Microwave Synthesis and Characterization of Mesoporous SnO_2 as Anode Material for Lithium-Ion Batteries

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Lithium-ion batteries are state of the art in battery technology for mobile applications, because of their high-energy density, longer lifespan and more flexible cyclability in comparison to other battery technologies. Despite the performance, there is still much room for improvement in the fields of safety and sustainability.

SnO_2 is a good candidate for future anode materials due to its high theoretical capacity (790 $mAh \cdot g^{-1}$) [1], the lithium uptake and release at a potential of ≈ 0.6 V vs. Li/Li^+ and because of its economical as well as its environmental applicability. The main disadvantage of SnO_2, however, is the large volume expansion-contraction during cycling, which can reach up to 358 % [2]. The expansion/contraction problem can be overcome using SnO_2 with structurally ordered mesoporosity. The mesoporous structure minimizes the diffusion length for the Li^+-ions, the large surface area offers a huge number of active sites for Li^+-insertion and the porous structure can buffer the volume effects, thus increasing the thermal and mechanical stability of the electrode material.

In this study, we could reduce the synthesis time from hours to several minutes by using a microwave setup instead of a conventional hydrothermal synthesis. In the presence of sodium dodecyl sulfate (SDS) with $SnCl_4 \cdot 5H_2O$ high surface areas of up to 196 $m^2 \cdot g^{-1}$ and ordered 3 nm wide *meso*-pores, as deduced from N_2 sorption isotherms (Fig. 1), were obtained.

For electrochemical characterization, electrodes were prepared by mixing mesoporous SnO_2, carbon black as conductive additive, carboxymethyl cellulose as binder and water as solvent. The electrodes were assembled in a Swagelok® t-cell with lithium-metal counter electrodes and 1 M $LiPF_6$ in 1:1 v/v ethylene carbonate/dimethylcarbonate as electrolyte.

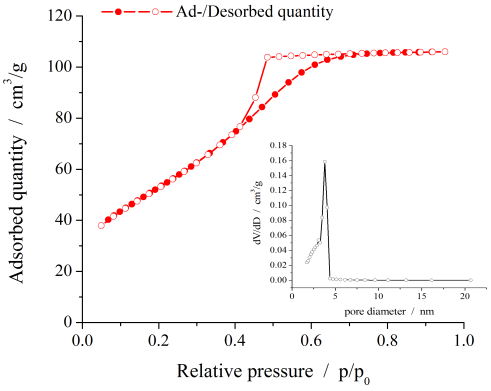

Figure 1: N_2 isotherm of mesoporous SnO_2 from microwave-assisted synthesis in presence of sodium dodecyl sulfate as SDA (inset: pore distribution).

[1] SnO_2 and TiO_2 Nanosheets for Lithium-Ion Batteries, J. S. Chen, X. W. Lou, Mater. Today 15 (2012) 246.

[2] Thin-Film Crystalline SnO_2-Lithium Electrodes, T. Brousse, R. Retoux, U. Herterich, D. M. Schleich, J. Electrochem. Soc. 145 (1998) 1.