259h Drying, Film Formation and Particle Coalescence in Polymer Films and Coatings: a Theoretical and Experimental Study

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In the polymer coatings area, maximizing throughput is usually more art than science. This is because of the lack of understanding of the interplay between various processes such as the drying of the coating, particle coalescence and film formation. Numerous screening experiments are needed to determine optimal processing conditions.

In order to speed up such an optimization, we have developed a model that can not only accurately describe the drying of the coating, but can also couple the drying phenomenon to the film formation and – potentially -- mechanical properties of the final product. The drying model consists of a coupled heat and mass transport mechanism which results in a model with four adjustable parameters. The four parameters were obtained as fits to experimental data and subsequently the model was tested for other sample and processing conditions. Clearly the model was shown to accurately describe both the weight loss and the temperature evolution for a variety of cases. The drying model was tested for changing oven temperatures, solids content, initial sample thickness and initial sample density. The model results in each case agreed very well with experimental observations.

The drying model in turn was coupled to a mechanistic model describing particle coalescence. Here we started with the Eckersley-Rudin approach (viscoelastic deformation of particles under capillary pressures) and modified it to incorporate the time dependence of temperature, composition, and viscosity. We looked at the dependence of the “degree of coalescence” of the final film on the preparation conditions and the initial formulation. The model was validated against experimental data (AFM and mechanical testing), and a good qualitative agreement was found.