Biomaterials Plenary Session
Room 101A - Session BP-SuA

Biomaterials Plenary

Moderator: Stephanie Allen, The University of Nottingham, UK

3:00pm **BP-SuA1 Common Principles in Synthetic Mechanophores and Mechanoresponsive Biomolecules*, Kerstin Blank,*** Max Planck Institute of Colloids and Interfaces, Germany **INVITED**

Much effort is currently invested in the development of (bio)materials with well-defined mechanical properties. This is motivated by the desire to measure cell generated forces *in situ* at the molecular level and to direct cellular behaviour using controlled mechanical stimuli. In parallel, materials scientists aim at the development of self-reporting and self-healing materials that respond to mechanical force in a predefined way. Key to all these efforts are mechanosensitive molecular building blocks, such as synthetic small molecule mechanophores and mechanoresponsive biomolecules.

Focussing on common principles that guide the design of mechanosensitive molecules, I will introduce our current set of synthetic and biological mechanical building blocks. Following a mechanical calibration at the single molecule level, these building blocks are equipped with a fluorescent reporter system that reports on the mechanical state of the molecule. This allows us to directly correlate the force acting on an individual molecule with a fluorescence readout so that a molecular force sensor is obtained. Considering the above applications, such sensors report on mechanical material deformation in a highly sensitive manner down to the single molecule level. Our approach further opens up new routes towards correlating the bulk and molecular mechanical properties of a material.

3:40pm **BP-SuA3 Formation of Stacked Lipid Lamellae and Development of Myelin-like Structures Is Promoted by a Surfactant Protein B Analog: A Micropipette Study of Lung Surfactants at Microscopic interfaces*, David Needham,*** Duke University*; E. Parra, K. Konoshita,* University Southern Denmark, Denmark **INVITED**

The present study is a microscopic interfacial characterization of a series of lung surfactant materials performed with the micropipette technique. We measured the equilibrium and dynamic surface tensions for a series of animal-derived and synthetic lung surfactant formulations, including a Super Mini-B (SMB)-containing formulation. Somewhat surprisingly interfacial structures were found to occur at these microscopic air-water interfaces (see Figure below) for the SMB-containing formulation over time and during area compression at the microscopic air-water interface. We compared the results to other lung surfactants, including: native surfactant obtained from porcine lungs (NS) and the commercial, animal-derived formulations Curosurf, Infasurf and Survanta. The presence of SMB promoted vesicle condensation as thick membrane multilayers beneath the interface, the nucleation and growth of microtubes emanating from these lamellae and their subsequent transformation into helices. The dimensions of these tubes (2-15 mm diameter) and their linear (2-3 mm/s) and volumetric growth rates (20-30 mm^3/s) were quantified, and no specific effects were found on them for increasing SMB concentrations from 0.1 to 4%. Nevertheless, we found a direct correlation between the number of tubes and SMB contents, which suggests that SMB molecules are the promoters of tube nucleation in these membranes. Microtube formation was also observed in Infasurf, and in NS only after subsequent expansion and compression, but neither in the other clinical surfactants nor in protein-free preparations. The connection between this data and the observations from the lung surfactant literature concerning the widely reported “near-zero surface tension” for lung surfactant films and intact alveolar surfaces will also be discussed.

4:20pm **BP-SuA5 Stem Cell Biophysics: From 3D Tissue Analyses to Gels of Controlled Flexibility, Heterogeneity, and Thickness*, Dennis Discher,*** University of Pennsylvania **INVITED**

Scarring is a long-lasting problem in higher animals, and reductionist approaches that include studies of stem cells could aid in regenerative treatments. Following our early studies showing homogeneous matrix elasticity can direct stem cell lineages in vitro [Engler et al. Cell 2006], our latest studies involve a new platform wherein copolymerization of collagen I with polyacrylamide produces minimal matrix models of scars (MMMS) in which fractal-fibre bundles segregate heterogeneously to the hydrogel subsurface [Dingal et al. Nature Materials 2015]. Matrix stiffens locally—as in scars—while allowing separate control over adhesive-ligand density. Based on expression analyses of injured mesenchymal tissue, detailed analyses of key pathways focus on scar-like phenotypes of mesenchymal stem cells (MSCs). These cells spread and polarize quickly, increasing nucleoskeletal lamin-A while also slowly up-regulating the ‘scar marker’ smooth muscle actin (SMA). Surprisingly, expression responses to MMMS exhibit less cell-to-cell noise than homogeneously stiff gels. Such differences from bulk-average responses arise because a strong SMA repressor, NKX2.5, slowly exits the nucleus on rigid matrices. NKX2.5 overexpression overrides rigid phenotypes, inhibiting SMA and cell spreading, whereas cytoplasm localized NKX2.5 mutants degrade in well-spread cells. MSCs thus form a ‘mechanical memory’ of rigidity by progressively suppressing NKX2.5, thereby elevating SMA in a scar-like state.

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