Experimental report

14/02/2017

Proposal: **9-10-1481** **Council:** 4/2016

Title: Developing µRheoSANS for ultra-hig shear rate rheometry and SANS of fluids

Research area: Physics

This proposal is a new proposal

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Samples: D_2O
Octanol
Sodium salicylate in powder
NaCl powder
cetylpyridinium chloride in powder
sodium dodecyl sulfate in powder

Instrument	Requested days	Allocated days	From	To
D22	4	2	02/12/2016	05/12/2016

Abstract:

RheoSANS contributes significantly to our growing understanding of the response of complex fluids and soft matter to stress and strain. However, industrial processes often shear fluid at rates that are up to two orders of magnitude greater than current capabilities. To achieve the higher shear rates, we propose a new method µRheoSANS combining pressure-driven slit rheometry and SANS. We request experiment time on D22 to probe two objectives: 1. to illustrate and evaluate the new method, and 2. to investigate new physics at the higher shear rate. In particular, we will test the breakup of wormlike micelles at high stress.

Developing µRheoSANS for ultra-high shear rate rheometry and SANS of fluids

Intro

The goal of this experiment is to develop and use RheoSANS methods to measure fluid structure property relationships at higher shear rate than previously possible. Wormlike surfactant micelle solutions serve as model fluids here that align towards the flow direction during sufficiently rapid simple shear flow. To achieve substantially higher shear rates, it is necessary to use pressure driven flow instead of couette flow. The inhomogeneity of shear rate in pressure driven Poiseuille flow complicates either the data acquisition or analysis procedures. A primary objective is thus to demonstrate these procedures. Of interest is the portion of fluid at highest shear rates, adjacent to the channel walls, which we sought to isolate through these experiments.

Report of Expts

During 3 days of beam time from 02/12/2016 to 05/12/2016, we obtained data from two surfactant solutions, in various conditions of flow. The flow cell was a rectangular duct (with 8 mm width and depth either 500 µm or 100 µm), and the neutron beam was projected transverse to the flow and along through either the wide or narrow direction of the thin channel.

One method to isolate the SANS pattern arising from the fluid adjacent to the channel wall is to use a narrow 50 µm x 1 cm aperture and project the beam along the wide direction of the channel. Some experimentation was required to develop an efficient method to align the channel in this way. It was then possible to obtain scattering patterns as a function of distance from the channel wall.

The other method to isolated near wall scattering is to project the beam through the orthogonal direction through the entire depth, obtaining a pair of scattering patterns at two slightly different applied stress.

Results

Using the first method mentioned above, several series of scattering patterns were obtained at different flow rate. At each flow rate, a spectrum of fast to slow shear rate is produced, with highest shear rate near the channel wall and the slowest in the channel center. The degree of alignment varies correspondingly across the channel depth (Figure 1).

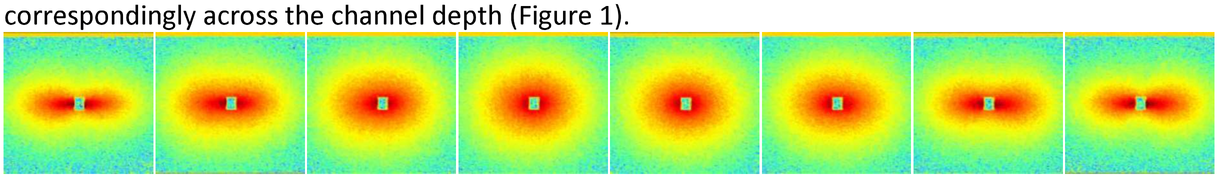

Figure 1. A series of scattering patterns obtained at a single flow rate. The figures at the extreme right and left are adjacent to the channel walls, with intermediate patterns at equally spaced intervals in between.

These results validate the second method, which yields similar results, albeit from an orthogonal direction.

The results obtained here are consistent also with couette flow RheoSANS, when the same shear rates are compared. Using the new methods, we obtained RheoSANS at shear rates up to 20,000 s^{-1}, approximately an order of magnitude faster than it is possible to test the same fluid with traditional RheoSANS.

Conclusions and implications

The two methods are valid and complementary. It will be important to refine and optimize the techniques for use with other fluids and at still higher shear rates, which are relevant to industrial processes.