The interchain pressure effect in elongational flow of polystyrene melts and concentrated solutions

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Based on the Extended Interchain Pressure (EIP) model (Wagner and Rolón-Garrido, 2009), the elongational viscosity data of Bach et al. (2003) and Huang et al. (2013, 2015) on monodisperse polystyrene melts and concentrated polystyrene solutions in oligomeric styrene are analyzed. The EIP model allows a parameter-free modeling of the elongational viscosity of monodisperse polystyrene melts, based exclusively on the linear-viscoelastic relaxation modulus. When the dependence of the interchain tube pressure effect on polymer concentration and molar mass of the oligomeric solvent in the stretch evolution equation is taken into account, agreement of the EIP model is also obtained with the elongational data of polystyrene solutions in the investigated range from 13% to 100% (melt) polymer concentration, based solely on the linear-viscoelastic relaxation modulus, polymer concentration and molar mass of the solvent. The evolution of stretch depends on 3 terms, which are affine deformation, Rouse stretch relaxation, and the interchain pressure term (Marrucci and Ianniruberto, 2004). The relaxation time of the interchain pressure is proportional to the Rouse time of the solution and to the 4th inverse power of an effective polymer concentration, which depends on the molar mass of the solvent. With just 2 equations, a Doi-Edwards-type stress equation and a stretch evolution equation, and without any free nonlinear-viscoelastic parameter, the EIP model predicts in agreement with experimental evidence that at low Weissenberg numbers $Wi_R = \dot{\varepsilon}\tau_R < 1$, melts and solutions show extension thinning behaviors, while at $Wi_R \cong 1$ solutions switch to extensional thickening or show a more or less constant steady-state elongational viscosity η_E, and melts continue with extension thinning behavior with a scaling of approximately $\eta_E \propto Wi_R^{-0.5}$.