Influence of drying rate on Li-ion battery anodes

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Introduction

During production of anodes for Li-ion batteries, the particulate active material is dispersed in a solvent together with additives and a polymeric binder. This highly viscous slurry is coated on metallic foils and the solvent is removed by drying. During solidification of the coating, a complex internal structure evolves. An understanding of the correlation between processing conditions and electrode properties is of great interest regarding production costs and improving electrode performance.
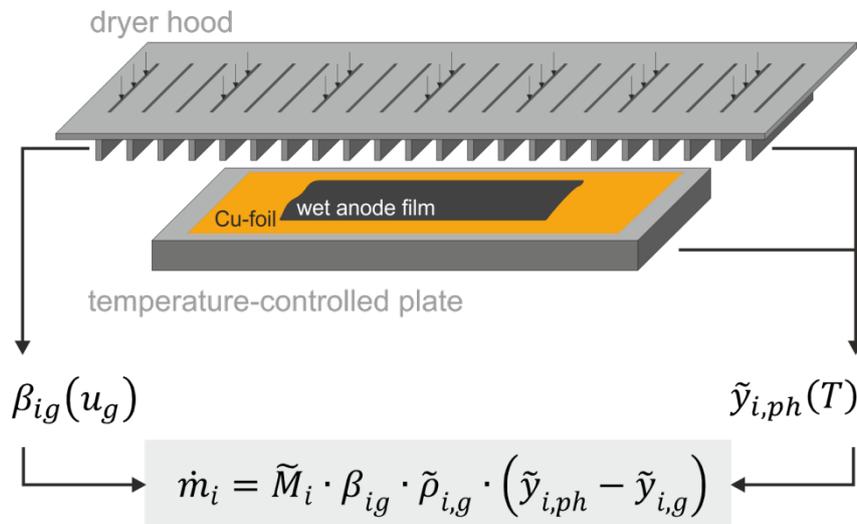
Figure 1: Schematic drawing of the experimental coating and drying set-up consisting of an impingement dryer hood with a moving temperature controlled carrier beneath the dryer. Drying rates $\dot{m}$ were varied by changing mass transfer coefficients $\boldsymbol{\beta_{ig}}$ via nozzle outlet velocity $\boldsymbol{u_g}$ and by changing mole fraction at equilibrium $\tilde{y}_{i,ph}$ via experimental temperature $\boldsymbol{T}$.

The focus of the experiments presented here was on the processing of an anode material system with graphite as active material. Two different binder systems were used: a polymeric binder dissolved in an organic solvent and a latex binder dispersed in water. The electrode slurries were knife-coated on copper foil and dried at highly defined processing conditions in a laboratory set-up by impingement drying. Figure 1

shows a schematic drawing of the experimental coating and drying set-up. Drying rates were varied systematically by changing temperatures and gas phase mass transfer conditions separately. To investigate if calendering is capable of compensating for the drying influence, selected electrodes were subjected to a high level of compression.

Experimental methods and results

Area weight and film thickness were measured and porosity of the electrode coatings was calculated from these values. The influence of drying conditions was characterized by measuring the adhesion of the electrode layer on the metallic substrate in 90°-peel-tests. For adhesion testing, stripes with a width of 30 mm and a coating length of minimum 40 mm were used.
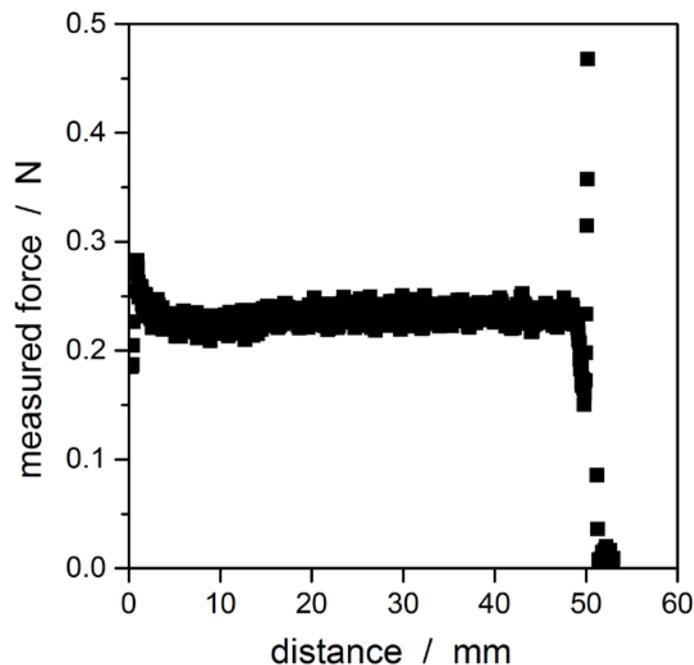
Figure 2: Measured force during peel off for an electrode coating, processed with a latex binder dispersed in water.

Adhesion force was calculated by averaging the necessary force for peel off (Figure 2) and dividing it by the sample width. The drying rate was determined as the dominant factor influencing adhesion force. At higher drying rates, the adhesion is decreased for both binder systems. The dependency of electrode adhesion on drying conditions is attributed to differences in binder distribution over film height. Peel tests with calendered and non-calendered electrodes show that calendering increases the electrode adhesion, but had no influence on the observed trend.

For comparison of the two different binder systems, the coatings were dried within the same range of drying rates. A greater drying rate dependency was observed for the system with dissolved polymeric binder.

Acknowledgements