CPP 1: DRG-DPG SYMPOSIUM Rheology I

Time: Monday 9:30–12:15 Location: C 130

Invited Talk CPP 1.1 Mon 9:30 C 130

Multiple glassy states and mechanics of soft colloids — •Dimitris Vlassopoulos — FORTH and Univ. of Crete, Hereklion, Greece

Colloidal glass transition and its manipulation represent a topic of ever increasing scientific interest. Hard sphere colloids and more recently their mixtures with linear non-adsorbing polymers has been the systems most frequently studied. Perhaps the most interesting recent observation is the melting of a (repulsive) glass upon adding polymer depletant, and the transition into a re-entrant different (attractive) glass upon further increasing the strength of depletion. Here, we are interested in changing the pair interaction potential. In particular, we use colloidal star polymers, a model system with ultrasoft interactions. We study their vitrification under different conditions: temperature-dependent solvent, mixtures with linear chains and binary asymmetric star mixtures. We find a wide range of glass transitions, which we try to rationalize by invoking the cage picture and with support from mode coupling theory. We demonstrate to power of rheology to act both as a sensitive detection tool and as a means of inducing structural changes. Concerning the former, the data are summarized in terms of kinetic state diagrams. For the latter, we present the phenomenology of yielding of the star glasses and suggest possible connections to aging. The main outcome is, we believe, an enhanced ability to tailor the flow of glassy suspensions of soft particles. In collaboration with E. Stiakakis, G. Petekidis, C. N .Likos, C. Mayer, E. Zaccarelli, F. Sciortino, M. Helgeson, N. J. Wagner, H. Iatrou, N. Hadjichristidis.

CPP 1.2 Mon 10:00 C 130

Shear stresses of colloidal dispersions at the glass transition in equilibrium and in flow — Jerome Crassous[1], Miriam Siebenbürger[1], •Matthias Ballauff[1], Markus Drechsler[2], David Hajnal[3], Oliver Henrich[3], and Matthias Fuchs[3] — [1]Physikalische Chemie I, Universität Bayreuth, 95440 Bayreuth — [2]Makromolekulare Chemie II, Universität Bayreuth, 95440 Bayreuth — [3]Fachbereich Physik, Universität Konstanz, 78457 Konstanz

We consider a model dense colloidal dispersion at the glass transition, and investigate the connection between equilibrium stress fluctuations, seen in linear shear moduli, and the shear stresses under strong flow conditions far from equilibrium, viz. flow curves for finite shear rates. To this purpose thermosensitive core-shell particles consisting of a polystyrene core and a crosslinked poly(N-isopropylacrylamide)(PNIPAM) shell were synthesized. Data over an extended range in shear rates and frequencies are compared to theoretical results from integrations through transients and mode coupling approaches. The connection between non-linear rheology and glass transition is clarified. While the theoretical models semi-quantitatively fit the data taken in fluid states and the predominant elastic response of glass, a yet unaccounted dissipative mechanism is identified in glassy states.

CPP 1.3 Mon 10:15 C 130

Optical Microrheology applied to different Soft Matter Systems and compared to Classical Bulk Rheology — Anna Kozina[1], •Pedro Diaz-Leyva[1,2], Christian Friedrich[2,3], and Eckhard Bartsch[1,2] — [1]Institut für Makromolekulare Chemie, Universität Freiburg, Germany — [2]Institut für Physikalische Chemie, Universität Freiburg, Germany — [3]Freiburger Materialforschungszentrum, Universität Freiburg, Germany

Over years it has been very important to understand how the macroscopic properties of soft materials are depending on their microstructure. Concerning mechanical properties such as viscosity and/or elasticity, they have been measured typically by Classical Bulk Rheology (CBR) which works at a macroscopic level. In this work we discuss a technique known as Optical Microrheology (OMR) which characterize the same mechanical properties, but using a microscopic approach. This method exhibits two important features: First, OMR is a non-invasive and non-destructive technique. Second, OMR is capable to reach high frequencies. We explore the capabilities of OMR studying several systems showing a clear viscoelastic behavior, but appreciably different in terms of microstructure. We use Dynamic Light Scattering in order to measure the dynamics exhibited in the materials, and consequently we can get the rheological moduli $G'(\omega)$ and $G''(\omega)$. We compare our results with those obtained by CBR applied on the same systems. Finally we discuss the possible origin of discrepancies between the results obtained with OMR and CBR respectively.

CPP 1.4 Mon 10:30 C 130

Macro- and micro- rheology of a soft colloidal suspension with tunable glassines — •Dirk van den Ende, Eko Purnomo, Siva Vanapalli, and Frieder Mugele — Physics of Complex Fluids, University of Twente, The Netherlands

We studied both the macro- and micro- rheology of soft thermosensitive microgel suspensions that can be tuned continuously and reversibly between the glassy state at low and the liquid state at high temperature. In the glassy state, the rheological properties (G', G'', and J) of the suspensions depend strongly on their age [1]. They can be described quantitatively by the soft glassy rheology (SGR) model. The underlying mechanism for the aging is the increase of the structural relaxation time τ_s as the system ages. However, τ_s is experimentally inaccessible by small amplitude frequency sweep experiments. Therefore we tested the recently introduced strain rate frequency superposition (SRFS) technique. The evolution of $\tau_s(t)$ as determined with SRFS is consistent with the predictions of the SGR model based on the linear measurements. Hence, no macroscopic inhomogeneities occur in the sample. The relaxation time τ_s is also determined from the mean square displacement (MSD) of probe particles, embedded in the system, using a Confocal Scanning Laser Microscope. This technique provides not only the MSD values but also the displacement distributions, which are indicative for heterogeneity of the suspension.

[1] E.H. Purnomo, D. van den Ende, J. Mellema, and F. Mugele, Europhys. Lett. 76, 74 (2006).

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Invited Talk CPP 1.5 Mon 11:00 C 130

Thermo-Rheological Properties of Fiber Networks — •Christian Friedrich, Yasmin Korth, and Martin Kühne — Freiburg Materials Reserch Center (FMF), University Freiburg, Stefan-Meier-Str. 21, 79104 Freiburg i. Brsg., Germany

The dispersion of fibers (nm-thick and mikrom-long fibers) in matrices, without bundling or aggregation, is of crucial importance for the beneficial combination of fiber properties with those of matrix fluids. For multi-walled carbon nanotubes (mwCNT) dispersed in ionic liquids (IL), we developed a technique enabling good dispersion of these fibers in the matrix fluid. Using different analytical tools (rheology, centrifugation) we were able to discriminate gel-forming varieties of CNT from those who do not gel. For those who give gels, we identified the concentration regions in which networking is dominant. While the temperature dependence of fibers modulus is crucial for the understanding of gels modulus temperature dependence, the module scaling with concentration depends on the fibers persistence length. In the last part of our presentation we deal with possibilities of its determination on the basis of morphological as well as rheological techniques. Although mwCNT-dispersions are highly polydisperse in persistence, an estimation of gels plateau modulus with the MacKintosh-Model is possible.

CPP 1.6 Mon 11:30 C 130

Nonlinear rheology of a glassy solution of semiflexible polymers — •Jens Glaser[1], Christian Hubert[1], and Klaus Kroy[1,2] — [1]Inst. f. Theoretische Physik, Universität Leipzig, PF 100920, 04009 Leipzig — [2]Hahn-Meitner-Institut, Glienicker Str. 100, 14109 Berlin,

Recent experimental studies on purified solutions of the semiflexible biopolymer F-actin show a pronounced transition from shear softening to shear stiffening behavior as a function of different physiological parameters. The results suggest a surprising invariance of the rheology of the F-actin solution with respect to the choice of the control parameter. We rationalize this property in terms of the recently introduced glassy wormlike chain (GWLC) model, where the nonlinear response is traced back to a strong stretching of the relaxation spectrum of an ordinary wormlike chain, quantified by a single stretching parameter which is the height of free energy barriers slowing down the relaxation of the polymer. Predictions for the maximum strain of the network, apparent power-law stiffening exponents and analytical results are given. The relation of the stretching parameter to changes in the physiological parameters is discussed.

[1] Semmrich C, Storz T, Glaser J, Merkel R, Bausch, A. R, Kroy K, Proc Natl Acad Sci USA, In Press (2007)
[2] arXiv:0705.0490, arXiv:0711:2427

CPP 1.7 Mon 11:45 C 130

Dynamics of branch point withdrawal for pom-pom melt — •Manfred H. Wagner and Víctor H. Rolón-Garrido — Polymertechnik/Polymerphysik, TU Berlin

According to tube model ideas, chain stretch at deformation rates below the inverse Rouse time of the chain, is only possible for polymer topologies with two or more branch points. The basic topologies which embody this idea are the H-molecule with two side chains, and the pom-pom molecule with q>2 side chains at each end of the backbone. According to the pom-pom hypothesis, maximum chain stretch of the backbone is limited by branch point withdrawal, i.e. the side chains are drawn into the tube of the backbone as soon as the relative tension in the backbone reaches a value of q. This so far unproven hypothesis can now be tested by considering recent elongational experiments by Nielsen et al. [Macromolecules 39, (2006) 8844] on a nearly monodisperse polystyrene pom-pom melt with q=2.5. The material strain measure determined from the experiments is found to be consistent with a constant maximum stretch, independent of the elongation rate, which is, however, significantly larger than q. To achieve quantitative agreement between experiment and modelling, (1) dynamic dilution of the backbone, which increases the tube diameter of the backbone and reduces equilibrium tension, (2) finite extensibility effects, (3) transition from chain stretch to tube squeeze at lower strain rates, and (4) the dynamics of branch point withdrawal need to be considered. Integrating all of these features in a stretch evolution equation with multiple time scales, the fundamental pom-pom hypothesis is confirmed.

CPP 1.8 Mon 12:00 C 130

Deformation of Inclusions and Lamellae in Melt Extension of Blends of Polystyrene and a Styrene-Butadiene Block Copolymer — •Ulrich Alexander Handge[1], Matthias Buschnakowski[2], and Goerg Hannes Michler[2] — [1]Polymer Physics, Department of Materials, ETH Zürich, CH-8093 Zürich — [2]Department of Physics, Martin-Luther-University Halle-Wittenberg, D-06099 Halle/S.

The end-use properties of block copolymers depend on their composition and microstructure. Blending block copolymers with a homopolymer can lead to materials with specific end-use properties and reasonable costs. Here we studied the melt rheology of blends of a styrene-butadiene block copolymer (LN3) and polystyrene (PS 158K, BASF AG). Three blends of LN3 and PS 158K were prepared with $\Phi = 20, 40$ and 80 wt.% PS 158K. Linear viscoelastic shear oscillations and melt elongation tests were performed at 170 °C. The deformation of the blend morphology with strain was investigated using transmission electron microscopy. PS 158K and LN3 formed a two-phase blend with a PS 158K or a LN3 matrix. The block copolymer chains of LN3 were arranged in a lamellar phase. Our rheological experiments revealed that the complex modulus, the extensional viscosity and the recoverable deformation of the PS 158K/LN3 blends mainly resulted from a mixing effect of the properties of PS 158K and LN3. In melt elongation, the inclusions in the PS 158K resp. LN3 matrix were deformed into an elongated shape, and the alignment of the lamellae of the LN3 block copolymer matrix for $\Phi = 20\%$ and 40% increased with strain.