Development of High-Performance Electrochemical Conversion Batteries

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Abstract

As a promising post lithium-ion battery technology, commercial lithium-sulfur battery cathodes currently suffer from the insulating sulfur and the irreversible polysulfide loss. These challenges restrict the development of a high-performance lithium-sulfur battery cathode with a sufficient sulfur loading and content of above 4.0 mg cm^{-2} and 65 wt.%, respectively, in a cell with a reasonable low electrolyte-to-sulfur ratio of less than 10.0 uL mg^{-1}. Here, we present innovations on a carbon nanofiber electrode for enabling lithium-sulfur batteries to operate excellently with a high amount of sulfur (14.4 mg cm^{-2} and 71 wt.%) and a low electrolyte-to-sulfur ratio of 4.0 uL mg^{-1}. The cells output a stable discharge capacity and Coulombic efficiency of above 650 mA·h g^{-1} and 98%, respectively, for 100 cycles. Such excellent electrochemical efficiency and stability demonstrate a high capacity retention of above 90% with a high areal capacity and energy density of 10 mA·h cm^{-2} and 20 mW·h cm^{-2}, respectively, in a cell with a low electrolyte-to-sulfur ratio of only 4 uL mg^{-1}. In conclusion, the electrochemical enhancements and engineering designs of the cathode substrates make them advanced cathode designs for the development of high-loading/content sulfur cathodes in high-energy-density lithium-sulfur batteries.