A study of binary blends under uniaxial extensional flow: Do polymer melts behave differently from solutions?

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The qualitative difference between polymer melts and solutions in extensional flow is now a well-established phenomenon, while polymer melts show a monotonic thinning behavior for all applied strain rates, polymer solutions exhibit an initial thinning behavior followed by a strong thickening trend. Recently, new relaxation mechanisms such as inter-chain tube pressure or alignment–induced friction reduction, have been proposed to explain this peculiar behavior, which is difficult to comprehend within the framework of a 'standard' tube model.
In this work, we have designed and characterized a specific set of polystyrene blends, where long polystyrene chains are diluted in different short chain matrices of varying molar mass, hence spanning the range from melts to solutions. Interestingly, we see that all blends show different transient hardening behavior but same steady viscosity when stretched beyond their equilibrium length. Thus indicating, that indeed a universal behavior could be achievable in fast non-linear flows.
To realize this universality, we need to identify the right scaling. Hence, a new system is designed where long PS chains are dissolved in an oligomeric styrene at different weight fractions ranging from very concentrated to semi-dilute solutions. Two unique scaling is observed in the linear and non-linear regime respectively, which means a universal behavior in non-linear flow can only be achieved by explicitly normalizing the experimental data in this regime.

The outcome of this work both challenges the current framework of modified tube models and perhaps lays the foundation towards building a much-desired universal model for linear polymers.