Experimental report

14/08/2019

Proposal: 9-10-1526 **Council:** 4/2017

Title: A rheo-SANS study of the correlation between elastic strain and alignment in polymer-like systems

Research area: Soft condensed matter

This proposal is a new proposal

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Local contacts: Lionel PORCAR

Samples: Wormlike micelles - CpCl/NaSal + D2O/NaCal

Instrument	Requested days	Allocated days	From	To
D22	4	4	20/09/2018	24/09/2018

Abstract:

We propose to develop a generic procedure for rheo-structure studies using a well-studied polymer-like viscoelastic micellar solution. Within this proof-of-concept study, we will link the elastic extension of a viscoelastic fluid to the well-defined alignment factor used to describe polymer-like and wormlike systems. The experiments are carried out in the 1-2 and 1-3 planes of shear, providing structural links to the shear and normal stresses. By mapping out the elastic strain and comparing it to the alignment of the micellar segments, we will be better able to produce a tensorial stress-SANS rule, forming an intimate relationship between structure and the rheology of soft matter systems.

Recovery rheology via rheo-SANS: Application to step strains under out-of-equilibrium conditions

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Introduction

The goal of this study is to investigate the structural evolution of wormlike micelles under non-equilibrium flow conditions. It has been shown in previous studies that polymers undergo distinct stress relation behaviors, if the polymers experience external shear prior to the step strain test. With our recently-developed framework [1], we hypothesize such behaviors can be understood with the recoverable strain, the amount of deformation that can be recovered after the sudden release of the stress.

Experimental design

We devise a two-step protocol to investigate the stress relaxation behaviors under non-equilibrium conditions. We first enforce the shear history to the material be applying large-amplitude oscillatory shear flow until steady-alternating state has reached. The materials are immediately subjected to different amounts of step strains to observe both stress relaxation and structural evolution.

We specify 5 different tests, varying by the amount of step strain in the second interval. In tests i and ii, we apply the step strains as +2 and -2. In tests iii, iv and v, the step strains are applied based on the recoverable strains, and they correspond to the recoverable strain γ_{rec} of 0, 2 and -2.

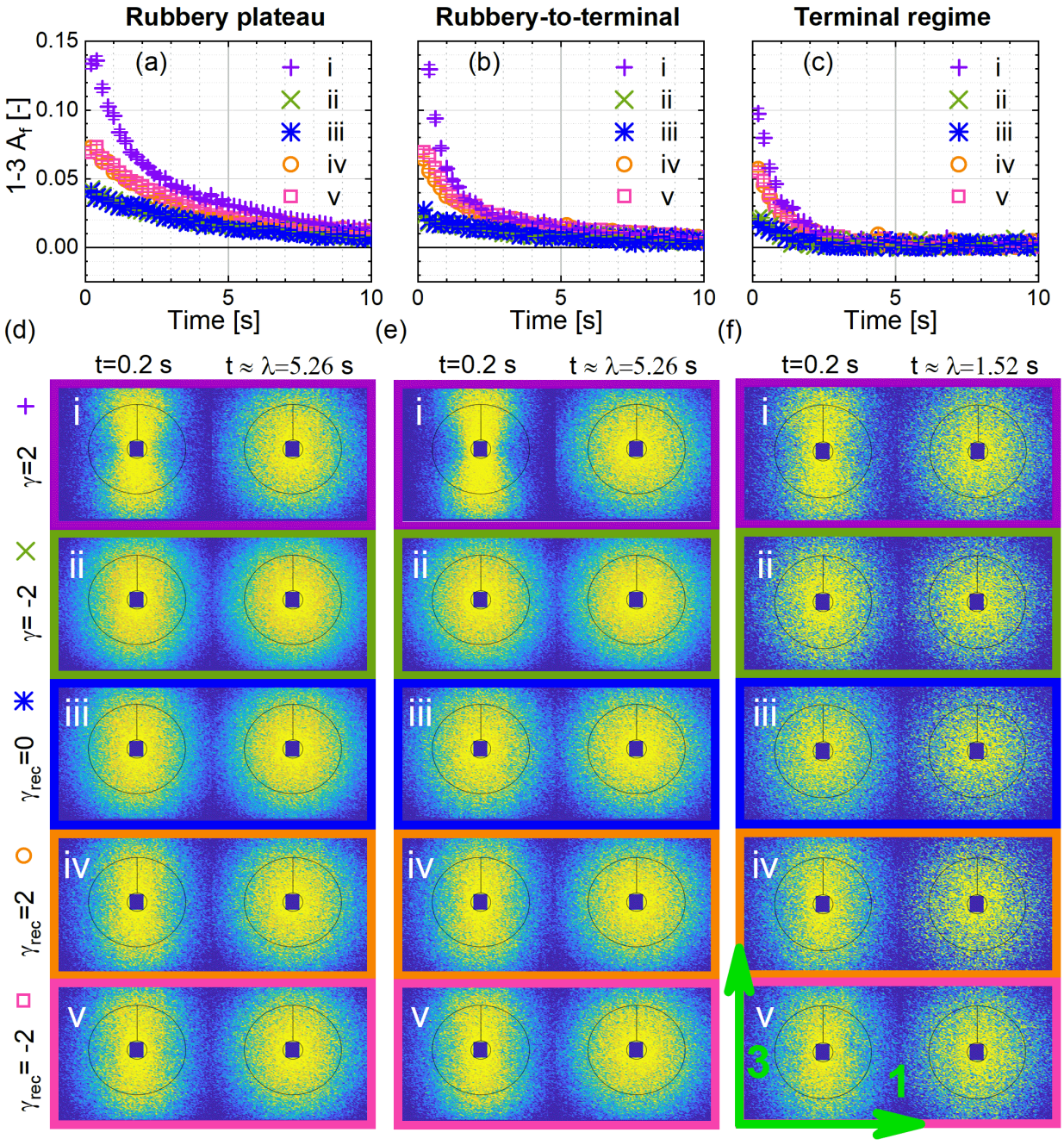
We study the microstructural evolution with both the rheo-SANS and flow-SANS setup to monitor 2 different orientations.

Results

We investigated the response in three distinct frequency regimes, including the rubbery plateau, rubbery-to-terminal, and terminal regimes. As shown in Fig. 1, in test i and ii, stepping to total strains of 2 and -2, we observe distinct structural evolution, where the alignment in test i is much stronger than test ii. However, stepping to the recoverable strains of 2 and -2, the same alignment decays are demonstrated in test iv and v. Stepping to the zero recoverable strain nearly brings the material back to its isotropic state.

Conclusion

With rheo-SANS setup implemented in ILL, we have demonstrated that the recoverable strain is an important measure. We have shown that information regarding prior shear history is included in the recoverable strain. More importantly, to properly perform a step strain test under a non-equilibrium condition, one has to measure and quantify the amount of recoverable strain.



References

1. Lee, J. C.-W., Weigandt, K. M., Kelley, E. G., & Rogers, S. A. (2019). Structure-property relationships via recovery rheology in viscoelastic materials. Physical Review Letters, 122(24), 248003. https://doi.org/10.1103/PhysRevLett.122.248003