MM 11: Biomaterials

Time: Monday 11:45–13:30 Location: IFW D

MM 11.1 Mon 11:45 IFW D

Macromolecular HPMA-based drug delivery system - behavior in protein environment — •Xiaohan Zhang[1], Bart-Jan Niebuur[1], Petr Chytil[2], Tomas Etrych[2], Sergey K. Filippov[2], Alexey Kikhney[3], Florian Wieland[3], Dmitri I. Svergun[3], and Christine M. Papadakis[1] — [1]Technische Universität München, Physik-Department, Fachgebiet Physik weicher Materie, Garching, Germany — [2]Institute of Macromolecular Chemistry, Academy of Sciences of the Czech Republic, Prague, Czech Republic — [3]European Molecular Biology Laboratory, DESY, Hamburg, Germany

Copolymers based on N-(2-hydroxypropyl)methacrylamide (HPMA) having cholesterol side groups self-assemble into ellipsoidal nanoparticles (NPs) in aqueous solutions [1,2]. The core and the shell are formed by cholesterol and by HPMA, respectively. They have been proposed as drug carriers. However, little is known on their behavior in human blood environment.

We use synchrotron small-angle X-ray scattering (SAXS) to investigate HPMA copolymers in an aqueous solution of human serum albumin(HSA), which is very abundant in human blood, to investigate the influence of HSA on the NPs' structure. The length of the NPs is reduced even if very small amounts of HSA are present. We speculate that HSA binds to cholesterol groups and removes them from the NPs.

[1] S. K. Filippov, et al., Biomacromolecules, 2012, 13, 2594
[2] S. K. Filippov, et al., Biomacromolecules, 2013, 14, 4061

MM 11.2 Mon 12:00 IFW D

Dealloying-based nanoporous metallic materials for orthopedic implant applications — •Ilya Okulov[1], Artem Okulov[1,2], Berengere Luthringer[3], Jürgen Markmann[1], Regine Willumeit-Römer[3], and Jörg Weissmüller[1] — [1]HZG, Institute of Materials Research, Division of Materials Mechanics, Germany — [2]Institute of Metal Physics, Ural Branch of RAS, Russia — [3]HZG, Institute of Material Research, Division of Metallic Biomaterials, Germany

The close match of stiffness between orthopedic implant material and bone is critically important to ensure fast healing of injured tissues. Here, we propose a design strategy to develop metallic materials possessing Young's modulus matching that of human bone using liquid metal dealloying (LMD). LMD is a process of selective dissolution of one or several elements from the solid precursor into the liquid metal, while the remaining elements simultaneously organize and form a porous structure. To demonstrate our strategy, we developed interpenetrating-phase Ti-Mg composites and microporous TiZr alloys by LMD. The Young's modulus of the microporous TiZr alloys is adjustable in a range of 3.2 to 15.1 GPa by controlling metal fraction. The Young's modulus of the Ti-Mg composites can be as low as 25 GPa. These low values of Young's modulus become interesting in a view of high yield strength of the microporous TiZr and the Ti-Mg composites reaching up to 480 MPa and 450 MPa, respectively. This strongly suggests opportunities as future advanced implant materials will significantly enhanced performance.

MM 11.3 Mon 12:15 IFW D

In-situ SEM / TEM fracture tests on (modified) pine sap wood — •Mona-Christin Maass[1], Maximilian Wentzel[2], Holger Militz[2], and Cynthia Volkert[1] — [1]Institute of Materials Physics, Georg-August-University of Göttingen, Friedrich-Hund-Platz 1, Göttingen, Germany — [2]Wood Biology and Wood Products, Georg-August-University of Göttingen, Büsgenweg 4, Göttingen, Germany

There is evidence that intrawall failure of wood occurs at the interface between the S1 and S2 cell wall layer. However, up to now, the fracture mechanisms of the cell wall remain unexplored. Therefore, we performed fracture tests of pine wood tracheid cell walls which are important because pine – mostly made of tracheid cells – is very common. Our experimental setup enables us to create a crack in the cell wall and to observe the crack propagation in-situ with an electron microscope.

We have observed that crack propagation is not continuous, but intermittently starts and stops accompanied with a change in propagation direction. We attribute this intermittent behavior to the abrupt change of the microfibril angle at the interface between the S1 and S2 cell wall layer and propose that the resultant increase in toughness is a driving force for the natural adaptation of the layered structure. Additionally, we will investigate pine sap wood that has been heat-treated or modified with a methylol resin. The treated wood has higher resistance against fungi but reduced bending and tensile strength relative to untreated wood. Here, the goal is to understand the reasons for the poorer mechanical properties on the basis of the crack behavior.

MM 11.4 Mon 12:30 IFW D

Nanoscale mechanical properties of wood: Effects of heat treatment and sample preparation — •Salimeh Saleh[1], Dominik Tönnies[1], Maximilian Wentzel[2], Holger Militz[2], and Cynthia Volkert[1] — [1]Institute of Materials Physics, University of Göttingen, Germany — [2]Department of Wood Biology & Wood Products, University of Göttingen, Germany

The mechanical properties of wood depend on both the complex hierarchical cellular structure and on the mechanical behavior of the constituent materials. Here, we use nanoindentation to investigate the local mechanical properties of the cell walls, with the goal of understanding how they contribute to the bulk mechanical behavior of wood. Quantitative nanoindentation studies require however a smooth specimen surface. Up until now, this has usually been achieved by using specific embedding materials that unfortunately enter the cell wall, thereby changing their mechanical properties. Here, we investigate methods to prepare suitable nanoindentation specimens using (ultra) microtome from Pine wood and Eucalyptus wood that is either unembedded or embedded with materials such as paraffin that do not enter the cell walls. The Eucalyptus wood is an untreated state and heat-treated at various temperatures and water vapor pressures. We observe that the wood samples become highly heterogeneous after heat treatment: In some regions the elastic modulus is high (~100 GPa), while in other regions it is low (~5 GPa). A possible explanation is that the cellulose becomes spatially localized after heat treatment.

MM 11.5 Mon 12:45 IFW D

Electrospinning biopolymer nanofiber mats for medical and biotechnological applications — •Sarah Vanessa Homburg, Timo Grothe, Nils Grimmelsmann, and Andrea Ehrmann — Bielefeld University of Applied Sciences, Faculty of Engineering and Mathematics, Bielefeld, Germany

Electrospinning enable creating nanofiber mats from diverse polymers by "dragging" fibers from a polymer solution by a high electric field and depositing them on a substrate. Fiber properties can be controlled by spinning and solution parameters.

While several polymers need toxic or other hazardous solvents, biopolymers can often be spun from aqueous solutions. Additionally, several biopolymers can be used in diverse medical and biotechnological applications, e.g. for tissue engineering, enhanced wound healing, or controlled drug release, but also as filters in different industries. On the other hand, water-soluble nanofiber mats necessitate an additional crosslinking step for most applications.

The presentation gives an overview of the electrospinning principle, spinnable biopolymers and the challenges of crosslinking water-soluble fibers. Possibilities of co-spinning different polymers allowing fiber creation from unspinnable polymers are shown. Physical and chemical properties of nanofibers from different polymers and polymer blends are given.

MM 11.6 Mon 13:00 IFW D

Impact of coordination on the mechanical behavior of polymeric structures — •Huzaifa Shabbir[1] and Markus Hartmann[2] — [1]Faculty of Physics, University of Vienna, Boltzmanngasse 5, 1090 Vienna, Austria — [2]Faculty of Physics, University of Vienna, Boltzmanngasse 5, 1090 Vienna, Austria

(Reversible) cross-linking is a common strategy to specifically tailor the mechanical properties of polymeric systems. Often, these cross-links are weaker than the covalent bonds holding the structure together. The reversibility of cross-links provides self healing.

In the current study, Monte Carlo simulations are used to study the influence of the coordination of cross-links on the mechanical properties of polymeric systems. In the simulations, the number of monomers participating in one cross-link defines its coordination. Recent theoretical and simulation approaches deal mostly with two fold coordinated cross-links only [1,2]. Here we aim at closing this gap by explicitly manipulating the coordination of cross-links using an effective description with REBO like interactions.

The results show that the presence of cross-links dramatically increase the stiffness and toughness of the investigated structures. Compared to two-fold coordinated structures, three-fold coordinated cross-links show smoother load-displacement curves and show in general a much richer mechanical behavior due to the increased number of possible bond topologies.

[1] Nabavi et al., Soft Matter 12, 2047 (2016) [2] Nabavi et al., Phys. Rev. E 91, 032603 (2015)

MM 11.7 Mon 13:15 IFW D

Surface, interface and bulk sensitive x-ray absorption spectroscopy probed by total electron yield in liquid cell — •Daniela Schön[1,2], Jie Xiao[1], Ronny Golnak[1], Marc F. Tesch[1], and Emad F. Aziz[1,2] — [1]Institute of Methods for Material Development, Helmholtz-Zentrum Berlin für Materialien und Energie, Albert-Einstein-Strasse 15, 12489 Berlin, Germany — [2]Freie Universität Berlin, Department of Physics, Arnimallee 14, 14195 Berlin, Germany

Total electron yield (TEY) is often adopted as a probing method for x-ray absorption spectroscopy (XAS). One electrode connecting to sample surface and measuring sample drain current is a common practice to obtain TEY-XA spectra, which makes the TEY method surface sensitive, owing to the short mean-free-path of photoelectrons. In this study, we demonstrate that the interface and bulk sensitive XAS can be individually probed by TEY as well when two electrodes are connected to the front and back sides of a liquid cell. The interfacial dipole layer is argued to be the key factor that separates the x-ray excited electron-hole pairs at interface and generates the resulting electric current which is eventually detected by ammeter as the TEY signal. The mobility and long-distance transportability of positive ions in liquid provides an indispensable assistance to realize the current flow in the liquid bulk. In the two-electrode connection scheme, the acquired current signal produces intensity peaks and dips for the interface and bulk species, respectively, upon the resonant excitations at their corresponding absorption edges.