Tailoring nucleation and growth of Li_2S by electrolyte anion selection: A step forward to achieving full utilization of sulfur for high performance Li-S batteries

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Untamed deposition of lithium sulfide (Li_2S) imposes an adamant limitation to achieve high capacity of lithium sulfur (Li-S) batteries. Solvents with high Gutmann donor number (DN) can elevate the sulfur utilization with amending the discharging pathway; however, the approach reveals its inadequacy of severe Li metal corrosion. Herein, we report that three-dimensional (3D) Li_2S growth can be attained by utilizing salt anions with high-DN. Ex-situ analyses and electrochemical measurements demonstrate that, with increasing the DN of the anion, 3D Li_2S growth is more favored based on an increased Li_2S solubility. As a result, the use of Br^- leads to 95 % of sulfur utilization during a discharge process. In addition, the electrolytes with high-DN anions have more compatibility with Li metal electrodes compared to those with high-DN solvents. Based on the amelioration, the new approach enables a high sulfur-loaded Li-S battery of 4 mAh cm^{-2} areal capacity. This finding offers a facile but effective strategy to modulate Li_2S growth mode while maintaining the Li metal stability for high-performance Li-S batteries.