WS_2 Nanopetal Catalyst Embedded in 3D rGO-CNT Aerogel for High Areal Capacity Lithium-Sulfur Batteries

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Lithium sulfur (Li-S) batteries have attracted significant attention owing to their higher theoretical energy density and lower cost in contrast to the conventional lithium ion batteries (LIBs).[1] However, the practical application of Li-S battery is still impeded by the poor cycling performance owing to the low electrical conductivity of S and its discharge product, and the dissolution of polysulfide intermediates that causes the polysulfides “shuttle effect”.

Recently, the community aims to tackle these great challenges by physical trapping of the LPSs in various porous carbon materials, or chemical bonding of the LPSs with the help of polar inorganics/polymers.[2] Although great improvements have been achieved by physical trapping/chemical bonding methods, however, significant loss of capacity is inevitable, due to the lithium polysulfides dissolving, especially in long-term cycling. Moreover, most of the reported Li-S batteries were performed with low sulfur loading (< 2 mg cm^{-2}) and areal capacity (< 3 mAh cm^{-2}) because the thick electrode with high sulfur loading would result in limited kinetics for both lithium ions and electrons.[3-4]

Herein, we report a novel cathode material consisting of WS_2 nanopetal catalyst homogeneously embedded in reduced graphene oxide-carbon nanotube (WS_2-rGO-CNT) aerogel with ordered channels for stable and high areal capacity Li-S batteries (Figure 1a and b). The WS_2-rGO-CNT aerogel combines the advantages of strong chemical bonding for polysulfide adsorption, catalytic effect for fast polysulfide redox reaction and three-dimensional (3D) conductive porous carbon network for fast and efficient e^-/Li^+ transportation. Thus the resulting 3D porous WS_2-rGO-CNT aerogel accommodating the Li_2S_6 enables stable cycling performance (90.7% capacity retention after 100 cycles), excellent rate capability (614 mAh g^{-1} at 2 C) and high areal capacity of 6.8 mAh cm^{-2} at 0.5 C (Figure 1c and d). The results suggest that embedding the nano-catalyst in a porous conductive network is an effective approach to achieve stable and high areal capacity Li-S batteries.

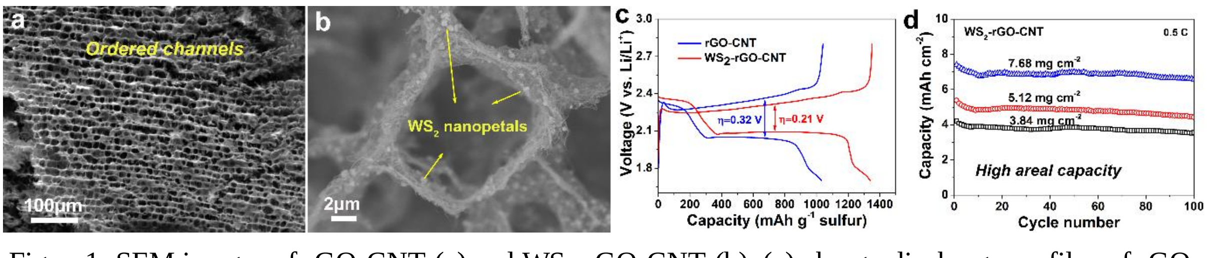

Figure1. SEM images of rGO-CNT (a) and WS_2-rGO-CNT (b), (c) charge-discharge profiles of rGO-CNT and WS_2-rGO-CNT, (d) areal capacity of WS_2-rGO-CNT with different sulfur loadings.

References:

[1] Y. Yang, G. Zheng, Y. Cui, Chem. Soc. Rev. 42 (2013), 3018-3032.

[2] A. Manthiram, Y. Fu, S.-H. Chung, C. Zu, Y.-S. Su, Chem. Rev. 114 (2014), 11751-11787.

[3] M. Yu, J. Ma, M. Xie, H. Song, F. Tian, S. Xu, Y. Zhou, B. Li, D. Wu, H. Qiu, Adv. Energy Mater. 7 (2017), 1602347.

[4] R. Fang, S. Zhao, P. Hou, M. Cheng, S. Wang, H. M. Cheng, C. Liu, F. Li, Adv. Mater. 28 (2016), 3374-3382.