BOOK OF ABSTRACTS

SupraLife Final International Conference

29 September - 3 October 2025

University of Aveiro, Portugal

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WELCOME LETTER

Dear SupraLife Friends and Colleagues,

It is our pleasure to welcome you to the SupraLife Final International Conference entitled "Supramolecular Multifunctional Biomaterials and Systems for Biomedical and Healthcare Applications", which takes place in the pleasant city of Aveiro, Portugal, from 29th September to 3rd October 2025.

The Final International Conference includes an outstanding scientific program consisting of 15 plenary lectures by world-renowned scientists well-known for their extensive expertise and experience in the supramolecular and biomaterials' chemistry fields. The plenary speakers will present a comprehensive overview of the research activities headed by their own research groups and in collaboration with other research groups, industry practitioners or clinicians. The lectures will cover the topics of *biomimetic and bioinspired supramolecular systems, functional supramolecular polymers, dynamic stimuli-responsive soft polymeric materials and hydrogels, self-assembled supramolecular (bio)materials and structures, multiscale and hierarchical biomaterials, injectable systems, bioactive and bioinstructive surfaces and structures for drug/protein/cell delivery, drug screening, biosensing, theranostics, tissue engineering and regenerative medicine strategies*. The scientific program will also include oral and poster presentations selected from contributed abstracts submitted by students and early-career scientists to enable them to share and discuss their scientific discoveries, interact closely and exchange ideas with peers. Awards will be given to the three best oral communications and to the best three poster communications. The Young Scientists' Networking Forum will provide plenty of opportunities for young scientists to network with peers in an informal and relaxed atmosphere.

We would like to express our sincere thanks to the Plenary Speakers and Chairs of the different sessions for their kind availability and for sharing their work and expertise. We extend our gratitude to the Oral and Poster presenters for sharing their work, as well as to all Attendees for joining us in Aveiro for the SupraLife Final International Conference!

Moreover, we are also very grateful to the SupraLife's consortium partners, Associate Laboratory CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, as well as to all Sponsors for their invaluable support.

Last, but not least, a special thanks to the Local Organizing Committee for their tireless support, effort, commitment, and professionalism, and extremely important contribution to the success of this event.

We hope that you all find the SupraLife Final International Conference stimulating and that you enjoy your stay in the beautiful city of Aveiro, and we look forward to meeting you and exchanging further in shaping together the future of supramolecular biomaterials and systems for healthcare!

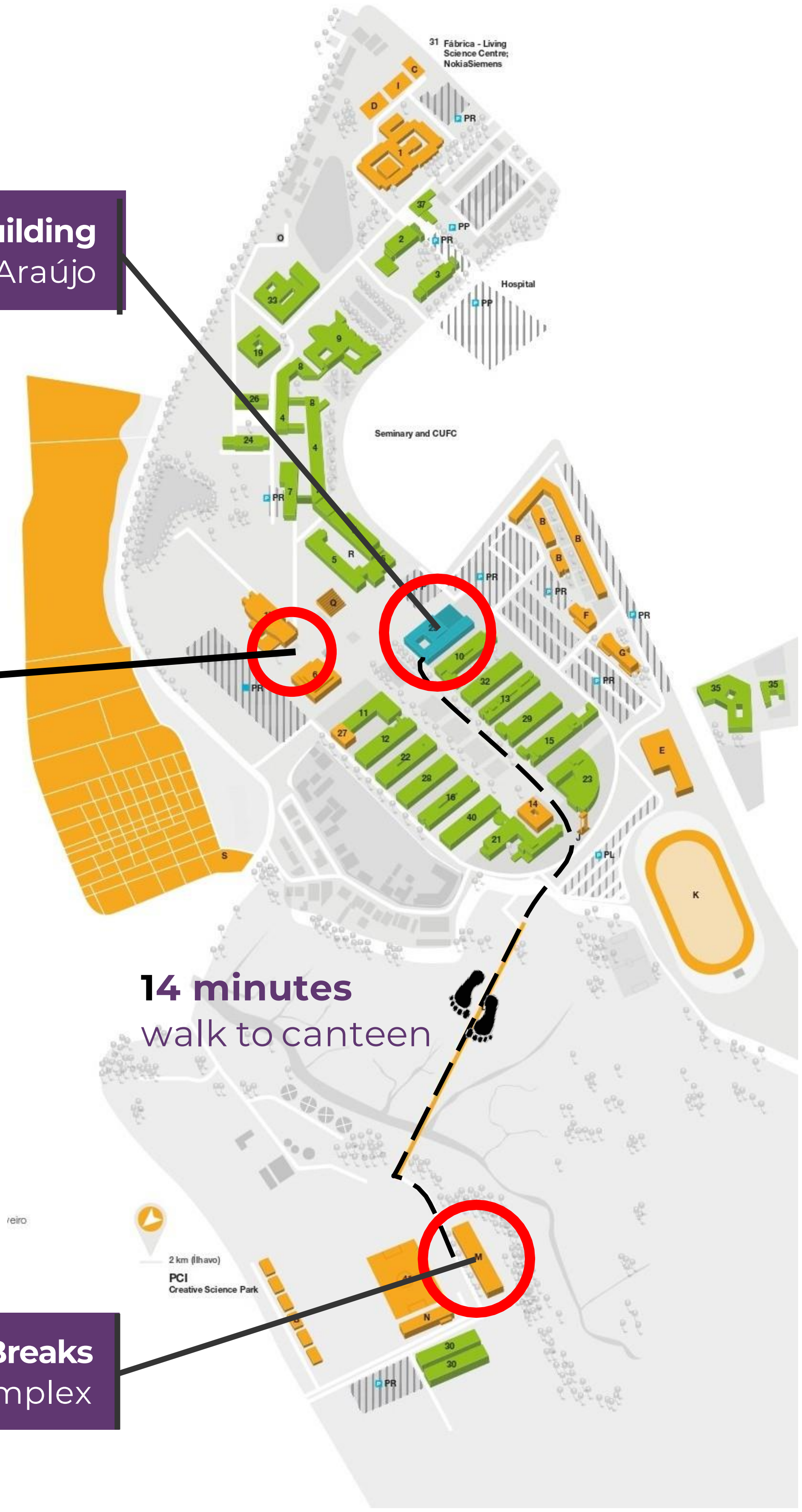
The Chairs of the SupraLife Final International Conference,

João F. Mano

João Borges

João Borges

UNIVERSITY OF AVEIRO
CAMPUS MAP



Central and Rectorate Building
Auditorium Renato Araújo

Coffee Breaks and Poster Sessions
University Gallery - "Catacumbas"

14 minutes
walk to canteen

Lunch Breaks
Crasto Canteen Complex

Monday, September 29th **Auditorium Renato Araújo – Central and Rectorate Building | University of Aveiro**	
13:30 - 19:00	Registration
14:30 - 15:00	Opening Ceremony **Artur Silva** (Vice-Rector for Research, Innovation and 3rd Cycle of the University of Aveiro, Portugal) **João Borges & João F. Mano** (Coordinators of SupraLife project at the University of Aveiro, Portugal)
Chairs: **João Borges** (University of Aveiro, Portugal) & **João F. Mano** (University of Aveiro, Portugal)	
15:00 - 15:45	**PL1. Samuel Stupp** (Northwestern University, USA) *Bioactive supramolecular materials for regenerative medicine*
15:45 - 16:30	**PL2. Alberto Saiani** (The University of Manchester, UK) *Engineering β-sheet peptide supramolecular hydrogels for biomedical applications*
16:30 - 17:30	Coffee Break & Poster Session
Chairs: **Matthew Webber** (University of Notre Dame, USA) & **Mónica Martínez-Orts** (Institute for Advanced Chemistry of Catalonia, Spain)	
17:30 - 18:15	**PL3. Ian Hamley** (University of Reading, UK) *Bioactive self-assembling peptides and lipopeptides*
18:15 - 18:30	**OC1. Carlos Redondo-Gómez** (i3S, University of Porto, Portugal) *An enzyme-regulated peptide hydrogel model to mimic pathological calcifications*
18:30 - 18:45	**OC2. Torsten John** (Constructor University, Germany) *Molecular mechanisms of peptide assembly for biomaterials*
18:45 - 19:00	**OC3. Mohamed Elsawy** (The University of Manchester, UK) *Antibacterial peptide nanofibers: A promising strategy for combating antimicrobial resistance in infected wounds*
19:00 - 21:30	Welcome Reception
Tuesday, September 30th **Auditorium Renato Araújo – Central and Rectorate Building | University of Aveiro**	
8:30 - 17:00	Registration
Chairs: **Tina Vermonden** (Utrecht University, The Netherlands) & **Francisco Fernandes** (Sorbonne University, France)	
9:00 - 9:45	**PL4. João F. Mano** (University of Aveiro, Portugal) *Multi-scale assembly of cells-rich constructs*
9:45 - 10:30	**PL5. Cecília Roque** (FCT-NOVA University of Lisbon, Portugal) *Protein based materials – Bioinspired systems for unusual applications*
10:30 - 11:30	Coffee Break & Poster Session
Chairs: **Ian Hamley** (University of Reading, UK) & **Ana Rita Pinho** (University of Aveiro, Portugal)	
11:30 - 11:45	**OC4. Francisco Fernandes** (Sorbonne University, France) *Ice templating extracellular matrix proteins as a pathway to develop multi-tubular tissue biomimetic hydrogels*
11:45 - 12:00	**OC5. Michele Bianchi** (University of Modena and Reggio Emilia, Italy) *Multifunctional biointerfaces based on micro/nanopatterned (conductive) materials*

Funded by the European Union

The SUPRALIFE project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101079482.

12:00 - 14:30	Lunch Break & Networking
Chairs: **Alberto Saiani** (The University of Manchester, UK) & **Colin Bonduelle** (University of Bordeaux, France)	
14:30 - 15:15	**PL6. Matthew Webber** (University of Notre Dame, USA) *Supramolecular design for on-demand delivery of insulin and glucagon*
15:15 - 16:00	**PL7. Tina Vermonden** (Utrecht University, The Netherlands) *Dynamic shrinking hydrogels to engineer narrow tubular structures*
16:00 - 16:15	**OC6. Stefan Mommer** (ETH Zurich, Switzerland) *Tough supramolecular hydrogels through homoternary CB[8] host-guest complexation*
16:15 - 16:30	**OC7. Bárbara Matos** (i3S, University of Porto, Portugal) *Supramolecular peptide nanostructures for prostate cancer targeted drug delivery*
16:30 - 16:45	**OC8. Sanne van de Looij** (Utrecht University, The Netherlands) *Thermo-adaptive hydrogels for mechanical stimulation in cartilage tissue engineering*
16:45 - 17:00	**OC9. Julián Fuentes** (University of Aveiro, Portugal) *Desolvation-induced assembly of human platelet lysate into nanoparticles for controlled drug delivery*
17:00 - 19:00	Coffee Break & Poster Session
21:30 - 23:30	Young Scientists' Networking Forum
Wednesday, October 1st **Auditorium Renato Araújo – Central and Rectorate Building | University of Aveiro**	
Chairs: **Job Boekhoven** (Technical University of Munich, Germany) & **Roza Szweda** (Adam Mickiewicz University, Poland)	
8:30 - 17:00	Registration
9:00 - 9:45	**PL8. E. W. "Bert" Meijer** (Eindhoven University of Technology, The Netherlands) *From supramolecular polymers to functional materials and systems*
9:45 - 10:30	**PL9. Patricia Dankers** (Eindhoven University of Technology, The Netherlands) *From design of supramolecular monomers to unexpected supramolecular polymer behavior – Possibilities for cell and organoid cultures*
10:30 - 11:15	Coffee Break & Poster Session
Chairs: **Christoph Weder** (University of Fribourg, Switzerland) & **Michele Bianchi** (University of Modena and Reggio Emilia, Italy)	
11:15 - 11:30	**OC10. Mónica Martínez-Orts** (Institute for Advanced Chemistry of Catalonia, Spain) *A promising strategy to trigger superselective disassembly of stimuli-responsive supramolecular fibers*
11:30 - 11:45	**OC11. Bram Bakker** (Eindhoven University of Technology, The Netherlands) *Dynamic, robust and bioactive ureidopyrimidinone-platelet lysate hybrid hydrogels*
11:45 - 12:00	**OC12. Julieta Paez** (University of Twente, The Netherlands) *Nucleic acid bioinspired, conductive, fibrillar supramolecular hydrogels for engineering heart tissue models*
12:00 - 12:15	**OC13. Roza Szweda** (Adam Mickiewicz University, Poland) *Translation of encoded chiral information into polymer properties*
12:15 - 12:30	**OC14. Victor Veenbrink** (Eindhoven University of Technology, The Netherlands) *Automated discovery of ECM-mimicking supramolecular assemblies through cell painting and machine learning*

12:30 - 14:30	Lunch Break & Networking
Chairs: E. W. “Bert” Meijer (Eindhoven University of Technology, The Netherlands) & **Rui Sun** (University of Bristol, UK)	
14:30 - 15:15	**PL10. Job Boekhoven** (Technical University of Munich, Germany) *Regulating non-equilibrium self-assembly with chemical fuels – Spinning ribbons, dissipative structures, and an approach towards synthetic life*
15:15 - 15:30	**OC15. Valeria Castelletto** (University of Reading, UK) *Minimal peptide sequences that undergo liquid−liquid phase separation via self-coacervation or complex coacervation with ATP*
15:30 - 15:45	**OC16. David Reis** (ITQB, NOVA University of Lisbon, Portugal) *Catalytic peptide-based coacervates for enhanced function through structural organization and substrate specificity*
15:45 - 16:00	**OC17. Sudeep Koppayithodi** (University Jaume I, Spain) *Reactive coacervates show budding and membrane formation*
16:00 - 16:15	**OC18. Federica Pedrini** (Università degli Studi di Roma “Tor Vergata”, Italy) *Dynamic DNA nanomaterials enabled by enzyme-mediated dissipative hybridization chain reaction*
16:15 - 16:30	**OC19. Elena Spezzani** (University of Parma, Italy) *Monitoring multivalent DNA origami-cell interactions in real time via single particle tracking*
16:30 - 17:00	Coffee Break & Poster Session
18:00	Meeting time for Gala Dinner at the Central and Rectorate Building | University of Aveiro
19:00 - 23:00	Gala Dinner
Thursday, October 2nd **Auditorium Renato Araújo – Central and Rectorate Building | University of Aveiro**	
Chairs: Cecília Roque (FCT-NOVA University of Lisbon, Portugal) & **Mohamed Elsawy** (The University of Manchester, UK)	
9:00 - 9:45	**PL11. Colin Bonduelle** (University of Bordeaux, France) *Polypeptides: from proteins to new approaches in polymer synthesis*
9:45 - 10:30	**PL12. Luisa De Cola** (University of Milano, Italy) *Supramolecular and hybrid responsive nanomaterials for living organism*
10:30 - 11:30	Coffee Break & Poster Session
Chairs: Julieta Paez (University of Twente, The Netherlands) & **Dominik Schauenburg** (Maastricht University, The Netherlands)	
11:30 - 11:45	**OC20. Qi Wang** (Radboud University Nijmegen, The Netherlands) *A universal supramolecular clamping strategy for proximity-induced reactivity on polymersome interfaces*
11:45 - 12:00	**OC21. Valentin Marot** (University of Bordeaux, France) *Polypeptide-based in situ forming depots as long-acting injectable for the controlled release of therapeutic molecules*
12:00 - 12:15	**OC22. Shree Bagchi** (Eindhoven University of Technology, The Netherlands) *Bottom-up synthesis of artificial cells – Engineering life-like systems*
12:15 - 12:30	**OC23. Ana Rita Pinho** (University of Aveiro, Portugal) *Engineering compartmentalized self-assembling scaffolds for in vitro modeling of complex tissues*

12:30 - 14:30	Lunch Break & Networking
Chairs: **Luisa De Cola** (University of Milano, Italy) & **Torsten John** (Constructor University, Germany)	
14:30 - 15:15	**PL13. Christoph Weder** (University of Fribourg, Switzerland) *Mechanochromic polymers made with supramolecular mechanophores*
15:15 - 15:30	**OC24. Dominik Schauenburg** (Maastricht University, The Netherlands) *Tuning life-like materials: From reversible bonds to regenerative function*
15:30 - 15:45	**OC25. Iana Lychko** (FCT-NOVA University of Lisbon, Portugal) *Reflectin-inspired self-assembling systems for functional supramolecular biomaterials*
15:45 - 16:00	**OC26. Edoardo Sisti** (Istituto di Ricerche Farmacologiche Mario Negri, Italy) *Hybrid hydrogels for locoregional drug delivery*
16:00 - 17:00	Coffee Break & Poster Session
17:00 - 19:00	Social Program
Friday, October 3rd **Auditorium Renato Araújo – Central and Rectorate Building | University of Aveiro**	
Chairs: **Patricia Dankers** (Eindhoven University of Technology, The Netherlands) & **Paulina N. Bernal** (University Medical Center Utrecht, The Netherlands)	
9:00 - 9:45	**PL14. Carlijn Bouten** (Eindhoven University of Technology, The Netherlands) *Materials-driven in-situ tissue regeneration*
9:45 - 10:30	**PL15. Marcy Zenobi-Wong** (ETH Zurich, Switzerland) *Architecting Scaffolds with Light*
10:30 - 11:30	Coffee Break & Poster Session
Chairs: Marcy Zenobi-Wong (ETH Zurich, Switzerland) & Stefan Mommer (ETH Zurich, Switzerland)	
11:30 - 11:45	**OC27. Hossein Goodarzi Hosseinabadi** (Eindhoven University of Technology, The Netherlands) *Supramolecular heart patch for controlled drug release and mechanical support in myocardial infarction therapy*
11:45 - 12:00	**OC28. Paulina N. Bernal** (University Medical Center Utrecht, The Netherlands) *Dynamic hybrid gelatin bioresins with supramolecular-covalent networks for enhanced cell migration and self-assembly in volumetric light-based bioprinting*
12:00 - 12:30	Closing Ceremony, Best Oral and Poster Awards **João Borges & João F. Mano** (University of Aveiro, Portugal)

LIST OF PRESENTATIONS

Samuel Stupp

Northwestern University

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Samuel Stupp is Board of Trustees Professor of Materials Science and Engineering, Chemistry, Medicine, and Biomedical Engineering at Northwestern University. He also directs Northwestern's Simpson Querrey Institute for BioNanotechnology and the Center for Bio-Inspired Energy Science, an Energy Frontiers Research Center funded by the U.S. Department of Energy. Stupp has been a pioneer in the development of self-assembling supramolecular materials and is focused on functions relevant to regenerative medicine, renewable energy, and robotic soft matter. The materials of interest include supramolecular polymers, organic/inorganic hybrid materials, biomolecular structures, and organic electronic materials. Stupp is a member of the National Academy of Sciences, the National Academy of Engineering, the American Academy of Arts and Sciences, the Royal Spanish Academy, the Latin American Academy of Sciences, the Academy of Sciences of Costa Rica, and the National Academy of Inventors. His awards include the Department of Energy Prize for Outstanding Achievement in Materials Chemistry, the Materials Research Society Medal Award, the International Award from The Society of Polymer Science in Japan, the Royal Society Award in Soft Matter and Biophysical Chemistry, and three national awards from the American Chemical Society: the ACS Award in Polymer Chemistry, the Ronald Breslow Award for Achievement in Biomimetic Chemistry, and the Ralph F. Hirschmann Award in Peptide Chemistry. He has received honorary degrees from Eindhoven Technical University, Gothenburg University, and the National University of Costa Rica, as well as distinguished professorships from Hong Kong University, the Institute for Bioengineering of Catalonia (Severo Ochoa Professor), Nanyang Technological University in Singapore, Eindhoven Technical University, and Ecole de Physique et de Chimie in Paris.

ABSTRACT

Bioactive Supramolecular Materials for Regenerative Medicine

S. Stupp
Departments of Materials Science and Engineering, Chemistry, Medicine, and Biomedical Engineering,
Center for Regenerative Nanomedicine, Northwestern University

Regenerative medicine is a critical unmet need for the 21st century and beyond in order to secure transformative improvements in healthspan. The aim of this area of biotechnology is to regenerate tissues lost to trauma, degenerative diseases, or aging. Over the past few decades, most efforts have focused on the use of cell, gene, or growth factor therapies, which face challenges in scalability, short half lives, cost, and safety, among others. A logical frontier for this field is the use of bioactive materials that communicate with cells in order to drive de novo tissue formation. This approach mimics the natural way tissues form during development, homeostasis, or post injury, that is relying on protein, peptide or glycan signals nested in the mechanically supportive scaffolds of extracellular matrices (ECMs). Using this bio-inspired notion, our laboratory has focused on the development of bioactive supramolecular materials for regeneration as artificial ECMs that biodegrade safely into naturally occurring components. Supramolecular dynamics in large assemblies of peptides or glycopeptides makes these systems ideal to “directly” activate cell receptors or amplify signaling by endogenous growth factors. These regenerative therapies are also by far more scalable than cells and can have longer half-lives than protein or nucleic acid biologics. The lecture will illustrate the use of these supramolecular systems in spinal fusion, cartilage repair for osteoarthritis, stroke, neurodegenerative diseases, as well as acute and chronic spinal cord injury.

Acknowledgments: ERC, Academy of Finland

Alberto Saiani

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Alberto Saiani PhD, FRSC is Professor of Molecular Materials at the University of Manchester, School of Materials & Manchester Institute of Biotechnology, UK. He graduated in 1994 with a PhD in polymer physics from the University Louis Pasteur, Strasbourg, France. Following his PhD he held a number of post-doctoral positions in Belgium, Japan and the UK. In 2000 he was appointed lecturer at the University Blaise Pascal, Clermont-Ferrand, France before joining in 2002 the University of Manchester. His research work spans a wide area of experimental polymer and biopolymer science and focuses on understanding the chemical architecture - thermodynamic - structure - physical property correlations in complex polymeric systems using state of the art techniques, which includes neutron and X-ray small angle scattering on large scale facilities. His work encompasses a variety of synthetic and biological polymeric materials including polyurethanes and polyureas elastomers; and protein and peptide hydrogels (www.PolymersandPeptides.co.uk). In 2013 he was awarded a 5-year Research Fellowship by the Engineering and Physical Science Research Council (EPSRC, UK) to pursue his work on self-assembled peptide biomaterials. In 2016 he was elected fellow of the Royal Society of Chemistry.

ABSTRACT

Engineering β-sheet peptide supramolecular hydrogels for biomedical applications

A. Saiani

Division of Pharmacy and Optometry & Manchester Institute of Biotechnology, School of Health Sciences, Faculty of Biology, Medicine and Health, The University of Manchester, UK

The use of non-covalent self-assembly has become a prominent strategy in material science offering practical routes for the construction of increasingly functional materials for a variety of applications ranging from electronic to biotechnology. A variety of molecular building blocks can be used for this purpose; one such block that has attracted considerable attention in the last 20 years is de-novo designed peptides.

Our group work has focussed on the development of a technological platform for the design of novel biofunctional hydrogels exploiting the self-assembly of so-called β-sheet forming peptides. These hydrogels can be easily functionalised using specific biological signals and can also be made responsive through the use of enzymatic catalysis and/or conjugation with responsive polymers. Through the fundamental understanding of the self-assembly and gelation processes of these peptides across length scales we have been able to design hydrogels with tailored properties for a range of applications from tissue engineering, cell culture and drug delivery to 3D bioprinting and biosensing.

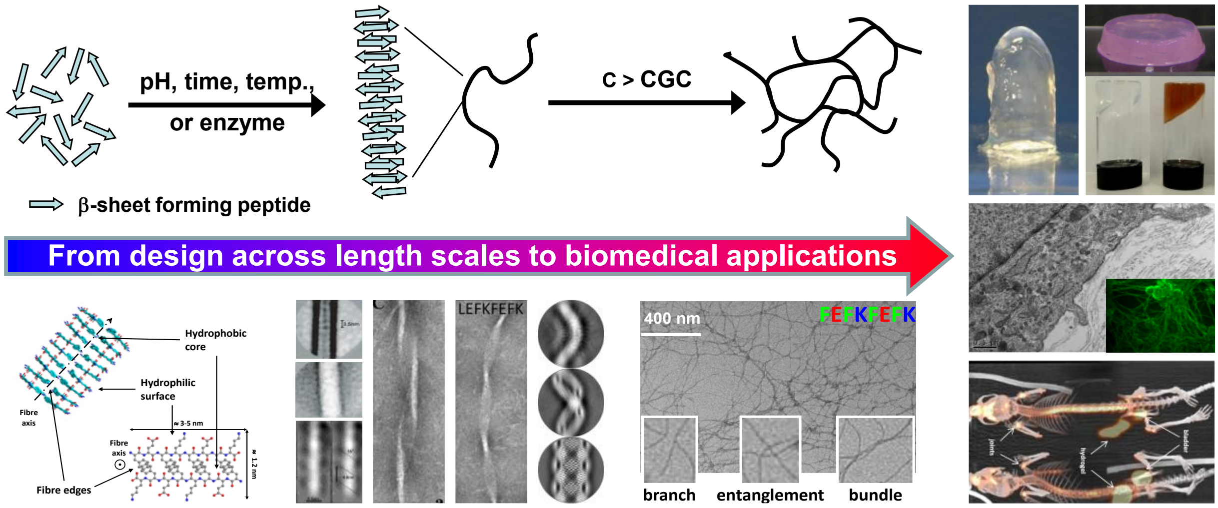

Figure 1. Schematic representation of the self-assembly and gelation pathway of β-sheet forming peptides and their characterisation and application.

Here I will discuss our group's journey from biomolecular design and materials formulation to their potential use in the biomedical sector as well as the challenges encounter along the commercialisation and translational pathways and future directions.

Acknowledgments: Funding: EPSRC Research Fellowship (Grant n°: EP/K016210/1) & MRC Acellular/Smart Materials – 3D Architecture: UKRMP Hub (Grant n°: MR/R015651/1)

References:

References are available at our group website: www.polymersandpeptides.co.uk

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Professor **Ian W. Hamley** is Diamond Professor of Physical Chemistry at the University of Reading. He has more than 25 years' experience of research on biomaterials, materials for regenerative medicine and healthcare, peptides, polymers and biosurfactants. He received a Royal Society- Wolfson Research Merit Award in 2011, the RSC Peter Day Award for Materials Chemistry (2016) and the MacroGroup UK Medal (2017) and is currently an EPSRC Senior Fellowship holder. He has supervised more than fifty postdoctoral and postgraduate researchers and has published over 500 papers and books.

ABSTRACT

Bioactive Self-Assembling Peptides and Lipopeptides

#I. W. Hamley,* V. Castelletto
Dept of Chemistry University of Reading, Whiteknights, Reading RG6 6AD, UK

I will review selected examples of recent work in my group that exploits the self-assembly propensity of designed peptides and lipopeptides to control their diverse structures and bioactivities in aqueous solutions and gels. I will discuss arginine-containing surfactant-like peptides which show diverse nanostructures including a new type of □-helical nanotube,[1-2] and hydrogel and emulsion formation along with remarkable bioactivity such as selective antimicrobial activity.[3-5] I will also briefly outline selected discoveries on bioactive self-assembling lipopeptides including those with applications in tissue engineering and the production of cultured meat,[6] and those with properties as antimicrobials, biosurfactants, model colloid systems,[7-8] and in regenerative medicine (wound healing).[9]

References:
[1] Castelletto, V.; Seitsonen, J.; Ruokolainen, J.; Hamley, I. W., Alpha Helical Surfactant-Like Peptides Self-Assemble Into pH-Dependent Nanostructures. Soft Matter 2020, 17, 3096-3104.
[2] Castelletto, V.; Seitsonen, J.; Ruokolainen, J.; Piras, C.; Cramer, R.; Edwards-Gayle, C. J. C.; Hamley, I. W., Peptide Nanotubes Self-Assembled from Leucine-Rich Alpha Helical Surfactant-Like Peptides. ChemComm 2020, 56, 11977-11980.
[3] Castelletto, V.; Barnes, R. H.; Karatsas, K.-A.; Edwards-Gayle, C. J. C.; Greco, F.; Hamley, I. W.; Seitsonen, J.; Ruokolainen, J., Restructuring of Lipid Membranes by an Arginine-Capped Peptide Bolaamphiphile. Langmuir 2019, 35, 1302-1311.
[4] Castelletto, V.; Barnes, R. H.; Karatzas, K. A.; Edwards-Gayle, C. J. C.; Greco, F.; Hamley, I. W.; Rambo, R.; Seitsonen, J.; Ruokolainen, J., Arginine-Containing Surfactant-Like Peptides: Interaction with Lipid Membranes and Antimicrobial Activity. Biomacromolecules 2018, 19, 2782-7294.
[5] Castelletto, V.; Edwards-Gayle, C. J. C.; Hamley, I. W.; Pelin, J. N. B. D.; Alves, W. A.; Alguilar, A. M.; Seitsonen, J.; Ruokolainen, J., Self-Assembly of a Catalytically Active Lipopeptide and its Incorporation into Cubosomes. ACS Appl. Bio. Mater. 2019, 2, 3639-3648.
[6] Rosa, E.; Mello, L. R.; Castelletto, V.; Dallas, M. L.; Accardo, A.; Hamley, I. W., Cell Adhesion Motif Functionalized Lipopeptides: Nanostructure and Selective Myoblast Cytocompatibility. Biomacromolecules 2023, 24 (1), 213-224.
[7] Hamley, I. W.; Adak, A.; Castelletto, V., Lysine-Rich Lipopeptide Micelles: Influence of Chirality and Sequence in Model Colloidal Systems and Biosurfactants. Nature Commun. 2024, 15, 6785.
[8] Adak, A.; Hamley, I. W.; Castelletto, V.; de Sousa, A. S. L.; Karatsas, K.-A.; Wilkinson, C., Self-Assembly and Antimicrobial Activity of Lipopeptides Containing Lysine Based Tripeptides. Biomacromolecules 2024, 25, 1205-1213.
[9] Adak, A.; Castelletto, V.; Hamley, I. W.; Seitsonen, J.; Jana, A.; Ghosh, S.; Mukherjee, N.; Ghosh, S., Self-assembly and Wound Healing Activity of Biomimetic Cycloalkane-Based Lipopeptides. ACS Appl. Mater. Interfaces 2024, 16, 58417-58426.

João Mano

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João F. Mano (PhD in Chemistry, 1996; D.Sc. in Tissue Engineering, 2012) is Full Professor at the Department of Chemistry, University of Aveiro (Portugal), where he directs the Doctoral Program on Biotechnology. He also holds visiting/adjunct professorships in France, South Korea, and Malaysia. Since 2022, he is vice-director of CICECO – Aveiro Institute of Materials, leading the COMPASS Research Group.His research focuses on biomaterials, polymers, and cell-based strategies for regenerative and personalized medicine, including biomimetic and nano/micro-technology approaches for biomedical devices, advanced therapies, drug screening, and engineered disease models.He has published 750+ papers (35,000+ citations, h=96), 40+ book chapters, and edited 14 books/special issues. He has supervised 100+ MSc/PhD students and 40+ postdocs, filed 15+ patents, and co-founded METATISSUE (human-derived hydrogels) and CELLULARIS Biomodels (cell-based disease models). He serves as Editor-in-Chief of Materials Today Bio and participates in editorial boards and scientific societies worldwide.Prof. Mano has delivered 120+ invited/keynote talks and reviewed for 340+ journals and numerous funding agencies. His awards include the ERC Advanced Grants (2015, 2021), ERC Proof-of-Concept Grants (2018, 2020, 2022), the European Materials Gold Medal (FEMS, 2023), George Winter Award (2020), and Doctor Honoris Causa titles from Lorraine (2019) and Utrecht (2022), among many other national and international recognitions.

ABSTRACT

Multi-scale assembly of cells-rich constructs

J.F. Mano
CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal

Bioinspired engineered microenvironments provide cells with a holistic “instructive niche” that offers the adequate entourage for cellular control both in space and time. Such approaches are important to design hierarchical constructs with applicability, for example, in tissue engineering or in the development of in vitro models for drug screening. We have been proposing strategies of combining cells and biomaterials in controlled submillimetre compartments, namely: (i) cell encapsulation in liquified capsules with thin biomaterials shells formed by polyelectrolytes complexation for the autonomous development of microtissues; (ii) soft compartments created by the combination of cells and thin micro-membranes, where the biomaterial is crumpled into the shape of miniaturised scaffolds by the traction forces of the cells; (iii) individual cells with modified surface using glycoengineering principles. Such hybrid elements can be used as building blocks to be assemble into large constructs to produce macroscopic tissues using bottom-up tissue engineering methodologies. We demonstrated the possibility of creating hierarchical constructs based on distinct bottom-up technologies, using hydrogels as the continuous binder of these living hybrid elements. We showed that cells in the original compartments may behave depending on the original microenvironment, and independently of the external milieu.

Cecília Roque

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Cecília Roque is a Full Professor in Bioengineering and head of the Biomolecular Engineering Lab at the School of Science and Technology, NOVA University of Lisbon. She is UCIBIO Director since February 2023. Cecilia holds a degree in Chemical Engineering (Major in Biotechnology) and a PhD in Biotechnology from Instituto Superior Técnico. Cecília has been a Visiting Scholar at the University of Cambridge and at the Catholic University of America, a Post-doctoral researcher at the Institute of Biotechnology (University of Cambridge) and at INESC-MN (Lisbon, Portugal), and a Visiting Professor at the University of Cambridge, University of Nantes, University of São Paulo, City University of New York and KTH Royal Institute of Technology in Stockholm. Her research focus on biomimetics merging chemistry, biotechnology and engineering, and her work has been merited with several national and international distinctions. She has been awarded Starting and Proof-of-concept grants from the European Research Council.

ABSTRACT

Protein Based Materials - Bioinspired Systems for unusual applications

ACA. Roque

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Peptide and protein self-assembly can generate modular and tunable materials with unique molecular recognition and self-powered stimuli-responsive properties.

Peptide and protein self-assembly in non-conventional solvents as ionic liquids originates new materials, with properties distinct from the corresponding water-based assemblies, namely molecular recognition towards analytes, air-stability, high-encoding capacity and transduction potential.

Firstly, the molecular self-assembly mechanisms of bio-based molecules in ionic liquids are complex and still poorly understood, as ionic liquids themselves present self-assembling properties. One of our goals has been to understand how peptides and proteins adopt new hierarchical assemblies in non-aqueous environments.

Secondly, the amphiphilic nature of ionic liquids facilitates the creation of compartments in which hydrophobic moieties, as liquid crystals, are entrapped. Such hybrid materials result from the co-assembly of functional components – liquid crystals for reporting, ionic liquid as solvent, biopolymer as matrix - which give rise to molecular recognition properties towards volatile organic compounds (VOCs) not seen in the individual components. When casting the hybrid gels as thin films, they exhibit dual optical and electrical stimuli-responsive properties in the presence of VOCs. Films of hybrid gels are studied as gas sensing materials in a custom-built electronic nose, supported by a dedicated automatic classifier based on support vector machines for data processing. On the other hand, the generated liquid crystal textures are extremely rich and varied and thus can be used to generate random and unpredictable optical textures for dynamic anti-counterfeiting tags.

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References

[1] A. Hussain, A.T.S. Semeano, S.I.C.J. Palma, A.S. Pina, J. Almeida, B.F. Medrado, A.C.C.S. Pádua, A.L. Carvalho, M. Dionísio, R.W.C. Li, H. Gamboa, R.V. Ulijn, J. Gruber, A.C.A. Roque, Adv. Funct. Mater., 2017, 1700803 1–9.
[2] C. Esteves, G.M.C. Santos, S.I.C.J. Palma, H.M.A. Costa, V.D. Alves, A.R. Porteira, B.M. Morais, I. Ferreira, H. Gamboa, A.C.A. Roque, Mater. Today Bio. 2019, 1, 100002.
[3] A.T.S. Semeano, D.F. Maffei, S. Palma, RWC. Li, BDGM. Franco, A.C.A. Roque, J. Gruber, Food Control, 2018, 89, 72–76.
[4] J. Frazão, S. Palma, HMA Costa, C. Alves, A.C.A. Roque, M. Silveira, Sensors, 2021, 21(8), 2854.
[5] C. Esteves, SICJ Palma, HMA Costa, C Alves, GMC Santos, E Ramou, ALM Carvalho, V Alves, A.C.A. Roque, Adv. Mater., 2022, 2107205, 1–14.

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Matthew Webber is the Keating-Crawford Collegiate Professor of Engineering, an Associate Professor in the Department of Chemical & Biomolecular Engineering, and the Director of the Berthiaume Institute for Precision Health at the University of Notre Dame (USA). His research group is interested in applying supramolecular principles, leveraging defined and rationally designed non-covalent interactions, to improve biomaterials and drug delivery. Prof. Webber received a BS in Chemical Engineering from the University of Notre Dame and a PhD in Biomedical Engineering from Northwestern University. Subsequently, he was an NIH NRSA postdoctoral fellow at MIT. He is the recipient of the American Diabetes Association Pathway Accelerator Award, the JDRF Career Development award, the NSF CAREER award, and the AIChE Owens-Corning Award. In 2023, he was inducted to the College of Fellows of the American Institute of Medical and Biological Engineering.

ABSTRACT

Supramolecular Design for On-Demand Delivery of Insulin and Glucagon

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Achieving stable blood glucose remains a persistent challenge in diabetes management, as current therapies cannot replicate natural glycemic control and often cause dangerous fluctuations. We are developing supramolecular biomaterials that enable autonomous, glucose-responsive release of both insulin and glucagon to address hyper- and hypoglycemia. For insulin, we employ dynamic-covalent motifs based on boronate ester chemistry, where phenylboronic acids (PBAs) reversibly bind diols. Glucose competes with polymer-bound diols, reducing crosslink density and accelerating insulin release. To improve sensitivity, we designed diboronate (DiPBA) motifs that form bidentate interactions with glucose, yielding hydrogels and nanocomplexes with enhanced responsiveness and sustained glycemic control for up to one week in diabetic swine. Complementarily, we engineer glucagon delivery systems based on glucose-directed supramolecular assembly and liquid–liquid phase separation. These materials stabilize depots under normoglycemia and disassemble upon glucose depletion, releasing glucagon to counter hypoglycemia. Together, these strategies demonstrate the potential of supramolecular design to create adaptive, autonomous systems for bidirectional glucose regulation, advancing toward closed-loop biochemical therapies for diabetes.

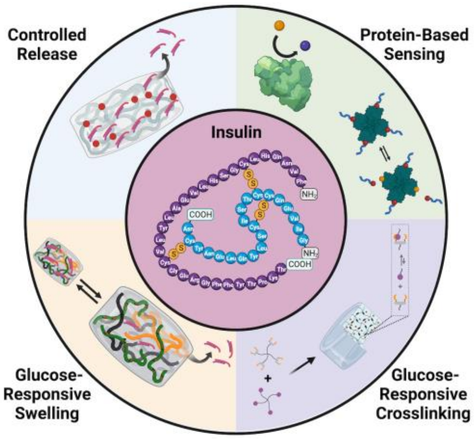

Figure 1. Mechanisms of glucose-responsive function in supramolecular biomaterials designed for insulin and glucagon delivery

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Tina Vermonden obtained her Ph.D. degree in 2005 in Organic Chemistry at Wageningen University. In 2005, she joined the Department of Pharmaceutics at Utrecht University (The Netherlands) as a postdoc working on hydrogels as scaffolds for tissue engineering. During an exchange project, she worked on the diffusion of macromolecules in hydrogels at the Department of Pharmaceutics at the University of Minnesota (Minneapolis, USA) in the group of prof. R.A. Siegel in 2008. In 2009, she was appointed as assistant Professor and in 2020 as full Professor at the Department of Pharmaceutics in Utrecht. She participated as PI in several national and international collaboration programs and has been supervisor of 20 PhD students. In 2014, she was awarded the prestigious VIDI-grant and Aspasia-grant of Dutch Research Council for research on hydrogels that release drug-loaded micelles. In 2021, she obtained a VICI-grant for research on shrinking printing for kidney engineering. Since 2022, she acts as associate editor for the ACS journal Biomacromolecules.

ABSTRACT

Dynamic Shrinking Hydrogels to Engineer Narrow Tubular Structures

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The development of physiologically relevant in vitro models is essential for tissue engineering, disease modeling, and drug screening. A key challenge in biofabrication is replicating micrometer-scale tubular structures, such as nephrons in the human kidney. Existing methods like hydrogel casting and 3D bioprinting face limitations in cell seeding efficiency and balancing high resolution with cell viability. To overcome these issues, we introduce a hydrogel shrinking strategy based on host–guest supramolecular interactions to fabricate small-diameter tubular scaffolds. Our system uses methacrylated hyaluronic acid and dextran, functionalized with cyclodextrin and adamantane groups, forming reversible bonds. Initially, competitor guests inhibit interpolymer interactions; their release triggers hydrogel contraction, reducing volume up to eightfold while preserving cell compatibility. We seeded conditionally immortalized human proximal tubule epithelial cells (ciPTECs) onto preformed channels. During shrinking, cells adhered well, remained viable, and formed a continuous monolayer, confirmed by confocal imaging. This approach enables precise fabrication of renal-scale tubular constructs while maintaining cytocompatibility and structural integrity, offering a promising platform for advanced organ-mimetic models in biomedical research.

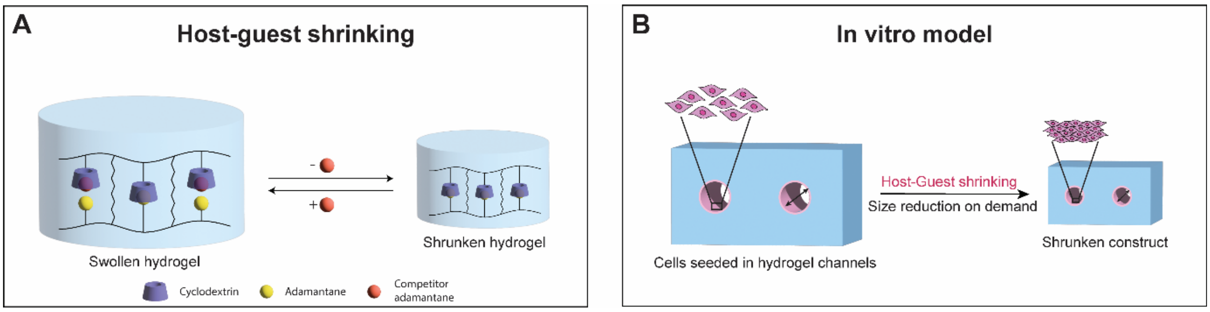

Figure 1. A: Mechanism of the host-guest shrinking approach. B: Application of the host-guest shrinking to obtain tubular in vitro models of smaller diameters.Acknowledgments: ERC, Academy of Finland

References:

D. Iudin, et al. Shrinkable Hydrogels through Host–Guest Interactions: A Robust Approach to Obtain Tubular Cell-Laden Scaffolds with Small Diameters. Advanced Functional Materials 2024, 2416522.
M. Viola, et al. Thermal Shrinking of Biopolymeric Hydrogels for High Resolution 3D Printing of Kidney Tubules. Advanced Functional Materials 2024, 2406098. doi.org/10.1002/adfm.202406098
G. Di Marco, et al. Tunable Thermoshrinkable Hydrogels for 4D Fabrication of Cell-Seeded Channels. Advanced Functional Materials 2025, 2502042

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E.W. "Bert" Meijer is Distinguished University Professor in the Molecular Sciences, Professor of Organic Chemistry at the Eindhoven University of Technology and co-director of the Institute for Complex Molecular Systems. After receiving his PhD degree at the University of Groningen with Hans Wynberg, he worked for 10 years in industry (Philips and DSM). In 1991 he was appointed in Eindhoven, while in the meantime he has part-time positions in Nijmegen, MPI-Mainz, and Santa Barbara, CA.

Bert Meijer is a member of many editorial advisory boards, including Advanced Materials and is associate editor of the Journal of the American Chemical Society. Bert Meijer has received several awards, including the Spinoza Award in 2001, the ACS Award for Polymer Chemistry in 2006, the AkzoNobel Science Award 2010, the International Award of the Society of Polymer Science Japan in 2011, the Cope Scholar Award of the ACS in 2012, the Prelog Medal in 2014, the Nagoya Gold Medal in 2017 and the Chirality Medal in 2018. In 2020 he is knighted by the king to be Commander in the Order of the Netherlands Lion. He is an honorable member of several academies and societies, including the Royal Netherlands Academy of Science, where he is appointed to Academy Professor in 2014. Since 2022 he is also a visiting professorial fellow of the University of New South Wales in Sydney, Australia.

ABSTRACT

From supramolecular polymers to functional materials and systems

E.W. ”Bert” Meijer
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Ever since the first polymers were discovered, scientists have debated their structures. Before Hermann Staudinger published the brilliant concept of macromolecules, it was generally assumed that the properties of polymers were based on the colloidal aggregation of small particles or molecules. Since 1920, polymers and macromolecules have been synonymous with each other; i.e. materials made by many covalent bonds connecting monomers in 2 or 3 dimensions. Although supramolecular interactions between macromolecular chains are evidently important, e.g. in nylons, it was unheard of proposing polymeric materials based on the interaction of small molecules. Breakthroughs in supramolecular chemistry have shown that polymer materials can be made by small molecules using strong directional secondary interactions; the field of supramolecular polymers emerged (Figure 1). In a sense, we have come full circle [1]. Many of the concepts of macromolecular polymers apply to supramolecular polymers, with only one important difference with fascinating consequences: the dynamic nature of the bonds that form polymer chains. This concept created the field of supramolecular materials, where novel unexpected properties are discovered. By controlling supramolecular interactions between molecular fragments, it became easier to design materials with unconventional responsive behavior and dynamic functionalities. In all cases, control over the position of the molecules in time and space is key to arrive at the required functionality. Different supramolecular approaches and selected external stimuli will be discussed in the lecture, with special emphasis on supramolecular materials with, on the one hand, highly ordered morphologies that will change their properties on the action of light, pressure, temperature, or the addition of chemicals. On the other hand, applications in spin filtering, biomaterials and OLEDs will be discussed.

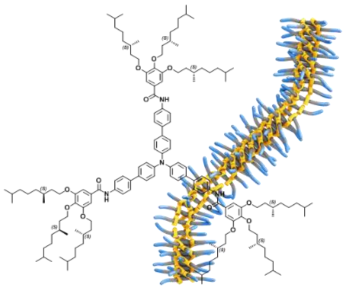

Figure 1. Supramolecular polymer

References:
[1] T. Aida, E.W. Meijer, Supramolecular polymers - we've come full circle, Israel J. of Chem. 60, 33-47 (2020)

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Patricia Y.W. Dankers PhD, PhD, is full professor in Biomedical Materials and Chemistry in the Institute for Complex Molecular Systems (ICMS), and the Departments of Biomedical Engineering and Chemical Engineering & Chemistry at the Eindhoven University of Technology (TU/e). She studied chemistry at the Radboud University of Nijmegen, the Netherlands, where she majored in biochemistry and organic chemistry. During her PhD in natural sciences/chemistry at the Eindhoven University of Technology in the group of prof. dr. E.W. (Bert) Meijer, she combined her fascination for biochemistry and supramolecular chemistry. She developed and studied supramolecular bioactive biomaterials by introducing a modular approach. Here, she laid the foundation for the supramolecular polymers nowadays used by Xeltis in their RestoreXTM technology to treat patients with cardiovascular pathologies. After her PhD defense in 2006, she worked for the company SupraPolix in Eindhoven, and in the laboratory of Pathology and Medical Biology at the University Medical Center Groningen where together with prof. dr. Marja J.A. van Luyn she initiated the bioartificial kidney project in the Netherlands. She defended her second PhD thesis in medical sciences on kidney regenerative medicine at the University of Groningen in 2013. In 2010 she worked at Northwestern University in Chicago, USA, in the research group of prof. dr. Samuel I. Stupp. She has climbed every step on the academic ladder, from assistant professor (2008) and tenured associate professor (2014) till full professor (2017). Moreover, she is co-founder of UPyTher (2020), VivArt-X (2022) and the Helmond Biotech-materials Hub (HBH, 2023).

She received Veni, Vidi & Vici (2008, 2017, 2023) and ERC starting & ERC PoC (2012, 2017) grants. She has been awarded various prizes, such as the Journal of Polymer Science Innovation award at the ACS (2019), the KNCV Gold Medal (2020) and the Ammodo Award for Fundamental Science (2021). Recently, she was one of the main applicants on the funded Gravitation Program to found the Research Center for Interactive Polymer Materials (IPM), in Eindhoven (2022). She is a co-founder of the spin-off companies UPyTher (2020) and VivArt-X (2022), and the Helmond Biotech-materials Hub (HBH, 2023).

ABSTRACT

From design of supramolecular monomers to unexpected supramolecular polymer behavior – possibilities for cell and organoid cultures

Patricia Y.W. Dankers

Institute for Complex Molecular Systems, Department of Biomedical Engineering, Department of Chemical Engineering & Chemistry, Eindhoven University of Technology, Eindhoven, The Netherlands

The integration of synthetic components into biological systems will shape the future of regenerative medicine. In nature, tissues and cells are formed by complex, intricated molecular compositions held together by both covalent and directed non-covalent interactions. They can be regarded as complex molecular systems. The formulation of an artificial extracellular matrix (ECM) from synthetic building blocks that can assemble and disassemble into supramolecular polymers on demand is proposed to lead to complex tissue-inspired materials. We showed the importance of various design criteria to mimic different aspects of the ECM in a supramolecular way; e.g. we showed the effect of supramolecular monomer design on cell behavior, the effect of dynamics on cell adhesion and introduced stress stiffening properties into supramolecular hydrogels. Unexpectedly, it was more recently found that our supramolecular polymer fibers in solution phase separate into liquid droplets, i.e. into so-called tactoids, and that they can act as self-standing systems. In future we aim to answer whether these supramolecular fibers and tactoids in solution can be used for neuronal cell culturing and beyond.

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Self-assembly brings together molecules to create architectures with properties beyond the molecule. Biology also uses self-assembly to create its structural components. However, biology is vastly better at creating molecular assemblies than us synthetic chemists. So, inspired by biology, we ask ourselves, can we synthesize molecular assemblies as complex, intricate, and beautiful as biology does?

In the BoekhovenLab, we design, synthesize, and study molecules to introduce new bio-inspired concepts to supramolecular chemistry. The overarching goals are to create new supramolecular materials as sophisticated as biology's materials, to push the boundaries of supramolecular chemistry, and, one day, to synthesize life from the bottom up. The BoekhovenLab is best known for developing chemically fueled self-assembly. Here, molecular self-assembly is regulated using chemical energy, just like biology does with fuels like ATP. We introduced the immensely popular carbodiimide-fueled reaction cycle that is now widely used by scientists around the globe. We discovered completely new molecular architectures that can only exist when consuming chemical fuel. We developed new ways of making compartments competing for energy, just like life does. We also found materials with completely unique properties.

ABSTRACT

Regulating non-equilibrium self-assembly with chemical fuels-Spinning ribbons, dissipative structures, and an approach towards synthetic life

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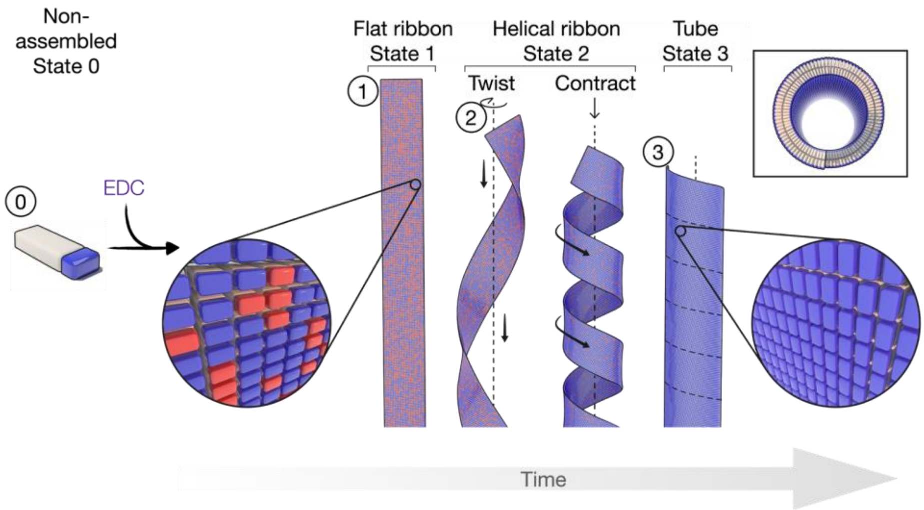
Molecular self-assembly—where molecules organize into larger structures via non-covalent interactions—has become a cornerstone of supramolecular chemistry. Today, we can design Gigadalton-scale assemblies with near-atomic precision, enabling applications from advanced materials to everyday technologies like liquid crystal displays. Yet, nature outperforms us: biological systems use the same non-covalent forces but achieve dynamic, adaptive structures by integrating chemical reactions. In cells, self-assembly is governed not only by structure but also by function and energy consumption. These systems operate far from equilibrium, powered by chemical reaction cycles that create and regulate dynamic assemblies. Despite their importance, the principles underpinning non-equilibrium self-assembly remain largely unexplored.

In this lecture, I will present our recent efforts to uncover the mechanisms that govern chemically fueled, non-equilibrium self-assembly. I will introduce a generalizable reaction cycle that enables energy-driven formation and regulation of supramolecular structures. Through three recent examples—self-spinning ribbons, fuel-driven droplets that undergo periodic dissolution, and other adaptive materials—I will illustrate how such systems behave in fundamentally different ways from equilibrium assemblies. I will conclude with our outlook on how mastering non-equilibrium assembly may lay the foundation for building synthetic life.



Acknowledgments: ERC, Academy of The BoekhovenLab is grateful for support from the European Research Council (ERC starting grant 852187 and consolidator grant 101124380) . This research was conducted within the Max Planck School Matter to Life supported by the German Federal Ministry of Education and Research (BMBF) in collaboration with the Max Planck Society.

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Colin Bonduelle is a research director at CNRS (HDR 2018) and leads research at LCPO, Université de Bordeaux, focusing on bioinspired polymers at the interface of biology and medicine. He completed his PhD in molecular chemistry at the University of Toulouse with Didier Bourissou and was a postdoctoral fellow under the supervision of E. Gillies at Western University in Canada, where he worked on the design and self-assembly of amphiphilic dendrimers and block copolymers. He is now an expert in ring-opening polymerization (ROP) and currently works on the synthesis and application of protein-like polymers using N-carboxyanhydrides. He has for instance developed new tools towards aqueous ROP and Polymerization-Induced Self-Assembly (PISA). His recent work also includes ring-expansion methodologies to mimic antimicrobial peptides (in collaboration with Institut Pasteur). He is co-author of more than 60 articles and 10 patents. He was selected for the CNRS "Cadre à Haut Potentiel" (CHP) class of 2022 and is currently supervising a team of 9 PhD students.

ABSTRACT

Polypeptides: from proteins to new approaches in polymer synthesis

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Proteins are natural building blocks that possess many features still unrivaled by their synthetic counterparts, including chemical diversity, hierarchical structure, specific chemical modification, and programmed system dynamics. Combined with their potential for metabolism in living systems (biodegradation, etc.), these properties make proteins highly attractive for designing the polymers of tomorrow. While significant advances have been achieved in genetic engineering, a major remaining challenge is optimizing large-scale protein production (extraction, recombinant protein, etc.). Interestingly, the most economical and efficient route to polypeptides is a chemical approach: the ring-opening polymerization (ROP) of amino acid N-carboxyanhydride (NCA) monomers (Figure 1).[1] Compared to proteins, peptidic polymers are much simpler macromolecules in which amino acids are statistically repeated. However, these polypeptides combine advantageous features of synthetic polymers (solubility, processability, rubber elasticity, etc.) with those of natural proteins (secondary structure, functionality, biocompatibility, etc.).[2] Recent progress in this field has been impressive, and this talk will illustrate: 1) how the secondary structure of polypeptide guide the design of advanced materials,[3] 2) how aqueous ROP of NCA monomers can be extended to a PISA process,[4] and 3) how polymerization of NCAs can afford simplified analogues of natural proteins.[5]

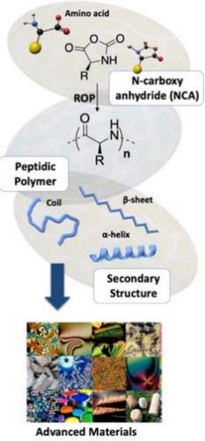

Figure 1. Peptidic polymers are ideal analogues of proteins to design advanced materials.

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References:
[1] J. Cheng et al., *Chem. Soc. Rev.* **2017**, 46, 6570.
[2] G.G. Qiao et al., *Chem. Soc. Rev.* **2020**, 49, 4737.
[3] *Polym. Chem.* **2018**, 9, 4100. c) *Biomacromolecules* **2018**, 19, 4068. d) *Nature Commun.* **2020**, 11, 2051. e) *ACS Appl. Polym. Mat.* **2024**, 6, 15, 8733. f) *Biomacromolecules* **2024**, 25, 3033.
[4] a) *Angew. Chem. Int. Ed.* **2020**, 59, 622. b) *Polym. Chem.* **2021**, 12, 6242. c) *Macromol. Commun.* **2024**, 2400079. d) *Macromolecules* **2025**, 58, 13, 6466.
[5] a) *Biomacromolecules* **2021**, 22, 57. b) *J. Am. Chem. Soc.* **2021**, 143, 3697. c) *Polym. Chem.* **2022**, 13, 600. d) *Angew. Chem. Int. Ed.* **2022**, 61, e202209530. e) *Prog. Polym. Sci.* **2023**, 147, 101752. f) *J. Am. Chem. Soc.* **2025**, 147, 28, 24213.

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Luisa De Cola, born in Messina, Italy, studied chemistry at the University of Messina, graduating in 1983. She began a postdoctoral fellowship in the group of Professor Lidia Vallarino at Virginia Commonwealth University, Richmond, USA, in 1984. She returned to Italy in 1986 to join the group of Professor Vincenzo Balzani, University of Bologna, as a Researcher of the Italian National Research Council (CNR). In 1990, De Cola was promoted to Assistant Professor at the same university. From 1998–2004, she was a Full Professor at the University of Amsterdam, The Netherlands. In 2004, she joined the faculty at the University of Münster, Germany, and became a member of the board of the Center for Nanotechnology, Münster, Germany. In 2012, she was appointed Axa Chair of Supramolecular and Bio-Material Chemistry, at the University of Strasbourg/ISIS, France. Currently, she is a professor at the University of Milan and head of the Materials for Health Unit at the Istituto di Ricerche Farmacologiche Mario Negri (IRCCS), Milan, Italy. She is also a visiting scientist at the Institute of Functional Interfaces at the Karlsruhe Institute of Technology (IFG-KIT), Germany. Among her awards are the ERC advanced grant (2010), the Izatt–Christensen Award in Macrocyclic and Supramolecular Chemistry (2019), and the Gold Medal Natta (2020). She was Nominated Chevalier de la Légion d' Honneur by the then-President of France, François Hollande. She is a member of the German National Academy of Sciences Leopoldina, of the Accademia dei Lincei, Italy, a Fellow of the American Institute for Medical and Biological Engineering (AIMBE) and a Chemistry Europe Fellow.

Luisa De Cola has published more than 400 papers, filed 40 patents, and is Editor in Chief of ChemistryEurope, the flagship gold open access journal of Chemistry Europe.

ABSTRACT

Supramolecular and hybrid responsive nanomaterials for living organism

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The use of nanomaterials is gaining importance for medical applications such as imaging agents, drug delivery, tissue regeneration. We have recently reported disulfide-bridged organosilica nanoparticles with cage-like morphology, and assessed in detail their toxicity and bioaccumulation in vitro and in vivo [1-4]. Exploring further the use of responsive organic groups we report on organosilica nanoparticles containing single-stranded nucleic acids. The oligonucleotides, can be covalently embedded in the silica network, and their behavior has been investigated [5]. However, the system can be programmed to be more dynamic and responsive by designing supramolecular organo-silica systems based on PNA- derivatives that can self-assemble through direct base paring or can be joined through a bridging functional nucleic acid, such as the ATP-binding aptamer [6]. These systems can be followed by confocal microscopy in different cell lines and their biological effect was measured in cells to assess the biological effect of the aptamer. The use of silica nanocapsules has recently proved to be an exceptional interesting way to to enhance coral settlement through the development of biomimetic microhabitats that replicate the chemical landscape of healthy reefs. The responsive capsules able to entrap large biomolecules are described, and embedded in a hydrogel to slow down the release of the actives. We engineered a soft biomaterial, SNAP-X, composed of silica nanoparticles, biopolymers and algal exometabolites, to enrich reef microhabitats with bioactive molecules from crustose coralline algae. Coral settlement was enhanced over 20-fold using SNAP-X coated substrates compared to uncoated controls. SNAP-X is designed to gradually release chemical signals slowly (> 1 month) under natural seawater conditions, and it can be rapidly applied to natural reef substrates via photopolymerization, further facilitating the light-assisted 3D printing of microengineered habitats[7]. Finally an examples on how self-assembly of platinum metal complexes can occur in solution but also in living organisms. The supramolecular process in transparent animals can be visualized by the bright emission of the assembly and we have studied the process in the small freshwater polyp Hydra. We found that using water soluble luminescent platinum complexes we can follow the assembly in the body of the animal and that the self-assembly trigger unexpected biological event such self-regeneration of tissues.

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References:

[1] P. Picchetti et al. ACS Nano 2021, 15, 9701–9716.
[2] P. Picchetti, et al. J. Am. Chem. Soc. 2021, 143, 7681-7687.
[3] M. Sancho Albero, et al. Adv. Healthcare Mater., 2023, 12, 2202932.
[4] M. Sancho Albero, et al. Materials Today Bio, 2025, 30, 101433.
[5] P. Picchetti et al J. Am. Chem. Soc. 2023, 145, 22896-22902.
[6] P. Picchetti et al J. Am. Chem. Soc. 2023, 145, 22903-22912.
[7] D. Wangpraseurt et al. Trends in Biotechnology, 2025, https://doi.org/10.1016/j.tibtech.2025.03.019.

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Christoph (Chris) Weder is a Professor of Polymer Chemistry and Materials at the Adolphe Merkle Institute (AMI) of the University of Fribourg, Switzerland. His main research interests are the design, synthesis, investigation, and application of functional polymers, especially stimuli-responsive and bio-inspired materials, which are often designed on the basis of supramolecular interactions. Weder was trained in chemistry and materials science at the Swiss Federal Institute of Technology (ETH) Zurich, carried out postdoctoral research at the Massachusetts Institute of Technology, returned to ETH for a Habilitation, and in 2001 joined Case Western Reserve University in Cleveland (USA) as Professor of Macromolecular Science and Engineering. In 2009 Weder moved to the newly established Adolphe Merkle Institute, which he directed from 2010 to 2022. From 2014 to 2020, he also served as the founding director of the Swiss National Center of Competence in Research Bio-Inspired Materials. Weder is an associate editor of ACS Applied Polymer Materials, a member of the Swiss Academy of Engineering Sciences, and a fellow of the American Chemical Society's Division of Polymer Chemistry.

ABSTRACT

Mechanochromic Polymers made with Supramolecular Mechanophores

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Stimuli-responsive polymers that dynamically adjust their properties in response to environmental cues enable a broad range of functions, including mechanical morphing, actuation, self-healing, and mechanochemical transduction. By leveraging the reversible nature of non-covalent interactions, we engineered various classes of such adaptive materials. This presentation will highlight our recent efforts to develop polymers capable of detecting and reporting macroscopic strains and stresses. A common strategy to render polymers mechanochromic is the incorporation of so-called mechanophores. These molecular motifs transduce mechanical forces into chemical reactions or structural changes that lead to optical changes. While many mechanophores rely on covalent bond scission, which makes their activation irreversible, an alternative approach is the use of supramolecular mechanophores, which enable reversible mechanochromic behavior. We have developed several families of supramolecular mechanophores, including rotaxanes, cyclophanes, and loop-forming motifs. These constructs all feature multiple optically active, electronically interacting moieties whose proximity can be mechanically modulated. By exploiting operating principles such as fluorescence quenching, excimer formation, energy transfer, and charge-transfer interactions, these motifs provide immediate and reversible visual cues, for example, fluorescence turn-on or emission color changes, that directly signal mechanical deformation. Finally, the influence of mechanophore design and polymer architecture on the sensitivity, reversibility, and practical utility of the mechanochromic response will be discussed, highlighting opportunities for the development of next-generation, force-responsive materials.

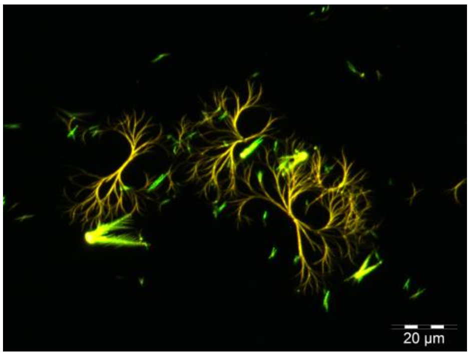

Figure 1. Fluorescence microscopy image, revealing the change in emission color upon (dis)assembly of an excimer-forming mechanophore.

Acknowledgments: I am indebted to the many students, postdocs, and collaborators who made this work possible, including Jessica Clough, Linlin Deng, Marc Karman, Derek Kiebala, Tatsuya Muramatsu, Yoshimitsu Sagara, Stephen Schrettl, Iulia Scarlat, Shohei Shimizu, Nobuyuki Tamaoki, Hanna Traeger, and Ester Verde. Our recent work on mechanochromic polymers has been supported through the National Center of Competence in Research (NCCR) Bio-Inspired Materials, a research instrument of the Swiss National Science Foundation (SNSF) under Grant No. 51NF40_182881, the Army Research Office under Grant No. W911NF-23-2-0075, the Swiss State Secretariat for Education, Research and Innovation (SERI) through the Bilateral Science and Technology Cooperation Programme with Asia (Grant No. EG_JP_special_032023_22), and the Adolphe Merkle Foundation.

References:

1. Y. Sagara, M. Karman, E. Verde-Sesto, K. Matsuo, Y. Kim, N. Tamaoki, C. Weder, J. Am. Chem. Soc. 2018, 140, 1584–1587.
2. Y. Sagara, H. Traeger, L. Jie, Y. Okado, S. Schrettl, N. Tamaoki, C. Weder, J. Am. Chem. Soc. 2021, 143, 5519-5525.
3. H. Traeger, D.J. Kiebala, S. Schrettl, C. Weder, Angew. Chem. Int. Ed. 2021, 60, 16191-16199.
4. D.J. Kiebala, A. Dodero, C. Weder, S. Schrettl, Angew. Chem. Int. Ed. 2024, 63, e202405922.
5. S. Shimizu, J.M. Clough, C. Weder, Y. Sagara, Angew. Chem. Int. Ed. 2025, 64, e202510114.

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Carlijn Bouten's interdisciplinary research is directed towards new engineering approaches to regenerate cardiovascular tissues and organs inside the human body and covers the complete pipeline from basic idea to clinical application. At the fundamental level, her team concentrates on the mechanobiological reciprocity between cells and (synthetic) extracellular matrices, understanding their role in regulating the growth, organization, regeneration, and degeneration. The obtained knowledge is used to (re)generate tissues using the in situ tissue engineering concepts. This approach harnesses the immune response to implanted cell-free degradable materials and subsequent tissue remodeling under hemodynamic conditions. Since 2017, Prof. Bouten has spearheaded the Dutch gravitation program 'Materials-Driven Regeneration', and in 2022, she received an ERC advanced grant to start the RE-ALIGN program on restoring cardiac structural organization in situ. Just recently, she was awarded the SUMMIT grant for excellent research teams as a co-applicant of the DRIVE-RM program. Next to her research, Bouten serves on professional organizations and boards, including the Netherlands Organization for Health Research and Development board. She is also an elected member of AcademiaNet for Outstanding Female Scientists and Scholars in Europe, and member of the Royal Netherlands Academy of Arts and Sciences.

ABSTRACT

Materials-driven in-situ tissue regeneration

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We investigate and design in situ cardiovascular tissue engineering technologies using instructive, cell-free, biodegradable synthetic scaffolds as an approach to creating living heart valves and vessels. This lecture addresses the challenges to designing scaffolds that function upon implantation and during the process of tissue formation and scaffold degradation; are capable of harnessing the natural host response through principles of mechanobiology, and provide the necessary cues for a stable and organised load-bearing extracellular matrix under in vivo hemodynamic conditions. I will describe how biomimetic in vitro models are used in direct comparison with in vivo small-animal experiments to provide handles for optimising scaffold properties. Current challenges concentrate on advancing the clinical translation of the technology by analysing the influence of patient characteristics and comorbidities on neo-tissue formation, as well as compliance with minimally invasive strategies. The outcomes will offer new perspectives for patient-specific, readily available grafts that will transform into living, endogenous cardiovascular replacements at the site of destination.

Acknowledgments: Financial support by the Gravitation Program “Materials Driven Regeneration”, funded by the Dutch Research Council (024.003.013), is gratefully acknowledged.

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Marcy Zenobi-Wong is a Full Professor of Tissue Engineering and Biofabrication at ETH Zürich in Switzerland. She is a Mechanical Engineer by training, and received her Bachelor degree from MIT, and Master/PhD from Stanford University. She leads a multidisciplinary team with strong focus on biofabrication technologies including light-based bioprinting and on the development of advanced biomaterials for tissue regeneration. She has held leadership roles in the International Society for Biofabrication, Swiss Society for Biomaterials and Regenerative Medicine (SSB+RM), and the Institute for Biomechanics, ETH Zürich. She currently serves on the editorial board of Advanced Healthcare Materials and on the Executive Editorial Board of Biofabrication.

ABSTRACT

Architecting Scaffolds with Light

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The human body is permeated by physiological spaces at the organ, tissue, cell and molecular level. These spaces provide critical means of transport, communication, signal propagation, morphogen diffusion, cellular crosstalk, and localized biochemical reactions. Constriction of these spaces, such as arterial occlusion or tissue fibrosis, are associated with pathologies. Given the omnipresent nature of such spaces within tissues and organs, the scaffold's negative 'void' space becomes a critical factor in designing scaffolds for tissue engineering. Here we describe the implementation of filamented light (FLight) Biofabrication to exert control over a scaffold's internal 3D architecture. Examples from the musculoskeletal system are discussed as well as advances of Flight printing for human scale tissues and printing within the body.

Acknowledgments: The authors gratefully acknowledge funding from the Swiss National Science Foundation, Horizon Europe and Innosuisse.

References:

[1] H. Liu et al., Advanced Materials. 2022, 34, 2204301

Oral Communication

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ABSTRACT 1

An enzyme-regulated peptide hydrogel model to mimic pathological calcifications

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The mineralization of the extracellular matrix (ECM) of non-skeletal, soft tissues, known as pathological/ectopic calcification, can occur as result of different disease processes or abnormal metabolism. In-depth mechanistic understanding of pathological mineralization, such as breast and vascular calcification, remains limited. Biomimetic hydrogels represent valuable platforms for modelling the formation of these pathological mineral deposits in vitro. For such purposes, we took advantage of a self-assembling peptide amphiphile (PA)-based hydrogel system (Figure 1), and enhanced its ECM-recapitulation ability [1] by incorporating enzyme-mediated biomechanical and chemical tuneability over time. This supramolecular biomimetic hydrogel relies on the ability of inositol polyphosphate IP_6 (a natural phosphate-containing carbohydrate used here as PA´s gelator) to be degraded by 4-Phytase (a specific phosphohydrolase). As this enzyme generates IP_n metabolites, the release of inorganic phosphate (Pi) modulates hydrogel stiffness in a precise time-dependent manner, reversibly binds calcium ions, and consequently tunes the differential growth of either amorphous or crystalline hydroxyapatite on-demand. These findings aim to expand our understanding of the role of ECM stiffness and chemical cues (calcium ions and inorganic phosphate) on the formation of ectopic calcifications in kidneys, joints, brain, heart valves, arteries, among others [2].

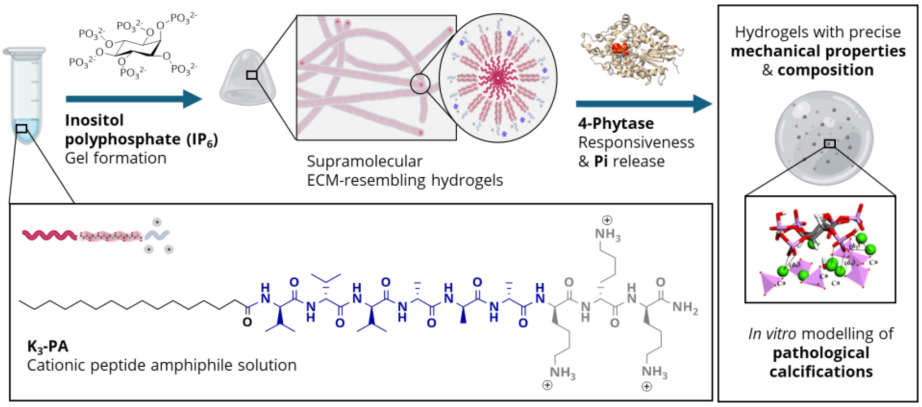

Figure 1. Enzyme-regulated peptide amphiphile hydrogel model to emulate the dynamic role of the ECM and its phosphate-mediated mineralisation in soft tissues.

Acknowledgments: CR-G & HSA thank the MOBILIsE project funded by the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 951723, as well as the MSCA Postdoctoral Fellowship under Grant Agreement no. 101152638. RQ-G thanks the Postgraduate Studies System (SEP) and the Student Affairs Vice Rectorate (VIVE) from the University of Costa Rica (UCR).

References:

[1] R. Freeman et al., Science, 2018, 362 : 808.

[2] E. Bertazzo et al., Nat Mater, 2013, 12 : 576.

ABSTRACT 2

Molecular Mechanisms of Peptide Assembly for Biomaterials

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Biology has evolved complex functions through the precise self-assembly of biomolecules into defined morphologies. Understanding the molecular mechanisms governing these processes, and the interactions between supramolecular structures, is essential for elucidating disease-related pathways and accelerating the development of advanced biomaterials. A particular focus lies on fibril-forming peptides and proteins, which are associated with neurodegenerative disorders but also offer potential for functional applications. This research combines biophysical experiments with molecular modeling and simulations to explore the dynamic behavior of peptides [1]. Emphasis is placed on the self-assembly mechanisms of amyloid-forming peptides and their translation into bioactive nanofibrils for virus binding and neuroregeneration. [2,3] Interfaces, especially membrane surfaces, are highlighted as critical modulators of fibril formation [4] To dissect these interactions, techniques such as fluorescence spectroscopy, quartz crystal microbalance measurements, and molecular dynamics simulations are employed to probe peptide aggregation and membrane-disruptive activity. This work contributes to a deeper molecular understanding of peptide self-assembly and supports the design of functional biomaterials inspired by biological systems.

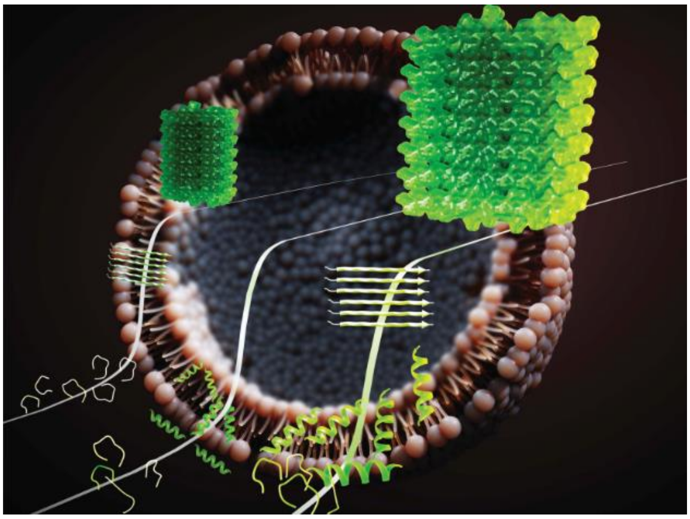

Figure 1. Peptides self-assemble into fibrillar structures under the influence of liposomes. [4]

Acknowledgments: T.J. acknowledges financial support from the Alexander von Humboldt Foundation through a Feodor Lynen Research Fellowship during his Postdoctoral Research in the “Department Synthesis of Macromolecules ”, led by Prof. Dr. Tanja Weil, at the Max Planck Institute for Polymer Research. Funding from the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation, project number 189853844, SFB TRR 102, B1, Prof. Dr. Bernd Abel) is acknowledged.

References:

[1] T. John et al., ACS Chem. Neurosci,. 2024, 15 : 716.

[2] M. Hayn, T. John et al., Adv. Funct. Mater., 2024, 34 : 2316260.

[3] Y.-L. Tsai et al., ChemRxiv., 2024, doi:10.26434/chemrxiv-2024-mzghg.

[4] T. John et al., Chem. Sci., 2023, 14 : 3730.

ABSTRACT 3

Antibacterial Peptide Nanofibres: A Promising Strategy for Combating Antimicrobial Resistance in Infected Wounds

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Antimicrobial resistance (AMR) is one of the top public health challenges globally, estimated to have caused 4.95 million deaths in the last decade, of which 1.27 million reported in 2019.[1] Innovative antimicrobial biomaterials could help minimise the reliance on antibiotics for the treatment of topical bacterial infections; an emerging strategy that could potentially contribute to overcoming AMR. In this context, we have developed a library of short self-assembling peptides that form β-sheet nanofibrous structures [2,3] and investigated their antibacterial activity against a range of pathogenic bacteria, the ESKAPE pathogens, which are commonly implicated in wound infections and possess multi-drug resistance against commonly used antibiotics. In essence, all tested peptide nanofibres showed antibacterial activity with Gram -ve (G-ve) bacteria being more sensitive (bactericidal effect) compared to Gram +ve (G+ve). Transmission electron microscopy revealed that the bactericidal activity is mediated via insertion of peptide nanofibres in the bacterial cell membrane, forming pores and disrupting membrane integrity. This mechanism was confirmed by using 8-anilino-1-naphthalenesulfonic acid (ANS) fluorophore, where significantly higher fluorescence was observed for cells treated with peptide nanofibres compared to controls, as ANS binds to the disrupted membrane lipids of the former. Scanning electron microscopy and confocal fluorescence microscopy showed rounded cell morphology for cells treated with peptide nanofibres, indicating 'stress' conditions. Both prevention of formation and disruption of biofilms were also achieved post treatment with peptide nanofibres. Our results suggest that applying our peptide nanofibres to chronic wound infections could help with treatment of infection and accelerate the healing process, where G-ve bacteria predominate the microbiome, invading deeper layers of skin and causing significant tissue damage.[4]

References:

[1] C. J. L. Murray et al., The Lancet 2022, 399 : 629.
[2] J. K. Wychowaniec et al., Biomacromolecules 2020, 21 : 2670.
[3] M. Soliman et al., Small 2025, 21 : 2408213.
[4] A.F. Cardona et al., Clin. Infect. Dis. 2015, 61 : S69.

ABSTRACT 4

Ice templating extracellular matrix proteins as a pathway to developmulti-tubular tissue biomimetic hydrogels

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Native tubular tissues such as arteries, veins, trachea or the urethra share a vast number of compositional and architectural features. They are largely composed of type I collagen and can be simplified as a couple of concentric tubular structures that host epithelial and muscular cells, respectively [1]. Here, we present a new family of collagen-based macroporous tubular materials as a multi-purpose tissue scaffold for tubular tissues based on a hierarchical assembly of the Extracellular Matrix (ECM) proteins. Our strategy relies on coupling the bottom-up assembly of collagen into fibrillar structures to the top-down shaping process of ice templating to produce materials that can be swiftly colonized by the cells of the host patient. Our group has developed a processing strategy to produce macroporous type I collagen biomaterials using ice templating and topotactic fibrillogenesis [2,3] which replicate both the hierarchical arrangement of the ECM (in the nanometer range) and the macroscopic morphology of tubular tissues (in the centimeter range). This multi-scale organization provides the structural and biological cues to recapitulate the cells' microenvironment found in native tissues while ensuring proper mechanical behavior (30-60 Kpa) [4]. The obtained materials were thoroughly characterized using TEM, SEM, and *ad hoc* mechanical testing. Cell colonization was tested *in vitro* for the luminal side—using endothelial (HUVEC) and epithelial (A549) cells—and on the adventitial side, using mesenchymal (hMSC) and muscle (SMC) cells. *In vivo* implantation in tracheal site of sheep are ongoing. Our approach provides a versatile porous structure and topography that mimics the native composition of native tubular tissues, achieving essential physiological functions. Precise control over fabrication parameters enables us to create a common biomaterial tailored for the replacement of different tubular tissues.

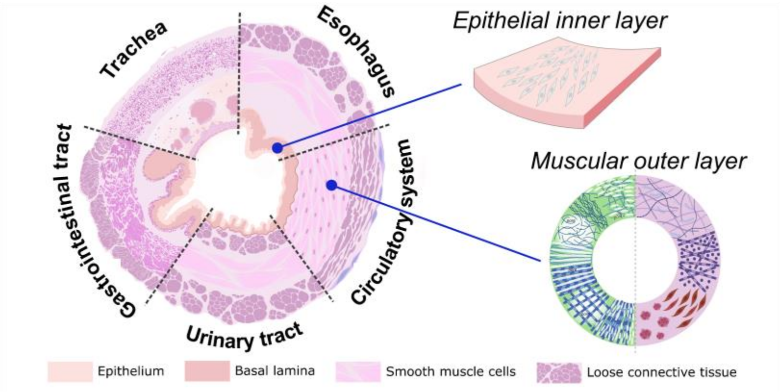

Figure 1. Tubular native tissues share a number of features our approach recapitulates the shared features of tubular tissues to provide versatile biomimetic platforms for tubular tissue engineering.

References:

[1] I. Martinier, *Chem. Soc. Rev.,* 2025, accepted.
[2] C. Rieu, *ACS Appl. Mater. Interfaces., 2019,* 11 : 14672.
[3] C. Parisi, *Biomater. Sci., 2022,* 10 : 6939.
[4] I. Martinier, *Biomater. Sci., 2024,* 12 : 3124.

ABSTRACT 5

Multifunctional Biointerfaces based on Micro/Nanopatterned (Conductive) Materials

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Multifunctional biointerfaces are engineered surfaces designed to interact with cells and achieve the desired biological outcomes by leveraging on the combination of multiple functionalities. At UNIMORE, in the "Advanced Biomaterials Laboratory", we are strongly committed to the development of micro- and nanopatterned electroactive substrates capable of enhancing specific cellular dyanmics, including cell adhesion, differentiation and migration, for applications ranging from regenerative medicine to in vitro lab-on-chip devices. In this talk I will give a brief summary of our recent research in this area. In particular, I will show the possibility of exploiting both the conductivity and nanopatterning of conductive polymers to promote in vitro neuronal development as a new platform for nerve tissue regeneration [1,2]. Next, I will report on the possibility of triggering the initial differentiation of muscle cells simply by culturing C2C12 cells on biodegradable conductive blends of MXene/PLA [3]. Finally, I will show that elastomeric soft micropillar forests can be an ideal plaform for studying under live imaging how cancer cell migrate in a semi-confined environment, representing a valuable tool for the development of novel in vitro diagnostic devices.

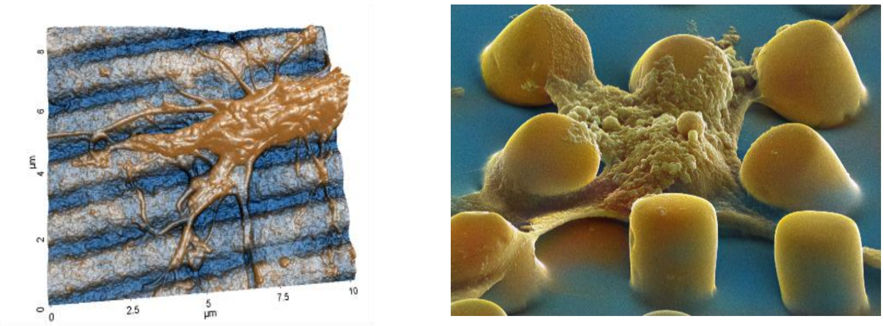

Figure 1. 3D-AFM image of a growth cone on a nanopatterned PEDOT:PSS substrate (left); SEM image of a glioblastoma cell migrating between PDMS micropillars (right).

Acknowledgments: The authors would like to thank the "FAR2024PD" funding (University of Modena and Reggio Emilia) for supporting part of the present work.

References:

[1] M. Bianchi et al., ACS Applied Materials and Interfaces, 2023, 15 : 59224.
[2] A. Lunghi et al., Nanotechnology, 2024, 36 : 015301.
[3] A. Lunghi et al., ACS Biomaterials Science & Engineering, under review.
[4] B. Bighi et al., Progress in Biomedical Engineering, 2025, 7 : 012005.

ABSTRACT 6

Tough supramolecular hydrogels through homoternary CB[8] host—guest complexation

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Supramolecular hydrogels have been transformative to material sciences due to their dynamic and tunable properties, relying on reversible non-covalent interactions instead of covalent bonds. This reversibility represents an efficient strategy for energy dissipation, paving the way for tough and robust hydrogels with innovative solutions in load-bearing medical and technological applications.[1] Due to their high binding constants, especially the use of Cucurbit[n]uril (CB[n]) host–guest complexes has become a popular way to mediate gelation of polymer chains. Among its different homologues, CB[8] is able to form multitopic complexes where two guests are bound simultaneously. Consequently, it can host a variety of guest structures and connected to this, the thermodynamically stable complexes are used as cross-links exhibiting a broad range of binding constants. Regarding the structure–property relationship of CB[8]-based hydrogels, it is the binding constant that largely dictates the mechanical properties of the hydrogels. Despite the great potential of CB[8] complexes as highly dissipative cross-links, toughness and fracture energies of tough CB[8] hydrogels for load-bearing applications have remained under-explored. Therefore, we decided to explore the potential of CB[8]-mediated hydrogels as load-bearing materials (Figure 1). In our work, we use homoternary 1:2 host–guest complexation of a new series of customizable monomers based on diallyl benzyl methyl ammonium chlorides (DABMAC) to mediate cross-links in polymer networks. We optimize our formulations to obtain hydrogels that exhibit high stretchability, toughness and fracture energy, while maintaining an overall water content of ~88%.

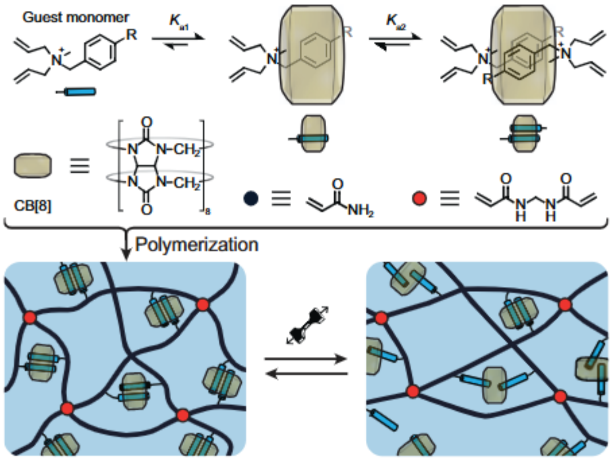

Figure 1. Concept for the synthesis of tough supramolecular hydrogels using homoternary CB[8] host—guest complexation.

Acknowledgments: M.S, I.M, and S.M. are grateful for the Swiss National Science Foundation for supporting this work (Ambizione Grant, PZ00P2_202141). Further, the authors would like to thank Prof. Dr. Mark W. Tibbitt for helpful discussions on this project.

References:

[1] N. Petelinšek et al, Adv. Sci., 2024, 11 : 2307404.

ABSTRACT 7

Supramolecular peptide nanostructures for prostate cancer targeted drug delivery

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Despite the advances in cancer therapies, prostate cancer (PCa) remains one of the most common cancer among men worldwide. Many current treatment options are limited by systemic side effects, underscoring the need for improved targeted drug delivery systems. In this context, supramolecular nanobiomaterials have attracted increasing attention with self-assembling peptides being recognized as particularly promising, owing to their ability to respond to specific stimuli [1]. In PCa, several tumor-associated enzymes have been explored to develop enzyme-responsive peptide-drug conjugates. Notably, prostate-specific antigen (PSA) has received significant attention due to its exclusive activity within the PCa microenvironment [2,3]. In this work, we combined the proteolytic susceptibility and self-assembling properties of peptides to design a PSA-cleavable peptide amphiphile (PA). The engineered PA consists of a hydrophobic alkyl tail, a short structural domain (AAAA), and a previously reported PSA-cleavable sequence (RSSYRSL) [3]. The designed PA, first synthesised using microwave-assisted solid-phase peptide synthesis, was able to self-assemble into well-defined nanofibers above a critical aggregation concentration of 40 μM. These nanofibers displayed a median diameter of 9 nm, a positive surface charge and a β-sheet secondary structure. This communication will present the use of PSA-cleavable PAs as versatile and targeted drug delivery platforms for PCa treatment.

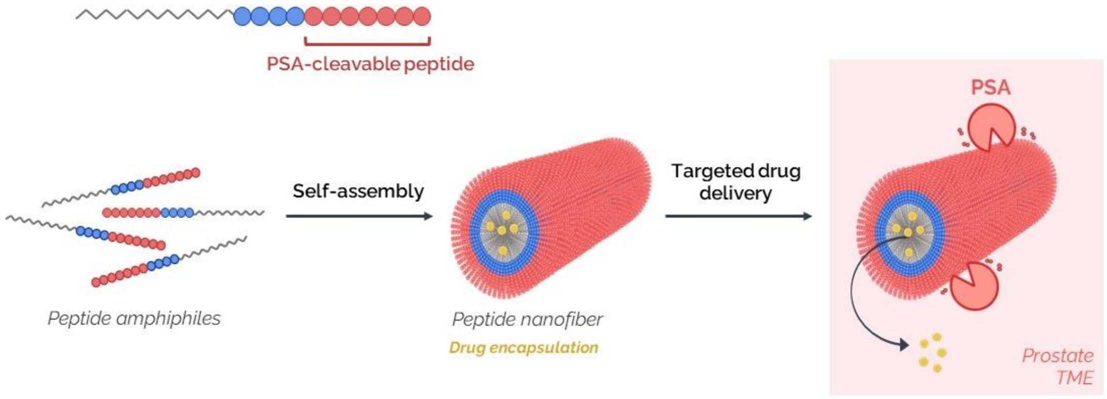

Figure 1. Self-assembly of prostate-specific antigen (PSA)-cleavable peptide amphiphile into nanofibers for targeted drug delivery to prostate tumors.

Acknowledgments: This work was funded through the MOBILIsE project, which received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 951723.

References:

[1] Y. Shi et al., Biomat. Sci., 2019, 7 : 5132.

[2] S. Pereira et al., Acta Biomaterialia, 2022, 140 : 530.

[3] S. R. Denmeade et al., Prostate, 2001, 48 : 1.

[4] B.E.M. Elsadek et al., Biochemistry and Biophysics Reports, 2021, 26 : 1.

ABSTRACT 8

Thermo-adaptive hydrogels for mechanical stimulation in cartilage tissue engineering

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With material characteristics that can easily be tuned to mimic the natural tissue environment, hydrogels are interesting biomaterials for tissue engineering applications. Of particular interest are dynamic hydrogels that provide encapsulated cells with different mechanical cues. As highly mechanosensitive cells, chondrocytes are known to respond to mechanical stimulation in native cartilage [1]. In this research, we developed a thermo-adaptive hydrogel based on gelatin, to provide cyclic mechanical stimulation to encapsulated Articular Chondrocyte Progenitor Cells (ACPCs) by repeated shrinking and swelling of the material over time. The thermoresponsive polymer (GelNHMa) was synthesized by grafting chains of N-isopropylacrylamide (NIPAM) and 2-hydroxylethyl acrylate (HEA) onto the gelatin backbone. The HEA was then methacrylated (Ma), enabling photocrosslinking and precise material tuning. Optimization of the polymer and hydrogel compositions for shrinkability, stability, shrinking cyclability and cytocompatibility of encapsulated ACPCs, resulted in a stable GelNHMa hydrogel that can shrink up to 65% in volume and allows for cellular imaging. Different regimen of swelling-shrinking cycles were then tested for their influence on chondrocyte differentiation and extracellular matrix deposition. This study highlights the potential of GelNHMa hydrogels as a scalable, simplistic alternative for complex bioreactors in mechanical stimulation in cartilage engineering.

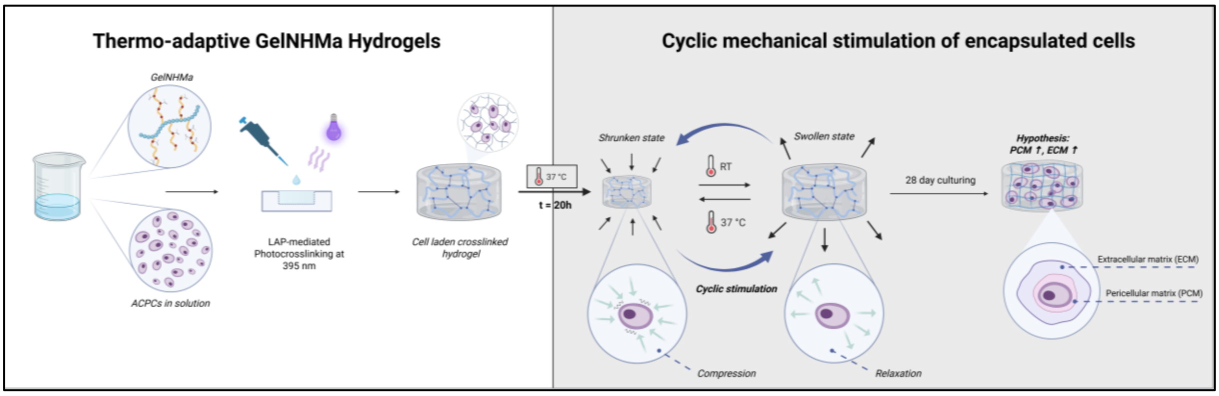

Figure 1. Schematic overview of how thermo-adaptive GelNHMa hydrogels can be used to provide cyclic mechanical stimulation to encapsulated cells.

Acknowledgements: This research is part of the project LS-NeoCarE (with project number NWA.1389.20.192) of the research programme NWA-ORC which is financed by the Dutch Research Council (NWO). S.M.L, G.D.M. and T.V. also thank the Dutch Research Council (NWO/VICI 18673) for financial support.

References:

[1] Z. Zhao et al., Journal of Cellular and Molecular Medicine, 2020, 24 : 5408.

ABSTRACT 9

Desolvation-Induced Assembly of Human Platelet Lysate into Nanoparticles for Controlled Drug Delivery

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Harnessing supramolecular interactions for the design of biomaterials enables the fabrication of functional nanostructures under mild and tunable conditions [1]. In this work, we report the formation of protein-based nanoparticles from human platelet lysate (hPLMA) via a desolvation-driven assembly process. The addition of ethanol to aqueous hPLMA induces a conformational transition of proteins from α-helices to β-sheet structures, promoting their organization into spherical nanoparticles through non-covalent interactions [2]. To stabilize the resulting structures, UV photo-crosslinking is applied in a second step, generating covalent bonds that lock the supramolecular assembly in place [3]. A Design of Experiments (DOE) approach was employed to investigate the influence of key formulation parameters — hPLMA concentration, pH, ethanol addition ratio, and the presence of ionic background — on nanoparticle size and dispersibility. The process yielded colloidally stable nanoparticles with tunable size distributions below 200 nm. These hPLMA nanoparticles demonstrated high encapsulation efficiency for two chemotherapeutic agents, doxorubicin and temozolomide, with sustained release profiles under physiological conditions. Cellular studies confirmed effective drug delivery and selective cytotoxicity in cancer cells, supporting their potential as bioinspired nanocarriers for anticancer therapy.

This work establishes a new strategy to create structurally stable nanomaterials from complex biological protein mixtures via an initial supramolecular assembly followed by covalent fixation. The hPLMA-based system combines natural protein functionality with process control, offering a versatile platform for therapeutic delivery applications.

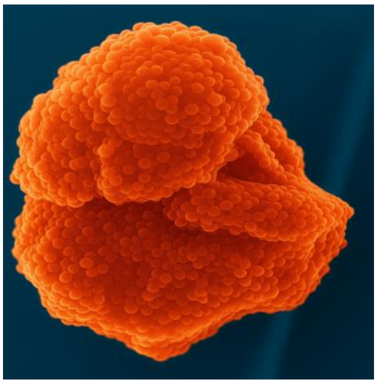

Figure 1. Scanning electron microscope picture of hPLMA nanoparticles (coloured).

Acknowledgments: This work is funded by the HORIZON-MSCA-2021-DN-01 call (Doctoral Networks - Joint Doctorates modality) of the Horizon Europe 2021 research and innovation programme under the Marie Skłodowska-Curie actions, within the scope of the project “Innovative Tools to Treat and Model Complex Cancer Environments,” TheraTools (Ref. 101073404).

References:

[1] K. Langer et al., Int J Pharm. 2003, 257 : 169–180

[2] I. Hassanin & Elzoghby, Cancer Drug Resistance. 2020, 3 : 930–946

[3] S. Santos et al. Adv. Healthc. Mater., 2018, 7 : 1800849

ABSTRACT 10

A promising strategy to trigger superselective disassembly of stimuli-responsive supramolecular fibers

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Within the diversity of functional self-assembled materials, stimuli-responsive Supramolecular Polymers (SPs) are gaining special interest [1]. Their non-covalent nature, endows SPs with the ability to reversible self-assemble in response to external stimuli, including light. Moreover, SPs are also able to respond to the mutliple changes occuring at the internal level in tumor microenvironment, where the altered enzymatic activity is outstanding. However, the use of SPs as drug delivery vehicles is still challenging. The construction of SPs based on the BTA core (benzene-1,3-5-tricarboxaminde) are becoming promising carriers for hydrohobic drugs [2]. In our group, we have expertise on the design of BTA-based discotic amphiphiles that self-assemble into supramolecular nanofibers in water.[3,4] The C3-symmetry of BTA allows us to incorporate three identical wedges designed to imprint specific responsiveness. In this work, we strategically incorporated two responsive-motifs to the discotic target: azobenzene (AZB, light response) and the tetrapeptide Gly-Phe-Leu-Phe (GFLG, enzyme response). To achieve fine control of the supramolecular disassembly of the fibers, we combined ultraviolet (UV) light irradiation with the incubation of the fibers with Cathepsin B (CTSB, a cancer-related protease). The use of HPLC-MS (High-resolution reversed-Phase Liquid Chromatography coupled to Mass Spectrometry) and TEM (Transmission Electron Microscopy) were crucial to monitor the fiber degradation. Our findings revealed that the synergistic combination of light and enzyme stimuli led superselective disassembly of the supramolecular fibers, which is an outstanding advance for their use as vehicle for anticancer drugs.

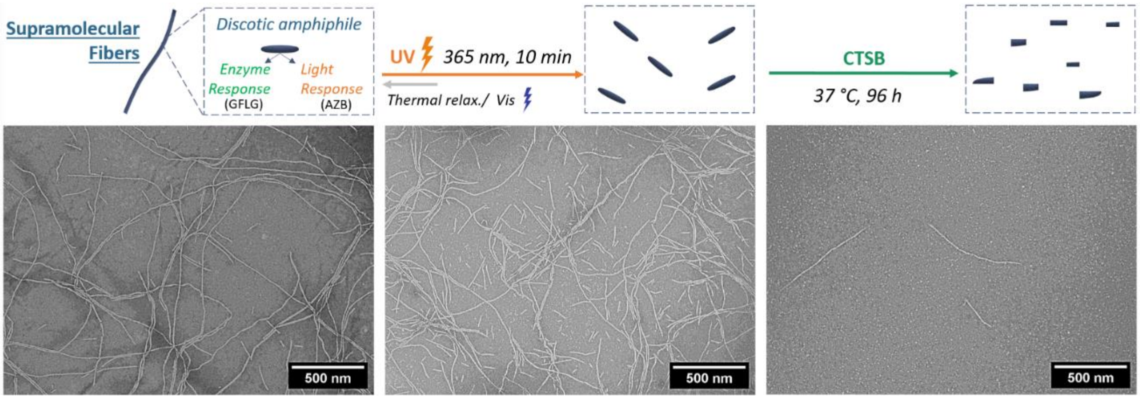

Figure 1. Representative TEM micropraphs of the superselective disassembly of BTA-based fibers from the initial state (left), after 10 min of ultraviolet irradiation (center) and 96 hours after incubation with Cathepsin B (right).

References:

[1] M. Martínez-Orts et al., Int.J. Mol. Sci., 2024, 25: 4077.

[2] R. Santini et al., Nanoscale. 2025, 17 : 10985.

[3] E. Fuentes et al., J. Am. Chem. Soc., 2020, 142 : 10069.

[4] E. Fuentes et al., J. Am. Chem. Soc., 2022, 144 : 21196.

ABSTRACT 11

Dynamic, robust and bioactive ureido-pyrimidinone-platelet lysate hybrid hydrogels

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Hydrogels are polymeric 3D porous structures which have been widely used as platforms for cell adhesion and proliferation, making them and excellent target as ECM mimicking materials.[1,2] In this work, we developed robust, dynamic and bioactive ureido-pyrimidinone (UPy)-platelet lysates (PL) based hydrogels as platforms for 3D culture (Figure 1). We aim to combine the bioactivity and biocompatibility of PL with the dynamicity and mechanical robustness assigned to the supramolecular UPy moieties to create high-performance hybrid hydrogels in better recreating the native ECM of tissues and organs.[3] UPy and PL were both functionalized with methacrylate groups, allowing them to form a composite hydrogel. The effects of varying UPy, PLMA and crosslinker concentration on the physicochemical and *in vitro* biological properties of the resulting hydrogels were studied and compared to the native PLMA and UPy hydrogels.[4] Bioorthogonal click chemistry reaction was also studied as alternative crosslinking mechanisms, enabling the preparation of hydrogels without the need for any external stimulus. UPy monomers were functionalized with DBCO or BCN groups and PL was functionalized with azide groups. The physicochemical and morphological properties of both hydrogel formulations were studied by rheology, microscopy, UV-Vis and the *in vitro* performance investigated. So far, we were able to form hydrogels using PLMA as a crosslinker for UPy hydrogels, resulting in hybrid hydrogels. These hydrogels exhibit stress relaxation as a result of the supramolecular UPy moieties and have a similar storage modulus when compared to pure PLMA with a significantly lower w/v % (0.5 vs 10%). Additionally, protein release show slower release from the hydrogels after photocrosslinking when compared to the controls. These results open new perspectives in the development of dynamic, robust and bioactive hydrogels in better recreating living systems.

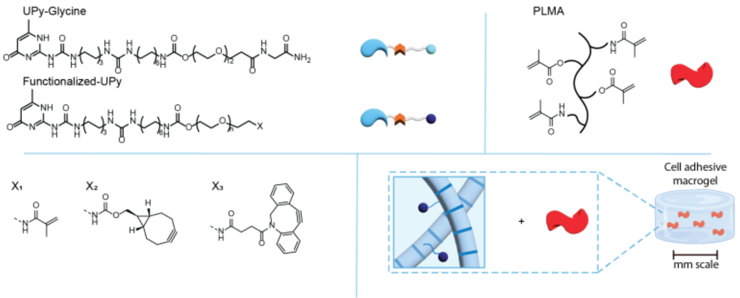

Figure 1. Schematic overview of the chemical structures and build up of the UPy-PLMA hybrid hydrogels.

Acknowledgments: This work was financially supported by the European Union's Horizon Europe research and innovation programme under grant agreement no. 101079482 ("SUPRALIFE"). J.B. gratefully acknowledge FCT for the individual contract (10.54499/2020.00758.CEECIND/CP1589/CT0007). This work was developed within the scope of the project CICECO – Aveiro Institute of Materials, UIDB/50011/2020 (DOI 10.54499/UIDB/50011/2020), UIDP/50011/2020 (DOI 10.54499/UIDP/50011/2020) and LA/P/0006/2020 (DOI 10.54499/LA/P/0006/2020), financed by national funds through the FCT/MCTES (PIDDAC). We acknowledge support from the Dutch Ministry of Education, Culture, and Science, Gravitation program 024.005.020 (Interactive Polymer Materials)

References:

[1] H. Kamata et al., *Adv. Healthc. Mater., 2015,* 4: 2360-2374

[2] S. Amirthalingam et al., *Mater Horiz., 2023,* 10: 3325-3350

[3] L. Rijns *et al., Adv.Mat., 2024,* 36

[4] S. Santos et al, *Adv. Healthc. Mater., 2018,* 7: 1800849

ABSTRACT 12

Nucleic acid bioinspired, conductive, fibrillar supramolecular hydrogels for engineering heart tissue models

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Cardiovascular disease (CVD) is the primary cause of deaths among cardiac patients, demanding significantly more interventions in this field; for instance, by engineering cardiac tissue models to study CVD and to test novel therapeutics. Thereby, cardiac cells are embedded in hydrogels and electrically stimulated to prompt tissue formation[1]; but common hydrogels used are not conductive, thus limiting applicability. Guanosine quadruplexes (GQ) are bioinspired supramolecular structures that propel the development of derived self-assembled GQ-hydrogels with conductive properties [2]. The challenge, however, is to formulate GQ-hydrogels under mild conditions and which are stable enough to facilitate their use as scaffolds for tissue models, while keeping fibrillar structure and conductivity. Herein, we develop innovative GQ hydrogels by combining guanosine analogues with biopolymers and metal ions, and investigated their suitability to support cell culture. Mechanical strength, stability, and conductivity of GQ-hydrogels were tuned with introduction of metal ions, while keeping the hierarchical microfibrous and porous network. Hydrogel bioactivity was adjusted by supplementation with biological polymers [3]. We demonstrate GQ hydrogels successfully formulated as matrices for culture of (cardiac) cells, showing fast gelation time, fibrillar microstructure, tunable mechanics, and regulable bioactivity. These smart biomaterials are promising for engineering tissue cardiac models.

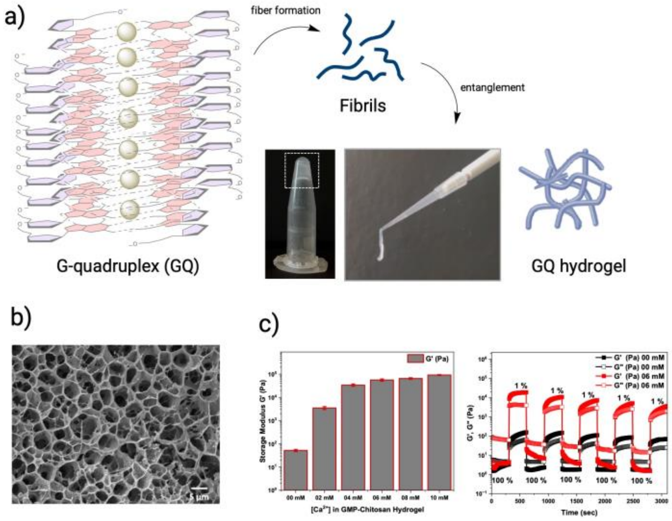

Figure 1. a) Schematic representation of supramolecular GQ hydrogels. b) SEM micrograph showing fibrilar, porous microstructure of the hydrogel and c) rheological characterization demonstrates tuning of mechanical properties via adjustment of metal ion concentration.

Acknowledgments: We acknowledge funding from the EU through MSCA PF (Rhythm project, ID 101067198) and the University of Twente (StartUp J.I.P.).

References:

[1] Tenreiro et al., Npj Regen Med, 2021, 6 : 30.

[2] Thakur et al., ChemNanoMat, 2021, 7 : 613.

[3] Thakur et al., manuscript in preparation.

ABSTRACT 13

Translation of encoded chiral information into polymer properties

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Nature encodes structure and function in biopolymers through stereochemistry and precise control over monomer sequences. Inspired by this strategy, macromolecular engineering has advanced toward translating sequence control into the realm of synthetic polymer materials [1]. In this talk, I will present our recent efforts to design abiotic polyurethanes with precisely defined sequence of monomers and stereocenters [2], enabling programmable folding behavior and structural complexity [3,4]. Our results reveal how subtle variations in chiral information at the molecular level can dramatically affect macroscopic properties, opening new pathways for creating synthetic macromolecules that mimic essential features of protein-based materials. I will demonstrate how the careful selection and positioning of chiral building blocks influence chain mobility, folding behavior, and the ability to self-organize. By systematically introducing stereocenters, we can guide polyurethane chains into distinct secondary structures—such as helices and sheet-like conformations—in entirely abiotic environments. Importantly, this structural control translates directly into material properties. These findings demonstrate the potential of precision-engineered advanced polymers materials opening new perspectives for developing artificial protein analogs from entirely synthetic macromolecules. Altogether, this work demonstrates how encoded chiral information can be harnessed to program both the structure and function of synthetic polymers, bringing us closer to designing functional, protein-mimetic materials.

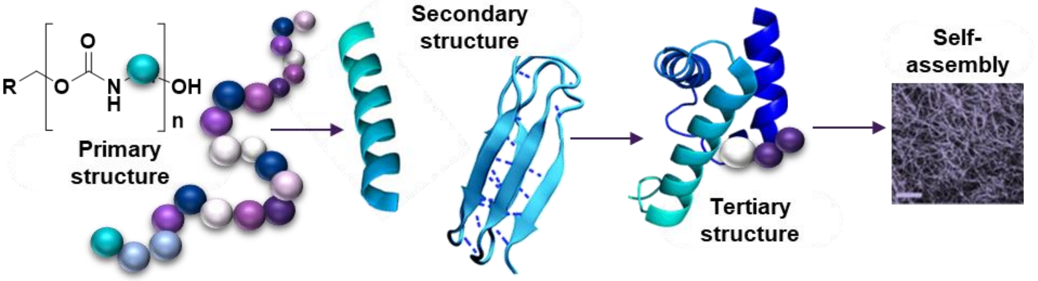

Figure 1. Encoding information in monomer sequences to control polymer folding and self-assembly—towards programmable materials that mimic features of protein-based systems.

Acknowledgments: I thank the Polish National Science Centre (No 2018/31/D/ST5/01365, No 2021/42/E/ST4/00010, No 2021/43/I/ST4/01294), European Research Council No 101116700 and National Centre for Research and Development (LIDER/27/0148/L-12/20/NCBR/2021) for financial support.

References:

[1] R. Szweda, Prog Polym Sci 2023, 145 : 101737.

[2] P. Cwynar et al., Eur Polym J, 2023, 182 : 111706.

[3] W. Forysiak et al., Polym Chem, 2022, 13 :2980.

[4] M. Szatko et al., ACS Biomater. Sci. Eng. 2024, 10(6) : 3727.

ABSTRACT 14

Automated Discovery of ECM-Mimicking Supramolecular Assemblies through Cell Painting and Machine Learning

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Replicating the complex functionality of the extracellular matrix (ECM) is a central goal in biomaterials research. Supramolecular materials based on ureido-pyrimidinone (UPy) chemistry offer a modular and versatile platform to address this challenge. They can self-assemble through quadruple hydrogen bonding, π–π stacking, and hydrophobic interactions and incorporate bioactive peptide motifs [1]. Extensive libraries of multifunctional UPy-based assemblies can be generated to mimic ECM cues, by systematically varying supramolecular components. Exploring such a diverse design space requires an efficient, high-throughput screening strategy (Figure 1A). To this end, we adapted the Cell Painting assay [2] to characterize cellular responses to peptide-functionalized UPy assemblies in solution. This high content screening assay creates unique morphological profiles by staining eight cellular compartments using six dyes (Figure 1B). U-2 OS cells were treated with fibronectin, its functional fragment FNIII(9–10), and a library of UPy-based peptide assemblies designed to mimic fibronectin-like behavior. The resulting high-dimensional morphological profiles, analyzed through machine learning techniques, enabled the identification of supramolecular assemblies capable of inducing a fibronectin-like phenotype. Altogether, this approach demonstrates that modular supramolecular assemblies can be rationally designed to reproduce key aspects of ECM-mediated cell behavior. Combining supramolecular chemistry with high-content imaging and data-driven analysis provides a versatile toolkit for screening biomimetic materials. Future work will expand on these findings to explore additional peptide motifs and formulations, bringing us closer to synthetic ECM analogues with precisely tunable properties.

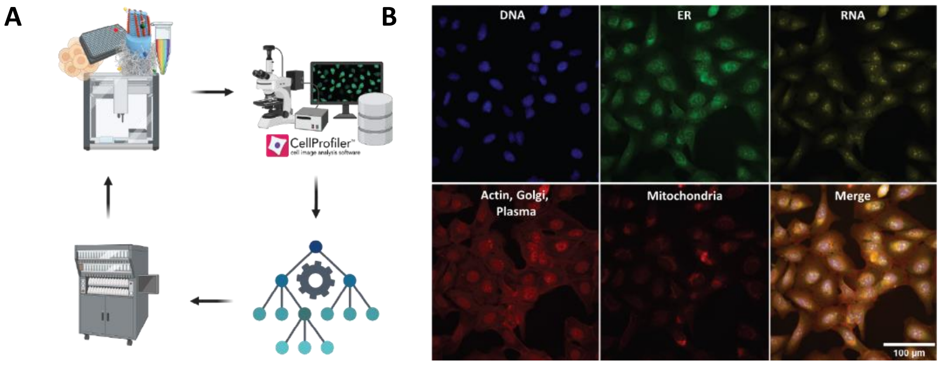

Figure 1. Screening supramolecular assemblies. A) The automated approach consisting of material synthesis, formulation screening and analysis. B) Representative images of U-2 OS cells stained with the Cell Painting dyes.

References:

[1] M. Diba et al., Adv. Mater., 2021, 33 : 2008111

[2] M. A. Bray et al., Nature Protocols, 2016, 11 : 1757–1774

ABSTRACT 15

Minimal Peptide Sequences That Undergo Liquid–Liquid Phase Separation via Self-Coacervation or Complex Coacervation with ATP

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The simple (self-)coacervation of the minimal tryptophan/ arginine peptide sequences W2R2 and W3R3 was observed in salt-free aqueous solution [1]. The phase diagrams were mapped using turbidimetry and optical microscopy, and the coacervate droplets were imaged using confocal microscopy complemented by cryo-TEM to image smaller droplets. The droplet size distribution and stability were probed using dynamic light scattering, and the droplet surface potential was obtained from zeta potential measurements. SAXS was used to elucidate the structure within the coacervate droplets, and circular dichroism spectroscopy was used to probe the conformation of the peptides, a characteristic signature for cation−π interactions being present under conditions of coacervation. These observations were rationalized using a simple model for the Rayleigh stability of charged coacervate droplets, along with atomistic molecular dynamics simulations which provide insight into stabilizing π−π stacking interactions of tryptophan as well as arginine−tryptophan cation−π interactions (which modulate the charge of the tryptophan π-electron system). Remarkably, the dipeptide WR did not show simple coacervation under the conditions examined, but complex coacervation was observed in mixtures with ATP (adenosine triphosphate). The electrostatically stabilized coacervation in this case provides a minimal model for peptide/nucleotide membraneless organelle formation. These are among the simplest model peptide systems observed to date able to undergo either simple or complex coacervation and are of future interest as protocell systems.

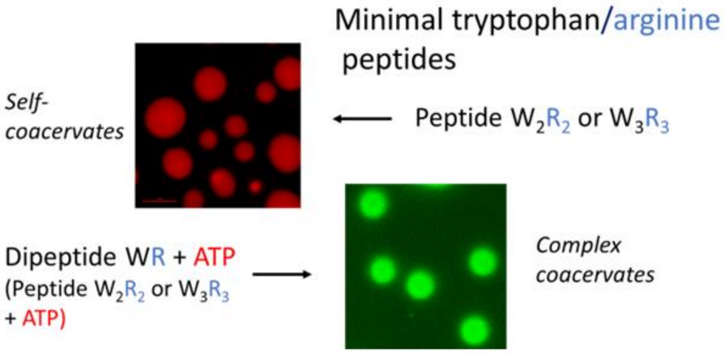

Figure 1. W_2R_2 and W_3R_3 self coacervates and WR+ATP complex coacervates.

Acknowledgements: This work was supported by EPSRC Fellowship grant (reference EP/V053396/1) to I.W.H. We thank Diamond for the award of SAXS beamtime on B21 (refs SM32486-1 and SM32486-3) and Nathan Cowieson, Katsuaki Inoue, and Nikul Khunti for assistance. We acknowledge use of facilities in the Chemical Analysis Facility (CAF) at the University of Reading.

References:

[1] V. Castelletto et al., Biomacromolecules, 2024, 25 : 5321.

ABSTRACT 16

Catalytic peptide-based coacervates for enhanced function through structural organization and substrate specificity

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Enzymes are believed to have evolved from small peptides [1]. While peptides have been effectively employed as catalysts in organic reactions, their utilization in aqueous environments remains a challenge due to their inherent conformational heterogeneity. Cells employ membrane-bound and membrane-less organelles (MLOs), with the latter forming via liquid-liquid phase separation (LLPS) of intrinsically disordered proteins (IDPs) through peptide motifs or nucleic acid interactions [1]. Compartmentalization via LLPS is present in nature in different processes, such as in the β-carboxysome biogenesis [2]. While coacervation has been studied as a strategy to enhance enzyme activity, catalytic peptide coacervates remain largely unexplored. In this work, we show the impact of coacervation via LLPS on a 12 residue-long peptide characterized by a flexible beta-hairpin conformation, with modest phosphatase activity towards pNPP and affinity towards phosphorylated assemblies [3]. These coacervates featured densely packed, structured domains and a stabilized β-hairpin conformation compared to soluble peptides. Guest molecule partitioning depended on charge and hydrophobicity, and the peptide shows affinity for phosphorylated proteins like BSA, TAU, and CotB. Remarkably, P7 coacervates achieve a 15,000-fold increase in catalytic efficiency toward pNPP, highlighting their potential for advancing enzymatic applications.

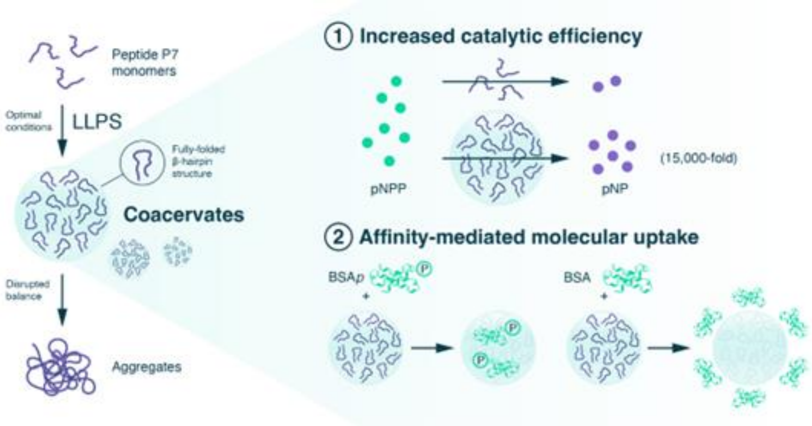

Figure 1. P7 peptide-based coacervates efficiently hydrolyze phosphate esters, exhibiting a 15,000-fold increase in catalytic efficiency when compared to soluble peptides, and selectively sequester phosphotyrosine assemblies through affinity interactions.

References:

[1] M. Frenkel-Pinter et al., Chem Rev. 2020, 120(11): 4707.

[2] Wang et al., Nature, 2019, 566m : 131.

[3] Li P, et al., Nature ,2012, 483(7389) : 336.

REACTIVE COACERVATES SHOW BUDDING AND MEMBRANE FORMATION

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Reactive coacervates are systems with one or more components that can undergo chemical transformations while being an integral part of coacervation, which may or may not be triggered by external stimuli.[1] Here, we discuss how to utilize reactive coacervate environments to enhance reaction kinetics,[2] guide hierarchical self-assembly, and show life-like properties.

The chemically triggered reactive complex coacervates undergo self-immolative transformations to generate the same products in different environments: hydrophilic and amphiphilic. The surrounding environment dictates the packing order and relative distribution of reaction products within their matrix. These self-assemblies then evolve to show life-like properties such as budding and membrane formation in hydrophilic and amphiphilic microcompartments, respectively. Coacervate composition significantly influences the reaction rates and guides hierarchical self-assembly.

We were able to showcase the potential of reactive coacervates as a versatile platform to control both reaction and self-assembly pathways for controlled supramolecular self-assembly and synthesis in a confined environment. This work has future applications in the controlled synthesis of advanced materials in aqueous environments, such as COFs and cages.[3]

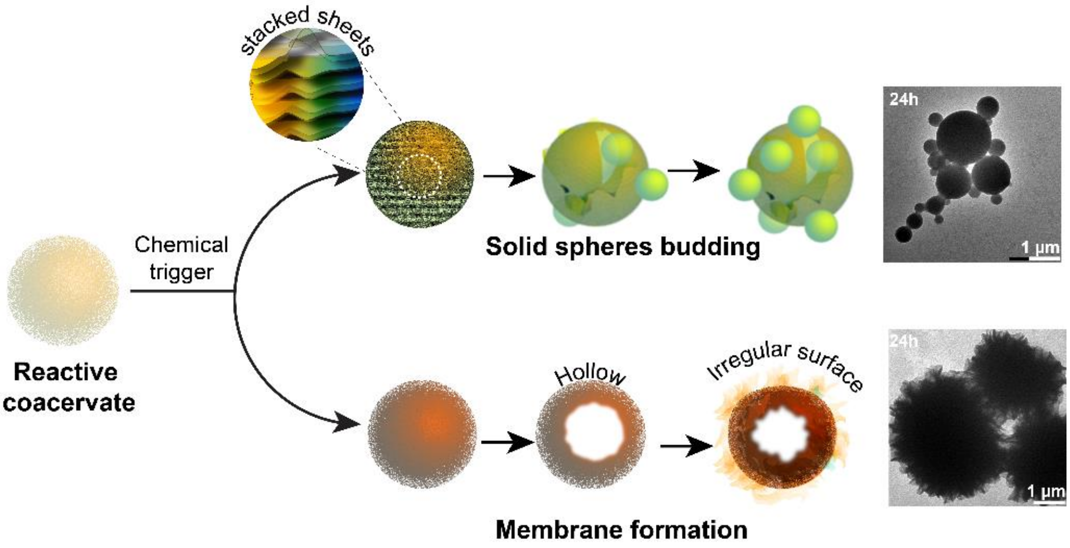

Figure 1. Schematics of structural metamorphism of reactive coacervates due to the chemically triggered reaction cascade inside their matrices. Transmission electron micrographs of each sample after 24 hours at the far-right end; scale bar: 1 µm.

Acknowledgments: S.K. and N.S. thank Ministerio de Ciencia, Innovación y Universidades, and Plan Estatal de Investigación Científica y Técnica y de Innovación for grant number PID2022143047NA-I00 and the support from Generalitat Valenciana for CIDEGENT PlaGenT grant no. CIDEXG/2022/16 for the project PRONESS. N.S. acknowledges UJI for funding (UJI-2023-08)

References:

[1] S. Koppayithodi et al, J. Am. Chem. Soc., 2025, 147(6) : 5293.

[2] I. B. A. Smokers et al, Acc. Chem. Res., 2024, 57(14) : 1885.

[3] O. Yaghi et al, Nature, 2003, 423 : 705-.

ABSTRACT 18

Dynamic DNA nanomaterials enabled by enzyme-mediated dissipative Hybridization Chain Reaction

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Biological supramolecular assemblies exhibit dynamic behaviors that is crucial for environmental responsiveness and regulation. Mimicking such non-equilibrium dynamics in synthetic systems holds great potential for the development of adaptive materials with life-like properties. Thanks to the high programmability of DNA-DNA interactions and the use of nucleic acids as chemical fuels to drive non-equilibrium processes, dissipative DNA nanotechnology has recently emerged as a powerful tool for engineering responsive biomaterials.

We propose here a novel strategy to implement dissipative control over the Hybridization Chain Reaction (HCR), a DNA assembly technique that involves the polymerization of two metastable hairpins. To do this, we induce a dissipative behavior by enzyme-mediated fuel consumption of a "tailed-controlled HCR“ [1]. We re-designed a fuel that causes the disassembly of polymers into small oligomers through a strand displacement process, and as the fuel-consuming unit we use an enzyme that selectively recognize and degrades the fuel. This allows the DNA nanostructure to reform in a cyclic and dissipative way [2]. We have developed two orthogonal strategies using different enzyme-fuel pairs: RNA fuel/RNase H and phosphorylated DNA fuel/Lambda Exonuclease. These systems enable programmable and reversible DNA assembly, highlighting how chemically fueled enzyme-regulated networks can be used to engineer dynamic supramolecular architectures.

References:

[1] X. Liu et al., Sci. Adv. 2022, 8(2), eabk0133.
[2] E. Del Grosso et al. , Angew. Chem. Int. Ed. 2022, 61(23): e202201929.

ABSTRACT 19

Monitoring Multivalent DNA Origami–Cell Interactions in Real Time via Single Particle Tracking

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The DNA origami method provides a powerful platform for the programmable self-assembly of nanoscale architectures with precise spatial organization of functional moieties [1,2]. Leveraging the modular and highly addressable nature of DNA nanostructures, we present rod-shaped DNA origami constructs functionalized with ligands—either anti-EGFR antibodies or anti-EGFR aptamers—to investigate multivalent interactions at the cell membrane interface. These hybrid nanoconjugates exemplify the integration of synthetic precision with biological specificity, offering a compelling model system for studying dynamic receptor-ligand binding events. Using single- molecule tracking (SMT) microscopy, we quantify key parameters such as diffusion coefficient (D) and dissociation rate constants (K_{off} and K_{on}), enabling a supramolecular-level understanding of interaction kinetics on live cell membranes [3]. Our results differentiate specific versus nonspecific binding and reveal how ligand identity influences binding stability and membrane dynamics. Notably, the DNA origami constructs exhibit preferential binding profiles toward cancer cells, suggesting potential for engineered selectivity in therapeutic delivery systems. This work highlights the potential of SMT as a powerful tool for studying the dynamics of supramolecular interactions at biological interfaces, providing quantitative insight into binding specificity, mobility, and interaction lifetimes at the nanoscale.

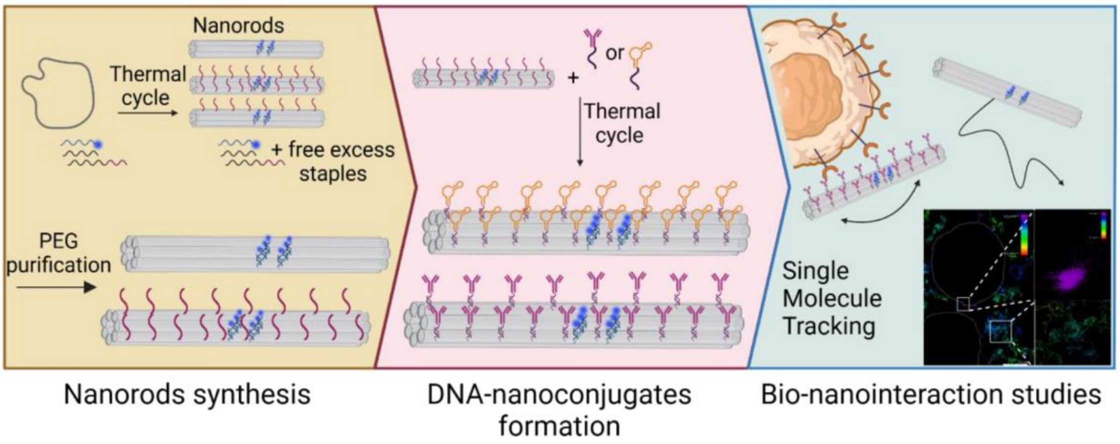

Figure 1. Schematics rendering of the workflow.

Acknowledgments: This work was supported by the Irene Curie Fellowship and the ICMS (T.P.). A.B. and E.S. acknowledge financial support under the National Recovery and Resilience Plan (NRRP, 2022FPYZ2N) and the COMP-R Initiative (MUR 2023-2027). I.V.Z. thanks the Flanders Research Foundation (FWO) (12A6N25N).

References:

[1] K. F. Wagenbauer et al., Nat. Nanotechnol., 2023, 18 : 1319.

[2] P. Zhang et al., Nat. Commun., 2020, 11 : 3114.

[3] J. Corzo, Biochemistry and Molecular Biology Education, 2006, 3 : 413.

ABSTRACT 20

A Universal Supramolecular Clamping Strategy for Proximity-Induced Reactivity on Polymerase Interfaces

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Controlling molecular reactivity through spatial organization lies at the heart of supramolecular chemistry. Inspired by nature's use of molecular proximity to orchestrate selective and efficient transformations, we report a universal supramolecular clamping platform that enables proximity-driven reactivity on nanostructures. Utilizing a pyrene-based anchoring system, reactive partners are noncovalently immobilized on the surface of polymersomes through π–π interactions, effectively increasing their local concentration and promoting site-specific chemical transformations in aqueous environments. We apply this strategy to accelerate inverse-electron-demand Diels–Alder (iEDDA) reactions, achieving >10,500-fold rate enhancement compared to untemplated conditions. This proximity effect enables real-time fluorescence tracking of reaction kinetics and operates independently of covalent or biomolecular templates. Unlike conventional DNA-templated or host–guest systems, our supramolecular clamp is fully modular, synthetically accessible, and broadly adaptable to diverse chemical contexts. This work introduces a powerful platform for supramolecular reaction control, offering new opportunities in bioorthogonal chemistry, stimuli-responsive materials, and nanoreactor design. By translating molecular recognition into reaction acceleration on dynamic soft matter scaffolds, our approach underscores the potential of supramolecular chemistry to engineer reactivity with precision in complex aqueous systems.

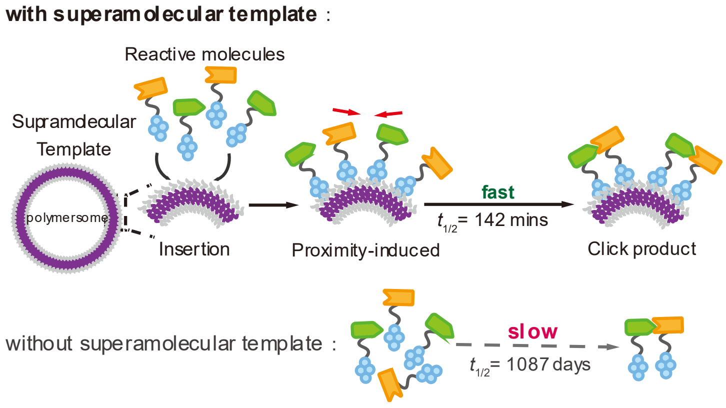

Figure 1. Supramolecular Template-Driven Acceleration of Click Reactions via Polymersome-Induced Molecular Proximity.

Acknowledgments: Q.W. acknowledges the funding from the China Scholarship Council (grant no. 202206740004). K.N. acknowledges the funding from Radboud-Glasgow Collaboration Fund 2023-2024. D.A.W. acknowledges the funding from European Research Council under the European Union's Seventh Framework Programme (FP7/2007-20012)/ ERC-CoG 101044434 "SynMoBio".

References:

[1] S Zhang et al., Nature Chemistry. 2023, 15 : 240.

[2] Q Wang et al., Submitted.

ABSTRACT 21

Polypeptide-based In Situ forming depots as Long-Acting Injectable for the controlled release of therapeutic molecules

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Long Acting Injectables (LAIs) have attracted increasing interest compared to traditional oral or parenteral routes, as they enable prolonged systemic exposure from a single dose. LAIs reduce side effects linked to high dosing frequency and improve patient compliance, adherence, and Active Pharmaceutical Ingredient (API) bioavailability [1]. This study aims to develop a biocompatible and biodegradable polymeric in situ forming depot via a solvent exchange mechanism, to enable the controlled release of an API [2]. Many polyester-based LAIs described in the literature or used commercially lead to acylation reactions that alter the API's chemical structure [1], limiting compatibility with certain molecules. Synthetic polypeptides are promising alternatives, combining the benefits of synthetic polymers (e.g. solubility, processing) and natural proteins (e.g. secondary structure [3], functionality, biocompatibility). Here, we developed a library of polypeptides via ring-opening polymerization (ROP) of N-carboxyanhydride (NCA) monomers [4], enabling depot formation upon subcutaneous injection. Their capacity to form a stable depot and control the release of the active pharmaceutical ingredient (API) was evaluated in vitro. Additionally, the interactions between the API and various peptide-based polymers were examined in solution.

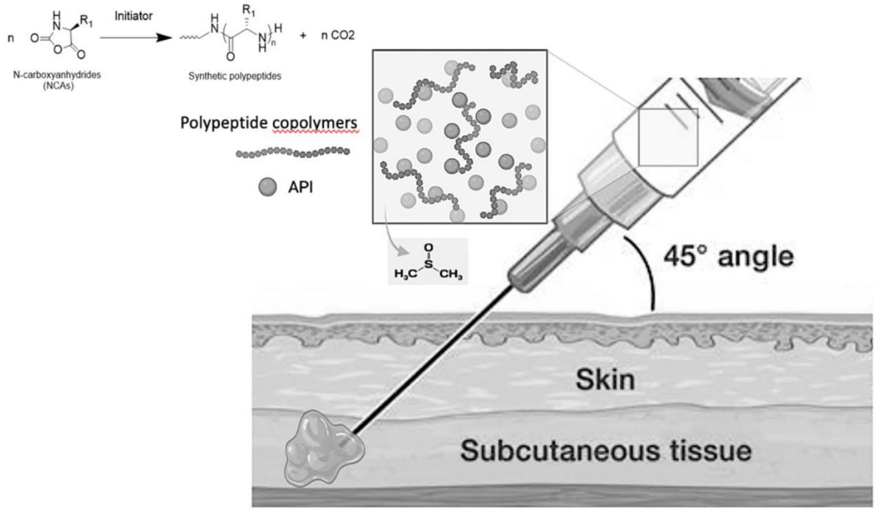

Figure 1. Polypeptide-based formulation enabling depot formation after subcutaneous injection for the controlled release of an Active Pharmaceutical Ingredient (API).

Acknowledgments: This project is funded by the ANRT (Agence Nationale de la Recherche et de la Technologie); CIFRE N° 2022/1731

References:

[1] C. Nkanga et al., Advanced Drug Delivery Reviews, 2020, 164: 19.

[2] C. Roberge et al., Journal of Controlled Release. 2020, 319 : 416.

[3] C. Bonduelle. « Secondary Structures of Synthetic Polypeptide Polymers ». Polymer Chemistry, 2018, 9(13): 1517.

[4] A. R. Mazo et al., Chem. Soc. Rev., 2020, 49 : 4737.

ABSTRACT 22

Bottom-up synthesis of artificial cells – Engineering life-like systems

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Cells perform complex functions through dynamic molecular interactions, yet replicating these functionalities in-vitro remains challenging. In this work we use chemistry and engineering tools as building blocks to design Artificial Cells - minimal compartmentalized structures that mimic specific cellular behavior. Building on this, our goal is to go beyond single units and develop Artificial Tissues – responsive materials composed of artificial cells as functional, interacting building blocks. These systems act as first steps in bridging the gap between synthetic constructs and biological complexity.

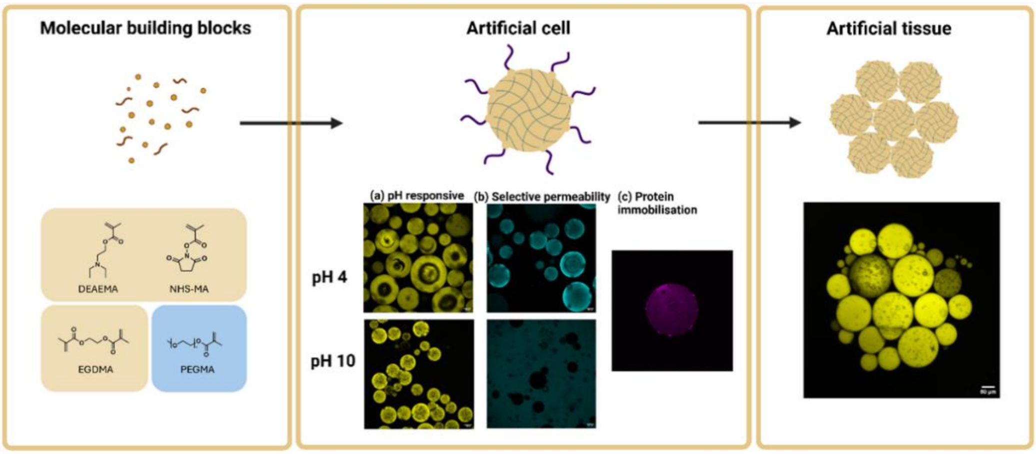

Figure 1. Using molecular building blocks for artificial cell synthesis. Further crosslinking of artificial cells for formation of artificial tissues. (a) Swelling of microgels in acidic media. Yellow – fluorescein polymerised into the backbone. (b) Selective uptake of dye into microgels in acidic media. Cyan – Sulfo-rhodamine B. (c) Uptake of his tagged protein after functionalisation of microgel core with NTA. Magenta – His-tagged mScarlet3

Acknowledgments: We gratefully acknowledge the Gravitation Program “Materials Driven Regeneration”, funded by the Netherlands Organization for Scientific Research (024.003.013)

ABSTRACT 23

Engineering compartmentalized self-assembling scaffolds for in vitro modeling of complex tissues

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The structural complexity and functional heterogeneity of native tissues have driven tissue engineering toward biomimetic and compartmentalized scaffolds that better replicate physiological conditions. In this context, we developed scalable, biocompatible gelatin-based liquid capsules, functionalized with hydroxypyridinone (HOPO) and coordinated with iron, as dynamic incubator units for 3D in vitro models. [1] These capsules feature a self-healing protein-based shell that enables multiple injections of different macromolecules, cells and structures without compromising capsule's integrity, supporting the creation of hierarchical co-culture environments. [2] To develop distinct cellular compartments and recreate complex tissue interfaces, we leveraged the self-healing properties of the capsules to enable the in situ self-assembly of E3-type peptide amphiphiles (PA-E3) triggered by calcium chloride ($CaCl_2$). These PAs form nanofibrous gel networks that mimic the extracellular matrix. Various strategies for PA gel formation and injection were evaluated, along with the biocompatibility of the system and its ability to generate intricate interfaces within the capsule. The injection of PAs into these capsules enables the formation of multicompartment systems with distinct interfaces, allowing the modulation of more sophisticated tissue architectures for advanced bioengineering applications. This innovative, liquid-compartmentalized platform integrates molecular self-assembly with macroscopic functionality, offering a robust tool for hierarchical tissue modeling and advancing applications in regenerative medicine and tissue engineering.

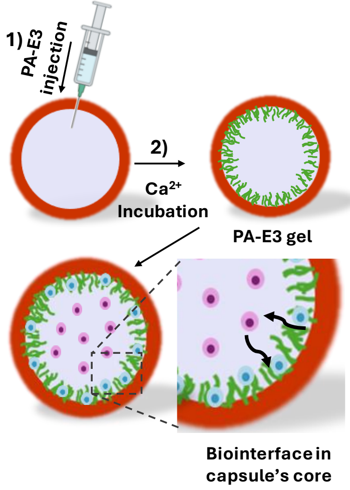

Figure 1. Self-assembly of PA-E3 hydrogels within gelatin-based capsules enables the formation of biointerfaces mimicking various cellular environments.

Acknowledgments: The authors acknowledge: the European Research Council (ERC) through the project "Reborn" (ERC-2019-ADG-883370); European Union's Horizon Europe Research and Innovation Program under grant agreement No. 101079482 ("SUPRALIFE"); Portuguese Foundation for Science and Technology (FCT) through "CICECO-Aveiro Institute of Materials", UID/50011 & LA/P/0006/2020 (DOI 10.54499/LA/P/0006/2020), financed by national funds through the FCT/MEC (PIDDAC); AO Foundation through the project (AOCMF-21-04S). A.R. Pinho acknowledge the FCT PhD grant (2021.05888.BD).

References:

[1] A. R. Pinho et al., Small, 2024, 20 : 2305029.
[2] A. R. Pinho et al., Adv. Funct. Mater., 2025, 35 : 2425715.

ABSTRACT 24

Tuning Life-Like Materials: From Reversible Bonds to Regenerative Function

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Non-covalent interactions control the shape and function of many biomolecules, such as DNA base pairing, protein structure, ligand–receptor binding, and lipid membrane organization. At the core of dynamic covalent chemistries (DCCs) lies the use of reversible covalent bonds, allowing materials to adapt their structure and properties under thermodynamic control. Inspired by nature, we employ multi-stimuli-responsive dynamic covalent chemistries that respond to endogenous triggers (e.g., redox conditions, pH, enzymatic activity) and exogenous cues (e.g., temperature, light, or small molecules) [1]. We focus particularly on the reversible interactions between boronic acids and salicylhydroxamates, which form highly chemoselective conjugates under neutral aqueous conditions and respond to mild oxidative stress or pH changes[2,3]. These underexplored motifs are integrated into biopolymers such as proteins and polysaccharides, as well as synthetic polymer platforms, and are combined with established dynamic covalent systems, including hydrazones, oximes, disulfides, (thio)esters, Michael acceptors, and reversible Diels–Alder adducts [4]. By embedding DCC principles into material design, we create biomaterials that simultaneously meet the complex demands of regenerative medicine: biocompatibility, adaptability, self-healing, controlled degradation, and tunable biofunctionality—highlighting their transformative potential in biomedical applications.

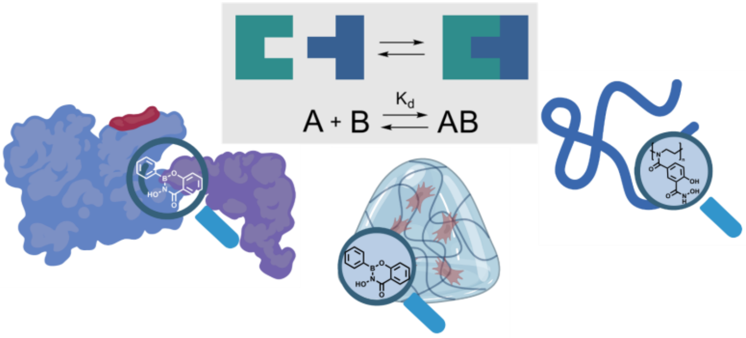

Figure 1. Schematic overview of how thermo-adaptive GelNHMa hydrogels can be used to provide cyclic mechanical stimulation to encapsulated cells.

Acknowledgements: I would like to express my sincere gratitude to the appointment committee of Maastricht University and my colleagues for the opportunity and support associated with my position as Assistant Professor. Furthermore, I warmly thank Professor Tanja Weil for the inspiring work, scientific innovations, and invaluable experiences I was able to gain during my postdoctoral research in her group, as well as for her continued support and mentorship.

References:

[1] S. J. Rowan et al., Angew. Chem. Int. Ed., 2002, 41 : 898.

[2] D. Schauenburg et al., Angew. Chem., 2024, 136 : e202314143.

[3] M. Raabe et al., Macromolecular Bioscience, 2022, 22.2 : 2100299.

[4] D. Schauenburg & T. Weil, Adv. Sci., 2023, 2303396.

ABSTRACT 25

Reflectin-inspired self-assembling systems for functional supramolecular biomaterials

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Cephalopods offer a rich source of inspiration for the design of functional and sustainable biomaterials. Reflectins are a unique family of structural proteins responsible for the dynamic optical properties and camouflage abilities of cephalopods, characterized by their ability to undergo reversible self-assembly into nano- and microstructures *in vivo*. Our work presents an integrated investigation ranging from the molecular building blocks of reflectins to their scalable production, self-assembly behavior, and material processing. We begin by exploring the self-assembling properties of a minimal protopeptide unit (YMDMSGYQ), revealing its ability to form supramolecular hydrogels and optically active films driven by hydrophilic/hydrophobic interactions centred on tyrosine residues [1]. Moreover, we demonstrate that due to its self-assembly properties, the protopeptide can be used to fabricate peptide-based submicron fibers using solution blow spinning with modulating fiber architecture through solvent conditions [2]. Next, we move to full-length reflectin variants and started by addressing key bioprocessing challenges for their recombinant production, comparing purification strategies and identifying an efficient non-chromatographic method yielding >90% purity and 88% recovery [3]. We then investigate the dynamic, reversible self-assembly full-length reflectin variants, demonstrating rapid pH-triggered nanostructure formation with high reversibility and potential for biophotonic applications [4]. Together, these studies establish a multidisciplinary foundation for the development of reflectin-inspired supramolecular biomaterials with applications in optics, sensing, and bioengineering.

Acknowledgments: The authors acknowledge funding from the European Research Council under the EU Horizon 2020 research and innovation programme (SCENT-ERC-2014-STG-639123, 101069405-ENSURE-ERC-2022-POC1 and 101158248-UNMASK-ERC-2023-POC), the European Union's Horizon 2020 programme under grant agreement no. 899732 (PURE project), and from FCT – Fundação para a Ciência e Tecnologia, I.P., through the projects PTDC/BII-BIO/28878/2017, PTDC/CTM-CTM/3389/2021, Research Unit on Applied Molecular Biosciences – UCIBIO (UIDP/04378/2020 and UIDB/04378/2020), Associate Laboratory Institute for Health and Bioeconomy – i4HB (LA/P/0140/2020), and the research fellowships SFRH/BD/147388/2019 for IL, UI/BD/151154/2021 for IP and 2022.11305.BD for CS.

References:

[1] A. M. G. C. Dias, et al., Frontiers in Chemistry, 2023, 11 : 1-14

[2] A. M. G. C. Dias, et al., Frontiers in Chemistry, 2022, 10 : 1-9

[3] I. Lychko, et al., Separation and Purification Technology, 2023, 315 : 1-11

[4] I. Lychko, et al., Mater. Adv., 2025, 6 : 157-167

ABSTRACT 26

Hybrid hydrogels for locoregional drug delivery

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Injectable hydrogels for locoregional drug delivery are a promising alternative to systemic therapies, enabling precise, site-specific treatment while minimizing off-target effects [1], especially for solid tumors like hepatocellular carcinoma (HCC). In this study, we developed an injectable matrix tailored for HCC treatment, featuring rapid in situ gelation, biocompatibility, and controlled biodegradability and release, key for minimally invasive therapy [2]. Using the Fenton reaction [3] as a fast radical-based crosslinking method, we achieved gelation (<2 min in vitro) of GelMA/PEGDA hydrogels. For improved biocompatibility, we tried different iron sources to initiate gelation. Fine-tuning of GelMA derivatization and polymer concentrations enabled shear-thinning behaviour, tuneable rheological properties, and slow enzymatic degradation of the matrix, ideal for sustained drug release. Rheological and spectroscopic analyses confirmed crosslinking efficiency and structural integrity. To enhance selective drug delivery, we synthesized stimuliresponsive silica nanoparticles loaded with specific drug. The NPs were fully characterized and integrated into the matrix. This crosslinking strategy also allowed the fabrication of soft microgel-based systems, paving the way for 3D-printable biomaterials. Our multifunctional hydrogel platform offers a flexible and innovative solution for localized delivery of drugs or biomolecules.

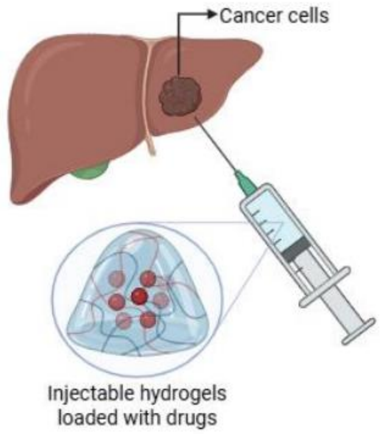

Figure 1. Schematic representation of hydrogels application.

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References:

[1] W. Yang et al., J. of Mater. Chem. B, 2023, 12 : 332.

[2] N. Mohaghegh et al., Acta biomaterialia, 2023, 172 : 67.

[3] A. Reyhani et al., Macromolecular Rapid Communications, 2019, 40 : 1900220.

ABSTRACT 27

Supramolecular Heart Patch for Controlled Drug Release and Mechanical Support in Myocardial Infarction Therapy

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A major challenge in cardiac repair after myocardial infarction is the heart's limited regenerative capacity combined with fibrotic scar formation, which compromises the heart contractile and pumping function. To address this, we examined a modular, supramolecular-based heart patch that combines mechanical support, tissue adhesion, and controlled drug delivery to enable anti-fibrotic therapy after heart infarction. The patch consists of two components: (i) a hydrogel based on chain-extended ureido-pyrimidinone (UPy) poly(ethylene glycol) with catechol moieties for covalent adhesion to cardiac tissue [1], and (ii) an electrospun mesh of chain-extended UPy-polycarbonate to tune mechanical properties, porosity, and permeability [2]. We compared this supramolecular patch to a fibrinogen-based patch (TISSEEL). Both patch formulations adhered robustly to ex vivo cardiac tissue, with the UPy patch providing sustained release of indocyanine green (ICG) and TGFβ-pathway inhibitors (SB431542, SB505124), which inhibited SMAD3 signalling for at least 4 days in vitro. Preliminary in-vivo studies on mouse models demonstrated stable patch adherence for at least one week. This versatile platform offers a promising potential for targeted modulation of post-infarction fibrosis and supports future integration of bioactive therapies for cardiac regeneration.

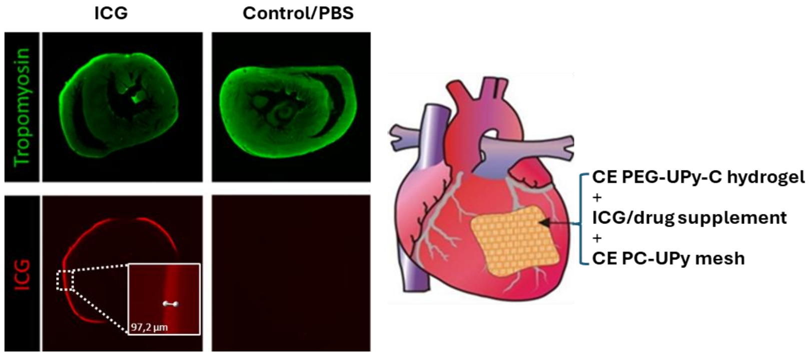

Figure 1. Application of the ICG-labeled supramolecular patch for myocardial repair. Tropomyosin staining (green) shows preserved muscle structure in both ICG and PBS samples. The ICG signal (red) indicates the localization of drug release with ~97 µm penetration in the ex vivo mouse hearts tissue. The schematic illustrates patch placement on the epicardium for targeted delivery and retention using a multi-component supramolecular design.

References:

[1] J. W. Peeters, et al. Patent # WO 2016/018145, 2016.

[2] H. M. Janssen, et al. Patent # WO 2005/042641 A1.

ABSTRACT 28

Dynamic hybrid gelatin bioresins with supramolecular-covalent networks for enhanced cell migration and self-assembly in volumetric light-based bioprinting

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Bioprinting is a powerful tool in biomedical research, enabling the precise patterning of cell-laden materials into hierarchical structures. However, developing biomaterials that mimic the dynamic microenvironment provided by the native extracellular matrix to facilitate cellular processes, while still maintaining high shape fidelity post-fabrication, remains a significant challenge. Covalently crosslinked hydrogels offer high shape fidelity but limit cell self-assembly and migration, potentially hindering biological processes that rely on matrix remodeling. In contrast, supramolecular hydrogels are biologically more permissive but lack mechanical robustness. Here, we present HybriGel, a gelatin-based hybrid hydrogel that integrates reversible β-cyclodextrin–adamantane host–guest interactions with covalent methacryloyl crosslinking.[1] This hybrid material demonstrates decoupling of shape fidelity from cellular permissiveness, enabling cell migration and self-assembly, as well as organoid proliferation within highly elastic, slow-relaxing matrices with subtly enhanced viscoelastic properties. We show that the mechanical and physical properties of HybriGel influence mechanotransduction, chemotactic motility, vascular morphogenesis and organoid assembly and proliferation. The higher bulk stiffness of these hydrogels compared to purely covalent gels enables high shape fidelity printing, so we leverage these features in combination with volumetric bioprinting[2] to develop large-scale cell-laden constructs. As a proof-of-concept, we model T cell–cancer organoid interactions, demonstrating HybriGel's potential as a dynamic platform for immunotherapy screening and tissue modeling.

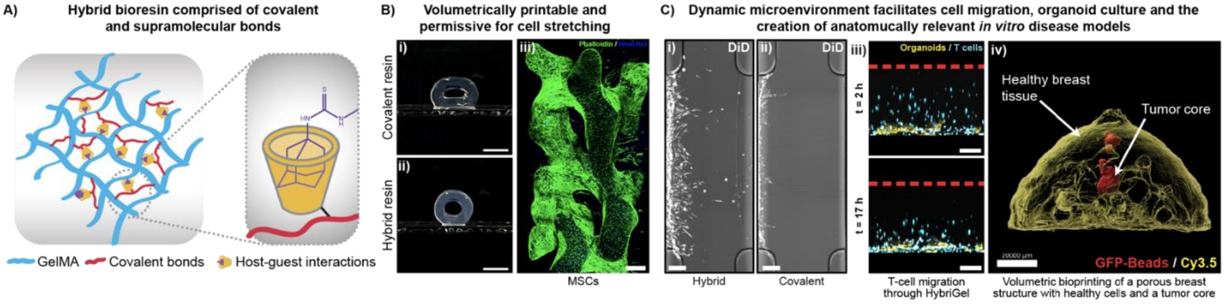

Figure 1. A) Hybrid bioresin consisting of a gelMA backbone functionalized with adamantane isothiocyanate and crosslinked in the presence of acrylated β-cyclodextrin, capable of forming covalent bonds and supramolecular host-guest interactions upon exposure to light in the presence of a photoinitiator. B) This bioresin is printable via volumetric bioprinting. C) The dynamic nature of this resin facilitates various biological processes such as chemotaxis-driven cell migration, shown with mesenchymal stromal cells (white) that more readily migrate.

Acknowledgments: This project received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement no. 949 806, VOLUME-BIO) and from the European's Union's Horizon 2020 research and innovation programme under grant agreement no 964 497 (ENLIGHT).

References:

[1] M. Falandt et al., BioArxiv, 2025, DOI:10.1101/2025.01.06.631505.

[2] P. N. Bernal et al., Adv. Mater., 2022, 34 : 2110054.

POSTER SESSION

ABSTRACTS

Poster Session 29th september – 3rd october
Multipurpose Gallery - "Catacumbas"

1 **N. Sivoria**
Biomolecular condensate-mediated modulation of Hydrogel Viscoelasticity

2 **I. Padrao**
Structural and biochemical characterization of Octopus skin: Cellular architecture, Pigments and Proteins

3 **C. L. Soares**
Bioinspired design of a new engineered reflectin protein

4 **M. Lopes**
Bioinstructive Peptide-based Supramolecular Multilayered Nanobiomaterials for Stimulating Neurite Outgrowth

5 **K. Rolińska**
Development of Gelatin-Based Films Modified with a DeepEutectic Solvent: Toward a Functional Biomaterial

6 **L. C. Almeida**
Stimuli-responsive supramolecular hydrogels via dynamicboronate ester bonds for 3D cell culture

7 **N. Pramanik**
Enzymatic and Magnetic driven microgel to enhance therapeutic delivery to complex tissue microenviroment

8 **M. J. Martínez-Morales**
Aqueous Ring-Opening Polymerization Induced Self-Assembly Towards Nanomedicine

9 **V. Sousa**
G-quadruplex hydrogels from PNIPAAm-Styrene random copolymers assembled at room temperature for advanced biomedical applications

10 **R. Sun**
Cytomimetic calcification in chemically self-regulated prototissue

11 **M. Carreira**
Contactless acoustic assembly of liquid-core microcapsules for tissue engineering

12 **L. H. Reichembach**
Development of Sustainable Pullulan-Based Adhesives Functionalized with Lipoic Acid for Tissue Engineering

13 **M. E. Luiz**
Contactless Ultrasound-Induced Cell Alignment for Bioengineered Cardiac Tissue Models

14 **L. Oliveira**
Layer-by-layer for stimuli-responsiveness on natural-based polymer membra

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15 **H. Edgar-Vilar**
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ABSTRACT 1

Biomolecular condensate-mediated modulation of Hydrogel Viscoelasticity

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To comprehend and replicate a wide variety of biological and environmental patterns in a synthetic system, it is of interest to develop energy-driven self-assembly processes. DNA-histone condensates form temporally controlled transient self-assembly in the presence of trypsin (already present in the system), which hydrolyses histones and causes disassembly. Introduction of this dynamic self-assembly to an electric field in a gel matrix results in several types of DNA patterning throughout the gel matrix, which can be modulated by the trypsin concentration, reaction mixture incubation time, and gel porosity. Notably, only free DNA pass through the gel, and the micrometre-sized DNA-histone condensates cannot due to their large size. The rate at which trypsin releases DNA determines how much DNA is transported and accumulated in various zones. The presence of DNA enhances the native gel's viscoelasticity, and adjusting the enzyme concentration or the DNA-histone condensate's dissociation rate can produce a pattern of gel viscoelasticity in various zones [1]. We believe enabling spatiotemporally controlled DNA patterning by applying an electric field will be potentially important in designing different kinds of spatiotemporally distinct dynamic materials.

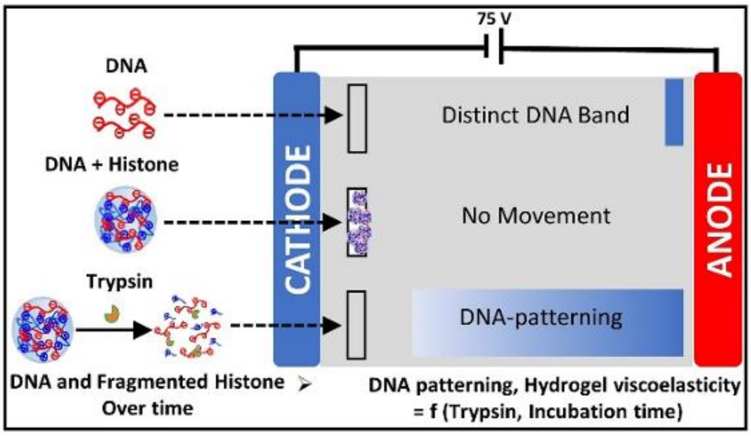

Figure 1. Schematic representation of the DNA-patterning (results in the pattern of gel viscoelasticity) when the transient self-assembly is subjected to the electric field in the gel matrix.

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References:

[1] N. Sivoria et al., Langmuir, 2024, 40 : 13505–13514.

Structural and biochemical characterization of Octopus skin: Cellular architecture, Pigments and Proteins

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Octopus skin is very dynamic and allows the animal to change their coloration almost instantly through a combination of contractile and pigmentary cells [1]. We focused on the morphoanatomical and (bio)chemical analysis of Octopus vulgaris skin, with a special focus at its chromatic cell types (leucophores and iridophores). We firstly characterized these specialized cells using a combination of microscopy techniques such as light microscopy, Transmission Electron Microscopy (TEM) and Focused Ion Beam Scanning Electron Microscopy (FIB-SEM). We then performed metabolomics, proteomics and transcriptomics analysis of skin extracts. We identified the pigments from chromatophores, which present antioxidant behavior[2], and proteins such as reflectins and crystallins, the first known for their role in light scattering and structural coloration[3]. Our results help to understand the hierarchical organization and functional diversity of octopus skin components. This fundamental work offers insights on potential relevant bioinspired systems and stimuli-responsive materials with potential applications on biosensing, UV protection materials and others.

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References:

[1] E. N. Shook et al., Curr. Opin. Neurobiol., 2024, 86 : 102876.

[2] D. M. Esparza-Espinoza et al., Food Sci. Technol., 2022, 42.

[3] A. Chatterjee, Biomimetics, 2022, 7(2) : 66.

ABSTRACT 3

Bioinspired design of a new engineered reflectin protein

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Structural proteins are a source of inspiration for designing new engineered protein sequences with distinct chemical and physical properties. Spider silk is remarkable for its mechanical properties, mainly consisting of spidroin proteins. Spidroins are characterized by the existence of two non-repetitive terminal domains – N- and C-terminal; and a central repetitive region. The hydrophilic terminal domains improve solubility during protein synthesis and play a crucial role in fiber formation[1]. Similar to recombinant spidroins, reflectin proteins are prone to aggregate and hard to dissolve. Other works have reported that flanking repetitive motifs from structural proteins with spidroin's terminal domains improves solubility and production yield [3],[4]. Herein, we designed an engineered reflectin sequence flanked by the NT conserved domain from E.australis MaSp1 and the CT conserved domain from A.ventricosus MiSp. We used a highthroughput expression screening varying the growth medium, inducer concentration, and expression period from 2 hours to 4 hours to optimize the solubility of the recombinant protein. Our results suggest that the number of residues flanked by the terminal domains influences the effect of the NT and CT domains, and thus solubility. The promising results are valuable for tailoring reflectins with enhanced solubility, which facilitates the development of new advanced materials.

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References:

[1] L. Eisoldt et al., Biopolymers, 2012, 97 : 355-361.

[2] M. Andersson et al., Nat. Chem. Biol., 2017, 13(3) : 262–264.

[3] R. Ramos et al., ACS Macro Lett., 2021, 10(5) : 628–634.

ABSTRACT 4

Bioinstructive Peptide-based Supramolecular Multilayered Nanobiomaterials for Stimulating Neurite Outgrowth

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Bioengineering soft, hydrophilic, and dynamic extracellular matrix (ECM)-mimetic constructs that are able to reproduce and capture the multitude of physicochemical signals present in the native neuronal microenvironment remains one of the major goals of neuronal tissue engineering. In recent years, the rapidly growing field of supramolecular chemistry, combined with advances in tissue engineering and regenerative medicine, has opened exciting new opportunities for the design of innovative ECM-mimetic supramolecular biomaterials. These systems are uniquely suited to modulate cell behavior and ultimately foster the growth of functional neural tissues [1,2]. Peptide amphiphiles (PAs) are particularly appealing molecular building blocks because of their fibrillar topography and their ability to display high densities of bioactive cues, both of which are required to instruct neuronal growth and guide axonal projections across hostile lesion environments [2,3]. Herein, we report the development of multilayered thin films aiming to recreate the soft, hydrated, and fibrillar neural ECM microenvironment. The co-assembly of positively charged PA molecules with the oppositely charged HA resulted in the formation of well-ordered β-sheet secondary structures, as demonstrated by the 1D nanofibrous network observed in (PLL/HA)5/K2PA-IKVAV films. In vitro assays revealed that these bioactive ECM-mimetic nanofilms promote higher neuronal viability, enhance overall cell morphology, and significantly stimulate neurite outgrowth of primary cortical neurons when compared to non-bioactive biopolymeric formulations. Furthermore, the versatility afforded by the layer-by-layer technique enabled the translation of the multilayered thin film concept into free-standing membranes that were further stabilized via carbodiimide crosslinking chemistry. This additional step enhanced their stiffness and stability under physiological conditions, thereby increasing their potential to be used as implantable biomaterials. Collectively, these results highlight the promise of bioinstructive peptide-based multilayered systems as advanced candidates for neuronal tissue regeneration..

Acknowledgments: This work was funded by the European Union's Horizon Europe research and innovation programme under the grant agreement No. 101079482 ("SUPRALIFE"), by the Programa Operacional Regional do Centro – Centro 2020, in the component FEDER, and by national funds (OE) through FCT/MCTES, in the scope of the project "SUPRASORT" (PTDC/QUI-OUT/30658/2017, CENTRO-01-0145-FEDER-030658), and by the project "JumpIN" (PTDC/BTM-MAT/4156/2021). M. Lopes, C.F.V. Sousa, M. Torrado, S.G. Patrício and J. Borges acknowledge FCT for the individual PhD grants (2020.05210.BD, 2020.04408.BD, SFRH/BD/146754/2019) and individual Assistant Researcher contracts (2020.00366. CEECIND, 2020.00758.CEECIND), respectively. This work was developed within the scope of the project CICECO – Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC).

References:

[1] M.P. Lutolf, J.A. Hubbell, Nature Biotechnology 2005, 23, 47.

[2] Z. Álvarez, A.N. Kolberg-Edelbrock, I.R. Sasselli, J.A. Ortega, R. Qiu, Z. Syrgiannis, P.A. Mirau, F. Chen, S.M. Chin, S. Weigand, E. Kiskinis, S.I. Stupp, Science 2021, 374, 848.

[3] M.J. Landry, F.G. Rollet, T.E. Kennedy, C.J. Barrett, Langmuir 2018, 34, 8709.

ABSTRACT 5

Development of Gelatin-Based Films Modified with a Deep Eutectic Solvent: Toward a Functional Biomaterial

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Gelatin (GL), despite its widespread use in material science, is inherently limited by its brittleness and poor antioxidant capacity. On the other hand, deep eutectic solvents (DES) are a new class of green, biodegradable additives that act as plasticizers and functional modifiers, capable of improving flexibility, intermolecular interactions, and bioactivity in polymeric systems [1,2]. In this study, we propose an innovative strategy to overcome these limitations by incorporating a ternary deep eutectic solvent (DES) composed of choline chloride, tannic acid, and citric acid into GLbased films. The modification aimed to enhance the films' tensile properties, antioxidant performance, and UVblocking capabilities.

ATR-FTIR spectroscopy revealed molecular interactions between GL and DES components, indicating successful integration. The addition of DES significantly improved the flexibility of the films, with elongation at break reaching up to 252%. Furthermore, the modified films displayed remarkable antioxidant properties, achieving DPPH radical scavenging efficiencies of up to 94%, significantly outperforming unmodified GL. Cytotoxicity assessment using L929 fibroblast cells confirmed acceptable biocompatibility of the materials. Notably, the films also provided excellent UV shielding across the ultraviolet spectrum while preserving high transparency in the visible range.

These results demonstrate the potential of DES-modified gelatin films as multifunctional materials suitable for applications requiring enhanced mechanical performance, oxidative stability, and UV protection, particularly within the realm of sustainable bioplastics.

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References:

[1] E. Jakubowska et al., Food Hydrocoll., 2020, 108 : 106007.
[2] K. Rolińska et al., Food Chem., 2024, 444 : 138375.

ABSTRACT 6

Stimuli-responsive supramolecular hydrogels via dynamic boronate ester bonds for 3D cell culture

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Hydrogels based on natural polymers such as hyaluronic acid (HA) – a ubiquitous natural biopolymer in the native extracellular matrices (ECM) of tissues – and proteins such as gelatin have garnered significant attention for biomedical applications due to their intrinsic biocompatibility, biodegradability, and biological activity [1, 2]. However, to better mimic the dynamic and adaptive nature of ECM, enhanced functionalities such as self-healing, injectability, and responsiveness to physiological stimuli are essential to develop next-generation biomaterials [3]. In this study, we report a novel two-component soft hydrogel system, containing phenylboronic acid (PBA) and a catechol-like group – hydroxypyridinone (HOPO) – grafted onto HA and gelatin, respectively (Figure 1). The dynamic boronate ester bonds established between PBA and HOPO groups endow the hydrogel with reversible crosslinking, resulting in a soft material with remarkable pH- and temperature-responsiveness. Importantly, HOPO provides improved oxidative stability over commonly used catechol groups, which are prone to degradation in alkaline and oxygenated environments. The reversible interactions within the hydrogel network were confirmed by UV-Vis and NMR spectroscopy using different PBA/HOPO ratios. Rheological studies performed at different pH and temperature values revealed tunable mechanical properties suitable for soft tissue engineering applications (e.g. G' = 336 ± 62 kPa, 37 °C, pH 7.4), while in vitro cell viability assays demonstrate their cytocompatibility. These results highlight the potential of this dynamic hydrogel system as a multifunctional platform for 3D cell culture in tissue engineering applications.

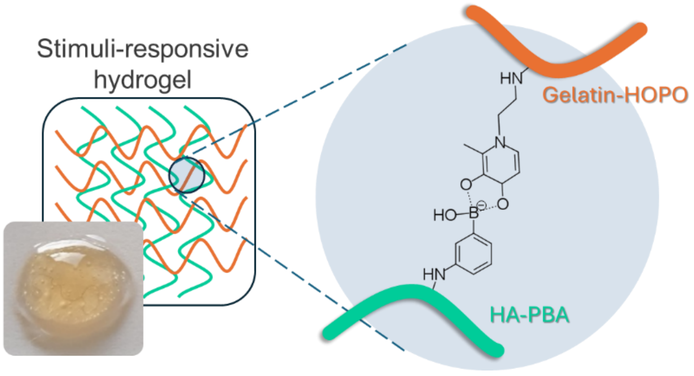

Figure 1. Schematic illustration of the mechanism behind the assembly of the soft HA-PBA/Gelatin-HOPO hydrogels.

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References:

[1] V. Sousa et al., Biomacromolecules, 2023, 24 : 3380-3396.

[2] M. C. Gomes et al., Adv. Healthc. Mater., 2021, 10 : 2100782.

[3] P. Lavrador et al., Adv. Funct. Mater., 2021, 31 : 2005941.

ABSTRACT 7

Enzymatic and Magnetic driven microgel to enhance therapeutic delivery to complex tissue microenviroment

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Complex tissue structures remain challenging for traditional nanotechnology to penetrate effectively during targeted therapeutic chemical delivery to specific cells. Collagenase and Gelatinases are crucial enzymes that denaturize and degrade collagen-fibronectin-laminin networks in living systems during tissue repair. The current work uses the biomimetic method of woodworms' wood digging to engrave the complex tissue structure of living systems using enzymatic and magnetically driven microgel movement. Under directed magnetic field, superparamagnetic and fluorescently active enzymatic microgels create hollow tunnels through gelatin-based hydrogel constructs. This hollow tunnel formation enables nutrient and oxygen delivery to target cells within the tissue structure. Further, the sculpture approach[1] facilitates the engraving process of the organ's derived native tissue environment, enabling oxygen and nutrients to reach target cells. This delivery mechanism offers therapeutic opportunities in complex tissue settings, including tumor.

Acknowledgments: Authors acknowledge European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No [Project -101180630].

References:

[1] M. C. Mendes et al., Adv. Mater., 2024, 36(41) : e2402988.

ABSTRACT 8

Aqueous Ring-Opening Polymerization Induced Self-Assembly Towards Nanomedicine

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Polypeptide-based polymeric nanoparticles represent a promising solution for the development of drug delivery systems, offering benefits such as biocompatibility, biodegradability, and self-assembly capacity [1]. However, their conventional synthesis through ring-opening polymerization (ROP) requires the use of organic solvents to maintain strict anhydrous conditions, a limitation that restricts their application in the biomedical field [2]. In recent years, the ROPISA (ring-opening polymerization-induced self-assembly) method in aqueous media has emerged as an efficient and sustainable alternative. This method allows copolymers and nanoparticles to be obtained in a single step and under aqueous conditions [3,4].

In this study, ROPISA was employed to encapsulate doxorubicin (DOX) in PEG-b-PBLG nanoparticles. The objective of this study was to evaluate the effect of different variables on drug encapsulation. Given that doxorubicin, in its hydrophilic form, possesses a primary amino group that can react with BLG-NCA monomers, it was decided not to add it initially. Instead, it was added once polymerization was complete, after two hours, when the pH is acidic and monomer consumption is almost complete, and after sixteen hours, when the pH has returned to basic. This strategy enabled the avoidance of undesirable secondary reactions and the exploitation of pH changes to enhance drug solubility.

The results demonstrated that the duration and extent of polymerization, when applied in conjunction, significantly influence the encapsulation of doxorubicin. In these conditions, it is important to note that the addition of DOX did not alter the structure of the copolymers or the morphology of the nanoparticles. These results further confirmed that the time of drug addition and the degree of polymerization are important factors to consider when optimizing the encapsulation of doxorubicin. Overall, our approach provides a basis for novel alternatives to enhance DOX encapsulation using aqueous ROPISA of NCA by exploiting potential non-covalent interactions involving the drug and amino acid side chains.

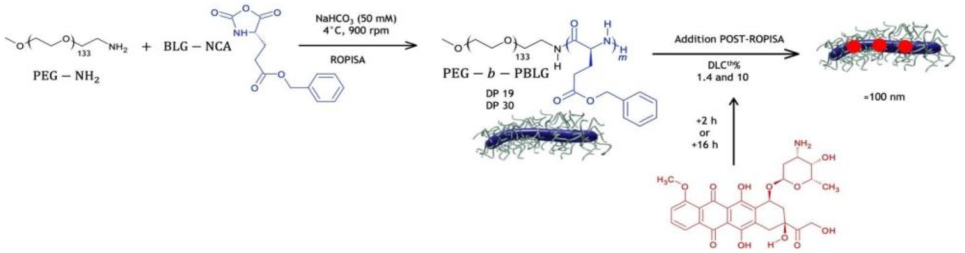

Figure 1. Schematic representation of the synthesis of PEG-b-PBLG copolymers with degrees of polymerization DP19 and DP30 via ROPISA, followed by nanoparticle formation and simultaneous DOX encapsulation during the self-assembly step. Two different drug loading contents (1.4% and 10%) and two DOX addition times (2 and 16 hours) were studied to evaluate their effect on nanoparticle formation and encapsulation efficiency.

Acknowledgments: Financial support from the University of Bordeaux and scientific support from the LCPO (UMR 5629) are gratefully acknowledged.

References:

[1] M. Stepanova et al., Pharmaceutics, 2023, 15(11) : 2641.
[2] C. Grazon et al., Angew. Chem. Int. Ed., 2020, 59(2) : 622-626.
[3] H. Beauseroy et al., Macromol. Rapid. Commun., 2024, 45(14) : 2400079.
[4] C. Grazon et al., Polym. Chem., 2021, 12(43) : 6242-6251.

ABSTRACT 9

G-quadruplex hydrogels from PNIPAAm-Styrene random copolymers assembled at room temperature for advanced biomedical applications

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G-quadruplex hydrogels have gained significant attention due to their unique self-assembling properties and potential applications in biomedicine and material science [1,2]. However, traditional G-quadruplex hydrogels are rather unstable, particularly under physiological conditions, and often require complex assembly processes involving heating and cooling cycles due to the low solubility of guanosine in water. Poly(N-isopropylacrylamide) (PNIPAAm) offers a thermoresponsive platform characterized by a lower critical solution temperature (LCST) near physiological conditions (~32 °C). Below this temperature, PNIPAAm chains remain hydrated and highly exposed to water. Above the LCST, the polymer undergoes a phase transition, collapsing into a hydrophobic state, which reduces water exposure and promotes aggregation of the polymeric chains [3,4]. We hypothesize that such behavior could be used as a source of inspiration to improve the stability of G-quadruplex hydrogels since the hydrophobic pockets created by PNIPAAm's aggregation can shield sensitive G-quadruplex structures from water molecules.

In this study, a novel PNIPAAm-styrene-boronic acid (BOH) statistical (stat) polymer was synthesized to develop stable G-quadruplex hydrogels that assemble directly at room temperature. By coupling guanosine monophosphate (GMP) to PNIPAAm-stat-Styrene-BOH via cyclic dynamic boronate ester bonds, a G-quadruplex hydrogel was developed. The synergistic effect of the hydrophobic interactions granted by the styrene molecules and the G-quadruplex assembly was demonstrated, as hydrogelation did not occur either with the homopolymer or in the absence of G-quadruplex assembly. The G-quadruplex assembly was further investigated using thioflavin T (ThT) fluorescence assays and powder x-ray diffraction (PXRD). Additionally, rheological assays revealed that the hydrogel exhibits pronounced shear-thinning behavior and short relaxation times, both arising from its dynamic network. By leveraging the synergy between hydrophobic interactions and G-quadruplex supramolecular assembly, a promising approach is offered to design stable and dynamic supramolecular hydrogels that hold great promise for applications in controlled drug delivery and tissue engineering.

Acknowledgments: This work was funded by the European Union's Horizon Europe research and innovation programme under the grant agreement no. 101079482 ("SUPRALIFE"). This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020 (DOI 10.54499/UIDB/50011/2020), UIDP/50011/2020 (DOI 10.54499/UIDP/50011/2020) & LA/P/0006/2020 (DOI 10.54499/LA/P/0006/2020), financed by national funds through the FCT/MEC (PIDDAC). The financial support by FCT through the individual PhD grants (2020.06771.BD, DOI 10.54499/2020.06771.BD – V.S.; 2020.06767.BD, DOI 10.54499/2020.06767.BD – L.P.G.M.), and individual Assistant Researcher contracts (2023.07239.CEECIND – J.M.M.R.; 2020.00758.CEECIND/CP1589/CT0007, DOI 10.54499/2020.00758.CEECIND/CP1589/CT0007 – J.B.) under the Scientific Employment Stimulus – Individual Call is gratefully acknowledged.

References:

[1] V. Sousa et al., Biomacromolecules, 2023, 24 : 3380-3396.

[2] G. M. Peters et al., J. Am. Chem. Soc., 2015, 137 : 5819-5827.

[3] A. Halperin et al., Angew. Chem. Int. Ed., 2015, 54 : 15342-15367.

[4] L. Tang et al., Prog. Mater. Sci., 2021, 115 : 100702.

ABSTRACT 10

Cytomimetic calcification in chemically self-regulated prototissue

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The fabrication of cytomimetic materials capable of orchestrated and adaptive functions remains a significant challenge in bottom-up synthetic biology. Inspired by the cell/matrix integration of living bone, here we covalently tether distributed single populations of alkaline phosphatase-containing inorganic protocells (colloidosomes) onto a crosslinked organic network to establish viscoelastic tissue-like micro-composites. The prototissues are endogenously calcified with site-specific mineralization modalities involving selective intraprotocellular calcification, matrix-specific extra-protocellular calcification or gradient calcification. To mirror the interplay between osteoblasts and osteoclasts, we prepare integrated prototissues comprising a binary population of enzymatically active colloidosomes capable of endogenous calcification and decalcification and utilize chemical inputs to induce structural remodelling. Overall, our methodology opens a route to the chemically selfregulated calcification of homogeneous and gradient tissue-like mineralmatrix composites, advances the development of bottom-up synthetic biology in chemical materials research, and could provide potential opportunities in bioinspired tissue engineering, hydrogel technologies and bone biomimetics.

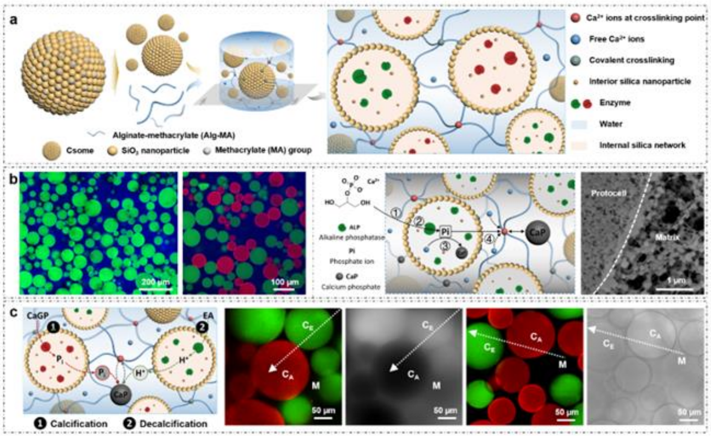

Figure 1. (a) Schematic illustrating the construction of protocell/matrix-integrated prototissues. (b) Left: Confocal fluorescence microscopy images showing prototissues with varying protocell arrangements. Green fluorescence represents fluorescein isothiocyanate (FITC)-labelled alkaline phosphatase (ALP); red fluorescence indicates rhodamine B isothiocyanate (RITC)-labelled bovine serum albumin (BSA). Right: Calcification in protocell/matrix-integrated prototissues. (c) Left: Schematic depicting the calcification remodelling process. Right: Images of calcified and decalcified prototissues. Green fluorescence denotes FITC-labelled esterase; red fluorescence indicates RITC-labelled ALP.

Acknowledgments: The authors thank the Swedish Research Council for an international postdoctoral fellowship grant (2020-00747, R.S.), a Marie Sklodowska-Curie grant (101061428, R.S.) under Horizon Europe and the ERC Advanced Grant Scheme (EC-2016-674ADG 740235, S.M.) for financial support.

References:

[1] R. Sun et al., Nat. Commun., 2025, 16 : 4138.

ABSTRACT 11

Contactless acoustic assembly of liquid-core microcapsules for tissue engineering

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In recent years, efforts have been directed towards developing systems that aim to replicate native tissue microarchitecture, enhancing cell viability and organization. Although various assembly strategies have been explored, many face challenges related to scalability and prolonged processing times. Acoustic assembly has emerged as a promising technique, enabling rapid, contactless organization of modular units through precise control of parameters such as frequency, amplitude, and chamber geometry. Here, we present an acoustic-based platform for the assembly of liquid-core microcapsules encapsulating polycaprolactone microparticles and mesenchymal stromal cells. Microcapsules were obtained via electrohydrodynamic atomization using an aqueous two-phase system, then embedded in a gelatine methacrylate matrix. Acoustic waves were applied to organize the capsules into well-defined patterns prior to photo-crosslinking, achieving spatial arrangements aligned with computer simulation predictions. Constructs maintained high cell viability for 14 days and supported the formation of microaggregates within the microcapsule's liquid-core. To demonstrate scalability and complexity, multi-layered capsule assemblies were successfully patterned. Additionally, co-culture feasibility was validated by seeding human umbilical vein endothelial cells onto the construct surface, illustrating potential for enhanced cellular interactions. This modular assembly approach provides a scalable and versatile strategy for engineering tissue-mimetic constructs with the ability to advance in vitro models and bottom-up tissue engineering applications by enabling contactless and rapid organization of cell-laden units.

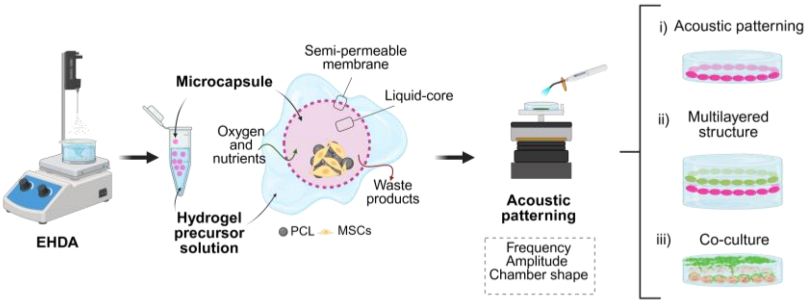

Figure 1. Schematic representation of the fabrication and patterning of liquid-core microcapsules using electrohydrodynamic atomization (EHDA) and acoustic assembly. Microcapsules were generated using EHDA and resuspended in a hydrogel precursor solution. Acoustic patterning enables the formation of different structural microcapsule arrangements that can be fixed in a hydrogel upon photopolymerization. This process allows for (i) precise spatial arrangement of microcapsules through acoustic patterning, (ii) the creation of multilayered structures by sequentially layering different constructs, and (iii) development of co-culture systems in which cell laden microcapsule constructs are seeded with endothelial cells to promote cellular interactions.

Acknowledgments: The authors acknowledge the Portuguese Foundation for Science and Technology (FCT)/MCTES in the scope of the project "TETRISSUE" (PTDC/BTM-MAT/3201/2020), the European Research Council for project "REBORN" (ERC-2019-AdG-883370) and CICECO-Aveiro Institute of Materials: UIDB/50011/2020, UIDP/50011/2020, & LA/P/0006/2020, financed by national funds through FCT/MEC (PIDDAC). M. Carreira acknowledges the financial support given by FCT with the doctoral grant (2021.04542.BD). T. Serra and R. Tognato acknowledge the financial support of the project AOCMF-21-04S by AO Foundation, AO CMF. AO CMF is a clinical division of the AO Foundation - an independent medically-guided not-for-profit organization.

ABSTRACT 12

Development of Sustainable Pullulan-Based Adhesives Functionalized with Lipoic Acid for Tissue Engineering

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To date, clinically applied tissue adhesives (e.g., cyanoacrylates) are far from ideal due to intrinsic cytotoxicity and weak tissue integration, lacking inherent tissue-specific bioactivity or capacity for controlled drug delivery. Therefore, multifunctional bioadhesives that bind strongly to biological tissues are being sought [1]. In this work, pullulan, a natural, biodegradable, and non-toxic polysaccharide, was chemically modified for potential use in adhesive formulations. The polymer was first functionalized with allyl groups and subsequently with amine groups. These modifications introduce a range of possible interactions, imparting supramolecular features to the material [2]. In a second step, the amine-functionalized pullulan was bound to α-lipoic acid, a naturally occurring compound known for its ability to undergo ring-opening polymerization. This strategy enables the formation of a molecule with adhesive properties, resulting in a material capable of bonding different surfaces. Compared to conventional medical adhesives—which suffer from issues like high stiffness, cytotoxicity, and poor degradability—lipoic acid-based adhesives show better biocompatibility and adaptability for biomedical use [3]. This approach offers a sustainable and tunable platform for developing bioadhesives with potential applications in areas that benefit from biocompatible, stable, and renewable materials.

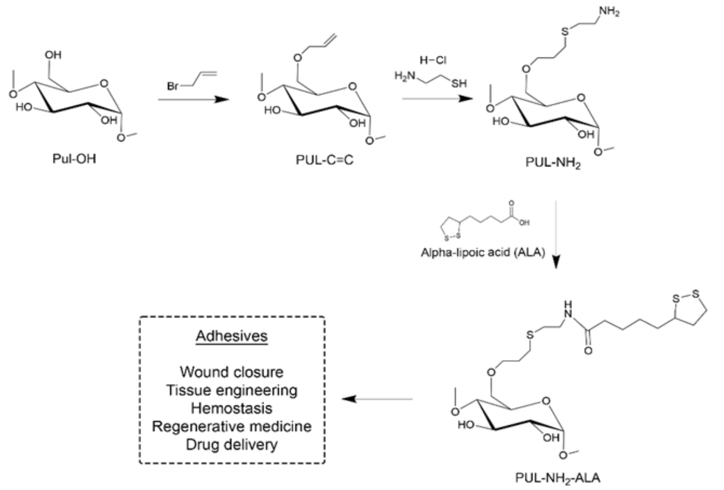

Figure 1. Schematic representation of the chemical modification of pullulan (PUL-OH) to introduce amine groups to the polymer (PUL-NH_2), followed by conjugation with lipoic acid (ALA). The resulting functionalized polymer (PUL-NH_2-ALA) is used as bioadhesive.

Acknowledgments: This work was funded by the European Union's Horizon Europe research and innovation program under the grant agreement No. 101091765 ("BUCCAL-PEP"). This work was also developed under the project CICECO-Aveiro Institute of Materials UIDB/50011/2020 (DOI 10.54499/UIDB/50011/2020), UIDP/50011/2020 (DOI 10.54499/UIDP/50011/2020) & LA/P/0006/2020 (DOI 10.54499/LA/P/0006/2020), financed by national funds through the FCT/MEC(PIDDAC). J.M.M.R. gratefully acknowledge FCT for the individual Assistant Researcher contract (10.54499/2023.07239.CEECIND/CP2840/CT0004) under the Scientific Employment Stimulus – Individual Call.

References:

[1] W. Zhu et al., Acta. Biomater., 2018, 74 : 1-16.

[2] A. M. Costa et al., J. Am. Chem. Soc., 2020, 142 : 19689-19697.

[3] S. Pal et al., Science, 2024, 385 : 877-883.

ABSTRACT 13

Contactless Ultrasound-Induced Cell Alignment for Bioengineered Cardiac Tissue Models

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Replicating the anisotropic architecture of native cardiac tissue remains a critical challenge in tissue engineering. Cell spatial organization plays a key role in modulating mechanical and functional tissue processes, directly influencing tissue maturation and contractility. Current methods used to spatially organize cells, such as microfabrication and bioprinting, frequently rely on complex equipment and often present limited scalability, hampering their broader application in tissue engineering. Here we present a simple and scalable ultrasound-based strategy to align a high density of cardiac cells within a photocrosslinkable hydrogel matrix. H9C2(2-1) cells were suspended in a gelatin methacryloyl (GelMA) precursor solution and exposed to a 2 MHz standing acoustic field, generated by piezoelectric transducers driven by a sine wave signal from a function generator. After 20 minutes of acoustic actuation, the construct was photocrosslinked to preserve the cell arrangement. Preliminary results show the acoustic actuation induces the formation of parallel cell arrangements, with maintained architecture and cell viability for at least 14 days. Additionally, cell–cell connectivity was observed along the patterned regions. This approach enables the biofabrication of structurally organized cardiac fibers and establishes a foundation for future strategies aimed at promoting functional maturation, including contractile function and electrophysiological activity. Overall, this platform offers a simple, scalable, and high-throughput method with strong potential to recapitulate native-like tissue anisotropy for both fundamental studies and disease-specific applications.

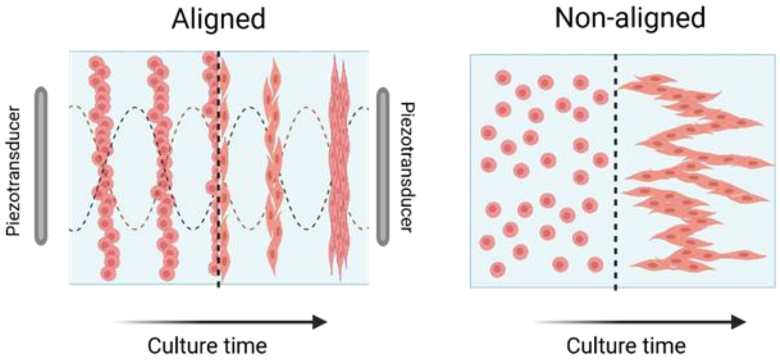

Figure 1. Schematic representation of the fabrication and patterning process used to induce the alignment of H9C2(2-1) cells. Left: Application of a 2 MHz acoustic field using piezoelectric transducers results in the spatial arrangement of cells along the pressure nodes of a standing wave. Right: In the absence of acoustic stimulation, cells remain randomly distributed and do not form organized structures. Over time, aligned cells promote contact formation and elongation along the patterned lines, in contrast to the disperse distribution seen in non-aligned conditions.

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ABSTRACT 14

Layer-by-layer for stimuli-responsiveness on natural-based polymer membranes

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In this work, we propose the use of a highly bioactive natural based material found in blood, bovine serum albumin (BSA), for the development of shape-changing materials. The main aim of the work will be to take advantage of the diverse swelling ability when crosslinked at different densities in hydrated environments to promote shape changes.

Firstly, BSA was methacrylated, rendering BSA-MA. A layer by layer strategy (LbL) was used to produce membranes in a dipping robot (Figure 1). In brief, layers of a natural based polymer were intercalated with layers of Polyethylenimine (PEI) in order to promote electrostatic interactions. After, membranes with 200 layers were obtained and crosslinked using EDC/NHS. A photomask was used to promote higher and lower crosslinking densities on these membranes, enabling inducing motion in different axes when swelled in aqueous solutions. Diverse photocuring patterns were used to explore their natural swelling ability. Controls using membranes without photocuring and membranes with photocuring but no pattern were also evaluated. Morphological and structural characterization of the developed membranes, as well as mechanical tensile testing were performed. When immersed in solution, the membranes showcased instant shape-changing ability when using 0.2 wv% of protein and diagonal photocuring pattern. The swelling ability of each membrane was characterized to relate shape change to the applied pattern. This change was characterized by measuring the degree of the curvatures of the membranes and the time to produce thin and hollow tubes. In the future, cells will be incorporated, and the ability for producing micron-sized vascular structures will be evaluated.

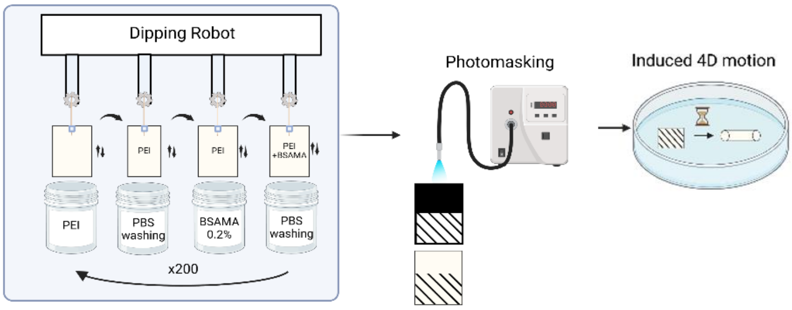

Figure 1. Schematic representation of the layer-by-layer (LbL) assembly, the photopatterning, and 4D motion.

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ABSTRACT 15

Aqueous Emulsion Bioprinting of Living Architectures with Programmable Porosity and Anisotropy

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Bulk hydrogels are comprised of nanoporous polymer networks, and thus restrict cell motility, cell-cell interactions, and nutrient diffusion in bioengineered tissues [1,2]. To overcome these challenges, interest has shifted toward the fabrication of interconnected microporous hydrogels, which improve nutrient transport, facilitate cell migration, and promote tissue ingrowth. Current fabrication methods, however, often rely on cytotoxic porogenic agents, limiting scalability and biocompatibility [1-3]. This work presents a tunable and bioprintable microporous hydrogel bioink based on GelMA-HAMA aqueous two-phase systems (ATPS). By leveraging the immiscibility between GelMA and aqueous porogen solutions comprised of polyethylene oxide and xanthan gum, we developed a simple, yet robust method to generate highly interconnected porous networks, achieving porosities up to 70%. Crucially, this approach allows for cell inclusion within the pre-gel solution, minimizing washing steps and providing precise control over the hydrogel microarchitecture. The formulated photocrosslinkable bioinks were 3D printed using a viscoelastic support bath, enabling freeform fabrication of anisotropic structures that supported favorable cell proliferation and alignment. This platform offers a scalable, biocompatible route to fabricate functional tissue scaffolds with controlled porosity and geometry in physiological conditions that uphold cellular activity, advancing the toolbox of bioinks to generate programmable porous constructs.

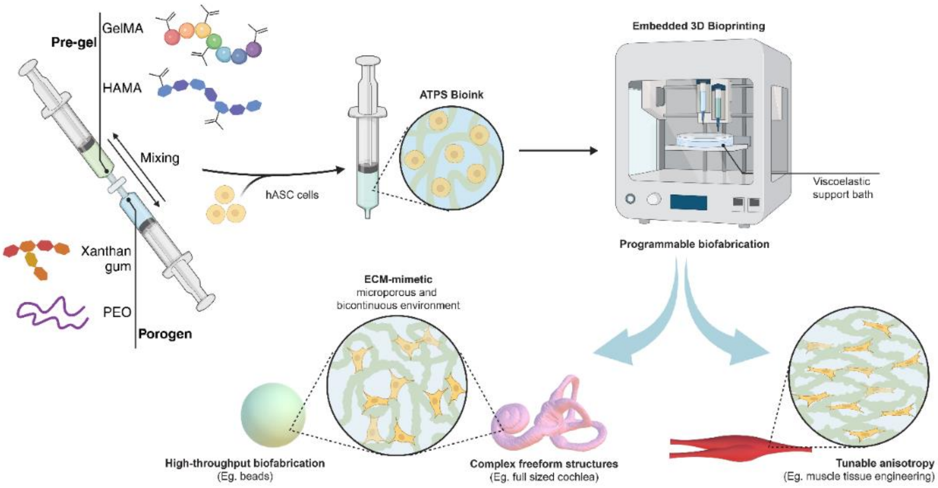

Figure 1. Schematic of ATPS hydrogel mixing and fabrication of freeform and interconnected microporous structures as well as tunable anisotropic tissue analogs.

Acknowledgments: This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). This work was also funded by the European Union's Horizon Europe research, innovation program under the scope of the SUPRALIFE project (Grant agreement 101079482), and by the GreenNanoBone project (Grant agreement 101177877).

References:

[1] G. L. Ying et al., Adv. Mater., 2018, 30(50).

[2] S. Yi et al., Small, 2022, 18(25).

[3] X. S. Qin et al., Regen. Eng. Transl. Med., 2022.

ABSTRACT 16

Polypeptide-based nanoparticles for targeted oligonucleotide delivery in endometriosis

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Endometriosis is a very common gynaecological disorder, affecting almost 10% of women in the reproductive age, which is defined as the growth of endometrium-like tissue outside the uterus [1]. With symptoms including painful menstruation, painful intercourse, and infertility, the women affected experience a tremendous loss in quality of life [1]. At present, treatment is largely symptomatic and hormone-based, but such therapeutics lack efficiency, and are accompanied by undesired effects, such as the impossibility to become pregnant during the treatment [2]. Recent studies have showed that persistent tissue inflammation with subsequent fibrosis play a crucial role in the pathophysiology of endometriosis [3]. In this project, the goal is to develop an innovative treatment that addresses the root cause of endometriosis, rather than the symptoms. Such novel therapeutic involves the targeted delivery of RNA with inflammation and fibrosis resolving activity. To take full benefit of RNAs as therapeutics, delivery systems are required to effectively protect and direct their cargo to their intended site of action, and yield release once inside the cell. Elastin-like polypeptides (ELPs) represent non-immunogenic, biodegradable and highly versatile building blocks for the design of nanoparticles [4]. They are biologically inspired materials which undergo phase separation upon thermal trigger. If correctly engineered, they provide a tool to obtain monodispersed populations of micelles that allow for the encapsulation of a variety of drugs [4]. A schematic of the project is depicted in Figure 1.

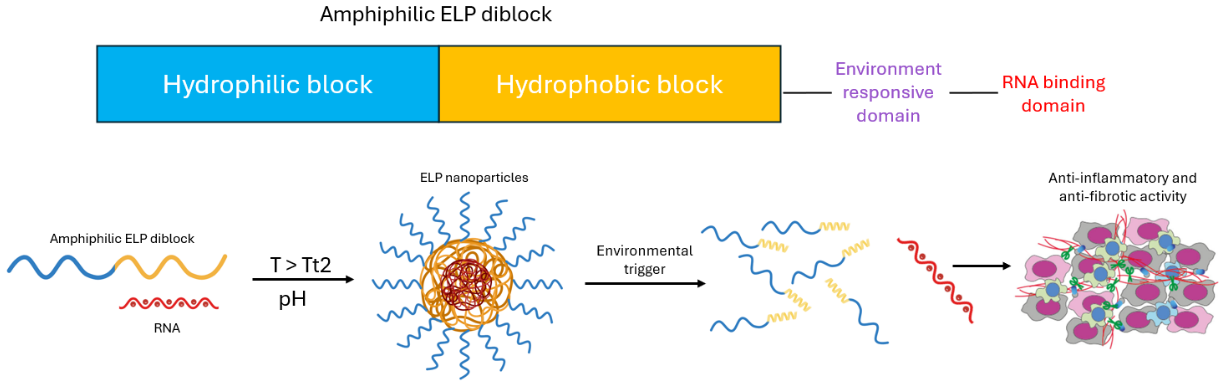

Figure 1. Novel protein-based nanoparticles for responsive and targeted delivery of RNA to resolve inflammation and mitigate fibrosis in endometriosis.

Acknowledgments: Thanks to the funding agency NWO and to the partners RiboPro, Mercurna, Ardena and Endometriose Stichting Nederland.

References:

[1] K. T. Zondervan et al., N. Engl. J. Med., 2020, 382 : 1244-1256.

[2] C. M. Becker et al., Hum. Reprod. Open, 2022, 2022 : 1-26.

[3] S. W. Guo, Human Reproduction, 2018, 33 : 353-356.

[4] D. H. T. Le et al., Molecular Systems Design & Engineering, 2019, 4 : 545-565.

ABSTRACT 17

Magnetic human-derived sponges for bone regeneration

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Human-derived biomaterials play a crucial role in Tissue Engineering and Regenerative Medicine due to its superior biocompatibility, biodegradability, and non-immunogenicity [1]. Here, we propose the incorporation of magnetic nanoparticles (MNPs) in these materials to obtain an advanced scaffold for bone regeneration that can be remotely actuated. With this, iron oxide (Fe3O4) MNPs were incorporated into a Platelet Lysates Methacryloyl (PLMA) solution, molded and crosslinked to form gels followed by freeze-drying to create sponges. This approach allows the creation of macroporous scaffolds with great biochemical characteristics, enhanced in vitro stability, and the ability to be controlled byusing an external magnetic field [2,3]. Results from cell culture assays in both PLMA and PLMA sponges with MNPs show that cells remain viable and exhibit high proliferation rates for up to 21 days under all three studied conditions: control, static under the influence of a magnetic field, and dynamic under a cyclic magnetic field. Their ability to respond to magnetic stimuli makes these sponges promising devices for modulating cellular phenotypes through mechanotransduction pathways.

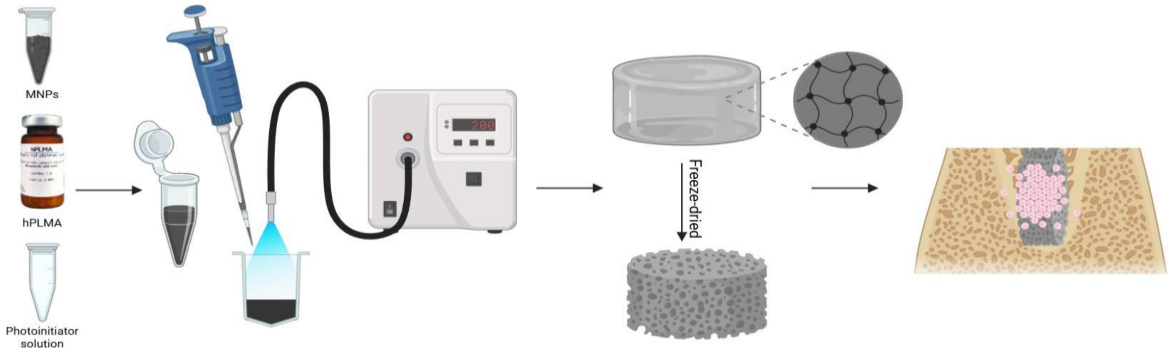

Figure 1. Schematic Representation of the production of magnetic PLMA sponges.

Acknowledgments: This work was supported by national funds (OE) through Fundação para a Ciência e a Tecnologia (FCT), I.P., in the scope of the Project "O2Cells" (2022.04237.PTDC), by the European Union (EU)'s Horizon Europe through the project "Reborn" (ERC-2019-ADG-883370) and the MSCA Postdoctoral Fellowships, Grant Agreement 101130836 (Hybrid living bioengineered hierarchical constructs with self-oxygenating capability for bone engineering). The individual contract 2021.02196. CEECIND (DOI 10.54499/2021.02196.CEECIND/CP1659/CT0002), awarded to Dr Ana Sofia Silva, is also acknowledged.

References:

[1] S. C. Santos et al., Adv. Healthc. Mater., 2022, 11 : 2102383.

[2] L. F. Santos et al., Adv. Healthc. Mater., 2023, 12 : 2300605.

[3] B. M. F. Ladeira et al., Tissue Eng. Part C Methods, 2022, 28 : 325–334.

ABSTRACT 18

Formulation and characterization of hydrogels combining self-assembling peptides and poloxamer P407 for 3D-printing

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In the last few years, 3D printing has brought tremendous advancement in the biomedical field. Nevertheless, the need for bio-inks that meet the required properties to be both printable and support cell viability is still a current challenge. Hydrogels are attractive for bio-ink formulation due to their high water content, viscoelastic properties, and porous structure. Thus, they are ideal scaffolds to mimic the extracellular matrix. Notably, some macromolecular hydrogels made from biopolymers have shown suitable mechanical properties for 3D printing. However, they often lack cell-adhesion moieties [1]. Additionally, other polymers can exhibit responsivity to external stimuli (temperature, pH, light…) but have little been explored in 3D printing.

On the other hand, the study of printing supramolecular hydrogels is emerging. Indeed, besides their design flexibility, some peptides (small proteins made of short amino acids sequences) can self-assemble in various structures (β-sheet, a-helix, …) to generate three-dimensional scaffolds highly compatible for cell development. However, the few attempts to print peptide gels have faced some limits regarding the fidelity and complexity of the printed objects [2].

Consequently, combining the properties of polymer and peptide systems would broaden the range of new potential bio-inks. Two hybrid hydrogels were formulated with poloxamer 407, a thermosensitive polymer already used in biomedical applications [3] with self-assembling peptides: Fmoc-DDIKVAV (a laminin derivative) or Ac-ILVAGK-NH2 (reported for skin burn treatment) [4].

Thus, we characterized these two multicomponent hydrogels by rheology to assess their mechanical properties. Also, we performed differential scanning calorimetry (DSC), infrared spectroscopy (IR), and circular dichroism (CD) to investigate the internal structure and intermolecular interactions. In most cases, peptides and P407 combine their structures without interfering, leading to attractive viscoelastic properties (thixotropy, shear-thinning behavior) for their future use in 3D printing.

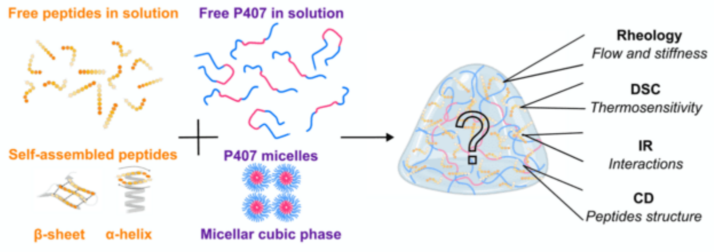

Figure 1. Physico-chemical caracterization of hybrid hydrogels made of sellf-assembling peptides and poloxamer 407.

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References:

[1] J. Jial et al., Acta Biomater., 2014, 10 : 4323–4331.

[2] A. C. Farsheed et al., Adv. Mater., 2023, 35 : 2210378.

[3] G. Dumortier et al., Pharm. Res., 2006, 23 : 2709–2728.

[4] Y. Loo et al., Biomaterials, 2014, 35 : 4805–4814.

ABSTRACT 19

Engineering of Unitary Tumor-Stroma Lung Organoids in Tissue-Specific Matrices

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Lung cancer (LC) is the leading cause of cancer-related deaths worldwide, accounting for approximately 1.8 million fatalities [1]. Its high mortality highlights the urgent need for more effective personalized treatments, which depend on the development of more predictive preclinical models [2]. Conventional tumor organoid models fabricated in hydrogel domes lack key stromal cell components of the tumor microenvironment and often form multiple heterogeneous structures, limiting reproducibility and standardization in pre-clinical drug screening [3]. To address these limitations, we conducted a comparative study using bioengineered unitary tumor-stroma lung organoids cultured in Geltrex (standard basement membrane extract matrix), and explored alternative tissue-specific extracellular matrix biomaterials including those comprising lung porcine-derived decellularized ECM (dECM), or human collagen I. This strategy enabled the assembly of tumor organoids via supramolecular cell-matrix interactions and the assessment of how different matrix mimetic biomaterials influence lung tumor architecture and tumor-stroma interactions, aiming to enhance such organotypic in vitro models for anticancer drug screening in vitro.

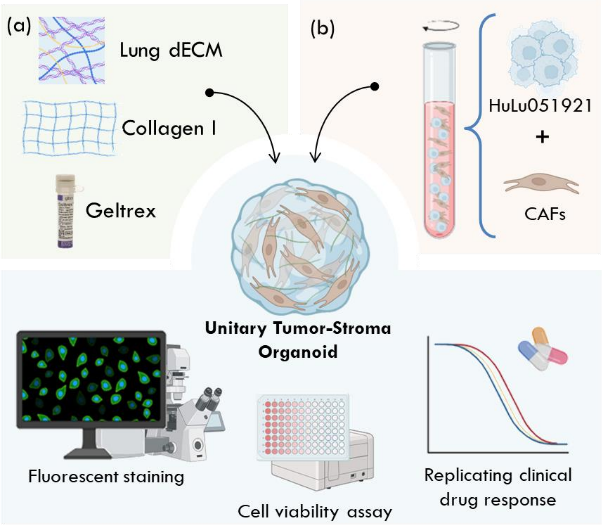

Figure 1. Schematic representation of the three main phases of methodology conducted in this work.

Acknowledgments: This work was developed within the framework of EU INSPIRE project (grant ID: 101057777 a Cluster 1 - Health). This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UID/50011 & LA/P/0006/2020 (DOI 10.54499/LA/P/0006/2020), financed by national funds through the FCT/MCTES (PIDDAC) and by the European Union's Horizon Europe research and innovation programme under the grant agreement No. 101079482 ("SUPRALIFE").

References:

[1] Y. Zhang et al., Nat. Commun., 2024, 15 : 3382.

[2] V. de Sousa et al., Pathobiology, 2018, 85 : 96-107.

[3] B. LeSavage et al., Nat. Mater., 2022, 21 : 143-159.

ABSTRACT 20

Engineering human-based nanocomposite materials to develop complex 3D single and multi-material structures for tissue regeneration

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Human platelet lysates (hPL) have been used in regenerative medicine as a source of growth factors and other bioactive proteins. However, 3D printing of protein-based biomaterials remains a challenge due to the lack of rheological and mechanical properties. Maia et al. (2023) showed that the incorporation of nanoparticles in proteinaceous matrices could improve those properties and subsequently their printability [1]. Thus, this work presents a strategy to use functionalized nano-hydroxyapatite (nHAp) to reinforce PL-based materials in order to confer the necessary properties for 3D extrusion printing. To achieve that, the incorporation of 1 and 5% (w/v) functionalized nHAp (nHAp-MA) into a solution with hPL with its methacrylated counterpart (hPLMA), and a photoinitiator (LAP) was performed using EDC/NHS carbodiimide chemistry. Results showed that by fine-tuning the rheological properties, we obtain 1 and 5% nanocomposite inks with similar rheological behavior, shear thinning profiles, flow index behavior, yield stress. The addition of hydroxyapatite increased the recovery values in the thixotropic tests, leading to better shape retention. By filament fidelity analysis, optimal printing conditions were found, with similar printing speeds, and higher pressure for 5% nanocomposite inks. Complex single and multi-material structures were developed with different layers and compared with the original CAD files to calculate printability. Mechanical properties performed on bulk nanocomposite hydrogels showcased that more stable and robust hydrogels were obtained when loaded with 1% functionalized nanoparticles in comparison to 5%. Biocompability in vitro and in vivo was demonstrated showing the potential of these materials for bone regeneration.

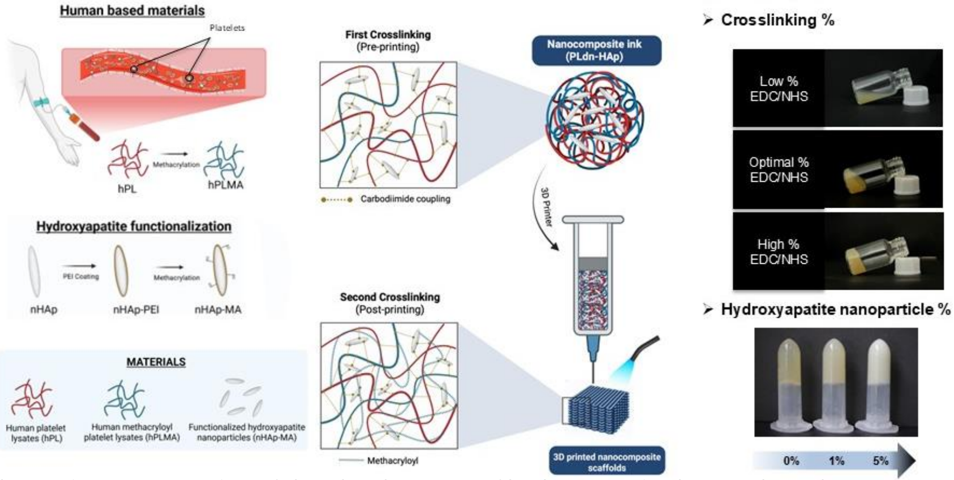

Figure 1. Schematic representation of the development of hydroxyapatite-human based nanocomposite materials.

Acknowledgments: The authors wish to acknowledge FCT for the PhD grant (2023.00647.BD, M.C.) and individual Junior Researcher contract (2022.04605.CEECIND, R.S-A). This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). This work was also funded by the European Union's Horizon Europe research and innovation programme under the grant agreement No. 953169 ("InterLynk") from which we also wish to acknowledge the research grant BI/UI89/10722/2023, M.C, and grant agreements No. 101079482 ("SUPRALIFE") and No. 101191729 ("m2M).

References:

[1] J. R. Maia et al., Methods, 2023, 212 : 39-57.

ABSTRACT 21

Development of dual-crosslinked gelatin hydrogels serving bone tissue engineering

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Annually, more than 2 million bone grafts are exploited to treat critical-sized bone defects [1]. However, despite the variety of treatments, up to 20% of these cases fail to heal [2]. While autografts are characterized by an injury at the donor-site, donor-site morbidity and a limited quantity of harvestable bone tissue, the allografts have a risk of infectious disease transmission as well as potential immune rejection [1,2]. A strong focus within the tissue engineering field is on the development of gelatin-based scaffolds containing optimized biophysical cues and cell formulations [3]. Viscoelasticity is an important biophysical cue targeting osteogenic differentiation. However, gelatin-methacryloyl (GelMA), considered the gold standard due to its ease of production and use, as well as the more recently developed thiolated gelatin/gelatin-norbornene (GelSH/GelNB) system, which results in homogenous network formation characterized by the absence of oxygen inhibition, result in a covalently crosslinked matrix with poor viscoelasticity. Hence, in this work, two bifunctional gelatin derivatives were developed with each derivative containing complementary photocrosslinkable as well as dynamic bond moieties. A first derivative incorporates norbornene (82%) and cyclodextrin (26%) functionalities while a second derivative incorporates thiol (77%) and tyrosine (40%) functionalities. Both were structurally characterized using UV-VIS spectrometry, rheology and 1H-NMR spectroscopy. The biomaterial ink, made by mixing both derivatives and Li-TPO-L as photo-initiator, was characterized by rheology as well as mass-swelling, solvent-uptake and gel-fraction experiments. In future work, the ink will be further optimized to target osteogenic biophysical cues and will be evaluated to support osteogenic differentiation.

References:

[1] V. Campana et al., J. Mater. Sci. Mater. Med., 2014, 25 : 2445–2461.

[2] T. Winkler et al., Bone Joint Res., 2018, 7 : 232–243.

[3] L. Parmentier et al., Int. J. Biol. Macromol., 2024, 254 : 127619.

.

ABSTRACT 22

Ferric ion–tannic acid supramolecular nanofilms modulate oxygen release dynamics from calcium peroxide

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Deprivation of O_2 (hypoxia) in cells is correlated with the pathophysiology of cancer, cardiovascular and kidney diseases, metabolic disorders, and infections. In tissue engineering (TE), 3D scaffolds with cells have shown great promise; however, the inadequate perfusion of soluble factors, including O_2, is a key limitation. Calcium peroxide (CPO) can release O_2 for several days; yet it is associated with severe cytotoxicity due to the high levels of H_2O_2 and ROS generated due to its fast-paced hydrolysis. Here, we developed O_2-generating particles with tunable degradation and release profiles by modifying CPO-particles with a nanofilm based on the supramolecular coordination of the ferric ion (Fe^{III}) with tannic acid (TA) (Fe(III)-TA) [1] (Fig. 1). SEM and TEM analysis confirmed the formation of a uniform, continuous and porous layer on the particles. O_2 release was measured under hypoxic (< 3–5%) conditions. O_2 generation was controlled by the film, avoiding the typical burst associated with pristine CPO-particles. Adipose stem cells (hASCs) were cultured with particles at several concentrations (0-100 ug/mL) in ultra-low adhesion surfaces. Cells stretched around and incorporated the CPO-coated particles, forming aggregates. Fe(III)-TA coating facilitated cell attachment and organization, enhancing O_2 diffusion within the aggregates, enabling significant reduction of necrotic core formation. The reduction in hypoxia marker expression further supports the Fe(III)-TA-coated CPO particles role in sustaining a favorable cellular microenvironment. This simple, fast, and effective coating enables controlled oxygen release and its cytocompatibility is ideal for TE applications.

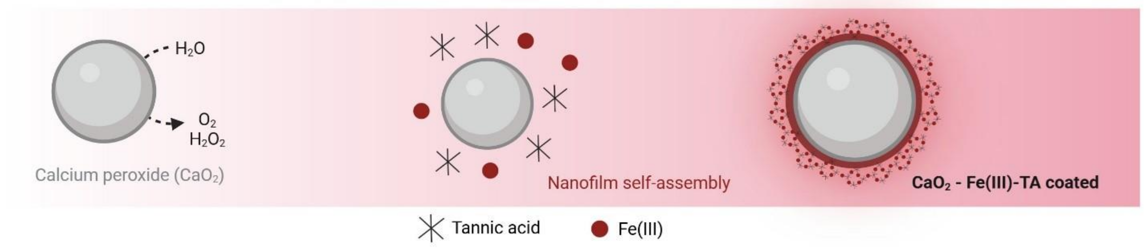

Figure 1. Ferric ion (FeIII)-tannic acid (TA) nanofilm synthesis on CaO_2 particles.

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References:

[1] B. J. Kim et al., Adv. Mater., 2017, 29(28) : 1–7.

ABSTRACT 23

Development of a Capsule-Based Bioink for Enhanced Cell Protection in 3D Bioprinting

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3D bioprinting has emerged in the past decades as a great technology that enables the precise deposition of different materials to form complex structures. However, integrating living cells into bioinks presents significant challenges. During the printing process, cells experience considerable stresses from the high shear forces applied within the nozzle, which can result in low post-printing survival rates [1]. Additionally, printed constructs often lack nutrient and oxygen diffusion in their inner layers. Another complication lies in the need to careful select the biomaterial, which must be compatible with cellular requirements to support viability and function. To address these challenges, this work presents the development of a new bioink that leverages from the unique properties of liquid-core capsules. Produced via an aqueous biphasic system, these capsules feature liquid cores that can encapsulate cells [2]. These are sufficiently robust to support the shear stresses felt during the extrusion process while providing an ideal liquid environment for cells to proliferate and differentiate. This strategy reduces the dependency on bioink materials to simultaneously meet structural and biological demands, instead supporting the development of microtissues within the capsules and promoting the paracrine communication between neighbouring ones. The ultimate goal is to overcome existing challenges in 3D bioprinting, aiming for the creation of more functional tissue constructs.

Acknowledgments: This work was financed by the European Research Council Advanced Grant "REBORN" (grant agreement n. ERC-2019-ADG-883370) and supported under Horizon Europe project PRISM-LT (GA: 101070913).

References:

[1] B. Tan et al., J. Mater. Chem. B, 2021, 9(27) : 5385–5413.

[2] S. Vilabril et al., Adv. Healthc. Mater., 2021, 10(10) : 1–11.

ABSTRACT 24

Foam-based Thiol-ene Inks for Porous Biomaterial Fabrication

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One of the main limitations of hydrogel-based materials in tissue engineering (TE) is their low porosity, which limits cell proliferation and migration. To address this, materials such as macroporous hydrogels, aerogels, cryogels and fibrous scaffolds have been developed, yet they often involve time-consuming and complex processing. [1] Foam-based materials are a simpler alternative that can be produced via air injection using natural polymers. [2,3] However, their long-term stability remains a challenge, due to drainage, coarsening and disproportionation. Natural stabilizers (e.g. surfactants, proteins and polysaccharides) or chemical crosslinking can be used to improve their stability and retain scaffold porosity. [4]

Herein, we produced natural thiol-ene foam-based inks for 3D extrusion printing via mechanical stirring (Figure 1), composed of a modified polysaccharide - hyaluronic acid-norbornene (HA-NOR) - and blood-derived proteins - human platelet lysates (hPL). Foams composed of 2.5% (w/v) HA-NOR and 5% (w/v) hPL showed uniform bubble formation, high foaming capacity and rapid light-induced gelation under 20 s. Rheological analysis showed the inks had a viscoelastic and shear-thinning behavior, crucial for 3D printing. Simple shapes were extrusion printed, yet foam stability requires further improvement, which will be addressed by adding natural stabilizers, such as glycyrrhizic acid.

Although preliminary, these results highlight the potential of thiol-ene foams as printable and biofunctional porous scaffolds for TE.

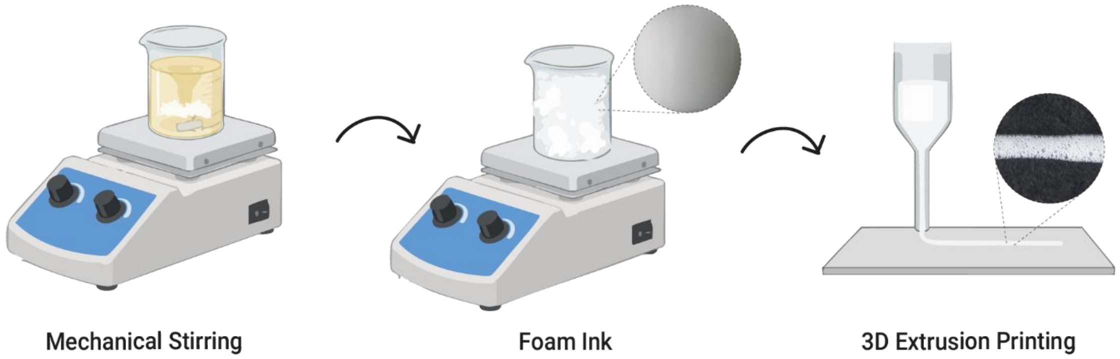

Figure 1. Schematic representation of the hPL/HA-NOR foam production and extrusion printing.

Acknowledgments: Work developed under the project CICECO-Aveiro Institute of Materials (UIDB/50011/2020, UIDP/50011/2020 and LA/P/0006/2020), financed by national funds through the FCT/MEC (PIDDAC). This work was also funded by the European Union's Horizon Europe research and innovation programme under the Grant Agreement No. 101079482 ("SUPRALIFE"), the European Union's Horizon 2020 research and innovation programme under the scope of InterLynk project with grant agreement No. 953169 and by the EU-funded M2m project with grant agreement No. 101191729. A.P. M. gratefully acknowledges the research fellowship (BI/UI89/11121/2024) in the frame of the project InterLynk. R.S.A. (10.54499/2022.04605.CEECIND/CP1720/CT0021) and J.M.M.R. (CEECIND/01363/2018) gratefully acknowledge FCT for their individual researcher contracts.

References:

[1] M. S. Flores-Jiménez et al., ACS Appl. Bio Mater., 2023, 6 : 1-23.

[2] A. Mostafavi et al., Appl. Phys. Rev., 2021, 8 : 041415.

[3] F. Serpe et al., ACS Appl. Mater. Interfaces, 2025, 17 : 13632-13645.

[4] X. Hu et al., Compr. Rev. Food Sci. Food Saf., 2023, e13284.

ABSTRACT 25

Hybrid additive manufacturing for the development of highly bioactive multimaterial 3D-printed scaffolds for osteochondral regeneration

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Multimaterial scaffolds offer a promising approach for repairing interfacial tissues, like osteochondral tissue, by replicating native mechano-biological environments. Additive manufacturing enables precise integration of hybrid materials to match specific tissue characteristics. [1]

Herein, we propose to develop a multimaterial scaffold for osteochondral regeneration, where two distinct inks were formulated, both incorporating human platelet lysates (hPL): 1) a self-setting calcium phosphate-based (CaP) ink, with and without hPL – mimicking bone compartment and 2) a photopolymerizable hPL-based ink, with and without hydroxyapatite nanoparticles (nHAp) – mimicking cartilage compartment. These were used to biofabricate complex structures using two additive manufacturing techniques based in extrusion 3D printing: robocasting and light-based printing for ink 1 and 2, respectively. [2,3]

Rheological properties of the inks were evaluated, and printing parameters (velocity, pressure, light intensity) were optimized. The resulting scaffolds were assessed for microstructure via microscopy and for mechanical performance. The interfacial adhesion between ceramic and hydrogel phases was also evaluated. For the bone compartment of the scaffold characterization tests, such as mechanical tests (compression), morphological tests (SEM) and crystalline phases analysis were performed. CaP-based scaffolds demonstrated good mechanical integrity and excellent shape fidelity. For the cartilage compartment of the scaffold, rheological characterization revealed suitability of the developed inks for 3D extrusion printing strategies with accurate reproduction of several shapes and patterns. Photocrosslinked scaffolds demonstrated suitable mechanical properties and sustained protein release overtime. Future studies will include the development of an nHAp gradient for the cartilage phase, that will be printed on top of the bone phase.

Acknowledgments: The authors wish to acknowledge FCT for the PhD grant (2023.00647.BD, M.C.), individual Junior Researcher contract (10.54499/2022.04605.CEECIND/CP1720/CT0021, R.S-A), and Auxiliar Researcher contract (2023.07934.CEECIND, P.M.C. Torres). This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). This work was also funded by the European Union's Horizon Europe research and innovation programme under the grant agreement No. 953169 ("InterLynk") from which we also wish to acknowledge the research grant BI/UI89/10722/2023, M.C, by the European Union's Horizon Europe research and innovation programme under the grant agreement No. 101191729 ("M2m"), and by the European Union's Horizon Europe research and innovation programme under the grant agreement No. 101079482 ("SUPRALIFE").

References:

[1] B. Zhang et al., J. Mater. Chem. B, 2020, 8 : 8149–8170.

[2] M. V. Coelho et al., Calcium phosphate based bioactive injectable bone cements (Master Thesis), UA, 2024.

[3] R. Sobreiro-Almeida et al., Adv. Sci., 2024, 2406569.

ABSTRACT 26

Bioorthogonal Modulation of Immune Cell Assemblies for the Fabrication of Next-Generation Living Materials

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This study integrates immune cell surface engineering to create living building blocks while addressing the challenges of current immunotherapies, particularly systemic delivery. The focus involves using immune cells as platforms for covalent ligation with a bioorthogonal polymer through the Strain-Promoted Azide-Alkyne Cycloaddition (SPAAC) reaction. In this approach, NK-92 MI cells, a natural killer cell line with enhanced cytotoxicity, are employed as the biological units for assembly and the objects of metabolic glycoengineering (MGE). By introducing exogenous sugar analogs into cellular metabolic pathways, the foundation for covalent ligation is provided, as the immune cells then take control of the system, forming high cell density self-regulating living materials. Emphasizing the precise click chemistry demonstration, the study delves into the chemical intricacies of immune cell modification, highlighting the interplay between MGE and SPAAC reactions. By integrating NK-92 MI cells into this framework, the study not only tailors cellular interactions but also demonstrates enhanced functional outcomes, particularly the ability to target and eliminate cancer cells. This work provides insights into developing biofunctional living materials with potential applications in immunotherapy, offering innovative biomedical solutions by leveraging the autonomy, cytotoxic potential, and dynamic responsiveness of this new class of immune living materials.

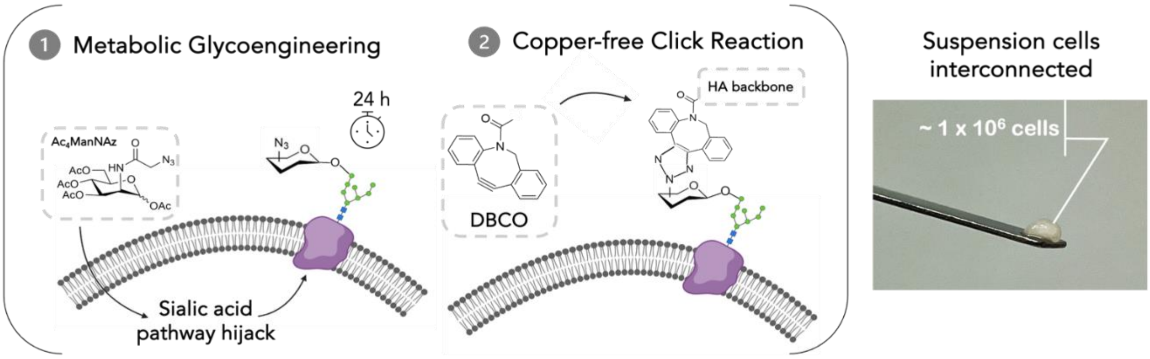

Figure 1. Schematics of the two-step assembly of immune cell-based living materials with high cell density via (1) metabolic glycoengineering and (2) SPAAC reaction.

Acknowledgments: This work was funded by the European Union's Horizon Europe research and innovation program under the Grant Agreement No. 101079482 ("SUPRALIFE"). The authors also acknowledge the funding from the project CICECO-Aveiro Institute of Materials, UID/50011 & LA/P/0006/2020 (DOI 10.54499/LA/P/0006/2020), financed by national funds through the FCT/MCTES (PIDDAC).

References:

[1] J. Han et al., Nat. Commun., 2023, 14(1).

[2] K. Nagakahama et al., Nat. Commun., 2018, 9(1).

[3] W. Kim et al., J. Control. Release, 2021, 329 : 223-236.

[4] P. Lavrador et al., Nat. Mater., 2024.

ABSTRACT 27

All-aqueous strategies for the controlled diffusion of low-molecular-weight molecules

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Green technologies for the development of DDSs (Drug Delivery Systems) offer a promising alternative, improving bioavailability and therapeutic efficacy, while reducing environmental impact and risks associated with the use of organic solvents. Despite their challenges, technologies based on fully aqueous systems represent viable alternatives for the creation of sustainable and safe DDSs. However, the encapsulation and controlled release of hydrophilic low-molecular-weight molecules (<1000 Da) remain challenging due to their high-water solubility and reliance on drug-polymer interactions, which regulate mesh size of the network to enable a controlled release [1].

In this study, a polymeric system with alginate and ε-poly-L-lysine was developed, processed under fully aqueous conditions, to lower the molecular weight cut-off of liquid-core capsules to values below 1000 Da, allowing hydrophilic molecules to be retained. By adjusting the complexation time, the pH of ε-poly-L-lysine, as well as the addition of a post-processing step to the system, we tested the concept using low-molecular-weight dyes with various chemical natures (e.g., charge). With respect to all investigated molecules, a high retention rate and controlled release profiles were obtained.

In counterpart, efforts towards capsule miniaturization are also underway, aiming to increase their application by improving diffusion control and making them suitable for situations where smaller particle size is required.

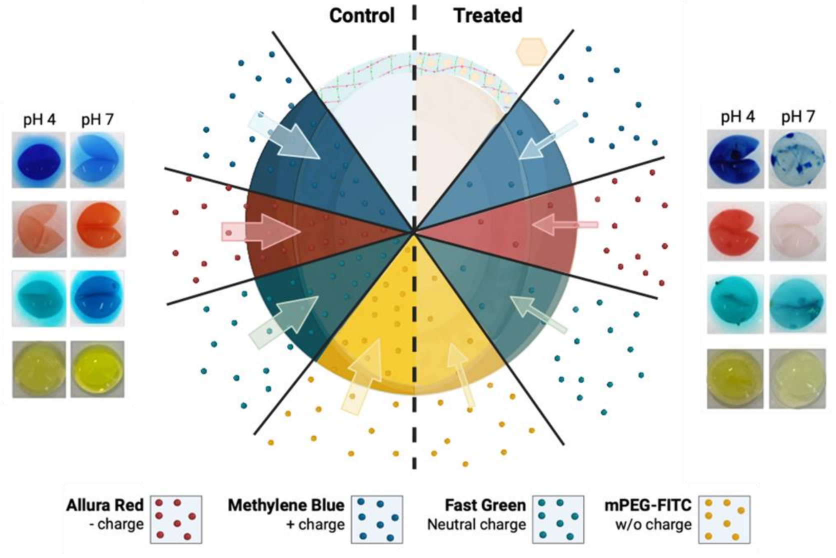

Figure 1. Schematic representation of dye permeation across capsule membranes in the absence and presence of post-processing step. Visual representations of permeability and dye-membrane interactions are shown, after 1 hour of incubation, in solutions containing dyes with distinct molecular charges: Methylene Blue (positively charged); Allura Red (negatively charged); Fast Green (Zwitterionic) and mPEG-FITC (Uncharged). Despite visual differences in dye distribution, permeation into the capsule core was observed under all conditions, however, the post-treatment led to the formation of intermolecular interactions within the membrane, contributing to a more controlled diffusion of dyes, as indicated by the thinner inward arrows, suggesting an improvement in membrane selectivity in encapsulation strategies.

Acknowledgments: This project has received funding from the European Union – Health and Digital Executive Agency (HADEA) – under the call HORIZON-HLTH-2021-IND-07, under the grant agreement No 101057430 ("SusPharma").

References:

[1] B. S. Neves et al., Green Chem., 2024, 4417-4431.

ABSTRACT 28

Cell-Curvature Interactions: The impact of Curvature Gradients on Cellular Behaviour and Mechanosensing

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Cells interpret and interact with their surroundings through dynamic outside-in and inside-out signalling involving the extracellular matrix and neighbouring cells. While many studies highlight how micro- and nanoscale surface features affect cell behaviour, fewer have explored how substrate curvature influences cellular dynamics, despite it being a fundamental feature in nature across all scales. [1]. Cells can sense substrate curvature through their mechanosensitive proteins, adapting their cytoskeletal dynamics to regulate critical physiological and pathological processes, such as embryogenic development, wound healing, and cancer metastasis. Additionally, reports have shown that both curvature gradients and axis impact cell migration through a phenomenon known as curvotaxis, where cells exhibit curvature-dependent migratory mechanisms that arise from the diverse assembly of migratory entities, leading to unique cellular dynamics and migration profiles [2-4].

Herein, we investigate how increasing curvature influences the behaviour of human adipose-derived stem cells (hASCs), using an Archimedean spiral as a model system, where curvature decreases at a constant rate. Spiral patterns were created through UV-photopatterning and fibronectin incubation, generating cell-adhesive motifs specifically along the spiral lines. hASCs were seeded on these substrates, and their response to varying curvature degrees was assessed by analysing key mechanobiological markers. Cells ability to sense and navigate through the curvature gradients was also evaluated through live-imaging assays. This study underscores how curvature influences cell behaviour, offering new insights into the field of mechanobiology.

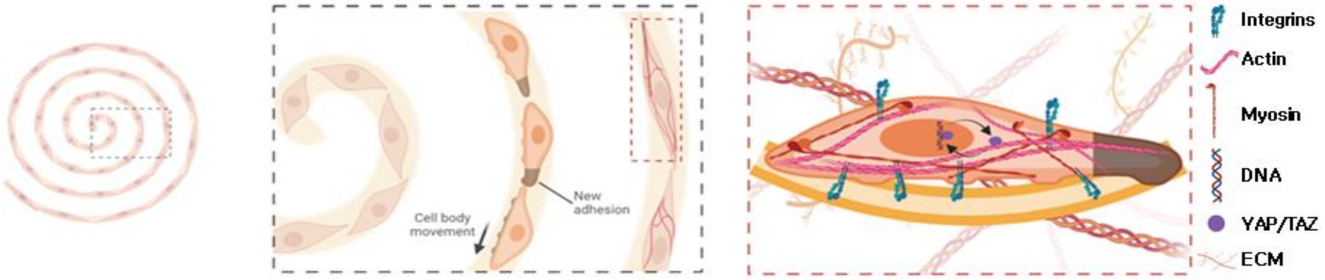

Figure 1. Schematic representation of how adipose-derived stem cells respond to increasing curvature in an Archimedean spiral, highlighting key cellular processes and players involved in mechanobiological sensing and transduction.

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References:

[1] D. Baptista et al., Trends in Biotechnol., 2019, 37 : 838-854.
[2] M. Werner et al., Adv. Sci., 2017, 4 : 1600347.
[3] L. Feng et al., PNAS Nexus, 2023, 2 : 1-9.
[4] L. Pieuchot et al., Nat. Commun., 2018, 9 : 3995.

ABSTRACT 29

Hybrid Supramolecular-Synthetic Bioinks: Leveraging BTA-Based Polymers for Tunable Mechanics in PEG Hydrogels

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The development of synthetic extracellular matrices (ECMs) for tissue engineering calls for materials that combine structural hierarchy with robust mechanical resilience and dynamic responsiveness. Supramolecular polymers based on benzene-1,3,5-tricarboxamide (BTA) offer an attractive platform due to their self-assembly into one-dimensional fibers, forming dynamic hydrogels that closely mimic ECM nanostructures. Given the mechanical weakness that limits their standalone use in load-bearing contexts, several crosslinking strategies will be evaluated to reinforce the supramolecular network, such as thiol-ene and dynamic covalent chemistries. We investigate a modular strategy to integrate BTA polymers into conventional PEG-based hydrogel systems: by doping PEG hydrogels with BTA analogues, we aim to transfer advantageous features such as tunable viscoelasticity into these established synthetic matrices. The rheological, structural and biochemical properties of the resulting hydrogels are characterized to understand how molecular-scale design principles translate into macroscale mechanics such as stiffness, stress relaxation, and degradability. These hybrid supramolecular materials with tunable covalent reinforcement can offer a versatile platform for engineering ECM-inspired bioinks tailored for complex tissue regeneration and advanced biofabrication.

Acknowledgments: This work was supported by the European Union through a European Research Council (ERC) Consolidator Grant awarded to Matthew Baker under the Horizon Europe programme (Grant agreement ID: 101088285).

ABSTRACT 30

Combining supramolecular and covalent interactions to achieve mechanical tunability in human dECM-based scaffolds

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Decellularized extracellular matrices (dECM) remain potent building blocks for the development of engineered tissues, as they inherently emulate the biochemical complexity of native tissues. However, this same complexity becomes an obstacle that prevents the modulation of their independent mechanical properties in a reproducible manner.[1] Here, we sought to improve the mechanical programmability of dECM-based matrices by mobilizing both covalent and supramolecular crosslink chemistries in human dECM (hECM). To this end, a conventional methacrylation approach[2] was combined with a previously described supramolecular acrylation strategy.[3] By adjusting the extent of covalent and supramolecular (meth)acrylation, it is possible to generate soft hydrogels of equal stiffness (≈55 Pa) while modulating their viscoelastic and strain-stiffening behaviour. Changing the biophysical profile of the hydrogels is shown to influence the behaviour of encapsulated mesenchymal stem cells, producing stark changes in cell proliferation, morphology and phenotype, thus providing an opportunity to control cell fate. Rheological analysis reveals that the strain-induced stiffening of the matrix is accompanied by increased viscoelasticity, providing greater insight into the strain-dependent evolution of the mechanical properties of the ECM over time.

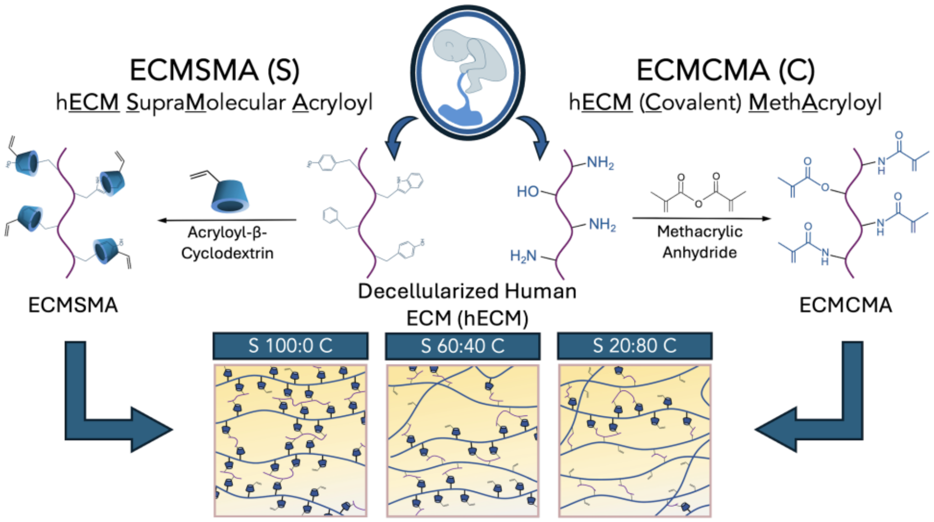

Figure 1. Schematic representation of the combined covalent-supramolecular crosslinking of hECM.

Acknowledgments: Funding – European Research Council, for project REBORN (ERC-2019-ADG-883370); Horizon Europe for SUPRALIFE (101079482); Fundação da Ciência e Tecnologia (FCT) through the individual contract 2020.01647.CEECIND and the doctoral grant 2022.10626.BD. CICECO - Aveiro Institute of Materials UID/50011 & LA/P/0006/2020 (DOI 10.54499/LA/P/0006/2020), financed by national funds through the FCT/MCTES (PIDDAC).

References:

[1] J. F. van Sprang et al., J. Mater. Chem., 2025, 13 : 610

[2] I. A. Deus et al., Biomater. Adv., 2022, 13 : 112574.

[3] B. M. Ladeira et al., Biomaterials, 2025, 320 : 123270.

Synthesis of Thermoresponsive Polysaccharides-based Biomaterials for Tissue Engineering Application

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A series of glycosaminoglycans mimics derived from polysaccharides have been synthesized via organic synthetic methods and conjugated with thermoresponsive poly(N-isopropylacrylamide) (pNIPAM) and poly(2(dimethylamino) ethyl methacrylate) (pDMAEMA) [1-4]. To develop robust, thermoresponsive, and bioactive surfaces for tissue engineering, the layer-by-layer assembly technique was employed to construct biocompatible polyelectrolyte multilayers formed by electrostatic interactions between polycations and polyanions using these polysaccharide- based materials. The resulting multilayers were characterized for their physical and thermoresponsive properties, and their interactions with proteins and support for cell growth were systematically evaluated.

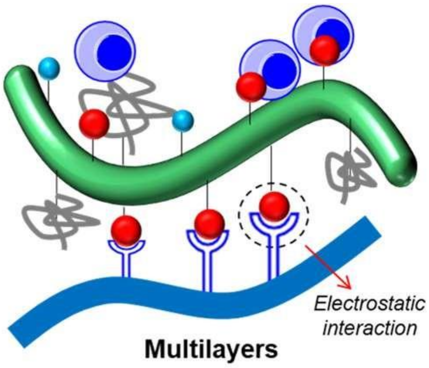

Figure 1. Biocompatible polyelectrolyte multilayers formed by electrostatic interactions between polycations and polyanions for tissue engineering applications.

Acknowledgments: Fundings from German Research Foundation (Gr 1290/12-1, ZH 546/3-1), China Scholarship Council, International Graduate School AGRIPOLY supported by the European Regional Development Fund and the Federal State Saxony- Anhalt are grated.

References:

[1] K. Zeng et al., ACS Appl. Mater. & Interfaces, 2022, 14, 48384-48396.

[2] K. Zeng et al., Cellulose, 2023, 30, 8355-8368.

[3] K. Zeng et al., ChemBioChem, 2019, 20, 737-746.

[4] K. Zeng, Y. Yang, Y. T. Lu et al., Adv. Mater., 2021, 33, 2000717.

ABSTRACT 32

Oxygen-modulated biomimetic “breathing” tissue from photo-crosslinked protocells

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Living tissues are multicompartmental constructs with specialized cells of various chemical compositions. Inspired by the hierarchical structure and dynamic deformations of the lung alveoli, this research presents a ‘Breathing’ prototissue that mimics alveolar architecture and function. Utilising bottom-up biomimetic designs, photo-crosslinkable protocells have been developed, utilizing a complexation between two biopolymers. They can encapsulate various biomolecules and microparticles, serving as functional programmable protocells. We have employed antagonistic activity between enzymes within the protocells to render rhythmic oxygen (O_2) bubble formation and consumption, yielding a controlled reversible expansion and contraction of the protocells. The photo-crosslinking of the protocells results in a formation of self-standing interconnected prototissues with defined complexities, significantly, without the need for additional supporting matrices. The assembled prototissues exhibit collective expansion and contraction behaviour similar to those observed in the alveoli. The ‘Breathing’ tissue have been proven to be used as O_2 generating, storing and releasing units as they can retain the generated O_2, and the O_2 can be slowly released into a hypoxia environment. Our strategy provides a pathway for creating matrix-free self-standing prototissues with organized microarchitectures, emulating in living tissues and enabling the recreation of rudimentary cellular behaviors.

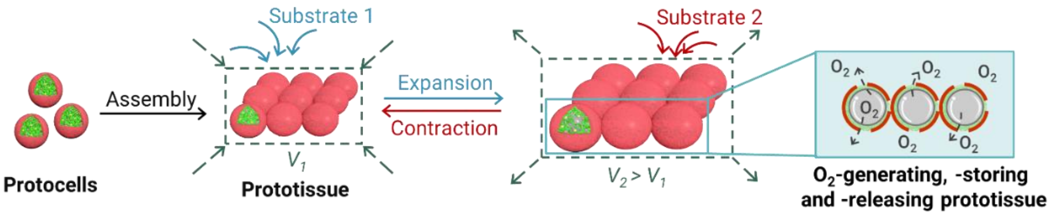

Figure 1. Scheme illustrating the fabrication of the 'Breathable' prototissues.

ABSTRACT 33

Hierarchical Self-Assembly of Sequence-Defined Oligourethanes Modulated by Stereocontrol

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Hierarchical self-assembly is one of the most effective approaches for the development of functional and smart systems [1]. This process is well established in biological systems, as exemplified by the formation of the quaternary structure of proteins or DNA double helix [1,2]. However, controlling hierarchical assemblies requires precise molecular design and stereocontrol to understand the non-covalent interactions involved in the process [1,2]. In this context, sequence-defined molecules as building blocks of complex architectures are one of the most interesting strategies to be explored [3,4,5].

Polyurethanes are a family of polymers linked by a carbamate unit and are widely used across global industries, due to their structural features and chemical stability [6]. These properties, along with their synthetic versatility, make polyurethanes promising candidates as protein analogs in abiotic systems. In this regard, recent examples of sequence-defined polyurethanes reported by our group mark the beginning of a new generation of urethane-based functional systems [7,8,9]. Herein, we report sequence-defined oligourethanes using chiral monomers as building blocks. We investigated how changing the absolute configuration of the stereocenters modulates their self-assembly behavior. In one case, spectroscopic and microscopic characterization in organic solvents revealed the formation of fibrillar structures from folded oligourethanes which evolve, upon external stimuli, to 3D networks forming supramolecular gels, indicative of hierarchical self-assembly (Figure 1). These results highlight the stereocontrolled sequence-defined oligourethanes as promising candidates for the development of novel functional systems.

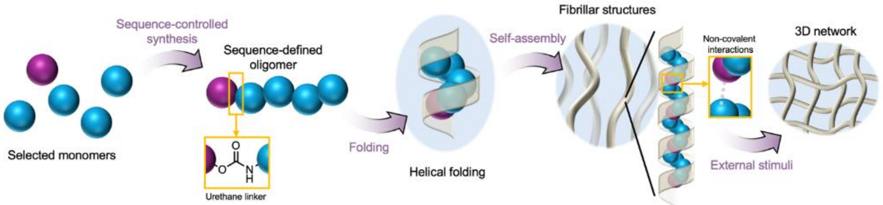

Figure 1. Schematic representation of the steps involved in hierarchical self-assembly for sequence-defined oligourethanes.

Acknowledgments: This research was funded by the Polish National Science Center (OPUS LAP No 2021/43/I/ST4/01294) and by the European Research Council (ERC StG 1011167000).

References:

[1] Shao et al., Angew. Chem. Int. Ed. 2024, 63, e202403263;

[2] Sang & Liu, Chem. Sci. 2022, 13, 633-656.

[3] Lutz et al., Science 2013, 341, 1238149.

[4] Szweda, Prog. Polym. Sci. 2023, 145, 101737.

[5] Lutz, Eur. Polym. J. 2023, 1991, 112465.

[6] Wu et al., Polymer 2025, 327, 128361.

[7] Forysiak et al., Polym. Chem. 2022, 13, 2980-2987.

[8] Cwynar et al., Eur. Polym. J. 2023, 182, 111706.

[9] Szatko et al., ACS Biomater. Sci. Eng. 2024, 10, 3723-3738.

ABSTRACT 34

Replacing Matrigel with hPLMA for Consistent and Ethical 3D Cell Culture Applications

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The transition to human-derived biomaterials is critical for advancing ethical and clinically relevant 3D cell culture systems. In this study, we evaluated the performance of methacryloyl human platelet lysates (hPLMA) — a xeno-free, human-derived hydrogel, benchmarking it against Matrigel, the widely used but animal-derived matrix with an unethical tumor origin [1,2]. Human adipose-derived stem cells (hASCs) were encapsulated in both materials and cultured for 14 days. Both materials supported high viability and proliferation for 7 days, but hPLMA promoted consistent cell growth and intricate networks, while Matrigel induced rapid spreading, leading to massive cell clusters and eventually the hydrogel degradation after 7 days. Although macrophage culture in both materials showed low cytokine levels, the transcriptomic profile of hASCs in Matrigel revealed a constant high expression of immune-related genes, especially after 5 days. In contrast, hASCs in hPLMA had minimal expression of immune response genes and higher expression of genes associated with cell migration, adhesion, and matrix organization, showing hPLMA's ability to mimic the natural cell environment. These results position hPLMA as a robust, xeno-free alternative to Matrigel—ideal for drug testing, organ-on-chip and tissue models applications. Its human origin enhances physiological relevance while minimizing immune activation, paving the way for more predictive and ethical in vitro models.

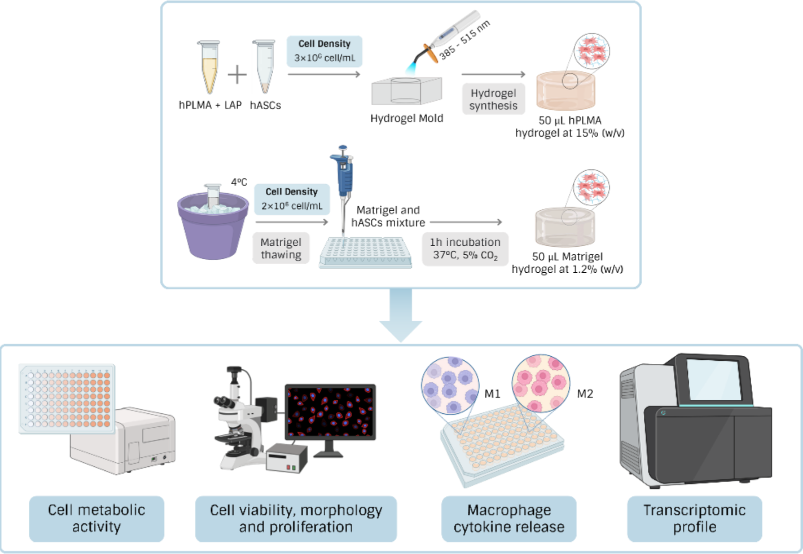

Figure 1. Schematic illustration of the synthesis of hPLMA and Matrigel hydrogels and subsequent comparative analyses, namely determination of cells' metabolic activity, viability, morphology and proliferation, material's immunogenicity and cells' transcriptomic profile.

Acknowledgments: The transcriptomic laboratorial processing was performed by the Genomics Scientific Platform at i3S (Porto, Portugal), with the assistance of Ana Mafalda Rocha.

References:

[1] S. C. Santos et al., Adv. Healthc. Mater., 2018, 7, 1800849.

[2] H. K. Kleinman et al., Semin. Cancer Biol., 2005, 15, 378-386.

ABSTRACT 35

Decoding Liquid-Liquid Phase Separation Toward Minimalist Peptide Design

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Liquid-Liquid Phase Separation (LLPS) forms membraneless organelles enhancing biochemical processes. The stickers-and-spacers model, mainly validated in Prion-like RNA Binding Proteins, explains LLPS [1-5]. We extended this research to broader protein contexts and functionalities by developing a novel computational approach for motif discovery and characterization in 178 phase-separating proteins (PhSePs). DPRs (Droplet-Promoting Regions) of PhSePs showed enrichment in Gly, Ser, Pro, and Ala, with a higher ration of polar residues and fewer hydrophobic/aromatic residues. A comparative analysis of peptide motifs (3-6 residue combinations) between PhSePs and non-PhSePs revealed 129 statistically significant motifs enriched in DPRs. Key features included Gly-rich sequences with aromatic, charged, or polar residues and homopeptide repeats, such as QQQQ, GRGG, SRGG, and YGGG. Motif presence and frequency analysis uncovered both widely distributed and highly repetitive motifs contributing to phase separation propensity. Based on these findings, we developed a data-driven approach for minimalistic peptide design, exploring co-occurrences of motif trios in PhSePs. We designed 8 diverse peptides incorporating various motif combinations and amino acid distributions. Our approach bridges a non-biased computational approach with experimental validation, offering insights into key sequence determinants and mechanisms of phase separation, with potential for designing minimalistic synthetic.

References:

[1] D. De Sancho, Biophys. J. 2022, 121, 4119–4127.
[2] P. Borcherds et al., Curr. Opin. Struct. Biol. 2021, 67, 41–50.
[3] S. Boeynaems et al., Trends Cell Biol. 2018, 28, 420–435.
[4] J. Wang et al., Cell. 2018, 174, 688–699.
[5] E.W. Martin et al., Science. 2020, 367, 694–699.

ABSTRACT 36

Strategic Chirality Tuning in Water Soluble Pyrene Pyridine (PyPe) Molecules: Self-Assembly and Co-Self-Assembly Approaches

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The development of supramolecular materials via non-covalent interactions presents a powerful and cost-effective strategy for constructing functional organic systems with tunable optical and structural properties [1,2]. In this work, we report the design and supramolecular behavior of pyridine–pyrene (PyPe) dyes for constructing helical self-assembled systems. Mono- and dicationic PyPe derivatives were synthesized via quaternization with chiral and achiral aliphatic chains. These systems exhibit helical supramolecular polymerization (HSP) in both polar and non-polar solvents, driven by π–π stacking and electrostatic interactions. PyPe chromophores also form chiral assemblies via ionic interactions with binaphthyl sulphonate (BNS) anions [3], showing strong circular dichroism (CD) and efficient chirality transfer. Furthermore, PyPe was combined with chiral tartaric acid (TA) [4], forming hydrogen-bonded assemblies that also exhibit HSP, as confirmed by CD. These materials display reversible, stimuli-responsive behavior and undergo light-induced [2+2] photocycloaddition, enabling control over supramolecular topology. The combined effects of π-conjugation, ionic interactions, hydrogen bonding, and chiral chain design highlight the potential of PyPe-based systems in optoelectronic, CP-OLED, and responsive material applications. This study emphasizes the synergistic role of π-conjugated PyPe cores, chiral TA-based hydrogen bonding, BNS ionic interactions, and chiral aliphatic chains in constructing dynamic, helical supramolecular assemblies with promising applications in optoelectronics, CP-OLEDs, sensing, and smart materials.

References:

[1] M. Rahaman et al., Chem. Eur. J. 2012, 18, 1290 – 1294.
[2] M. Xu et al., Angew. Chem., Int. Ed., 2022, 61, e202117042.
[3] Y. Wang, et al., Chem. Commun., 2017, 53, 7505-7508.
[4] X. Wang, et al., Front. Chem. Sci. Eng. 2020, 14, 1112–1121.

Smuggling drugs in pumpkins – Integration of CB[8] host-guest assemblies into hydrogels for controlled drug delivery

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Hydrogels are water-swollen polymer networks that have been increasingly explored as drug delivery systems. Their physicochemical properties can be precisely tailored, enabling spatial and temporal control over the release of the therapeutic molecules into the surrounding environment. One strategy to tune the release kinetics is by introducing drug–polymer interactions. Those can be of covalent or physical nature with varying binding affinities, typically slowing down the cargo diffusion and thus prolonging its release [1]. In this work, drug–polymer interactions are integrated in poly(ethylene glycol) (PEG) hydrogels through the use of cucurbit[8]uril (CB[8]) host–guest complexation. We employ the pumpkin-shaped CB[8], which is capable of simultaneously hosting two guest molecules [2], to engineer a cross-linker that can encapsulate a variety of cargo molecules. In a first step, we preform a 1:1 CB[8]–guest assembly with a reactive viologen guest, which is subsequently incorporated into PEG hydrogel network as a cross-linker (see Figure 1). In a second step, the threaded macrocycles act as little pockets, which can be loaded with small drug/cargo molecules as second guests, forming stable heteroternary 1:2 host–guest complexes within the hydrogel. We explore the correlation between the binding strength of cargo molecules and the kinetics profile of their release by characterizing binding affinities with isothermal titration calorimetry and performing release studies. In this work, we designed a simple CB[8] host–guest moiety that can selectively encapsulate and release diverse cargo molecules in a controlled manner and can be integrated into various existing polymer networks.

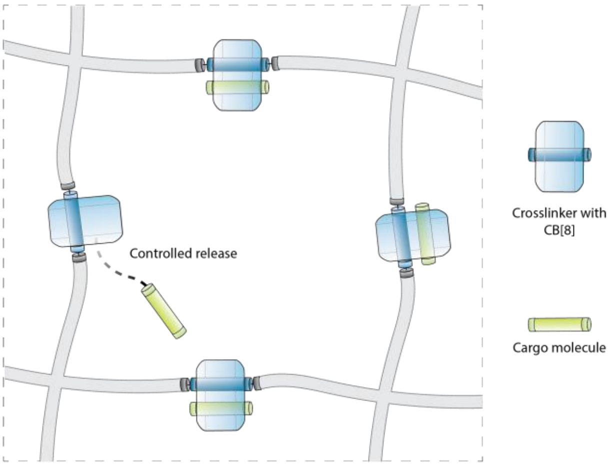

Figure 1. Scheme of polymer network containing CB[8] host–guest assemblies as cross-links with encapsulated cargo molecule.

Acknowledgments: N.P. and S.M. are grateful for the Swiss National Science Foundation for supporting this work (Ambizione Grant, PZ00P2_202141).

References:

[1] J. Li et al., Nature Reviews Materials. 2016, 1, 16071.

[2] J. Kim et al., Journal of the American Chemical Society. 2000, 122, 540–541.

ABSTRACT 38

Design of sugar-peptide hydrogels for the culture of liver spheroids

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The exploitation of short self-assembling peptides (SAPs) to design fully defined non-animal derived hydrogel (SAPH) scaffolds for 3D cell culture applications has become a prominent strategy over the last decade. The facile tuning of their physiochemical properties to suit different cells' needs allows their use for in-vitro engineering of 3D tissue models, especially the formation of spheroids and organoids [1,2].

Recently we have shown how negatively charged SAPHs are suitable for the culture of hepatic cells, particularly the HepG2 spheroids, which are commonly used for testing of drug toxicity [3]. Galactose (Gal) has been shown to promote hepatic cell function through specific interactions with asialoglycoprotein surface receptors (ASGP-Rs) [4]. In this study, we therefore decide to focus on the functionalization of the negatively charge EE(FEFK)2E based SAPH scaffolds with Gal for the culture of HepG2 spheroids.

Gal is introduced into the SAPH scaffolds using two strategies: 1) physical mixing and 2) immobilization onto the fibers' surface though bioconjugation. Conjugation of Gal to the peptide is achieved by synthesizing DBCO-modified Gal followed by click-reaction with an azido lysine terminated peptide. For both approaches the Gal-functionalized composite hydrogels are systematically characterized for structures and mechanical properties. HepG2 are then cultured over 14 days to form spheroids in which structures and functionality are analyzed.

Overall, this study demonstrates how the SAP can be used to construct fully chemically defined functional hydrogel scaffolds for the culture of hepatic spheroids.

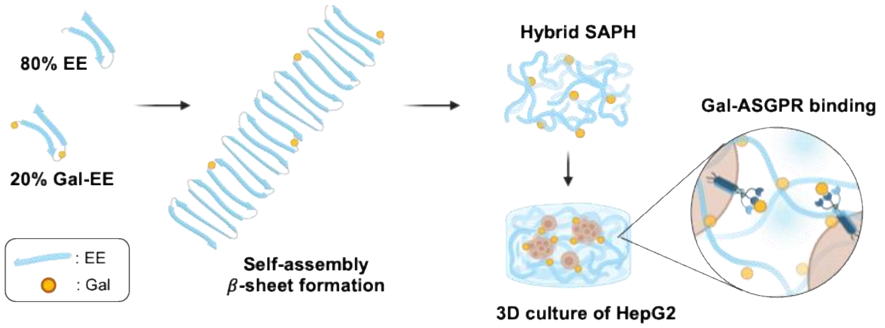

Figure 1. Schematic representation of the functionalization of our SAP through bioconjugation. Composites of SAPHs with varying functionalization levels are constructed by mixing the peptide with conjugated peptide. HepG2 spheroids are then cultured over 14 days.

Acknowledgments: This work was funded by The University of Manchester.

References:

[1] W. Li et al., Biomacromolecules. 2024, 25, 6967–6986.
[2] N. Tracey et al., Bioactive Materials. 2023, 21, 142-156.
[3] Y. Xin et al., Journal of Materials Chemistry B. 2024, 12, 12553-12566.
[4] G. Ji et al., Heliyon. 2024, 10, e24667.

ABSTRACT 39

Spin-labeled amphiphilic self-assembling peptides

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Spin labelling is a well-established technique that has been utilised for the purpose of gaining insights into biological processes and studying the self-assembly phenomenon in amyloids. The selective interaction with magnetic fields of paramagnetic species allows the selective observation and localization of this labels. In the present study, nitroxide-based spin labels were utilised in the functionalisation of short amphiphilic self assembling peptides. In combination with chemical caging strategies, self-assembly could be triggered to selectively create radical-containing peptide nanostructures. These nanostructures are of particular interest in the biological context, as they facilitate selective localization in specific cellular compartments, while achieving a high signal-to-noise ratio for radical readout. In the process of synthesising N-terminal functionalised peptide spin labels in conjunction with Fmoc-peptides of equivalent sequence, it was observed that divergent incorporation ratios were achieved by adjusting the Fmoc to TEMPO peptide ratio. Furthermore, the impact of these labelling processes on cell viability was investigated. The responsiveness of the system was achieved by functionalising the peptide backbone with a light immolative photocage.

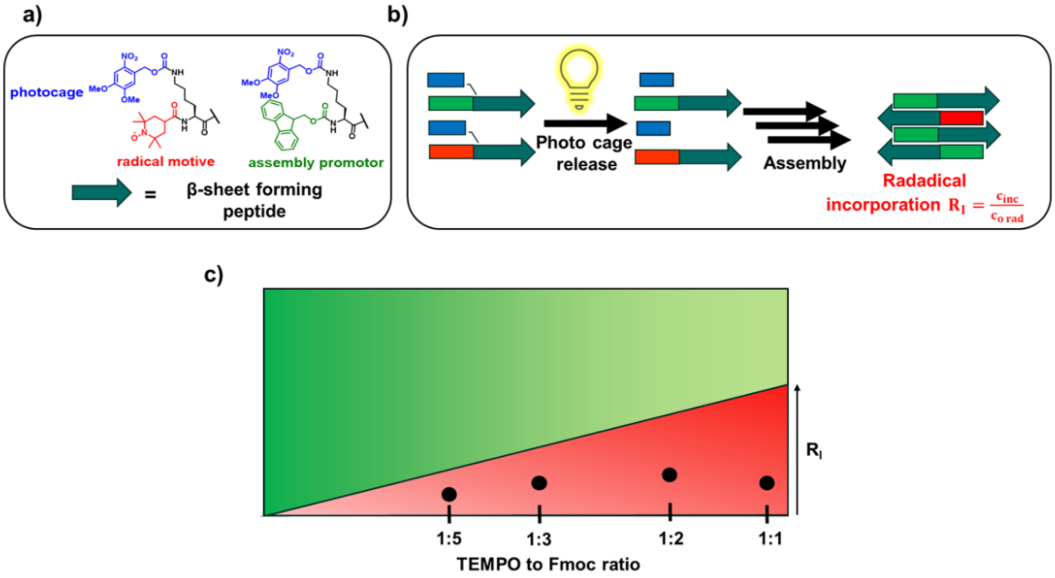

Figure 1. a) Chemical structure of the Nvoc-photo cage (blue), TEMPO-radical species (red), and assembly promotor Fmoc (green); ß sheet forming peptide sequence (arrow) b) Reaction cascade of light driven photo cage cleavage leading to peptide self-assembly and radical incorporation of the non-assembling TEMPO-peptide into Fmoc- formed nanostructures c) Visualization of the Co-assembly analysis by increasing the fraction of TEMPO-peptide within the total peptide concentration influencing the RI (black dots) of the system indicating the highest radical incorporation between 1:3 and 1:2 ratios.

Acknowledgments: P.K., D.Y.W.N. and T.W. gratefully acknowledge financial support from the Max-Planck society. The funders had no role in the study design, data collection and analysis.

References:

[1] Y. Ren et al. Nat. Synth (2025).
[2] P. Roth et al. Nat. Synth (2023) 2, 980–988.
[3] J. Ortony et al. Nature Mater (2014) 13, 812–816.

ABSTRACT 40

A fluorinated Janus-type dendrimer for nucleic acid delivery in amyotrophic lateral sclerosis murine *in vitro* models

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Over the past few years, the use of nucleic acids (NAs) as therapeutic agents has gained great interest for the treatment of various genetic disorders, such as amyotrophic lateral sclerosis, a fatal neurodegenerative disease characterized by motor neuron loss associated with muscle atrophy [1]. It has been reported that microRNAs (miRNAs), a class of small non-coding RNAs that modulate gene expression, play a central role in the development of muscle atrophy [2].

Delivering NAs inside the cell remains a major challenge. Among non-viral vectors, cationic lipids and polymers have shown to be promising for this application thanks to their ability to complex NAs and protect them from degradation. In this context, we have developed FJD2N, a gene delivery vector based on a fluorinated Janus-type dendrimer [3] bearing four terminal ammonium groups. This molecule self-assembles in aqueous solution forming positively charged micelles which can interact with the negatively charged phosphate backbone of nucleic acids through charge-assisted hydrogen bonding, resulting in the formation of stable dendriplexes [4].

We tested this nanocarrier on commercial cell lines as well as primary cell cultures derived from G93A-SOD1 mouse, a purported model of ALS. Immunofluorescence and molecular analysis displayed a good carrier internalization, no cytotoxic effects on proliferation and a significant modulation of the selected miRNA on the target genes implied in cell regeneration.

Based on these results, this new vector is a promising candidate for gene delivery applications and further in vitro tests on a larger scale are needed to better understand its functioning.

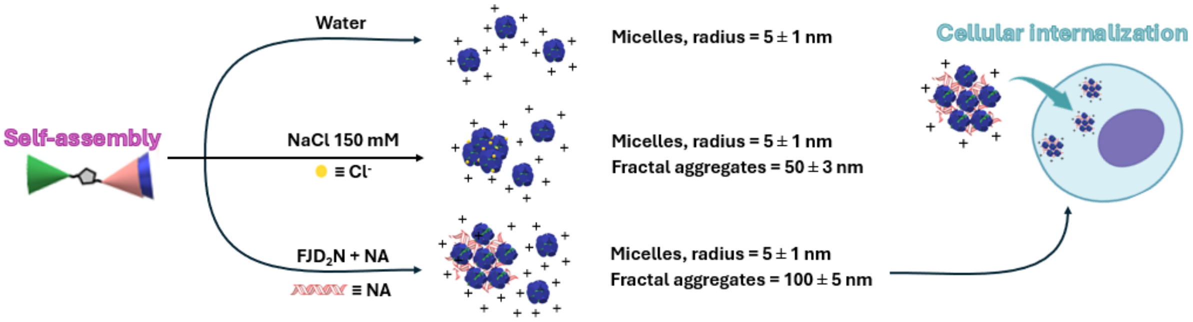

Figure 1. When dispersed in water, FJD2N self assembles in positively charged micelles which tend to form larger fractal aggregates in presence of ions and NAs. These complexes can be efficiently internalized working as gene delivery vectors.

Acknowledgments: Special thanks to Cal.Hub.Ria project for funding this research.

References:

[1] S. Marcuzzo et al., Exp Neurol, 2011, vol. 231, pp. 30-37.
[2] E. Giagnorio et al., J Cell Sci, 2021, vol. 134, Issue 12.
[3] M. Rosati et al., Macromolecules, 2022, vol. 55, pp. 2486-2496.
[4] F. Baldelli et al., Non-Viral Vectors for Gene Therapy, WO2023170543A1, 2023.

ABSTRACT 41

Aggregation-Induced Emission in Platinum-Based Biopolymers

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Platinum(II) complexes are cornerstone components in Aggregation-Induced Emission (AIE) systems, lauded for their remarkable capacity to exhibit intense phosphorescence upon aggregation [1]. The inherent flexibility of their coordination chemistry enables precise control over these critical intermolecular interactions, making them ideal candidates for engineering highly responsive luminescent materials [2]. Our research introduces an innovative strategy that harnesses the controlled modulation of aggregation to precisely regulate luminescence in AIE systems based on platinum.

To translate this foundational concept into tangible applications, we've developed a method to functionalize two abundant natural biopolymers—chitosan and pullulan—with platinum complexes. The subsequent induction of metallophilic interactions within the biopolymer matrix drives the desired aggregation, leading to a pronounced activation of phosphorescence.

These newly developed responsive materials show significant promise for advanced technological applications. A particularly noteworthy area of interest is mechanoluminescent sensing, where the materials are engineered to emit light in direct response to applied mechanical stress. In essence, this project establishes a novel class of AIE materials by seamlessly integrating platinum complexes within biopolymer matrices. By synergistically combining sophisticated coordination chemistry with tailored biopolymer functionalization, our ultimate aim is to develop smart luminescent systems endowed with tunable properties, making them exceptionally suitable for diverse applications in sensing, imaging, and other cutting-edge technologies.

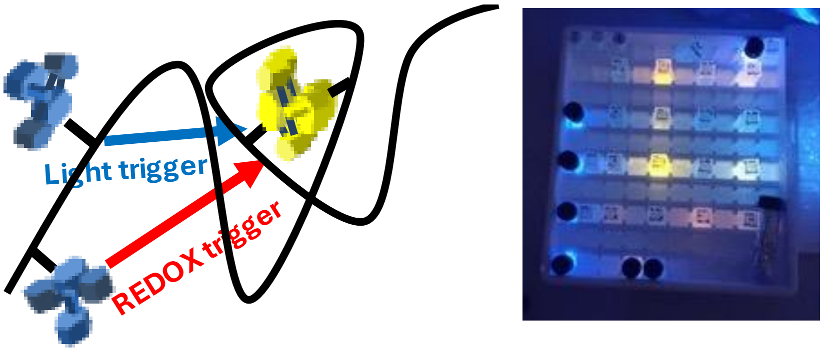

Figure 1. Schematic representation of functionalized polymer with Platinum complex

References:

[1] S. Carrara et al., J Am Chem Soc, vol. 139, no. 41, pp. 14605–14610.

[2] A. Aliprandi et al. Nat Chem, vol. 8, no. 1, pp. 10–15, Jan. 2016.

ABSTRACT 42

Cytoskeleton Stabilized Artificial Cells And Their Dynamic Behaviour

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The development and characterization of artificial cells is a research field of high potential for a wide range of applications. These artificial systems can mimic features and functions of life, being able to exchange proteins with each other or respond to changes in their environment as pH or temperature.1
One of the main classes of artificial cells is created by liquid-liquid phase separation; In our case, originating from the mixture of two opposite charged polypeptides of opposite charge, leading to micron-sized droplets, which need to be stabilized by a triblock polymer or protein-based material.2
These artificial systems are liquid-like and therefore mechanically fragile, which makes their manipulation difficult. For this reason, an artificial cytoskeleton based o. This cytoskeleton can be functionalized with different moieties for a variety n polydiacetylene fibers has been incorporated into artificial cells composed of amylose derivatives in order to add robustness to the system3of purposes, such as drug delivery or protein uptake.
The objective of this project is to develop an artificial cell system based on poly-aspartic acid and poly-lysine and introduce inside it an artificial cytoskeleton based on polydiacetylene fibers. These will be subsequently functionalized with different moieties such as DNA tags, peptide tags, biotin or the Ni-NTA complex in order to perform several useful processes to induce life-like behavior.

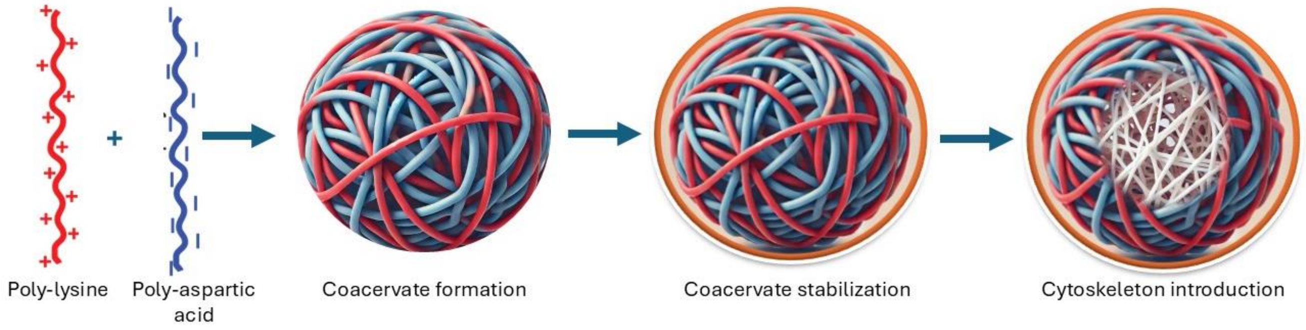

Figure 1. Scheme of the process for the artificial cell system formation and the introduction of an artificial cytoskeleton.

Acknowledgments: This work was suported by PRO-ARTIS -ERC-2023-ADG ST - 101141866 – ST**.**

References:

[1] AB Cook et al., Accounts of Materials Research. 2023;4(3):287–98.
[2] AB Cook et al., Journal of Polymer Science. 2022;60(9):1480–91.
[3] S. Novosedlik et al., Nature Chemistry. 2025, 17: 356–364.

Living photonic hydrogels for detecting antimicrobial resistance

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Antimicrobial resistance (AMR) is considered a global health emergency, causing millions of deaths worldwide. This occurs as a result of improper and overuse of antibiotics in human and veterinary medicine, intensive farming, agriculture, aquaculture, and the insufficient treatment of antibiotic waste [1]. Conventional antimicrobial susceptibility testing (AST) methods are time-consuming, expensive, and require standardization and the use of specialized equipment [2]. To overcome these limitations, novel biosensors using engineered smart hydrogels are herein proposed as an alternative. These hydrogels are synthesized to mimic microenvironments suited for cell growth, enabling the development of real-time, responsive, living cell-based biosensors. Natural biopolymers such as chitosan, agarose, alginate, and gelatin are ideal materials for these living hydrogels as they enable encapsulation and proliferation of cells and present excellent biocompatibility and biodegradability properties [3]. Moreover, these stimuli-responsive matrices can be integrated with photonic structures that serve as an optical transducer to allow naked-eye, label-free detection [4]. The novelty of this work is the use of living bacteria and photonic crystals in hydrogels to enable colorimetric detection of AMR via comparison of the output signal for resistant and non-resistant strains, offering an alternative low-cost, simple technology to overcome the limitations of the current AST methods.

Acknowledgments: The author Joana R. Martins acknowledges Fundação para a Ciência e a Tecnologia (FCT) the PhD Grant (2023.03975.BDANA). This research was supported by national funds through FCT, under projects UID/00285-Centre for Mechanical Engineering, Materials and Processes and LA/P/0112/2020.

References:

[1] S. K. Ahmed et al., Journal of Medicine, Surgery, and Public Health. 2024, 2, 100081.

[2] S. Rentschler et al., International Journal of Molecular Sciences. 2021, 22, 456.

[3] S. M. Hull et al., Advanced Materials. 2022, 34, 2103691.

[4] Z. Lu et al., Biosensors and Bioelectronics. 2022, 202, 114013.

ABSTRACT 44

Bioengineering endothelial basement membranes by culturing endothelial cells on bioactive supramolecular meshes

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Basement membranes (BMs) are specialized extracellular matrices (ECMs) that provide not only tissue separation and barrier functions, but also an instructive substrate for cell signalling and tissue shaping. BMs are supramolecular assemblies of various proteins (collagen IV, laminin, nidogen, perlecan), displaying time- and tissue-specific expression patterns. Different BMs undergo dynamic transformations throughout life (development, ageing and disease) and abnormal changes in the chemical and mechanical properties (crosslinking, thickening) of the BM are implicated in diseases. Here, we explore supramolecular meshes, obtained through the interfacial self-assembly of hyaluronan (HA) with peptide amphiphiles (PAs) [1], which contain bioactive domains of BM proteins, for the culture of endothelial cells (e.g. hCMEC/D3, an immortalized human cerebral microvascular endothelial cell line) to bioengineer endothelial basement membranes for in vitro models of the blood-brain barrier (BBB). This work focuses on investigating the adhesion and differentiation of endothelial cells when cultured on soft self-assembled PA/HA membranes and PA-coated rigid surfaces (transwell inserts).

Cells were able to interact with self-assembling membranes that supported their anchorage, proliferation and subsequent formation of a compact cell monolayer (Fig. 1.A). Deposited ECM proteins on PA/HA membrane (e.g. collagen type I, IV and laminin) were evaluated, and the immunofluorescence assay showed that endothelial cells expressed adherens junctions (VE-Cadherin, Fig. 1.B). In addition, trans-endothelial electrical resistance (TEER) measurements and permeability tests using fluorescently-labeled dextran of different molecular weights (4 and 70 kDa) were conducted to determine that barrier integrity was maintained over a 12-day culture period.

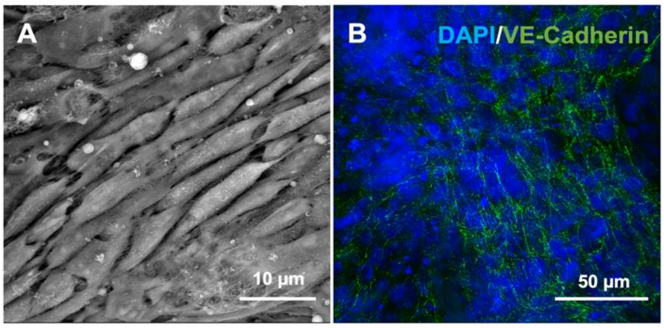

Figure 1. Cell morphology of hCMEC/D3 cultured on PA/HA membranes (12 days) as observed by scanning electron (A) and confocal (B) microscopy.

Acknowledgments: The work was funded by Fundação para a Ciência e a Tecnologia, I.P. (3D-BBB project, 2022.01690.PTDC). R. C. Pereira and H. S. Azevedo acknowledge the European Union's Horizon 2020 research and innovation program (MOBILIsE project, 951723).

References:

[1] R.M. Capito et al., Science. 2008 28;319(5871):1812-6.

[2] D.S. Ferreira, et al., Adv Healthc Mater. 2015 11;4(4):602-12.

ABSTRACT 45

Development of antibacterial stomatocytes Nanomotors

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The increasing resistance of bacteria to classic treatments-i.e. antibiotics- represents a global health threat and has been inscribed by the World Health Organization as one of its top 10 research priorities. Apart from the misuse of antibiotics, this resistance stems from the organization of bacteria in communities called biofilms. They form when free-floating bacteria (planktonic bacteria) attach to a surface, multiply, and secrete a matrix, made of extra-cellular polymeric substances (EPS), which protects them from external aggressions, like antibiotics. Within this biofilm, they also adopt collective behaviours that increase their resistance. Hence, the need for new innovative approaches to eradicate bacterial biofilms [1].

Here, bowl-shaped polymersomes, called stomatocytes [2], are coated with silver nanoparticles to create nanomotors activable by UV-visible light irradiation [3]. The combination of motion to enhance biofilm penetration and physically disrupt it [4], as well as the intrinsic broad spectrum antimicrobial properties of silver [1] should ensure antibacterial action.

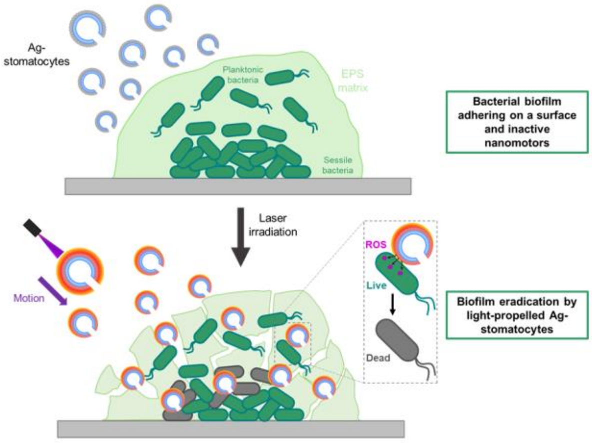

Figure 1. Light-driven silver coated stomatocytes (Ag-stomatocytes) nanomotors to eradicate bacterial biofilm.

Acknowledgments: Thanks to NWO, Meta, Merck and Nissan chem for funding this project.

References:

[1] Sahli et al., Theranostics. 2022, Vol. 12, Issue 5, 2383-2405.

[2] Pijpers et al., ACS Macro Lett. 2017, 6, 1217-1222.

[3] Jain et al., Acount of chemical research. 2008, Vol. 41, No. 12, 1578-1586.

[4] Jiang et al, J. Nanobiotechnol. 2023, 21, 388.

ABSTRACT 46

Enzyme-free phosphorylation-based peptide self-assembly

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Life continuously transduces energy to perform critical functions using energy stored in reactive molecules like ATP or NADH. ATP dynamically phosphorylates active sites on proteins and thereby regulates their function. Inspired by such machinery, regulating supramolecular behavior using energy stored in reactive molecules has gained traction.

However, existing synthetic systems that use transient phosphorylation face limitations due to enzymatic complexity or static behavior, hindering their application in simple model systems or protocells. Similarly, enzyme-free self-assembling systems often lack biological relevance and are prone to unwanted side reactions.

Here, we explore an enzyme-free chemical reaction cycle based on monoamidophosphate (MAP) that phosphorylates histidine-modified peptide precursors. This phosphorylation regulates peptide self-assembly in complex coacervation and coiled-coil formation. We show that the phosphorylated products can drive phase separation, forming dynamic droplets sustained by ongoing MAP conversion. Additionally, phosphorylation induces a kinetically asymmetric cycle stabilizing coiled-coil formation and enhancing helicity.

These systems offer a minimal, bioinspired framework for exploring how phosphorylation can modulate peptide assembly and dynamics in the absence of enzymes.

References:

[1] S. M. Poprawa et al., Nature Communications 2024, 15, 4204.

[2] D. N. Woolfson, Fibrous Proteins: Structures and Mechanisms 2017, 35-61.

ABSTRACT 47

Biomimetic materials for urethra organoids culture

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Organoids are miniaturized three-dimensional layered constructs offering unprecedented resemblance to organs. These models provide a new framework to study processes at the organ level and could offer an alternative to in vivo applications in regenerative medicine. The standard procedure to grow organoids relies on inducing the self-assembly of stem cells in Matrigel or Basement Membrane Extract (BME). However, both are tumour-derived hydrogels, with a poorly controlled microenvironment that lacks hierarchical structure, and has a composition radically different from the native extracellular matrix (ECM)[1][2]. In parallel, in Urology, there is increasing demand for urethral reconstruction from both males and females. Current clinical solutions rely on grafts painfully harvested from patients, which often lead to recurrence of strictures[3]. An alternative is to propose a new source of epithelial cells for urethral reconstruction within a biomimetic matrix suitable for grafting.

Our lab has established, for the first time to our knowledge, urethra-specific organoids with a distinct urothelium from the bladder. We propose to culture these on new materials composed solely of ECM proteins, with a porous structure promoting nutrient and oxygen diffusion (Fig. 1). We compare, i) fibrillar native-like collagen matrices, ii) materials derived from decellularised ECM, and iii) standard BME. Materials were fabricated by ice-templating and topotactic fibrillogenesis [4].

Our biomaterials recapitulate key tissue features and support urethra organoid culture. Unlike BME, they are compatible with clinical translation and could represent a new alternative for patient-specific urethral reconstruction.

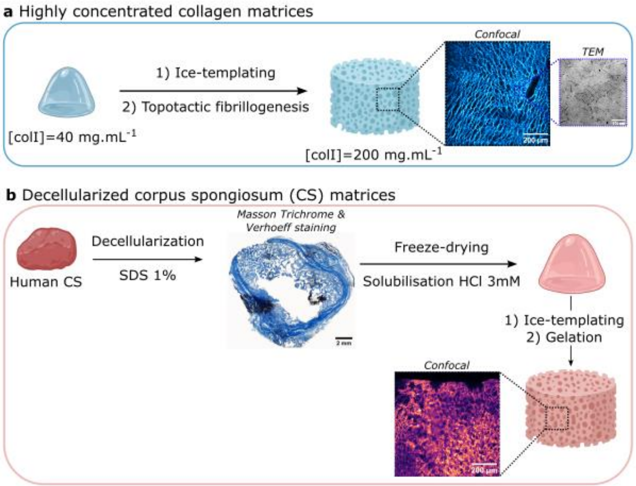

Figure 1. Elaboration of biomimetic matrices from type I collagen or decellularized extra-cellular matrix solutions for the culture of urethra-specific organoids.

References:

[1] M.T. Kozlowski et al., Commun Biol. 2021, 4.
[2] K. Kretzschmar et al., Dev Cell. 2016, 38, 590-600.
[3] M. Ortac et al., Urol Res Pract. 2023, 49, 11-18.
[4] I. Martinier et al., Biomater Sci. 2024, 12, 3124-3140.

ABSTRACT 48

Human protein-based ultrathin membranes toward the development of self-assembled cell aggregates for osteo differentiation

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Tissue engineering has increasingly focused on creating scaffolds that closely mimic native tissues to better replicate human physiology and support intrinsic cell behavior. However, traditional approaches often rely on man-dependent structures, such as hydrogels, sponges, or bioprinter constructs, which passively host cellular activity. Here, we propose a disrupting system where cells actively architect their microenvironments, adapting their surroundings to meet dynamic needs.

This innovative system employs human protein-based ultrathin membranes, generated through the instantaneous and bulk formation of amyloid-like nanofibrils from human platelet lysate (PL) using the ionic liquid cholinium tosylate as a fibrillating agent [1]. These membranes demonstrated to be an excellent substrate for BM-MSCs to adhere, proliferate, and self-organize into 3D microtissues. Remarkably, BM-MSCs were observed to tightly fold the fibril membranes into a spheroid-like 3D configuration, while maintaining high viability for up to 21 days – without developing a necrotic core characteristic of traditional spheroids. When cultured in osteogenic medium, this cell self-arrangement results into more compact aggregates, compared to basal medium.

Additionally, expression of specific markers indicates these 3D microtissues are compatible with osteogenic differentiation, with macroscopic differences observed across study groups.

In summary, human protein-based ultrathin membranes provide a bioactive platform where cells autonomously construct 3D microenvironments, offering a promising avenue for osteo regeneration and advancing tissue engineering paradigms.

Acknowledgments: Manuel Pires-Santos acknowledge the financial support provided by the Portuguese Foundation for Science and Technology (FCT) for the doctoral grant (2024.01120.BD) and by the project “O2Cells” (2022.04237.PTDC). This work has also been financed by the European Research Council Advanced Grant “REBORN” (grant agreement no. ERC-2019-ADG-883370). This work was funded by the European Union’s Horizon Europe research and innovation program under grant agreement no. 101079482 (“SUPRALIFE”). TThis work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UID/50011 & LA/P/0006/2020 (DOI 10.54499/LA/P/0006/2020), financed by national funds through the FCT/MCTES (PIDDAC).

[1] C.F. Monteiro et al. ACS Nano (2024). 18 (24).

ABSTRACT 49

Gelatin-microgels as colloidal building blocks in volumetric additive manufacturing

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In 2021, around 15.4 million people worldwide were affected by a spinal cord injury (SCI), which can result from trauma or non-traumatic conditions like tumors or infections [1]. Since damaged neurons cannot self-repair, SCI can cause partial or complete and temporary or permanent loss of function. The majority of treatments focus solely on ensuring patient's survival and stabilizing their condition, rather than restoring the structure and function completely. Volumetric additive manufacturing (VAM) is an emerging technique in tissue engineering, which is also promising for SCI repair due to its gentle nature, since neural cell types are naturally sensitive to shear stress and pressure [2]. . However, only a limited number of photo-crosslinkable bioinks has been described so far for use in VAM. Microgels are colloidal particles made up of water-swollen, crosslinked polymers. In the context of VAM, they can be considered as powerful building blocks for assembly into 3D scaffold materials. Therefore, in this project, a novel gelatin microgel-based resin is being developed to allow VAM printing of neural scaffolds. In this research project, a bifunctional methacrylated and norbornene-functionalized gelatin (gelMANB) was produced according to previously described protocols and their degree of substitution (DS) determined to be 90% (MA) and 10% (NB) through an ortho-phtalic aldehyde assay [3]. The gelatin solutions were further characterized in terms of their viscosity and crosslinking kinetics. Since the gelMANB-microgels are produced by using a microfluidic setup (Figure 1), the solution's viscosity needs to be lower than 10 mPa.s to allow efficient flowing. As for the crosslinking time, it is required to be lower than 2 min, which is the approximate period of UV-illumination in the setup. Additionally, thiolated gelatin (gelSH), to be used as a thiol-crosslinker during VAM printing employing thiol-ene crosslinking [4], was developed as well. In the context of VAM, it is important to evaluate the crosslinking kinetics of the gelMANB microgels – gelSH resin. Additionally, disks with an 8 mm diameter and a 2 mm height were printed using VAM, washed and post-cured under a UVA-lamp emitting light of 365 nm with intensity 8 mW cm^{-2}. Following printing, frequency sweep analysis was performed on the printed disks to determine whether the microgels would significantly affect the mechanical properties of printed scaffolds. Further experiments include NE-4C mouse neural stem cell encapsulation to determine the microgels' effect on their viability and differentiation.

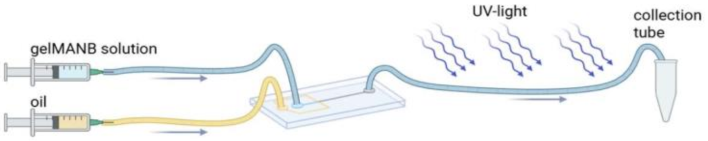

Figure 1. Microfluidic chip setup for gelMANB microgel production. A gelMANB solution and oil are injected in a controlled manner (using syringe pumps) through the microfluidic chip using their respective inlets. At the interface of oil and polymer solution, droplets are formed that flow further to the outlet which is connected to a tube guiding the microgels under UV-light to allow photo-crosslinking. After crosslinking the tube runs to a collection tube where the produced microgels are collected.

References:

[1] Spinal cord injury. https://www.who.int/news-room/fact-sheets/detail/spinal-cord-injury.
[2] B. M. Gaub et al. Proc. Natl. Acad. Sci. 117, 848–856 (2020).
[3] A.I. Van Den Bulcke et al. Biomacromolecules 1, 31–38 (2000).
[4] S. V. Vlierberghe et al. , P. Eur. Polym. J. 47, 1039–1047 (2011).

ABSTRACT 50

How to train your Reactive Coacervates to Self-Assemble?

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Phase-separated coacervates provide a unique microenvironment that can enhance reaction kinetics and direct multi-hierarchical self-assembly, similar to early cellular evolution [1]. Nature exemplifies this control through dynamic, far from equilibrium structures like microtubules, which rely on continuous energy dissipation [2]. Inspired by these biological processes, we aim to develop artificial fuel-driven reaction cycles that enable transient self-assemblies like coacervates/hydrogels in aqueous environments [3]. Using dithioketene based Michael acceptors as fuels and deactivated nucleophilic monomers as building blocks, we introduce "reactive coacervates" [4] that undergo chemically triggered self-immolative transformations. Our system initiates when the fuel (Reactant 1) interacts with a surfactant forming surfactant coacervates, (Figure 1) which serve as reaction hubs. When a nucleophilic building block (Reactant 2) like an amine/ thiol is introduced, the fuel reacts to form an oily product within the coacervate droplet and a gaseous by-product (CH_3SH). Over time these droplets grow and phase separate to a macroscopic oily layer that rises to the surface, visually clarifying the solution. In the absence of nucleophiles, the surfactant coacervate undergoes internal reorganization, leading to non-classical self-assembly. This proceeds via intermediate tactoids with elongated and anisotropic structures or well-defined crystals. Through this approach we aim to establish reversible reaction cycles that control the (dis)assembly of materials on demand, with particular emphasis on fuel efficiency, kinetic control, and waste management via gaseous or insoluble by-products.

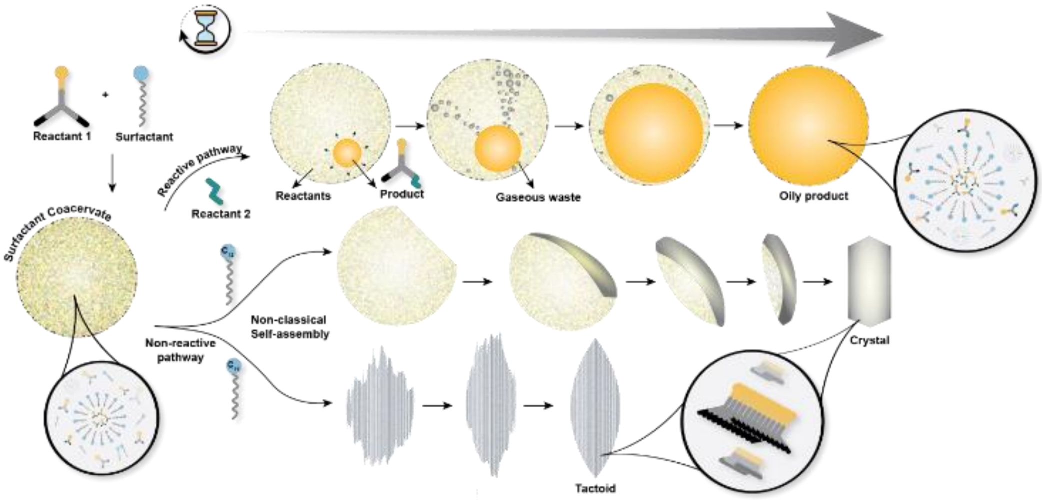

Figure 1. Reactive and non-reactive pathways for evolution of phase separated droplets.

Acknowledgments. P.R. and N.S. acknowledge the Generalitat Valenciana for the CIDEGENT PlaGenT grant (CIDEXG/2022/16) for the PRONESS project, as well as to the Ministerio de Ciencia y Técnica y de Innovación for the new grant for Project MASS-UP under the Plan Estatal de Investigación Científica y Técnica y de Innovación (PID2022-143047NA-I00). We also appreciate the assistance of Cristian Vincent Barrera at Universitat Jaume I, Spain, for their contributions to the ESI-MS, and NMR measurements.

References:

[1] N. A. Yewdall et al., Current Opinion in Colloid & Interface Science 2021, 52, 101416.

[2] O. Valiron et al., Cell. Mol. Life Sci. 2001, 58, 2069–2084.

[3] S. Paul et al., Angew Chem Int Ed 2024, 63, e202406220.

[4] S. Koppayithodi et al., J. Am. Chem. Soc. 2025, 147, 5293–5299.

ABSTRACT 51

Mild and Selective Axial Functionalization of Phosphorus(V) Phthalocyanines via O-Alkylation

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Phosphorus(V) phthalocyanines (PcP) are promising photosensitizers for biomedical applications due to their cationic nature, strong near-IR absorption and high singlet oxygen (SO) generation efficiency [1]. A key advantage of these complexes is the opportunity to directly introduce axial ligands, which enables precise control over their properties [2].

This study presents a novel approach for the selective O-alkylation of PcP derivatives bearing hydroxyl axial ligands. This development provides a mild and general strategy for axial functionalisation.

This approach was demonstrated on the example of the alkylation of hydroxyl axial ligands of P(V) tetra-15-crown-5-phthalocyanine, with iodine-derivative of triethyleneglycol (Scheme 1). The reaction conditions were optimised by systematically varying the solvent, base, temperature and time. The solvent was found to play a key role in the deprotonation of hydroxyl axial ligands, with acetonitrile ensuring complete conversion of the starting material. Varying equivalents of the alkylation agent allows controlling the formation of mono- and dialkylated products. Furthermore, the first PcP complex with two different axial ligands was obtained in yields up to 70%. This product exhibited an elevated SO quantum yield approaching 100% and commendable water solubility, positioning it as a promising candidate for biomedical applications.

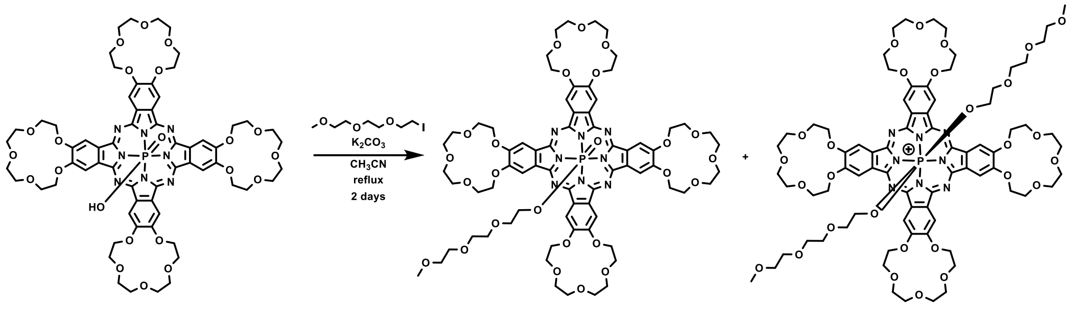

Figure 1. The alkylation of the hydroxyl axial ligands of the P(V) 15-crown-5-phthalocyanine.

Acknowledgments. This work was supported by the Russian Science Foundation (Grant N° 24-73-10192)

References:

[1] T. Furuyama et al., Journal of the American Chemical Society. 2014, 136(2), 765–776

[2] E.A. Safonova et al., Dyes and Pigments. 2024, 225, 112095

ABSTRACT 52

Natural-based nanocomposite photocurable inks via organic/inorganic phase interaction for biofabricating multimaterial hierarchical constructs

#J. R. Maia [1], M. Bilo [1], D. S. Fidalgo [2], P. D. Rebolo [2], A. S. Silva [1], M. Parente [2], R. Sobreiro-Almeida [1]*, J. F. Mano [1]*

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Multi-tissue regeneration remains a clinical challenge with limited long-term functional restoration, requiring multilayered hierarchical constructs. Biofabrication, namely, extrusion-based, can manufacture demanded robust biomimetic scaffolds, but is limited by inadequate phase integration, poor dispersion of bioactive fillers, and suboptimal rheological and mechanical performances. This study presents an ink engineering strategy to advance nanocomposite inks of two naturally-derived matrices: a protein - bovine serum albumin methacrylate (BSAMA), and a polysaccharide - hyaluronic acid methacrylate (HAMA); selected for their biocompatibility and complementary mechanical and cytocompatibility profiles. Bioactive glass nanoparticles (BGNP), known for osteoinductivity and chondrogenic potential, are functionalized and covalently immobilized within both matrices through 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide (EDC) and N-hydroxysuccinimide (NHS) chemical coupling. This primary crosslinking enables the interfacial interaction between organic/inorganic phases, generating printable rheological properties and ensuring uniform particle dispersion. A secondary visible-light post-printing photocuring strategy could integrate robust constructs. This strategy transforms low-viscosity precursors into tunable shear-thinning formulations that promote apatite formation and support adipose-derived stem cells' metabolic activity and viability. BSAMA offers higher cytocompatibility, and HAMA provides superior mechanical strength; Their seamless integration through their photocrosslinkable moieties enables the fabrication of multi-tissue biomimetic scaffolds. Finite element modelling confirmed the mechanical performance of the constructs and validated their clinical potential.

Acknowledgments. The authors also wish to acknowledge the support of the European Union (EU) Horizon 2020 for the project InterLynk (Grant agreement: 953169), as well as the Horizon Europe m2M project (Grant agreement: 101191729). The authors also acknowledge Fundação para a Ciência e Tecnologia for the following grants: (DOI: 10.54499/2022.04605.CEECIND/CP1720/CT0021), (BI/UI89/10303/2022), (PTDC/BTM-MAT/3201/2020), and (PRT/BD/154735/2023). The work was developed within the scope of the project CICECO-Aveiro Institute of Materials (DOI:10.54499/UIDB/50011/2020), (DOI: 10.54499/UIDP/50011/2020), and (DOI:10.54499/LA/P/0006/2020), financed by national funds through the FCT/MEC (PIDDAC).

ABSTRACT 53

Heat-set Ni(II) and Yb(III)-Supramoelcular gels: Ultrasensitive Fluorescent ‘Turn-ON’ Detection of m-phenylenediamine using Ni(II)-metallogel

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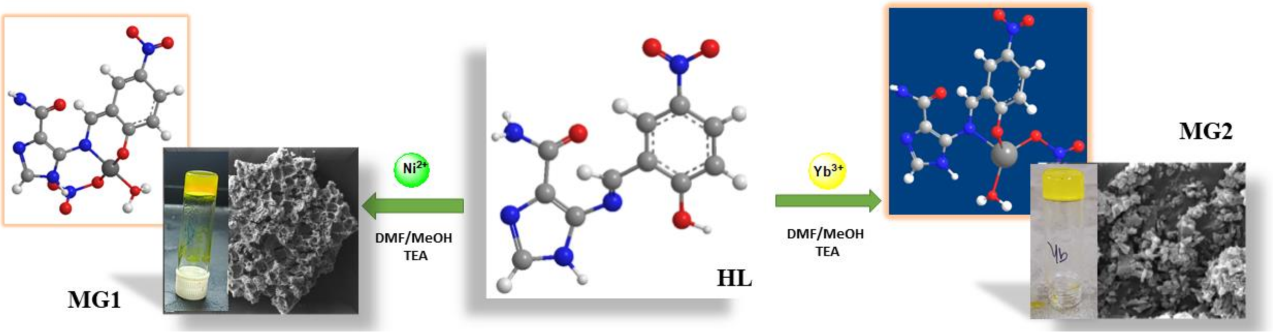
New versatile Schiff base ((E)-5-(2-hydroxy-5-nitrobenzylideneamino)-1H-imidazole-4-carboxamide) (HL) gelator was synthesised as well as structurally verified with different spectral analysis (FT-IR, HRMS and ^{1}H-NMR). Further, HL gelator was immobilised by DMF/MeOH (1:1) solvents and addition of triethylamine (Et_3N) with $Ni(NO_3)_2 \cdot 6H_2O$ and anhydrous $Yb(NO_3)_3$ at room temperature formed Ni(II)-induced (MG1) and Yb(III)-induced (MG2) supramolecular gel, respectively. MG1 and MG2 were synthesized for identification and detection of pollutants (aromatic amines(AAs)). Different spectro-microscopic and analytical techniques (Powder-XRD, Rheological measurements, scanning electron microscope (SEM), absorption and emission studies) were used to characterized MG1 and MG2. The identification of MG1 and MG2 structure features and its non-covalent interactions was determined by Powder-XRD analysis. The analysis of SEM exposed the sponge porous like structure with compactness and small pebbles like structure morphological features in MG1 and MG2, respectively. The investigation of rheology shows a thermal stability up to 100 ℃ and rigidity nature of MG1 and MG2. Moreover, the emission studies of MG1 as fluorogenic show response towards the *m*-phenylenediamine (MPD) pollutant. The materials MG1 show fast response towards MPD pollutant and can be probably utilised for the recognition or environmental controlling of pollutants with low limit of detection.



Acknowledgments. Authors are grateful to NIT Uttarakhand, B.L.J Govt. PG College Purola and MANIT Bhopal for supporting this research work.

References:

[1] Singh et al., Dalt. Trans. 2023, 52, 7088.
[2] Singh et al., , Langmuir 2024, 40, 5121.

ABSTRACT 54

Constructing a material-instructive cell line

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In the field of tissue engineering, biomaterials are used as a scaffold for cells to regenerate injured tissues. Many biomaterials are biodegradable to some degree, i.e. the material gets broken down over time and replaced by natural tissue [1]. However, this process is not controlled and can therefore lead to fibrosis or loss of support in the regenerating tissue. The goal of this research is to establish a feedback-responsive scaffold degradation system, where not only the biomaterial has an influence on the cell, but the cell can actively degrade the material upon mechanical cues. The first steps towards this system entail the expression of yeast lipase CALB in human cells. Yeast lipases have been used in literature for the hydrolysis of ester bonds several polyesters and supramolecular polymers based on ureido-pyrimidinone modified polycaprolactone (i.e. UPy-PCL) [2,3]. We show that yeast lipases are able to degrade UPy-PCL scaffolds under physiological conditions, without cell cytotoxic effects to human cells. The next step is to gain control over the expression of functional CALB by conditional expression in human cells, and to further quantify the degradation potential of the enzyme towards these UPy-PCL scaffolds.

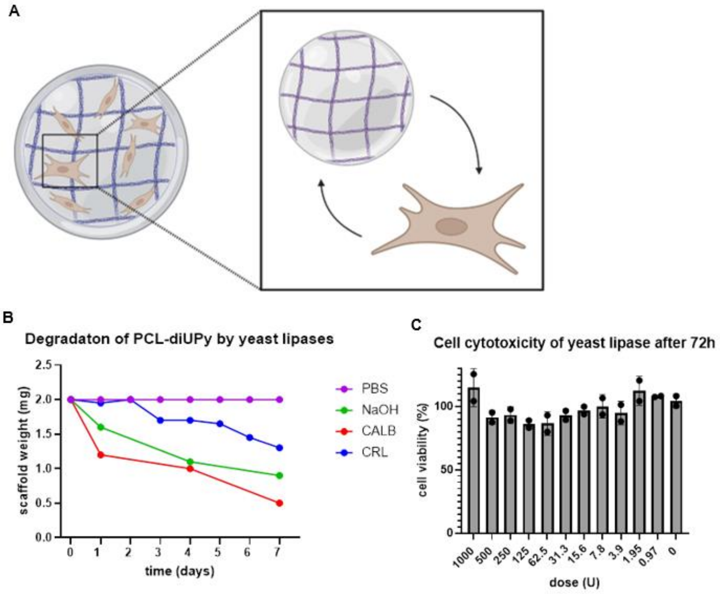

Figure 1. (a) schematic representation of the aim of the project. (b) yeast lipases are able to degrade PCL-diUPy scaffolds at physiological conditions. PBS was used as a negative control, 1 M NaOH as a positive control. Candida antarctica lipase B (CALB) was able to degrade PCL-diUPy efficiently. Lipase from Candida rugosa (CRL) degrades PCL-diUPy, but at lower efficiency. (c) Yeast lipase is not toxic to human cells. HEK293T cells were exposed to high concentrations of CRL for 72h. Cell viability was assessed using a PrestoBlue assay, showing no cytotoxic effect of the lipase.

Acknowledgments: We kindly thank H. Rijkers for his work on the establishment of the assays presented in this work. This work is supported by the Interactive Polymer Materials Research Center (IPM, NWO gravitation program).

References:
[1] S. Tajvar et al, International Biodeterioration & Biodegradation, 2023, 180, 105599.
[2] Q. Ma et al, J. Polym. Environ., 2020, 28, 2947-2955.
[3] L. Pastorino et al, Enzyme and Microbial Technology, 2004, 35, 321-326.

ABSTRACT 55

Hydrogel-delivered triple treat for colorectal peritoneal metastases: a local immunotherapeutic approach

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Colorectal cancer (CRC) is a leading cause of cancer mortality, with ~1.9 million new cases annually.1 Peritoneal metastases (PM) occur in 5–20% of patients at diagnosis and up to 80% post-mortem, underscoring their underestimated prevalence.2,3 Current treatments—cytoreductive surgery, intraperitoneal chemotherapy, and systemic regimens—fail to prevent recurrence, with rates up to 71.5% within one year.4 Despite screening, global CRC incidence continues to rise, driven by lifestyle factors.1,2,5 Limitations of existing therapies include poor drug accumulation in the peritoneum and tumour-driven immune evasion.5 To address this unmet need, we propose We propose an intraperitoneal drug delivery platform based on supramolecular UPy–PEG hydrogels. This injectable, biocompatible matrix forms a local depot along the peritoneal surface, prolonging drug retention and enabling controlled antibody release. As proof of concept, anti-PD-1 and anti-EGFR antibodies are incorporated aiming to block PD-1 signalling and restoring cytotoxic T-cell activity and counteracts tumour immune suppression. While EGFR inhibition both suppresses signalling and promotes Fcγ receptor-mediated immune recognition, driving tumour lysis. Antibody structure and activity should be preserved during encapsulation, which can be confirmed by release and binding assays. Optimised gelation should ensure functional release, thus, retaining both structural integrity and biological activity, supporting the hydrogel's potential as a vehicle for immunotherapy. Furthermore, this strategy offers the possibility to enhance tumour-localised immune responses while reducing systemic toxicity associated with intravenous delivery. By enabling sustained and functional release of the antibodies directly into the peritoneal environment, this approach may establish a foundation for new adjuvant therapies, aimed at improving the treatment of colorectal peritoneal metastases.

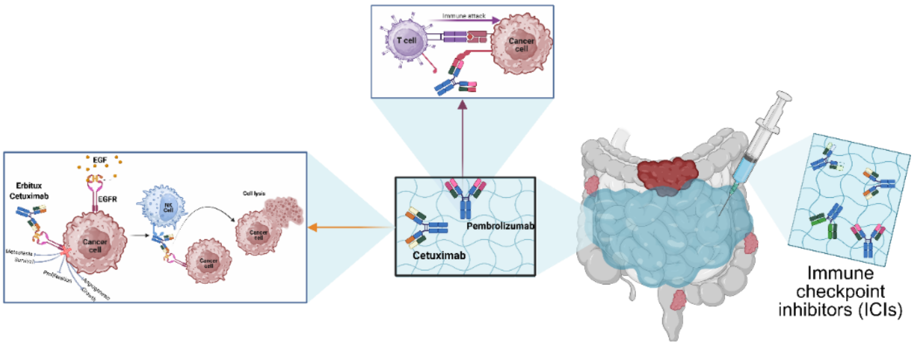

Figure 1. Local hydrogel delivery of immune checkpoint inhibitors targeting colorectal peritoneal metastases. Cetuximab blocks EGFR signalling on tumour cells and promotes antibody-dependent cellular cytotoxicity (ADCC) induced by NK-cells, while pembrolizumab inhibits PD-1 on T cells to enhance cytotoxic immune responses. Encapsulation of the antibodies in the UPy hydrogel enables sustained intraperitoneal delivery for local immunotherapy.

Acknowledgments: This research was supported by the ERA4Health initiative under the NANOTECMEC project Triple Treat, funded by national agencies participating in the European Partnership on Translational Cancer Research.

References:

1. World health organisation & international agency for research on cancer. Global Cancer Observatory. https://gco.iarc.fr/en.
2. Rawla, P., Sunkara, T. & Barsouk, A. Epidemiology of colorectal cancer: incidence, mortality, survival, and risk factors. Prz Gastroenterol 14, 89 (2019).
3. Kranenburg, O., Speeten, K. van der & Hingh, I. de. Peritoneal Metastases From Colorectal Cancer: Defining and Addressing the Challenges. Front Oncol 11, 650098 (2021).
4. Breuer, E. et al. Site of Recurrence and Survival After Surgery for Colorectal Peritoneal Metastasis. JNCI: Journal of the National Cancer Institute 113, 1027–1035 (2021).
5. Cañellas-Socias, A., Sancho, E. & Batlle, E. Mechanisms of metastatic colorectal cancer. Nature Reviews Gastroenterology & Hepatology 2024 21:9 21, 609–625 (2024).

ABSTRACT 56

Chemical Fuel Self-Assembly of Multicomponent Supramolecular Organic Frameworks

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Metal–organic frameworks (MOFs) and covalent–organic frameworks (COFs) are crystalline porous materials with applications in molecular separation, recognition, and catalysis. [1] However, the rigid crystalline nature of MOFs and COFs often leads to low solubility and poor stability in solutions, limiting their use in homogeneous-phase applications such as catalysis and drug delivery. [2] To address these issues, Supramolecular Organic Frameworks (SOFs) have emerged as promising alternatives. Built via supramolecular polymerization of carefully designed molecular building blocks, SOFs form periodic 2D or 3D networks that retain porosity and order in solution. They offer solution processability and tunable responsiveness to external stimuli. [3]

In biology, supramolecular systems remain in nonequilibrium steady states through consumption of chemical fuels, a process called dissipative self-assembly (DSA). This mechanism allows living systems to control the formation, function, and lifetime of dynamic assemblies such as the cytoskeleton. Most synthetic supramolecular materials, however, form under thermodynamic equilibrium, limiting adaptability. Inspired by nature, studies have demonstrated fuel-driven DSA principles to artificial non-equilibrium systems. [4]

We designed a novel redox-responsive, multicomponent 2D SOF based on host-guest interactions between guest-functionalized porphyrins and ditopic (host) linker molecules. The redox-responsive nature of this system enables dynamic control over its self-assembly by modulating the supply of redox chemical fuels, thereby allowing the implementation of DSA. In this work, we report the synthesis of the SOF building blocks and present preliminary studies on the SOF's assembly behaviour and response to redox stimuli.

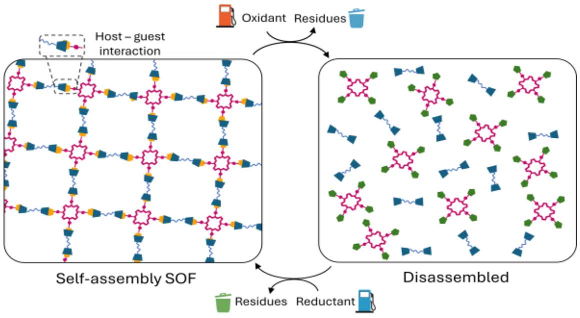

Figure 1. Schematic representation of fuel-driven self-assembly of SOF (e.g., using host-guest interactions).

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References:

[1] a) J. L. Atwood et al., John Wiley & Sons, **2013**; b) J. Kim et al., *Nature* **2003**, 423, 705–714.
[2] S. Furukawa et al., *Chem. Soc. Rev.* **2022**, 51, 4876–4889.
[3] D.-W. Zhang et al., *Acc. Chem. Res.* **2022**, *55*, 2316–2325.
[4] a) J. Boekhoven et al., *Chem. Soc. Rev.* **2017**, 46, 5519–5535; b) T. M. Hermans et al., *Chem. Soc. Rev.* **2017**, 46, 5476–5490; c) J. Boekhoven et al., *Chem* **2020**, 6, 552–578.

ABSTRACT 57

Coacervate-Droplet Cased Synthetic Cells Regulated By Activated Carboxylic Acids (ACAs)

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Regulating the formation and dissolution of active complex coacervate droplets with chemical reactions offers a powerful synthetic cell model. Such active droplets are also helpful in understanding the non-equilibrium nature of membrane-less organelles. Like many membrane-less organelles, these droplets rely on high-chemical potential reagents, like ATP, to maintain their transient nature. This study[1] explores Activated Carboxylic Acids (ACAs) as a high-chemical potential fuel to modulate the lifetime of peptide-based coacervates through transient pH changes. We demonstrate that nitroacetic acid, a commonly used ACA, can effectively induce the formation and dissolution of coacervates by transiently altering the solution's pH. The system, comprising the zwitterionic peptide Ac-FRGRGD-OH and polyanions, forms coacervates upon protonation at low pH and dissolves as the pH returns to neutral. Our findings indicate that the lifetime of these synthetic cells can be fine-tuned by varying the amount of ACA added, and the system can be refueled multiple times without significant interference from by-products. This ACA-driven reaction cycle is versatile, accommodating various coacervate compositions and enabling the uptake of diverse compounds, making it a valuable model for compartmentalization. The study underscores the potential of ACA-fueled coacervates as a platform for investigating biomolecular condensates and developing synthetic life systems.

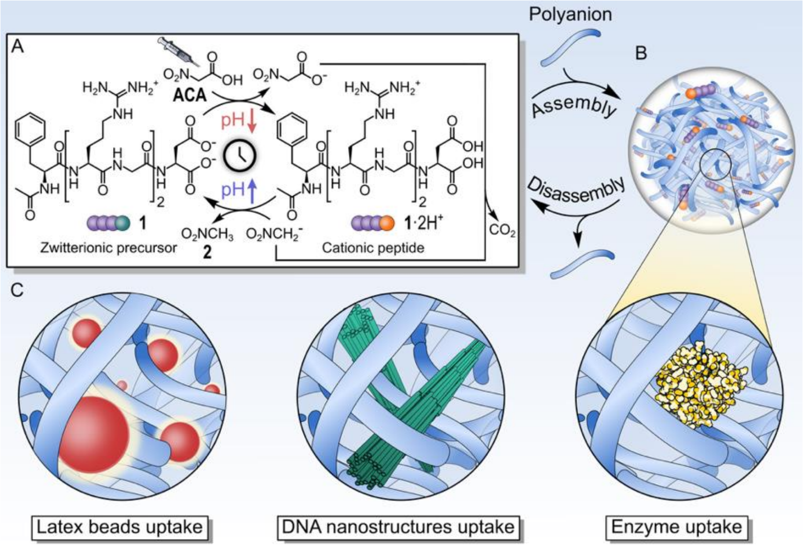

Figure 1. Schematic representation of the nitroacetic acid (**ACA**) reaction cycle coupled to Ac-F(RG)$_2$D-OH (**1**) protonation and deprotonation to induce coacervation through a transient pH variation. A) Upon addition of **ACA** to a neutral solution of **1**, the pH drops, resulting in a transient cationic peptide (**1**·2H$^+$) that can bind an anionic polymer (blue strand) and phase–separate into a coacervate-based droplet (B). Decarboxylation and back proton transfer of the conjugate base of **ACA** raise the pH, bringing the system back to its initial equilibrium state. C) These transient coacervates can ideally be used to uptake a wide range of compounds, such as latex beads, DNA nanostructures, and enzymes, for further applications.

References:

[1] M. Valentini et al., ChemSystemsChem. 2025, 7, e202400083.

ABSTRACT 58

Advanced magnetic materials for ethanol dehydration: the role of selenide-based powders in magnetic membranes

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Developing high-performance membranes for ethanol dehydration is essential for energy-efficient biofuel production. Composite membranes based on sodium alginate were prepared by incorporating magnetic selenide-based fillers with adjusted magnetic properties to enhance pervaporation performance. These fillers are hypothesised to promote selective water transport through magnetic interactions within the membrane matrix. Structural and physicochemical characterization confirmed uniform dispersion at an optimal loading, leading to improved membrane selectivity and permeability. The highest-performing membrane achieved a pervaporation separation index (PSI) over 1300 $kg \cdot m^{-2} \cdot h^{-1}$, indicating a significant enhancement over membranes without magnetic fillers addition. Further testing under various ethanol concentrations and temperatures revealed that lower temperatures and higher ethanol content improved separation efficiency. These results suggest that magnetic domains formed within the membrane create preferential channels for water transport via magnetic field interactions, significantly improving dehydration efficiency. Such magnetically structured membranes offer a promising, energy-efficient strategy for selective ethanol purification in biofuel production.

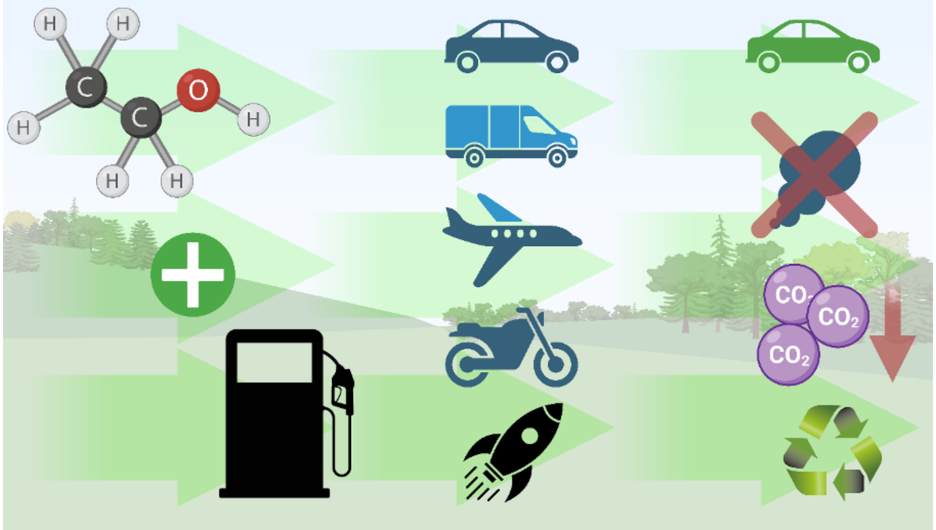

Figure 1. Diagram showing the environmental benefits of using biofuel based on anhydrous ethanol.

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ABSTRACT 59

Polysaccharide-based films for food packaging applications

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Considering the escalating global issue of plastic waste pollution, this study focuses on the development of fully biodegradable food packaging films as a sustainable alternative to synthetic polymers. Traditional plastic packaging, while effective in preserving food, contributes significantly to environmental degradation. In response to this challenge, this research highlights the use of natural, renewable resources to design packaging solutions and creating circular economy. In this case, biodegradable films are composed of natural polysaccharides like chitosan or sodium alginate. Unfortunately, these materials have insufficient mechanical properties, making it necessary to introduce modifications to enhance their durability. Therefore, to enhance the mechanical and functional properties of these films, nanolignin particles were incorporated. Additionally, chestnut extract was included for its antibacterial properties, extending the shelf life of packaged food. In this research the hydrophilic, barrier and morphology properties of the films were measured. Next, mechanical properties, such as tensile strength and elongation at break, were analyzed. Among the tested configurations, the chitosan film with 0.02g of Kraft nanolignin demonstrated the most favorable results, highlighting the potential of nanolignin integration. The results confirm that these biodegradable films exhibit satisfactory properties, positioning them as a viable alternative to conventional plastics.

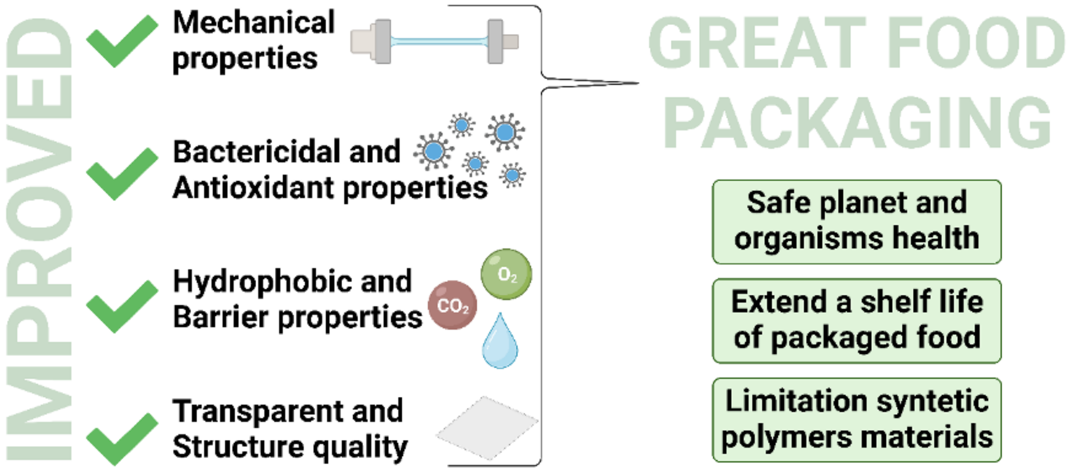

Figure 1. Films for food packaging applications.

Acknowledgments: J.J would like to thank L'Oréal Polska and the Ministry of Education and Science (MEiN) as part of the "For Women in Science" program. This research was funded in part by the National Centre of Science, Poland 24/53/N/ST11/03807. For the purpose of Open Access, the author has applied a CC-BY public copyright licence to any Author Accepted Manuscript (AAM) version arising from this submission.

ABSTRACT 60

Bioengineering a humanized bone-on-a-chip model with 3D porous scaffolds

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There is an urgent need to develop robust platforms to test and optimize new therapies for bone healing.[1] In recent years, organ-on-chips (OoCs) have emerged as a strong candidate for their cutting-edge microscale systems that mimic organ-level functions by integrating perfusable microchannels and cells.[2]

The aim of this work is to create a novel biomimetic 3D bone-on-a-chip model utilizing human extracellular matrix (ECM)-derived cryogels as an innovative platform to investigate the effects of advanced therapeutic products on bone regeneration in an injured site. For this, cryogels from methacryloyl human ECM (hECM-MA) were fabricated, exhibiting unique shape memory, a fully interconnected macroporous network, and enhanced structural stability. Human bone marrow mesenchymal stem cells (hBM-MSCs) were then cultured on these macroporous scaffolds, with different cryogel stiffnesses rendering promising results. The cells were able to self-organize within the pores, demonstrating high cell viability up until three weeks in culture. Interestingly, a moderate degree of cell infiltration throughout the scaffolds was observed. Furthermore, the incorporation of this cryogel in a PDMS microfluidic chip also showed cells adhered well to the scaffold, demonstrating the potential of this dynamic system for long term cell culture. Overall, this study validates the feasibility of hECM-MA cryogels integration into microphysiological systems to develop a physiologically relevant bone model to study therapeutics efficacy on tissue regeneration.

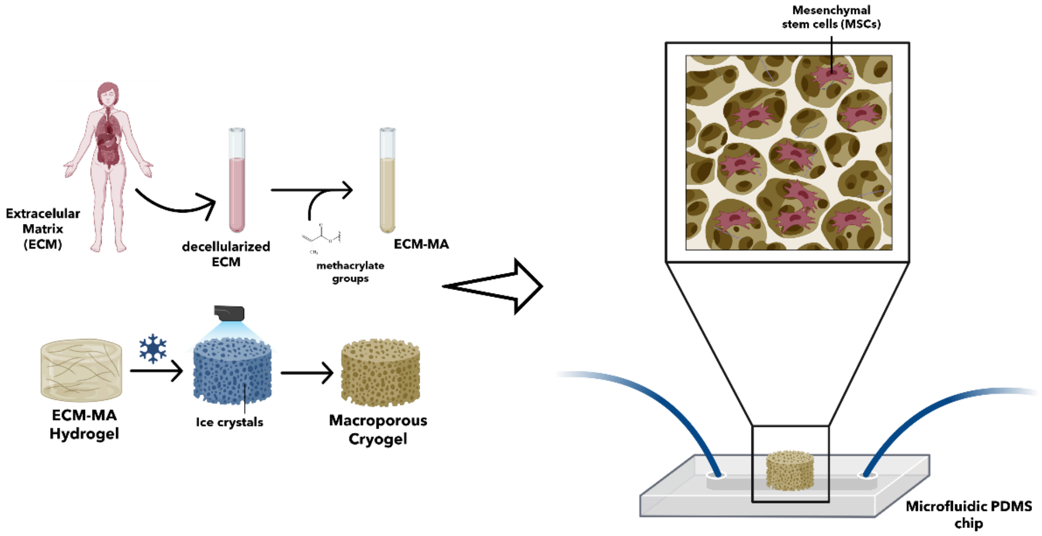

Figure 1. Schematic illustration of protein chemical modification, cryogel formation, and its integration into a microfluidic chip for continuous hBM-MSCs cell culture.

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References:

[1] S. Nadine et al., Biomater. Adv., 2022, 140 : 213058.

[2] C. F. Monteiro et al., Int. Mater. Rev., 2024, 70 : 31.

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