Synthesis and Characterization of Cost-Effective Carbon Aerogel Electrodes via Ambient Drying for EDLC Applications

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Carbon aerogels are unique mesoporous materials consisting of 3-dimensionally interconnected nanometer-sized carbon particles (2~30 nm) and they have been considered as an ideal electrode of electrical double layer capacitors (EDLCs). The advantages of carbon aerogels for electrode materials are high specific surface area (~1000 m^2/g), low electrical resistivity (~0.03 Ω·cm), and controllable pore size. Especially, the monolithic form of carbon aerogel diminishes the contact resistance, making it an excellent electrode material for EDLC applications [1-3].

The objective of this study includes to develop a cost-effective process for synthesizing RF (resorcinol-formaldehyde) aerogels by an ambient drying instead of conventional supercritical drying and to improve the specific capacitance of carbon aerogel electrodes by optimization of the process variables. In this work, the effects of process variables like the R/C (resorcinol/cataly -st) molar ratio, solid concentration and initial pH of the RF solution, pyrolysis condition, and activation condition on the physical/electrochemical properties of RF aerogels and carbon aerogels have been experimentally investigated.

Reagent-grade resorcinol and formaldehyde were mixed with the 1:2 molar ratio and deionized water was used as a solvent to control the final concentration. Sodium carbonate was added as a base catalyst. The R/C molar ratio was varied a range of 500 and 2000, and the solid concentration of RF solutions was controlled between 30 and 40 wt %. After complete mixing for 1 h, the initial pH of the RF solution was adjusted to the desired level (3.0~7.5) with dilute nitric acid and ammonia water. Synthesized RF solution was gelated for 96 h in oven at 50°C. RF wet gels were ambiently dried in R.T~50°C after exchanging pore water with acetone. Carbon aerogels were prepared via pyrolyzing RF aerogels under nitrogen flow in a tube furnace at 600 °C-1200 °C. Fig. 1 shows an overall experimental flowchart for synthesizing carbon aerogel electrodes. Fig. 2 shows microstructures of synthesized RF/carbon aerogels depending on their initial pH of the RF solutions. In this work, a typical galvanostatic charge/discharge method and the cyclic voltammetry were used to carry out the electrochemical measurement. The specific capacitance of synthesized carbon aerogel electrodes versus the initial pH of the RF solution is given in Fig. 3.

References

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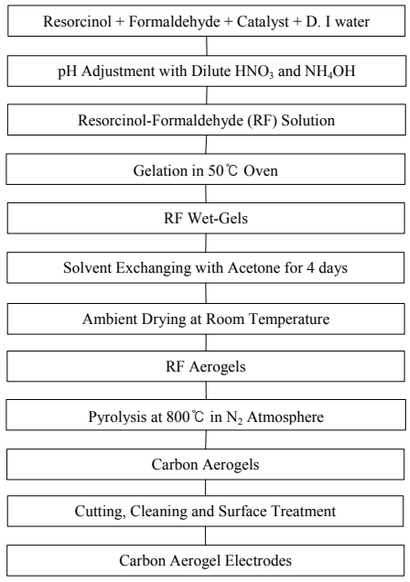

Fig. 1. Overall experimental flowchart.

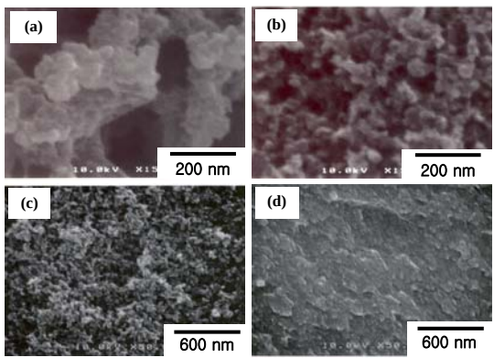

Fig. 2. SEM micrographs of RF/carbon aerogels: (a) RF aerogel (solution pH = 6.0), (b) carbon aerogel (solution pH = 6.0), (c) carbon aerogel (solution pH = 5.5), and (d) carbon aerogel (solution pH = 7.0).

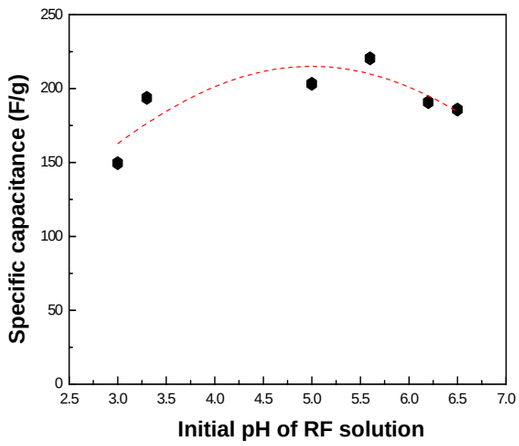

Fig. 3. Specific capacitance of carbon aerogels depending on the initial pH of the RF solution (maximum capacitance = 220.4 F/g).