BP 26: Biomaterials and Biopolymers (joint session BP/CPP)

Time: Thursday 9:30–12:45 Location: BAR/SCHÖ

BP 26.1 Thu 9:30 BAR/SCHÖ

Characterization and Application of Honey-PVA Electrospun Scaffolds in Tissue Engineering — •Catalina Navarrete-Vera[1], Karen Yáñez[2], Cristian Acevedo[2], and Tomas Corrales[1,2] — [1]Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile — [2]Centro de Biotecnología Daniel Alkalay Lowitt, Universidad Técnica Federico Santa María, Chile

Tissue engineering seeks to develop functional biomaterials that integrate seamlessly with biological systems. Electrospinning with static collectors enables the production of nanostructured scaffolds suitable for cell regeneration (10.1021/acsomega.3c06436). Incorporating natural components, such as honey, valued for its regenerative, anti-inflammatory, and antimicrobial properties, offers a route to bioactive wound-dressing alternatives (10.1016/j.carbpol.2019.05.004).

In this study, Manuka and Ulmo honeys were each combined with PVA to generate nanofibers and scaffolds via electrospinning. AFM force spectroscopy was used to assess individual fiber mechanics, and SEM and cell-culture assays were employed to evaluate morphology and biocompatibility. Both formulations produced fibers of similar diameter (100-300 nm) and nanomechanical stiffness (˜200 MPa), while honey-containing scaffolds improved cell growth over controls. These results indicate that Ulmo honey is a promising alternative to Manuka honey for tissue-engineering applications.

BP 26.2 Thu 9:45 BAR/SCHÖ

Additive Manufacturing in Wound Care Innovation from Sugarcane Bagasse — •Ahmed El-Hussein Elnewishy[1], Muhammad Mounir[1], Mona Tarek[1], and Ita Junkar[2] — [1]Biotechnology Program, Faculty of Science, Galala University — [2]Department of Surface Engineering, Jožef Stephan Institute, Ljubljana, Slovenia

Three-dimensional (3D) printing technology is capable of creating highly complex, customizable objects, offering unique advantages for various biomedical applications through methods such as inkjet-based, extrusion-based, and light-assisted techniques. This study focuses on using direct ink writing for additive manufacturing to print antibacterial wound dressings, addressing a critical gap in the current wound care market. The management of chronic and acute wounds presents significant challenges facing human health and overall wellness. Current wound dressing fails to meet patients needs in terms of high adhesion, poor gas exchange, low moisture retention, and the use of systemic and synthetic antibiotics. Additionally, the presence of unused agricultural waste and weak waste management increase greenhouse gas emissions, thus contributing to global warming. To address these issues, we utilized agricultural waste, specifically sugarcane bagasse, to create biopolymer 3D printing ink for wound dressings. We extracted cellulose from sugarcane bagasse and antibacterial bioactive compounds from plant extracts. The synthesized ink was then printed and post treated to enhance mechanical properties. We evaluated the cytotoxicity, antibacterial activity, and morphological structure of the patches using scanning electron microscopy.

BP 26.3 Thu 10:00 BAR/SCHÖ

FCS-Based RNA Payload Quantification and FLIM Analysis of pH-Dependent Lipid Phase Transitions in Lipid Nanoparticless — •Bernhard Kirchmair[1], Judith Müller[1], Thomas Kellerer[2], Ekaterina Kostyurina[1], and Joachim Rädler[1] — [1]Ludwig-Maximilians-Universität München, Germany — [2]Max Planck-Institut für Biochemie, Martinsried, Germany

Lipid nanoparticles (LNPs) emerged as one of the most promising delivery systems for transfecting mammalian cells with synthetic messenger RNA (mRNA). However, LNPs show a substantial heterogeneity both in shape and cargo and the precise mRNA payload and stoichiometric ratios in multi-component nucleic acid delivery remain poorly quantified. In this project we investigate how mRNA payload depends on LNP size and surface composition using fluorescence correlation spectroscopy (FCS) supported by dynamic light scattering, enabling estimation of particle concentration and RNA copies per LNP. Fluorescence cross-correlation spectroscopy further allows measurement of siRNA/mRNA ratios in mixed cargos. To link payload properties to endosomal escape rates and hence delivery efficiency, we probed pH-dependent lipid phase transitions using fluorescence lifetime imaging (FLIM) and fluorescence anisotropy, capturing changes both in bulk lipid phases and in intact LNPs. These measurements build a framework to monitor structural changes relevant to endosomal escape and can be applied to other LNP formulations and cargo types. Quantitative knowledge about content and ratios will ultimately support the delivery of genetic programs for regulated gene expression.

BP 26.4 Thu 10:15 BAR/SCHÖ

pH-dependent phase transitions in ionizable lipid mesophases — •Ekaterina Kostyurina[1], Susanne Liese[2], Akhil Sudarsan[2], Julian Philipp[1], and Joachim Rädler[1] — [1]Faculty of Physics, Ludwig-Maximilians University, 80539 Munich, Germany — [2]Faculty of Mathematics, Natural Science, and Materials Engineering, Institute of Physics, University of Augsburg, 86159 Augsburg, Germany

Lipid Nanoparticles (LNPs) have proven valuable in modern medicine as a medium for RNA delivery. Nanoparticles containing cationic ionizable lipid (CIL), cholesterol and structural lipids complex with nucleic acids into size-controlled particles that transport nucleic acid molecules across cell membranes via the endocytic uptake pathway. The delivery efficiency of a drug or vaccine is directly related to the efficiency of the endosomal release. Here, we study pH-dependent structural transitions of the CIL core phase which are believed to play an essential role in this process. We use bulk phases of ionizable lipid/cholesterol as a model system of the LNP core which allows us to study the structure of the lipid phases with high precision using X-ray diffraction. We show that the commonly used ionizable lipids overcome the inverted micellar-inverted hexagonal phase transition within the pH range typical for endosomal life cycle, and connect structural properties of the phases with LNP efficacy. Furthermore, we are aiming to understand the thermodynamics of these phase transitions by combining experimental measurements with theoretical modeling. This will help to better understand the structure-activity relation of LNPs and to increase the delivery efficiency in clinically relevant LNP delivery systems.

BP 26.5 Thu 10:30 BAR/SCHÖ

To gel or not to gel? Assembly phase changes of engineered spidroin proteins induced by temperature and time — •Isabell Tunn[1,2,3], Dmitry Tolmachev[2,4], Adam L. Harmat[2,4], Nea B. Möttönen[1,2], Alberto Scacchi[2,4,5], Maria Sammalkorpi[2,4], and Markus B. Linder[1,4] — [1]Department of Bioproducts and Biosystems, Aalto University, Finland — [2]Academy of Finland Center of Excellence in Life-Inspired Hybrid Materials (LIBER), Aalto University, Finland — [3]Fraunhofer Institute for Applied Polymer Research (IAP), Germany — [4]Department of Chemistry and Materials Science, Aalto University, Finland — [5]Department of Mechanical and Materials Engineering, University of Turku, Finland

Bioinspired silk-like proteins offer exciting possibilities for developing the next generation of advanced materials - from medicine to food packaging. Here, we investigate the temperature- and time-dependent assembly behaviour of engineered silk-like proteins into hydrogels conducting experiments and molecular dynamics simulations.* Phase transitions are controlled by entropic changes in flexible glycine-rich regions and hydrophobic interactions of alanine-rich α-helical regions. High-temperature gelation proceeds through interactions between alanine-rich domains, leading to β-sheet formation while time-induced gelation occurs via protein percolation mainly driven by dimerization of terminal domains. These findings provide guidelines for engineering protein-based materials with tailored assembly properties and gel characteristics, advancing the rational design of biomimetic soft materials. *https://doi.org/10.1016/j.ijbiomac.2025.147712

BP 26.6 Thu 10:45 BAR/SCHÖ

Power-Law Analysis of Force Relaxation and Creep Compliance in Nanoindentation of Glassy Gelatin in Humid Air — Paul Zech, Martin Dehnert, Mario Zerson, and •Robert Magerle — Fakultät für Naturwissenschaften, TU Chemnitz

Gelatin-based materials are widely used in food technology, drug delivery systems, and tissue engineering. Water acts as a plasticizer, softening gelatin and reducing its glass transition temperature. Using AFM-based nanoindentation experiments, we examined the mechanical response of a gelatin film to nanoindentations under constant strain (force relaxation) or constant stress (creep compliance) at a wide range

of tip approach velocities and relative humidity levels. Scaling analysis using a fractional rheology model reveals that force relaxation and creep compliance exhibit universal power-law behavior. Temporal evolution depends only on the tip indentation time, which defines the externally imposed timescale of the process, and the power-law exponent α, which characterizes the degree of viscoelasticity. At relative humidity $> 85\%$, the α values differ between the force relaxation and creep compliance data. This indicates differences in the underlying molecular processes.

15 min. break

Invited Talk BP 26.7 Thu 11:15 BAR/SCHÖ

Directed evolution of material-producing bacteria — •André Studart — Complex Materials, Department of Materials, ETH Zürich

Engineers often use high temperatures, pressures and polluting chemicals to make synthetic materials. By contrast, biology produces remarkable materials like wood and bone using widely available chemicals in water and at ambient temperature. The ability of organisms to create materials under mild conditions relies on the intricate biological machinery of living cells. Notably, natural selection processes have evolved such machinery for hundreds of millions of years to fulfill the demands of biological environments. Can we harness the machinery and evolutionary processes of biology to create materials more sustainably while still meeting engineering needs ? To explore this question, we utilized a microfluidic platform to evolve material-forming microorganisms towards cell mutants that meet the high productivity needed in industrial processes. Using cellulose-producing bacteria as an example, we show that this directed evolution approach enabled the isolation of a bacterial mutant that produces up to 70% more cellulose than its native counterpart. The overproducing bacterial strain offers an attractive alternative to wood to meet the growing demand for cellulose in the textile, medical and packaging industries. Beyond cellulose, the proposed technology offers a compelling approach to isolate bacteria for the bio-fabrication of other sustainable materials, such as silk, polyesters and clay-based bricks.

BP 26.8 Thu 11:45 BAR/SCHÖ

Controlling Axonal Outgrowth of Organoids by 3D Nanoprinted Scaffolds — •Tobias Müller[1], Malte Siegmund[1], Emma Wollesen[1], Kim Krieg[2], Ole Pless[2], Jan Hahn[3], Robert Zierold[1], and Robert Blick[1] — [1]Center for Hybrid Nanostructures, University of Hamburg, 22761 Germany — [2]Fraunhofer ITMP, Discovery Research Screening Port, 22525 Germany — [3]Section Facility Mass Spectrometry and Proteomics, University Medical Center Hamburg-Eppendorf, 20246 Germany

Cortical organoids are promising models for neurodegenerative disease research, yet their integration into defined neural networks remains challenging. We use two-photon polymerization (2PP) to fabricate three-dimensional scaffolds that direct axonal outgrowth and support organoid integration into engineered circuits.

Scaling structures from single neurons to millimeter-scale organoids introduces adhesion and imaging challenges. We address this by combining tailored scaffold geometries with a polydimethylsiloxane (PDMS)-based anchoring strategy, critical-point drying and quantitative analysis of electron microscopy images. Walls, stairs and microwires enhance organoid-scaffold interactions, promoting axonal outgrowth along intended paths and reducing extension into non-target regions.

These results demonstrate that 2PP-fabricated microarchitectures can guide axon growth and stabilize organoid-substrate contact, enabling more controlled organoid-based neuronal networks and advancing brain-on-a-chip approaches.

BP 26.9 Thu 12:00 BAR/SCHÖ

Stimulus-induced biomechanical perturbations via smart hydrogel microstructures — •Katja Zieske — Max Planck Institute for the Science of Light, Erlangen, Germany

Cells reside within complex three-dimensional extracellular matrices, where mechanical interactions play essential roles in tissue development, and disease progression. To mimic these interactions, we developed a lab-on-a-chip platform that applies spatially and temporally controlled mechanical perturbations using intelligent hydrogel microstructures.

First, we optimized material composition and photopolymerization parameters and demonstrated reliable, stimulus-dependent expansion and contraction of the hydrogel microstructures within microfluidic chambers. Using these microstructures, we then applied compressive forces to Matrigel and collagen networks. Finally, we applied mechanical perturbations to cellular systems.

By mimicking cellular pushing forces with hydrogel microstructures, this lab-on-a-chip system provides a versatile tool for studying mechanical remodeling of biopolymers and cellular systems.

BP 26.10 Thu 12:15 BAR/SCHÖ

Functionally Connecting High- and Low-Density Neuronal Networks Using 3D-Nanoprinted Structures — •Emma Wollesen, Malte Siegmund, Tobias Müller, Josephine Hoppe, Robert Zierold, and Robert Blick — Center for Hybrid Nanostructures, University of Hamburg, 22761 Hamburg, Germany

Tracing the propagation of interneural communication from high- to low-density networks is essential for exploiting information processing at the single-cell level. Given the multitude of synaptic connections, high-density networks of hiPSC-derived neurons may generate bursts of action potentials, a key communication mode that can be analyzed at the single-cell level in receiving low-density networks. Here, we move toward such a cultivation platform by evaluating 3D nanoprinted (3DN) structures fabricated by two-photon polymerization for their efficiency in facilitating connected high- and low-density networks. We demonstrate the prerequisite formation of hiPSC-derived low-density neuronal networks in tower-shaped 3DN structures. For augmentation with high-density networks, a stomach-shaped structure and connecting elements were fabricated. A minimum structure height of 30 micrometers proved critical for clear network demarcation. For future region-specific chemical stimulation, millimeter-scale structures for media reservoir separation were conceptualized, and fabrication feasibility was confirmed, requiring a 10 micrometer overlap and a suitable shear angle at structure interfaces. These results extend established 3DN platforms for low-density networks and support the integration of neural networks into Brain-on-a-Chip applications.

BP 26.11 Thu 12:30 BAR/SCHÖ

Multiplex sensing of respiratory viruses using surface plasmon resonance spectroscopy — •Ghazaleh Eshaghi[1], David Kaiser[1], Hamid Reza Rasouli[1], Dominik Gary[2], Tobias Fischer[2], Katrin Frankenfeld[2], Abhishek Sharma[3], and Andrey Turchanin[1] — [1]Institute of Physical Chemistry, Friedrich Schiller University Jena, 07743 Jena — [2]Forschungszentrum für Medizintechnik und Biotechnologie (fzmb) GmbH, 99947 Bad Langensalza, Germany — [3]BioNavis Ltd., Hermiankatu 6-8H, 33720 Tampere, Finland

We present label-free and real-time biosensing of three major respiratory viruses using the Multi-Parametric Surface Plasmon Resonance (MP-SPR) technique. In this approach, MP-SPR SPR Au sensors are functionalized with ultrathin (˜1 nm) azide-terminated carbon nanomembranes (N3-CNMs), enabling covalent attachment of virus-specific antibodies and thereby providing selective immobilization of target antigens on the sensor surface. We demonstrate specific detection of SARS-CoV-2, Influenza A, and Respiratory Syncytial Virus (RSV) antigens with negligible cross-reactivity and high reproducibility in both PBS-P buffer (physiological pH) and clinically relevant nasopharyngeal swab matrices. For SARS-CoV-2, Influenza A, and RSV antigens, we determine dissociation constants (KD) of 7.0 * 0.5 nM, 86 * 4 pM, and 3.0 * 0.2 pM, respectively, with corresponding limits of detection (LOD) of ˜65 pM, ˜80 pM, and ˜2 pM.