, if the energy density can be increased [5,6]. Electronic devices that require fast charging, air / waterproof energy storage devices (e.g. remote wind farms), military vehicles (compact cars for tanks, starters, submarines, fuzzes, etc.) for rapid acceleration at short distances, or to start the engine at short distances in electric or hybrid vehicles power etc. are within the application areas of supercapacitors that can be effectively used in the future [7].

Transition metal oxides (TMO) based electrochemical capacitors provide better electrochemical stability than conductive polymers and higher specific capacitance than conventional carbon materials [8]. In general, the metal oxide capacity is not as good as expected, and for this reason many researchers have sought to assemble and produce hybrid materials based on graphene in order to improve capacitance performance [9]. V_2O_5 is also an important material due to applications such as batteries, supercapacitors, electrochromic devices [10–12]. In particular, vanadium oxides (VO_X), which are abundant in the soil and inexpensive, are being extensively investigated as cathode materials for supercapacitors. The balanced oxidation states of the vanadium oxides and layered structures allow a much higher charge storage capacity than other cheap transition metal oxides. V_2O_5 is used as electrode material since it exhibits high capacity and ease of preparation. Since V_2O_5 exhibits a modest electrical conductivity, composites of V_2O_5 and carbonaceous materials are used to improve electrode performance for electrochemical capacitors [10,13–15].

In previous studies, mostly aqueous solutions were used for SC electrodes. In addition, VO_x thin films processed with different annealing temperatures, nanowire-VO composites, VO_x thin films produced by electrospinning and sol-gel techniques, electrochemical deposition of conductive polymers on CNT-VO_x, VO_x, and films with various thicknesses have high capacitance values, low scan rates. The method used in the present work is thought to be a great advantage for super-capacitors in industrial applications, since it does not require high-quality substrates, unlike widespread use especially for metal oxides, low cost, ease of use, storage medium storage and other methods. By comparing the performances of supercapacitors produced with the methods used up to now, the CBD method has achieved more

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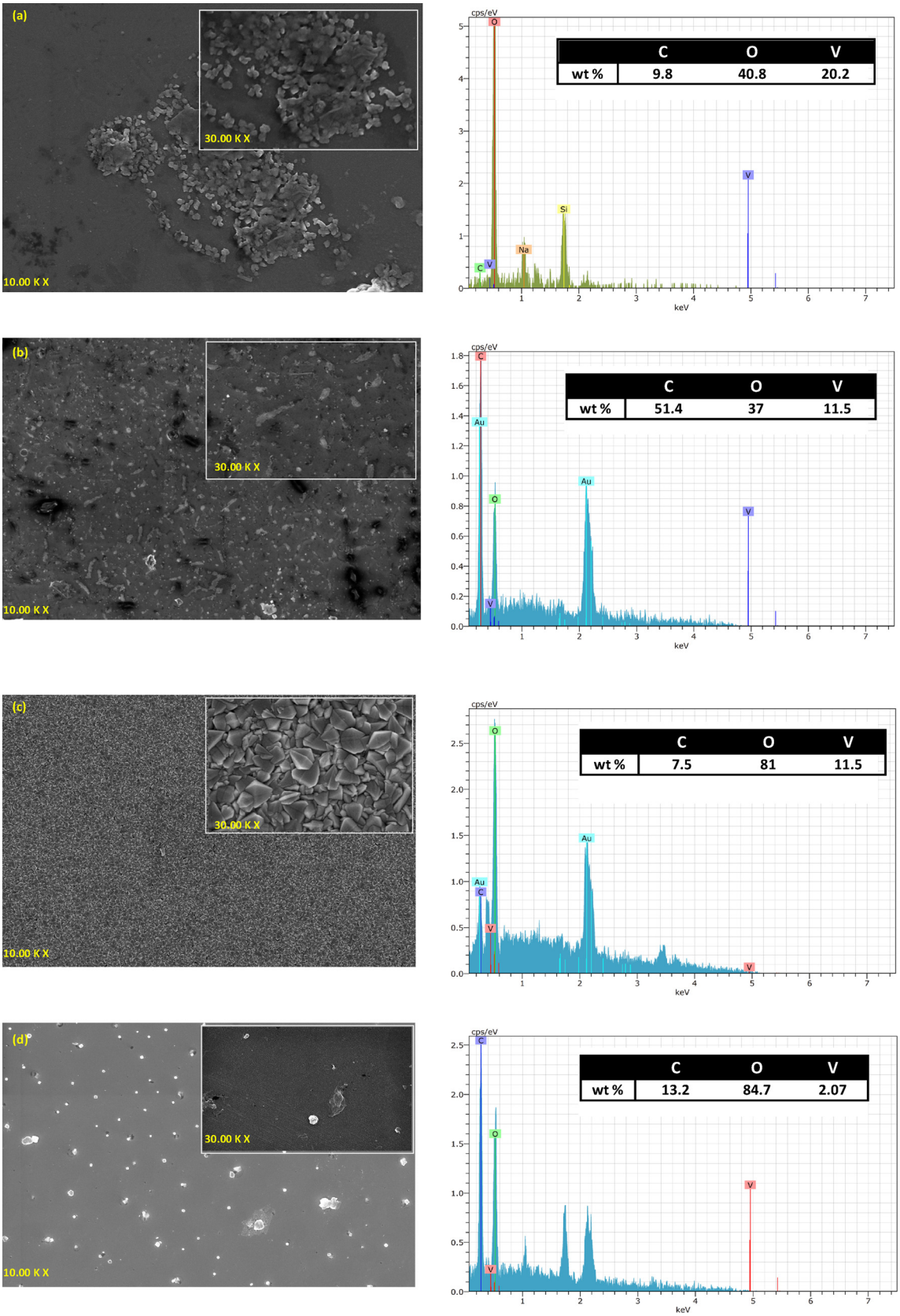

Fig. 1. EDX and SEM analyses of **(a)** GLASS/GO/V_2O_5 **(b)** PMMA/GO/V_2O_5 **(c)** FTO/GO/V_2O_5 **(d)** ITO/GO/V_2O_5.

efficient results at higher scan rates. For this reason, our aim in this study is to synthesize graphene oxide (GO) using Hummers Method and to obtain GO / VO thin film structure by chemical bath storage (CBD) on different substrate materials (glass, PMMA, ITO and FTO). To investigate the current-voltage (C-V), specific capacitance-voltage (C_S-V), energy densities and structural properties of the obtained thin films for