

Supercapacitor 어플리케이션을 위한 ZnO-graphene의 nanocomposite 전극 재료의 준비를 위한 손쉬운 방법

Facile method for the preparation of ZnO-graphene nanocomposite electrode material for supercapacitor applications

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Key words : Graphene, ZnO, Supercapacitor

1. Introduction

Nowadays, graphene based materials are very attractive to researchers in various areas due to their wide potential applications (especially in energy storage), such as lithium-ion batteries, supercapacitors, solar cells, and hydrogen storage [1]. Graphene, a single layer of carbon atoms tightly packed into a two-dimensional honeycomb sp² carbon lattice. Due to its good physical and chemical properties, graphene has to be used as the electrode of electrochemical supercapacitor (ESCs) [2].

Improving the capacitive performance of graphene-based energy storage materials by growing metal oxides on the graphene nanosheets has thus become a topic of major interest. Zinc oxide (ZnO) has triggered worldwide research interest as a wide-band-gap (3.37 eV) semiconductor material for its tremendous potential applications in electronic and optoelectronic devices [3, 4]. Because of its good electrochemical activity and eco-friendly nature, Researchers have begun to study zinc oxide to be a promising electrode material for supercapacitor.

Herein, we are reporting ZnO-graphene-nanocomposite electrode for supercapacitor. The electrochemical properties of this composite were investigated by cyclic voltammetry (CV). The structural, and morphological of the graphene-ZnO nanocomposite were characterized by X-ray diffraction (XRD), Fourier transform infra-red (FTIR), and field emission scanning electron microscopy (FE-SEM).

2. Experimental Procedure

Graphene oxide was synthesized from expandable graphite powder by the modified Hummer's method [5]. The Zn(OH)₂-GO composite was achieved by sonochemical process. Briefly, 50 mg of GO was dispersed to 20 mL of double distilled water and sonicated for 30 min. 0.01M of Zn(NO₃)₂ was dissolved into 10 mL of DI water. The above

solution was dropwise added into the GO solution with continuous sonication for 30 min to produce uniform dispersion. Afterwards a dilute NaOH solution was dropped in to the solution to form a brownishblack suspension with a pH value of the solution reached 9.

The Zn(OH)₂-GO composites were used as precursor to subject into an automated focused microwave synthesis system and treated for 2 min. It was found that the color of suspension had changed from brownish into purely black, indicating the successful chemical reduction of GO. The as-synthesized product was washed thoroughly with distilled water and centrifuged at 10000 rpm for 10 minutes to remove the residuals. The obtained final product was dried in a hot air oven at 100 °C for 3 h, resulting in the formation of graphene-ZnO nanocomposite. To prepare the graphene-ZnO nanocomposite films, certain amount of the obtained graphene-ZnO solution was dropped onto the ITO substrates (current collector) spin coated at 3000 rpm for 20 s and dried at 80 °C.

The crystal structure of the ZnO-graphene nanocomposite was determined by Rigaku X-ray diffractometer. Fourier transform infrared spectra were measured at room temperature with an FTIR spectrometer (Thermo Scientific Systems, Nicolet-6700). The morphology of the nanocomposite was evaluated by field emission scanning electron microscope (JSM-6700F, JEOL Ltd). The electrochemical experiment was investigated by using AUTOLAB PGSTAT302N electrochemical work station in 1M KCl solution.

3. Results and Discussion

Fig.1. shows the XRD pattern of ZnO-graphene nanocomposite. Graphene nanosheets exhibit a weak (100) diffraction peak at 44.5°. The ZnO nanoparticles were crystallized with the wurzite (hexagonal) structure and a preferred orientation of (101) plane [6].

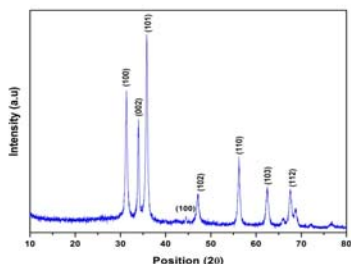


Fig.1. X-ray diffraction pattern of ZnO-graphene nanocomposite.

FTIR spectroscopy was used to confirm the reduction of oxygen-containing groups of graphene oxide. The broad peak appeared at 3428 cm^{-1} (Figure is not shown) is attributed to the stretching vibration of the O–H bond. The peak at 1631 cm^{-1} is assigned to the vibrations of the adsorbed water molecules and the contributions from the vibration of aromatic C=C [7]. For the ZnO NPs, an absorption band in the range of $440\text{--}465\text{ cm}^{-1}$ is observed due to the formation of Zn–O bond [8]. The results imply that most of the oxygen-containing functional groups of GO were reduced.

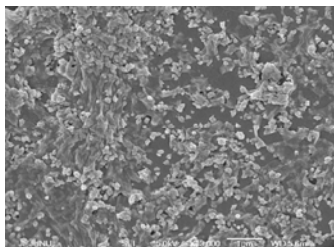


Fig.2. FESEM image of ZnO-graphene nanocomposite.

Fig.2. shows the FESEM image of ZnO-graphene nanocomposite. It can be seen that the graphene nanosheets are covered by densely packed and irregularly shaped ZnO nanograins, spreading in a large-scale.

The electrochemical properties of the as prepared graphene and ZnO-graphene nanocomposite electrodes were investigated by cyclic voltammetry (CV) in 1M KCl electrolyte solution. **Fig.3.** shows the CV curves of graphene and ZnO-graphene nanocomposite at a scan rate of 50 mV/s. It could be observed that both CV curves have similar and close to rectangular shape, indicating an ideal supercapacitor behavior of the electrode. The calculated specific capacitance value of graphene and

graphene-ZnO electrodes from CV curve at a scan rate of 50 mV/s are 39.31 and 72.44 F/g.

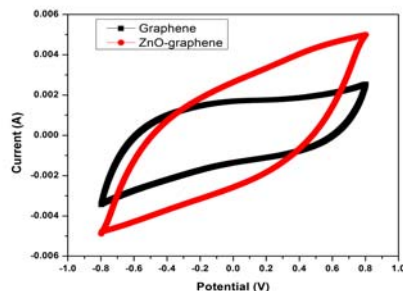


Fig.3. CV curves of graphene and ZnO-graphene electrodes.

4. Conclusion

ZnO-graphene nanocomposites have been synthesized by microwave –assisted method and investigated its structural, morphological and electrochemical properties. Graphene–ZnO nanocomposite showed a high capacitance value of 72.44 F/g at 50 mVs^{-1} in the potential range of -0.8-0.8 V. The Graphene–ZnO nanocomposite exhibited enhancement in the supercapacitance value compared to the pure graphene.

Acknowledgment

This work was supported by National Research Foundation of Korea Grant (2009-0087091). A part of this research was supported by 2000 Jeju Sea Grant College Program funded by Ministry of Land, Transport and Maritime Affairs (ML TM), Republic of Korea.

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