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Using controllable electrochemically reduced graphene oxide (ERGO) as high-capacitance electrode material for supercapacitors

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Supercapacitors are promising energy storage devices due to their ability to fulfill the energy and the power gap between conventional capacitors and batteries, though they deliver an unsatisfactory energy density when compared with batteries. Nowadays, many efforts have been made to improve the performance of supercapacitors by developing novel electrode materials. Graphene has been considered as a candidate electrode material for supercapacitors because of its fascinating physico-chemical properties. It can be produced by the reduction of graphene oxide (GO). Among various methods of preparing reduced graphene oxide (rGO) including chemical reduction, thermal reduction and multi-step reduction, the electrochemical reduction of GO is a green and easy synthetic route for preparing rGO. However, as an electrode material for supercapacitors, the electrochemically reduced graphene oxide (ERGO) has shown an unsatisfactory capacitive performance because the reduction process is uncontrollable. The purpose of this study is to explore the effect of the reduction degree of ERGO on its electrochemical performance in aqueous electrolyte for supercapacitors' application.

The electrochemical reduction of GO film was performed with cyclic voltammetry (CV) method. A standard three-electrode cell was employed within the potential window from -1.2 to 0 V (vs. Saturated Calomel Electrode) in 1 M Li_2SO_4 aqueous solution (pH = 7, 9 and 11). The capacitive properties of the ERGO were characterized with CV and constant current charging-discharging in 1 M Li_2SO_4.

As a result of appropriate electrochemical reduction cycles, a satisfactory value of the specific capacitance of ERGO can be obtained. Interestingly, this value decreases dramatically with the increasing reduction cycles imposed on the GO film. This decrease may be due to the restack and structural defects of the ERGO sheets, which in turn affect the surface wettability and the conductivity of ERGO in the electrolyte. We have also tested the effects of 1M Li_2SO_4 with different pH values on reduction efficiency of ERGO, which showed no significant correlation in between.

This study introduced a green and fast electrochemical synthesis method in ERGO preparation. The reduction degree of ERGO can be controlled by the number of repetitive reduction cycles. With optimal number of reduction cycles of ERGO in aqueous electrolyte, it exhibits the highest specific capacitance and cycling stability. When the cycle number of reduction further increases, the performance of ERGO suffers a decline. Therefore, the electrochemical performance of the ERGO in the aqueous electrolyte may be largely affected by the reduction degree of ERGO during the electrochemical reduction process.

Biography

Ran Bi is a PhD student in the Department of Industrial and Systems Engineering at The Hong Kong Polytechnic University under the supervision of Professor Kam Chuen Yung. His research interests mainly focus on the design, synthesis and applications of graphene-based materials for supercapacitors and lithium ion batteries.

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