Electrochemical Performances of Flexible Solid-State Fibre Supercapacitor Based on Polypyrrole/ Reduced Graphene Oxide

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Abstract: A flexible solid-state fibre supercapacitor was fabricated through a simple electrochemical deposition process of polypyrrole/reduced graphene oxide (PPy/rGO) onto the surface of carbon bundle fibre, using polyvinyl alcohol enriched with potassium hydroxide as a solid-state electrolyte. The surface morphology revealed a high degree of porosity in the PPy/rGO composite; facilitating the ionic penetration, leading to an excellent electrochemical performance. The fabricated supercapacitor recorded a specific capacitance of 96.16 F g-1, with an energy density of 13.35 Wh kg^{-1} and a power density of 322.85 W kg^{-1}. It showed remarkable pliability at various angles as evidenced by the shape of the cyclic voltammetry curves that remained unchanged. After a series of charging-discharging cycles, the electrochemical performances of the supercapacitor deteriorated due to the changes in the structural properties such as the reduction in pore size, and transformation of the structure of rGO from amorphous to graphitic. In addition, the chemical environment of the electroactive material was disturbed because of the formation of the hydrogen-bridge bond and the red-shift of the N-H bending. Consequently, these led to the low diffusion of electrolyte ions, high interfacial resistance, and electronic disorder in the electroactive material because of the collapse of the scaffold, inefficient diffusion of electrolyte ions, and an increase in the electron density that interfered with the electron transfer in the electroactive material.

***Keywords*:** Flexible supercapacitor, graphene, polypyrrole, stability

INTRODUCTION

Flexible supercapacitor have been attracted great attention in recent years, which are desirable for developing lightweight, thin and efficient electronic device. In order to achieve efficeient flexible supercapacitor, substrates with excellent mechanical properties and easy modification by active layers are required. Carbon-based fibres have been used owing to its great flexibility, light weight, and stability under ambient conditions. The choice of electroactive materials also plays important roles in determining the electrochemical performances of supercapacitor devices. Recently, graphene has been reputed to be a promisingcarbon material because of its theoretically large surfacearea, excellent conductivity, good capacitance behavior,and low production cost [1]. On the other hand, electrically conducting polymers such as polypyrrole (PPy) is an attractivepseudocapacitor because of its excellent electrical and capacitance properties, good environmental stability, and ease of preparation [2].

MATERIALS AND METHODS

A three-electrode system of electrochemical deposition was used to deposit the PPy/rGO composition a CBF electrode from an aqueous solution. The electrochemical deposition was performed for 5 min at a constant potential of 0.8 V, where a CBF was used as a working electrode, with a saturated calomel electrode (E vs SCE/V) and platinum (Pt) rod as the reference and counter electrodes, respectively. The as-prepared electrodes were dipped in a solid-state electrolyte and entangled together to fabricate the symmetric supercapacitors device.

RESULTS AND DISCUSSION

The excellent specific capacitance and long-life cycles with good capacity retention are important evaluation parameters for the supercapacitor device. The highly porosity in the surface morphology of PPy/rGO, helps in improving the ionic penetration in the electrodes, subsequently enhanced the specific capacitance value. However, the PPy-rGO supercapacitor device had capacity retention values of 73% and 39% after 500 and 1000 cycles of charging and discharging, respectively. The decrement was presumably related to the deterioration of the electroactive materials, degradation of the polymer chain and changes in the structural configuration[3, 4].

CONCLUSIONS

A flexible and bendable supercapacitor device was fabricated by using a simple and low-cost electrochemical deposition of PPy and rGO on the surface of carbon bundle fibre and assembled into supercapacitor devices usinga solid-state electrolyte. The formation of a high porosity structure in the PPy-rGO efficiently increased the ionic penetration, which remarkably enhanced the specific capacitance value of 96.16 A g^{-1} at a current density of 1 A g^{-1}.However, PPy/rGO has low capacity retention across the 1000 cycles of charging/discharging process. It shows that the capacity retention decreased continuously and able to maintain only 39% of its original capacitance after 1000 continuous charging-discharging cycles at a current density of 1 A g^{-1}. The decrease in the capacity retention was due to the reduced in pore size, degradation of the electroactive materials, and the changes in the chemical environment.

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