Dynamic Behavior of Fluid-Fluid Interfaces with a Complex Microstructure

Leonard Sagis [C, S]
Wageningen University, Food Physics Group, Wageningen, Netherlands
leonard.sagis@wur.nl

The surface rheological properties of fluid-fluid interfaces often play an important role in the dynamics of multiphase fluids. They affect the dynamics of emulsions, foam, coatings, biological fluids, free surface flows, or immiscible blends. When the interfaces in these systems have a complex microstructure, their response to an applied deformation tends to be highly nonlinear. The applied deformation induces changes in the microstructure of the interface, which result in shear thinning and thixotropic behavior. Most currently available constitutive models for the surface stress tensor cannot account for this type of highly nonlinear behavior. In this paper we will discuss recent advances in the development of nonlinear constitutive equations for the stress-deformation behavior of fluid-fluid interfaces in the framework of nonequilibrium thermodynamics. As an example we will discuss models for the shear thinning behavior of fluid-fluid interfaces stabilized by anisotropic colloidal particles (relevant for example in Pickering emulsions or Pickering foam), in the context of the classical irreversible thermodynamics (CIT) framework, and the general- equation-for-the-nonequilibrium-reversible-irreversible-coupling (GENERIC) framework. In these models the nonlinear response of the interface to a deformation is introduced through a dependence of the surface stress tensor on a scalar and a tensorial structural variable. We present the time evolution equations for these structural variables, and evaluate the ability of these models to describe shear thinning behavior of an interface in a simple shear field. We find that the CIT model gives realistic predictions only for small departures from equilibrium, whereas the GENERIC framework allows us to create models valid also far from equilibrium.