

## CPP 3: Focus: Structure and Dynamics of Responsive Hydrogels I

Time: Monday 10:15–12:45

Location: H37

**Invited Talk**

CPP 3.1 Mon 10:15 H37

**Interactive hydrogels** — ●WALTER RICHTERING — Physical Chemistry, RWTH Aachen University, Aachen, Germany

With macroscopic and microscopic hydrogels it is possible to prepare stimuli sensitive materials that are able to adapt to their environments. We will present examples illustrating how hydrogen bonding and charge interaction can be used to tune properties of hydrogels and microgels both in the bulk and at oil - water interfaces.

CPP 3.2 Mon 10:45 H37

**Structure of thermoresponsive polymer hydrogels** —

●CHRISTINE M. PAPADAKIS<sup>1</sup>, JOSEPH ADELSBERGER<sup>1</sup>, AMIT KULKARNI<sup>1</sup>, ABHINAV JAIN<sup>1</sup>, ANDREAS MEIER-KOLL<sup>1</sup>, WEINAN WANG<sup>1</sup>, ACHILLE M. BIVIGOU-KOUMBA<sup>2</sup>, ANDRÉ LASCHEWSKY<sup>2</sup>, and PETER MÜLLER-BUSCHBAUM<sup>1</sup> — <sup>1</sup>TU München, Physikdepartment E13, Garching — <sup>2</sup>Universität Potsdam, Institut für Chemie

Thermoresponsive polymer gels display strong changes in volume when heated above the lower critical solution temperature (LCST). They are thus attractive candidates for e.g. controlled ultrafiltration.

We investigate thermoresponsive polymer hydrogels based on poly(N-isopropyl acrylamide) (PNIPAM) with the focus on the influence of polymer architecture on the morphology. PNIPAM homopolymers as well as diblock and triblock copolymers with a longer PNIPAM block and hydrophobic polystyrene (PS) end blocks are investigated [1]. Structural studies were carried out using mainly small-angle neutron and X-ray scattering (SANS). The homopolymers form a transient gel, whereas the diblock copolymers form a jammed solution of core-shell micelles and the triblock copolymers physically cross-linked micellar networks. The latter constitute an attractive alternative to chemically crosslinked networks.

1. K. Troll, C. M. Papadakis, et al., *Colloid Polym. Sci.* 2008, 286, 1079. A.M. Bivigou Koumba, A. Laschewsky, et al., *Macromol. Chem. Phys.* 2009, 210, 565. A. Jain, C. M. Papadakis et al., *Macromol. Symp.*, accepted.

CPP 3.3 Mon 11:00 H37

**Salty Microgels – Smart Microgels in Presence of the Hofmeister Series** —

●MICHAEL ZEISER<sup>1,2</sup>, YVONNE HERTLE<sup>1,2</sup>, PETER BUSCH<sup>3</sup>, and THOMAS HELLWEG<sup>1,2</sup> — <sup>1</sup>University of Bayreuth, 95440 Bayreuth, Germany — <sup>2</sup>Bayreuth Center for Colloids and Interfaces, 95440 Bayreuth, Germany — <sup>3</sup>Jülich Center for Neutron Science, Forschungs-Neutronenquelle Heinz Maier-Leibnitz, 85747 Garching, Germany

The nature of individual ion properties, so called Hofmeister effects, play a significant role within natural mechanisms. Foaming of ocean water, secondary effects on protein structures and crystallization are just few examples among many.

*Smart* microgels are networks of colloidal size which are able to respond to external stimuli, such as temperature, by a change in their colloidal dimension. At a certain critical value the particles undergo a volume phase transition. Tuning this volume phase transition can be implemented by changing the chemical composition, solvent etc.. In this study we explored the influence of certain ions on two different thermoresponsive microgel systems. We probed structures and dynamics on different length scales by the usage of different light scattering techniques and small angle neutron scattering.

CPP 3.4 Mon 11:15 H37

**on the finite-extensibility effect of a single polymer chain** —

●BING MIAO<sup>1</sup>, THOMAS A. VILGIS<sup>1</sup>, STEFANIE POGGENDORF<sup>2</sup>, and GABRIELE SADOWSKI<sup>2</sup> — <sup>1</sup>Max-Planck-Institute for Polymer Research, Mainz, Germany — <sup>2</sup>Laboratory of Thermodynamics, Department of Biochemical and Chemical Engineering, Technische Universität Dortmund, Dortmund, Germany

We investigate the finite-extensibility effect on the equilibrium size of a single polymer chain by using a Flory-type calculation. A divergence in the elastic free energy of the polymer chain is introduced to take into account the finite-extensibility. This is of particular importance when considering swelling of polymer networks which is constrained by the finite-extensibility of the polymers. From the analysis of our model, finite-extensibility effect is quantified. Compared to the results of Flory's classic theory, finite-extensibility reduces the equilibrium size

of the chain and this effect becomes important for short chains and/or when there exists strong repulsive interaction between monomers of the chain. A typical system of this type is the highly-charged and highly-crosslinked gel.

CPP 3.5 Mon 11:30 H37

**New pNIPAM microgels for immobilization of proteins** —

●KORNELIA GAWLITZA, MARCEL RICHTER, and REGINE VON KLITZING — TU Berlin, Stranski-Laboratorium, Strasse des 17. Juni 124, 10623 Berlin, Deutschland

Poly-N-isopropylacrylamide (pNIPAM) belongs to the group of the so called “smart“ hydrogels and is one of the most studied water swellable microgel systems. Due to the reversibility of the volume phase transition at around 32°C, pNIPAM is qualified for applications like drug delivery and biocatalysts.<sup>1,2</sup>

In our studies, we synthesized new pNIPAM microgels with suitable properties to reach an immobilization of proteins and hence a new biocatalyst. Therefore, we followed two different strategies: First, we tried to synthesize big hydrogels and second, we used the new comonomer Allylglycine (AG) as anchor points for the enzyme. The characterization of the synthesized microgels was done by Dynamic Light Scattering (DLS) and Atomic Force Microscopy (AFM).

Furthermore, we used the received pNIPAM hydrogels for some immobilization experiments with BSA.<sup>3,4</sup> The following analysis of this experiments was done using the Bradford-assay in combination with fluorescence spectroscopy.

[1] K. Kratz, T. Hellweg, W. Eimer, *Polymer* (2001), 42, 6531 [2] R. Pelton, *Adv. Colloid Interface Sci.* (2000), 85, 1 [3] L. Bromberg, M. Temchenko, T. A. Hatton, *Langmuir* (2003), 19, 8675 [4] C. Yan, A. Elaissari, C. Pichot, *J. Biomed. Nanotechnol.* (2006), 2(3/4), 208-216

CPP 3.6 Mon 11:45 H37

**Temperature sensitivity of colloidal gels measured by multi-speckle DLS** —

●MARTIN MEDEBACH, MICHAEL GRADZIELSKI, and REGINE V. KLITZING — Stranski Laboratory, Technische Universität Berlin, Strasse des 17. Juni 124, 10623 Berlin

We investigated the dynamical behaviour of colloidal systems by the multispeckle DLS method. The multispeckle method is useful to measure the correlation function on a time regime of  $\tau=0.1$  seconds up to several days. It also provides the possibility to measure time resolved dynamics. Using this method it was found in the past that vesicle gels behaves heterogeneous. In our measurements we could also verify that vesicle gels react sensitive on temperature changes. This could also be the reason of the temporal fluctuations that are visible in distinct  $\tau$ -channels. This temperature sensitivity was checked in more detail by applying temperature pulses of different amplitudes. The T-sensitivity depends on particle concentration and on how strong the noise is correlated at the measured  $\tau$ -channel. A system that reacts very sensitive on temperature changes are concentrated PNIPAM microgel particles. The phase transition is detected by the multispeckle method and shows a slowing down of the dynamics at the LCST and a minimum of the noise in the  $\tau$ -channels. On higher scattering vectors it was possible to do the multispeckle correlation on length scales smaller than the particle size. Here, the fluctuations inside of a particle could be detected at different temperatures.

CPP 3.7 Mon 12:00 H37

**Smart Biocompatible Hydrogels constructed with oligo(ethylene glycol) (macro)monomers** —

JEAN-FRANCOIS LUTZ<sup>1</sup> and ●ANDRÉ LASCHEWSKY<sup>2</sup> — <sup>1</sup>Fraunhofer Institute for Applied Polymer Research, Potsdam — <sup>2</sup>University of Potsdam

The main target of our research is to develop novel intelligent polymeric materials for bio-applications. Indeed, synthetic polymers play a key-role in various areas of modern medicine and biotechnology (e.g. bioseparation, controlled drug release, non-viral gene delivery, diagnostics, implants). However, paradoxically, only a few established polymer structures (e.g. PEG, PEI, PLGA, PNIPAM) have been so far widely used in Life Science. In this context, developing new generations of “bio-relevant” macromolecules is an extremely important target, both from a fundamental and technological point of view.

A good example of our synthetic work is our recent design of thermoresponsive polymers based on oligo(ethylene glycol)

(macro)monomers. The stimuli-responsive behavior of these new polymers can be precisely controlled by simply varying their molecular structure. Moreover, in comparison to standard thermoresponsive polymers (e.g. PNIPAM) these novel structures possess the advantage to exhibit a reversible phase transition. Hence, we are currently evaluating the potential of these novel biocompatible polymers in various bio-applications. In the present talk, the relevance of this new class of thermoresponsive macromolecules for preparing physically or chemically-crosslinked hydrogels will be discussed.

**Invited Talk**

CPP 3.8 Mon 12:15 H37

**Dynamics of thermosensitive microgel particles** — ●MATTHIAS BALLAUFF — Soft Matter and Functional Materials, Helmholtz-Zentrum Berlin

We present a survey on recent studies on the dynamics of thermosensitive microgels in aqueous solution. The particles consist of a solid polystyrene core onto which a shell of crosslinked poly(N-isopropylacrylamide) (PNIPA) is grafted. As cores we use spherical

particles as well as dumbbell-shaped colloids consisting of two spheres attached to each other. Depolarized dynamic light scattering (DDLS) gives quantitative information about the translational and rotational diffusion coefficient (1). The volume fraction of these particles can be adjusted by the temperature of the system in a continuous fashion. This allows us to study the rheology of such suspension up to high volume fractions. The moduli  $G'$  and  $G''$  in the linear viscoelastic regime as well as the flow curves as the function of the shear rate are found to be in good agreement with the predictions of mode-coupling theory (2).

1. S. Bolisetty, M. Hoffmann, S. Lekkala, Th. Hellweg, M. Ballauff, L. Harnau, Coupling of Rotation Motion with Shape Fluctuations of Core-Shell Microgels Having Tunable Softness, *Macromolecules* 2009, 42, 1264-1269

2. M. Siebenbürger, M. Fuchs, H. H. Winter, M. Ballauff, Viscoelasticity and shear flow of concentrated, noncrystallizing colloidal suspensions: Comparison with mode-coupling theory, *J. Rheol.* 2009, 53, 707-726