Experimental report

22/05/2019

Proposal: **9-10-1530** **Council:** 4/2017

Title: Determination of transient elasticzone in supercooled and glassy states.

Research area: Soft condensed matter

This proposal is a new proposal

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Samples: Silica
Ethylene Glycol

Instrument	Requested days	Allocated days	From	To
D33	0	0		
D11	0	0		
D22	4	4	29/06/2018	03/07/2018

Abstract:

When a liquid is supercooled while crystallization is avoided, its dynamic slows down significantly by several orders of magnitude. The dynamic in a glass-forming liquid is found to be heterogeneous. In the past two decades there has been much interest in understanding the glass phenomenon based on this concept of dynamic heterogeneity (DH). In this proposal we seek to correlate the evolution of DH with the nonlinear behavior of sheared glass-forming liquids. We hope to demonstrate that the transient elastic zone (TEZ), within which the shear-induced elastic deformation persists, can be used as the structural indicator, related to the complex structural relaxation and rapid growth of relaxation times seen on approaching the glass transition.

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Cite this: *Phys. Chem. Chem. Phys.*, 2019, **21**, 38

Local elasticity in nonlinear rheology of interacting colloidal glasses revealed by neutron scattering and rheometry†

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Received 17th August 2018, Accepted 27th September 2018

DOI: 10.1039/c8cp05247f

rsc.li/pccp

The flow of colloidal suspensions is ubiquitous in nature and industry. Colloidal suspensions exhibit a wide range of rheological behavior, which should be closely related to the microscopic structure of the systems. With *in situ* small-angle neutron scattering complemented by rheological measurements, we investigated the deformation behavior of a charge-stabilized colloidal glass at particle level undergoing steady shear. A short-lived, localized elastic response at particle level, termed as the transient elasticity zone (TEZ), was identified from the neutron spectra. The existence of the TEZ, which could be promoted by the electrostatic interparticle potential, is a signature of deformation heterogeneity: the body of fluids under shear behaves like an elastic solid within the spatial range of the TEZ but like fluid outside the TEZ. The size of the TEZ shrinks as the shear rate increases in the shear thinning region, which shows that the shear thinning is accompanied by a diminishing deformation heterogeneity. More interestingly, the TEZ is found to be the structural unit that provides the resistance to the imposed shear, as evidenced by the quantitative agreement between the local elastic stress sustained by the TEZ and the macroscopic stress from rheological measurements at low and moderate shear rates. Our findings provide an understanding on the nonlinear rheology of interacting colloidal glasses from a micro-mechanical view.

1. Introduction

Flowing colloidal suspensions are of great importance in our life as well as in a wide variety of industrial applications, such as pharmaceuticals, polymer processing, cosmetics, and transportation technologies. Therefore, there has been much interest in understanding the flow behaviors of colloids.[1,2] The simplest form of colloidal suspensions is the suspension of hard spheres. Extensive computational,[3,4] theoretical[5–7] and experimental investigations of scattering[8–10] and imaging techniques,[11–13] have been performed to study the rheology of hard-sphere colloids. These results significantly broadened our knowledge on how the microscopic structure and flow of hard-sphere colloids are determined by the volume fraction of the colloidal particles and the shear rate $\dot{\gamma}$. Nevertheless, a large amount of colloidal suspensions of everyday and technological importance are not hard-sphere systems, but are characterized by more complicated interparticle interactions. These interactions, such as the electrostatic repulsion and van der Waals attraction, extend far beyond the range of the excluded particle volume.[14] Because of the extended range of interaction, their rheological properties are often rather different from those of hard-sphere colloidal suspensions at the same volume fractions.[2,7] The microscopic mechanism of the flow of interacting colloidal suspensions demands further studies.

In this work, we investigate the relation between the microscopic structure and rheology of a charge-stabilized colloidal glass as a model colloidal system with soft repulsive interactions. One reason for the current excitement stems from the

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† Electronic supplementary information (ESI) available: Sample preparation and characterization, SANS experiment, spherical harmonic expansion method, BD simulation, viscosity calculation details. See DOI: 10.1039/c8cp05247f

