Fabrication and performance of $Li_4Ti_5O_{12}$/C Li-ion battery electrodes using combined double flame spray pyrolysis and lamination technique

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Rechargeable lithium-ion batteries (LIBs) are known for their high energy and power densities, high efficiency and long cycle life, making this battery type the power source of choice for the electronic consumer market. A major factor currently hampering the success of LIBs, determined for electromobility and stationary energy storage devices, is their high production cost per kWh. Innovations and optimizations in production, process and automation engineering of large-scale LIB production lines are of particular importance to enhance the cost efficiency. The current industrial LIB production route consists of three major steps, (1) slurry-based electrode preparation (2) cell assembly and (3) formation and aging, of which especially electrode manufacturing is highly complex and labor-intensive.

In the current research, we specifically focus on an alternative electrode fabrication method, called double flame spray pyrolysis and lamination technique (DFSP/lam), to meet the requirements in today's LIB cost efficiency [1]. In-situ carbon coated active materials for the anode side are synthesized using DFSP technique. Physicochemical properties of nanoparticles are determined using powder X-ray diffraction and transmission electron microscopy. Specific carbon characteristics are investigated via thermogravimetric analysis and Raman spectroscopy. The filter-collected composite powder is then immediately laminated onto a conductive substrate in merely one additional step. Using this extraordinarily fast technique, the application of typically used solvents and binders for paste fabrication becomes redundant, giving this method an economic advantage.

Experimental results show that $Li_4Ti_5O_{12}$/C-composite anodes can be successfully prepared using the DFSP/lamination technique, presenting slightly enhanced specific discharge capacities compared to reference electrodes as prepared by conventional slurry-based doctor blading method. Moreover, variations in lamination pressure were detected to play a significant role in electrochemical performance.
By optimizing the material design, i.e. particle size, carbon quality, -quantity and -distribution, as well as electrode design, i.e. porosity and tortuosity, future improvements in capacity retention during extensive cycling are anticipated. Long-term research goal is to assemble a complete all-solid-state LIB cell using electrodes manufactured via DFSP/lam technique.

References:

[1] M. Gockeln, S. Pokhrel, F. Meierhofer, J. Glenneberg, M. Schowalter, A. Rosenauer, U. Fritsching, M. Busse, L. Mädler, R. Kun, J. Power Sources 374 (2018) 97-106.