Fabrication of practical high energy density cathode using commercial ketjen black and aqueous binder for lithium-sulfur batteries

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As a soaring demand of large-scale electrical energy storage systems for applying various upcoming markets such as a portable energy device, electric vehicle, unmanned aerial vehicles, people all around the world have tried to develop next-generation battery system beyond current lithium-ion batteries (LIB). Lithium-sulfur batteries (LSB) system has been regarded as a most promising candidate due to its high theoretical specific capacity of 1,675 mAh g^{-1} and theoretical energy density of 2,600 Wh kg^{-1}. Although numerous published papers show outstanding electrochemical performances of their cathode, still it is very difficult to fabricate practical high energy density cathode system. Herein, we develop a practical and facile cathode system composed solely of commercial products, like elemental sulfur, ketjen black (KB), polyethylenimine (PEI), and polyacrylic acid (PAA) as an aqueous binder. PEI attached KB surface (PEI@KB) composite is prepared via simple mixing of both suspensions and attached PEI ratio is easily controlled by altering the input amount of PEI source in mixing step. Further, fabrication of high sulfur loading cathode up to 4.5 mg cm^{-2} is facilitated by straightforward ball-milling sulfur, PEI@KB, and PAA. This high energy density cathode exhibits high initial discharge capacity of 4.64 mAh cm^{-2}, which satisfy the required areal capacity of 4 mAh cm^{-2} from EV industries [1] and lasts stably during 100 cycles under 0.5 C-rate. PEI coating material enhances the adhesion ability between both PEI@KB and PAA and/or cathode materials and Al-foil current collector enabling strong integrity of cathode even with high sulfur loading amount. Moreover, a plenty of amine group in PEI can capture the lithium polysulfide species during a long-term galvanostatic cycling.

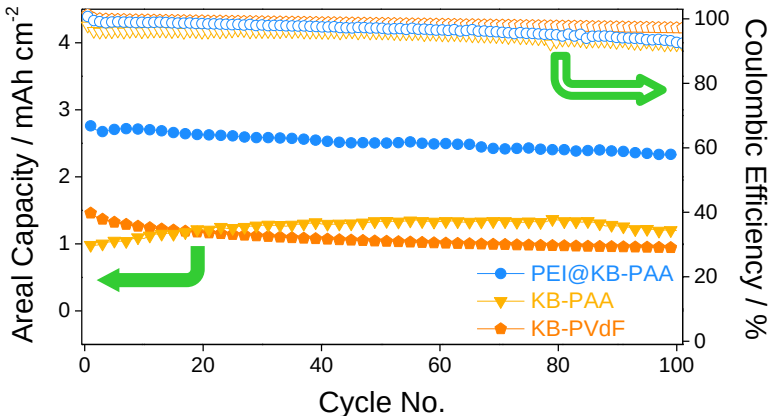

Figure 1. Comparison of electrochemical cycling performance and Coulombic efficiency of PEI@KB-PAA, KB-PAA, and KB-PVdF at 0.5C.

References:

[1] R. Fang, S. Zhao, Z. Sun, D.W. Wang, H.M. Cheng, F. Li, Adv. Mater. 1606823 (2017) 1–25.