THE MOLECULAR ORIGIN OF STRESS GENERATION IN WORMLIKE MICELLES, USING A RHEO-SANS LAOS APPROACH

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We subjected surfactant wormlike micelles (6% cetylpyridinium chloride/sodium salicylate) to Large Amplitude Oscillatory Shear (LAOS) and made simultaneous measurements of the macroscopic stress and Kuhn segment alignment, using time-resolved Rheo-Small Angle Neutron Scattering.
By viewing both the stress and orientational order parameter waveforms as being the results of a sequence of physical processes we link the non-linear oscillatory response with steady flow and linearly oscillatory responses, thus elucidating the transient response of the system to a wide range of mechanical perturbations. This has resulted in the discovery of two new features of the response of the system: 1) a critical shear rate above which sample shear bands; 2) the ability and degree with which the material is 'overoriented', compared to stationary shear banded flow. This gives us an insight into the microscopic mechanisms for energy dissipation in the system.
Moreover, in the process of linking the responses to LAOS and steady shear we have uncovered an extra oscillatory stress which has zero average orientational order and thus violates the stress-optical relation. The origin of this dichotomy is yet to be determined, but the magnitude of the issue cannot be understated.

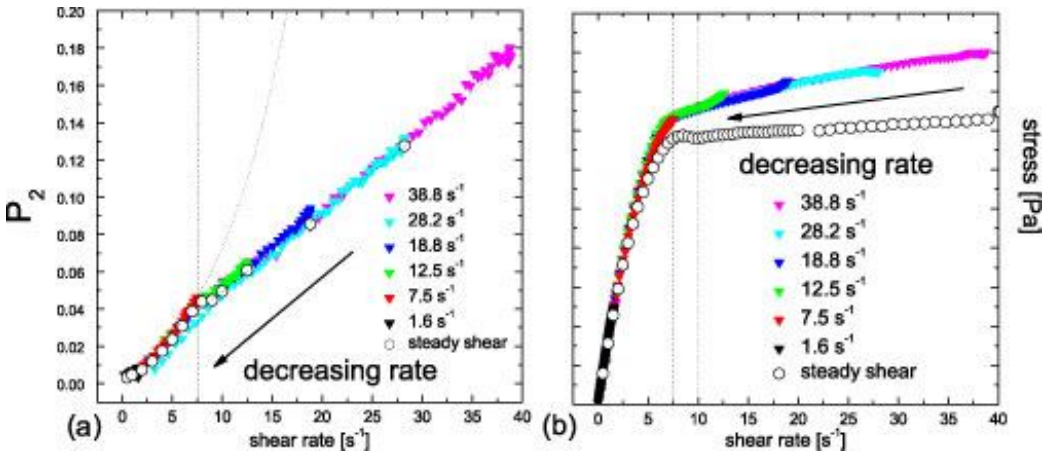

Fig. 1 The average orientational order parameter (left) and oscillatory stress (right) as a function of shear rate during a decreasing rate sweep at an angular frequency of $\omega = 0.0245$ rad s^{-1} (colored triangles) compared with the flow curve stress obtained from steady-shear measurements (unfilled circles).