Time resolved evolution of soft condensed matter under flow
Workshop report, Leuven, 22-23 January 1999

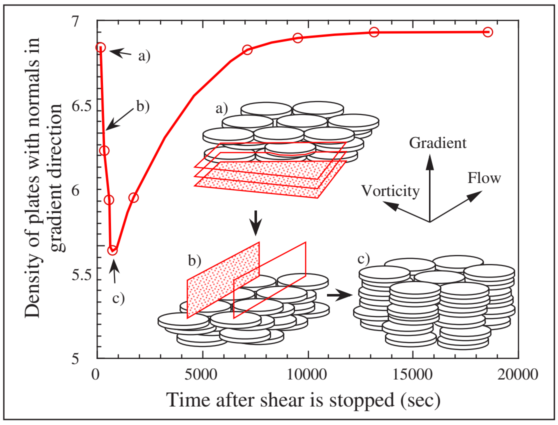

Figure 1 (left): Density of particles orientated with normals in the gradient direction as a function of time after a high shear rate is removed as calculated from neutron diffraction measurements. The insert shows the structural change observed; a) layered structure produced by high shear rates, b) intermediate structure formed after a few seconds after a high shear rate is removed, c) equilibrium columnar structure. The red planes indicate planes of particle centres present in the sample which cause strong scattering [from Brown, Rennie and Clarke].

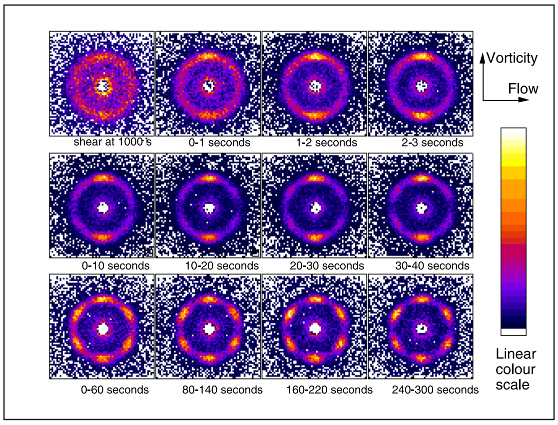

Figure 2 (right): The evolution of the small angle neutron scattering pattern from the dispersion with time after a shear of 1000 s^{-1} is removed (see also front page) [from Brown, Rennie and Clarke].

About 60 participants came to the monastery of La Foresta in Leuven, to attend a workshop dealing with "Time resolved evolution of structure in soft condensed matter", with a special emphasis on flowing systems. The workshop was a kick-off meeting of a workgroup of the COST-P1 action on "Technology driven physics". COST is an initiative of the EU to improve collaborations throughout Europe and some associated countries. COST is an acronym that stands for European co-operation in the field of scientific and technical research. COST offers limited financial support to improve collaborative research by sponsoring workshops and short scientific missions for young scientists. Different COST actions are in progress in various areas of science and technology. An action of possible importance to rheologists is action P1: "Soft condensed Matter". One of the five workgroups of this action focuses on the developments in the study and modeling of structure development under flow and the implications on the rheological behavior. Prof. G. Mittchel (Reading) and Prof. J. Mewis (Leuven) coordinate this workgroup. The relation between structural changes and the rheology of complex fluids is receiving more and more attention. Structure probing techniques are being adapted to the study of flowing systems, requiring relatively good time resolution and applicabilty to anisotropic systems. These techniques are traditionally more in the expertise of traditional chemistry and physics. Hence collaborative research in this area seems very appropriate indeed. Applications of various techniques were presented at the workshop; examples-Small angle scattering of Light, Neutrons and X-rays-Diffusing wave spectroscopy and related multiple scattering techniques-rheo-optical methods (polarimetry)-confocal microscopy-(transient) rheology. The material classes to which these techniques are applied were very diverse, e.g. surfactant phases, liquid crystalline polymers, colloidal dispersions, polymer blends and block copolymers. Topics also included phase transitions, phase separation, polymer and colloidal crystallization, all in relation to the flow behavior. Theoretical approaches to the modelling of these complex fluids included molecular models and continuum mechanics. The differences and similarities between material classes and approaches were exciting.

A particular contribution to this workshop was devoted to the study of the time resolved transition between shear induced structures and static structure in a concentrated dispersion of model plates, presented by A.B.D. Brown (Cambridge), coauthors S.M. Clarke (Cambridge) and A.R. Rennie (London). Plates of nickel II hydroxide with a low polydispersity (13%), diameter of 80 nm, and thickness of 10 nm were prepared and dispersed in water [1]. The interactions between these plates were controlled using polyacrylate and salt to give repulsive interactions with a range of ~6 nm, making the system an approximation to a model dispersion of hard plates. When the plates are highly concentrated they spontaneously form a columnar phase [2] (see inset of Fig. 1c). At low shear rates (10 s^{-1}) the shear field aligns the columnar phase, with the columns along the flow direction. At higher shear rates (> 100 s^{-1}) the dispersion undergoes a transition to a layered phase with planes of particles normal to the gradient direction (see inset of Fig. 1a). This high shear phase relaxes to the equilib-

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rium columnar phase when the shear is removed. The dynamics of this relaxation were followed using small-angle neutron scattering and a neutron diffraction technique, described elsewhere [3]. The small-angle neutron scattering patterns (Fig. 2), show the evolution of positional order within the sample after shear is removed. Order forms in the vorticity direction after a few seconds as shown by the peak above and below the beam stop. This indicates layers forming normal to this direction, as shown schematically in the inset of Fig 1b. Over a period of a few minutes hexagonal order forms, and this final structure was found to be the equilibrium columnar phase. Throughout these positional rearrangements, the orientational order decreases as shown by the diffraction results given in Fig. 1. Following this the orientational order increases again, over a period of a number of hours.

As a result of the workshop some specific topics were chosen, that will be the subject of collaborative research. More information on these collaborations and on the COST action in general can be obtained from our web site www.AR.ethz.ch/COST/.

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