Drop Impact experiments: a tool to investigate fast bi-extensional flow of polymeric liquids

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Abstract

The collision of a liquid drop against a small target results in the formation of a thin liquid sheet that extends radially until it reaches a maximum diameter and subsequently recedes. We investigate the corresponding fast bi-extensional flows of high molecular weight homopolymers, and supramolecular living polymer solutions. Both systems exhibit shear thinning behavior. Experiments indicate the presence of two expansion regimes: the capillary regime, where the maximum expansion does not depend on the fluid's zero-shear viscosity, and the viscous regime, where the expansion is reduced with increasing polymer concentration (hence, zero-shear viscosity) due to viscous dissipation. The expansion process is expected to be controlled by a combination of shear (on the target) and biaxial (in air) deformations. We propose an approach toward a rational description of the phenomenon for Newtonian and non-Newtonian fluids by evaluating the viscous dissipation due to shear and extensional deformations, yielding a quantitative prediction of the maximum spreading factor of the sheet as a function of the relevant viscosity. We find that the biaxial viscosity is the appropriate quantity to describe the maximum expansion of both viscoelastic and viscous sheets. For solutions of polymeric thinning fluids, shear dissipation is negligible compared to extensional dissipation.