Electrochemical properties of coaxial electrospun porous carbon nanotube wrapped sulfur cathode materials for lithium-sulfur battery

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The lithium–sulfur (Li–S) battery technology received significant attention owing to high theoretical energy density and cost-effective in order to mitigate current energy challenge. However, Li-S batteries requires significant improvement to overcome the problem associated with poor electrical conductivity (5×10^{-30} S cm^{-1}) of sulfur and high solubility of polysulfide in the organic electrolyte causes capacity fading as well as short cycle life [1,2]. In this study, the porous carbon nanotube (p-CNT) was used to prepare p-CNT/sulfur composite as cathodes for lithium sulfur batteries. The p-CNT were prepared by electrospinning using coaxial nozzle (17-23G). Core solution was prepared by mixing PMMA (Mw=120,000) with DMF until the mixture became a homogeneous gel. The sheath solution was prepared by PAN (Mw=150,000), DMF and SiO_2 nanoparticle (4-12 wt%). The respective flow rate of core and sheath solutions are 1 ml/h and 2ml/h while the tip-to-collector distance of 10 cm and electrical potential of 14 kV was maintained. Thereafter, as-electrospun PAN/PMMA composite fiber precursors were stabilized in air at 280°C for 2h (1°C/min), and subsequent heat-treatment in N_2 atmosphere at 800°C for 2h (3°C/min). Consequently, a controlled etching of SiO_2 was performed by hydrofluoric acid. At the end, sulfur wrapped p-CNT was synthesized keeping the sulfur loading content of 75wt%. The structural and morphological properties was examined by XRD, FE-SEM and TEM. To investigate the electrochemical performances, CR2032 coin-type cells were assembled in an argon-filled glove box using as-prepared cathode materials. The lithium foil, polyetylene, 1M LiTFSI/DME:DOL (1:1 vol.%), 0.1M $LiNO_3$ were used as the counter electrode, separator, and electrolyte, respectively. The p-CNT/S electrode exhibited superior performance with a high discharge capacity of 1,310 mAh g^{-1} at the first cycle and maintained a satisfactory cyclability. The obtained result was compared with the CNT without any pore by keeping same sheath solution except SiO_2 nanoparticles. Hence the outstanding electrochemical performance of p-CNT was accredited to the existence of pores which carry sulfur content or enable Li^+ diffusion to innerside of CNT, effectively.

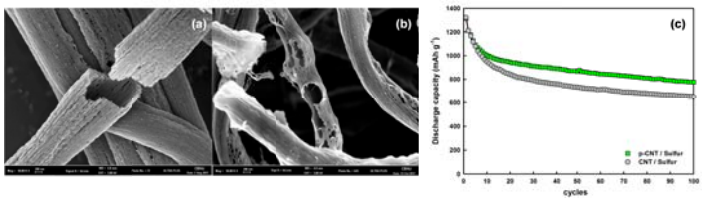

Fig.1 FE-SEM images of CNT (a), p-CNT(b), and cycling performance (c) of CNT/Sulfur and p-CNT/Sulfur used lithium sulfur batteries.

References:

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[2] K. Zhang, K. Xie, K. Yuan, W. Lu, S. Hu, W. Wei, M. Bai, C. Shen, J. Mater. Chem. A. 5 (2017) 7309-7315.