Facile synthesis of Tin selenide (SnSe) nanoparticles on reduced graphene oxide (rGO) as promising anodes for Lithium-ion and Sodium-ion Batteries

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Progress in technology requires the advancement of electrochemical energy storage to support a wide range of applications in different scales, from small portable electronics to electric vehicles and even large scale renewable energy harvesting. Recently, development of advanced lithium-ion batteries (LIB) have fueled the growth of hybrid and electric vehicles. Sodium-ion batteries (SIB) on the other hand has garnered renewed interest due its low cost and high abundance which is able to support grid scale energy storage. In these aspects, Sn-based anodes have been of great interest due to the high lithium storage capacity (Sn: 994 SnO: 875 SnS: 782 SnSe: 596 mAh/g).[1] Among these materials, there has only been a handful of reports on tin selenide (SnSe & $SnSe_2$). In 2011, Choi *et al* synthesized $SnSe_2$ nanoplates-graphene composites via colloidal approach for LIBs with reversible capacities of 640 mAh/g after 30 cycles.[2] Recently, Kim *et al* synthesized SnSe-C via ball milling for SIBs with high reversible capacities of 707 mAh/g after 50 cycles. [3] Herein, we present the synthesis of SnSe nanoparticles (NP) on rGO via facile hydrothermal reaction and annealing. This approach produces SnSe NP of 15-20 nm uniformly distributed on rGO (Fig 1a). When cycled as an anode in LIB, SnSe/rGO delivered 702, 592, 472, 376, and 311 mAh/g at current densities of 50, 200, 500, 800, and 1000 mA/g respectively (Fig 1b). After the increasing current density cycling, the electrode recovered 90% of its initial capacity when cycled at 50 mA/g. In terms of cycle life, SnSe/rGO delivered 545 mAh/g capacity after 150 stable charge-discharge cycles at 200 mA/g with 88% capacity retention. SIB cycling are in progress but preliminary results are promising. The morphology allows SnSe to be strongly anchored on rGO sheets which acts as a buffer to reduce volume changes during cycling and hence improve cycling stability. Furthermore, the small NP on rGO facilitate rapid lithium update and release hence improved rate cycling. Therefore, the improved cycling performance of SnSe/rGO will attract greater interest towards selenide based anode materials for both LIB and SIB applications.

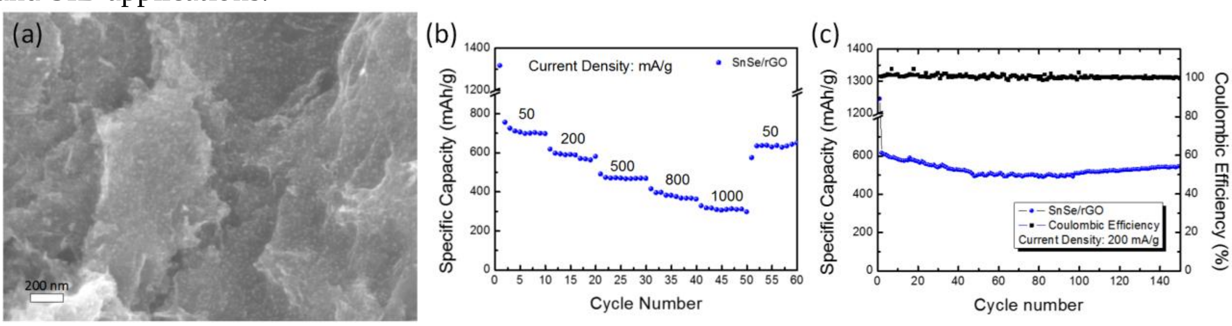

Fig 1 (a) SEM image of SnSe/rGO (b) Rate capability of SnSe/rGO (c) Cycling performance SnSe/rGO at current density of 200 mA/g and its corresponding coulombic efficiency

Reference to a journal publication:

[1] C. M. Park, J. H. Kim, H. Kim, H. J. Sohn, Chem. Soc. Rev. 39 (2010) 3115-3141.
[2] J. Choi, J. Jin, I. G. Jung, J. M. Kim, H. J. Kim, S. U. Son, Chem. Comm. 47(2011) 5241-5243.
[3] Y. Kim, Y. Kim, Y. Park, Y. N. Jo, Y. J. Kim, N. S. Choi, K. T. Lee, Chem. Comm. 51(2015) 50-53.