CPP 9: Poster: Biopolymers and Biomaterials

Time: Monday 17:30–19:30 Location: P2

CPP 9.1 Mon 17:30 P2

AFM Micromechanics on Spheres and Capsules from Engineered Spider Silk — •Martin Peter Neubauer[1], Claudia Blüm[2], Thomas Scheibel[2], and Andreas Fery[1] — [1]Department of Physical Chemistry II, University of Bayreuth, Germany — [2]Department of Biomaterials, University of Bayreuth

Spider dragline silk exhibits astonishing mechanical properties combining high tensile strength and elasticity. Scheibel et al. were able to biochemically synthesize and engineer the crucial proteins accounting for the characteristic features of natural spider silk. Thus, it was possible to create a variety of structures such as spheres, capsules, hydrogels, fibers and films. Future applications are seen e.g. in the field of tissue scaffolds, biocompatible coatings or drug delivery [1].

Our aim is to perform force spectroscopy experiments in order to come to a profound understanding of the mechanical properties of these new materials. As main device we are using the atomic force microscope (AFM). The colloidal probe setup allows for single sphere/capsule measurements providing us with valuable and precise information about the response of the investigated systems to a defined mechanical stress. In addition to parameters like sample stiffness or adhesion it is also possible to monitor the release behaviour of capsules as a function of the applied force. Therefore, the classic AFM is combined with a fluorescence microscope [2].

[1] J.G. Hardy, L.M. Römer, T.R. Scheibel, Polymer, 49, 4309, (2008)

[2] P.A.L. Fernandes, M. Delcea, A.G. Skirtach, H. Möhwald, A. Fery, Soft Matter, 6, 1879, (2010)

CPP 9.2 Mon 17:30 P2

Surface characterization of cellulose films and pulp by atomic force microscopy — •Christian Ganser[1,3], Oliver Miskovic[1,3], Franz Schmied[1,3], Robert Schennach[2,3], and Christian Teichert[1,3] — [1]Institute of Physics, University of Leoben, Franz Josef Straße 18, 8700 Leoben, Austria — [2]Institute of Solid State Physics, Graz University of Technology, Petersgasse 16/2, 8010 Graz, Austria — [3]CD-Laboratory for Surface Chemical and Physical Fundamentals of Paper Strength, Graz University of Technology, Petersgasse 16/2, 8010 Graz

To obtain a deeper insight into the binding mechanisms of pulp fibers in a fiber network, an atomic force microscopy (AFM) investigation was performed on cellulose films and single pulp fibers. A chemical modification of cellulose films via spincoating of hemicellulose was performed to modify the binding strength. A comprehensive roughness characterization after spincoating revealed the morphological influence.

Further, the morphology under wet and ambient conditions was investigated to follow the drying process of the pulp fibers during the production cycle on a paper machine. Here, the swelling and dewetting of single pulp fibers is studied to simulate such a cycle and to monitor morphological changes.

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CPP 9.3 Mon 17:30 P2

The Salvinia effect: Measuring the water adhesion on structures of biological air retaining surfaces — •Daniel Gandyra[1], Matthias Mail[1], Aaron Weis[1], Anke Kaltenmaier[1], Matthias Barczewski[1], Stefan Walheim[1], Kerstin Koch[4], Martin Brede[3], Alfred Leder[3], Holger Bohn[2], Wilhelm Barthlott[2], and Thomas Schimmel[1] — [1]Institute of Applied Physics, Institute of Nanotechnology, and Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology — [2]Nees-Institut for Biodiversity of Plants, University of Bonn — [3]Lehrstuhl Strömungsmechanik, Fakultät für Maschinenbau und Schiffstechnik, University of Rostock — [4]Biologie und Nanobiologie, Hochschule Rhein-Waal

A novel mechanism for long-term air retention under water is found in the sophisticated surface design of the water fern Salvinia. Its floating leaves are evenly covered with complex hydrophobic hairs retaining a layer of air when submerged under water. Surprisingly the terminal cells of the hairs are hydrophilic. These hydrophilic patches stabilize the air layer by pinning the air*water interface [1]. This *Salvinia Effect* provides an innovative concept to develop biomimetic surfaces with long-term air-retention capabilities for under water applications. In order to understand this stabilization effect one has to measure the water adhesion of those structures. We show a novel method to determine the water adhesion on those surfaces.

[1] Barthlott, W.; Schimmel, T. et al.: The Salvinia paradox: superhydrophobic surfaces with hydrophilic pins for air-retention under water. Advanced Materials 22, 2325-2328, 2010.

CPP 9.4 Mon 17:30 P2

Wrinkling of cross-linked semiflexible polymer networks — •Pascal Müller and Jan Kierfeld — Physics Department, TU Dortmund, Dortmund

Filamentous protein networks and their elastic properties play an important role in cell mechanics. We simulate regular and random two-dimensional networks of crosslinked semiflexible rods in order to gain a basic understanding of wrinkling, which occurs when such networks of semiflexible polymers are sheared. Although the initial configurations are strictly two-dimensional, displacement into the third dimension results in lower energies compared to flat networks and leads to the formation of wrinkles under shear.

We find that amplitude and wavelength of wrinkles are determined by stiffness and bending rigidity of the rods as well as global parameters like the density of the network and the applied shear stress.

CPP 9.5 Mon 17:30 P2

Star-PEG-Heparin-Polyelectrolyte-Hydrogels - Experiment, Theory, and Simulation — •Ron Dockhorn[1,2], Jens-Uwe Sommer[1,2], Uwe Freudenberg[1], Petra B. Welzel[1], Kandice Levental[1], and Carsten Werner[1] — [1]Leibniz Institute of Polymer Research Dresden, D-01069 Dresden, Germany — [2]Technische Universität Dresden, Institute for Theoretical Physics, D-01069 Dresden, Germany

We are studying a new class of biohybrid networks made of heparin, a rod-like highly charged glycosaminoglycan, and non-charged, elastic 4-star-shaped-polyethylene glycol by using experiment, theory, and simulation. We focus on the network structure by simulations and determine the defects, the functionality of heparin, and percolation threshold of the gels. Also, we develop a mean-field type model to understand the combined effects of counterions and a good solvent on the swelling properties of the gels. It has been shown that this interplay lead to nearly constant heparin concentration in the swollen gel under physiological conditions, independent of the mole-fraction at preparation while allowing large variations of the degree of swelling and storage modulus. Furthermore, we are able to predict the degree of swelling and heparin level for different molar masses of the building blocks allowing a rational design of the hydrogels. This opens the possibility to synthesize gels which allow a constant release of heparin-binding signaling molecules while independently controlling the mechanical properties to optimize matrices with both mechanical and biomolecular cues for cell replacement-based therapies.

CPP 9.6 Mon 17:30 P2

Protein reentrant condensation induced by Fe^{3+} and Al^{3+} — •Felix Roosen-Runge[1], Benjamin Heck[1], Fajun Zhang[1], Maximilian W. Skoda[2], Robert Jacobs[3], and Frank Schreiber[1] — [1]Institut für Angewandte Physik, Universität Tübingen — [2]ISIS, Rutherford Appleton Laboratory, United Kingdom — [3]Department of Chemistry, University of Oxford, United Kingdom

Several globular proteins has been found to show reentrant phase behavior upon adding the trivalent salt Y^{3+}, i.e. they aggregate for intermediate salt concentrations but occur in stable solution both at high and low salt concentrations [1]. Here we report on results for the physiological salts Al^{3+} and Fe^{3+} for the model protein *bovine serum albumin* (BSA). From zeta potential measurements we observe a charge inversion driven by binding of salt ions on the protein surface, which clearly goes beyond the effect due to pH-change of the solution. Small-angle X-ray scattering (SAXS) provides further information on protein shape and interactions. We observe conformational changes for BSA at different salt conditions. While at low salt concentrations electrostatic repulsion dominates the interaction, this interaction is lost in the aggregation regime. For high salt concentrations charge stabilization is recovered. The findings imply a universality of the phenomenon of

reentrant condensation in protein systems, pointing towards new paths of controlling the protein phase behavior.

[1] F. Zhang et al., Phys.Rev.Lett. 101, 148101 (2008); F. Zhang et al., Proteins 78, 3450 (2010)

CPP 9.7 Mon 17:30 P2

Broadscale examination of the influence of disorder on semiflexible polymers — •Sebastian Schöbl, Klaus Kroy, and Wolfhard Janke — Institut für Theoretische Physik, Universität Leipzig

The structure and behaviour of biological cells is essentially affected by the biomechanical properties of semiflexible polymers. In the form of networks, such as the cytoskeleton, they build up the basic scaffold of eukaryotic cells.

In order to study the mechanical properties of these highly complex systems, both interactions of the polymer with the surrounding network and further perturbing influences have to be taken into account. We investigate the equilibrium structure of semiflexible polymers in different potential landscapes by Monte Carlo simulations. The resulting properties over a wide parameter range with respect to both polymer stiffness and volume fraction of the background potential are presented. The observables taken into account are radius of gyration, end-to-end distribution, tangent-tangent-correlations and curvature distribution.

CPP 9.8 Mon 17:30 P2

Shear-flow enhanced conformational fluctuations of single-tethered DNA molecules — •Katrin Günther, Kristin Laube, and Michael Mertig — Technische Universität Dresden, Institut für Physikalische Chemie, Mess- und Sensortechnik, 01069 Dresden, Germany

Several processes in life science and nanotechnology involve the transport and manipulation of long polymers. Due to its self-recognizing and self assemling properties in conjunction with its variability in length, DNA is a useful target for verifying theoretical polymer models.

Our work focuses on analysing the thermal fluctuations of single, surface-tethered DNA molecules in hydrodynamic shear flow by fluorescence microscopy. Instead of staining DNA with conventional intercalating fluorescent dyes, known to modify DNA properties, we use quantum dots for marking and observing the free end. Conformational transformations at particular shear rates are related to the morphology model of Brochard-Wyart.

CPP 9.9 Mon 17:30 P2

Forces of Interaction between Blank, Grafted and Blank-Grafted Colloids by Using Optical Tweezers — •Tim Stangner, Christof Gutsche, Mahdy M. Elmahdy, and Friedrich Kremer — Institut für Experimentelle Physik I, 04103 Leipzig, Deutschland

Optical tweezers are experimental tools with extraordinary resolution in positioning (+/- 1 nm) a micron-sized colloid and in the measurement of forces (+/- 50 fN) acting on it - without any mechanical contact. Here, we report the direct measurements of the interactions between blank, grafted and blank-grafted colloids across three types of salts different in their valence (KCl, CaCl2, and LaCl3). The forces are repulsive at all measured distances in all three cases, decaying with distance and showed valency dependence. For the symmetric blank colloids (SiO2), the experimental data are well described by the Derjaguin-Landau-Verwey-Overbeek (DLVO) theory revealing that the effective colloidal charge decreases with increasing counterions valence. In the case of symmetric grafted colloids (SiO2 grafted with poly(acrylic acid)), the data are quantitatively described by the Jusufi et. al. model for spherical polyelectrolytes brushes which takes into account the entropic effect of the counterions. In the asymmetric case (blank against grafted) the experimental data are described by Alexander de Gennes model which only takes into account the steric force.

CPP 9.10 Mon 17:30 P2

Influence of Pulse Duration on the Polymerization Characteristic of Photosensitive Polymers and Biomolecules by Multiphoton Polymerization — •Andreas Omenzetter[1], Sascha Engelhardt[1], Martin Wehner[2], and Arnold Gillner[2] — [1]Lehrstuhl für Lasertechnik, RWTH, Steinbachstraße 15, Aachen — [2]Fraunhofer-Institut für Lasertechnik, Steinbachstraße 15, Aachen

High resolution 3D microstructures are of great interest for various applications. These structures may prove beneficial in the field of tissue engineering. Here cells, biomaterials and polymers are combined in order to replace or improve biological tissue.

We use the technique of multiphoton polymerization (MPP) which allows polymerization of a prepolymeric resin in a very confined area. For this process very high photon densities are necessary making the use of highly focused pulsed laser radiation crucial. The probability for MPP is much higher in the focal volume than in the surrounding area. That makes it possible to generate microstructures with a resolution of about 100 nm and less.

We have focused our work on the influence of laser pulse-duration on the size of the smallest possible structures, called voxels (volume pixel). For this reason we compare the influence of different laser sources with different pulse durations on voxel formation. The main advantage of longer pulses are the lower technical preconditions and thus a possibility of a turn-key machine. This will lower costs and may result in an upscaling of the otherwise slow MPP process by parallelization.