Mesoporous Carbon Film via Spin Coating Soft Templating Method for Supercapacitor Electrode

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Abstract: Mesoporous carbon films were prepared by using spin coating self-assembly soft templating method onto titanium foils as substrates. A surfactant of triblock copolymer Pluoronic F127 (F127) which act as structure directing agent for the pore structure geometry tuning while preparing the mesoporous carbon film and carbon precursor of resorcinol (R) and formaldehyde (F) was used in the study. It was then carbonized to obtain the final product of F127/RF carbon film. The samples were characterized by electrochemical analysis. The carbonized F127/RF film show excellent electrochemical property for supercapacitor application and the specific capacitance 15.23 $mFcm^{-1}$ at 5 mV s^{-1} scan rate was obtained using electrolyte of 1.0 M potassium chloride (KCl) neutral aqueous solution. These results suggest that the mesoporous F127/RF carbon film-coated titanium foil is a promising candidate for high performance electrodes for electric double layer capacitors (EDLC).

Keywords: mesoporous carbon, soft templating method, supercapacitor, electrode characterization

INTRODUCTION

As the demand of portable and wearable electronic devices keep increasing, the development of flexible, lightweight, environmentally friendly and high-performance energy storage/conversion devices become a focal point for the researchers to focus on. One of the most potential devices which are more important for modern life is the flexible supercapacitor or electric double layer capacitor (EDLC) devices. Therefore, the development of an environmentally friendly, simple and cost-effective electrode material with good conductivity, high specific surface area and useful pore structure is crucial for supercapacitor application. More recently, the nanostructured highly ordered mesoporous carbon materials (OMCs) with tailored and interconnected porous structures have attracted considerable attention because of their unique chemical and mechanical stabilities, electronic and thermal conductivities, facilitated mass transport, and superior electric properties [1-3]. Herein we report a simple, reproducible, eco-friendly, environmentally benign and cost-effective strategy for the production the OMC thin film for the freestanding and non-adhesive flexible supercapacitor electrode materials.

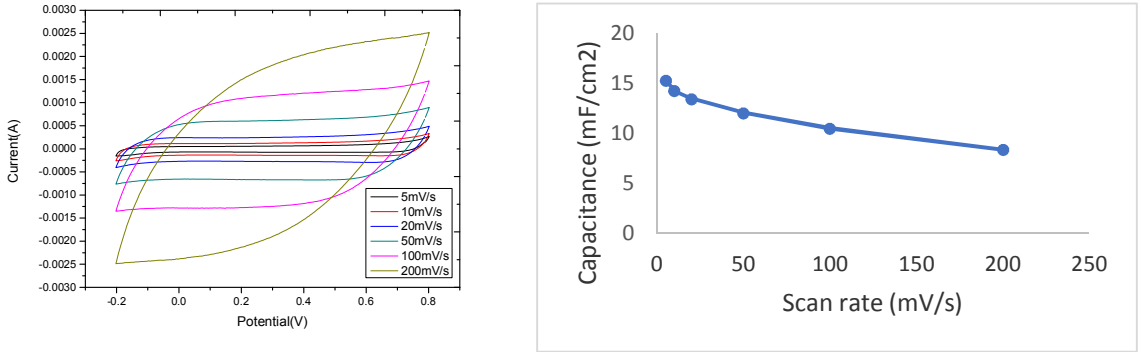
MATERIALS AND METHODS

F127/RF carbon film were synthesized and modified according to Mitome et al. 2014. Resorcinol (R) was dissolved in ethanol solution, and then triblock copolymer 'Pluronic F127' (F127) was added and stirred for 60 min. After that, formaldehyde (37 wt%) (F) was added to the above solution and the solution was stirred for 10 min. Finally, hydrochloric acid (HCl) was added as a catalyst to the solution. After stirring at various stirring time, the resultant solution was deposited dropwise onto a Ti substrate, and then the substrate was spun up to 1000 rpm for 60 s. The deposited sample was heated at 90 °C for 5 h. Then, the resultant sample was carbonized under a nitrogen atmosphere at different temperature for 3 h at a heating rate of 2.3 °C min^{-1}. The electrochemical properties will be

investigated in a three-electrode cell containing 1.0 M potassium chloride (KCl) (neutral) as the electrolyte with Pt plate and Ag/AgCl/saturated KCL serve as the counter and reference electrodes respectively.

RESULTS AND DISCUSSION

In general, the initial efforts to estimate the electrochemical performance of electrodes is by CV curves. Fig. 1 shows the CV curves of F127/RF carbon film samples optimized at carbonization temperature of 700°C for 3 h which is 15.23 mF cm^{-2} at lowest 5 mV s^{-1} of scan rate. It shows nearly rectangular shapes at various scan rates ranging from 5 to 200 mV s^{-1}, indicating the ideal double-layer behaviour of supercapacitor after carbonization. The specific capacitance decreases gradually from 15.23 mF cm^{-2} at 5 mV s^{-1} to 8.37 mF cm^{-2} when the scan rate increases to 200 mV s^{-1}. These results clearly indicate that the electrochemical performance of carbon film materials was successfully obtained in this study.



(a) (b)

Fig. 1. Cyclic voltammograms (CV) of the F127/RF film at different scan rate (a) and capacitance of the F127/RF film as a function of scan rate (b)

CONCLUSIONS

In summary, F127/RF carbon films with homogeneous, continuous, and crack-free have been successfully synthesized by using a simple method based on self-assembly and spin coating method. After carbonization at 700°C for 3 h, F127/RF film show excellent electrochemical property for supercapacitor application and the specific capacitance up to 15.23 $mFcm^{-1}$ respectively at 5 mV s^{-1} the lowest scan rate which are comparable or even better performance compared to the reported literature. It proved that the pore structure and existence of mesopores seem to contribute to the reduction of the diffusion resistance of ions in the electrode. This high performance and lightweight architecture material might open a new avenue for advanced applications in energy storage devices.

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