Sulfur-Loading in Hollow Carbon Capsules for Li-S Battery Cathodes

Naeun Yoon, Yeseul Choi, Nahyeon Kim and Jung Kyoo Lee*

Department of Chemical Engineering, Dong-A university, Busan 49315, Korea

E-mail: jklee88@dau.ac.kr

Energy storage devices with high energy and power densities are highly demanding for application to electric vehicles (EV) and energy storage systems (ESSs). Among various candidates, lithium-sulfur (Li-S) batteries have attracted a great attention due to its high theoretical capacity (1675 mAh g^{-1}) and energy density (2600 Wh kg^{-1}). However, Li-S batteries have several intrinsic problems such as poor electrical conductivity of sulfur and discharge products, and shuttle effects of lithium polysulfides dissolved in electrolytes.

Sulfur-loading in carbon hosts has been widely studied to resolve these problems. In this study, we prepared hollow carbon spheres (HCS) by using pyrolytic polymer microspheres as templates. Herein, polymer microspheres (PS-COOH) were synthesized by the emulsifier-free emulsion copolymerization of styrene with acrylic acid under N_2 atmosphere(Fig. 1a)[1]. To prepare the HCS samples, as-prepared polymer templates were coated with sucrose-carbon gel followed by carbonization to form a thin carbon-shell layer and to pyrolyze the core polymer microspheres at the same time[2].

Sulfur-loaded S/HCS composites, which are S/HCS-IM and S/HCS-PM, were prepared by two different loading method. The S/HCS-IM were prepared by impregnation of sulfur dissoloved in carbon disulfide (CS_2) on HCS (Fig. 1d) and S/HCS-PM prepared by physically mixing HCS with sulfur (Fig. 1c). Both S/HCS samples were then anealed at 155 °C to facilitate melt-diffusion of sulfur inside the pores of HCS. To enhace the electrochemical properties, a carbon-coated separator (CCS), which was made by coating commercial flake-type graphite on polypropylene (PP) membrane, was employed.

As the results of electrochemical responses, S/HCS-IM delivered excellent cycling stability and about two times higher reversible capacities than S/HCS-PM, which suggests that a wet-impregnation method (IM) is more effective to disperse sulfur into carbon hosts compared with the physical mixing method (PM). Especially, S/HCS-IM coupled with CCS exhibited much higher specific capacity indicating that shuttling effects were much suppressed to enhance sulfur utilization.

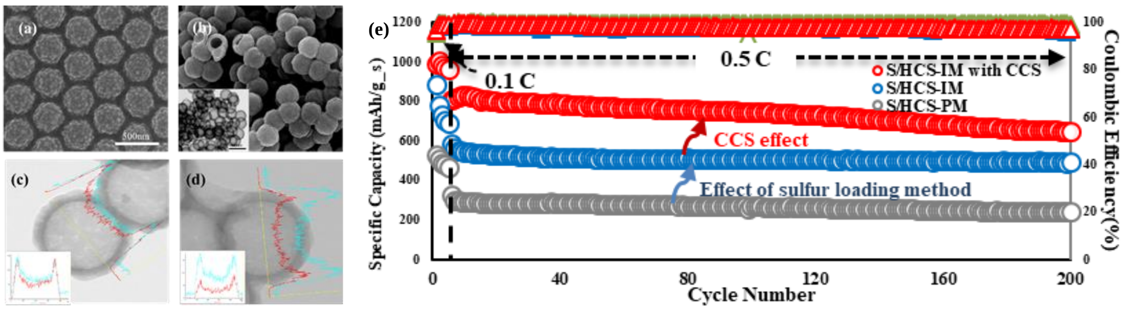

Fig. 1. SEM image of (a) PS-COOH and (b) HCS with its TEM image in the inset, TEM-EDS line scanning profiles of (c) S/HCS-PM, (d) S/HCS-IM, and (e) cycling performances of S/HCS-IM with CCS, S/HCS-IM and S/HCS-PM.

References:

[1] J.-H. Lee, S.-J. Kang, Y. Lee, J.-D. Nam, Polym. Bull., 64 (2010) 717-725.

[2] Z. Li, Y. Jiang, L. Yuan, Z. Yi, C. Wu, Y. Liu, P. Strasser, Y. Huang, Acs Nano, 8 (2014) 9295-9303.

[3] D.S. Yun, H.-S. Lee, H.G. Jang, J.W. Yoo, Bull. Korean Chem. Soc., 31 (2010) 1345-1348.