Well-dispersed Amorphous Ta₂O₅ Chemically Grafted onto Multi-Walled Carbon Nanotubes for High-performance Lithium Sulfur Battery

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Modification of commercial separators with conductive and active barrier layers towards soluble polysulfides is an effective way to combat the shuttle effect and improve the utilization rate of sulfur in lithium-sulfur (Li-S) batteries. Herein, well-dispersed amorphous Ta₂O₅ was chemically grafted onto oxidized multi-walled carbon nanotubes (CNT-O) under mild conditions by a one-pot solvent evaporation method. The prepared Ta₂O₅/CNT-O composite was used as a modified separator layer in a Li-S battery, which combined the advantages of the intertwined structure of conductive CNT-O and the chemisorption ability of Ta₂O₅. Cyclic voltammetry (CV) curves and X-ray photoelectron spectroscopy (XPS) verified the catalytic effect of Ta₂O₅ on the redox reactions during the discharge/charge processes and the strong chemical interactions between polysulfides and Ta₂O₅. Scanning electron microscopy (SEM) images of the modified separators after cycling revealed that the well-dispersed amorphous Ta₂O₅ could immobilize soluble polysulfides through chemical interactions and prevent aggregation of the insoluble products (Li₂S₂, LiS₂ and S₈) during the redox reactions, leading to a uniform redistribution of the sulfur species inside the modification layer, which could ensure the conductivity of the modification layer and high utilization rate of sulfur during long-term cycling processes. A Li-S cell prepared with Ta₂O₅/CNT-O modified separator exhibited a high initial specific capacity of 1230.7 mAh/g at a current density of 0.2 C and stable cycle performance with a decay rate of only 0.11% per cycle over 500 discharge/charge cycles.

Keywords: Lithium Sulfur Battery, Modified Separator, Chemical Grafting, Amorphous Ta₂O₅, Cycle Performance

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