Study of Bubble Formation Defect in Drying Process

Reza Pourdarvish, Ronald P. Danner, J. Larry Duda
Center for the Study of Polymer Solvent Systems, Department of Chemical Engineering,
The Pennsylvania State University, PA16802
Email: rup100@psu.edu

Abstract

In creating thin films of polymers by solution processing, a common problem is the undesirable formation of bubbles during the drying process. Several strategies can be employed to reduce the level of bubble formation by changing conditions within the dryer or by using different solvents. Practical experience shows that bubbles can be created well below the boiling point of the solvent. Also, it has been observed that the degassing of the polymer solutions result in reduced bubble formation, indicating a relationship between the presence of air and bubble formation. This work is based on a hypothesis that if the solubility of air in the polymer solution increases with solvent concentration, then the solution can become super saturated with air as the concentration of the solvent is reduced during the drying process. To test this hypothesis we have chosen the model system of polyvinyl acetate, toluene and nitrogen. Experimental methods were developed to measure the solubility of nitrogen in the polymer-solvent system as a function of solvent composition and temperature. The group-contribution lattice-fluid equation of state was used to correlate the thermodynamic behavior of the ternary system, utilizing experimental measurements to determine key parameters in the equation of state. In addition, experiments were conducted to measure the diffusion coefficients of the nitrogen and toluene over a range of compositions and temperatures. A free volume model was then used to correlate the diffusivity data so that the diffusional behavior of the ternary system can be predicted over a broad range of conditions. Finally, the thermodynamic and diffusivity correlations were incorporated into a multi-component drying model to predict saturation behavior in the polymer solution during the drying process.