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Multi-component hollow nanostructure endows tin dioxide with outstanding lithium storage performance

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ABSTRACT

Herein, the huge volume variation and poor conductivity issues of SnO_2 incurred are well addressed by fabrication of a TiO_2@SnO_2@C hollow nanosphere composite (TiO_2@SnO_2@C HS) with a satisfying synergistic effect of component and structure. As a result, the as-fabricated TiO_2@SnO_2@C HS presents excellent lithium storage performance, delivering high capacities of 937.5 and 605.7 mAh g^{-1} at 200 and 1000 mA g^{-1} after 250 and even 1000 cycles, respectively. The facile fabrication process and excellent lithium storage performance may make this TiO_2@SnO_2@C HS a promising candidate for advanced lithium-ion battery anode materials.

1. Introduction

Currently, with high theoretical capacity and improved safety, SnO_2 is deemed to be one of the most promising candidates for replacing the graphite anode to meet the demand of next generation lithium-ion batteries (LIBs) for high capacity and safety [1,2]. But, the practical application of SnO_2 in LIBs is blocked by its intrinsic problems of huge volume change and poor conductivity which lead to poor cycling and rate performances of batteries. It is commonly suggested that compositing SnO_2 with carbon or composite matrixes consisting of carbon and TiO_2 by a rational way can effectively improve SnO_2 performance owing to the synergistic effects of multiple components [3–10]. Additionally, hollow structure is also considered to be beneficial to improve the SnO_2 performance by virtue of the sufficient hollow free space and larger surface area. Therefore, preparation of hollow nanostructure of TiO_2/SnO_2/C composites is an effective strategy for improving the performance of SnO_2 materials. However, the conventional preparation process of hollow nanostructure of TiO_2/SnO_2/C composites is tedious, as shown in Fig. 1. So, it is still a challenge to obtain a satisfying TiO_2/SnO_2/C composite.

Herein, we have successfully prepared an interestingly hollow nanospherical TiO_2/SnO_2/C composite by an elaborate facile approach, as shown in Fig. 1. Compared to the conventional strategies [11–13], our strategy exhibits more facile nature. Besides, we have demonstrated that this particular architecture endows the as-fabricated composite with outstanding lithium storage.

2. Experimental section

2.1. Preparation of TiO_2@SnO_2@C HS

TiO_2 nanosphere precursor was prepared according to our previous work [14]. Then, 0.1 g TiO_2 was dispersed in 140 ml mixture composed of ethanol and deionized water (volume ratio of 1:1) by ultrasound. After that, 0.4 g hexadecyltrimethyl ammonium bromide, 1.5 ml ammonium hydroxide, and 0.1 ml tetraethyl orthosilicate were continuously added into above mixture. After stirring for 4 h, the as-prepared TiO_2/SiO_2 composite was gathered by centrifugation, washed with ethanol and deionized water, and dried at 70 °C overnight. Ultrasonic dispersion of 0.1 g TiO_2/SiO_2 into 60 ml deionized water containing 1.2 g glucose, and then addition of 0.2 g stannous chloride dehydrate and 0.044 g ammonium fluoride in 30 min interval under stirring. After that, the suspension was transferred into a stainless steel autoclave with Teflon-liner and put into an oven at 180 °C for 24 h. After the autoclave naturally cooled down to room temperature, the collection of precipitated TiO_2/SnO_2/polysaccharide composite was the same as TiO_2/SiO_2. After further carbonization of TiO_2/SnO_2/polysaccharide under Ar atmosphere at 500 °C for 3 h, the TiO_2@SnO_2@C HS was obtained.

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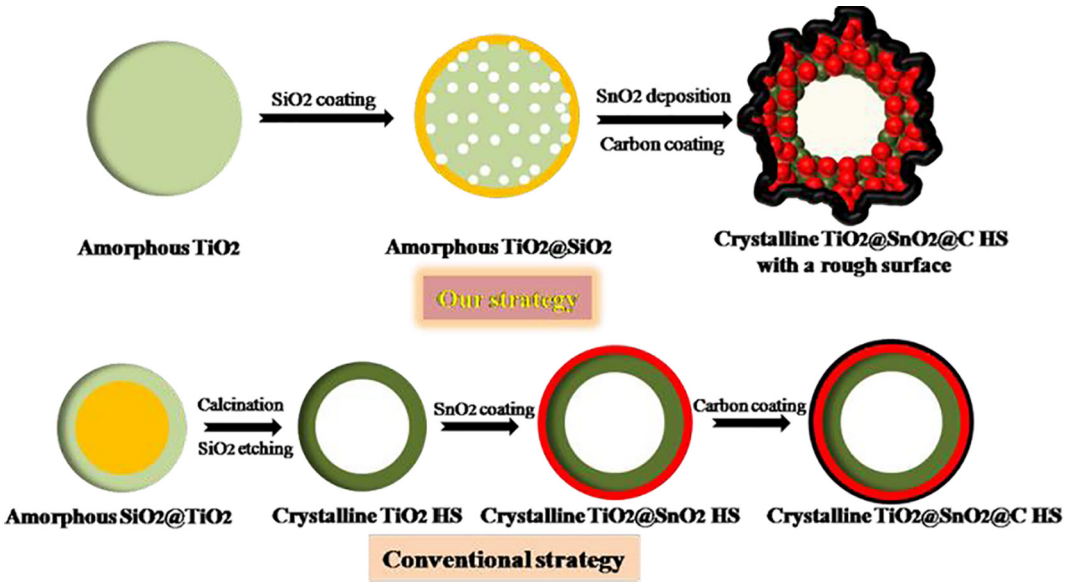

Fig. 1. The preparation schematic of TiO_2@SnO_2@C HS.

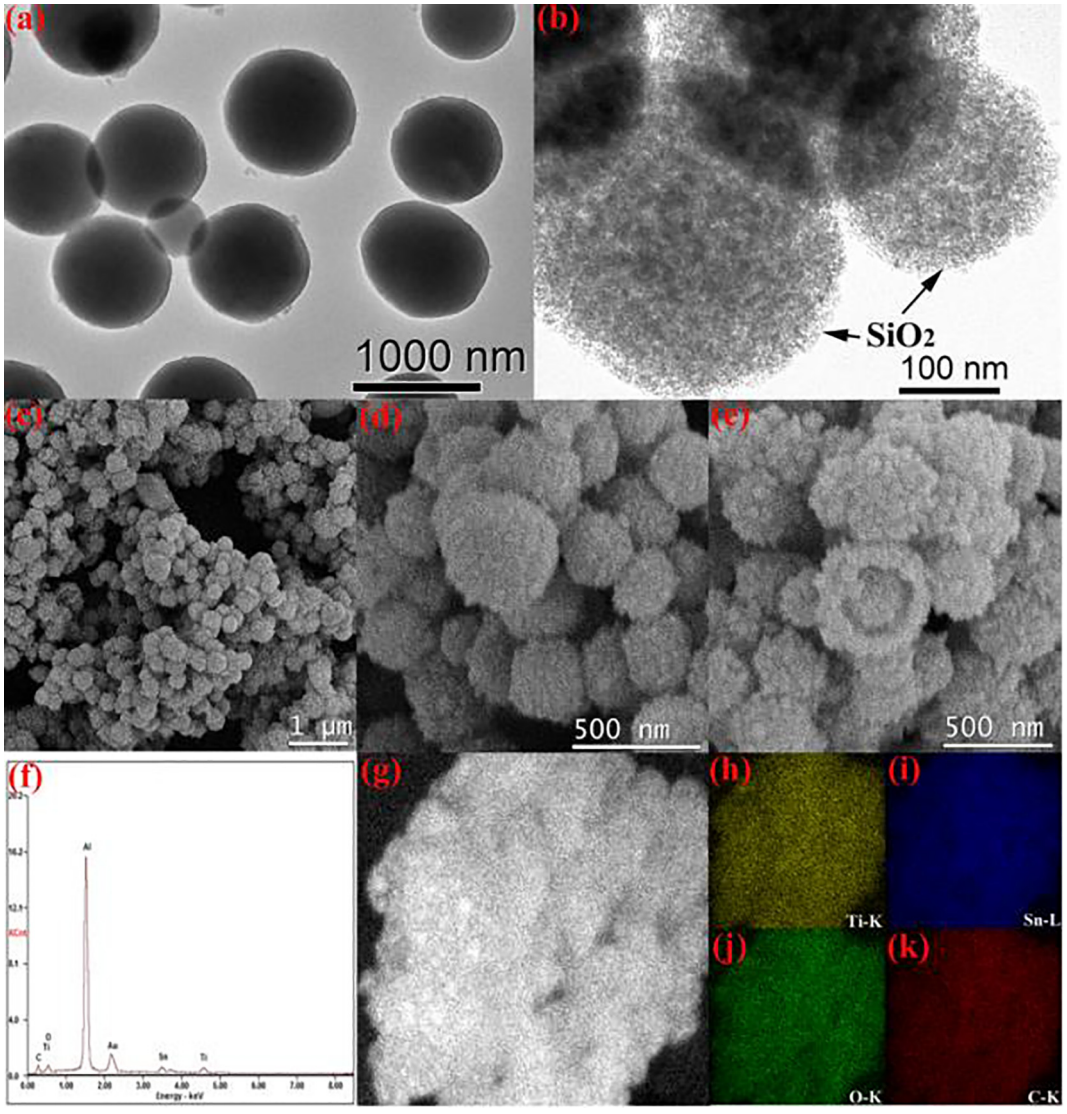

Fig. 2. TEM images of (a) TiO_2 and (b) TiO_2/SiO_2; (c–e) SEM images, (f) EDX spectrum and (h-k) EDX elemental mappings of TiO_2@SnO_2@C HS.