In-situ carbon coating of flame made $LiMn_2O_4$ nano-particles for batteries

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Mobile, safe and non-toxic energy storage with higher specific energy and power is demanded for evolving devices. Rechargeable Li-ion batteries with nanosized $LiMn_2O_4$ as active cathode material can fulfil these requirements (Shen *et al.*, 2001). The capacity fading, however, by material decomposition (Amine *et al*., 2004) currently limits its life cycle. Its carbon coating can prevent the Mn-ion dissolution into the electrolyte (Han *et al.*, 2007).

Here, a fast and single-step synthesis method to continuously produce carbon coated nano-$LiMn_2O_4$ is presented (Ernst *et al*. 2008). Figure 1 shows the setup that can be divided into an oxygen rich particle formation zone in the bottom and an oxygen lean coating zone at the top, after acetylene injection. In the oxygen rich zone a flame spray pyrolysis (FSP) unit produces core $LiMn_2O_4$ particles (Ernst *et al*. 2007) which are in-situ coated upstream in the tube with carbon black by partially oxidizing acetylene. Enclosing the FSP reactor is needed to precisely control the oxygen content otherwise no carbon black can be formed because of air entrainment form the turbulent FSP flame (Ernst *et al*. 2008). To avoid post combustion of carbon the hot off-gas is cooled with nitrogen quench gas. The coated particles were collected on a glass-fibre (GF) filter with the aid of a vacuum pump.

The resulting powders were analyzed by XRD, BET, TGA and TEM. Multiple phases of Li-Mn-O were detected by XRD ($LiMn_2O_4$, $LiMnO_2$, Mn_3O_4 and MnO) as a result of $LiMn_2O_4$ reduction in the presence of acetylene at elevated temperatures whereby the degree of reduction could be controlled by the length of the coating zone. Particles with d_{BET} of approximately 50 nm and a coating-layer thickness of 5 to 15 nm (evaluated from TEM images) were produced.

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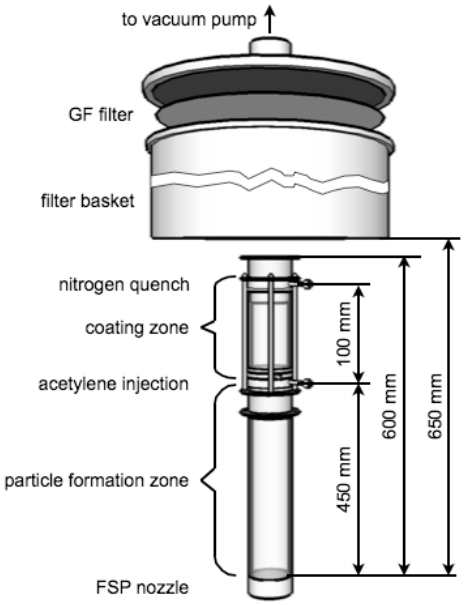

Figure 1. FSP setup for single-step synthesis of CB coated Li-Mn-O nano particles.

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