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Nonlinear rheology of entangled systems: The case of living polymers (micelles) Y. THOMAS HU, Unilever R&D — We have studied shear banding in Couette flow using a combination of particle tracking velocimetry (PTV), small angle light scattering, microscopic visualization, and flow birefringence. Time-resolved local shear rate characterization by PTV has enabled a first direct study of the kinetics of shear banding. A first stage, which precedes banding, is tilting of shear rate during which local shear rate increases towards the inner and decreases towards the outer gap surface. A shear banding stage then proceeds with a low shear band growing away from the outer gap surface. Shear rate tilting is found to be due to a coupling of local shear thinning with the non-zero stress gradient of the flow geometry. The low shear band starts when local shear rate at the outer surface "touches down" to a critical re-entanglement shear rate. The effective lifetime of the shear bands is the same as the chain re-entanglement time. These factors lead us to suggest that both the progression from tilt to shear banding and the interface between the low and high shear bands are subject to a common local entanglement / disentanglement criterion. For solutions with surfactant concentration above a critical vlaue, constitutive curves constructed from local shear rates show that there is not a unique stress – shear rate relation in the shear band coexistence regime, suggesting constitutive instability. The critical entanglement density at which consitutive instability occurs is estimated. The similarities and differences between the rheology of living polymers and that of the conventional polymers are discussed.

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