

IS THE TUBE MODEL APPLICABLE FOR ENTANGLED POLYMER DYNAMICS AT LARGE DEFORMATIONS

Sh.-Q. Wang, Y. Wang, P. Boukany

University of Akron

swang@uakron.edu

In this talk, I show that none of the three leading nonlinear rheological phenomena can be depicted by the tube model. These are (a) shear stress overshoot upon sudden startup shear, (b) non-quiescent relaxation after a large step strain, and (c) persistent shear banding during startup shear. It appears that the tube model skipped the basic physics required to explain why and how the entanglement network must break down during large deformations. Its many symptoms arise from the unrealistic assumption that the primitive chain in the tube could relax as fast as allowed by the Rouse dynamics. Consequently, the shear stress is only related to the chain orientation in shear either at applied rates below the Rouse rate or after chain retraction within the Rouse time. The excessive chain alignment produces non-monotonic relations between the resulting shear stress and imposed strain, for startup shear and step deformations, without having to introduce a molecular mechanism for the collapse of the entanglement network. We discuss accumulating experimental observations that question the utility of the tube model as an adequate theory for polymer rheology under large deformations.