Effect of Cell Design on Li-S Battery Discharge Power Capability

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Due to the high theoretical energy density (2600 $Wh.kg^{-1}$) and high theoretical specific capacity (1674 $mAh.g^{-1}$), intensive effort has been deployed in Li-S battery research. Although Li-S battery has been demonstrated to achieve high sulfur utilization at the active material level, its energy density at the electrode and cell level is still not competitive to the existing benchmark Li-ion batteries under the practical application conditions. The challenge is primarily due to the requirement of high sulfur electrode areal capacity loading and the requirement of excess non-active cell components that are needed to achieve the acceptable cell electrochemical performance, such as high weight percentage of conductive carbon host within the cathode formulation and the excess amount of electrolyte (or high electrolyte to sulfur weight ratio – E/S ratio). To further improve the energy density and power capability of Li-S batteries, we must gain more fundamental understanding of how these cell design factors impact the Li-S cell performance. In this report, we have systematically studied the effect of several cell design parameters on the Li-S cell electrochemical performance and investigated their interactions. The correlation between sulfur-cathode loading ($mg.cm^{-2}$ S), the E/S ratio and the cell discharge current density ($mA.cm^{-2}$) is determined. The effect of E/S ratio and discharge current density on sulfur utilization for cathodes with sulfur loading ranging from 2.5 to 11 $mg.cm^{-2}$ is shown in Figure 1. The major factor influencing the Li-S cell discharge rate capability is found to be the E/S ratio. Under the same E/S ratio, the impact of sulfur loading on sulfur utilization at various discharge rates is negligible. However, the sulfur loading strongly influences the Li-S cell cycling stability. The effect of cathode density (g/cm^3) on the Li-S cell power performance with cathode of multiple sulfur loadings is also investigated.

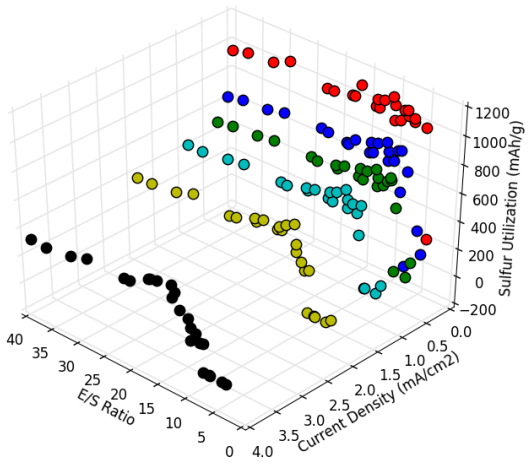

Figure 1. E/S ratio and current density effect on sulfur utilization