CPP 38: Focus: Rheology II (joint focus with DRG)

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

Invited Talk CPP 38.1 Fri 9:30 C 130

The Rheology of Biological Cells — Mathias Sander[1], Benjamin Tränkle[1], Pablo Fernandez[2], Pramod Pullarkat[2], Lutz Heymann[3], Nuri Aksel[3], and •Albrecht Ott[1,2] — [1]Biologische Experimentalphysik, Universität des Saarlandes, Saarbrücken, Germany — [2]former address: Experimentalphysik 1, Universität Bayreuth, Bayreuth, Germany — [3]Technische Mechanik und Strömungsmechanik, Universität Bayreuth, Bayreuth, Germany

The mechanical properties of biological cells are important for many biological processes, among them embryogenesis, wound-healing and cancer. They are determined by the cytoskeleton, an active polymer gel, whose properties are poorly understood. Here we study cell rheological properties using a home built, single-cell rheometer. It consists of a single cell that is suspended between two parallel plates of cell-size. We observe that active and passive cell mechanical properties are clearly separated by their timescales. We show that the passive properties can be decomposed into a linear superposition of an elastic and a plastic response. While the elastic response can be easily understood from the mechanical properties of the cell cytoskeleton, the plastic response remains difficult to understand given current molecular knowledge. We present a novel technique, cell monolayer shearing. Here we create a single layer of about 10^6 isolated cells that adhere to the top and bottom plates of a standard rheometer. We use Fourier transform rheology to determine the degree of nonlinearity of the cell mechanical response. We show that we can assess cell adhesion-rupture in a very quantitative way. We present other interesting applications.

CPP 38.2 Fri 10:00 C 130

Rheological and (di)electric measurements on biopolymers, like blood systems — •Angelika Bender, Ulrich Förter-Barth, and Prof. Peter Eyerer — Fraunhofer Institute for Chemical Technology ICT, Pfinztal, Germany

In medical devices, like stents, being implanted into human body or dialysis apparatus transporting human blood, it is important to prevent clot formation. We have developed a method for detecting and monitoring blood coagulation and clot formation, said method enabling immediate intervention for clot destroying.

For the purpose of verification of (di)electric effects known for Naphtalin, water and polymers, oscillatory rheological measurements on coagulating blood have been combined with parallel electric measurement by means of an electrometer triggered by rheometer software as well as with parallel dielectric measurements.

Coagulation of blood being a viscoelastic liquid can be monitored by rheological measurements. Coagulation of blood as a biopolymer comprises formation of a haemostatic clot of fibrin. The measured electric signal coincide with curves characterising the coagulation of the blood probe, storage modulus for rheological measurements, and indicates start, progress and end of coagulation of the blood probe.

CPP 38.3 Fri 10:15 C 130

Competition of inertia and deformability - lateral motion of deformable particles in duct flow — •Timm Krüger, Badr Kaoui, and Jens Harting — Eindhoven University of Technology, Eindhoven, The Netherlands

The lateral motion of deformable particles in a planar Poiseuille flow has not been entirely understood. On the one hand, it is known that the deformability of particles (expressed by the capillary number, Ca, the ratio of viscous fluid and elastic particle stresses) promotes a migration towards the centerplane of the flow in the absence of inertia (zero Reynolds number, Re = 0). On the other hand, inertia effects are responsible for an outward migration of rigid particles (Ca = 0) close to the centerplane. We present 3D simulation results for systems with both finite Ca and Re and discuss the interplay of inertia and deformability effects.

CPP 38.4 Fri 10:30 C 130

Chromatographic, spectroscopic and rheological characterization of long chain branching induced by thermo-oxidative degradation of low-density polyethylene — •Victor Hugo Rolon-Garrido[1], Martin Zatloukal[2,3], and Manfred H Wagner[1] — [1]Chair of Polymer Engineering/Polymer Physics, TU Berlin, Fasanenstrasse 90, D-10623 Berlin, Germany — [2]Polymer Centre, Faculty of Technology, Tomas Bata University in Zlin, TGM 275, Zlin 76272, Czech Republic — [3]Centre of Polymer Systems, University Institute, Tomas Bata University in Zlin, Nad Ovcirnou 3685, 760 01 Zlin, Czech Republic

Low-density polyethylene was thermo-oxidatively degraded, i.e. degraded in the presence of air, by a one thermal cycle (1C) treatment during times between 30 and 90 minutes, and by a two thermal cycles (2C) treatment, i.e. after storage at room temperature an already previously degraded sample was further degraded during times between 15 and 45 minutes. Changes in the molecular weight distribution were detected by GPC and the intrinsic viscosity. Branching was confirmed by FTIR measurements. The enhanced strain hardening effect observed in uniaxial extension experiments presents a decisive evidence for an increased long-chain branching (LCB) content in both 1C and 2C samples. Elongational viscosity data were analyzed by the MSF and the Wagner-I model. It can be stated that elongational rheology is a powerful method to detect structural changes due to thermo-oxidative degradation.

CPP 38.5 Fri 10:45 C 130

Carbon dioxide plasticized polymer melts - An interpretation by means of the free volume concept — •Bernadette Duscher[1,2], Alois Schausberger[2], and Wolfgang Stadlbauer[1] — [1]Transfercenter für Kunststofftechnik GmbH, Franz-Fritsch Str. 11, A-4600 Wels — [2]Johannes Kepler University, Altenberger Str. 69, A-4040 Linz

CO_2 is a well established physical foaming agent for polymers. However, dissolving carbon dioxide under pressure strongly affects the rheological properties of the melt. The influence of pressure and of low molecular weight diluents ($M<M_c$) on the material functions are determined via oscillatory measurements. Therefore, a common plate-plate-system in a pressure cell is used. Relations based on the free volume concept are used to interpret the experimental results. In case of linear polymers (PS, PP) the time-concentration-superposition is simple. The mastercurve is created by shifting the dynamic moduli of the CO_2-diluted polymer melt to the dynamic moduli of the neat polymer. The shift factors obtained are corrected by the effect of pressure. In addition, by use of the generalized Doolittle relation the concentration dependent horizontal shift factors a_c are calculated. The rheological properties of carbon dioxide plasticized polymer melts as well as the molar plasticizing activity A of an additive can be predicted.

Independently of the horizontal shift a_c, an additional shift b_c on the modulus axis is found by a vanGurp-Palmen plot. The relation $b_c = w^2$ is applied and the vertical shifts are calculated. w is the weight fraction of the entangled polymer.

CPP 38.6 Fri 11:00 C 130

A sequence of physical processes determined and quantified in LAOS: A quantitative approach — •Simon Rogers — Forschungszentrum Jülich, Jülich, Germany

An entirely new way of analyzing linear and nonlinear oscillatory material responses is presented. The new quantitative sequence of physical processes (SPP) method is based on viewing generic nonlinear responses as sequences of 2D planes imbedded in a 3D space defined by the strain, strain-rate, and stress axes. Associated with each plane is a normal vector that wholly determines its orientation, which can be used to gain physically meaningful information by calculating the angles between a modified form of the normal vector and two reference vectors. Using this analysis technique, time-dependent phase and complex modulus, or dynamic modulus, information is obtainable throughout a period for arbitrary oscillatory responses. The new technique is applied to the Bingham plastic model, model power-law fluids, the Hershel-Bulkley model, and the nonlinear Giesekus model, to accustom the audience to its function.

CPP 38.7 Fri 11:15 C 130

Microscopic relaxation processes in branched/linear polymer blends by Rheo-Sans — •Nino Ruocco[1], Wim Pyckhout Hintzen[1], Aurel Radulescu[1], Dieter Richter[1], Peter Lindner[2], and Daniel Read[3] — [1]Forschungszentrum Jülich, JCNS-1, Jülich, Germany — [2]Institut Laue-Langevin, Grenoble, France — [3]Department of Applied Mathematics, University of Leeds, UK

The present study focuses on the hierarchical relaxation processes in a cayley-tree polymer, dispersed in linear polyisoprene (PI) using a Rheo-SANS combination. The introduction of branching points, which join different generations, and the dynamics of the embedding linear matrix have a huge impact in the dynamic relaxation spectrum. Molecular variables that are relaxed on the time scale of experiment and those, which are frozen or quenched, can be distinguished. Within a RPA treatment, taking into account the different degrees of freedom, the observed loss of anisotropy after a fast step strain can be correlated with the fast relaxation of the outer arms and a slow one for the inner section: a hierarchical relaxation from the tips inwards to the branching point leads to isotropization of the chain ends with loss of orientation in a diluted tube. Microscopic access to relaxation processes and the corresponding structural parameters is enabled through uniaxial step strain experiments at strain rates faster than their inverse relaxation time. The parameter space is scanned by appropriate SANS experiments in the respective time domains, which uniquely resolve the difficulties in extracting dynamics of the minority component from macroscopic rheology, which is dominated by the matrix.

CPP 38.8 Fri 11:30 C 130

Investigation of the Miscibility and Phase Separation of Molten PP/PE Blends via Rheometry — •Matthias Mihalic and Alois Schausberger — Institute of Polymer Science, Johannes-Kepler-Universität, A-4040 Linz, Austria

Rheometry is a powerful tool for the detection of phase separation in molten polymers and thus for the investigation of the solubility of each component in a mixture. The sample preparation for such measurements typically involves one or several crystallization steps, which in turn induce phase separation in the sample. Neither will this phase separation be balanced out by diffusion in the melt, nor is the rheometer suitable to be used as a compounder. Consequently, one might get somewhat distorted results. Therefore it seems desirable to avoid any crystallization between the compounding and the rheological characterization of a blend.

To this end, an experimental set-up was designed such that after compounding, the molten blends are directly injected into the measuring cell of a rheometer, where the dynamic moduli are determined.

In case of miscibility, the relaxation time spectrum of a blend can be simply calculated from the combined molar mass distributions of the components. Otherwise, phase separation will be reflected in the spectrum of the mixture obtained from dynamic mechanical data. The measurement results are further analyzed using the model of Gramespacher and Meissner in order to gain information about the phase structure of the blend. In addition, by preparing blends of different concentrations, the boundaries of miscibility are checked.

CPP 38.9 Fri 11:45 C 130

Influence of carbon dioxide on the viscoelastic properties of polystyrene melts — •Ulrich A. Handge[1,2] and Volker Altstädt[1] — [1]Department of Polymer Engineering, Faculty of Engineering Science, University of Bayreuth, Universitätsstraße 30, 95447 Bayreuth — [2]Helmholtz-Zentrum Geesthacht, Institute of Polymer Research, Max-Planck-Strasse 1, 21502 Geesthacht

The addition of carbon dioxide to polystyrene strongly influences the viscoelastic properties of polystyrene. Carbon dioxide is dissolved in the polymer matrix and acts as a plasticizer. Generally, the glass transition temperature and the viscosity of polystyrene/carbon dioxide solutions decrease with increasing carbon dioxide concentration. In this work, the linear viscoelastic properties of solutions of polystyrene melts with carbon dioxide are investigated. A rotational rheometer which is equipped with a pressure cell allows one to perform experiments using a plate-plate rheometry. The pressure cell can be filled with the blowing agent carbon dioxide, and torque and normal force are transferred via a magnetic coupling to the measurement head of the rheometer. We study the transient shear rheology and test superposition principles of the rheological properties with respect to time, temperature, pressure and concentration of the blowing agent. These measurements allow us to analyze the linear viscoelastic properties of polystyrene/carbon dioxide solutions, in particular the influence of carbon dioxide on the average relaxation time of polystyrene. Our data indicate that glass transition temperature and average relaxation time of polystyrene are strongly influenced by the addition of carbon dioxide.

CPP 38.10 Fri 12:00 C 130

An in-situ investigation of the draw resonance phenomenon in film casting of a polypropylene melt — Teodor Burghelea[1], Hans Jurgen Griess[2], and •Helmut Muenstedt[2] — [1]Universite de Nantes, Nantes Atlantique Universites, CNRS, Laboratoire de Thermocinetique de Nantes, UMR 6607, La Chantrerie, Rue Christian Pauc, B.P. 50609, F-44306 Nantes Cedex 3, France — [2]Institute of Polymer Materials, Friedrich-Alexander-University Erlangen-Nu *rnberg, D-91058 Erlangen, Germany

An experimental investigation of the stability of the casting process of a polypropylene film is presented. Several flow regimes are identified: stable, oscillatory and chaotic. Measurements of the velocity distribution along and across the extruded film corresponding to each drawing regime are presented. The intermittent physical rupture of the film's edges observed within the chaotic drawing regime is explained by the emergence of a "V - shaped" region of high axial gradients of the axial velocity component which indicates a highly inhomogeneous distribution of tensile stresses. By measurements of the statistics of the fluctuations of both the film's width and velocity a continuous (second order) imperfect bifurcation towards oscillatory states is found. The fluctuation data acquired before the chaotic regime is reached can be fitted by the stationary Landau-Ginsburg equation. The observation of a stable limit cycle at the onset of the bifurcation identifies it as a supercritical Hopf bifurcation. The experimentally found scaling of the onset and amplitude of the bifurcation with the Weissenberg number indicates that elasticity destabilizes the drawing process.