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Rational design of 1D mesoporous MnO@C nanorods as anode material for improved Li-storage properties

As the rapid emerging of portable intelligent products and electromobile, lithium ion batteries (LIBs) have become the leading force of energy storage devices, due to its miniature and portability, high energy density, high working potential (~ 3.7 V) and long life span.[1],[2] As an anode material for commercial LIBs, graphite has not met the demand of energy storage market owing to its low specific capacity (372.0 mA h g^{-1}) and inferior rate capability.[3],[4] Accordingly, it is of utmost urgency to develop an advanced anode material for LIBs application. Transition metal oxides (TMOs), owing to their high theoretical capacity and abundant resources, have attracted many researchers' attentions. Among them, MnO has been considered as promising anode candidate because of cost-effective, abundant resources and low reduction potential (~ 0.3 V vs. Li^+/Li).[5] However, MnO still have not escaped from intrinsic disadvantages, which are low electrical conductivity and large volumetric expansion during the charge-discharge processes. In order to address these challenges, we adopt in situ carbon coating method to synthesize 1D mesoporous MnO@C nanorods via a solvothermal reaction coupled with subsequent thermal treatment. In the preparation process, the homogeneous in situ carbon coating has been realized, and the diameter and pore size of nanorods are well regulated because of the solvent effect. According to different volume ratio of H_2O and isopropanol (IPA) in solvothermal reaction, the resultants are named as MnO@C-1 (the mixture: 40 ml IPA), MnO@C-2 (the mixture: 20 ml IPA and 20 ml H_2O) and MnO@C-3 (the mixture: 40 ml H_2O). As an anode for LIBs, MnO@C-3 displays remarkable excellent rate capability (1202.6 mA h g^{-1} at 0.1 A g^{-1} and 1085.7 mA h g^{-1} at 2.0 A g^{-1} with the capacity retention of 90.3%). This fantastic improvement of electrochemical performances benefits from the synergistic effect of well-designed structure characteristics. Firstly, lots of carbon coating nanoparticles gather into 1D nanorods and form a large conductive network, which can immensely enhance material conductivity. Secondly, mesoporous structure can effectively remit the volume expansion and increase the contact area of electrode/electrolyte, contributing to lithiation and delithiation. These characteristics improve transfer efficiency of ion/electron during the charge-discharge processes, greatly upgrading rate capability.

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References

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Figures

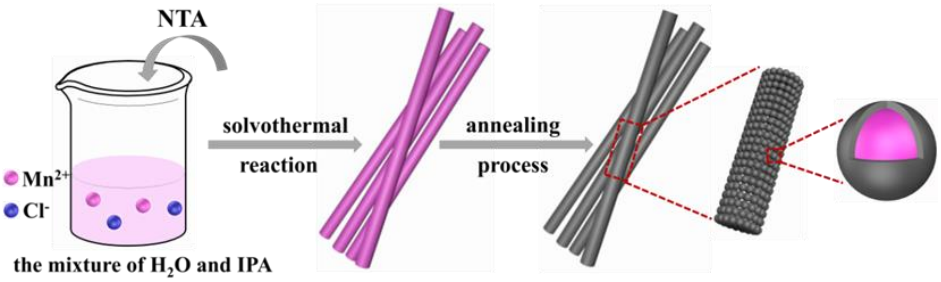

Figure 1: The schematic illustration of preparation process for 1D mesoporous MnO@C nanorods.

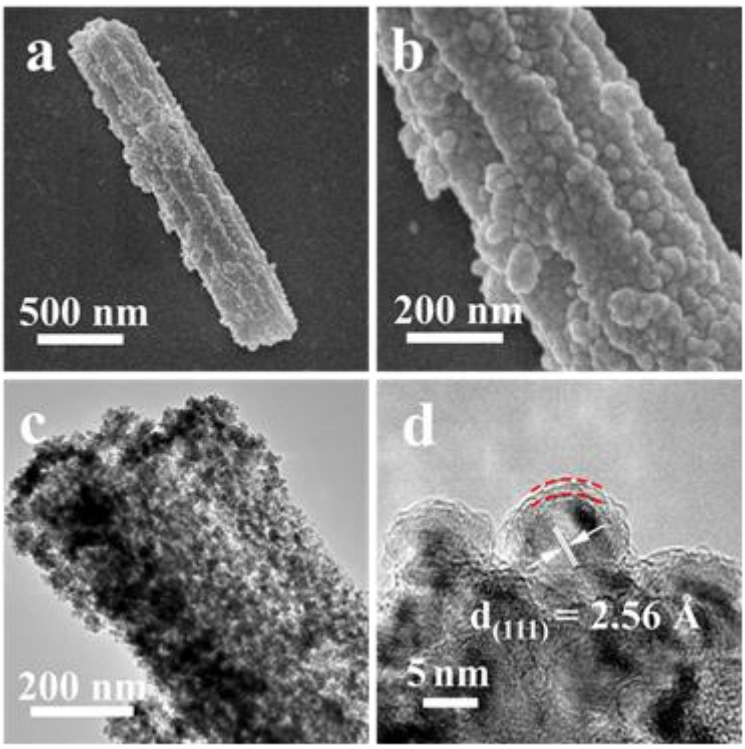

Figure 2: (a-b) SEM images, (c) TEM image and (d) HR-TEM image of MnO@C-3.

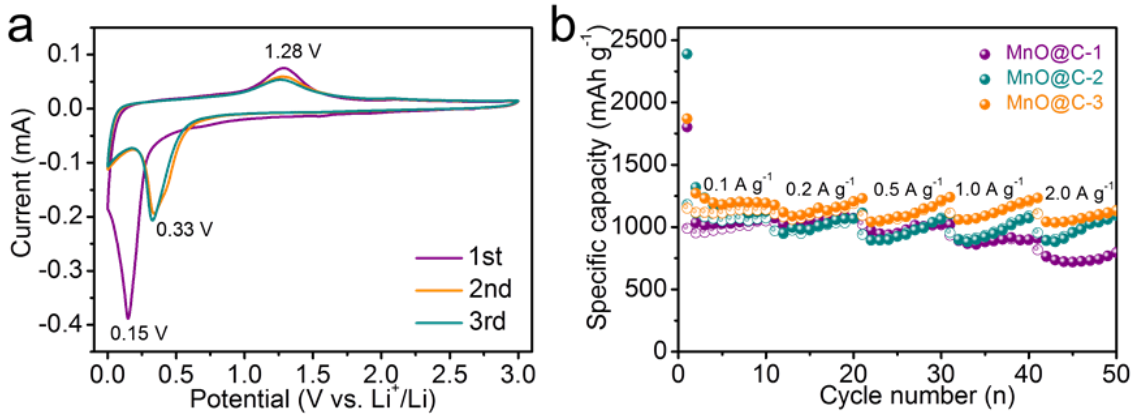

Figure 3: (a) CV curves with the potential of 0-3 V at the scan rate of 0.1 mV s^{-1} for MnO@C-3. (b) The rate capabilities of MnO@C-1, MnO@C-2 and MnO@C-3.