Black Phosphorus Anode: Realizing Fast Charging Lithium-ion Batteries

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With a high theoretical capacity (2596 mAh/g) and a safe lithiation potential (0.7V), black phosphorus (BP) demonstrates potential for fast charging lithium-ion batteries (LIBs). However, its application is significantly hindered by low conductivity and severe volumetric expansion (approximately 300%). Moreover, the intrinsic flaws of fast charging LIBs are concerning, such as irregular solid electrolyte interphase (SEI) formation and capacity loss due to the dissolution of lithium polyphosphides (shuttle effect). In this research, zinc phosphate is introduced as a multifunctional additive to mitigate the dissolution of lithium polyphosphides, enhance the reaction kinetics of the battery, and form a regular, LiF-rich, and conductive SEI. Consequently, the zinc phosphate-modified BP anode demonstrates exceptional long-term cycling stability and high-rate performance, exhibiting a capacity retention of 1735 mAh/g after 600 cycles at a rate of 1C. Moreover, even at an elevated rate of 4C, it retains a significant capacity of 1330 mAh/g after 250 cycles, which corresponds to a minimal capacity loss of merely 0.04% per cycle. Finally, this research collectively demonstrates the promising potential of the zinc phosphate-modified BP anode for wide application, as it has a similar cost to commercialized graphite (Gr) and silicon-carbon (Si/C) anodes while achieving outstanding fast charging performance compared to these two anodes. Additionally, the utilization of high energy ball milling (HEBM) throughout the entire material synthesis process is considered an environmentally friendly and efficient approach to mass production.

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