

Chapter 11 Questions

1. What physical information about stress contributions can be obtained from so-called stress jump experiments?
2. What is the basic principle of *passive microrheology*? What is the major advantage in rheology of using passive microrheology and DWS?
3. What are the major advantages of using active rather than passive microrheology? What viscosity is obtained in this type of experiment?
4. What principal dimensionless groups are used when discussing electrorheological fluids and what concepts do they express?
5. Discuss electrostatic interparticle forces for particles at interfaces.
6. What geometries are commonly used in 2D rheometry to measure the surface shear viscosity?

Chapter 11 Answers

1. When the flow is suddenly arrested in a suspension with a non-elastic medium, the hydrodynamic forces also suddenly drop to zero because they are a function of the instantaneous shear rate. The other forces require some structural rearrangements which require a finite amount of time. Hence, if the stress transient can be measured sufficiently fast, the initial instantaneous drop in stress can be distinguished from the subsequent relaxation, thus separating the hydrodynamic from the other stress contributions.
2. In passive microrheology the thermal motion of a tracer particle is measured. Using the generalized Stokes-Einstein relationship (eqn. 11.1), the mean squared displacement of the tracer particle due to Brownian motion can be related directly to the viscoelastic modulus of the medium experienced by the tracker particle. In this manner rheological information about the local environment of the particle can be obtained over a very wide range of time scales.
3. With active microrheology a force is applied to a particle, the resulting motion of which is followed. Applying Stokes' law a viscosity is computed. In this manner forces larger than the Brownian forces can be applied. Hence, systems with larger moduli can be probed. Also, in passive microrheology the probe is in thermal equilibrium with its surrounding and cannot drive it spontaneously out of equilibrium, which limits its response to the linear region. With active microrheology nonlinear behavior can also be analyzed. The viscosity so obtained depends on the local microstructure of the dispersion and the local velocity field, which is not simple shear, thus it is not necessarily identical with the bulk viscosity. Therefore, it is termed *microviscosity*.
4. For non-Brownian particles the electrostatic polarization forces now counteract the hydrodynamic forces due to flow and a dimensionless number can be defined as the ratio between the two. This is called the Mason number:

$$Mn = \eta_m \dot{\gamma} / 2\epsilon_0 \epsilon_m \beta^2 E^2$$

When Brownian motion is also present, an additional group can be defined as the ratio of the characteristic electrostatic energy over the thermal energy:

$$\lambda = \pi \epsilon_0 \epsilon_m \beta^2 E^2 a^3 / 2k_B T$$

5. For particles at an interface between a polar and a non-polar phase the screened Coulomb interaction is still important, as it is generally so in bulk phases. In addition the asymmetry in counterion distribution, because of the presence on the non-polar phase causes a dipole perpendicular to the interfaces, which leads to a long-range repulsion that can force particles to move much further apart than would be the case in a bulk phase. The strength of interaction also becomes a weaker function of the salt concentration than is the case in bulk phases.

6. Possible geometries include a rod which is moved by means of an external magnetic field, a bicone rheometer with its largest diameter located at the interphase, and a double-wall ring rheometer, which corresponds to a double-wall Couette in bulk rheometry.