A membrane-free lithium/polysulfide semi-liquid battery for large-scale energy storage

Yuan Yang[a], Guangyuan Zheng[b] and Yi Cui[c]
[a]Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139
[b]Department of Chemical Engineering, [c]Department of Materials Science and Engineering, Stanford University, Stanford, CA 94305

Large-scale energy storage represents a key challenge for renewable energy and new systems with low cost, high energy density and long cycle life are desired. In this article, we develop a new lithium/polysulfide (Li/PS) semi-liquid battery for large-scale energy storage, with lithium polysulfide (Li_2S_8) in ether solvent as a catholyte and metallic lithium as an anode. Unlike previous work on Li/S batteries with discharge products such as solid state Li_2S_2 and Li_2S, the catholyte is designed to cycle only in the range between sulfur and Li_2S_4. Consequently all detrimental effects due to the formation and volume expansion of solid Li_2S_2/Li_2S are avoided. This novel strategy results in excellent cycle life and compatibility with flow battery design. The proof-of-concept Li/PS battery could reach a high energy density of 170 W h kg^{-1} and 190 W h L^{-1} for large scale storage at the solubility limit, while keeping the advantages of hybrid flow batteries. We demonstrated that, with a 5 M Li_2S_8 catholyte, energy densities of 97 W h $kg^{-1}$and 108 W h L^{-1} can be achieved. As the lithium surface is well passivated by $LiNO_3$ additive in ether solvent, internal shuttle effect is largely eliminated and thus excellent performance over 2000 cycles is achieved with a constant capacity of 200 mA h g^{-1}. This new system can operate without the expensive ion-selective membrane, and it is attractive for large-scale energy storage.

References:

1. Yuan Yang, Guangyuan Zheng and Yi Cui, A membrane-free lithium/polysulfide semi-liquid battery for large-scale energy storage, ***Energy Environ. Sci.***, 2013,**6**, 1552-1558