Protein-based microporous carbon nanoplates for supercapacitors

Young Soo Yun[1], Min Eui Lee[2], Min Jae Joo[2], Se Youn Cho[2], and Hyoung-Joon Jin[2,*]

[1]*Department of Materials Science and Engineering, Seoul National University, Seoul 151-742, Republic of Korea*
[2]*Department of Polymer Science and Engineering, Inha University, Incheon 402-751, Republic of Korea*

hjjin@inha.ac.kr

Despite their high power density, the energy density of supercapacitors is an order of magnitude lower than that of conventional batteries. Advanced carbon-based nanomaterials can improve the energy density of supercapacitors. Supercapacitors can be classified into two categories with respect to their energy storage mechanisms. One is the electric double-layer capacitor, where the capacitance comes from the pure electrostatic charge accumulated at the electrode/electrolyte interface. It requires electrode materials with high surface area and pores adapted to the size of the ions n the electrolyte.[1,2] The other is the pseudocapacitor, in which fast and reversible faradic processes take place due to electro-active species.[3] The incorporation of heteroatoms can considerably improve the specific capacitance of carbon nanomaterials because the heteroatoms induce pseudocapacitive behavior and improve the polar properties of the carbon nanomaterials.[3-5]

In this study, novel protein-based microporous carbon nanoplates containing numerous heteroatoms were fabricated from regenerated silk fibroin by the carbonization and activation of KOH. Each carbon nanoplate had a large surface area (2553.3 m^2/g), and contained the electro-active heteroatoms nitrogen (5.1 wt%) and oxygen (10.7 wt%). The nanoplates' electrical conductivity at 300 K, 1.15×10^4 S/m, is comparable to that of highly doped silicon. The carbon nanoplates exhibited excellent electrochemical performance, displaying a specific capacitance of 264 F/g in aqueous electrolytes, a specific energy of 133 Wh/kg, a specific power of 217 kW/kg, and a stable cycle life of over 10000 cycles.

References

[1] P. Simon, Y. Gogotsi, Nat. Mater., 7, (2008) 845.
[2] L. L. Zhang, X. S. Zhao, Chem. Soc. Rev., 38 (2009) 2520.
[3] Y. S. Yun, JY. Shim, YS. Tak, H.-J. Jin, RSC adv., 2, (2012) 4353.
[4] Y. S. Yun, CB. Im, H. H. Park, I. H. Hwang, YS. Tak, H.-J. Jin, J. Power Sources, 234, (2013) 285.
[5] Y. S. Yun, S. Y. Cho, J. Shim, B. H. Kim, S.-J. Chang, S. J. Baek, Y. S. Huh, Y. Tak, Y. W. Park, S. Park, H.-J. Jin, Adv. Mater., 25 (2013) 1993.

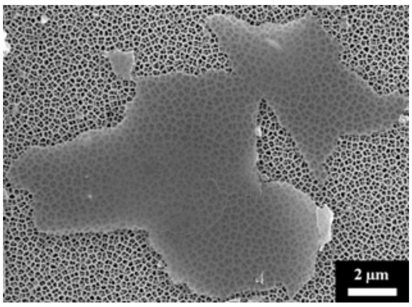

Figure 1. FE-SEM image of the carbon nanoplates on alumina template membranes.