Graphene and N-doped Graphene Coated with SnO_2 Nanoparticles as Super-capacitor Electrodes

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Super-capacitor is considered as a promising high-power source for digital communications and electric vehicles due to its high power capability and long cycle life compared with batteries. Carbon-based materials with high surface area, long cycle life and good mechanical properties are usually used in double-layer capacitors[1]. As a novel carbon nanomaterial, graphene has attracted enormous interest due to its unique properties, such as extraordinary electrical properties and ultral-arge specific surface area. Recently, graphene sheets coated with SnO_2 nanoparticles have been synthesized to improve the capacity and cyclability of super-capacitors. It is known that defects and aggregation deteriorate electrical conducting property of graphene and influence the bonding between graphene and metal oxides. In this work, graphene- and nitrogen (N)-doped graphene-supported SnO_2 films were prepared and solid-state super-capacitors were fabricated employing graphene-based films and polyvinyl alcohol (PVA)-H_3PO_4 gel as electrodes and electrolyte, respectively. The electrochemical properties of the devices were studied.

Graphene and nitrogen-doped graphene were synthesized by a solvothermal method at 200 ºC for 10-20 h, using tetrachloromethane (CCl_4, 2.0 mL), lithium nitride (Li_3N, 1.0 g), and potassium (K, 1.0g) as carbon precursor, nitrogen dopant, and catalyst, respectively. Graphene and N-doped graphene thin films were prepared by a blade coating method on glass slides, and then subjected to a heat treatment at 250ºC for 1h to remove organic materials. SnO_2 nanoparticles supported on graphene films were synthesized through a chemical-solution routine using $SnCl_2$ as a precursor [2]. 100 mg of $SnCl_2$ was dispersed in 10mL of deionized water, and 175 μL of hydrochloric acid (HCl, 38%) was added to the mixture. The solution was then sonicated for 10 min. After sonication, the graphene film was immersed in the solution for 30 min-60 min, and rinsed with deionized water followed by drying in air.

Graphene based super-capacitors were fabricated using polyvinyl alcohol (PVA)-H_3PO_4 gel (0.8 g H_3PO_4 in 10 mL 10% PVA solution) as electrolyte, which was placed between two pieces of graphene based electrodes. The as-fabricated devices were dried at room temperature in atmosphere, and subjected to electrochemical measurements for the evaluation of their super-capacitor behavior. Scanning electron microscopy (SEM) and transmission electron microscope (TEM) were used to characterize the morphology and structure of the obtained graphene-based materials. Energy dispersive X-ray spectrometer (EDS) and X-ray diffraction (XRD) analyses were carried out to investigate the composition and crystal structures of SnO_2/graphene. The electrochemical (EC) performance of as-fabricated super-capacitors was measured using cyclic voltammetry (CV), cyclic charge/discharge (CCD), and electrochemical impedance spectroscopy (EIS).

For instance, as given in Figure 1, it was observed that the incorporation of SnO_2 significantly enhanced the electrochemical performance of graphene based super-capacitor (Figure 1a), and the CV curve of SnO_2/graphene super-capacitor displayed nearly rectangular shape, indicating that an efficient electrical double layer was established at both graphene based electrodes (Figure 1b).

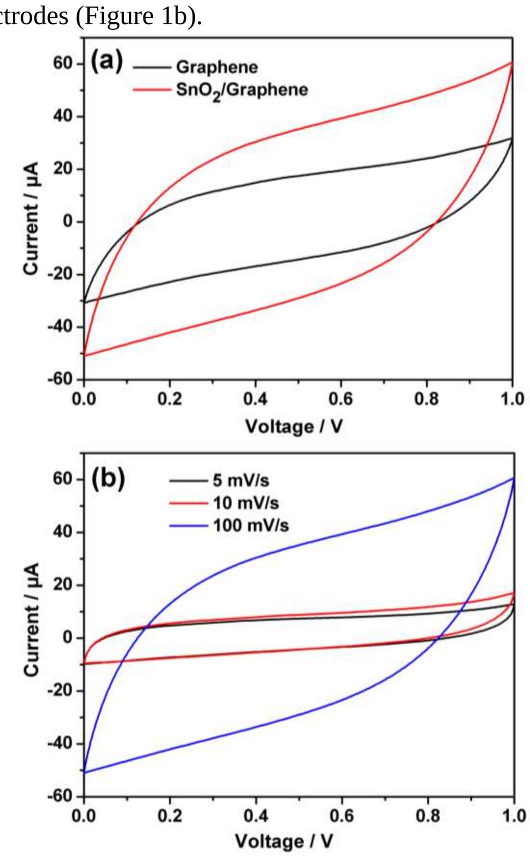

Figure 1 The performance of graphene-based super-capacitors: (a) Cyclic voltammetry curves obtained at 100mV/s for graphene and SnO_2/graphene, and (b) cyclic voltammetry curves obtained at different scan rates for SnO_2/ graphene capacitor.

In summary, graphene and N-doped graphene with few defects were prepared by a solvothermal method. Electrochemical measurements indicate that the incorporation of SnO_2 nanoparticles can enhance the performance of graphene-based super-capacitors significantly.

Acknowledgements

This work was partially supported by the National Natural Science Foundation of China (51172113), the Shandong Natural Science Foundation for Distinguished Young Scholars (JQ201118), the Taishan Scholar Overseas Distinguished Professorship program, the Qingdao Municipal Science and Technology Commission (12-1-4-136-hz), and the Faculty Research Grant and the Sabbatical Leave Award from Missouri State University.

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