Degradation of polymers in dilute solutions subjected to jetting flows

S. Formenti[1], B. Keshavarz[2], J. Du[2], G.H. McKinley[2], C. Clasen[1]

[1]KU Leuven, [2]MIT

Complementary to the CaBER technique, the Rayleigh Ohnesorge Jetting Extensional Rheometer (ROJER) is able to probe the extensional response of low-viscous weakly viscoelastic fluids, which are widely encountered in applications such as inkjet printing or spraying. A recent study has also pointed out that the thinning dynamics of weakly viscoelastic jets are governed by a slightly different force balance compared to static capillary bridges. Hence, a scaling of R ∝ exp(-t/2λ) has to be considered to determine the correct relaxation time in case of ROJER experiments, in contrast with the R ∝ exp(-t/3λ) scaling classically employed in CaBER-type experiments. However, experimental results on dilute solutions of high molecular weight flexible polymers show even larger discrepancies between the relaxation times obtained from CaBER and ROJER experiments, which cannot be explained only by considering the different force balances.

This paper introduces an experimental study focussing on a possible reduction of molecular weight due to the high shear rates that polymer chains are subjected to in the jetting nozzle. Choosing high molecular weight dilute solutions suitable for both ROJER and CaBER experiments allows to compare the relaxation times obtained from jetting rheometry with static capillary breakup experiments performed both on fresh solutions and samples recovered after undergoing the jetting process. Systematic changes in the relaxation times are correlated to a decrease in molecular weight in the solutions after jetting as determined through gel permeation chromatography. In particular for the highest molecular weights, relaxation times calculated from ROJER experiments show a significant reduction compared to CaBER experiments on fresh samples, while they match CaBER results obtained on the solutions recovered after jetting. This degradation phenomena will be related to critical stresses experienced in the nozzle as well in the jet.