Tayloring of morphology, dimensions and magnetic properties of α-MnO2 nanoparticles by the change of reaction parameters

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We have controlled the diameter and length of MnO_2 nanorods through the selective regulation of the reaction temperature, reaction time and concentration of KMnO4 in the reaction mixture. MnO_2 nanorods have been synthesized with high yields (figure 1a) by the reduction of $KMnO_4$ in the acidic environment under hydrothermal conditions. According to the XRD all the present materials have commonly crystallized with α-MnO_2-type structure.

It has been found out that a concentration of $KMnO_4$ in the reaction mixture has the highest impact on the diameter and length of α-MnO_2 nanorods mainly due to the increased pressure in the reaction vessel. When the number of mmols of $KMnO_4$ has been increased from 1.6 to 6 mmols the average diameter decreased from 35 to 20 nm while the range of nanorods lengths has also been reduced significantly. The length of nanorods on the other hand can also be successfully regulated with the reaction time. MnO_2 is not stable in the acidic environment and it is further reduced to Mn^{2+}. With prolongation of reaction time from 6 to 24 h the average length was reduced from approximately 2 to 1 μm.

Recently we have found out that the presence of Fe^{3+}(aq) ions in the reaction mixture triggers the growth of α-MnO_2 nanotubes (figure 2) [1] instead of nanorods. Here we show that the concentration of Fe^{3+}(aq) ions in the reaction mixture has affected the transition temperature in α-MnO_2 nanotubes (figure 1b). With the increased concentration the transition temperature increased from 14.4 to 16.4 K (figure 2). At the same time also the Pauli-like temperature independent contribution to the magnetic susceptibility increased. The results show that Fe^{3+} ions have an intrinsic effect on the electronic structure of α-MnO_2 nanotubes.

References:

[1] Umek P, Gloter A, Pregelj M, Dominko R, Jagodič M, Jagličić , Zimina A, Brzhezinskaya M, Potočnik A, Filipić C, Levstik A, and Arčon D; *J. Phys. Chem C*, 113 (2009), 14798–14803.

Figures:

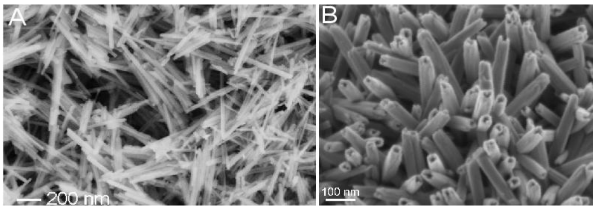

Figure 1. FE-SEM images of α-MnO_2 (a) nanorods and (b) nanotubes.

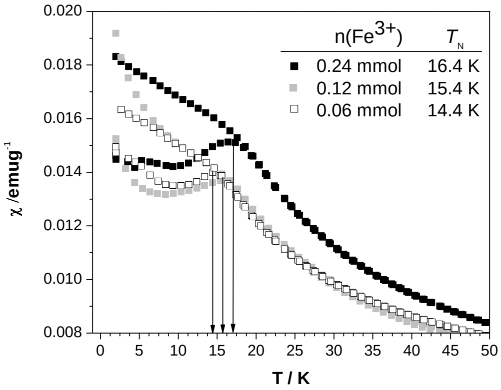

Figure 2. Temperature dependence magnetic susceptibility, χ, for α-MnO_2 nanotubes doped with different amount of Fe^{3+}.