Characteristic drying stages and their impact on film morphology during drying of particulate electrode coatings

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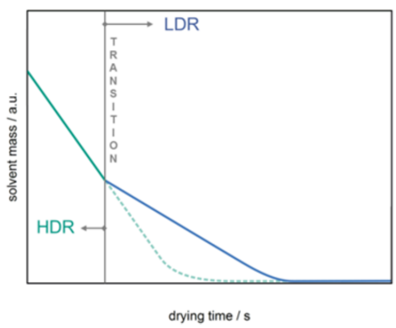
Particulate coatings are widely spread in a multitude of applications ranging from paper to battery coatings. Although the paramount importance of the drying step for film properties is well known[1], experimental drying processes are prevalently based on empirical parameter studies rather than a sound scientific understanding. Particularly, the impact on film solidification and component distribution has received very little scholarly attention in the field of battery coatings. Even though various models exist, especially for paper coatings[2] and latex dispersions[3,4,5], their applicability to battery coatings has not yet been sufficiently examined.

In this work, electrode slurries were applied on a copper substrate and dried isothermally and homogeneously under well-defined boundary conditions in a unique and optimized impingement drying set-up. The drying rates adjusted by the film temperature and the mass transfer coefficient fell within the range applied in industrial drying processes thereby providing valuable results for both academia and production. The experimental approach developed in this work allows for the identification of critical drying stages, in which, for instance, binder migration occurs. Binder migration is an undesired effect in Li-ion battery electrodes that can be particularly observed at high drying rates. Initiating the drying either at a low or high drying rate, an instantaneous transition to a high/low drying rate was carried out after defined drying times. The high drying rate triggers binder migration towards the free surface, while a low drying rate results in a less accentuated binder distribution. The resulting curves of the experimental approach at hand allowed for the revelation of characteristic film states on the basis of the dry films' properties. In extensive studies, the adhesive force, which served as an indirect measure for the binder concentration at the copper/film interface, was determined for the prepared specimen by conducting 90° peel tests. The binder concentration at the film surface as well as the copper/film interface of delaminated films was characterized using energy dispersive X-ray spectroscopy (EDX). Experimental drying curves that show a markedly constant rate period down to mass loadings of less than 10% were incorporated, thereby providing a link between drying time and solvent volume fraction. The known volume fractions during drying allowed for linking the drying conditions with the film state (Figure 1 – Illustration of the experimental approach: the drying rate is altered after defined drying times (*left*); decrease in adhesive force for various transition times).



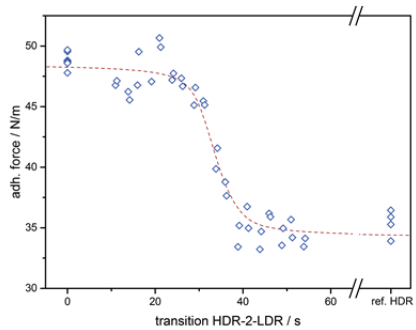


Figure 1 – Illustration of the experimental approach: the drying rate is altered after defined drying times (*left*); decrease in adhesive force for various transition times, which were translated into volume fractions by the experimental drying curves (*right*).

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