Stress Development-Relaxation in Glassy Polymer Films

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ABSTRACT

During the drying of glassy polymer films, stresses can develop as the coating solidifies from a solution, dispersion, or reactive mixture. In many applications, the growing stresses may become sufficient to overcome cohesive and adhesive strengths, thus adversely affecting coating appearance, functional properties, and performance. In an effort to understand stress behavior and control stress-induced defects in solvent-cast coated films, we developed a simple stress model based on the non-equilibrium structure of glassy polymers. The model uses computed solvent concentration and temperature profiles, describing the dynamics of the drying process, to predict stress evolution in a solvent-cast coated film. We test the validity of the model against experimental stress data reported in the literature for polystyrene films cast from a toluene-based formulation. The results indicate that (i) fundamental understanding of drying-induced glass transition and (ii) its impact on volumetric, transport, and mechanical properties, are critical factors to capture the stress behavior in glassy polymer films. Effects of process conditions, type of solvent, plasticizer content, and coating thickness on stress evolution and the magnitude of residual stresses are also discussed.