ESRF	**Experiment title:** Structure of nano-composite materials in extensional flows	**Experiment number**: SC 865
Beamline: ID02A	**Date of experiment**: from: 8/09/2001 to: 10/09/2001	**Date of report**: 25/02/2002
Shifts: 6	**Local contact(s)**: Pierre Panine	

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Report: The scientific objective of this proposal was to elucidate the relationship between the extensional flow properties (strain and stress fields) and the kinetics of the induced structures (orientation, aggregation, phase transition, etc.). The nano-composite materials studied are composed of sepiolite clay particles (rigid rods 1 micrometer long and 0.010 micrometers in diameter) in a water-soluble polymer, polyethylene oxide. The trajectory of the strain field within the sample volume has been well characterized by particle imaging velocimetry, in order to apply pure extensional flows in the desired extensional rate and viscosity domains (Fig. 1).

A new extensional flow device developed at the "Laboratoire de Rhéologie", has allowed to combine extensional flow with SAXS on ID02 at the ESRF. Time-resolved information has been obtained on the orientation kinetics of the fibers in the polymer matrix. Analysis of extensional transient and steady state regimes revealed the main characteristics of the extensional flow of these nano-composite suspensions. The scattering along vertical or horizontal axes correspond to the mean of scattering intensity in a domain of 25 degrees around respectively vertical axes z or horizontal axes y. The extend of anisotropy was deduced from the scattering curves by extracting the value of the scattering intensity along vertical and horizontal axes at a certain Q vector Q (= 0.05 nm^{-1}). This anisotropy parameter is chosen such that the isotropic scattering patterns of the nano-composites at rest correspond to 0. Under steady states, the fibers are aligned along the extensional direction. The evolution of the anisotropy parameter versus strain rate has allowed defining the rate of organization of the fibers at increasing extensional flow rates (Figs. 2 and 3). Under transient states, time evolution of the anisotropy parameter permitted to identify the time scales at which the fibers get aligned in the extensional flow field (Fig. 4) and the time scales over they relax in the polymer matrix (Fig. 5). During the relaxation phase the anisotropy parameter follows exponential decay.

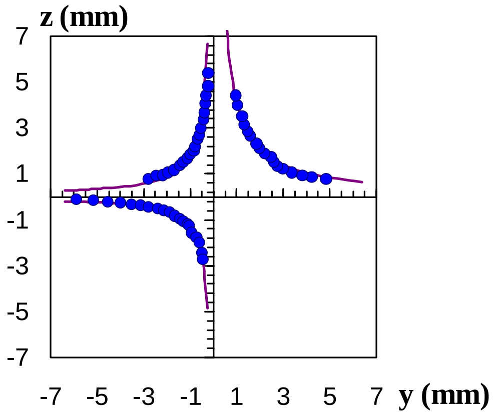

Fig. 1 Extensional flow streamlines, visualization by P.I.V.

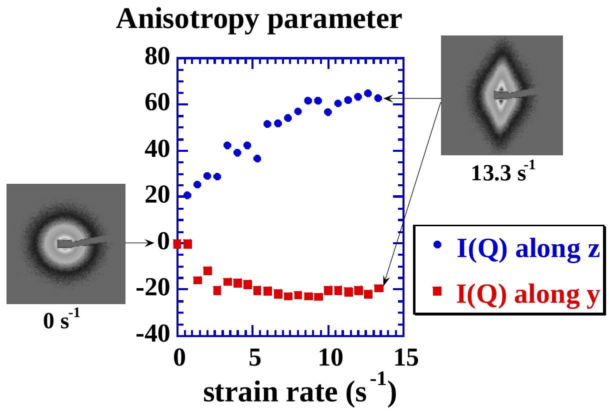

Fig. 2 Enhance of the order parameter at increasing strain rates in horizontal direction.

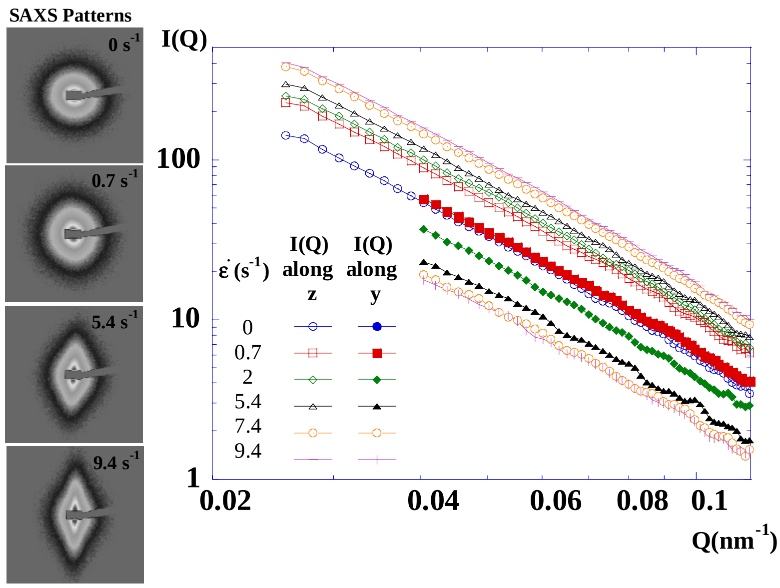

Fig. 3 Extensional flow in horizontal direction at increasing strain rates.

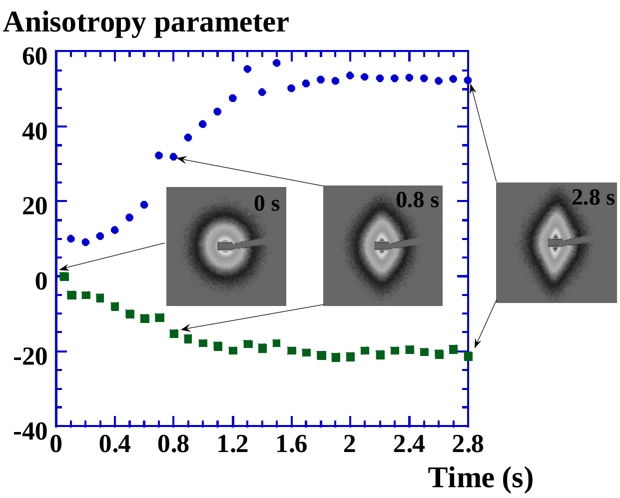

Fig. 4 Onset of extensional flow in horizontal direction at 7.9 s^{-1}

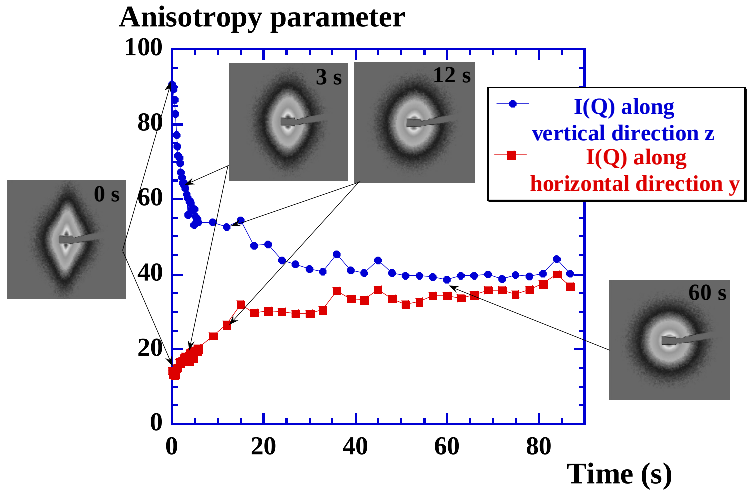

Fig. 5 Relaxation of the sample after cessation of extensional flow in horizontal direction at 7.9 s^{-1}