HYBER Symposium 2018

24.-25. May, Dipoli Congress Center, Espoo

Auditorium Lumituuli

ACADEMY OF FINLAND

CENTRES OF EXCELLENCE IN RESEARCH

HYBER Centre of Excellence

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Molecular Engineering of Biosynthetic Hybrid Materials

HYBER Symposium 2018
24.-25. May
Auditorium Lumituuli, Dipoli Congress Center

Day 1 – Thu 24.5.

8:45-9:30 Coffee and breakfast, **Capitolium**
9:30 Welcome - CoE HYBER Director Olli Ikkala

Chair Olli Ikkala

9:45 **Jan van Hest**, Eindhoven University of Technology, Netherlands
"Adaptive Compartments with Life-Like Behavior"

10:30 **Marina Ruths**, University of Massachusetts Lowell, USA
"Interaction Forces and Nanotribology of Surfaces Modified with Bioinspired Polymer Coatings"

-------- Short break, 5 min --------

11:20 **Stanislav Gorb**, University of Kiel, Germany
"Fly on the Ceiling: Animal Attachment Devices and Biologically-Inspired Adhesives"

12:05 - 14:00 Lunch, **Capitolium** (posters)

Chair Orlando Rojas

14:00 **Guang Yang**, Huazhong University of Science & Technology Wuhan, China
"Current Trends of Bacterial Cellulose in Functional Materials and Biomedical Applications"

14:45 **Liangbing Hu**, University of Maryland College Park, USA
"Nanocellulose for Nanotechnologies"

15:30 – 16:30 Coffee, **Capitolium** (posters)

Chair Orlando Rojas

16:30 **Carlos Driemeier**, Brazilian Bioethanol Science and Technology Laboratory (CTBE), Brazil
"Multiscale Biomass Architecture in Sugarcane Biorefineries"

17:15 **Emily Cranston**, McMaster University, Canada
"Using Weak Magnetic Fields to Stimulate Alignment in Nanocellulose Systems"

18:00 Poster session, **Capitolium**
19:00 Dinner, **Restaurant Metso**

Day 2 – Fri 25.5.

8:45-9:30 Coffee and breakfast, **Capitolium**

Chair Markus Linder

9:30 **Chris Holland**, University of Sheffield, UK
"Silk Protein Self-Assembly: Bioinspiration for Polymer Process Engineering"

10:15 **Dong Soo Hwang**, Pohang University of Science and Technology (POSTECH), S. Korea
"Cation–π Interactions in Load Bearing Biomacromolecules"

-------- Short break, 5 min --------

11:05 **José Carlos Rodríguez-Cabello**, BIOFORGE, University of Valladolid, Spain
"Recombinamer-based dynamic systems"

11:50 – 13:00 Lunch, **Capitolium** (posters)

Chair Merja Penttilä

13:00 **Tuomas Knowles**, University of Cambridge, UK
"Artificial nanomaterials from natural proteins"

13:45 **Markus Linder**, HYBER, Aalto University
"Phase Separations in the Assembly of Protein Materials"

14:30 Closing remarks, coffee
Capitolium

Professor **J.C.M. (Jan) van Hest**
Eindhoven University of Technology, Netherlands

"*Adaptive Compartments with Life-Like Behavior*"

Dr. Hest leads the Bio-Organic Chemistry group at the Department of Chemical Engineering and Chemistry in Eindhoven University of Technology. The group develops compartmentalization strategies to construct micro and nanocapsules which can be applied in the areas of nanomedicine and artificial cell research. The nanomedicine research line in particular concerns medicine transport systems and synthetic vaccines. Using a combination of techniques from polymer science to protein engineering, well-defined carriers and scaffolds are developed for application in e.g. cancer treatment, immunology and ophthalmology.

The group is also active in the field of artificial and hybrid cells where they design and construct adaptive nano- and microcompartments with life-like properties, such as metabolism, organelle-mimetic behavior and cell growth and motility. His artificial nanoreactors can be incorporated as artificial organelles in living cells to complement or affect cellular processes.

Professor **Marina Ruths**
University of Massachusetts Lowell, USA

"*Interaction Forces and Nanotribology of Surfaces Modified with Bioinspired Polymer Coatings*"

Dr. Marina Ruths received her licentiate degree in Physical Chemistry at Åbo Akademi in Finland, and obtained her Ph.D. from the University of California, Santa Barbara. She currently works at the University of Massachusetts Lowell, focusing on forces and nanoscopic friction in confined systems containing adsorbed polymers, biopolymers, polyelectrolytes, liquid crystals, and self-assembled monolayers. She studies effects of surface roughness and strength of adhesion on nanoscopic friction, and works on direct measurements of forces and friction with the surface forces apparatus technique and with atomic force microscopy.

Professor **Stanislav Gorb**
Zoological Institute, Kiel University, Germany

"*Fly on the Ceiling: Animal Attachment Devices and Biologically-Inspired Adhesives*"

Dr. Gorb leads the Functional Morphology and Biomechanics group at the Zoological Institute in University of Kiel. Their research includes approaches of several disciplines: zoology, botany, structural biology, biomechanics, physics, and materials science. Using a variety of methods, the group studies mechanical systems and materials, which appeared in biological evolution. The research is mainly focused on biological surfaces specialised for enhancement or reduction of frictional or/and adhesive forces. Such surfaces are composed of highly-specialised materials and bear surface structures optimised for a particular function.

By experimentally testing different systems, the group tries to outline general rules of the interrelationship between structure and function. Since comparative studies on the microsculpture, ultrastructure, material properties, and attachment-detachment performances of several functional systems include a wide variety of organisms, some questions about the evolution of these systems can be resolved. In addition, the obtained results are useful for high-tech areas, such as micro- and nanotechnology, as well as for bionics (biomimetics) of novel surface-active and composite materials.

Professor **Guang Yang**
Huazhong University of Science & Technology Wuhan, China

"*Current Trends of Bacterial Cellulose in Functional Materials and Biomedical Applications*"

Dr. Yang is the academic leader of the 3BIO: Biofabrication, Biomacromolecules, Biomaterials lab in the College of Life Science and Technology in Huazhong University of Science and Technology. Her research group is focusing on utilizing bacterial cellulose in fabrication of various biomedical, functional materials such as skin tissue repair materials, artificial blood vessels, intervertebral disc replacement materials, controlled-release drug carriers, injectable embolization agents and electroactive hydrogels among several others. Furthermore, they are adopting engineered *Gluconacetobacter xylinum* and utilizing the assembly and arrangement of the cellulose fibrils to achieve highly specific, three-dimensional micro-patterns, which provide highly sophisticated multi-level tissue engineering scaffolds. The scaffolds induce directed cell adhesion and aggregation for applications in regenerative medicine.

Associate Professor **Liangbing (Bing) Hu**
University of Maryland College Park, USA

"*Nanocellulose for Nanotechnologies*"

Dr. Hu leads the Bing Research Group in University of Maryland Energy Research Center. The group is working on topics including emerging energy storage applications, sustainable nanomaterials (e.g. wood nanocellulose), nanomanufacturing and flexible, printed electronics. They have worked on various types of energy devices and technologies including Li-ion and Na-ion batteries, supercapacitors, next-generation solar cells and photo-electrochemical water splitting. Their research is focusing on not only solving the energy problems with scalable manufacturing techniques and earthly abundant materials, but also attacking their fundamentals with the understanding in nanoscale.

Bing research group is aiming to expand fundamental knowledge base of processing of biomaterials (especially nanocelluloses), that facilitates their incorporation in emerging technologies, including energy and environmental technologies, buildings, flexible electronics, clean water and beyond. The fundamental understanding of biomaterials will lead to extraordinary performance that is competitive with non-sustainable materials. Bing research group recently demonstrated that transparent paper could replace plastics, strong and tough nanocellulose composite could replace steel, and transparent wood could replace glass.

Dr. **Carlos Driemeier**
Brazilian Bioethanol Science and Technology Laboratory, Brazil

"*Multiscale Biomass Architecture in Sugarcane Biorefineries*"

Carlos Driemeier is a research scientist at the Brazilian Bioethanol Science and Technology Laboratory (CTBE), which integrates the Brazilian Center for Research in Energy and Materials (CNPEM). Concluded bachelor (2004) and doctorate (2008) degrees in Physics from Federal University of Rio Grande do Sul, with a research intern period at the University of Texas. Held a post-doctorate (2009) in photovoltaic systems at the Institute of Energy and Environment from the University of São Paulo. Works mainly with Condensed Matter Physics, specifically with surfaces, interfaces, physical chemistry of water, crystallography, and image analysis. Recent research has focused on the multiscale architecture of lignocellulosic biomass and its influence in biomass processing. Has a broad interest in data-intensive analyses, biomass valorization technologies, renewable energies, and the transformation of the global energy system.

Associate Professor **Emily Cranston**
McMaster University, Canada

"*Using Weak Magnetic Fields to Stimulate Alignment in Nanocellulose Systems*"

Dr. Cranston leads the Cranston Research Group at the Department of Chemical Engineering in McMaster University. Cranston Research Group aims to design high-performance materials to replace those that are based on non-renewable resources by learning from nature and using biological components. Currently, their bio-component of choice is nanocellulose. More specifically, they investigate and modify interfacial properties between nanocomposite components, thereby encompassing a wide range of disciplines including polymer and surface chemistry, nanotribology, and pulp and paper science.

Cranston Research Group seeks to address some of the most important unresolved scientific issues regarding the design of new nanocellulose composites including improving the compatibility between composite components, evaluating potential toxicity and biodegradability of nanocellulose-based products, and thoroughly (and reproducibly) measuring the physical, chemical and mechanical properties of these nanomaterials.

Professor **Chris Holland**
University of Sheffield, UK

"*Silk Protein Self-Assembly: Bioinspiration for Polymer Process Engineering*"

Dr. Chris Holland leads the Natural Materials Group in the Department of Materials Science and Engineering at the University of Sheffield. The group brings together researchers with a diverse set of backgrounds and interdisciplinary skills to better understand how Nature makes its materials, how they are used, how they evolved and what can we learn from them in making our own materials. The Natural Materials Group uses tools developed for the physical sciences to better understand Nature's materials, from latex to collagen, but with a focus on silk. By investigating unspun silk's flow properties the group has been able to gain unique insights into their biodiversity, structure and evolution. Additionally, the work has made important links between natural and industrial fibre processing which has lead to a fundamentally new way of designing, testing and fabricating bio-inspired materials.

In their research, the Natural Materials Group combines multiple instruments with rheology, from microscopes (confocal) and spectrometers (IR) to synchrotrons (SANS at ISIS and SAXS/WAXS at ESRF) in order to understand exactly how silk proteins arrange themselves into one of Nature's most impressive materials.

Associate Professor **Dong Soo Hwang**
Pohang University of Science and Technology, South Korea

"*Cation–π Interactions in Load Bearing Biomacromolecules* "

Dr. Dong Soo Hwang leads the Laboratory of Biomimetic and Environmental Materials in Pohang University of Science and Technology. Their aim is to understand physics and chemistry of marine biomaterials which will provide useful insights for designing biomaterials for biomedical applications. Isolation and characterization of the load bearing precusors in marine biomaterials is a prerequisite for mimicking those materials. Therefore, they aim to isolate, produce, and characterize novel load bearing biomaterials from marine organisms.

The group seeks to produce new intriguing building blocks for material fabrication by biotechnological methods. They study the mechanical and biomedical properties of the resulting biomimetic materials with various mechanical and biotechnological techniques, such as synchrotron X-ray diffraction and imaging, electron microscopy, atomic force microscopy and surface force apparatus.

Professor **Tuomas Knowles**
University of Cambridge, UK

"*Artificial nanomaterials from natural proteins*"

Dr. Tuomas Knowles leads the Knowles Lab - a small, interdisciplinary and interactive group based in the Department of Chemistry, the Cambridge Centre for Protein Misfolding Diseases and the Cavendish Laboratory in Cambridge. They bring together ideas and tools from chemistry and physics to develop new approaches to probe the behaviour of biological molecules. They are particularly interested in protein self-assembly, the processes by which proteins come together to form the nanoscale machinery of life. In this area, they are focused on understanding aberrant protein self-assembly that underlies neurodegenerative disorders such as Alzheimer's and Parkinson's disease.

The Knowles Lab is also interested in controlling the self-assembly of natural proteins to generate new types of functional materials. The goal of their research is to understand the physical and chemical factors which control the structures and dynamics of biomolecular assemblies, and the connections between the nanoscale characteristics of the component molecules and the physical properties of large-scale assemblies and their behaviour on a mesoscopic to macroscopic scale. The techniques used in their laboratory include biosensors, optical lithography, microfluidic devices and scanning probe microscopy and spectroscopy. They work with both natural and synthetic polymers and their interests range from fundamental chemical physics to technological applications in material science and molecular medicine.

Professor **José Carlos Rodríguez-Cabello**
BIOFORGE, University of Valladolid, Spain

"*Recombinamer-based dynamic systems*"

Dr. José Carlos Rodríguez-Cabello is a full professor at the Dept. of Condensed Matter Physics of the University of Valladolid. His current research interests include the development of biofunctional, smart and customized protein polymers towards obtaining advanced biomedical devices. In 1997, he founded BIOFORGE group in the University of Valladolid, which nowadays is an internationally recognized and word leading group in the field of recombinamers. In the HYBER Symposium, he will share the latest developments on recombinamer-based dynamic systems.

Professor **Markus Linder**
HYBER Centre of Excellence, Aalto University

"*Phase Separations in the Assembly of Protein Materials*"

Dr. Markus Linder, the vice-director of HYBER, leads the Biomolecular Materials research group in the School of Chemical Engineering, Aalto University. The Biomolecular Materials group seeks to understand and utilize biological design strategies for materials. In many cases nature serves as an inspiration for how high performance materials can be designed. Examples of such materials are the mineralized structures in seashells, silk fiber, and the adhesives of many marine organisms.

The Biomolecular Materials group tries to understand and copy how such materials function starting from a molecular level, and show how the structure of molecules and their interactions can lead to different materials properties. Proteins are especially interesting for this because the techniques of modern biology allow a very detailed molecular engineering of their structures.

They also study cellulose as a molecular material and utilize its special mechanical properties to enable completely new uses for it. New techniques such as synthetic biology will also open new possibilities for making and producing biological materials in the future. Results from their research may one day lead our society onwards from the plastic age to the biomaterials age and a more sustainable way of living.

List of posters

1	Ajdary, Rubina	Bio-Ink 3D Printing for Cell Cultivation
2	Anaya-Plaza, Eduardo	Native Tobacco Mosaic Virus – Phthalocyanine complexes: towards optoelectronic biohybrid materials
3	Arias, Manuel	Growing sustainable materials: long and branched filaments from fungi as material components
4	Arola, Suvi	Unique aspects of TEMPO-oxidized cellulose nanofibril/mixed-linkage β-glucan bionanocomposite gels
5	Bai, Long	Synergistic combination of cellulose nanofibrils and nanocrystals: phase behavior and depletion phenomena in Pickering systems
6	Batys, Piotr	A closer look into artificial silk proteins in aqueous solutions
7	Bertula, Kia	Hierarchical Self-Assembly from Nanometric Micelles to Colloidal Spherical Superstructures
8	Damania, Apeksha	Exosome-based targetted therapy for enhanced liver regeneration
9	Eklund, Amanda	Nanocellulose -TiO2 composites for photodegradation of organic contaminants
10	Greca, Luiz	Bacterial Cellulose 3D Structuring Towards New Applications
11	Griffo, Alessandra	Probing the Mechanical Properties of Biomolecules and Nanomaterials
12	Heise, Katja	Janus-type nanorods by surface-initiated polymer grafting from the reducing end-group of cellulose nanocrystals
13	Hokkanen, Matti	Scanning Droplet Adhesion Microscopy: Towards quantitative understanding of nanoscale wetting
14	Hu, Jinguang	Process nanocellulose into high-performance functional material
15	Huan, Siqi	3D-Printable Nanocellulose/Alginate Emulsion Gels Containing Poly(lactic acid)

16	Hynninen, Ville	Inverse Thermoreversible Mechanical Stiffening and Birefringence in a Methylcellulose/Cellulose Nanocrystal Hydrogel
17	Ijäs, Heini	Hybrid DNA Origami - Protein Devices as Sensors and Cellular Transport Vehicles
18	Julin, Sofia	DNA Origami Directed 3D Nanoparticle Superlattice
19	Kaya, Meryem Ecem	3D Nano-sized Filters Enable Controlled Interactions Between Microbial Populations
20	Korpi, Antti	Self-Assembly of Functional Crystalline Protein Cage Scaffolds
21	Kämäräinen, Tero	Harmonic Analysis of Wrinkled and Crumpled Colloidal Lignin
22	Laaksonen, Päivi	Colloidally stable entangled microcrystalline cellulose matrices in controlled drug release
23	Latikka, Mika	Wetting Characterization of Hydrophobic Surfaces with Magnetically Oscillated Droplets
24	Lehtonen, Janika	Affordable Nanocellulose Based Materials to Eliminate Bacteria from Drinking Water
25	Lemetti, Laura	Studying silk proteins with FRAP
26	Lepikko, Sakari	Accurate Growth of Dense Self-Assembled Monolayer using Atomic Layer Deposition
27	Lintinen, Kalle	Closed Cycle Production of Concentrated and Dry Redispersible Colloidal Lignin Particles with a Three Solvent Polarity Exchange Method
28	Liu, Qing	DNA Hybridization Chain Reaction (HCR) on Silica Nanoparticle Surface
29	Lohtander, Tia	A Method to Improve the Stability of Natural Dye Extracted from Willow Bark
30	Lundahl, Meri	Rheology of Cellulose Nanofibril Hydrdogel During Wet-Spinning
31	Majoinen, Johanna	Towards Long-Range Ordered sub-10 nm Carbohydrate Triblock Copolymer Thin Films

32	Martikainen, Lahja	High-resolution microscopy of agarose gels
33	Myllymäki, Teemu	Hydrogen bonding asymmetric star-shape derivative of bile acid leads to supramolecular fibrillar aggregates that wrap into micrometer spheres
34	Nurmi, Heikki	Highly mobile water lubricated raft on a superhydrophobic surface
35	Pigliacelli, Claudia	In situ generation of chiroptically active peptide gold superstructures
36	Raju, Geet	Onset of Novel Phase Behavior in Sedimenting Quincke Rollers
37	Rantasalo, Anssi	Synthetic Expression System for Eukaryotic Microorganisms
38	Reyes, Guillermo	Bio-based fibers with extended elongation and toughness
39	Savola, Pihla	Engineering Orthogonal Communication Between Bacterial Populations
40	Szilvay, Geza	High-level production of a designed resilin protein
41	Tardy, Blaise	Interfacial Assembly and Superstructuring of Cellulose Nanocrystals at the Air-Water-Air Interface
42	Wang, Ling	Porous Carbon Fibers from Lignocellulose as Fiber-shaped Supercapacitors
43	Westerholm-Parvinen, Ann	Microbial production of synthetic silk proteins
44	Xiang, Wenchao	Role of Native Cellulose Nanofibrils in Foam Dynamics
45	Zhang, Hang	Pavlovian materials

HYBER principal investigators:

Self-Assembled Materials

Prof. Olli Ikkala
Department of Applied Physics
Aalto University

The multidisciplinary Molecular Materials group consists of physicists and chemists aiming at **functional materials based on self-assembly and its hierarchies**.

Protein Genetic Engineering for Materials

Prof. Markus Linder
Department of Bioproducts and Biosystems
Aalto University

Biomolecular materials group seeks to **understand and utilize biological design strategies for materials**.

Biological Production and Synthetic Biology

Prof. Merja Penttilä
VTT / Dept. of Bioproducts and Biosystems
Aalto University

VTT Industrial Biotechnology develops **novel biotechnological production concepts for bioproducts**. By developing more efficient production strains, enzymes and processes, we create added value for our partners.

Plant Cells for Materials

Prof. Orlando Rojas
Department of Bioproducts and Biosystems
Aalto University

Bio-based Colloids and Materials group works in the area of natural polymers, **nanocelluloses** and the assembly behavior of **natural surfactants** and biopolymers.

Contact:

Coordinator Jukka Hassinen
jukka.hassinen@aalto.fi
+358453106166
(6/2018 -> Mirkka Jones)

HYBER acknowledges:

Aalto University

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