Chapter 10 Questions

1. Give examples of the effect of suspending medium viscoelasticity on particle migration.
2. What is the so-called Gleissle scaling for the steady state viscosity curves of filled viscoelastic systems?
3. How do the hydrodynamic interactions between particles affect the dynamic moduli of filled viscoelastic systems?
4. How is strain hardening in uniaxial extensional flow of polymers affected by adding spherical particles?
5. What happens to N_1 when particles are added to a viscoelastic medium?
6. We have a polymer melt that contains particles on which the same polymer has been grafted. How would the low shear viscosity change when the grafting density is systematically increased and the polymer weight of the brush is higher than that of the suspending medium?

Chapter 10 Answers.

1. Viscoelasticity often causes a particle migration opposite for the one caused by inertia in Newtonian media. In planar simple shear flow in dilute systems particles migrate to the nearest wall. In Poiseuille flow particles will migrate towards the central axis. At higher concentration this effect will be reduced. Interaction between particles can also lead to the formation of chains aligned in the flow direction.

2. The primary effect of adding particles on the log-log curve of shear stress versus shear rate is a shift parallel to the shear rate axis. This corresponds to a vertical shift in the log-log viscosity-stress curves. A similar plot of N_1 versus shear stress produces often parallel lines that shift downwards with particle loading, indicating that the scaling factors for N_1 and η differ.

3. Log-log plots of storage and loss moduli for filled polymers are parallel with that of the suspending medium. Hence, the relative moduli (defined by comparing moduli of the filled polymer with that of the pure polymer at the same frequency) are independent of frequency, at least for non-colloidal particles.

4. Particles reduce strain hardening of polymers. This is because the particles distort the local flow field and in general, tend to reduce the amount of extensional stretching of the polymer chains in the suspending medium.

5. N_1 increases when adding particles, at least when compared at the same shear rate. When filled system and pure polymer are compared at the same shear stress, N_1 actually decreases with filler content. The log-log N_1-σ curves for different particle contents are parallel.

6. At low grafting densities the brush does not ensure stability and hence flocculation occurs with the correspondingly high zero shear viscosities. At higher grafting densities stability sets in which leads to a decrease in viscosity. The brush stabilizes the particles as its molecular weight is higher than that for the free polymer such that the brush is wet by the suspending medium. At still higher grafting densities the free polymer does not wet the brush because of autophobic dewetting, thus increasing the viscosity again.