Capillary Suspensions in Coating Processes for Energy Storage Applications

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In many manufacturing processes for printed electronic components wet film coating plays a central role. The coating of wet layers (thickness: 50 - 200 µm) containing active material particles and several additives suspended in a solvent is a key element in the fabrication process of Lithium ion battery electrodes for instance.

In industrial electrode manufacturing slot-die coating is a well-established method due to high reliability and low production costs. Besides wet film homogeneity, edge contour accuracy has become a very important factor regarding the layer quality requirements. By applying intermittent coating processes several advantages regarding the process costs and product quality of electrodes can be achieved; however the importance of edge contour accuracy increases significantly. Blurred edges and especially superelevations need to be suppressed in order to guarantee for a high electrode layer quality.
Edge contours of coated layers are generally depending on the viscosity and surface tension of the coated fluid. In this presentation we want to discuss the influence of rheological properties on the resulting wet film edge contours which were analyzed applying 2D laser triangulation.

Generally, it was found that contour accuracy increases with increasing viscosity values in the low shear regime.

Furthermore, we introduce capillary suspensions as novel and smart formulation route for suspensions or inks to be used in coating processes [1]. Upon addition of a minor amount (about 1 vol-%) of a secondary liquid to a suspension, immiscible with the primary fluid phase, the low shear viscosity can be increased by more than one order of magnitude [2]. This increase in viscosity is due to the formation of a sample-spanning network composed of capillary bridges connecting particles or particle clusters.

During coating at high shear stresses the capillary network is destroyed leading to high shear viscosities similar to that of corresponding suspensions without added secondary fluid. After coating thin films the sample spanning network recovers quickly. Using capillary suspensions superior edge contours were achieved preventing superelevations and blurred edges (see: Fig. 1).

Furthermore, the added secondary fluid evaporates during drying and does not remain in the coated layer in contrast to conventional rheological additives. This offers the potential of improving the electronic properties of the coated layers, since no additional organic components are needed to control rheology or prevent settling and phase separation.

The effects of rheological properties including thixotropic network recovery, apparent yield stress and high shear viscosity on edge contours in doctor blade and slot-die coating are discussed in detail.

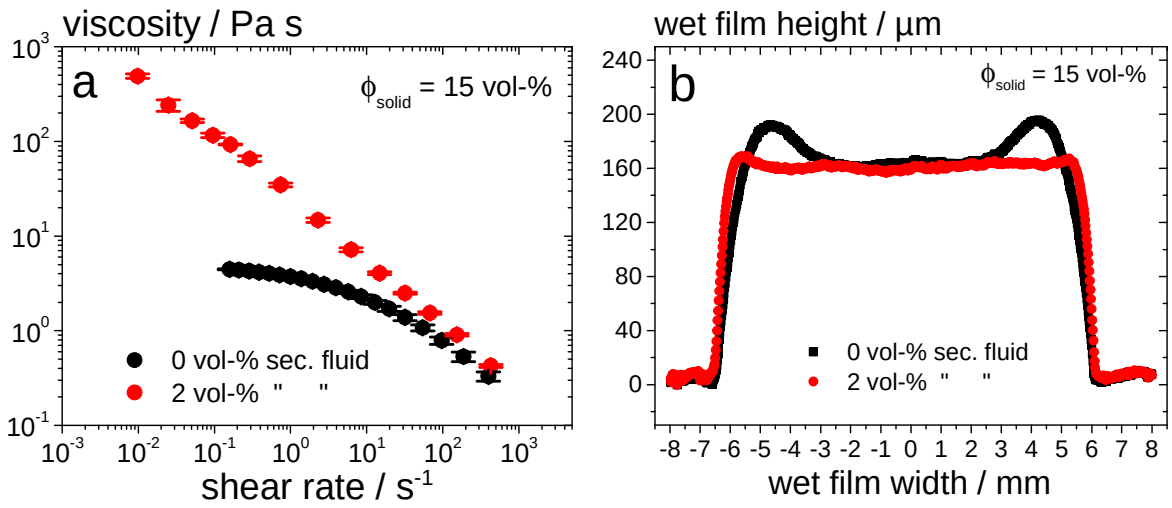

Fig. 1: a) Viscosity data as function of shear rate shown for a conventional suspension and a capillary suspension containing 2vol% of sec. fluid. b) Film contours of corresponding suspensions applying slot-die coating (determined by 2D laser triangulation).

References

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