Superior shuttling of lithium and sodium ions in manganese-doped titania @ functionalized multiwall carbon nanotubes anode

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ABSTRACT

In order to improve the electrochemical kinetics of anatase titania (TiO_2), Mn-doped TiO_2 incorporated with functionalized multiwall carbon nanotubes (MWCNTs) has been prepared by modified hydrothermal method and tested for both lithium (LIBs) and sodium-ion battery (SIBs) anode. The size of TiO_2 particles is controlled to ~35–40 nm, with almost even distribution on the MWCNTs surface. The nanostructuring and appropriate doping of cost-effective manganese into the TiO_2 host improved the electrochemical performance, in terms of high rate capability and specific capacity for both the rechargeable battery systems. For the LIBs, the first cycle charge capacity of 5%Mn-TiO_2/MWCNTs anode is 226.3 mAh g^{-1}, and after 80 cycles is retained to 176.4 mAh g^{-1}, as compared to the SIBs, in which the first cycle charge capacity is 152.1 mAh g^{-1}, and after 80 cycles is retained to 121.4 mAh g^{-1}. After testing the electrodes at a high current rate of 20 C, the nanocomposite electrode can still demonstrate charge capacity of 131.2 and 117.2 mAh g^{-1} under 0.1 C rate for LIBs and SIBs, respectively. The incorporation of Mn-ions (2+, 4+) is found to play a crucial role in terms of defects and vacancy creation, increasing conduction band electrons and lattice expansion to facilitate alkali metal ion diffusion for superior electrochemical performance. The combination of heteroatom doping, and use of a highly conductive additive in the form of MWCNTs has resulted in excellent electrode integrity, high ion accessibility, and fast electron transport. The outstanding cycling stability and remarkable rate performance make 5%Mn-TiO_2/MWCNTs a promising anode material for high-performance LIBs and SIBs.

KEYWORDS: Lithium-ion battery; Sodium-ion battery; TiO_2; MWCNTs; Anode; Doping