Shear banding in wormlike micelles

Sandra Lerouge

Department of Physics, Laboratory Matière et Systèmes Complexes, UMR 7057 Université Paris-Diderot/CNRS, 75205 Paris Cedex 13, France

We report on recent progress made on flows of living polymer fluids. Such fluids have been model systems for rheological research for more than twenty years and they continue to be fascinating. Like most if not all soft matter systems, living polymers have mesoscopic structure that can be readily reorganised by a flow. Generally, this structural reorganisation feeds back on the flow itself. Such an interplay between microscopic kinetics and macroscopic kinematics often leads to the emergence of shear-induced structures associated with highly nonlinear rheological behaviours as well as new organisation of the flow field. The shear banding phenomenon where the flow splits into domains bearing different shear rates is the prototypical example of such a flow/structure coupling. It has been observed in a wide range of complex systems but has been very intensively studied in wormlike micelles. In recent years, various tools have been developed to probe locally the flow properties and to provide a two-dimensional description of the flow. In this context, we will discuss the different time scales involved in the kinetics of formation of the shear banding flow following step shear rate and step shear stress. At long times, we will show that the coupling between the flow and the shear-induced structures leads to additional complexity in the flow dynamics due to the emergence of elastic instabilities on top of the shear banding flow. Such a phenomenology is not restricted to simple shear flow but can also be observed using other experimental protocols such as LAOS. The impact of such secondary flow instabilities on structural characterizations will also be discussed. Finally, we will show that elastic and inertio-elastic instabilities are also likely to develop on top of shear-thickening or shear-thinning wormlike micelles.