Biomaterial Surfaces & Interfaces

Room Naupaka Salon 5 - Session BI1-TuM

Biomaterials/Interfaces - Biointeractions

Moderator: Kaori Sugihara, Institute of Industrial Science, the University of Tokyo

8:40am **BI1-TuM-3 Dynamic Supramolecular Gels for 3D Cell Culture***, A. Chalard, H. Porritt,* University of Auckland, New Zealand*; A. Taberner,* The University of Auckland, New Zealand*; J. Fitremann,* CNRS, France*;* ***Jenny Malmstrom****,* University of Auckland, New Zealand

Cells sense and adapt to forces and physical constraints imposed by the extra cellular matrix. Such mechanotransduction plays a crucial role in cell function, differentiation and cancer. In our research group we are developing materials to achieve spatiotemporal control over mechanical properties.

Stiffness patterning of hydrogel scaffolds, through the use of stiffness gradients for instance, allows the modelling and studying of cellular responses to fibrotic mechanisms. Gelatine methacryloyl (GelMA) has been used extensively in tissue engineering for its inherent biocompatibility and the ability to precisely tune its mechanical properties. We have developed a method to photopattern the mechanical properties of GelMA hydrogels with visible light and using physical photomasks and projection with a digital micromirror device. This method allows to create hydrogels with areas of different stiffnesses and hydrogels with precise stiffness gradients. The mechanical properties of the resulting hydrogels have been characterised using force indentation with atomic force microscopy, which demonstrated the efficiency to spatially pattern the elastic modulus of GelMA according to the photomask or the projected pattern. (1)

In addition to pattern mechanical properties, it is interesting to include a dynamic aspect to cell-laden biomaterials, since native ECM is constantly reshaped by cells. Composite hydrogels are developed to bring different combinations of structures and properties to a scaffold by using different types and sources of materials. We have combined GelMA with biocompatible supramolecular fibers made of a small self-assembling sugar-derived molecule (*N*-heptyl-D-galactonamide, GalC7). The GalC7 fibers were directly grown in the GelMA through a thermal process, and it was shown that the presence of the fibrous network increased the Young's modulus of GelMA. Due to the non-covalent interactions that govern the self-assembly, these fibers were observed to dissolve over time, leading to a dynamic softening of the composite gels. Cardiac fibroblast cells were successfully encapsulated into composite gels for 7 days, showing excellent biocompatibility and fibroblasts extending in an elongated morphology, most likely in the channels left by the fibers after their degradation. These novel composite hydrogels present unique properties and could be used as tools to study biological processes such as fibrosis, vascularization and invasion. (2)

1) Chalard, Malmström, et al. Frontiers in Cell and Developmental Biology 2022, 10.

2) Chalard, Malmström, et al. BioMaterials Advances, 2024, accepted

9:00am **BI1-TuM-4 Supercritical Angle Raman Microscopy (SAR-M): A Versatile Tool to Study Molecular Conformations at Surfaces on the Example of Amyloid and α-Synuclein Proteins***, N. Münch, S. Das,* ***Stefan Seeger****,* University of Zurich, Switzerland

Supercritical Angle Raman Microscopy (SAR-M) emerges as a transformative technique for the in-depth study of molecular conformations at surfaces, providing unparalleled spatial resolution and sensitivity. This presentation explores the application of SAR-M to investigate the structural dynamics of amyloid and synuclein proteins, which are pivotal in neurodegenerative diseases such as Alzheimer's and Parkinson's. Utilizing the unique capabilities of SAR-M, we demonstrate its proficiency in capturing subtle conformational changes and aggregations of these proteins at the nanoscale, which are critical to understanding their pathological roles as well as the role of ions like Calcium.

Amyloid and synuclein proteins are known for their propensity to misfold and aggregate, forming insoluble fibrils that are toxic to neuronal cells. Traditional microscopy techniques often fall short in providing the necessary resolution and chemical specificity to study these proteins' surface interactions and early aggregation stages. SAR-M overcomes these limitations by exploiting the supercritical angle fluorescence to enhance Raman scattering signals, thereby achieving superior surface sensitivity.

Through a series of experiments, we detail the conformational mapping of amyloid-beta peptides and alpha-synuclein at different aggregation stages. The results reveal distinct molecular signatures and structural transitions, offering new insights into the mechanisms driving protein misfolding and aggregation. Additionally, SAR-M's capability to monitor these processes in real-time opens avenues for investigating the effects of potential therapeutic agents aimed at inhibiting or reversing protein aggregation.

Serrano D, Seeger S, Light: Science and Applications (2017) 6, e17066

Dubois A, Serrano D, Zhang X, Seeger S, Analytical Chemistry (2020) 4963

Münch NS, Das S, Seeger S, PCCP (2024), in press

9:20am **BI1-TuM-5 Biomimetic Leaf Surfaces as a Platform Technology to Study Bio-Interactions***,* ***Volker Nock****,* University of Cantebury, New Zealand*; S. Sale,* University of Canterbury, New Zealand*; A. Garrill,* University of Cantebury, New Zealand*; M. Bernach,* University of Cantebury, New Zealand, Germany*; M. Remus-Emsermann,* Freie Universität Berlin, Germany **INVITED**

Spatial and temporal variability of leave surfaces modulates plant-microbe and microbe-microbe interactions, creating diverse microenvironments for microbial colonizers such as bacteria and fungi. Mimicking leaf complexity on artificial surfaces greatly aids in the study of microorganisms residing on plant leaf surfaces [1]. Over the years, a number of surrogate surfaces aiming to replicate leaf surface topography have been proposed, ranging from simple nutrient agars to complex casts [1]. These surrogate surfaces are often used to deconstruct leaf surfaces into individual aspects, as this enables bio-interactions to be studied in separation [2].

In this paper I will discuss ongoing efforts to develop biomimetic leaf surfaces as a platform technology to study bio-interactions. In particular, I will focus on work related to bacterial colonization [2-4] and invasion by pathogenic rusts [6]. To date, this has involved *Arabidopsis thaliana* [2,3], as well as wheat, poplar, eucalyptus and mānuka mimics [5]. Incorporating properties such as leaf topography or hydrophobicity, these mimics all aim to promote colonizer survival in the absence of a living plant host. Characterizing agarose, polydimethylsiloxane (PDMS) and gelatin, we have determined PDMS to be one of the most suitable materials for leaf replicas [6]. Diffusion of water and nutrients to the surface of PDMS can be optimized by addition of fillers [7]. Increasing permeability, we have been able to demonstrate the possibility of delivering fructose to the surface, thus allowing division and distribution of bacteria to be affected [2]. Such leaf replicas have since also enabled us to culture in-vivo biotrophic rusts, normally considered "un-culturable" on artificial substrates due to the need for a living host [5], as well as helped to demonstrate that RNAi can be used to inhibit infections by these rusts [8].

1. Doan, H.K., Leveau, J.H.J., Phytopathology 105:1036-1042, 2015.
2. Bernach, M., PhD Thesis. 2024, University of Canterbury: Christchurch.
3. Soffe, R., et al., Sci. Rep. 9:14420, 2019.
4. Soffe, R., et al., Small 2002035, 2022.
5. Sale, S., PhD Thesis. 2024, University of Canterbury: Christchurch.
6. Soffe, R., et al., PLoS ONE 14:e021810, 2019.
7. Bernach, M., et al., Jpn. J. Appl. Phys. 58:SDDK01, 2019.
8. Degnan, R.M., et al., Mol. Plant Pathol. 24:191-207, 2022.

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