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Mechanistic constitutive model for wormlike micelle solutions with flow-induced structure formation SARIT DUTTA, MICHAEL GRAHAM, University of Wisconsin-Madison — We present a tensor constitutive model for stress and flow-induced structure formation in dilute wormlike micellar solutions. The fluid is treated as a dilute suspension of rigid Brownian rods whose length varies dynamically. Consistent with the mechanism of Turner and Cates [J. Phys.: Condens. Matter 4, 3719 (1992)], flow-induced alignment of the rods is assumed to promote increase of rod length that corresponds to the formation of flow-induced structures observed in experiments. At very high deformation rate, hydrodynamic stresses cause the rod length to decrease. These mechanisms are implemented in a phenomenological equation governing the evolution of rod length, with the number density of rods appropriately modified to ensure conservation of surfactant mass. The model leads first to an increase in both shear and extensional viscosity as deformation rate increases and then to a decrease at higher rates. If the rate constant for flow-induced rod growth is sufficiently large, the model predicts a multivalued relation between stress and deformation rate in both shear and uniaxial extension in agreement with experimental results. By design, the model is simple enough to serve as a tractable constitutive relation for computational fluid dynamics studies.

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