Supporting information

Solar synthesized tin oxide nanoparticles dispersed graphene wrapped carbon nanotubes as Li ion battery anode material with improved stability

Madhumita Sahoo and S Ramaprabhu*

Alternative Energy and Nanotechnology Laboratory (AENL)
Nano-Functional Materials and Technology Centre (NFMTC)
Department of Physics
IIT Madras, Chennai-600036
*Mail id: ramp@iitm.ac.in

1. Synthesis of MWNT

A measured quantity of mischmetal based alloy hydride catalyst was spread uniformly over a quartz boat and placed inside a quartz tube accommodated in a furnace. Ar gas was allowed to flow in room temperature for some time to establish the inert atmosphere inside. The temperature of the furnace was raised to 500 °C in Ar atmosphere and H_2 was allowed for 30 minute. Reducing gas was stopped and temperature was raised to 700 °C. Carbon precursor, C_2H_2 gas was allowed with optimized flow rate in this temperature for 30 min. Furnace was switched off after the optimized time reaction and the system was allowed to cool to room temperature under Ar flow. The as-grown carbon nanotubes were collected and labeled as as-grown MWNT (AG-MWNT). They contain impurities such as amorphous carbon and the metal catalyst particles. AG-MWNT was heated at 400 °C in air atmosphere for 2 h to remove the amorphous carbon impurities followed by refluxing in concentrated nitric acid (HNO_3; Fisher Scientific) at 60 °C for 24 h to dissolve away the metal catalyst present in the system. The final solution was washed

with D.I. water until pH 7, filtered and dried at 60 °C in vacuum oven. The dried sample was stored with the level of purified MWNT (MWNT).

2. Synthesis of gC

Graphene wrapped carbon nanotubes (gC) were synthesized in a customized catalyst assisted chemical vapor deposition technique as reported by us earlier. Alloy hydride used in the earlier process was used as the MWNT growth catalyst and graphite oxide (GO), prepared by modified Hummer's method was employed as the graphene precursor.

2.1. Synthesis of GO

2 g of graphite (Aldrich; 99.99 %; 45 μm maximum particle size) powder was added to 46 ml concentrated H_2SO_4 (Merck) under continuous stirring in an ice bath. After some stirring and mixing, 1g $NaNO_3$ (Merck) was added to the suspension slowly and further allowed to stir. 6 g of $KMnO_4$ (Merck) was added then to the above mixture suspension and the ice bath was removed. At room temperature, measured amount of water was added to the mixture. The suspension was again diluted with warm water under stirring. 30% H_2O_2 (Merck) was added to the above solution until, the color changed to bright yellow. The suspension was washed thoroughly with DI water (Millipore), filtered and dried in a vacuum oven at 50 °C. The dried sample is labeled as graphite oxide (GO).

2.2 Synthesis of gC

Alloy catalyst and GO were mixed mechanically in an optimized ratio and sprinkled over a quartz boat. The boat was positioned inside a tubular chamber with controlled atmosphere and

temperature. Ar was allowed to maintain the inert atmosphere. The system was heated to 250 °C in hydrogen flow for 30 min., until further increment to 700 °C in acetylene gas flow. Next processes of collecting and purification are the same as MWNT. The final product here was labeled as graphene wrapped carbon nanotubes (gC).

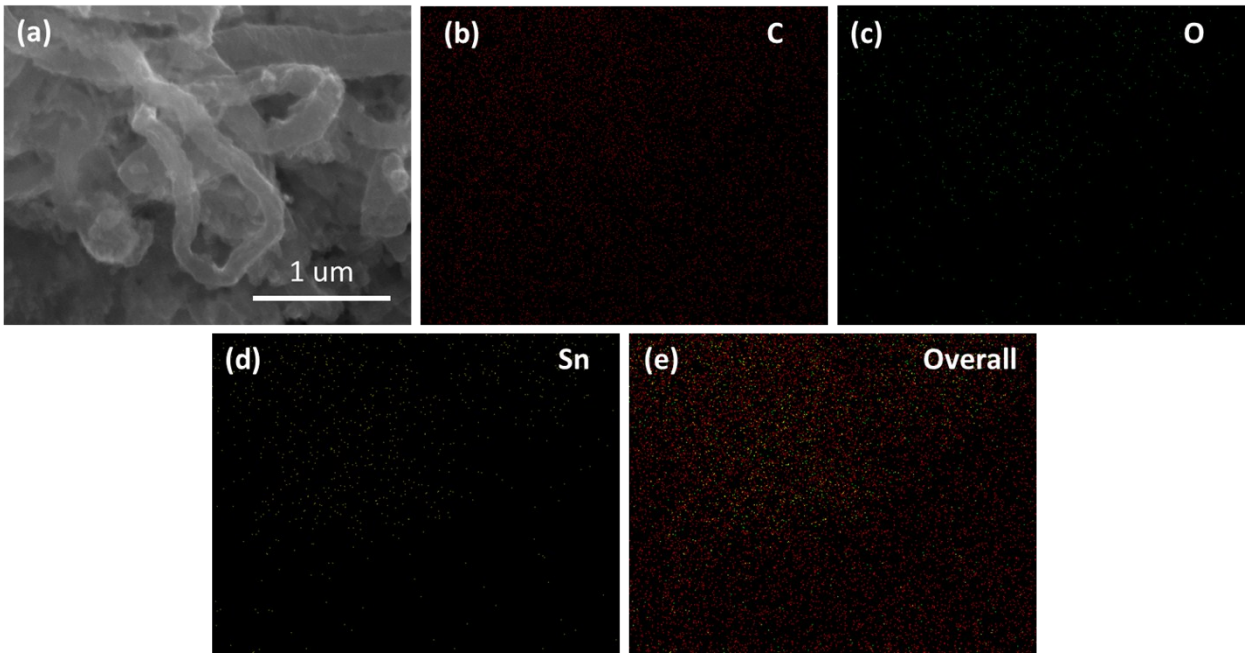

Fig. S1: (a) SEM image and (b-e) elemental mapping of SnO_2/gC.