CPP 2: DRG-DPG SYMPOSIUM Rheology II

Time: Monday 14:00–16:45 Location: C 130

Invited Talk CPP 2.1 Mon 14:00 C 130

Shear induced structures in lamellar systems: from layers to onions to onions and layers — •Walter Richtering — Physikalische Chemie RWTH Aachen

The size growth of multilamellar vesicles (MLV, *Onions*) of a nonionic surfactant system composed of 40wt% C10E3 in D2O was investigated by shear quench experiments, i.e. when the shear rate is reduced. The structural changes were monitored with the help of Rheo-Small Angle Neutron Scattering (SANS), Rheo-Small Angle Light Scattering (SALS) and optical microscopy. Two different pathways were observed. A continuous growth of vesicle size was found when the shear rate was reduced within the stability region of monodisperse MLV (Region III). However, a discontinuous pathway was observed for shear quenches from the monodisperse into the polydisperse MLV region (Region II). A shear quench into the high shear rate part of region II leads to a formation of lamellar domains which themselves follow the pathway of MLV formation in coexistence to the initial MLV structure. A shear quench into the low shear rate part region II leads to the formation of lamellar macro-domains, which display a tumbling behaviour and grow with time until the MLV formation process starts.

CPP 2.2 Mon 14:30 C 130

Linear to branched micelles transition: a rheometry and diffusive wave spectroscopy (DWS) study — •Norbert Willenbacher and Claude Oelschlager — Institut für Mechanische Verfahrenstechnik und Mechanik, Universität Karlsruhe, 76128 Karlsruhe

The shear modulus G* of aqueous wormlike micellar solutions of cetylpyridinium chloride and the strongly binding counterion sodium salicylate has been measured as a function of temperature, surfactant and salt concentration by using DWS based tracer microrheology as well as mechanical techniques including rotational rheometry, oscillatory squeeze flow and torsional resonance. Good agreement between both approaches is found in the frequency range from 0.1 to 100.000 rad/s. Upon increasing the salt concentration, at fixed surfactant concentration, the solutions exhibit two maxima of the zero shear viscosity. The first one is attributed to a transition from linear to branched micelles. From G' and G" at low and intermediate frequencies we obtain the mesh size of the entanglement network and the scission energy E_0. The latter passes through a maximum upon the transition from linear to branched micelles. In the frequency range above 10.000 rad/s a omega^3/4 scaling is observed for the loss modulus G" as expected for semiflexible objects. The persistence length lp is determined from the moduli in this frequency range. For the linear micelles lp decreases with increasing salt content as expected, but increases significantly upon the transition to the branched structure. The structural changes at the second viscosity maximum are not resolved so far, we will discuss the variation of lp and E_0 in this concentration range.

CPP 2.3 Mon 14:45 C 130

Thermorheological behaviour of polyethylene in dependence on molecular structure — •Ute Kessner, Joachim Kaschta, and Helmut Münstedt — Lehrstuhl für Polymerwerkstoffe, Universität Erlangen-Nürnberg, Martensstrasse 7, D-91058 Erlangen

The thermorheological behaviour of polyethylenes is strongly influenced by their molecular structure. In the literature, they are reported to be thermorheologically simple or complex. A clear distinction is not made, however, between the behaviour in the linear and nonlinear ranges of deformation. This paper systematically addresses this topic by presenting the activation energies of various polyethylenes determined in the linear and nonlinear range. Thermorheological simplicity was found for the linear ethylene homopolymers (HDPE) under all applied conditions. The LDPE investigated showed a thermorheologically simple behaviour in the linear range, but a thermorheologically complex behaviour in the nonlinear regime. The activation energy decreases with increasing stresses and approaches the value of the HDPE. Long-chain branched polyethylenes polymerised with metallocene catalysts do exhibit a thermorheological complexity in the linear and nonlinear range of deformation.

Various branching topographies lead to distinct differences in the thermorheological behaviour and result in different flow activation energies. Using these results it will be shown in which way the thermorheological behaviour of different polyethylenes can be used to get an insight into their branching architecture.

CPP 2.4 Mon 15:00 C 130

Non-equilibrium phenomena in sheared bottlebrush polymer solutions — •Silke Rathgeber[1], Hyung-il Lee[2], Krzysztof Matyjaszewski[2], and Emanuela Di Cola[3] — [1]Max-Planck Institut für Polymerforschung, Polymer Physik, 55128 Mainz, Germany. — [2]Carnegie Mellon University, Department of Chemistry, Pittsburgh, Pennsylvania 15213, USA. — [3]European Synchrotron Radiation Facility, 38043 Grenoble Cedex, France.

Time-resolved small-angle x-ray scattering (SAXS) experiments were carried out on concentrated solutions of bottlebrush polymers exposed to an external shear flow.[1] The rheological response of the sample were recorded online. We followed the complex structural changes occurring in a, perpendicular to the flow direction pre-aligned sample during its reorientation into the flow direction. In the stress-controlled rheometer mode the reorientation is accompanied by a shear thinning process with a reduction in viscosity of two orders of magnitudes. In the strain controlled mode the rheological response of the bottlebrush polymer solution to the rotational shear shows oscillations with changes in viscosity of almost two orders of magnitude. The SAXS data reveal that this oscillatory response is due to a reentrant phase transition between a shear molten phase and a line hexatic phase. It is not due to shear induced phase separation leading to shear band formation. The insitu-rheological SAXS measurements allow a detailed description of the structural changes occurring in the sample during structural built-up and break-down. [1] S. Rathgeber et al., Macromolecules 40, 7680 (2007).

break

Invited Talk CPP 2.5 Mon 15:30 C 130

Structure and dynamics of magnetorheological fluids — •Claus Gabriel and Hans Martin Laun — BASF AG, Ludwigshafen am Rhein, Germany

This presentation intends to give an overview of the rheological properties of magnetorheological fluids (MRF). MRF are used as force- or torque transmitting fluids in electronically controllable dampers and clutches.

Some fundamental structure-property relationships related to dynamic frequency sweeps will be discussed. The linear regime of deformation is the broader the higher the applied magnetic field is. In this regime MRF behave predominantly as elastic bodies and the dynamic moduli are essentially independent of the magnitude of the applied magnetic field. Outside the linear regime the internal structure of MRF breaks down. The MRF properties derived from dynamic experiments will be compared with those obtained from steady-shear experiments. Moreover, the dependence of rheological properties upon the composition of MRF will also be discussed.

An important precondition for a reliable determination of rheological properties of MRF is the homogeneity of the flux density in the shear gap. Depending on the type of MRF formulation a non-homogeneous flux density distribution may cause a significant segregation of the magnetisable particles within the MRF. An improved measurement design is proposed with which these segregation phenomena can be reduced to a minimum.

CPP 2.6 Mon 16:00 C 130

Shear-induced structures and viscoelastic effects in ferrofluids from nonequilibrium simulations — •Patrick Ilg — ETH Zürich, Polymer Physics, 8093 Zürich, Switzerland

Ferrofluids – suspensions of nano-sized magnetic colloids – have attracted considerable attention due to the possibility of manipulating their flow behaviour by external magnetic fields [1]. From extensive, nonequilibrium Brownian dynamics simulations of realistic model-ferrofluids [2], we obtain the flow- and field-dependence of viscosity coefficients and normal stress differences in planar shear flow. We also observe strong shear-induced structural changes and discuss their relation to rheological properties.

[1] M. Kröger, P. Ilg, S. Hess, J. Phys. Condens. Matter 14 (2003) S1503. [2] P. Ilg, E. Coquelle, S. Hess, J. Phys. Condens. Matter 18 (2006) S2757.

CPP 2.7 Mon 16:15 C 130

Shear-induced structural changes in nanoparticle aggregates: a time-resolved x-ray microscopy study

— •Günter K. Auernhammer[1], Jinyu Zhao[1], Doris Vollmer[1], Markus Weigand[2], and Kai Fauth[2] — [1]MPI Polymerforschung, Mainz, Germany — [2]MPI Metallforschung, Stuttgart, Germany

X-ray microscopy is an imaging technique which allows for a spatial resolution below 35 nm. Can it also be used to investigate shear-induced structural dynamics? When studying response to mechanical (shear) stimuli, the challenge lies in applying the stimuli with precision comparable to spatial resolution. We accomplished this by inserting a piezo actuator-driven shear cell into the focal plane of the x-ray microscope. We demonstrate the possibilities of this novel device by an investigation of shear-induced reorganization of 50 nm sized magnetite particles embedded in a polymer melt. As x-ray microscopy proves suitable for studying structural change, new prospects open up in physics at small length scales.

CPP 2.8 Mon 16:30 C 130

Transient behavior of thioxtropic flow studied by smoothed particle hydrodynamics

— •Andreas Wonisch, Torsten Kraft, Michael Moseler, and Hermann Riedel — Fraunhofer Institute for Mechanics of Materials, Woehlerstr. 11, 79108 Freiburg

Many complex fluids exhibit thixotropic behavior: Under shear viscosity gradually decreases with time, followed by a gradual increase if the shearing is stopped. This time and shear rate dependent rheological behavior can be linked to the breakdown and buildup of structure in the fluid. Here, we employ smoothed particle hydrodynamics (SPH) - a meshless, particle-based Lagrangian simulation method - to study thixotropic fluid flow in three dimensions. In our model the structure of each SPH particle is characterized by a scalar structure parameter which is related to viscosity. Thixotropy is introduced by specifying a constitutive equation for the time derivative of the structure parameter. Our numerical method is verified by several simple test cases which are in close agreement with analytical solutions. We then investigate the transient behavior of thixotropic flow at low Reynolds numbers numbers for an industrial impregnation and removal process which involves both solid wall and free surface boundary conditions. It is demonstrated that different wetting conditions (characterized by the contact angle) have a profound impact on the transient flow behavior.