Microwave-assisted synthesis of SnS and SnS/MWCNT anodes for sodium-ion batteries

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Sodium ion battery system is based on the migration of sodium ions through the electrolyte between the anode and cathode structures. This mechanism is analogues to that of a lithium ion battery system due to the similar physical and chemical properties of lithium and sodium metal as is well- known. Sodium ion battery system stands out because of the abundance and parallely cost advantage of sodium. Hence, the availability of various battery systems will be able to support the utilisation of renewable energy as well as powering mobile systems, including electric vehicles [1].

Several anode candidates have been studied in order to develop the sodium ion battery system with the highest accessible energy density. The following criteria are significant for designing anode materials: i) cheap and abundant starting materials; ii) lower redox potentials and stable working potentials; iii) high sodium storage capability; iv) high initial coulombic efficiency. Consequently, the hard carbon anode is the most powerful anode candidate for commercial SIBs due to its low redox potentials, high sodium storage capacity, and stable cycle life [2]. However, despite the intense study of hard carbon anodes, their theoretical capacity is around 300 mAh·g^{-1} and their initial coulombic efficiency ranges from 20–90% [3]. To overcome these challenges, other candidates have also been investigated. Among these, tin (Sn) and tin disulphide (SnS) have a relatively high specific capacity against sodium metal (Sn: 847 mAh·g^{-1}, SnS: 1022 mAh·g^{-1}) [4, 5]. Despite their high theoretical capacity, pulverisation occurs during the charge/discharge process due to volume expansion.

Herein, SnS and SnS/MWCNT anodes were synthesised via a microwave-assisted method in a short time of around 45 minutes. The influence of the microwave reaction time and the amount of MWCNTs added on the electrochemical performance of SnS and SnS/MWCNT anode samples for sodium ion batteries was investigated. Based on the test results, reaction durations of 15, 30 and 45 minutes were investigated and 45 minutes was determined to be sufficient for the intended outcome. Following this finding, the amount of MWCNTs was optimised. The results were evaluated in terms of reaction time, capacity retention and initial coulombic efficiency values. **Figure 1** depicts the discharge capacity results for all samples.

Looking at the galvanostatic charge/discharge test results, SnS-1 and SnS-2 samples which are synthesized by 15 min and 30 min., respectively, showed poor cycling performance and the capacity decreased rapidly. SnS-3 sample provided the more stable cycling performance and its capacity was 200 mAh·g^{-1} at 100th cycle.

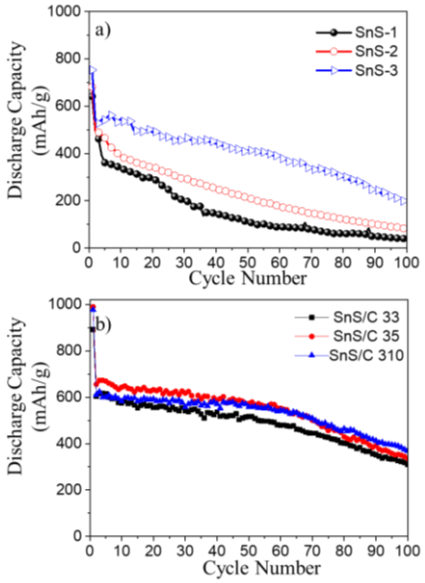

Figure 1. Discharge capacity comparison of the a) SnS-1 (15min), SnS-2 (30 min), SnS-3 (45 min), b) SnS/C 33 (3mg MWCNT addition), SnS/C 35 (5mg MWCNT addition), SnS/C 310 (10 mg MWCNT addition) at 36 mA·g^{-1} current density. Electrolyte: 1M $NaClO_4$ in PC- 5% FEC, Binder : Na-alginate.

To improve the capacity, MWCNT was added by certain amount varying with 3 mg, 5mg and 10mg to SnS-3 sample. MWCNT addition enhanced the obtained capacity due to the inreased electrical conductivity and surface area. Although the SnS/C-310 sample exhibited the highest capacity, its intial colombic efficiency was relatively low at 57 % . Thus, taking into consideration of initial colombic efficiency, the SnS/C-35 sample, with a values of 60 %, was regarded as the best performing sample overall.

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