MAR15-2014-008847

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Shear banding in time dependent flows of polymers and wormlike micelles

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We study theoretically the formation of shear bands in time-dependent flows of polymeric fluids and wormlike micellar surfactant solutions, focussing in particular on the commonly studied experimental protocols of step shear stress and shear startup. For each protocol, we perform a linear stability analysis to provide a fluid-universal criterion (with some caveats in the case of shear startup) for the onset of shear banding (following Moorcroft and Fielding Phys. Rev. Lett. 2013). In each case this criterion depends only on the shape of the experimentally measured rheological response function for that protocol, independent of the constitutive properties of the material in question. In this way our criteria in fact concern all complex fluids and not just the polymeric ones of interest here. (See Fielding Rep. Prog. Phys. 2014 for a study of these effects in a broad class of soft glassy materials including dense emulsions, microgels and dense colloids.) An important prediction is that pronounced shear banding can arise transiently in each of these time-dependent protocols, even in fluids for which the underlying constitutive curve of the material (stress as a function of strain-rate) is monotonic and a steadily flowing state is accordingly unbanded. Further details can be found in Moorcroft and Fielding J. Rheol. 2014.