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Fundamental Research to Practical Application, Structural Design of Lithium-Sulfur Batteries

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Perspective

Lithium Ion Batteries (LIBs) with stable electrochemistry and a long lifespan have been quickly developed and are now considered ideal power sources for portable electronic devices such as cell phones, computers, and electric vehicles Unfortunately, current LIBs based on insertion-type transition metals/metal oxides are unable to meet the rising energy density demands of long-range electric vehicles. It is critical to look for innovative electrode materials with low molecular/atomic weights and the ability to transport many ions/electrons per molecule/atom. Sulfur is one of the most abundant elements in the earth's crust, and its atomic weight of 32 g mol1 makes it a cost-effective and environmentally beneficial alternative to traditional Lithium Ion Batteries (LIB). Due to their high theoretical energy density of 2600 W h kg1 based on two electron transfer per S atom they have significant promise as energy storage devices. Li–S batteries have gotten a lot of attention since 2009, and they're considered one of the most promising prospects for next-generation batteries. Li-S batteries have been developed, and significant breakthroughs have been made. With the help of improved materials and architectures, sulphur cathodes with high sulphur utilisation (>90%), high sulphur content (>80 wt percent) outstanding cycling life (>1500 cycles), and C-rate performance (>40 C) have been realised up to now. With recent advancements in the Li-S system, it appears that Li–S batteries may soon be used in practical applications. To accomplish the aims of practical Li-S batteries (assumin g a practical discharge capacity output of 1000 mA h g1), rather substantial sulphur loadings of 3 mg-7 mg cm^2 are required. Aside from high areal capacity materials, energy density calculations should consider the entire device, which is required for practical Li-S batteries. The boundary conditions for achieving a high energy density of over 400 W h kg were a high sulphur loading of more than 2 mg cm^2 and an E/S ratio of less than 5 L mg Other primary factors like discharge capacity, discharge voltage, percent Li excess, Sulphur content in the cathode, and cathode porosity are rarely mentioned in the literature, but they play an important role in determining the gravimetric energy density, volumetric energy density, and cost of practical Li-S batteries.

The goal of this review is to offer advice on how to build suitable structural and parameter designs for Li-S batteries in real applications. The fundamentals, difficulties, and material design of traditional liquid-based Li-S batteries are first discussed. The correlations between gravimetric energy density, volumetric energy density, cost, and the other mentioned characteristics are then investigated in detail.

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A lithium metal anode, a separator, electrolyte, and a sulfur-based cathode make up a conventional Li-S cell. The two types of charge/discharge voltages are shown schematically in a typical Li–S cell setup. Lithium metal is oxidized to lithium ions during the discharge process, which move through the electrolyte to the Sulphur cathode, where Li forms conversion-type Li-S compounds. The typical discharge–charge patterns of a solid-liquid dual-phase Li-S electrochemical process S8 is reduced to $Li2S_4$, which offers 1/4 of the predicted capacity (418 mA h g1) due to 1/2 electron transfer per Sulphur atom at the first plateau around 2.3 V.