Microemulsion Synthesis of Tin oxide–Graphite Nanocomposites as Li-ion Battery Anodes

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Introduction

Sn-based Li storage materials are most noted for their high specific capacities either on the weight or volume basis. However, the large volume expansion and contraction problem in cycling is the major cause of material failure in applications. [1-2] Recent work has shown that a uniform dispersion of SnO_2 on carbonaceous materials can reduce the rapid capacity fading to some extent.[3] Here we report the synthesis of nanoscale SnO_2-graphite composites using a reverse microemulsion method and Tergitol 15-S-5 as the surfactant; followed by the evaluation of their electrochemical properties of interest to Li ion battery applications.

Experimental

Two water-in-oil reverse microemulsions using heptane as the oil phase and Tergitol 15-S-5 as the surfactant, were prepared. $SnCl_4$ and NH_4OH were dissolved in the aqueous phase of microemulsion 1 and microemulsion 2 respectively. The two microemulsions, and graphite powder were then mixed together and stirred. SnO_2-graphite composites were obtained after the mixture was evaporated to dryness and calcined at 600°C. 80 wt% of the composite, 10 wt% each of carbon black and polyvinylidene fluoride were used to formulate the working electrodes in two-electrode Li test cells. All cells were charged and discharged at 0.4 mA/cm^2 between 2V and 5mV on a Maccor Series 2000 battery tester.

Results and discussion

The particle size of the as-synthesized hydrous SnO_2 was between 15 and 20nm as shown in the TEM image of Fig. 1. Fig 1 also includes the SEM image of a composite containing 16.5wt% SnO_2 and shows that the SnO_2 nanoparticles were fairly uniformly distributed on the graphite surface. The electrochemical performance of pristine SnO_2 and three microemulsion-derived SnO_2–graphite composites (4.0wt%, 9.8 wt% and 16.5wt% of SnO_2 respectively) are compared in Fig. 2. For the composites with 4.0wt% and 9.8wt% of SnO_2, the first cycle specific capacities of 342 mAh/g and 384 mAh/g respectively only decreased by about 4% in 30 cycles. Although the 16.5wt% SnO_2 sample had the highest specific capacity (428 mAh /g), it also exhibited more pronounced capacity fading with 10% of the initial capacity lost in 30 cycles. There were therefore increasing ease and extent of SnO_2 agglomeration in composites higher in tin oxide contents.

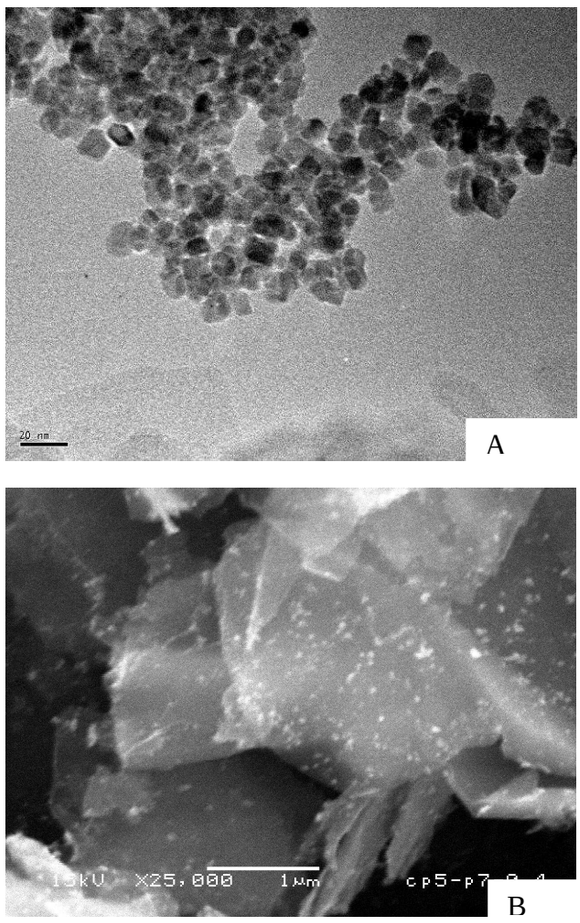

Fig.1 TEM image of (A) SnO_2 and SEM image of (B) composites (SnO_2 16.5wt%)

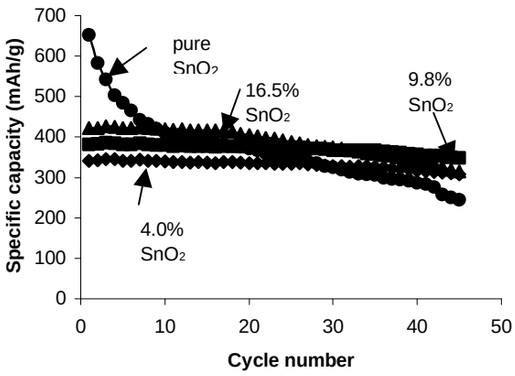

Fig.2 Cyclability of SnO_2 and various nanocomposites

References
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[3] J. Y. Lee, R. F. Zhang, and Z. L. Liu, Electrochem. Solid-State lett, **3**, 167 (2000).