POLISH - SWISS SYMPOSIUM ON BIOMATERIALS AND BIOFABRICATION

PROGRAM AND BOOK OF ABSTRACTS

AGH UNIVERSITY OF KRAKOW

3RD SEPTEMBER 2026

To exchange ideas, research results, and perspectives within the field of biomaterials science, engineering, and biofabrication. To meet, discuss, seek collaboration, and enhance partnership between Polish and Swiss biomaterials scientists.

Organizers

Dr. Patrycja Domalik-Pyzik
Prof. Elżbieta Pamuła

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Polish Society for Biomaterials

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Faculty of Materials Science and Ceramics,
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ENGINEERING OF BIOMATERIALS
THE OFFICIAL JOURNAL OF THE POLISH SOCIETY FOR BIOMATERIALS AND THE FACULTY OF MATERIALS SCIENCE AND CERAMICS / AGH UNIVERSITY OF KRAKOW

ENGINEERING OF BIOMATERIALS

THE OFFICIAL JOURNAL OF THE POLISH SOCIETY FOR BIOMATERIALS AND THE FACULTY OF MATERIALS SCIENCE AND CERAMICS / AGH UNIVERSITY OF KRAKOW

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Program

8:45 - 9:00	Opening remarks
	Experts' Panel
9:00 – 9:20	**Marcy Zenobi-Wong** *Structured Hydrogels for Tissue Engineering*
9:20 – 9:40	**Elżbieta Pamuła** *Biomaterials for Osteochondral Tissue Engineering*
	Rising Researchers
9:45 – 9:57	**Joanna Czechowska** *Hydroxyapatite-Based Self-Organizing Granules for Bone Substitution*
9:57 – 10:09	**Marcin Kotlarz** *Developing Hydrogel-Bioceramic Systems for Osteochondral Repair*
10:09 – 10:21	**Shipin Zhang** *Bacteria-Associated Signals in Osteoarthritis: Where to Find Them and What They Actually Do*
10:21 – 10:33	**Bin Wang** *Vitamin C-Induced Threshold Response Enables High-Fidelity Collagen Volumetric Printing*
10:33 – 10:45	**Anna Kusibab** *Gellan Gum Wound Dressings Enriched with Curcumin-Loaded Polymeric and Quercetin-Loaded Lipid Carriers for Chronic Wound Management*
10:45 – 11:15	**Coffee break (onsite)/Networking**

Next Gen Biomaterials: Stories from the Lab

Short oral presentations by early-career researchers to see the most up-to-date research results

1. **Hawdang Abdalla**: *Chiral Diamine–Triggered Formation of L-DOPA and Norepinephrine Polycatecholamine Nanoparticles for Photothermal Biointerfaces*
2. **Anna Baran**: *Can Fermented Tea Save The Future of Biomaterials?*
3. **Dimitar Boev**: *Multi-Wavelength Spatially Controlled Gene Editing in Biofabrication*
4. **Siyi Chen**: *Tissue Engineering of Fast-Maturing Human Knee Synovium Using Light-Printed Collagen-Fibrinogen Scaffold*
5. **Flora Chiper**: *In-situ FLight Bioprinting for Single-Stage Articular Cartilage Regeneration: an Ex-vivo Proof-of-Concept Versus Current Orthopaedic Approaches*

6. Ewelina Cichoń: *Poly(3-hydroxyoctanoate) (PHO)/Propolis Composites: FTIR and Morphological Characterization*
7. Mathis Goreau: *$Ga(OH)_3$ Nanoparticle Optimization and Gellan Gum Hydrogel Encapsulation*
8. Isabel Hui: *In Situ Trabecular Bone Engineering via Phase-Separated Hydrogels*
9. Amelia Jeneralczuk: Bleaching Intensity and Laser Activation Affect the Durability of Aesthetic Dental Composites
10. Kinga Kowalska: *Overcoming Processing Challenges in Direct Ink Writing of β-TCP/Phosphate Bioactive Glass Scaffolds*
11. Łukasz Luśtyk: *Designing Cancer Metastastasis to Bone Model: Novel Approach Combining CQDs/GelMA Bioink, 3D Biofabrication and CFD Modeling*
12. Stanisław Marecik: *Region-Dependent Exposure Control in Digital Laser Processing of Microfluidic Devices for Microgel Generation*
13. Justyna Matysek: *From Core Synthesis to Cell Testing: Development of a Folate-Functionalized Magnetic–Gold Nanoplatform for Ovarian Cancer Theranostics*
14. Alona Mintianska: *Biocompatibility Studies for Polydopamine-Modified Decellularized Plant Scaffolds*
15. Zuzanna Pawlak-Likus: *Development and Preliminary Antibacterial Evaluation of Alginate-Based Films Containing Centella Asiatica for Wound Dressing Applications*
16. Michał Pawłowski: *Phase-Field Modelling of Ice Templating in Natural Colloids: Predicting the Pore Architecture of Freeze-Cast Scaffolds*
17. Daniel Rodriguez Pinzon: *Controlling Hydrogel Microarchitecture with Filamented Light Printing*
18. Amna Sadiq: *Development of Hydroxyapatite-Reinforced Furan-Based Photocurable Composites*
19. Vanessa Stabla: *Heat-Treatment-Induced Hardness–Toughness Trade-off and Anisotropy Reduction in DMLS Ti6Al4V*
20. Zuzanna Szałaj: *Effect of a Commercial Mouthwash on Short-Term Degradation and Mechanical Stability of Surgical Sutures*
21. Kamila Walczak: *Covalent Integration of Chondroitin Sulfate into Oxidized Hyaluronic Acid Hydrogels*
22. Łucja Wieczorek: *Quercetin-Loaded Solid Lipid Particles: Cytocompatible In Vitro and Enhance Skin Epithelization in Ex Vivo Wound Model*

Experts' Panel

Prof. Marcy Zenobi-Wong

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Marcy Zenobi-Wong is a Full Professor of Tissue Engineering and Biofabrication in the Institute for Biomechanics 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. After a postdoc at the University of Michigan and Habilitation at the University of Bern, she moved to ETH Zürich. There she leads a multidisciplinary team with strong focus on light-based biofabrication technologies, development of advanced biomaterials, and gene editing of cells for tissue regeneration. She is the author of over 150 peer-reviewed publications (cited over 15000 times) and co-inventor on several licensed patents. She is an honorary member of the Swiss Society for Biomaterials and Regenerative Medicine (SSB+RM) and served as the General Secretary for the International Society of Biofabrication (ISBF). She serves on the editorial board for *Advanced Healthcare Materials* and the Executive Editorial Board of *Biofabrication*. In 2019 she was elected as Fellow to the European Alliance for Medical & Biological Engineering and Science (EAMBES).

Prof. Marcy Zenobi-Wong

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Structured Hydrogels for Tissue Engineering

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 our labs work to create structured hydrogels for use in tissue engineering. These methods range from microgel materials, phase separation, and use of filamented light (FLight) Biofabrication to exert control over a scaffold's internal 3D architecture.

Flight is a rapid, light-based bioprinting technique that leverages spatial light intensity variations and self-focusing light behavior to induce localized photocrosslinking within photoactive resins. Flight generates hydrogel constructs consisting of highly aligned, high-aspect-ratio microfilament networks and microchannel architectures. By providing native-like topographical guidance, FLight directs cellular orientation and extracellular matrix organization, offering a robust strategy for engineering complex anisotropic tissues such as muscle, tendon, cartilage and nerve.

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Acknowledgements

I would like to acknowledge the members of my research group past and present for their scientific contributions. Funding from the Swiss National Science Foundation, Innosuisse and the European Union is gratefully acknowledged.

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Elżbieta Pamuła is a full professor in biomaterials engineering, has a double degree in materials science and chemical technology, and after earning a PhD, a DSc and a professorship in materials science. She was appointed as a postdoctoral researcher at UCLouvin, Belgium, and as a visiting professor at the Sydney University. She leads a team at AGH University of Krakow focused on multifunctional implantable and injectable bone/cartilage substitutes and polymer and lipid processing into drug delivery systems to the lungs and skin. She has published more than 170 JCR listed papers and owns 12 patents. She was a Vice-Chair of the 27th European Society for Biomaterials Conference in 2015 and the 4th International Conference of Biomedical Polymers and Polymeric Biomaterials in 2018, both organised in Kraków. She has been the Chair of the Annual Conference of the Polish Society for Biomaterials (organised since 1990 in Rytro, Poland). In 2016 she was elected the President of the Polish Society for Biomaterials and in 2023 the Council Member of the European Society for Biomaterials, holding the function of Education Officer. She serves on the editorial board of *Regenerative Biomaterials* and *Bioactive Materials,* as well as Editor-in-Chief of *Biomaterials Engineering*. In 2020, the International Union of Societies for Biomaterials Science and Engineering awarded Prof. Pamuła the title of Fellow Biomaterials Science and Engineering (FBSE). In 2024 she was elected the Steering Committee Member of the International College of Fellows Biomaterials Science and Engineering (ICF-BSE) holding the position of Secretary.

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Biomaterials for Osteochondral Tissue Engineering

Biomaterials can support bone and osteochondral tissue regeneration and healing if they are specifically designed. First, they must eradicate pathogenic bacteria, followed by facilitating osteogenic / chondrogenic cell signaling and respective tissue expression processes. In our research, we design multifunctional biomaterials that provide mechanical support and are integrated with bone tissues (titania and zirconia ceramics) [1,2] or are made of biodegradable polymers (polyesters, polyanhydrides), so their disappearance from the treated lesion is correlated with native tissue ingrowth [3,4]. Both types of biomaterials can be modified to deliver drugs or biologically active substances to support bone tissue regeneration. We found that the deposition of calcium phosphate, collagen, or sulphated hyaluronan on polymer scaffolds promotes cell osteogenic differentiation and the healing of osteochondral defects [3,4]. We also developed biomaterials dedicated to infected bone that contain antibiotic-loaded polymeric or ceramic nanoparticles [1,2,5,6] or lipid nanoparticles loaded with antibacterial peptides [7]. They can be used as a component of injectable matrices [8] or immobilised on the pore walls of scaffolds, to obtain implantable medical devices, when mechanical support is particularly essential [1,2]. We also proposed an indirect 3D printing technique based on the sacrificial mould method, combined with enzymatic mineralisation to produce hydrogel-based scaffolds for osteochondral tissue regeneration [9]. The developed biomaterials release drugs in a controlled manner to be adapted to clinical needs. We provide evidence that our biomaterials are favourable for the treatment of bone tissue defects and osteochondral tissue engineering.

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Acknowledgements

This study was supported by the HORIZON-MSCA- 2023-SE-01-01 EngVIPO project (ID: 101183041), by the programme *Excellence Initiative – Research University* and by the subsidy for the AGH University of Krakow.

Rising Researchers

Dr. Joanna Czechowska

Joanna P. Czechowska is an Assistant Professor at the Department of Ceramics and Refractories, Faculty of Materials Science and Ceramics, AGH University of Krakow, Poland. She received her M.Sc. in Chemistry from Jagiellonian University in 2008, followed by a B.Eng. degree in Materials Engineering from AGH University of Krakow in 2009. She earned her Ph.D. (Dr. Eng.) in Materials Engineering from AGH University of Krakow in 2014. Dr. Czechowska is the co-author of numerous scientific publications and patents in the field of biomaterials. According to Scopus, she has authored 41 indexed publications and has an h-index of 15. Her research focuses on the design, synthesis, processing, and characterization of biomaterials for bone regeneration and regenerative medicine. Her expertise includes calcium phosphate bioceramics, bone cements, porous scaffolds for bone tissue engineering, and polymer–ceramic hybrid biomaterials. Her scientific achievements have been recognized with several prestigious international awards, including a Gold Medal at the International Exhibition of Inventions Geneva (2024), a Gold Medal at the International Warsaw Invention Show (2024), a Silver Medal at the iENA International Trade Fair “Ideas – Inventions – New Products” in Nuremberg, Germany (2024), and a Silver Medal at the 22nd International Exhibition of Inventions ARCA 2024 in Zagreb, Croatia. She has also received multiple Rector’s Awards of AGH University of Krakow for Scientific Achievements and a Rector’s Award for Teaching Achievements. Dr. Czechowska has supervised more than 15 undergraduate and master’s theses and currently serves as a co-supervisor of three doctoral dissertations. She has completed several international research internships and scientific stays, including at the Instituto de Cerámica y Vidrio, Spanish National Research Council (CSIC), Madrid, Spain (2009); Universitat Politècnica de Catalunya, Barcelona, Spain (2009); Anna University, MIT Campus, Chennai, India (2023); and Schmalkalden University of Applied Sciences, Germany (2026).

Joanna P. Czechowska

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Hydroxyapatite-Based Self-Organizing Granules for Bone Substitution

Biomaterials in the form of granules or microspheres have attracted considerable attention in bone tissue engineering due to their biocompatibility, ease of handling, and ability to serve both as standalone bone substitutes and as functional components of composite biomaterials [1]. Hydroxyapatite (HAp), owing to its chemical similarity to the mineral phase of natural bone and osteoconductive properties, is one of the most widely used components in these systems [2].

In this study, self-organizing hydroxyapatite–methylcellulose (HAp–MC) hybrid granules modified with different amounts of chitosan (CTS) and copper were developed. The influence of chitosan and copper incorporation on the self-assembly mechanism, physicochemical characteristics, mechanical performance, and antibacterial properties of the granules was investigated. Spectroscopic and thermal analyses confirmed that the materials are class I hybrids stabilized by weak intermolecular interactions, including hydrogen bonding and electrostatic forces. The results demonstrated that chitosan did not disturb the methylcellulose-mediated self-assembly process. Mechanical testing revealed that both the type and content of polymers significantly affected compressive strength. The HAp–MC–CTS granules exhibited favorable mechanical performance, which was attributed minly to intermolecular interactions between the polymeric components and the nanometric size of the hydroxyapatite crystals. In contrast, copper incorporation resulted in a slight reduction in compressive strength while preserving the structural integrity of the granules. Immersion in simulated body fluid confirmed the bioactive character of all granules through their apatite-forming ability. Furthermore, copper-modified granules exhibited pronounced antibacterial activity, resulting from the synergistic effects of copper and chitosan. These findings demonstrate that incorporation of copper in ionic or nanoparticular form into self-organizing HAp–MC–CTS hybrid hybrid granules provides a promising strategy for developing multifunctional materials combining potential bone-regenerative and antibacterial properties. Further in vivo studies are required to validate their clinical potential.

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Acknowledgements

This research was funded in part by National Science Centre, Poland (Project MINIATURA7 No.2023/07/X/ST11/00705). 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. Research project supported by program „Excellence initiative – research university" for the AGH University of Krakow. Research co-funded by the Faculty of Materials Science and Ceramics AGH University of Krakow, Kraków, Poland, Project No. 16.16.160.557.

Dr. Marcin Kotlarz

Marcin Kotlarz is a Postdoctoral Researcher at ETH Zürich in Tissue Engineering and Biofabrication Lab, where his work bridges structural biomaterials with engineered tissues to develop next-generation implants and treatments for osteochondral repair. Building on a PhD from Newcastle University, postdoctoral training at Trinity College Dublin, and R&D role at Johnson & Johnson, his work spans bioprinting, bioceramic additive manufacturing, and cartilage and bone tissue engineering.

Marcin Kotlarz

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Developing Hydrogel-Bioceramic Systems for Osteochondral Repair

Acknowledgements

This project received funding from Swiss National Science Foundation under grant No 10000207.

Full abstract available in the supplementary file for participants only

Dr. Shipin Zhang

Shipin Zhang is an oral surgeon by training, with a PhD in Oral Sciences from the National University of Singapore. She is currently a postdoctoral researcher at the Tissue Engineering + Biofabrication Laboratory in the Department of Health Sciences and Technology at ETH Zürich. Her research follows two parallel paths: understanding the mechanisms of musculoskeletal disease through *in vitro* and *in vivo* models as well as human data; and developing therapies that target the specific pathology uncovered along the way. Together, these two directions connect mechanistic discovery to patient-relevant solutions for joint diseases, particularly those disproportionately affecting women.

Shipin Zhang

Shipin Zhang[1*], Kejatana Bevc[1], Chiara Tschanze[1], Siyi Chen[1], Manoel Anantharajah[1], Marina Fonti[1], David Fercher[1], Marcy Zenobi-Wong[1]

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Bacteria-Associated Signals in Osteoarthritis: Where to Find Them and What They Actually Do

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Acknowledgements
This project has received funding from the European Union's Horizon Europe Research and Innovation Programme under grant agreement No 101095084. This work was supported by the Swiss State Secretariat for Education, Research and Innovation (SERI) under contract number 22.00462.

Full abstract available in the supplementary file for participants only

Dr. Bin Wang

Bin Wang is an interdisciplinary researcher with a PhD from the Technical University of Denmark (DTU) and postdoctoral training at ETH Zurich. His research focuses on photopolymerization-based additive manufacturing of hydrogels, bridging fundamental materials chemistry with engineering innovation. He develops biofabrication technologies and printable biomaterial systems that enable the rapid and precise fabrication of complex biological structures, with applications in tissue engineering, organ modeling, and regenerative medicine.

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Vitamin C-Induced Threshold Response Enables High-Fidelity Collagen Volumetric Printing

Acknowledgements

M.Z.-W. gratefully acknowledges funding from Swiss National Science Foundation, Bridge Discovery (40B2-0_211764) and the ETH Foundation (23-1 ETH-12). We thank Annalena Maier, Isabel Hui, Michael Winkelbauer and all the members of the Tissue Engineering and Biofabrication laboratory for the helpful discussions and inputs.

Full abstract available in the supplementary file for participants only

Anna Kusibab

Anna Kusibab is a fourth-year PhD student at the AGH Doctoral School and a member of the Regenerative Biomaterials & Drug Delivery Systems AGH – Prof. Pamuła's Research Group at the AGH University of Krakow, Facultyof Materials Science and Ceramics, Department of Biomaterials and Composites. She received her Engineer degree in Chemical Technology in 2021 and her MSc degree in Materials Science in 2022, both from AGH University of Krakow.Her research interests focus on biomaterials and drug delivery systems for regenerative medicine, particularly polymeric and lipid-based carriers, hydrogel wound dressings, local delivery of bioactive compounds and the biological evaluationof biomaterials for wound healing applications.

Anna Kusibab

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Gellan Gum Wound Dressings Enriched with Curcumin-Loaded Polymeric and Quercetin-Loaded Lipid Carriers for Chronic Wound Management

Chronic wounds are characterized by persistent inflammation and impaired tissue regeneration, creating a need for advanced wound dressings that support healing while locally delivering therapeutic agents. Curcumin (CU) and quercetin (QE) are natural bioactive compounds with antioxidant and anti-inflammatory properties relevant to wound healing. However, their poor aqueous solubility limits their direct application. Therefore, this study aimed to develop two delivery strategies based on CU-loaded poly(lactic-co-glycolic acid) (PLGA) particles and QE-loaded lauric acid (LAU)-based particles and integrate them into gellan gum (GG)-based wound dressings.

CU-loaded PLGA and QE-loaded LAU particles were prepared by emulsification methods and characterized by SEM and DLS. Their local skin delivery was evaluated using Franz diffusion cells. Suitable bioactive concentrations were selected using normal human keratinocytes. The carriers were then incorporated into ionically crosslinked GG matrices, and the resulting systems were evaluated with L929 fibroblasts and primary human macrophages.

Both approaches resulted in submicron carriers. CU-loaded PLGA particles exhibited a mean diameter of 243.8 ± 4.1 nm, whereas QE-loaded LAU particles reached 695.9 ± 32.6 nm. Both CU and QE were mainly retained within the skin, with minimal or no transfer to the receptor compartment, supporting their potential for local delivery. Preliminary keratinocyte studies enabled the selection of suitable concentrations for incorporation into the GG matrices. CU-based formulations showed good cytocompatibility with L929 fibroblasts. For several QE-based formulations, a reduction in metabolic activity was observed after 24 h, however, this effect was no longer apparent after 72 h. Evaluation of macrophage polarization revealed a tendency toward an increased M2 (pro-regenerative) to M1 (pro-inflammatory) ratio for both delivery strategies. After 72 h, CU-loaded PLGA particles and GG with CU-loaded PLGA particles significantly increased the M2/M1 ratio compared with the control. Similarly, QE-based formulations generally showed an increased M2/M1 ratio, although statistically significant differences were observed only for unloaded LAU particles and GG matrices containing unloaded LAU carriers. These results suggest that both active compounds and carrier materials may contribute to the observed immunomodulatory response.

The developed polymeric and lipid-based carriers represent two complementary strategies for the local delivery of CU and QE. The observed modulation of macrophage phenotype further supports the potential of these systems for the development of advanced biomaterials for chronic wound management.

Acknowledgements

I would like to express my gratitude to my supervisors, Prof. Elżbieta Pamuła and Prof. Justyna Drukała for their guidance and support. I am also deeply grateful to Ana Beatriz Sousa, Prof. Judite Novais Barbosa and Prof. Bożena Michniak-Kohn, whose expertise, collaboration, and support contributed to the results presented in this study. This research was supported by the 2026 subsidy of the Faculty of Materials Science and Ceramics, AGH University of Krakow (project no. 18184).

Next-Gen Biomaterials: Stories from the Lab

Hawdang Othman Abdalla

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Chiral Diamine–Triggered Formation of L-DOPA and Norepinephrine Polycatecholamine Nanoparticles for Photothermal Biointerfaces

Polycatecholamine-based biomaterials are attractive for photothermal and biointerfacial applications, with polydopamine (PDA) as the leading representative of this family.[1,2] However, reliable synthetic strategies for producing well-defined PL-DOPA and PD/L-Norepinephrine nanoparticles remain limited. Previous studies have examined how chiral diamines influence polycatecholamine assembly and how the stereochemistry of 1,2-diamines affects achiral PDA.[3]

In this work, we expand on these findings by evaluating a range of 1,2-diamines differing in backbone structure and chirality as initiators for the polymerization of L-DOPA and D/L-norepinephrine in hot water. This template-free method produces polymeric nanoparticles with size and dispersity governed by the structure and basicity of the diamine, in agreement with the cation–π-driven assembly mechanisms reported for polycatecholamines.[4,5] Their chemical composition, characterized by FTIR, XPS, and MS, was correlated to chirality-dependent circular dichroism (CD) responses.

The particles show stable hydrodynamic sizes by DLS and defined morphologies by SEM. When dried on polypropylene surfaces, the particle dispersions underwent further self-assembly into colloidal rods with hair-like macrostructures, suggesting their utility as mechanically robust scaffold materials. Their efficient NIR-responsive photothermal heating, together with biological evaluation, further supports their potential for photothermal therapy and chiral biointerface applications.

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Acknowledgements
The financial support from the National Science Centre under the SONAT BIS programme UMO-2024/54/E/ST11/00142 is acknowledged.

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Can Fermented Tea Save The Future of Biomaterials?

Introduction

Growing demand for sustainable materials is increasingly shaping the field of biomaterials and one of the polymers attracting considerable attention from researchers is nanocellulose produced by symbiotic culture of bacteria and yeasts (SCOBY). Although cellulose is already one of the most abundant natural polymers, the way it is produced matters. Microbial cellulose produced by microorganisms during kombucha fermentation is reported to be highly pure and crystalline, while exhibiting a unique nanofibrous morphology [1]. Moreover, SCOBY-derived cellulose can be subjected to acid hydrolysis to produce a printable hydrogel, opening new possibilities for 3D bioprinting.

Materials and Methods

SCOBY nanocellulose was obtained by introducing symbiotic culture of bacteria and yeasts into a sucrose-supplemented tea broth. After 7-14 days of fermentation, cellulose pellicle formed at air-liquid interface was collected. The obtained pellicle was washed with Mili-Q water, followed by treatment with 1.5M NaOH and 1.5% H_2O_2. Multiple washing steps in Mili-Q water were subsequently performed until a neutral pH was reached. The morphology of the obtained nanocellulose was characterised by Scanning Electron Microscopy (SEM). Acid hydrolysis was performed in 30% H_2SO_4 in 70°C [2]. Hydrolysed cellulose suspension was centrifuged and dialysed to obtain a neutral pH. The water content of the obtained gel was determined by weighing samples from each batch before and after freeze-drying.

Results and conclusions

SCOBY-derived cellulose obtained through fermentation demonstrates the potential to transform a simple, renewable resource into a functional biomaterial. The main challenge encountered during gel fabrication was controlling the water content of the cellulose suspension, which is critical for the reproducibility and further development of the material. Nevertheless, the obtained results demonstrate the feasibility of transforming SCOBY-derived cellulose into a gel-like material suitable for extrusion through acid hydrolysis. This work highlights fermentation as a promising route towards more sustainable biomaterials.

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Acknowledgements

This study was supported by the Programme ‘Excellence Initiative – Research University” for AGH and by the National Science Centre, Poland (2025/57/B/ST5/01898).

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Multi-Wavelength Spatially Controlled Gene Editing in Biofabrication

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Acknowledgements

We thank the whole TEB lab and Prof Dr Marcy Zenobi-Wong. This work was supported by an ETH Research Grant.

Full abstract available in the supplementary file for participants only

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Tissue Engineering of Fast-Maturing Human Knee Synovium Using Light-Printed Collagen-Fibrinogen Scaffold

Acknowledgements

The author would like to thank Innosuisse for the funding. Imaging was performed with the support of the ScopeM facility at ETH Zürich and the Center for Microscopy and Image Analysis at the University of Zürich.

Full abstract available in the supplementary file for participants only

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In-situ FLight Bioprinting for Single-Stage Articular Cartilage Regeneration: an Ex-Vivo Proof-of-Concept Versus Current Orthopaedic Approaches

Acknowledgements
LUMINATE / EU-Horizon; Balgrist Stiftung; Vontobel Stiftung

Full abstract available in the supplementary file for participants only

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Poly(3-hydroxyoctanoate) (PHO)/Propolis Composites: FTIR and Morphological Characterization

Introduction. Polyhydroxyalkanoates (PHAs) are bacterial biopolyesters valued for their biodegradability and biocompatibility, making them attractive for biomedical and packaging applications[1]. Propolis, a resinous substance collected by honeybees, is rich in phenolic acids and flavonoids and exhibits antibacterial, antioxidant and anti-inflammatory activity. Combining a PHA with propolis may yield bioactive composites for wound dressings or active packaging. Here, poly(3-hydroxyoctanoate) (PHO)/propolis composite films containing raw propolis were prepared. The effect of propolis loading on the chemical structure and surface morphology of the composites was assessed.

Materials and Methods. PHO/propolis composite films were obtained by solvent casting, with propolis contents of 0, 1, 5 and 10 wt% relative to the polymer. The chemical structure of films was investigated by FTIR spectroscopy whereas surface morphology was examined by SEM.

Results. FTIR spectra of all samples showed an intense carbonyl (C=O) stretching band at ~1726 cm^{-1}, characteristic of the PHA backbone. The position of this band was unaffected by propolis content. Increasing propolis loading (5 and 10 wt%) produced a progressive increase in absorbance around 1600-1620 cm^{-1}, a region associated with aromatic C=C skeletal vibrations of propolis phenolic and flavonoid compounds, together with a modest broadening of the low-wavenumber shoulder of the carbonyl band, confirming the successful incorporation of propolis into the film. SEM images showed raw propolis as irregular, flake-like particles. In the composites, propolis appeared as discrete deposits within the PHO matrix: the 1 wt% film displayed small, isolated aggregates, whereas the 10 wt% film exhibited a rougher, more porous surface, indicating particle agglomeration at higher propolis content.

Conclusions. PHO/propolis composite films were successfully obtained across a range of propolis contents. FTIR confirmed that propolis incorporation did not alter the PHO ester backbone but added aromatic/phenolic bands scaling with loading, while SEM showed an increasingly heterogeneous propolis distribution at higher loadings. These results support PHO/propolis composites as biodegradable, potentially bioactive materials for wound-care and active-packaging applications.

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Acknowledgements

Research funded by the statutory research fund of ICSC PAS. JR thanks to the support by the “PROM Programme short-term academic exchange.

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$Ga(OH)_3$ Nanoparticle Optimization and Gellan Gum Hydrogel Encapsulation

In recent years, inorganic-organic hybrid biomaterials have attracted significant attention for controlled drug release and tissue engineering applications. In this study, gallium hydroxide $Ga(OH)_3$ microparticles were synthesized via a controlled precipitation method and subsequently encapsulated within a gellan gum hydrogel matrix.

The precipitation parameters for $Ga(OH)_3$ were optimized, demonstrating that pH control within a narrow window of 5.5–6.5 is critical to maximize yield and prevent amphoteric redissolution. Optimal yield was obtained at a synthesis temperature of 20–65 °C. Microscopic evaluation showed well-defined spherical microparticles with porous surface architecture and an average diameter of approximately 200–300 µm, therefore, a smaller particle size should be achieved as nanoparticles were the primary aim of this study. Bacitracin was successfully encapsulated within the hydrogel formulation, achieving a high encapsulation efficiency (EE) of 80%. Cytotoxicity tests were performed across a concentration range up to 100 mg/ml (ANOVA + Dunnett post-hoc test). No statistically significant reduction in cell viability was observed compared to the control group (*ns*), maintaining viability above the 70% non-cytotoxic threshold.

These findings demonstrate that $Ga(OH)_3$-gellan gum composite microparticles possess high drug-loading capabilities and excellent cytocompatibility, making them promising candidates for local antibiotic delivery and biomedical applications.

Acknowledgements

This study was supported by the National Science Centre, Poland (2025/57/B/ST5/01898)a and by the Programme ‘Excellence Initiative – Research University’ and the subsidy for the AGH University of Krakow. M.G. acknowledges Erasmus Plus Program who supported his internship at the AGH University of Krakow.

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In Situ Trabecular Bone Engineering via Phase-Separated Hydrogels

Full abstract available in the supplementary file for participants only

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Bleaching Intensity and Laser Activation Affect the Durability of Aesthetic Dental Composites

Dental bleaching agents can alter the resin matrix and filler-matrix interface of restorative composites, affecting hardness, surface topography and wear behaviour. Laser activation may accelerate bleaching, but its influence on composite durability remains material- and protocol-dependent.

The aim of the study was to evaluate the effects of bleaching intensity and diode-laser activation on the microhardness, surface roughness and tribological resistance of four light-cured composites: G-aenial Universal Flo and Estelite Universal Flow High, Medium and Super Low. Sixty-five specimens per material were assigned to a control group or Opalescence 10%, 16% and 40% protocols, with corresponding laser-assisted groups.

Microhardness was measured by the Vickers method (0.98 N, 15 s), roughness (Ra) by 3D confocal laser microscopy, and tribological behaviour using a UMT Tribolab system in artificial saliva at 37°C under a 5 N load for 60 min. Laser-assisted groups were irradiated with an 810 nm diode laser (1.5 W, continuous mode, 90 s). Statistical significance was set at $p < 0.05$.

Bleaching significantly altered microhardness and roughness, with strong material-by-protocol interactions ($p < 0.001$). At 40% bleaching, microhardness fell by 28.1% in G-aenial (47.29 ± 0.71 to 33.99 ± 0.87) and by 29.5% in Estelite High (42.07 ± 1.69 to 29.68 ± 0.80). Roughness did not change monotonically with concentration: the largest Ra increases for G-aenial and Estelite Super Low occurred after 10% bleaching (0.198 to 0.278 and 0.060 to 0.118, respectively). Laser activation partially reduced hardness loss or roughness in several groups, but its effect was not uniformly protective; tribological response was likewise material- and protocol-dependent.

Table 1. Material-specific response to 40% bleaching

Material	HV control	HV 40%	ΔHV [%]	Ra control	Ra 40%
G-aenial Universal Flo	47.29	33.99	-28.1	0.198	0.205
Estelite Flow High	42.07	29.68	-29.5	0.114	0.125
Estelite Flow Medium	45.46	44.37	-2.4	0.037	0.069
Estelite Flow Super Low	55.72	45.97	-17.5	0.060	0.084

Overall, bleaching-induced changes were governed by both treatment protocol and composite composition rather than concentration alone. High-intensity bleaching produced the greatest hardness loss in selected materials, whereas surface roughness could peak after lower-concentration exposure. Diode-laser activation may partially mitigate some adverse changes but should not be considered universally protective. These findings support material-specific selection of bleaching parameters in patients with composite restorations.

Acknowledgements: “The task is financed under a commission from the Minister of Science and Higher Education entitled ‘Polytechnic Network VIA CARPATIA’ – 2nd edition, implemented in the years 2026–2030, with total funding of PLN 9,977,000.”

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Overcoming Processing Challenges in Direct Ink Writing of β-TCP/Phosphate Bioactive Glass Scaffolds

The development of printable calcium phosphate-based composite inks remains challenging in direct ink writing (DIW) of bone scaffolds due to the need to simultaneously achieve printability, shape fidelity and thermal stability. Here, we developed a reproducible fabrication strategy for β-tricalcium phosphate (β-TCP) scaffolds containing 5 wt.% Mg- or Sr-doped phosphate bioactive glasses [1].

Composite inks were prepared using an alginate-based binder and printed through a 20G nozzle into 15 × 15 × 3 mm scaffolds, followed by multistep debinding and sintering at 1000 °C for 2 h.

The optimized process enabled stable extrusion and reproducible scaffold fabrication with an average linear shrinkage of ~3%. X-ray diffraction identified β-TCP as the predominant crystalline phase and revealed composition-dependent phase evolution after sintering. SEM confirmed the preservation of the printed architecture and revealed distinct microstructural features associated with phosphate bioactive glass incorporation.

The developed fabrication strategy provides a reproducible route for manufacturing ion-releasing β-TCP/phosphate bioactive glass scaffolds for bone tissue engineering.

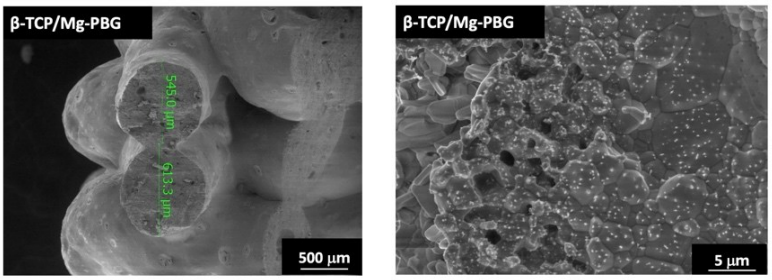

Fig 1. Representative SEM micrographs of the obtained β-TCP/Mg-PBG scaffold.

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Acknowledgements

This work was supported by the JECS Trust Mobility Fund (No. 2026-523) and AGH University of Krakow (Excellence Initiative – Research University, No. 16.16.160.557).

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Designing Cancer Metastastasis to Bone Model: Novel Approach Combining CQDs/GelMA Bioink, 3D Biofabrication and CFD Modeling

Metastasis is the leading cause of cancer-related death and drives patient morbidity. Bone is a main location for metastatic disease, and breast, prostate and lung cancers are the ones that commonly metastasize to this organ. Currently available in vitro models have their limitations, and to better understand the pathophysiological mechanism of bone metastasis, a functional bone tissue model is essential as there is a lack of good ex vivo models to study the disease. Bioprinting is an emerging technology for the highly reproducible three-dimensional 3D patterning of multiple microenvironments, allowing cells and biomolecules to be precisely distributed. In this technology, hydrogels like gelatin methacrylate (GelMA) are used as bioinks; however, GelMA encounters various constraints, such as mechanical durability and diminished immunogenic response. In this regard, carbon quantum dots (CQDs) have emerged as a favorable approach to improve the bioactivity and physical characteristics of GelMA by serving as a nano-reinforcement. Therefore, we propose a novel 3D bioprinted perfusable bone model design as a hopeful tool for studying bone cancer metastasis by combining CQDs/GelMA bioink, 3D biofabrication and CFD modelling. Firstly, the CQDs were produced through a microwave-based method by using mandarin orange juice as a carbon source and L-arginine as a nitrogen source. The properties of structural and chemical nature of synthesized CQDs were verified through UV-Vis spectroscopy, FTIR and TEM as well as the mechanical properties of CQDs/GelMA hydrogels were evaluated through dynamic mechanical analysis (DMA). Additionally, the biocompatibility of CQDs was demonstrated employing MTT assay and staining. Then, the three bioinks representing subtissues of the bone: GelMA with CQDs and β-TCP (calcified region of the bone), GelMA (bone/vessel interface) and GelMA/fibrin (vessel) were obtained as integral parts of the designed model. Extrusion bioprinting with the use of a supporting bath was employed to check their printability and their materials properties were evaluated by various methods: their morphology (SEM), characterization of mechanical properties and degradation behaviour (DMA, change of mass). The research was followed up by CFD simulations to provide an understanding of cancer cell attachment based on fluid flow within perfusable blood vessels. Based on the obtained results, it is concluded that the designed model and developed bioinks are suitable for cell survival and proliferation, leading to the conclusion of what parameters are potentially crucial for secondary tumor development, and thus that it can be used for the evaluation of potential therapies or for investigating pathogenic mechanisms e.g. metastasis of cancer.

Acknowledgements:
This work was supported by Polish National Science Centre through grant UMO-2020/39/I/ST5/03473. The authors would like to thank Dr inż. Marta Lipińska from Faculty of Materials Science and Engineering, Warsaw University of Technology for the help with transmission electron microscopy (TEM) observations.

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Region-Dependent Exposure Control in Digital Laser Processing of Microfluidic Devices for Microgel Generation

Digital light processing (DLP) is an attractive route to monolithic microfluidic devices manufacturing, since it can build three-dimensional fluidic architectures in a single step and avoids the bonding and alignment stages required by soft lithography. Its practical limit for embedded channels, however, is set not by the projected pixel size but by light bleeding. While the roof spanning a hollow channel is printed, ultraviolet light penetrates beyond the intended layer into the uncured resin trapped below, curing it and progressively occluding the channel.

In this study, we examine how the exposure protocol, rather than printer resolution, governs the patency of embedded microchannels. Specimens containing embedded microchannels of differing cross-section were printed on a DLP system operating at 385 nm (MAX X27 UV385, Asiga, Australia) fitted with a low-force lift tray, using a medical-grade photopolymer resin (KeyGuide, Keystone Industries, USA). Fine layers were used for the base and the microchannel walls, where geometric fidelity determines the channel cross-section. The bulk region above the channels, including the roof spanning the void, was printed with a thicker layer. To limit light penetration into the trapped resin beneath, the exposure in this region was reduced relative to the cured depth. Channel patency was assessed on sectioned specimens by optical microscopy (VHX-900F, Keyence, Belgium).

Under a uniform exposure protocol, channels below a certain cross-section were consistently found partially or entirely occluded by cured resin. The obstruction originated at the roof and propagated downwards. This confirms light bleeding, rather than incomplete clearing, as the primary cause of failure. Applying the region-dependent protocol, the same geometries were recovered fully open and unobstructed, with the channel cross-section matching the digital model. Channels as small as 54 µm were obtained in this way, i.e., twice the projector pixel pitch of the printer, and therefore the geometric minimum attainable on this hardware.

These results indicate that for embedded microchannels the limiting factor in DLP printing is the spatial distribution of the exposure dose rather than the nominal resolution of the projector: once bleeding is controlled, the pixel pitch itself becomes the binding constraint. Smaller enclosed channels have been reported, but only with purpose-built printers and custom-formulated resins, neither of which is available when a certified medical-grade material is required. Assigning exposure by build region is therefore a simple and transferable route to the hardware limit of a standard machine.

Acknowledgements
We acknowledge the National Science Center, Poland for the financial support provided by Preludium project (ID 2025/57/N/ST8/03399).

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From Core Synthesis to Cell Testing: Development of a Folate-Functionalized Magnetic–Gold Nanoplatform for Ovarian Cancer Theranostics

Introduction

Ovarian cancer is frequently diagnosed at an advanced stage and often relapses after platinum-based chemotherapy. Treatment is additionally limited by systemic toxicity and drug resistance. Theranostic nanoplatforms may combine targeted drug delivery with imaging-related properties in a single system [1], with the magnetic and gold components offering potential for future imaging applications. This study aimed to develop a carboplatin-loaded magnetic–gold nanoplatform coated with a chitosan–folate conjugate.

Materials and Methods

Fe_3O_4 nanoparticles were synthesized by two co-precipitation routes, decorated with gold, and coated with an in-house synthesized carboplatin-loaded chitosan–folate conjugate. Physicochemical characterization included FTIR, XRD, XPS, Raman spectroscopy, VSM, and TEM. OVCAR-3 cells were assessed by Live/Dead staining after one and three days, while 24-hour label-free 3D holotomography was used to monitor cell morphology and nanoparticle–cell interactions.

Results

The synthesis route markedly influenced nanoparticle quality and functionalization. The second route yielded cleaner, more crystalline, quasi-spherical particles of approximately 6–13 nm with magnetically soft behaviour. XPS showed nearly twofold higher surface gold content than in the first route, while FTIR confirmed formation and adsorption of the chitosan–folate conjugate. Live/Dead imaging suggested time- and concentration-dependent effects of carboplatin-containing formulations. Holotomography enabled real-time observation of cell morphology and indicated nanoparticle interaction and possible internalization by OVCAR-3 cells.

Conclusions

The optimized synthesis enabled preparation of a reproducible Fe_3O_4@Au–chitosan–folate–carboplatin (CBPT) nanoplatform with favourable physicochemical and cytocompatibility profiles, supporting further evaluation of its imaging and therapeutic potential in ovarian cancer theranostics.

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Acknowledgements

This study was supported by the subsidy (No 16.16.160.557) and by the Program “Excellence Initiative – Research University” for the AGH University of Krakow, Poland.

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Biocompatibility Studies for Polydopamine-Modified Decellularized Plant Scaffolds

Bioengineering nowadays follows a trend toward modifying nature-derived materials, addressing organ transplantation issues, rather than constructing artificial ones. Meanwhile, catecholamine functionalization and grafting have proven especially valuable in hydrogel preparation for wound healing and self-regeneration [1,2]. In the current research, we relied on the possibility of catecholamine-diamine perfusion, e.g. polydopamine with vicinal diaminocyclohexane, through previously decellularized spinach leaves.

The developed method enabled the simultaneous polymerization and coating of the cellulose surface for biological testing using a human lung fibroblast cell line (MRC-5). Collected FTIR and SEM data confirmed successful structural functionalization. Further investigation of cell viability was conducted in two ways, following the procedural evaluation of biomaterials – for the leaf samples themselves [3] and the prepared extracts [4]. An additional option involved seeding fibroblasts onto the sample surfaces for MRC-5 cell viability and proliferation studies.

Generally, the polydopamine-modified spinach leaf material showed no signs of cytotoxicity, while the chiral diaminocyclohexane not only enhanced the polydopamine polymerization process due to its basicity, but also altered cell adhesion to the modified material surface, depending on the enantiomer used. Despite the challenges encountered, promising results paved the way for identifying the adhesion prerequisites, which determine such cell behavior.

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Acknowledgements

The study was funded with the support of the NCN SONATA BIS grant number UMO/2024/54/E/ST11/00142.

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Development and Preliminary Antibacterial Evaluation of Alginate-Based Films Containing *Centella asiatica* for Wound Dressing Applications

Introduction

Alginate-based biomaterials are widely investigated for wound dressing applications due to their biocompatibility, hydrophilicity, and ability to form crosslinked structures under mild conditions. Incorporation of plant-derived bioactive compounds may further enhance their biological properties. *Centella asiatica* contains several bioactive constituents associated with wound healing and antimicrobial activity. Therefore, this pilot study aimed to develop alginate-based films containing *C. asiatica* and to perform a preliminary evaluation of their antibacterial properties.

Materials and Methods

Alginate-based films containing *C. asiatica* were prepared using two fabrication approaches differing in the method of ionic crosslinking with calcium chloride. In the first approach, 2% (w/v) alginate solutions with or without *C. asiatica* were cast into 10 cm Petri dishes and dried for 24 h, followed by crosslinking with 2% (w/v) $CaCl_2$ for 20 min. In the second approach, glycerol (1% v/v) and $CaCl_2$ (0.05% w/v) were incorporated directly into the alginate solution prior to casting, followed by drying for 24 h. *C. asiatica* concentrations of 0, 0.1, 0.25, 0.5, 0.75, and 1% were investigated during preliminary formulation optimisation. The obtained films were macroscopically evaluated for formation, integrity, handling, and homogeneity. Antibacterial activity was assessed using agar diffusion assays against *Staphylococcus aureus*, methicillin-resistant *S. aureus* (MRSA), and *Escherichia coli*, with films without *C. asiatica* serving as controls.

Results and conclusions

Both fabrication approaches enabled film formation; however, limitations in film integrity and handling indicated the need for further optimisation of fabrication and crosslinking conditions. *C. asiatica* was successfully incorporated within the investigated concentration range. No distinct inhibition zones were observed in agar diffusion assays, indicating no detectable antibacterial activity under the applied experimental conditions. This may reflect insufficient release of antibacterial constituents from the films rather than the absence of antimicrobial potential. Further optimisation of crosslinking conditions and *C. asiatica* release, followed by physicochemical and biological characterization, is required to evaluate the potential of these materials for wound dressing applications.

Acknowledgements

This work was supported by the EngVIPO project, funded by the European Union's Horizon Europe programme (HORIZON-MSCA-2023-SE-01-01) under Grant Agreement No. 101183041.

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Phase-Field Modelling of Ice Templating in Natural Colloids: Predicting the Pore Architecture of Freeze-Cast Scaffolds

Introduction

Freeze casting, or ice templating, solidifies a colloidal suspension directionally: growing ice crystals segregate the suspended phase, and sublimation leaves a pore network replicating them. In natural colloids this yields scaffolds whose lamellar spacing governs cell infiltration, permeability and mechanical anisotropy [1]. That process-structure link is still largely empirical. This work addresses its microscale origin: how local solidification conditions set the ice morphology that becomes the pore network.

Materials and Methods

Directional solidification is resolved by a phase-field model implemented in PRISMS-PF, applied to two-dimensional representative volume elements of a 1% w/v sodium alginate suspension in 5 M NaCl at initial colloidal volume fraction c_0. The model tracks the ice/suspension interface together with the redistribution, segregation and local packing of colloidal particles ahead of the growing crystals. Local conditions: the thermal gradient G and front velocity v, whose ratio sets the growth morphology [2], are imposed as fixed boundary conditions representative of freeze casting, the templated pore geometry follows from the simulated ice morphology.

Results

All data are model predictions, validation by confocal microscopy and X-ray microtomography is in progress. The simulations reproduce the lamellar ice morphology of freeze-cast alginate: N = 4-6 parallel ice crystals of distinct orientation grow competitively from the cold plate, those aligned closest to the thermal gradient eliminating their neighbours. Alginate is fully rejected by the growing ice and accumulates in the inter-lamellar channels, the predicted enrichment following cryoscopic equilibrium. The ice fraction extracted from the phase field falls within the porosity range reported for freeze-cast alginate scaffolds [1].

Conclusions

The model links local solidification conditions to the ice morphology that templates the pore network, giving a basis for predicting scaffold architecture rather than establishing it empirically. The predicted pore geometry and colloidal partitioning are consistent with data reported for freeze-cast alginate scaffolds [1]. Extension to whole-sample thermal fields is the next step.

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Acknowledgements

We gratefully acknowledge Polish high-performance computing infrastructure PLGrid (HPC Center: ACK Cyfronet AGH) for providing computer facilities and sup-> port within computational grant no. PLG/2026/019728. This research was conducted within the framework of statutory activities no. 16.16.110.663 at AGH University of Krakow.

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Controlling Hydrogel Microarchitecture with Filamented Light Printing

Acknowledgements
This work is supported by the LUMINATE project (https://luminateproject.eu/) and the Tissue Engineering and Biofabrication Laboratory at ETH Zurich.

Full abstract available in the supplementary file for participants only

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Development of Hydroxyapatite-Reinforced Furan-Based Photocurable Composites

Improving the healing of complex bone fractures remains a significant clinical challenge, particularly in the context of an aging population and in patients with cancellous bone fractures [1]. Consequently, photopolymerizable in situ organic–inorganic composites, which can be delivered in a liquid state and subsequently converted into mechanically robust solid materials under appropriate conditions, have attracted considerable interest as promising materials for fracture treatment [2].

In this work, a furan-based photocurable composite system was developed for potential use in cancellous bone fracture repair. A furan-vegetable oil macromonomer was synthesized and methacrylated to yield a UV-curable liquid resin. Composite formulations were then prepared by incorporating hydroxyapatite (HAp) at varying loadings (10-30 wt.%) and photopolymerized. Chemical structure was confirmed by IR spectroscopy, and mechanical testing was carried out to evaluate the effect of HAp content on composite performance and its relevance for bone substitute applications.

Structural analysis confirmed successful synthesis of the methacrylated furan-based macromonomer and formation of the photocured composite network upon UV exposure. Increasing amount of HAp increased tensile strength of composites (Fig. 1) and contributed to raise the Young's modulus from approximately 11 MPa to 51 MPa, while the strain at break decreased from around 24% to 15%, indicating a stiffer but less deformable network at higher filler content.

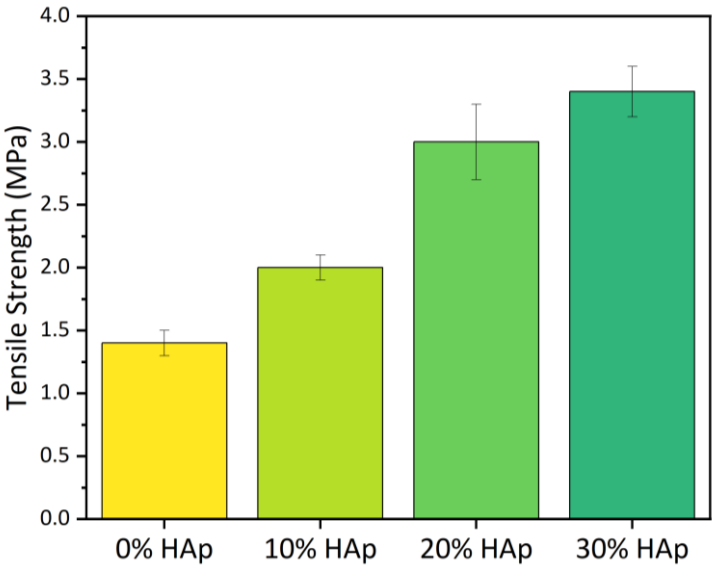

Figure 1. Tensile properties of HAp-reinforced furan-based material at 0, 10, 20 and 30 % of HAp concentration

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Acknowledgements

This work has been supported by research project Preludium Bis4 from the Polish National Science Center “New composite biomaterials prepared by photocrosslinking”, UMO-2022/47/O/ST5/01653

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Heat-Treatment-Induced Hardness–Toughness Trade-off and Anisotropy Reduction in DMLS Ti6Al4V

Direct Metal Laser Sintering (DMLS), a process-specific implementation of laser powder bed fusion, enables fabrication of complex Ti6Al4V components. However, rapid solidification produces a fine acicular α′-type morphology, residual stresses and orientation-dependent mechanical behaviour. Post-processing heat treatment may improve damage tolerance by relaxing residual stresses and reducing the mechanical significance of the directional microstructure.

The aim of the study was to evaluate the effect of annealing temperature on microhardness, Charpy impact toughness, mechanical anisotropy and fracture morphology of DMLS-produced Ti6Al4V ELI. Specimens were fabricated in XY and XZ orientations at a volumetric energy density of 127 J/mm³ and annealed at 650, 750, 850 or 950°C for 2 h under argon; the as-built state served as the reference.

Microhardness was assessed using the Vickers HV5 method on planes perpendicular and parallel to deposited layers. Charpy impact toughness was determined for both build orientations, and scanning electron microscopy (SEM) was used for microstructural and fractographic assessment. Hardness and impact-toughness anisotropy coefficients were calculated to quantify orientation dependence.

Increasing annealing temperature produced progressive softening together with a pronounced increase in impact resistance. At 950°C, perpendicular-plane hardness decreased by 18.8%, from 401.7 ± 20.8 to 326.0 ± 5.6 HV5, whereas mean Charpy impact toughness increased by 266.8%, from 14.29 ± 2.50 to 52.41 ± 8.50 J/cm². The hardness anisotropy coefficient decreased from 1.078 to 1.015 and the impact-toughness anisotropy coefficient from 1.397 to 1.031. SEM observations showed a gradual transition from defect-sensitive quasi-brittle fracture toward predominantly ductile microvoid coalescence. A strong inverse hardness–toughness relationship was observed ($r = -0.984$; $R^2 = 0.967$; $p = 0.003$).

Table 1. Mechanical response after heat treatment

Condition	HV5 (XZ)	HV5 (XY)	Kc (XZ) [J/cm²]	Kc (XY) [J/cm²]	Fracture mode
As-built	401.7	372.7	16.65	11.92	Quasi-brittle
650°C	387.7	361.3	21.30	17.45	Quasi-brittle
750°C	371.0	341.6	33.10	30.00	Mixed-mode
850°C	351.0	337.6	46.24	45.09	Predominantly ductile
950°C	326.0	321.3	53.20	51.60	Predominantly ductile

Overall, annealing produced a clear hardness–toughness trade-off while substantially reducing manufacturing-induced anisotropy. Within the investigated conditions, 850–950°C provided the most favourable combination of retained hardness, enhanced dynamic fracture resistance, near-isotropic mechanical response and predominantly ductile fracture behaviour.

Acknowledgements: “The task is financed under a commission from the Minister of Science and Higher Education entitled ‘Polytechnic Network VIA CARPATIA’ – 2nd edition, implemented in the years 2026–2030, with total funding of PLN 9,977,000.”

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Effect of a Commercial Mouthwash on Short-Term Degradation and Mechanical Stability of Surgical Sutures

Surgical sutures are biomaterials used to approximate wound edges and stabilize tissues during healing. In the oral cavity, saliva, pH fluctuations, antiseptics and mechanical loading may alter their behavior. This is particularly relevant for absorbable sutures, which require predictable strength retention, and braided materials prone to fluid sorption.

The aim of the study was to evaluate the effect of a commercial mouthwash on the short-term mechanical stability, mass changes and environmental pH of four USP 4-0 sutures: polyglactin 910 (PGLA40F0619), braided silk (SI40HR20), polypropylene monofilament (PP40F0619) and coated polyamide/Supramid (SB40HS20). The materials represented absorbable and non-absorbable, natural and synthetic, and monofilament and multifilament sutures.

Samples were conditioned at 37°C under static exposure. Mass, environmental pH and mechanical properties were assessed at baseline and after 3, 7, 10 and 14 days. Tensile testing was performed using a ZwickRoell Z050 universal testing machine at 10 mm/min, recording maximum breaking force and deformation before failure.

The mouthwash was acidic at baseline (pH ~5.43) and remained stable throughout incubation (5.36–5.44). Braided silk showed a mass increase of nearly 90% by day 3, whereas polypropylene exhibited the highest mass stability. Non-absorbable PP and SB retained stable breaking forces of approximately 7.3–9.5 N. PGLA showed the highest absolute breaking force, remaining at approximately 17 N on day 14 despite a transient decline around day 7. Key material-specific observations are summarized in Table 1.

Tab. 1. Suture characteristics and experimental response.

Suture	Manufacturer-declared profile	Experimental observation
PGLA	Absorbable polyglactin 910; complete hydrolytic absorption ~56–70 d	~17 N at day 14; transient decrease around day 7
SI	Braided silk; classified as non-absorbable	~90% mass increase by day 3; highest fluid uptake
PP	Polypropylene monofilament; non-absorbable, intended for durable support	Highest mass stability; stable breaking force
SB	Supramid: PA 6.6 strands in PA 6 sheath; non-absorbable	Stable breaking force; limited short-term deterioration

Acknowledgements: “The task is financed under a commission from the Minister of Science and Higher Education entitled ‘Polytechnic Network VIA CARPATIA’ – 2nd edition, implemented in the years 2026–2030, with total funding of PLN 9,977,000.”

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Covalent Integration of Chondroitin Sulfate into Oxidized Hyaluronic Acid Hydrogels

Introduction: Hyaluronic acid hydrogels crosslinked via dynamic hydrazone bonds (oxi-HA/ADH) form injectable, self-healing networks without cytotoxic crosslinkers, but HA alone provides limited biochemical cues for chondrogenesis [1]. Incorporation of oxidized chondroitin sulfate (oxi-CS), a glycosaminoglycan with prochondrogenic and anti-inflammatory activity, allows covalent integration into the same hydrazone network via its aldehyde groups, combining favorable gelation dynamics with enhanced bioactivity relevant to cartilage tissue engineering [2].

Materials and Methods: HA and CS were dissolved separately in UHQ water (1 g/100 mL each) and oxidized with sodium periodate in separate flasks: HA at a $NaIO_4$:HA molar ratio of 2:1 for 24 h and CS at $NaIO_4$:CS molar ratios of 0.5:1, 0.75:1, 1:1, and 1.25:1 for 4 h (both in dark conditions and at room temperature), followed by ethylene glycol quenching, dialysis (MWCO 3.5 kDa, 72 h), and freeze-drying to yield oxi-HA and oxi-CS. Hydrogels were prepared by crosslinking oxi-HA and oxi-CS with adipic acid dihydrazide (ADH), whereby the aldehyde groups of both oxidized polymers reacted with the hydrazide groups of ADH to form a covalently crosslinked, dynamic hydrazone network; gelation proceeded at 37 °C. The obtained hydrogels were characterized in terms of degree of oxidation, microstructure (SEM, optical microscopy), chemical structure (FTIR), swelling behavior and shape stability, pH of the surrounding solution after 24 h incubation, and biocompatibility (AlamarBlue, LDH, Live/Dead staining).

Results: Both HA and CS were successfully oxidized across the tested $NaIO_4$ ratios, with FTIR confirming aldehyde formation. Upon combination with ADH, all formulations gelled, yielding hydrogels with good shape stability, favorable swelling behavior, and preliminary biocompatibility results showing supported cell viability and metabolic activity without pronounced cytotoxicity. Overall, the developed formulations appear structurally robust and biologically favorable, supporting further evaluation for cartilage tissue engineering applications.

Conclusions: The dual oxidation of HA and CS, followed by their covalent incorporation into a single hydrazone-crosslinked network via ADH, represents a promising strategy for developing injectable hydrogels that combine the favorable gelation dynamics of HA with the biologically active, chemically integrated contribution of CS.

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Acknowledgements

This study was supported from the subsidy (No 16.16.160.557) and by the Program „Excellence initiative – research university" for the AGH University of Krakow.

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Quercetin-Loaded Solid Lipid Particles: Cytocompatible *In Vitro* and Enhance Skin Epithelization in *Ex Vivo* Wound Model

Quercetin is a widely known flavonoid present in various foods, such as onions, nuts, or tea. Due to its antioxidant and anti-inflammatory properties, quercetin supports tissue regeneration and may positively influence wound healing [1]. Wound healing is a very complicated process divided into four phases: haemostasis, inflammation, proliferation, and remodelling [2]. Each phase is regulated by growth factors. e.g., transforming growth factor beta (TGF-β), reactive oxygen species (ROS), or components of the immune system. Due to the complex structure of human skin and its healing, in vitro and in vivo testing of topical biomaterials often provides limited or inconsistent results [3].
In this study, the main research was focused on solid lipid microparticles prepared from lauric acid with encapsulated quercetin (LAU_Q). The microparticles were fabricated with hot emulsification method. Microparticles without addition of quercetin (LAU) were used as a control. The analysis included particle size distribution, morphology, and quercetin release profile into phosphate buffered saline (PBS). The cytotoxicity of the microparticles was investigated on L929 fibroblasts. They were also tested in an ex vivo human skin model, where the influence on skin epithelization was evaluated.
The LAU_Q particles observed under the SEM microscope had a spherical shape and an average diameter of 470 ± 15 nm. Release studies show that within 7 days 44% of encapsulated quercetin was released from LAU_Q into PBS. The Alamar Blue viability test showed an improvement in L929 cell metabolic activity for a microparticle concentration of 5 µg/mL where the resazurin reduction was approximately 60% higher as compared to the control. The human ex vivo skin model showed enhanced epidermal epithelization, however, exhibited patient-dependent variability.
In conclusion, the results support the applicability of LAU_Q microparticles as a candidate drug delivery system that improves skin repair. Their favourable physicochemical properties and biological activity warrant further development toward clinical-orientated wound care formulations.

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