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Yield-like flow transition in entangled polymers: what do we understand about non-Newtonian polymer flow behavior?

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In this talk, we discuss the latest results from our experimental studies of flow behavior of entangled polymers, in the context of the prevailing physical picture [1] prior to this work [2]. The model entangled polymers under study were 1,4-polybutadiene melts and their solutions. Flow behavior of these PBD samples was examined under various experimental conditions where shear flow was imposed by applying either a constant torque or a constant velocity on one of the two surfaces in a cone-plate shear cell (commonly known as controlled-stress or controlled-rate measurements respectively), and small or large step-strain was applied by a sudden displacement of one of the two surfaces in the same cell. The flow responses were found to be drastically different under these different conditions. When the applied shear stress was of a comparable magnitude to the elastic plateau modulus of the entangled solutions, a sharp yield-like constitutive transition was observed, revealing a discontinuous relationship between the shear rate and the shear stress, which was not anticipated according to the understanding prior to these experimental results. Such a discontinuity does not manifest itself in controlled-rate experiment and therefore has not been seen outside our lab. The implications of these results will be discussed to project our future efforts and activities. [1] Bent, J. et al, Science, 301, 1691 (2003); Graham, R. S et al, J. Rheol, 47, 1171 (2003). [2] Tapadia, P.; Wang, S. Q., Phys Rev. Lett., 91, 198301 (2003); Tapadia, P.; Wang, S. Q., Macromolecules, 37, 9083 (2004).