

CPP 48: (Hydro)gels and Elastomers

Time: Friday 9:30–12:00

Location: H39

Invited Talk

CPP 48.1 Fri 9:30 H39

The distribution of segmental order in polymer networks — ●MICHAEL LANG¹ and JENS-UWE SOMMER^{1,2} — ¹Leibniz Institut für Polymerforschung Dresden, Hohe Straße 6, 01069 Dresden — ²Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden

The monomer fluctuations and the distribution of segmental order is derived for a slip tube model of polymer entanglements assuming random walk statistics of the tube sections [M. Lang, J.-U. Sommer, *Physical Review Letters* 104 (2010) 177801]. The predictions are compared with simulation data of model networks that were created using the bond fluctuation method. The comparison reveals that local fluctuations of the tube statistics do not affect the distribution function as averaged over the full sample. Instead, length fluctuations of the confining tube control the shape of the distribution function. Furthermore, a narrowing of the distribution function is determined, if the cross-linking occurs on the time scale of the relaxation of the network strands. Almost instantaneously cross-linked poly-disperse samples do not show this narrowing and are well described by tube length fluctuations that agree to previous work on the dynamics of melts of star polymers. The difference between the stress optical law and the time average segment orientations is discussed and our results are compared to previous simulation studies in literature.

CPP 48.2 Fri 10:00 H39

Local chain deformation and stress distributions in strained elastomers — MARIA OTT¹, ROBERTO PÉREZ-APARICIO², HORST SCHNEIDER¹, PAUL SOTTA², and ●KAY SAALWÄCHTER¹ — ¹Institut f. Physik-NMR, Martin-Luther-Univ. Halle-Wittenberg, Betty-Heimann-Str. 7, D-06120 Halle, Germany — ²Laboratoire Polymères et Matériaux Avancés, CNRS/Rhodia, Saint Fons, France

Macroscopic strain applied to elastomeric networks induces changes in the orientation fluctuations of the chain segments [1]. This effect can be used to study the local stretching of elastically active chains by suitable NMR methods [2]. Importantly, the method also reveals inhomogeneities, i.e., distributions in local stress, which is particular relevant for elastomers filled with (nano)particles. We have studied a series of natural rubber samples with different cross-link densities and amounts of filler particles. The data is incompatible with predictions of the well-established affine-Gaussian model [3], but can be reproduced on the basis of more recent treatments of the local deformation based upon the tube and phantom models. For the first time, we demonstrate the existence of matrix overstrain in commercially relevant filled elastomers in agreement with simple hydrodynamic predictions.

- [1] J.-U. Sommer et al., *Phys. Rev. E* 78, 051803 (2008)
 [2] K. Saalwächter, *Prog. Nucl. Magn. Reson.* 51, 1-35 (2007)
 [3] P. Sotta, B. Deloche, *Macromolecules* 23, 1999-2007 (1990)

CPP 48.3 Fri 10:15 H39

Elastic properties of squeezed spheres made of superabsorbers — ●THOMAS JOHN and CHRISTIAN WAGNER — Experimentalphysik, Universität des Saarlandes

Superabsorbent polymers may absorb pure water up to 500 times its weight. Granulates of mm size can swell up to perfect spheres with up to 20 mm in diameter. The perfect spherical symmetry may be a combination of surface tension and inner pressure. Compressing of the spheres between two plates yields a force-strain relation. We present a model to calculate this force strain relation. The model conserves the volume and the restoring force is caused by the change of surface area made from the deformation. This is opposite to the Hertzian theory in contact mechanics, within the elastic modulus of the material plays the important role. Our model calculations are compared with experimental obtained force-strain data.

- [1] Lu, W.-M. et al, *Powder Technology* 116, 1, (2001). [2] Lin, Y.-L. et al, *Chemical Engineering Science* 63, 195, (2008).

CPP 48.4 Fri 10:30 H39

Investigation of a multiresponsive hydrogel based on poly(methoxydiethylenglycol acrylate) (PMDEGA) with azobenzene moieties — ●DAVID MAGERL¹, DAVID EGGER¹, ANNA MIASNIKOVA², ANDRÉ LASCHEWSKY², CHRISTINE M. PAPADAKIS¹, and PETER MÜLLER-BUSCHBAUM¹ — ¹TU München, Physik Depart-

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Stimuli-responsive hydrogels are of increasing interest because of their use in a variety of applications such as drug-delivery and sensors. In this context hydrogels that are responsive to one external stimulus like temperature, as it is the case for poly(methoxydiethylenglycol acrylate) (PMDEGA), are widely studied. [1] By addition of moieties of azobenzene groups to form a statistical copolymer, a second stimulus, namely light, can be added to the system.

In this study we are investigating in the complex interplay between the temperature and light sensitive properties in the P(MDEGA-stat-azoMDEGA) system with varied azoMDEGA content. Dynamic light scattering is used to probe the hydrodynamic radius in aqueous solutions. On the other hand, white light interferometry gives access to the time-resolved swelling behavior in thin films at the presence of a water vapor atmosphere.

- [1] Zhong, Q., et al., *Soft Matter*, 2012. 8(19): p. 5241-5249.

CPP 48.5 Fri 10:45 H39

Evaluation of Fluorophore-Functionalized Thermoresponsive Copolymers for Sensor Applications — ●SAHIKA INAL¹, JONAS D. KÖLSCH², LEONARDO CHIAPPISI³, DIETMAR JANIEZ⁴, MICHAEL GRADZIELSKI³, ANDRÉ LASCHEWSKY², and DIETER NEHER¹ — ¹Inst. of Physics and Astronomy, Univ. of Potsdam, Germany — ²Dept. of Chemistry, Univ. of Potsdam, Germany — ³Stranski-Laboratory, Dept. of Chemistry, TU Berlin, Germany — ⁴Fraunhofer Inst. for Applied Polymer Research, Potsdam, Germany

Water-soluble polymers respond to changes in solution temperature by altering their conformation [1]. Although the fundamental mechanisms leading to these solubility transitions are comparable for the most studied LCST-type polymers, e.g., poly(N-isopropylacrylamide) (pNIPAm) and oligo(ethylene glycol) methacrylate (OEGMA) based copolymers, each type of polymer backbone has a peculiar solvation behavior and experiences different changes in the micro-environment upon phase transition. Here, we investigate the solubility transition behavior of NIPAm- and OEGMA-based copolymers bearing a dye-functionalized comonomer through their temperature-dependent photophysical properties. With the polarity-sensitive dye incorporated to the side chains, the emission spectra of these copolymers are expected to undergo similar changes upon phase transition. However, the two dye-labeled polymers exhibit rather different fluorescence responses, pointing to particular solvation properties of acryl amide and ethylene oxide based polymers, and rendering them useful for different sensing strategies. [1] V. O. Aseyev et al., *Adv. Polym. Sci.* 2006, 196, 85.

CPP 48.6 Fri 11:00 H39

Immobilization of water soluble peroxidase within p-NIPAM microgel particles for the usage in organic solvents — ●KORNELIA GAWLITZA¹, RADOSTINA GEORGIEVA², and REGINE VON KLITZING¹ — ¹Stranski-Laboratorium, Institut für Chemie, Technische Universität Berlin — ²Charité Universitätsmedizin Berlin, Department of Enzyme Technology

Enzymes are of high research interest in the field of catalysis. To reach a high stability in the presence of organic solvents, enzymes can be immobilized within a polymer matrix. Microgel particles made of poly- N-isopropylacrylamide (p-NIPAM) are promising as polymer matrix due to their reversible shrinking above the volume phase transition temperature (VPTT). In this study, large p-NIPAM microgels with a cross-linker content of 0.25% were synthesized via surfactant free emulsion polymerization using a temperature ramp[1]. The polymer particles were characterized by Dynamic Light Scattering (DLS) and Atomic Force Microscopy (AFM). Afterwards, water soluble peroxidase was immobilized within the polymer network using a solvent exchange from polar to organic solvents[2],[3]. The immobilized system shows an enhanced activity in isopropanol and the localization of the enzymes has been proven by confocal laser scanning microscopy (CLSM). [1] Meng, Z.; Smith, M. H.; Lyon, L. A. *Colloid. Polym. Sci.* 2009, 287, 277. [2] Gawlitza, K.; Wu, C.; Georgieva, R.; Wang, D.; Ansorge-Schumacher, M.-B.; Klitzing, v. R. *Phys. Chem. Chem. Phys.* 2012, 14, 9594. [3] Gawlitza, K.; Wu, C.; Georgieva, R.; Ansorge-Schumacher, M.-B.; Klitzing, v. R. *Z. Phys. Chem.* 2012,

CPP 48.7 Fri 11:15 H39

Mechanical properties of magneto-sensitive elastomers: microscopic theory versus continuum-mechanics approach — ●DMYTRO IVANEYKO^{1,2}, VLADIMIR TOSHCHÉVIKOV², MARINA SAPHIANNIKOVA², and GERT HEINRICH^{1,2} — ¹Technische Universität Dresden — ²Leibniz-Institut für Polymerforschung Dresden e.V.

We compare predictions of continuum-mechanics approach and our microscopic theory [1,2] for the mechanical behaviour of magneto-sensitive elastomers (MSEs) under a uniform external magnetic field. The continuum-mechanics approach is based on the calculation of deformation-dependent demagnetization factor and predicts the elongation of MSEs. The microscopic theory explicitly considers the point-like dipole interactions between magnetic particles and gives a different sign of the magnetostriction depending on the spatial distribution of particles [1,2]. Also, the sample shape plays an essential role in the mechanical properties of MSEs. We show that the microscopic theory predicts the same results as continuum-mechanics approach in the case of ellipsoidal MSE samples with isotropic particle distributions. Moreover, the values of demagnetization factor are found to be the same for stochastic and isotropic lattice distributions. They change however considerably for chain-like particle distributions. Generalization of the continuum-mechanics approach for the case of anisotropic particle distributions is currently in progress.

[1] D. Ivaneyko et al., *Macromolecular Theory and Simulations* 20, 411 (2011).

[2] D. Ivaneyko et al., *Condensed Matter Physics* 15, 33601(2012).

CPP 48.8 Fri 11:30 H39

Computer Simulations of Magnetic Gels — ●RUDOLF WEEBER¹, SOFIA KANTOROVICH^{2,3}, and CHRISTIAN HOLM¹ — ¹Institut fuer Computerphysik, Universitaet Stuttgart, Allmandring 3a, 70569 Stuttg — ²Sapienza, University of Rome, Iazza A. Miro 5, 00185 Italy — ³Ural Federal University, Lenin Av. 51, Ekatarinburg, 620083 Russia

Magnetic gels consist of magnetic nano-particles embedded in a cross-linked polymer network. They have potential applications ranging from medicine to engineering, e.g., drug release systems and artificial muscles. These applications rely on the combination of the mechanical properties of the polymer network with the ability to modify and

control the sample with external magnetic fields due to the embedded magnetic nano-particles.

Today, many aspects of the synthesis of ferrogels are understood and the properties of gels can be characterized and tailored. However, many questions concerning the microstructure and its influence on macroscopic properties of magnetic gels are still open. Here computer simulations can help since they allow to study simplified model systems which focus on certain characteristic features of the material.

In this contribution we present a computer model for a gel, which is cross-linked by magnetic nano-particles. When the nano-particles orient to align to an external field, they drag the polymer chains attached to them and thereby deform the gel. In the presentation, we will explore the deformation mechanism in two and three dimensions as well as the elastic properties of the system.

CPP 48.9 Fri 11:45 H39

Large-strain detection using elastomeric sensors — ●TINA MEISSNER, MATTHIAS KOLLOSCHÉ, and REIMUND GERHARD — Universität Potsdam, Institut für Physik und Astronomie, Potsdam, Germany

Electroactive polymers (EAP) and soft stretchable conductors have been studied extensively to develop voltage-tunable dielectric elastomer actuators (DEA) that can achieve large deformations at low voltage. However, the advantages of this DEA technology can also be used for strain-sensing solutions. While conventional strain sensors, e.g. made of piezoelectric materials, are limited to strains not exceeding 2 to 3% due to their mechanical properties, elastomeric sensors are able to detect both small and large strains, up to 300%. Furthermore, they offer the advantages of high sensitivity in the low-stress regime, fast response times, low power consumption, and good weathering stability.

The proposed capacitive strain sensor consists of a dielectric elastomer film sandwiched between highly stretchable polymeric electrodes. Its functional principle is based upon the coupling between mechanical deformations and changes in the sensor's capacitance. We present experimental strategies to enable large reversible mechanical deformations as well as the use of ceramic/polymer nano-composites and molecular composites to adjust strain sensitivity and durability. One potential application is demonstrated on large-scale experiments: the sensor serving as a diagnostic tool for the structural health of infrastructural facilities.