

IOCFB
2026
Conference

The 2nd International Online Conference on Functional Biomaterials

8–10 July 2026 | Online

Program and Abstract Book

Organizers



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The 2nd International Online Conference on Functional Biomaterials

8–10 July 2026 | Online



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Prof. Dr. Pankaj Vadgama

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Dr. Lidy Fratila-Apachitei

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Welcome from the Chair

Dear Colleagues,

It is our pleasure to announce the **2nd International Online Conference on Functional Biomaterials (IOCFB2026)**. The conference is organized by the MDPI open access *Journal of Functional Biomaterials* (ISSN: 2079-4983, Impact Factor: 5.9) and will be held **online** from **8 to 10 July 2026**.

We warmly welcome you to join us at this conference, where we aim to provide a highly interactive platform for researchers around the world to share novel findings, discuss major achievements, and explore challenges in functional biomaterials development.

The main themes of the conference include:

1. Dental Biomaterials;
2. Bone Biomaterials;
3. Antibacterial Biomaterials and Surfaces;
4. Biomaterials for Tissue Engineering and Regenerative Medicine;
5. Biomaterials for Drug Delivery and Therapy;
6. Biomaterials and Implantable Devices for Healthcare;
7. Bioprinting and Bio-Fabrication;
8. Reactive/Smart Biomaterials.

This conference offers an excellent opportunity for researchers to present their latest work, engage in real-time discussions and participate in live Q&A sessions. Two types of live sessions will be featured: Oral Presentations and Flash Poster Presentations. With an open forum concept, the event provides a fully accessible and inclusive environment—removing geographical and travel barriers and placing all participants in the same interactive space. This setting not only promotes new research connections but also fosters fresh scientific directions through meaningful exchanges.

The conference will be held entirely online, with a modest registration fee and no travel or accommodation costs required.

Outstanding contributions from each session will be considered for conference awards. Additionally, rather than being limited to a single live poster session, participants are also invited to upload and display their work in the online poster gallery on the conference website. As a result, all poster submissions will now be eligible for awards.

We look forward to your participation in IOCFB 2026 and to fostering a vibrant, collaborative environment to advance functional biomaterials research.

Kind regards,

Prof. Dr. Pankaj Vadgama

School of Engineering and Materials Science, Queen Mary University of London, London, UK

On behalf of the IOCFB 2026 Secretariat



Prof. Dr. Pankaj Vadgama
Conference Chair

School of Engineering and
Materials Science, Queen Mary
University of London, London, UK



Journal of
Functional Biomaterials
an Open Access Journal by MDPI

The *Journal of Functional Biomaterials* (*JFB*, ISSN 2079-4983) is an international and interdisciplinary scientific journal that publishes regular research papers (articles), reviews, and communications about applications of materials for biomedical use. This specific research field is the result of collaborations between different disciplines: chemistry, medicine, pharmacology, engineering, and biology. The objective of this collaboration is to lead to the implementation of new devices to restore form and human body functions. The mission of *JFB* is to focus the attention on physicochemical characteristics and their importance in the interactions between biomaterials and living tissues as well as studies on the preparation, performance, and use of biomaterials in biomedical devices in physiological environments. Our aim is to encourage scientists to publish their results in as much detail as possible.

Impact Factor: 5.9 (2025); **5-Year Impact Factor:** 6.2 (2025)

Session Chairs



Dr. Serena Danti

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Prof. Dr. Meital Zilberman

Department of Biomedical Engineering, The Iby and Aladar Fleischman Faculty of Engineering, Tel Aviv University, Tel Aviv, Israel



Prof. Dr. Elisa Boanini

Department of Chemistry "Giacomo Ciamician", University of Bologna, Bologna, Italy

Keynote Speakers



Prof. Dr. Aldo R. Boccaccini

Institute of Biomaterials,
Department of Materials
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University of Erlangen-
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Prof. Dr. Mark Bradley

EaStChem School of Chemistry,
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Invited Speakers



Prof. Dr. Chiara Tonda Turo

Department of Mechanical and Aerospace Engineering, Politecnico di Torino, Torino, Italy



Prof. Dr. Yuta Kurashina

Division of Advanced Mechanical Systems Engineering, Institute of Engineering, Tokyo University of Agriculture and Technology, Tokyo, Japan



Prof. Dr. James Kit-Hon Tsoi

Dental Materials Science, Faculty of Dentistry, The University of Hong Kong, Sai Ying Pun, Hong Kong, China



Professor Christele Combes

CIRIMAT, Toulouse INP, Université de Toulouse, Toulouse, France



Prof. Dr. Dennis Douroumis

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Program at a Glance

	Day 1	Day 2	Day 3
Morning	Chair Welcome Speech Session 5 (part I). Biomaterials for Drug Delivery and Therapy Flash Poster (Session 5)	Session 7. Bioprinting and Bio-Fabrication Flash Poster (Session 7) Session 2. Bone Biomaterials Flash Poster (Session 2)	Session 1. Dental Biomaterials Flash Poster (Session 1) Session 6. Biomaterials and Implantable Devices for Healthcare Flash Poster (Session 6)
Break			
Afternoon	Session 5 (part II). Biomaterials for Drug Delivery and Therapy Session 8. Reactive/Smart Biomaterials Flash Poster (Session 8) Poster Breakout Session (S5 & S8)	Session 4. Biomaterials for Tissue Engineering and Regenerative Medicine Flash Poster (Session 4) Poster Breakout Session (S7 and 2 & S4)	Session 3. Antibacterial Biomaterials and Surfaces Flash Poster (Session 3) Poster Breakout Session (S1 and 6 & S3)

IOCFB 2026 Program

8 Jul 2026 (Wednesday)
Opening Ceremony
S5. Biomaterials for Drug Delivery and Therapy (part I)
Time: 09:00 CEST (Basel) | 15:00 CST Asia (Beijing) | 03:00 EDT (New York)

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
09:00–09:10	15:00–15:10	Welcome from the conference chair <i>Prof. Dr. Pankaj Vadgama</i>	
09:10–09:15	15:10–15:15	Welcome from the session chair <i>Dr. Filippo Rossi</i>	
09:15–09:35	15:15–15:35	Invited Talk Prof. Dr. Giuseppe Perale	The Use of a Xeno-Hybrid Bone Substitute in Pediatric Orthopedic Oncology: A New Clinical Paradigm
09:35–09:55	15:35–15:55	Invited Talk Prof. Dr. Yuta Kurashina	Applications of Nanosized Drug Delivery Systems Using Ultrasound
09:55–10:10	15:55–16:10	Presentation Chunxia Li	Functional Nanomaterials for Tumor Immunotherapy
10:10–10:25	16:10–16:25	Presentation Vinh-Han Dac Le	Layered Double Hydroxide-Engineered Oxidized Hyaluronic Acid/Gelatin/Carboxymethyl Chitosan Injectable Hydrogel Incorporating Salvianolic Acid B and Dexamethasone for Cartilage Regeneration
10:25–10:40	16:25–16:40	Presentation Bahareh Azimi	Streamlined Nanodrug Delivery Systems for Localized Cancer Therapy via Electrospinning and Electrospay
10:40–10:50	16:40–16:50	Break	
10:50–11:05	16:50–17:05	Presentation Gintaras Matulis	Semi-Solid Extrusion 3D Printing Enhances Epidermal Accumulation of Menthol from PVA-Based Transdermal Biomaterial Films: An Ex Vivo Comparative Permeation Study
11:05–11:20	17:05–17:20	Presentation Carla Serri	Optimization of Rutin- and Quercetin-Loaded Chitosan Nanoparticles for Enhanced Anti-Inflammatory Delivery
11:20–11:35	17:20–17:35	Presentation Chris Manglaris	Linking Neuroproteomics to Predictive Brain Drug Delivery: A Physicochemically-Informed Modeling Framework for Silver Nanocarriers in Alzheimer's and Parkinson's Disease
11:35–11:40	17:35–17:40	Flash Poster Presentation Pallavi Rattapal Meshram	Effect of Gelation Route on Pore Architecture, Swelling, and Degradation of Silk Fibroin Hydrogels
11:40–11:45	17:40–17:45	Flash Poster Presentation Berna Ateş	Cardiomyocyte Loaded Polymeric Microsphere Design for Treatment of Cardiac Regeneration after Myocardial Ischemia and In Vitro Evaluation
11:45–11:50	17:45–17:50	Flash Poster Presentation Roberta Rovelli	Dual-Ion Crosslinked Alginate Hydrogels for Combined Antioxidant and Anti-Inflammatory Delivery in Colon-Targeted Therapy
11:50–11:55	17:50–17:55	Flash Poster Presentation Ekaterina Naumenko	Prodigiosin-Loaded Microvesicles as a Novel Anticancer Drug
11:55–12:00	17:55–18:00	Flash Poster Presentation Alicja Tomasiak	Functional Performance and Biocompatibility of PEDOT:GABA Neurotransmitter-Loaded Coatings
12:00–12:05	18:00–18:05	Flash Poster Presentation Q&A	

S5. Biomaterials for Drug Delivery and Therapy (part II)
S8. Reactive/Smart Biomaterials

Time: 14:00 (CEST, Basel) 20:00 (CST Asia, Beijing) 08:00 (EDT, New York)			
CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
14:00–14:05	20:00–20:05	Welcome from the session chair Dr. Filippo Rossi	
14:05–14:25	20:05–20:25	Invited Talk Dr. Filippo Rossi	Microfluidic-Synthesized pH-Responsive Nanoparticle–Hydrogel Composites for Targeted Osteoarthritis Drug Delivery
14:25–14:40	20:25–20:40	Presentation Monika Rojewska	Influence of Mucoadhesive Polymer Interactions with Lipid and Mucin on Adhesion: Implications for Drug Delivery Systems
14:40–14:55	20:40–20:55	Presentation Jurga Bernatoniene	Microstructural and Mechanical Characterization of PVA-Based Drug Delivery Films Containing Menthol: Correlation Between SEM Morphology and Texture Analysis Across Three Manufacturing Methods
14:55–15:10	20:55–21:10	Presentation Ying Li	Dual-Loaded Curcumin and Phenformin Copolymer Micelles for Targeted Colorectal Cancer Therapy via Mitochondrial Stress and Metabolic Modulation
15:10–15:15	21:10–21:15	Welcome from the session chair—Dr. Serena Danti	
15:15–15:35	21:15–21:35	Invited Talk Dr. Fatemeh Mokhtari	Bioinspired Flexible and Stretchable Coil Structure from Functionalized Piezoelectric Nanofibers for Self-Powered Implantable Devices
15:35–15:55	21:35–21:55	Invited Talk Dr. Zhao Qin	Multiscale Mechanics of Hierarchical Porous Bone Studied by Physics-Informed AI
15:55–16:10	21:55–22:10	Presentation João Silva	Piezoelectric 3D-Printed Scaffolds Coupled with Ultrasound Stimulation for Improved Bone Tissue Engineering Strategies
16:10–16:25	22:10–22:25	Presentation Sara Ferraris	Sustainable Biomaterials for Smart Multifunctional Active Wound Dressings
16:25–16:30	22:25–22:30	Flash Poster Presentation Ahmad Zarwi	Innovations in Injectable Conductive Hydrogels for Neural Regeneration and Biointerface Compatibility
16:30–16:35	22:30–22:35	Flash Poster Presentation Aishwarya Devendra Murkar	Investigation of Carbon Dots for Toxic Metal Chelation Therapy Employing Red Blood Cell Membranes as a Biomimetic Model
16:35–16:40	22:35–22:40	Flash Poster Presentation Ruijie Xu	Biomimetic Patch for Vascular Repair and Patency Diagnosis
16:40–16:45	22:40–22:45	Flash Poster Presentation Q&A	
16:45–16:55	22:45–22:55	Break	
16:55–17:15	22:55–23:15	Poster Breakout Session S5 & S8	The Poster Sessions will take place in Zoom break-out rooms. The poster list will be announced later.

9 Jul 2026 (Thursday)
S7. Bioprinting and Bio-Fabrication
S2. Bone Biomaterials

Time: 09:00 CEST (Basel) 15:00 CST Asia (Beijing) 03:00 EDT (New York)			
CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
09:00–09:05	15:00–15:05	Welcome from the session chair Dr. Lidy Fratila-Apachitei	

09:05–09:35	15:05–15:35	Keynote Talk Prof. Dr. Aldo R. Boccaccini	Enhancing Bioinks for Biofabrication by Tailored Additions of Ion Releasing Bioactive Glass Nanoparticles
09:35–09:55	15:35–15:55	Invited Talk Prof. Dr. Min Wang	Organoid Bioprinting
09:55–10:10	15:55–16:10	Presentation Xinyang Zhang	New Natural Polymer-Based Bioinks and Their 3D Bioprinting for Liver Tissue Engineering
10:10–10:25	16:10–16:25	Presentation Xiaodie Chen	3D Bioprinting of New Hydrogel-Based Bioinks into Cell-Scaffold Constructs for Articular Cartilage Repair
10:25–10:30	16:25–16:30	Flash Poster Presentation Kristin Schüller	Top-Down and Bottom-Up Biofabrication of Biomimetic Cartilage Scaffolds for Regenerative Applications
10:30–10:35	16:30–16:35	Flash Poster Presentation Elisa Roldan Ciudad	Data-Driven Inverse Design of Electrospun Biomaterials with Controlled Fibre-Diameter Distributions for Tissue Regeneration
10:35–10:40	16:35–16:40	Flash Poster Presentation Q&A	
10:40–10:45	16:40–16:45	Welcome from the session chair <i>Prof. Dr. Elisa Boanini</i>	
10:45–11:05	16:45–17:05	Invited Talk Professor Christele Combes	Amorphous Calcium Pyrophosphate-Based Materials for Bone Reconstruction
11:05–11:25	17:05–17:25	Invited Talk Dr. Simone Sprio	Self-Hardening Bioactive Apatite Scaffolds for Bone Regeneration
11:25–11:40	17:25–17:40	Presentation Yujie Zhang	Digital Light Processing for β -TCP/PDLLA-co-TMC Nanocomposite Bone Tissue Engineering Scaffolds with Different β -TCP Concentrations
11:40–11:55	17:40–17:55	Presentation Paulina Kazimierczak	Bisphosphonate Delivery via a pH-Responsive Bone Implant for Accelerated Repair of Osteoporotic Bone Fractures
11:55–12:10	17:55–18:10	Presentation Gabriela Graziani	Ionized Jet Deposition of Bone-Mimetic, Complex Biomaterials
12:10–12:15	18:10–18:15	Flash Poster Presentation Silvia Marino	Compositional Control of Strontium-Substituted Hydroxyapatite Governs Bioactivity and Mechanical Response in Electrospun PCL/Gel Scaffolds
12:15–12:20	18:15–18:20	Flash Poster Presentation Emilly Bulhões	Surface Modification of n-HAp Increases the Compatibility with PLA Scaffold Composites
12:20–12:25	18:20–18:25	Flash Poster Presentation Q&A	

S4. Biomaterials for Tissue Engineering and Regenerative Medicine

Time: 14:00 (CEST, Basel) | 20:00 (CST Asia, Beijing) | 08:00 (EDT, New York)

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
14:00–14:05	20:00–20:05	Welcome from the session chair—Dr. Piergiorgio Gentile	
14:05–14:35	20:05–20:35	Keynote Talk Prof. Dr. Mark Bradley	Polymer Microarrays for the Control and Manipulation of Stem Cells
14:35–14:55	20:35–20:55	Invited Talk Prof. Dr. Chiara Tonda Turo	Shaping Cell Response through Engineered Natural-Derived Polymers and Hydrogels
14:55–15:15	20:55–21:15	Invited Talk Prof. Dr. Ana Ferreira-Duarte	Designing Bioinspired Biomaterials for Functional Tissue Regeneration
15:15–15:35	21:15–21:35	Invited Talk Prof. Dr. Dimitrios I. Zeugolis	Macromolecular Crowding in Tissue Engineering and Regenerative Medicine
15:35–15:50	21:35–21:50	Presentation Serena Munaò	From Spontaneous Differentiation to Functional Synaptic Networks: Neurogenic Modulation of SH-SY5Y Cells by Semiconductive P3HT Interfaces

15:50-16:05	21:50-22:05	Presentation Anna Rossanese	Synthesis and Characterization of Type I Collagen-Based Scaffolds Cross-Linked with Natural Polyphenols Extracted from Green Tea
16:05-16:20	22:05-22:20	Presentation Giovanni D'Atri	Injectable and Bioprintable RGD-Functionalized Hydrogels Support Chondrogenic Differentiation of Adipose Mesenchymal Stromal Cells
16:20-16:25	22:20-22:25	Flash Poster Presentation Karen J. Juarez-Navarro	Hybrid 3D-Printed/Electrospun Honeycomb PCL Scaffolds Improve Mechanical Stability and Promote Osteoblast Colonization
16:25-16:30	22:25-22:30	Flash Poster Presentation Inês Dias	Photodynamic Therapy: A Promising Strategy for Alveolar Bone Regeneration
16:30-16:35	22:30-22:35	Flash Poster Presentation Anna P. Abelova	Characterization of Cellular and Molecular Responses to Platelet-Rich Plasma (PRP) from Elderly Patients with Acute Inflammatory Conditions in Cell Culture
16:35-16:40	22:35-22:40	Flash Poster Presentation Q&A	
16:40-16:50	22:40-22:50	Break	
16:50-17:20	22:50-23:20	Poster Breakout Session S7 and S2 & S4	The Poster Sessions will take place in Zoom break-out rooms. The poster list will be announced later.

10 Jul 2026 (Friday)

S1. Dental Biomaterials

S6. Biomaterials and Implantable Devices for Healthcare

Time: 09:00 CEST (Basel) | 15:00 CST Asia (Beijing) | 03:00 EDT (New York)

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
09:00-09:05	15:00-15:05	Welcome from the session chair <i>Prof. Dr. Gianrico Spagnuolo</i>	
09:05-09:25	15:05-15:25	Invited Talk Prof. Dr. James Kit-Hon Tsoi	GenAI for Prosthodontics
09:25-09:40	15:25-15:40	Presentation Mohammad Islam	Graphene Oxide-Modified Portland Cement Enhances Bioactivity and Periapical Healing: An In Vitro and In Vivo Study
09:40-09:55	15:40-15:55	Presentation Fatima Khan	A Multifunctional Injectable Platform for Regenerative Endodontics
09:55-10:10	15:55-16:10	Presentation Youngjune Kim	A Dual-Action Hydrogel System for Endodontic Repair and Infection Control
10:10-10:15	16:10-16:15	Flash Poster Presentation Jiale Ma	Microstructurally Refined Ti-6Al-7Nb via High-Pressure Sliding Modulates Osteoblast Adhesion and Proliferation
10:15-10:20	16:15-16:20	Flash Poster Presentation Niki Karipidou	Design and Physical Characterization of 3D-Printed Collagen Scaffolds for Regenerative Dentistry
10:20-10:25	16:20-16:25	Flash Poster Presentation Les Kalman	Digital Workflow Development of Pin Reinforced Indirect Zirconia Posterior Restorations
10:25-10:30	16:25-16:30	Flash Poster Presentation Q&A	
10:30-10:35	16:30-16:35	Welcome from the session chair <i>Prof. Dr. Meital Zilberman</i>	
10:35-10:55	16:35-16:55	Invited Talk Prof. Dr. Dennis Douroumis	3D Printing of Personalised Drug Eluting Stents

10:55–11:15	16:55–17:15	Invited Talk Prof. Dr. Seung-Kyun Kang	Bioresorbable, Self-Deploying Electronics for Minimally Invasive Brain Interfaces
11:15–11:30	17:15–17:30	Presentation Tom Hanoon kogan	Micro and Nano-Structuring of Hydroxyapatite-MMT Loaded Hydrogels for Bone Regeneration Applications
11:30–11:45	17:30–17:45	Presentation Pedro Morouço	Biomaterials-Enabled Wearables in Sport: Closing the Validity Gap from Lab to Field
11:45–12:00	17:45–18:00	Presentation Angelika Banaś	Optimization of Carbon Nanotube Morphology in Self-Supporting Buckypapers for Bioelectronic Interfaces
12:00–12:05	18:00–18:05	Flash Poster Presentation Kesavamoorthy Muthu	Validation of Clinical CT-Based Volumetric Analysis for In Situ Monitoring of Orthopaedic Implants in Vivo
12:05–12:10	18:05–18:10	Flash Poster Presentation Szymon Smolka	Multifunctional Bioactive Coatings for Metallic Veterinary Implants
12:10–12:15	18:10–18:15	Flash Poster Presentation Q&A	

S3. Antibacterial Biomaterials and Surfaces

Time: 14:00 (CEST, Basel) | 20:00 (CST Asia, Beijing) | 08:00 (EDT, New York)

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
14:00–14:05	20:00–20:05	Welcome from the session chair <i>Prof. Dr. Pankaj Vadgama</i>	
14:05–14:20	20:05–20:20	Presentation Abdullah Abdullah	Electrochemically Synthesized Multifunctional PEDOT–Ceftazidime Films for Electrically Triggered, Advanced Bacteria-Responsive Antibacterial Coatings
14:20–14:35	20:20–20:35	Presentation Silvia Spriano	Peptoids Impart Antibiofilm and Cell Protective Actions to an Etched Titanium Surface
14:35–14:50	20:35–20:50	Presentation Frank Eduardo Meléndez Anzures	Gentamicin-Eluting TiO ₂ Nanotubes on Ti-24Zr-10Nb-2Sn Alloy for Enhanced Antibacterial Performance Against Staphylococcus aureus
14:50–15:05	20:50–21:05	Presentation Camilla Reggio	Balancing Cytocompatibility and Bacterial Resistance: Insights from Silver-Modified Ti6Al4V Co-Culture Studies
15:05–15:20	21:05–21:20	Presentation Linjia Li	Rapid and Broad-Spectrum Antimicrobial Behavior of Laser-Cladded Copper Surfaces for Infection-Resistant Biomaterials
15:20–15:35	21:20–21:35	Presentation António Guiomar	Neat Chitosan Films That Release Polyhexanide for Use in Antibacterial Wound Dressings
15:35–15:50	21:35–21:50	Presentation Abirami Karthikeyan	Bacterial-Mediated Synthesis of Silver-Doped ZnO Nanocomposites for Inhibition of Biofilm Formation and Quorum Sensing in Pseudomonas aeruginosa
15:50–15:55	21:50–21:55	Flash Poster Presentation Pery Freitas	Functionalized Surface of a Ceramic Carbonated Apatite Substrate with an Antibacterial α -Tocopheryl Phosphate Organic Layer
15:55–16:00	21:55–22:00	Flash Poster Presentation Julia Lisoń-Kubica	Bacterial Biofilms and Titanium Implants: Current Understanding, Clinical Challenges, and Emerging Surface Modification Strategies
16:00–16:05	22:00–22:05	Flash Poster Presentation Samir Zergat	Manufacturing of Tear Resistant Probiotic Loaded Membrane Patches for Application on Eardrums in Chronic Otitis Media Treatment
16:05–16:10	22:05–22:10	Flash Poster Presentation Julia Kolasa	Surface Modification Strategies for Mitigating Biofilm Adhesion on Glaucoma Drainage Devices in the Intraocular Environment: A Systematic Review

16:10-16:15	22:10-22:15	Flash Poster Presentation Felipe Cordova Lozano	Water-Stable Electrospun PVA Nanofibers via Vapor Crosslinking and Controlled In Situ Silver Nanoparticle Incorporation for Antimicrobial Applications
16:15-16:20	22:15-22:20	Flash Poster Presentation Ihtisham Ul Haq	Antimicrobial Effects of Sodium Alginate/Poly-L-Lysine Based Films and Their Deposition onto Urinary Catheters Using Ultrasonic Spray Coating
16:20-16:25	22:20-22:25	Flash Poster Presentation Q&A	
16:25-16:35	22:25-22:35	Break	
16:35-16:55	22:35-22:55	Poster Breakout Session S1 and 6 & S3	The Poster Sessions will take place in Zoom break-out rooms. The poster list will be announced later.

Poster List

Submission Id	Authors	Title
S1. Dental Biomaterials		
sciforum-157035	Miruna Andreea Anghel, CATALIN Popa, Alexandru Iliescu, Daniela Micu, Ioana Mitrut, Horia Manolea	Metrological Assessment of the Trueness of Prosthetic Metal Frameworks Manufactured Through Digital Techniques
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sciforum-172655	Iram Elamin, Subhasis Mandal, Meghna Rao, Ishraga Elsayed, Priscilla Okyere, Angela Hatton, Victor Hsia, Jiabing Fan	Engineering Trb3-Targeted Exosome-Mimetics to Promote Bone Regeneration in Osteoporosis
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Session 1. Dental Biomaterials

sciforum-181035: A Dual-Action Hydrogel System for Endodontic Repair and Infection Control

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Objectives: This study endeavors to engineer and evaluate a dual-functional hydrogel system integrating gelatin methacryloyl (GelMA) and 1-octyl-3-methylimidazolium tetrafluoroborate (OMIM-BF₄), with the objective of achieving optimal physicochemical properties, confirming biocompatibility, and enabling targeted disinfection of the root canal system while concurrently fostering stem cell-mediated tissue regeneration.

Materials & Methods: GelMA was synthesized via methacrylation of porcine-derived gelatin using methacrylic anhydride, followed by dialysis and lyophilization. Structural modification was confirmed through proton nuclear magnetic resonance (¹H NMR), with characteristic vinyl proton peaks appearing at ~5.5–6.0 ppm. The ionic liquid OMIM-BF₄ was incorporated into 10% (v/v) GelMA at concentrations of 0.1, 0.25, and 0.5 μL/mL. Fourier-transform infrared spectroscopy (FTIR) analysis confirmed successful integration of OMIM into the GelMA network without disruption of primary functional groups. Injectability was assessed by extrusion through a 25-gauge needle to simulate clinical delivery. Disc-shaped hydrogels were fabricated to evaluate swelling behavior and enzymatic degradation. Swelling capacity was quantified following 24-hour immersion in phosphate-buffered saline (PBS), while degradation kinetics were monitored over a 14-day period in the presence of 1 U/mL collagenase.

Results: GelMA methacrylation was confirmed by ¹H NMR with a distinct peak at ~5.5–6.0 ppm corresponding to vinyl protons, and FTIR verified OMIM-BF₄ incorporation into GelMA without altering key functional groups. All GelMA–OMIM formulations demonstrated favorable injectability and comparable swelling profiles across groups. Notably, the 0.25 μL/mL OMIM concentration exhibited the greatest resistance to enzymatic degradation, showing significantly slower mass loss over the 14-day period in 1 U/mL collagenase.

Conclusions: The dual-functional GelMA–OMIM platform represents a promising solution for injectable scaffold for root canal disinfection and regeneration.



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sciforum-181039: A Multifunctional Injectable Platform for Regenerative Endodontics

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Objective: In this study, we aim to develop and characterize an injectable, photocrosslinkable gelatin methacryloyl (GelMA) hydrogel incorporating manganese dioxide (MnO₂) nanoparticles as a multifunctional scaffold for dental pulp stem cell (DPSC) delivery in regenerative endodontics.

Methods: MnO₂ nanoparticles were synthesized via redox precipitation and characterized using transmission electron microscopy (TEM) and dynamic light scattering (DLS) to confirm morphology and particle size. Gelatin methacryloyl (GelMA) was synthesized by reacting porcine gelatin with methacrylic anhydride, followed by dialysis and lyophilization. Structural confirmation was done using proton nuclear magnetic resonance (¹H NMR). MnO₂ nanoparticles were incorporated into 10% (w/v) GelMA at concentrations of 25, 50, and 100 µg/mL. FTIR analysis was performed to assess nanoparticle–GelMA interactions. Hydrogel injectability was evaluated using a 25G needle. Swelling behavior was measured after 24 h of immersion in PBS. Enzymatic degradation was assessed over 14 days in 1 U/mL collagenase. Biocompatibility was assessed via the MTS assay using human dental pulp stem cells (DPSCs).

Results: TEM and DLS analyses confirmed spherical MnO₂ nanoparticles with an average size of ~60 nm. GelMA methacrylation was validated by ¹H NMR, with distinct vinyl proton peaks observed at ~5.5 and ~5.7 ppm, confirming successful functionalization with methacryloyl groups. FTIR spectra of MnO₂ revealed characteristic Mn–O stretching vibrations around 500–530 cm⁻¹ and broad –OH stretching peaks near 3400 cm⁻¹, confirming the presence of surface hydroxyl groups and metal–oxide bonding. All MnO₂–GelMA formulations maintained smooth injectability through a 25G needle. Swelling studies showed no statistically significant differences among groups. However, incorporation of MnO₂ reduced enzymatic degradation, with higher concentrations exhibiting slower mass loss over 14 days in 1 U/mL collagenase. MTS assays demonstrated high DPSC viability at 24 and 72 hours, with the 100 µg/mL MnO₂–GelMA group exhibiting the highest metabolic activity.

Conclusion: The MnO₂–GelMA hydrogel system exhibits promising characteristics as an injectable, cytocompatible, and degradation-resistant scaffold for regenerative endodontics.



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sciforum-175054: Bonding Performance, Mass Stability, and Mechanical Properties of Self-adhesive Resin Composites and Conventional Dental Composites: A Comparative Laboratory Evaluation

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Introduction: Self-adhesive resin composite (SARC) is gaining popularity due to its simplified clinical steps. The objectives of this study were to evaluate the bonding performance, mass stability and mechanical properties of three SARCs and to compare them with two conventional resin composites (RCs) using a universal adhesive system (UAS).

Materials and Methods: A total of 80 enamel blocks, 5 mm x 5 mm, were prepared and embedded in an acrylic mold. The surface of enamel was polished using 600-grit carbide paper to create a smear layer. After acid etching, a 2mmX2mm cylinder-shaped restoration was made either with one of three SARC materials or with two types of RC using UAS. The shear bond strength test was performed after 24 h of water incubation and after 1 year of artificial aging. The mass stability of the hexagonal-shaped SARC and conventional RC was evaluated using water sorption and solubility tests. The mechanical properties, including Vickers hardness, elastic modulus and creep, were evaluated after 24 h of water incubation and after 1 year of artificial aging.

Results: Both material type and aging showed a significant effect on bonding performance, mass stability and mechanical properties of SARC and conventional RC (p0.05). The shear bond strength of SARC was comparable to that of conventional RC+ UAS. Conventional RC showed less water sorption and solubility compared to SARC. The Vickers hardness, elastic modulus and creep properties of some SARC were inferior compared to those of conventional RC both at 24 h and at 1 year.

Conclusion: The bonding performance of SARC can substitute for that of conventional RC+ UAS; however, inferior mass stability and mechanical properties limit its use in routine dental restorative procedures.



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sciforum-175236: Design and Physical Characterization of 3D-Printed Collagen Scaffolds for Regenerative Dentistry

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Tissue engineering in regenerative dentistry integrates biomaterials and biofabrication strategies to develop advanced solutions for oral tissue repair; however, significant material and structural challenges persist due to the heterogeneous nature of oral tissues and the limited regenerative capacity of alveolar bone. Additive manufacturing offers a promising alternative to conventional grafting approaches, which are frequently associated with donor site morbidity, immune reactions, and clinical complications. In this study, collagen-based biomaterial systems were developed and systematically evaluated for extrusion-based three-dimensional (3D) bioprinting of scaffolds intended for alveolar bone regeneration. Four fabrication protocols were comparatively assessed, including a standard and optimized protocol, an externally crosslinked system, and a cost-effective approach employing a conventional 3D printer, enabling evaluation of processing–structure–property relationships. Following extrusion and freeze-drying, scaffold performance was characterized through comprehensive rheological analyses, as well as morphological and thermal evaluation using scanning electron microscopy (SEM), differential scanning calorimetry, and quantitative pore size analysis. Rheological results demonstrated consistent viscoelastic and shear-thinning behavior across all formulations, with well-defined linear viscoelastic regions and stable elastic responses over wide frequency ranges, indicating suitability for extrusion-based processing and post-fabrication integrity. SEM analysis revealed protocol-dependent microarchitectures, ranging from highly interconnected micro- and macro-porous networks favorable for mass transport to denser extracellular matrix-mimicking collagen fiber arrangements governed by a crosslinking strategy. Thermal analysis confirmed amorphous scaffold structures with distinct energy absorption profiles reflecting variations in network stability. While all protocols demonstrated potential for bone regeneration, the optimized standard protocol exhibited comparatively enhanced viscoelastic stability, interconnected porosity, and thermal resistance. Bioprinting results further demonstrate scaffold printability and provide insight into current processing limitations and directions for optimization. These findings highlight the critical role of bioink formulation and scaffold design in achieving mechanically robust, biomimetic structures, and support the continued development of 3D-printed collagen scaffolds as promising candidates for regenerative dentistry applications.



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sciforum-182087: Digital workflow development of pin-reinforced indirect zirconia posterior restorations

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Introduction

Digital dentistry is continuing to have a profound impact on the delivery of clinical care for patients and clinicians by providing improved efficiency and accuracy and a streamlined workflow. This preliminary investigation explored the use of the Stabilok Dentinal Pin System for pin-reinforced onlay preparation and assessment of an indirect zirconia posterior restoration using novel digital dentistry technologies.

Methods and Materials

A pinlay was prepared on a dentiform molar tooth. The Stabilok Dentinal Pin System was employed, and grade 1 titanium, 0.6 mm diameter dentin pins were placed. Thermography was employed to assess surface temperature of the drill and pin. Shade was determined using a digital shade assessment software. The pinlay preparation was scanned and optimized (Medit scanner and Medit Link software) and emailed to a commercial laboratory for the design and fabrication of a zirconia pinlay restoration. Using 3Shape, a four-surface pin reinforced restoration was designed and milled with a **multi-colored, multi-yttria zirconia (46% translucency; flexural strength of 1025 MPa)**.

Results

The pinlay restoration was seated on the prepared tooth without any fit issues. The restoration was deemed clinically acceptable. The surface temperature of the twist drill and pin were recorded as 20.16 and 21.17 degrees Celsius, respectively. The zirconia pinlay restoration shade was digitally assessed as 100% A1 (Vita).

Conclusion

Although it is a very limited study on a single typodont, this simulated preliminary investigation illustrated that pin-reinforced indirect posterior restoration using digital dentistry is an approach that is simple, efficient and accurate. The workflow resulted in a clinically acceptable zirconia restoration with minimal surface temperature change (5-degree increase compared to adjacent typodonts) during drilling and pin placement. Consideration of alternative restorative workflows, including both traditional and modified indirect techniques, remains essential to support accessible, patient-centered care while promoting sustainable and adaptable clinical workflows.



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sciforum-175267: Graphene Oxide-Modified Portland Cement Enhances Bioactivity and Periapical Healing: An *In Vitro* and *In Vivo* Study

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Introduction

Calcium silicate-based materials, particularly mineral trioxide aggregate (MTA), are widely used in vital pulp therapy and regenerative endodontics for their biocompatibility and ability to promote hard tissue formation. However, MTA is costly and has limitations associated with its radiopacifier, bismuth oxide. Portland cement (PC), with similar calcium silicate chemistry but without bismuth oxide, offers a cost-effective alternative but requires modification to enhance its mechanical and biological performance. Graphene oxide (GO), with high mechanical strength and bioactivity, is a promising additive for dental biomaterials. This study evaluated GO-incorporated Portland cement (GoP) as a novel restorative material.

Methods

GO was incorporated into PC at 1%, 2%, and 3% (w/w). Surface microhardness was assessed using a Through Indenter Viewing tester. Human peri-radicular fibroblast cells viability were assessed using MTT assays under direct, indirect, and eluate exposure. Vimentin expression was analysed by immunofluorescence. Cell attachment and morphology were examined by scanning electron microscopy (SEM), and biomineralisation was quantified by X-ray diffraction (XRD). An exploratory split-mouth *in vivo* study was conducted in a 1-year-old Labrador dog with traumatic irreversible pulpitis and apical periodontitis affecting all four canine teeth, comparing GoP with MTA.

Results

Microhardness increased with GO concentration, reaching 239.0 ± 33.1 HV at 3% GoP, up to a 5.3-fold increase versus PC. Cell viability was maintained or enhanced across all groups, with 2% GoP showing optimal response and strong vimentin expression. SEM demonstrated superior cell attachment on 2% GoP. XRD showed enhanced biomineralisation, with 3% GoP achieving the highest apatite fraction (11.65%), a 1.61-fold increase relative to MTA. *In vivo*, 2% GoP showed complete radiographic resolution of periapical lesions at 3 months, while residual radiolucency persisted in MTA-treated sites.

Conclusions

GoP improves mechanical performance, supports favourable cellular responses, and enhances biomineralisation, with promising *in vivo* healing outcomes. These findings suggest that GO-modified Portland cement, particularly at 2%, may serve as a cost-effective alternative to MTA for dental applications.



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sciforum-175283: In Vitro Validation of Calcium Phosphate-Loaded Microgels as In Vitro Niche Model for Dental Applications

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Recently, research on biomaterials has been focused on the development of platforms able to mimic the three-dimensional microenvironment of cells with bioactive signals to support cellular processes such as cell adhesion, proliferation and differentiation. In this regard, there is an increased interest in the use of hydrogels—particularly with the confinement of bioactive cues at the microscale—to mimic the cell niche through accurate control of cell-to-cell and cell-material interactions. In this work, we propose the design and fabrication of bioactive microgels containing sodium alginate loaded with calcium phosphate particles with micro- or sub-micrometric sizes via electrohydrodynamic atomization (EHDA) for use as in vitro models of hard tissue regeneration. Different processing strategies, from physical entrapment to in situ precipitation, were optimized. Morphological analyses (optical, SEM, TEM, and MicroCT) showed a narrow distribution of perfectly rounded particles with different spatial distributions of calcium phosphates and average diameters ranging from $223 \pm 18 \mu\text{m}$ to $850 \pm 64 \mu\text{m}$ as a function of mineral phase content and EHDA process conditions. Chemical/physical analyses (FTIR, TGA, and EDS) confirmed the presence of calcium phosphates in terms of chemical composition (i.e., Ca/P ratio) and relative volume fraction. In vitro studies were carried out to thoroughly investigate the response of dental pulp mesenchymal stem cells (DP-MSCs). Results demonstrated that the presence of calcium phosphates with different chemical compositions and/or particle sizes play an active role in the mechanisms of cells in terms of increased proliferation for up to 14 days and mineralization, as shown by alkaline phosphatase activity, thus contributing to mimicking the cell microenvironment. These results are promising for the development of in vitro models for the study of cellular behavior and for use as bioactive scaffolds for the regeneration of hard tissues, such as bone or dental-pulp complexes.



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sciforum-157035: Metrological assessment of the trueness of prosthetic metal frameworks manufactured through digital techniques

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The aim of the study was to investigate by two software applications the accuracy and precision of Co-Cr copings made through 4 different technologies, in order to obtain the validation of the dental dedicated measurement software and to evaluate the accuracy and trueness of the obtained alloy copings.

In this study, we analyzed 24 crowns made of Cobalt-Chrome using 4 different techniques to obtain the finished piece. The prosthetic pieces had the same design and were divided into 4 study batches (6 per batch) depending on the method of obtaining as follows: R- resin, W- wax, M- milling, S- sintering. For batches R and W the final piece was obtained through the classic melting and casting process. The restorations had the same master model and the images were captured using a Medit i600 cabinet scanner. Each STL file of each crown was superimposed on the reference STL file (design), using the alignment functions of both the Medit Crown Fit program and the Meshmixer alignment functions in order to quantify the accuracy by analyzing the deviation from the design. The results suggest that both software are capable of producing similar results in terms of deviation from design. The differences are below 0.01 mm, so they can be considered insignificant from a practical point of view.



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sciforum-169141: Microstructurally Refined Ti-6Al-7Nb via High-Pressure Sliding Modulates Osteoblast Adhesion and Proliferation

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Grain refinement through severe plastic deformation is a promising strategy to simultaneously tune the mechanical and surface properties of biomedical titanium alloys. High-Pressure Sliding (HPS) was applied to Ti-6Al-7Nb alloys plate with a thickness of 1 mm at 3 GPa with sliding distances of 5, 10, 15, and 20 mm, and a non-processed specimen served as the control. Microstructural evolution was characterized by X-ray diffraction and transmission electron microscopy. Additionally and tensile tests were performed to evaluate the mechanical properties. The biological responses of MC3T3-E1 mouse pre-osteoblasts cultured on the microstructurally refined specimens were examined *in vitro*. Cell attachment morphology was evaluated by immunofluorescence staining, while cell proliferation and early osteogenic differentiation were quantified using a WST-8 assay and real-time RT-PCR.

HPS processing under 3 GPa induced the evolution of an ultrafine-grained microstructure from the initial coarse-grained state, while suppressing phase transformation. The development of a preferred grain orientation was observed with increasing sliding distance. This structural evolution, combined with the UFG formation, led to enhanced mechanical properties, achieving high strength and hardness while retaining favorable total elongation.

The HPS-processed specimens also induced elongated cell morphology and polarized focal adhesion distribution compared with the control. Furthermore, enhanced proliferation and upregulated expression of early osteogenic genes, such as *RUNX2*, *COL1alpha*, and *Akp2*, were observed during early differentiation.

These findings demonstrate that HPS-processed Ti-6Al-7Nb with ultrafine grains achieves a favorable combination of high hardness, high tensile strength, and adequate total elongation, while also promoting osteoblast polarization and osteogenic gene expression. Such microstructurally refined Ti-6Al-7Nb alloys represent promising candidates for high-load biomedical applications, including narrow-diameter dental implants.



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sciforum-179420: Plasma-Assisted Bifunctionalization of Glass Fillers to Develop Contact-Active Antibacterial Dental Composites

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Quaternary ammonium silanes (QASi) are well-known antimicrobial agents due to their broad-spectrum biocidal activity and biocompatibility, making them attractive for biomedical and dental composite applications. The silanol groups of QASi can be covalently bonded to inorganic surface fillers, enabling the design of contact-active antibacterial interfaces. Nonetheless, silanes such as dimethyloctadecyl[3-(trimethoxysilyl)propyl]ammonium chloride (QASi-18) cannot form covalent bonds with polymers like methacrylic resin, used in dental materials, compromising mechanical properties. In this study, barium–aluminum silicate glass particle fillers were bifunctionalized to generate antibacterial surfaces, using QASi-18 and 3-methacryloxypropyltrimethoxysilane (MPS) as a coupling agent, to mediate a covalent bond between the filler particles and the methacrylic resin. The glass particle modification was performed through plasma-assisted surface activation, where nonthermal plasma parameters were adjusted to reduce the thermal degradation of the substances deposited on the filler particles. The bifunctionalized particles were characterized by FTIR, XPS, TG, particle size distribution and zeta potential measurements. Zeta potential exhibited a shift toward positive surface charge, indicating the presence of quaternary ammonium groups on the particle surface. Microbiological assays demonstrated antimicrobial activity against *Escherichia coli*, *Streptococcus salivarius*, and *Candida albicans*. After incorporation into resin composites based on bisphenol A-glycidyl methacrylate (Bis-GMA) and triethylene glycol dimethacrylate (TEGDMA), antimicrobial efficacy decreased but remained high, consistent with a contact-dependent mechanism governed by the accessibility of functionalized particles at the composite surface. The plasma parameters were adequate to preserve methacrylate groups, as observed by the FTIR spectrum contributing to composite reinforcement. Overall, these findings highlight plasma-assisted silane bifunctionalization as a promising strategy to engineer antibacterial biomaterials and surfaces.



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Session 2. Bone Biomaterials

sciforum-175206: BMP7-Modified Polycaprolactone Nanofibrous Scaffolds Improve Osteoblast Activity

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Introduction: Effective biomaterial integration with host bone cells remains a significant problem in the field of regenerative medicine. Biomaterials that act as both biological stimulants and structural scaffolds are required for bone healing. The polymer polycaprolactone (PCL) is strong enough to maintain its structure on its own, but lacks inherent osteo-inductive properties. One potential bioactive component for bone regeneration is Bone Morphogenetic Protein-7 (BMP7), which regulates osteoblast activity. This study aimed to create BMP7-integrated PCL scaffolds (PCL-BMP7) and evaluate their biological effects on MC3T3-E1 osteoblast cells.

Methods: PCL-BMP7 were fabricated via electrospinning with pure PCL membranes, whereas Pure PCL (PCL-Ct) was used as a control. Scaffold morphology and mechanical properties were characterized using scanning electron microscopy and tensile testing. Surface hydrophilicity was determined using contact angle analysis; molecular interactions were evaluated using X-ray diffraction and Raman spectroscopy. MC3T3-E1 cells were cultured on PCL-BMP7 and PCL-Ct. Cell attachment was observed by microscopy; MTT assay ("3- (4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide assay") was used to assess osteoblast viability. Wound healing, ALP (alkaline phosphatase activity) and mineral deposition were also evaluated by wound healing assay, ALP assay and alizarin red staining respectively. Data was analyzed by ANOVA and post hoc tests.

Results: In PCL-BMP7, SEM revealed a uniform fiber morphology and homogeneous BMP7 distribution. Raman and XRD analyses indicated enhanced molecular interactions. Contact angle measurements showed significantly improved hydrophilicity (**p0.01). MC3T3-E1 cells exhibited excellent attachment and spreading on PCL-BMP7 scaffolds. Increased osteoblast cell viability was observed by the MTT assay at 24, 48, and 72 hours respectively (*p0.05). Additionally, osteogenic capability and osteoblast wound healing were improved compared to Ct.

Conclusions: BMP7-functionalized PCL nanofibrous scaffolds improved osteoblast viability, healing capacity and osteogenic activity. These findings support the potential application of PCL-BMP7 scaffolds in regenerative dentistry and medicine.



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sciforum-175414: Development and biological *in vitro* study of three-dimensional printed poly(lactic acid) scaffolds coated with gelatin-based coaxial nanofibrous coatings for bone repair

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Bone grafting has been a challenge in recent decades, primarily because the "gold standard" methods, such as autografts, have low bioavailability and pose a risk to the donor site. Therefore, there still remains a focus on developing biocompatible polymer-based biomaterials as a scaffolds for bone restoration. Three-dimensional (3D) printing is a revolutionary technology for scaffold manufacturing. However, material extrusion printing remains limited by the resolution and smooth surface formation, which affects cell adhesion, proliferation, and subsequent bone restoration. This work focuses on the study of the effect of the biological behavior of gelatin/polyester-based coaxial nanofibrous (CNF) coatings on 3D-printed poly(lactic acid) (PLA) scaffolds. The results of scanning electron microscopy showed a good integration of the 3D-printed scaffolds and the nanofiber coating structures, while transmission electron microscopy revealed the core-shell structure of the electrospun CNF coatings based on PCL/Gt and PLA/Gt. Biological *in vitro* activity assessment showed that gelatin-coated scaffold-based CNF coatings promoted the cell adhesion and viability of a human fetal osteoblast (hFOB 1.19) cell line at 24 h and 21 days of culture, respectively, compared to the control, uncoated scaffolds, and those coated with pure polymer fibers. The highest alkaline phosphatase activity was observed on day 7, as an early marker for osteogenic differentiation. The formation of calcium phosphate mineral deposits was evident on day 14 for the CNF coatings. In conclusion, these results indicate that modifying the 3D-printed scaffolds with gelatin-based CNF coatings represents a possible application route for 3D-printed biomaterials for the improvement of the biochemical and topographical properties of scaffolds for bone repair. CET-S acknowledges the scholarship support from SECIHTI for his Ph.D. studies (CVU:1009583). The authors are grateful for the financial support given by the DGAPA-UNAM-PAPIIT IN106624, IN218223, and IN202924, and PAIP-FQ 5000-9222 projects.



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sciforum-174563: Digital Light Processing for β -TCP/PDLLA-co-TMC Nanocomposite Bone Tissue Engineering Scaffolds with Different β -TCP Concentrations

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Bone tissue engineering (BTE) eliminates many problems associated with traditional treatments for repairing diseased or damaged bones. As an essential component of BTE, porous artificial scaffolds provide structural support and also a microenvironment for seeded live cells. These scaffolds should be made of osteoconductive biomaterials for promoting new bone formation. Additive manufacturing (AM, i.e., 3D printing) is a powerful platform for fabricating advanced tissue engineering scaffolds. It allows precise control of structural characteristics (pore shape and size, porosity, etc.) of scaffolds that significantly influence their properties (mechanical, transport, biological, etc.). Digital light processing (DLP), an AM technology, can provide micron-level printing resolution and high printed structure fidelity, making it attractive for developing new BTE scaffolds. Most of current research on DLP of BTE scaffolds uses pure bioceramic or biomedical polymers. In this study, a new osteoconductive nanocomposite, β -tricalcium phosphate (β -TCP)-reinforced poly(D,L-lactide-co-trimethylene carbonate) (PDLLA-co-TMC), was developed and its DLP 3D printing into BTE scaffolds was investigated. β -TCP is a biodegradable bioceramic with good osteoconductivity, while PDLLA-co-TMC is a shape-memory biodegradable polymer. The resulting shape-memory β -TCP/PDLLA-co-TMC scaffolds can be used in minimally invasive surgery for bone regeneration. Using acetone, β -TCP suspensions in PDLLA-co-TMC were made as printing inks for DLP. Inks with 0, 5, 10, 15, 20, 25, 30 vol% of β -TCP nanoparticles, respectively, together with PEGDA, curcumin-Na (free radical inhibitor), curcumin (photoabsorber) and LAP (photoinitiator), were prepared and DLP-printed into scaffolds of the designed grid structure with square pores. Photocuring was then conducted. These nanocomposite scaffolds showed high fidelity to the design, with a 400 micron pore size and strut size. The strength of nanocomposite scaffolds could reach 3.13 MPa, approaching that of human cancellous bone and hence indicating their suitability for BTE. Cytocompatibility assessment using MC3T3-E1 pre-osteoblasts through Live/Dead staining and CCK-8 assay showed good biocompatibility of DLP-printed nanocomposite scaffolds.



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sciforum-179162: Engineering Injectable and Self-Setting Bone Grafts with In Situ Hierarchical Pores via Polyphosphate Coacervate and Gelatin–MgP Core–Shell Porogens

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Background: Injectable and self-setting bone substitutes hold significant value for minimally invasive repair of bone defects. However, these materials typically possess a dense structure, which conflicts with the porous architecture required for cell infiltration and bone regeneration. Conventional porogen strategies (e.g., porogen leaching and gas foaming) often compromise injectability or result in isolated pores, leading to suboptimal repair outcomes.

Methods: Using calcium polyphosphate (Ca-polyP) coacervate as the injectable matrix, we introduced MgP–gelatin core–shell powders (MgP:gelatin = 5:1) as functional porogens. The core–shell structure comprises a gelatin core coated with an alkaline MgP shell. Upon mixing with the acidic Ca-polyP coacervate, the MgP shell triggers an acid–base neutralization reaction that initiates self-setting and activates the setting-induced liquid–solid phase separation (SIPS) mechanism, generating abundant micropores (1–10 μm). Concurrently, the MgP shell serves as a physical barrier to delay water penetration into the gelatin core, ensuring undisturbed SIPS. After complete setting, gradual dissolution of the gelatin core results in the formation of interconnected macropores (40–60 μm), with optimal porosity achieved at day 5. The setting behavior, pore architecture, and biological functions were systematically evaluated.

Results: Through the MgP–gelatin core–shell design, we successfully fabricated bone repair scaffolds with a hierarchical "microporous wall + macroporous channel" structure. In vitro, the composite significantly promoted BMSC osteogenic differentiation, as evidenced by markedly elevated expressions of IBSP, OCN, and osterix. In vivo, the hierarchical porosity effectively guided host-cell infiltration and new bone formation; at 8 weeks post-implantation, bone volume fraction (BV/TV) and trabecular thickness (Tb.Th) were 1.37-fold and 1.23-fold higher than those of the blank control group, respectively, indicating enhanced repair of rat femoral defects.

Conclusion: By introducing MgP–gelatin core–shell porogens, this study resolves the critical challenge of achieving interconnected macropores in injectable self-setting materials. This strategy offers a versatile platform for designing bone repair materials that combine injectability, self-setting capability, and ideal porous architecture.



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sciforum-175948: Surface modification of n-HAp increases the compatibility with PLA scaffold composites

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The biocompatibility, biodegradability, and osteoconductivity of composite scaffolds based on poly(lactic acid) (PLA) and nanohydroxyapatite (n-HAp) make them exceptional materials for bone tissue engineering applications. Nonetheless, there are still issues with the hydrophilic HAp particles' incompatibility with the hydrophobic PLA matrix, which could jeopardize the stability, mechanical strength, and homogeneity of the composite. In order to improve compatibility and interaction between HAp and PLA, this study proposed surface modification of n-HAp utilizing poly(caprolactone-triol) (PCLT) as a functionalizing agent. To promote the formation of ester linkages, PCL-T and HAp were mixed with a polyacid. TGA, FTIR, SEM, TEM, zeta potential, and DLS were used to analyze the n-HAp/PCL-T 1 wt% nanoparticles. An internal mixer was used to melt blend 20 wt% of the nanoparticles into PLA. Lastly, scaffolds were produced by additive manufacturing via 3D printing.

Characterization analyses demonstrated the effectiveness of the functionalization, as confirmed by zeta potential results that indicate alteration on particle surface charge from +23 mV (n-HAp) to -23 mV n-HAp/PCLT 1 wt%. The functionalization also prevents PLA molecular chains from degrading during melt processing. SEM and TEM images of the PLA composites show that functionalization also enhanced n-HAp/PCLT dispersion within the polymer matrix, an important characteristic for cell proliferation.

In vitro bioresorption studies were thermally accelerated at 45 and 55°C. Two degradation regimes were identified: an initial diffusion-controlled process followed by hydrolytic degradation. The degradation times (t_{degrad}) were estimated for each scaffold, and the following order was observed: t_{degrad} PLA/n-HAp » PLA/nHAP-PCLT > PLA. The n-HAP presence contributes to water diffusion through the composite and accelerates the hydrolytic degradation process.

In conclusion, the surface modification of n-HAp using poly(caprolactone-triol) (PCLT) as a functionalizing agent enhanced the compatibility between HAp and PLA, increasing the dispersion and disaggregation of hydroxyapatite within PLA scaffolds.



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sciforum-179368: Bioactive and magnetic apatitic bone cement for bone regeneration

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Introduction. Bone regeneration in compromised physiological conditions requires biomaterials able to combine bioactivity and mechanical performance, and support the physiological bone healing processes by eliciting an appropriate cellular response. Apatitic bone cements (CPCs) are injectable biomaterials that self-harden in vivo into biomimetic hydroxyapatite, offering an attractive option for minimally invasive surgery. In this study, Fe-doped hydroxyapatite (FeHA) was incorporated into CPCs to develop magneto-responsive bone cements capable of enhancing regenerative outcomes through remote activation. The aim was to design and optimise a bioactive apatitic cement able to modulate biological activity on demand.

Methods. FeHA nanoparticles were synthesised by a neutralisation method and combined with α -tricalcium phosphate, previously obtained by solid-state reaction at 1400 °C, followed by rapid quenching, to produce magnetic CPCs. The influence of FeHA content, liquid-to-powder ratio, and additives on injectability, cohesion, and setting behaviour was investigated. The resulting cements were characterised in terms of phase composition, ion release, and surface morphology. Cytocompatibility, cell morphology, and osteogenic differentiation were evaluated in vitro, with and without exposure to static magnetic fields (SMFs). Tetracycline, a broad-spectrum antibiotic, was used as a model drug to evaluate the ability of magnetic-CPC to release therapeutic agents.

Results. Optimised magnetic CPCs containing 20% FeHA exhibited suitable rheological properties, reliable self-hardening, and stable magnetic behaviour. Tetracycline-loaded magnetic CPCs showed sustained release over 7 days, governed by interactions with the apatitic matrix. In vitro, magnetic activation significantly enhanced cell proliferation and osteogenic markers compared with non-activated controls, demonstrating the synergistic contribution of FeHA magnetisation and CPC bioactivity.

Conclusions. The magnetic bone cement developed in this work represents a promising injectable biomaterial for bone regeneration. Its ability to self-harden, support osteogenic processes, and be externally activated to modulate cellular behaviour highlights its potential for personalised, on-demand therapeutic strategies, particularly in patients with impaired regenerative capacity.



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sciforum-178928: Bioprinting of Imaging-Derived Bone Geometries: Toward Patient-Specific Alginate Hydrogel Femur Phantoms for Mechanical and Functional Testing

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Background: Patient-specific anatomical bone phantoms are increasingly needed for preclinical testing, surgical planning, education, and the development of bone-associated biomaterials. Conventional fabrication methods often struggle to reproduce complex anatomy while maintaining soft-material print fidelity. Freeform Reversible Embedding of Suspended Hydrogels (FRESH) enables high-resolution printing of soft biomaterials within a support bath, making it well-suited for constructing imaging-derived biological geometries.

Objective: This work highlights the use of FRESH printing to fabricate femur-like structures from 3D CT imaging data and discusses the functional relevance of shape-accurate, mechanically resilient hydrogel constructs as handling and workflow platforms.

Methods: A workflow is outlined in which a human femur geometry is reconstructed from 3D CT imaging, scaled as needed, converted to printable toolpaths, and fabricated via FRESH printing using sodium alginate hydrogel inks (typical 1.5–3% w/v) followed by calcium ion crosslinking in CaCl_2 (typical 50–200 mM) to form stable constructs. Following removal from the support bath, prints are assessed for geometric fidelity against the digital model, handling integrity, and basic mechanical performance using uniaxial tensile strain testing as a functional readout.

Results: Imaging-derived femur constructs produced via FRESH printing can closely replicate the intended geometry and remain robust during handling. Mechanical feasibility is supported by tensile testing demonstrating high strain tolerance (up to ~40%) with elastic recovery, indicating a stable hydrogel network suitable for repeated manipulation and functional evaluation. These constructs are intended to reproduce patient-specific geometry rather than native femur composition or load-bearing mechanical properties.

Conclusion: FRESH printing offers a practical route to generate anatomically accurate, mechanically resilient alginate hydrogel femur phantoms from clinical imaging data. Such constructs can serve as versatile platforms for bone-related biomaterials research, including comparative testing of printable inks, optimisation of reinforcement strategies, and integration with mineral phases or composite fillers to progressively approximate bone-relevant mechanics where needed.



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sciforum-179001: Bisphosphonate Delivery via a pH-Responsive Bone Implant for Accelerated Repair of Osteoporotic Bone Fractures

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Osteoporotic fractures represent a major clinical and socioeconomic challenge due to prolonged healing times. Current osteoporosis therapies are primarily based on oral administration of bisphosphonates, which inhibit osteoclast-mediated bone resorption. However, additional local administration of bisphosphonates directly to the fracture site may prove to be an effective strategy, increasing drug concentration where it is most needed and thereby accelerating bone regeneration.

The aim of this study was to develop a multifunctional bone implant that provides mechanical support at the site of osteoporotic fracture while simultaneously enhancing bone regeneration through local, pH-responsive delivery of a bisphosphonate drug. The novel implant was composed of chitosan, agarose, nanohydroxyapatite, and a pH-responsive zeolite-chitosan-bisphosphonate complex, forming a drug-delivery platform. In this system, chitosan served as a linker binding risedronate sodium to the zeolite carrier. The bond between the zeolite and the drug was pH-responsive, and exposure to an acidic environment led to degradation of the chitosan linker and subsequent drug release. It was hypothesized that, following implantation, the biomaterial would encounter acidic microenvironments generated during osteoclast-mediated bone resorption, triggering localized bisphosphonate release and suppression of osteoclast activity. In this study, a comprehensive microstructural and biological evaluation of the developed implant was performed to assess its biomedical potential.

The results demonstrated favorable microstructural and mechanical properties comparable to cancellous bone, including a highly porous microstructure and increased surface roughness. Furthermore, the implant exhibited excellent cytocompatibility, hemocompatibility, and osteoconductivity. It was also shown that a bone implant supported osseointegration with human bone in an *ex vivo* model.

The proposed bone implant represents a promising platform for local bisphosphonate delivery in osteoporotic fracture treatment, although further advanced biological studies are required to fully confirm its clinical efficacy.

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sciforum-183530: Can a Clay Material (Green Clay from Anyama) Improve Bone Healing? Study by Determining the Alkaline Phosphatase Level in Wistar Rats

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Introduction:

Implantology has revolutionized dentistry, and we are therefore witnessing a renewed interest in biomaterials inserted into the alveolar bone. Anyama is a city in Ivory Coast. Alkaline phosphatase is used as a marker of bone activity during bone healing.

The objective was to analyze the effects of Anyama green clay (AVA) on the alkaline phosphatase level during the healing of the alveolar bone of Wistar rats.

Methods:

Bone defects were created in 36 Wistar rats. The wounds were treated or not (control rats) with fine fractions of AVA (particle diameter 2 μ) at different pH levels (acidic, neutral, basic) in dry or paste form. Blood samples were collected on D0, D15, and D30 from the tail for the measurement of alkaline phosphatase.

A Kruskal-Wallis rank test was used to analyze the results.

Results:

The dry form of AVA causes an increase in alkaline phosphatase activity from day 0 to day 15 and stabilizes between day 15 and day 30, except at an acidic pH where we observed a strong increase from day 0 to day 30.

The acidic paste clay seemed to cause an abnormal increase in ALP levels.

However, there was no significant correlation between the pH of the clay and the fluctuations in alkaline phosphatase levels (p-value = 0.2268).

Conclusion:

Within the limits of this study, the dry form of AVA at basic pH could promote good bone formation.

The measurement of PAL must be completed by histological studies.



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sciforum-172655: Engineering Trb3-Targeted Exosome Mimetics to Promote Bone Regeneration in Osteoporosis

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Introduction:

Age-related osteoporosis is characterized by reduced bone mass and increased marrow adiposity, leading to ~200 million fractures annually. A key pathogenic mechanism is the dysregulated lineage commitment of mesenchymal stem cells (MSCs), which preferentially differentiate into adipocytes rather than osteoblasts. We previously identified Tribble Homolog 3 (Trb3) as a critical molecular regulator of MSC fate determination. Here, we engineered Trb3-enriched exosome mimetics (EM-Trb3) and evaluated their therapeutic potential for restoring bone regeneration in osteoporotic conditions.

Methods:

EM-Trb3 was generated using an extrusion-based approach from small-molecule-treated MSCs to enrich endogenous Trb3. Vesicle morphology, size distribution, and Trb3 expression were characterized by TEM, NTA, and ELISA. Osteogenic and adipogenic differentiation of MSCs treated with EM-Trb3 was assessed by various molecular approaches. To enhance bone targeting, EM-Trb3 was metabolically conjugated with alendronate (EM-Trb3-ALD), and bone-binding capacity was evaluated using Nile red-labeled vesicles. Therapeutic efficacy was assessed in osteoporotic mice following systemic administration of EM-Trb3-ALD, with bone regeneration quantified by micro-CT and histological analyses.

Results:

EM-Trb3 exhibited typical extracellular vesicle morphology and significantly elevated Trb3 levels. *In vitro*, EM-Trb3 enhanced osteogenic differentiation, evidenced by increased osteogenic gene expression, ALP activity, and mineral deposition, while suppressing adipogenesis through downregulation of adipogenic markers. *In vivo*, systemic administration of high-dose EM-Trb3-ALD significantly enhanced bone regeneration compared to EM alone, as demonstrated by micro-CT and histological evaluation. Mechanistically, EM-Trb3-mediated effects were associated with activation of Wnt/ β -catenin signaling.

Conclusion:

Trb3-enriched EMs effectively restore MSC osteogenic potential and enhance bone regeneration in osteoporotic models. This strategy represents a promising targeted therapeutic approach for osteoporosis treatment.



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sciforum-172204: Functionalization of Semicrystalline Hydroxyapatite Coatings with Citrate as New Approach in Orthopaedic Applications

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Introduction: Hydroxyapatite (HA)-based nanocoatings are used in orthopedics to promote osseointegration due to their chemical similarity to the mineral component of human bone. Functionalization of these coatings with citrate can enhance tissue mineralization, as citrate plays a key role in the activity of osteogenic cells and in stabilizing the bone matrix.

Methods: In this work, HA coatings were fabricated using Ionized Jet Deposition (IJD) and biomimetic deposition by simulated body fluid (SBF). Subsequently, they were loaded via citrate adsorption to identify which coating was more adequate for combination with citrate for future perspectives. Differences in morphology, roughness, and crystallinity between the two deposition techniques were evaluated. Citrate loading efficacy at three different concentrations (1, 10 and 50mM) was assessed by measuring citrate release in phosphate-buffered saline (PBS). Fibroblast cells (L929) were cultured for 24h with material extracts to test cytotoxicity.

Results: All coatings were composed of semicrystalline HA, as confirmed by FT-IR and XRD analyses. Moreover, post-deposition thermal treatment at 400°C increased the films' crystallinity. IJD-coatings are formed by globular aggregates, as observed by Atomic Force (AFM) and Scanning Electron Microscopy (SEM), with a thickness around 400nm. In contrast, SBF coatings exhibited similar morphology to IJD films and a needle-like shape, typical of HA crystals. SEM images, after citrate absorption, showed that IJD-made films maintained their original morphology, whereas SBF-coatings dissolved completely, making their functionalization impossible. FT-IR analysis of PBS collected after 5 days of immersion of IJD coatings confirmed the presence of a peak around 1550cm⁻¹, corresponding to the antisymmetric stretching of COO⁻ groups in citrate, more evident for loading concentrations of 10 and 50mM. L929 cells showed no cytotoxic effect against materials released from the coatings.

Conclusion: Based on these results, IJD-made coatings represent a suitable solution for citrate functionalization and may be used for further in-depth analysis and future orthopedic applications.



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sciforum-179366: Ionized Jet Deposition of bone-mimetic, complex biomaterials

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Bone regeneration is a key issue in orthopaedics and trauma, and biomimetic coatings are a versatile way to functionalize the surface of prostheses and implantable devices to make them interact with the surrounding bone-forming cells and foster more rapid regeneration.

Ideal coatings shall have high adhesion to the surface and submicrometric thickness to avoid cracking, and a suitable composition. Our research has demonstrated that Ionized Jet Deposition is a suitable technique to obtain the desired coating characteristics.

In particular, we showed that we can deposit complex materials, which include different calcium phosphates, bone apatite and bioactive glasses, maintaining the target stoichiometry. All coatings are nanostructured and have high surface roughness, and their thickness can be finely tuned by tuning deposition parameters. Crystallinity can be tuned by pre- or post-deposition heating, which also boosts adhesion.

Coatings can be deposited on a variety of substrates that span from titanium alloy prostheses to polymeric substrates (PCL, PLLA, and collagen blends, etc.).

In addition, flat or porous substrates can be coated in a conformal way, without altering their morphology.

Because of these characteristics, as well as the combination of biomimetic composition, high surface roughness and multiscale (nano- to microscale) features, coatings are capable of promoting MSCs' adhesion, proliferation and their differentiation towards an osteogenic lineage.

For these reasons, Ionized Jet Deposition appears as a promising technique for biomimetic coating deposition.



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sciforum-175013: Mapping the Influence of Unduloid Fields on Cytoskeletal and Nuclear Adaptation of hMSCs

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Introduction: Biomaterial surface geometry acts as a powerful cell-instructive cue at the biomaterial–tissue interface by reshaping cytoskeletal and nuclear architecture [1,2]. Uncovering how specific curvatures regulate these responses is essential for guiding the fate of human mesenchymal stromal cells (hMSCs). Here, we investigate concave and convex unduloid fields defined by two radii of curvatures ($r_1 = 135 \mu\text{m}$, $r_2 = 45 \mu\text{m}$) and their corresponding local principal curvatures to gain insight into curvature-dependent adaptation at the single-cell level.

Methods: Curvature fields were fabricated on polystyrene (PS) substrates using molds fabricated by micro-digital light printing, followed by replica molding into polydimethylsiloxane and final imprinting onto PS. hMSCs were cultured on curved and flat PS substrates for 24 hours, stained for F-actin and nuclei, and imaged by confocal fluorescence microscopy. The local principal curvatures (κ_1 , κ_2) were extracted at the nuclear centroid, enabling direct correlation of curvature with cellular behavior. Cell area, elongation, actin organization, nuclear deformation, and cell/nuclear orientation relative to the underlying geometry were analyzed in FIJI.

Results: hMSCs exhibited curvature-dependent adaptation. Locally convex regions ($\kappa_1 > 0$, $\kappa_2 > 0$) promoted isotropic spreading with prominent stress fibres, nuclear flattening, and apical actin cap formation. In contrast, cells in local concavities ($\kappa_2 < 0$) displayed reduced cell area, increased elongation and more rounded nuclei. In saddle areas ($\kappa_1 > 0$, $\kappa_2 < 0$), hMSCs aligned diagonally relative to the principal curvature directions, indicating curvature-dependent orientation. Cells on flat controls showed comparable spreading to cells on convex areas, but less pronounced actin cap formation. These findings suggest that varying local curvatures influence hMSC adaptation, potentially affecting subsequent cellular function and collective behavior.

Conclusions: Quantitative mapping of hMSC responses to local principal curvatures reveals curvature-specific adaptations that are highly relevant for biomaterial-induced cell modulation, such as osteoimmunomodulation.

1: Callens, S.J.P. et al. (2020). Biomaterials 232, 119739

2: Xiao, L. et al. (2023). J. Mater. Chem. B 11, 2550–2567



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sciforum-181721: Multiscale Mechanics of Hierarchical Porous Bone Studied by Physics-Informed AI

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Trabecular bone has hierarchical porous architectures that enable lightweight, damage-tolerant features, yet their performance depends on how mechanical properties scale with density across length scales. Classical cellular-solid theory captures many open-cell lattices, but it remains unclear whether a universal scaling function is sufficient to account for both large-scale porous structure and microscale lacunar features within the trabecular bone. As well as when microscale lacuna pores within the trabecular walls may drive a breakdown of density-controlled scaling. Here, we combine in-situ synchrotron tomography, diffusion-based generative modeling, and physics-based micromechanics to reveal an AI-enabled, scale-dependent transition in stiffness-density scaling of the trabecular bone with canonical hierarchical porous structures. We find that at the millimeter scale, the effective Young's modulus follows cellular-solid behavior that has a scaling factor of ~ 2 with the density. At the lacunar (microscale) level, based on simulations on thousands of lacunar microstructures, augmented by statistically faithful AI-generated ensembles, exhibit a markedly steeper dependence that has a scaling factor of 4~6 with the density. According to the massive simulation results, we find that this hypersensitivity arises from long-range interactions between void-induced stress fields that merge into system-spanning weak corridors, shifting load transfer from porosity control to matrix connectivity and promoting guided crack initiation and propagation. By preserving higher-order morphology while overcoming data scarcity, AI generation enables statistically robust quantification of this connectivity-controlled regime. Besides trabecular bone per se, these results may establish a general mechanism by which microscale defect topology can dominate stiffness in hierarchical porous materials beyond predictions from density alone.



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sciforum-175188: Mxene-Modified Ti/Hap Composites as a Biomaterial Platform for Bone Tissue Regeneration

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Problems related to the functioning of the skeletal system pose a significant challenge for modern regenerative medicine, which is due, among other things, to the progressive aging of the population and frequent injuries leading to bone damage. In many cases, it is necessary to use an implant that meets stringent requirements for biocompatibility, integration with the body, and interaction with surrounding tissues. For this reason, metal-ceramic composites are attracting increasing interest. Hydroxyapatite, thanks to its structure similar to natural bone tissue, exhibits bioactive properties and supports the bone regeneration process, while a metallic component, such as Ti6Al4V, ensures adequate mechanical strength. However, implants used in the hip and knee joints are subjected to significant tribological loads, which leads to their wear and may require revision surgery. One way to increase the durability of implants is to modify their surface in order to improve tribological properties and increase cell adhesion and proliferation. In this context, a promising solution is the use of MXene coatings, materials belonging to the group of two-dimensional structures that can reduce friction by forming stable tribological layers. MXenes are characterized by a large specific surface area, the possibility of incorporating medicinal substances, and high biocompatibility.

Ti/HAp composites were produced using powder metallurgy technology, with appropriately selected sintering parameters ensuring proper material consolidation. Next, a layer of MXene was applied to their surface to act as a lubricant, aimed at reducing friction and material wear during operation under load conditions. Physicochemical tests and structural analyses confirmed the validity of the adopted material concept and indicated the potential of the composites obtained in applications related to bone tissue regeneration.

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sciforum-182945: Polyetheretherketone as an alternative to titanium alloys in the additive manufacturing of orthopedic implants

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Background

The development of additive manufacturing technologies, including Selective Laser Melting (SLM), Direct Metal Laser Sintering (DMLS), and Powder Bed Fusion (PBF), has enabled the production of patient-specific orthopedic implants with complex geometries. Titanium alloys, particularly Ti6Al4V, Ti6Al7Nb, and Ti13Nb13Zr, are widely utilized due to their high mechanical strength and excellent corrosion resistance. However, increasing attention is being directed toward both the modification of existing titanium alloys and the exploration of alternative materials. In this context, high-performance polymers are emerging as a promising alternative to metallic biomaterials in orthopedic applications.

Methods

This study is based on an analysis of the current literature concerning the application of polyetheretherketone (PEEK) in additive manufacturing technologies, with particular emphasis on Fused Filament Fabrication (FFF). The physicochemical and mechanical properties of PEEK were evaluated in the context of its suitability for orthopedic implants. Based on a review of scientific articles published between 2017 and 2026, a literature review was conducted on the use of PEEK in orthopedic implants manufactured using 3D printing technology. Particular attention was paid to the selection of additive manufacturing process parameters and the effect of sample orientation during printing on the mechanical properties of the resulting structures.

Results

Polyetheretherketone (PEEK) is a homopolymer with a linear structure, characterized by high molecular weight. This material exhibits excellent mechanical properties, high chemical resistance and biocompatibility, which makes it suitable for wide use in medicine, particularly in biomedical engineering. PEEK implants, such as skull implants and orthopedic implants, are manufactured for the following purposes: bone plates and spinal, knee and hip implants.

Conclusions

The findings indicate that PEEK constitutes a promising alternative to titanium alloys in the additive manufacturing of orthopedic implants. Its favorable mechanical compatibility with bone tissue, combined with its chemical inertness and suitability for personalized fabrication, supports its growing role in modern implantology.



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sciforum-174712: Synergistic reinforcement of hydroxyapatite with graphene oxide for advanced bone regeneration

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Introduction: Hydroxyapatite (HA) is a widely utilized bioactive ceramic in bone tissue engineering, valued for its exceptional biocompatibility and chemical resemblance to natural bone mineral. Despite these advantages, HA's clinical application is often constrained by its intrinsic brittleness and poor mechanical performance. To overcome these drawbacks, graphene oxide (GO) is increasingly employed as a reinforcing agent. GO's remarkable mechanical strength make it an ideal candidate to enhance the structural integrity of HA, leading to the development of HA/GO composite materials.

Methods: This study details a comprehensive synthesis protocol for HA/GO composites specifically designed to improve osteointegration. The materials were fabricated using a wet chemical precipitation method. During this process, HA nanoparticles were nucleated and grown directly in the presence of GO sheets. This approach was chosen to ensure a uniform distribution of the reinforcement phase and to promote strong interfacial bonding between the HA crystals and the GO functional groups.

Results: The synthesis protocol successfully produced a homogenous composite material. The integration of GO into the HA matrix addressed the primary limitation of ceramic brittleness, creating a more robust scaffold. Preliminary assessments indicate that the uniform dispersion of GO sheets facilitates a synergistic effect, where the mechanical properties of the graphene derivative complement the inherent bioactivity of the hydroxyapatite.

Conclusions: HA/GO composites represent a significant advancement in the development of biomaterials for bone regeneration. By combining mechanical robustness with a surface chemistry conducive to cell growth, these composites offer a promising solution for bone tissue applications. The results suggest that the HA/GO system provides a superior environment for effective osteointegration compared to pure HA scaffolds.



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sciforum-179430: Tailoring MAO Coatings on Pure Magnesium via Electrical Parameters in a Multi-Component Electrolyte

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Introduction

Micro-arc oxidation (MAO) is a promising technique for modifying magnesium surfaces, enabling the formation of multifunctional oxide coatings with improved corrosion resistance and bioactivity. This study investigates the influence of electrical parameters on the formation and properties of MAO coatings on pure magnesium.

Materials and Methods

MAO coatings were produced on pure magnesium in a K-Na-Si-Ca-P-Cu-containing electrolyte under varying electrical conditions (300–400 V, 180–280 mA). The coatings were characterized in terms of morphology, chemical composition, topography, thickness, mechanical properties, adhesion to the substrate, wettability, and surface free energy.

Results

The results demonstrated that applied voltage was the dominant factor governing coating formation and properties. Increasing voltage led to thicker coatings with a more developed porous morphology and enhanced incorporation of electrolyte-derived elements. These changes were accompanied by improved mechanical properties (hardness, scratch resistance) and increased wettability and surface free energy compared with bare magnesium. Different electrical conditions yielded distinct functional profiles: higher voltages favored mechanical performance, while intermediate conditions promoted greater incorporation of calcium and phosphorus, suggesting enhanced bioactive potential.

Conclusions

The obtained MAO coatings exhibited properties relevant for biomaterial applications, including calcium and phosphorus incorporation, developed morphology, and improved wettability. Precise control of electrical parameters enables targeted design of coating structure and performance. These findings highlight the potential of MAO-treated magnesium for biodegradable implant applications. Future work will focus on corrosion behavior under physiological conditions and biological and antibacterial performance.

Funding

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Session 3. Antibacterial Biomaterials and Surfaces

sciforum-169864: Additive Manufacturing of Bio-Functionalized Ti-CuO Alloys: Mechanical and Biological Insights

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Introduction

Titanium (Ti) and its alloys are widely used as clinical implant materials in the medical and dental fields due to their excellent corrosion resistance and biocompatibility. However, peri-implant infection remains a major clinical challenge, creating a strong demand for inherent antibacterial functions in materials. Recently, alloying with antibacterial effect of Copper (Cu) has gained attention, but excessive Cu addition raises concerns regarding decreased mechanical properties and cytotoxicity. This study aimed to investigate the optimal composition of Ti-CuO alloys fabricated via the L-PBF method, focusing on CuO content in terms of antibacterial properties, mechanical performance, and cellular response.

Experimental Methods

Ti-CuO alloy specimens with CuO contents of 1.0, 1.5, and 2.0 mass% were fabricated by the L-PBF (Laser Powder Bed Fusion) method. Antibacterial evaluation was conducted using the film attachment method (compliant with JIS Z 2801) against *E. coli* and *S. aureus*. Mechanical properties were evaluated via Vickers hardness and tensile tests. Cell compatibility was assessed using MC3T3-E1 cells through proliferation assays and morphological observation. Furthermore, gene expression of peri-implantitis-related biomarkers was analyzed using real-time RT-PCR.

Results

The 1 mass% CuO-added material showed clear antibacterial activity against *E. coli*, though no significant effect was observed against *S. aureus*. Regarding mechanical properties, a decrease in ductility was confirmed with increasing CuO content; thus, 1 mass% CuO was determined as the optimal composition considering the balance of properties. Evaluation with MC3T3-E1 cells showed that the 1 mass% CuO group exhibited cell proliferation behavior comparable to pure Ti, with no evidence of significant cytotoxicity or excessive inflammatory response.

Conclusion

The 1 mass% CuO-added Ti alloy fabricated in this study demonstrated the potential to balance antibacterial activity against *E. coli* and favorable biocompatibility while maintaining mechanical properties. This alloy is considered a promising candidate for additive-manufactured implant materials aiming to achieve both antibacterial function and biocompatibility.



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sciforum-175259: Antimicrobial effects of sodium alginate/poly-L-lysine based films and their deposition onto urinary catheters using ultrasonic spray coating

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Introduction: Urinary catheters have revolutionized modern medicine by restoring organ function and positively affecting patients' quality of life; however, the process of catheter insertion gives microorganisms a chance to attach and cause infections known as catheter-associated urinary tract infections (CAUTI). The antimicrobial coatings on urinary catheters are a central focus for reducing microbial attachment on catheters and CAUTI. **Methodology:** To address this issue, we have developed antimicrobial coatings based on sodium alginate and poly-L-lysine. Antimicrobial films were prepared by dissolving sodium alginate (SA) in deionized water, followed by the addition of poly-L-lysine (PLL), corresponding to an SA:PLL volume ratio of 40:1, and mixed thoroughly. The solution was cast on Petri plates, and films were peeled off the next day and soaked in 5% CaCl₂ solution for cross-linking. The films were tested against two standard reference strains, *Staphylococcus aureus* (ATCC 25923) and *Escherichia coli* (ATCC 25922). Bacterial cultures incubated in the absence of any films were used as the untreated control. **Results:** Cross-linking increased the stability of CaCl₂-SA/PLL films, since they remained intact after immersing in PBS solution for 7 days. The resulting CaCl₂-SA/PLL inhibited *Escherichia coli* growth by 60-42% relative to SA films and by 64-68% relative to the control, while SA film alone showed 17-45% inhibition compared to the control. Regarding *Staphylococcus aureus*, CaCl₂-SA/PLL slightly reduced its growth compared to SA alone (4-14% inhibition), but both SA+PLL and SA alone showed substantial inhibition relative to the control (66-71% inhibition). **Conclusion:** The observed differences between Gram-positive and Gram-negative bacteria may be attributed to structural variations in their cell envelopes. Since CaCl₂-SA/PLL films showed antimicrobial effects, they were used to coat commercially available urinary catheters using ultrasonic spraying, allowing for the formation of a uniform coating with antimicrobial activity.



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sciforum-182964: Bacterial Biofilms and Titanium Implants: Current Understanding, Clinical Challenges, and Emerging Surface Modification Strategies

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Biofilms are complex microbial structures embedded in an extracellular matrix, exhibiting high resistance to antibiotics and host immune responses. Biofilm-associated infections on implant surfaces remain a major clinical challenge, often requiring implant removal and significantly affecting patient outcomes.

This systematic review aims to evaluate the influence of biomaterial type and surface properties on bacterial adhesion and biofilm formation, as well as to assess current strategies for improving the antibacterial performance of titanium-based implants.

A systematic literature review was conducted focusing on studies investigating biofilm formation on implant materials, including metals, polymers, ceramics, and composites. Particular attention was given to titanium alloys and surface modification techniques such as micro-arc oxidation and electrophoretic deposition. Key parameters analyzed included surface roughness, wettability, chemical composition, and surface energy.

The reviewed studies indicate that bacterial colonization is strongly influenced by both material type and surface characteristics. Although titanium and its alloys are widely used due to their favorable mechanical and biological properties, conventional Ti-6Al-4V alloys present limitations related to potential toxicity and susceptibility to biofilm formation. Emerging titanium alloys incorporating biocompatible elements such as niobium and zirconium demonstrate improved biological safety. Surface modification strategies, particularly composite coatings combining antibacterial agents and osteogenic properties, show promising results in reducing infection risk. However, commonly used antibacterial elements such as silver, copper, and zinc may present challenges related to cytotoxicity and long-term stability.

Material composition and surface engineering play a critical role in biofilm prevention on implant surfaces. Advanced titanium alloys and multifunctional surface modifications represent promising directions, though further research is required to develop stable, non-toxic, and clinically effective antibacterial solutions.



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sciforum-182189: Bacterial-mediated synthesis of silver-doped ZnO nanocomposites for inhibition of biofilm formation and quorum sensing in *Pseudomonas aeruginosa*

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Multidrug-resistant *Pseudomonas aeruginosa* poses a significant threat in healthcare settings, particularly in hospital-acquired infections, due to its intrinsic resistance mechanisms and adaptability. This multidrug-resistant bacterium forms biofilms and regulates diverse virulence factors through quorum sensing. The current study involved the acquisition of metal-tolerant bacterial isolates from a metal-contaminated location, which were subsequently assessed for their capacity to produce multifunctional nanocomposites. The biotransformation of the nanocomposites was visually validated by a rapid color change, mediated by the *Bacillus cereus* SASAK strain, which was confirmed through 16S rRNA sequencing and subsequently deposited in GenBank (MH885570). The biogenic nanocomposite underwent analysis using UV-Vis-NIR spectroscopy, FTIR, XRD, zeta potential analysis, HRTEM, FESEM, and EDX. The minimum inhibitory concentrations (MICs) of 2% Ag-ZnO nanocomposites were found to be 200 µg/mL, and sub-MICs of 2% Ag-ZnO were 100 µg/mL. The sub-MIC of 2% Ag-ZnO inhibited quorum-sensing-associated virulence factors and biofilm formation. Specifically, there was a marked decrease in violacein production (96.25%), swarming motility, and pyocyanin levels (1.87 µg/mL). Furthermore, biofilm formation and extracellular polymeric substance production were reduced by 81.1% and 83.9%, respectively. Extracellular protease activity also decreased, as evidenced by a reduction in zone size from 2.3 cm to 1.8 cm. Overall, these findings highlight the potential of silver-doped zinc oxide nanocomposites as effective anti-virulence agents targeting quorum-sensing pathways in multidrug-resistant *P. aeruginosa*.



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sciforum-174688: Balancing Cytocompatibility and Bacterial Resistance: Insights from Silver-Modified Ti6Al4V Co-Culture Studies

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The efficacy of silver's antibacterial properties in biomedical applications depends on the balance with cytocompatibility, influenced by its chemical form. Cysteine, a thiol-containing molecule, can bind silver and link it to surfaces, while reducing cytotoxicity. In this study, Ti6Al4V alloy was chemically pre-treated to enhance bioactivity and subsequently functionalized with a cysteine-silver solution (CT_cysAg).

The functionalization solution was analyzed using DLS, UV-Vis, and FTIR-ATR spectroscopy, evidencing the formation of cysteine-Ag complex compounds. Surface properties were examined through zeta potential measurements, FE-SEM coupled with EDS, XPS analysis, and silver release evaluation. The results of the chemical-physical characterization showed that the CT_cysAg surface contained silver ions (58%), Ag-S bonds (22%), and a limited fraction of silver nanoparticles (20%) with minimum release. CT_cysAg promoted the adhesion of human mesenchymal stem cells (hMSCs) and maintained normal cell morphology, while limiting bacterial clustering and biofilm development (*Staphylococcus epidermidis*, *Staphylococcus aureus*, and *Escherichia coli*). Additionally, CT_cysAg, in a co-culture model, sustained cell viability of hMSCs, in the presence of *S. aureus* bacteria while maintaining the inherent antimicrobial response.

In conclusion, this study reports the development of a cytocompatible, bacteriostatic Ti6Al4V surface obtained by chemical pre-treatment and cysteine-silver functionalization. With the co-culture test, we demonstrated a protective effect against *S. aureus*, supporting its potential for multifunctional implant applications.



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sciforum-175410: Comparative Evaluation of Silver Nanoparticles Synthesized via Green and Chemical Routes: Size-Dependent Antibacterial Activity

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In this study, a systematic evaluation was conducted on two distinct batches of silver nanoparticles (AgNPs) – batch 3, synthesized through an eco-friendly (green) route, and batch 6, prepared via a conventional chemical reduction process. Both nanoparticle types, along with silver nitrate (AgNO₃) solutions as controls, were tested for their antibacterial efficacy against *Escherichia coli* using the agar well diffusion method. *E. coli* cultures were streaked onto nutrient agar plates, wells were created, and varying concentrations of AgNO₃ solutions, batch 3 AgNP suspensions (mean diameter 11 nm), and batch 6 AgNP suspensions (mean diameter 7 nm) were applied. Plates were incubated at 37 °C, with inhibition zones measured at 10, 12, 14, 16, 18, 20, 22, 24, 36, and 48 hours.

Inhibition zones stabilized after 24 hours for both AgNO₃ ions and batch 6 AgNPs, with the latter consistently producing larger zones. In marked contrast, batch 3 exhibited no inhibition at any concentration or time point, a result attributed to its larger particle size and the use of a different stabilizing agent that likely limited silver ion release and nanoparticle–cell interactions. Batch 6 AgNPs outperformed AgNO₃ possibly due to the sustained ion release relative to AgNO₃ solutions and thereby enhancing overall efficacy.

Overall, the chemically synthesized batch 6 AgNPs demonstrated pronounced antibacterial potential against resistant *E. coli* strains, while the eco-friendly batch 3 nanoparticles failed to exert any measurable effect under comparable conditions. This clear divergence emphasizes the importance of optimizing both synthesis pathway and stabilizer composition to achieve effective and reproducible antimicrobial performance in nanosilver systems.



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sciforum-170246: Electrochemically Synthesized Multifunctional PEDOT–Ceftazidime Films for Electrically Triggered, Advanced Bacteria-Responsive Antibacterial Coatings

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Poly(3,4-ethylenedioxythiophene) (PEDOT) films incorporating the broad-spectrum β -lactam antibiotic ceftazidime (CAZ) were successfully synthesized via electropolymerization onto ITO/PET substrates. Cyclic voltammetry confirmed effective CAZ entrapment, as evidenced by anodic/cathodic peak shifts and enhanced charge storage capacity ($14.5 \pm 3.3 \text{ mC/cm}^2$). Electrochemical impedance spectroscopy revealed a significant increase in charge transfer resistance for PEDOT@CAZ ($10,738 \pm 508 \Omega$) compared to pristine PEDOT ($494 \pm 38 \Omega$), which was attributed to the insulating effect of CAZ domains and disruption of PEDOT's conjugated structure. Fourier transform infrared spectroscopy, scanning electron microscopy, and elemental analysis further verified the successful incorporation of CAZ into the PEDOT matrix. Surface characterization demonstrated high hydrophilicity ($12 \pm 0.9^\circ$) and increased surface roughness ($2.10 \pm 0.50 \mu\text{m}$), which are conditions typically favourable for bacterial attachment but effectively counteracted by the antimicrobial properties of CAZ. Passive release of CAZ was minimal ($1.2 \pm 0.1 \mu\text{g/cm}^2$); however, electrochemically stimulated release significantly enhanced antibiotic delivery ($49.5 \pm 5.9 \mu\text{g/cm}^2$). Importantly, bacterial species *Shewanella oneidensis* and *Pseudomonas aeruginosa* actively reduced and oxidized the PEDOT matrix, triggering responsive antibiotic release. These findings demonstrate that PEDOT@CAZ films synergistically combine conductive polymer electroactivity with bacteria-responsive localized antibiotic release, highlighting their potential as dual-action antimicrobial coatings for biomedical applications. Future studies should expand this concept beyond ceftazidime to other antibiotics, antimicrobial peptides, and unconventional agents like quorum-sensing inhibitors or bacteriophages.



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sciforum-174094: Enhanced Antimicrobial and Antibiofilm Functions of Fish Gelatin-Coated Maltol Gold Nanoformulations

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Introduction: The global rise of antibiotic-resistant and biofilm-forming pathogens necessitates the development of functional biomaterials with non-antibiotic antimicrobial mechanisms. Nano-enabled biomaterials combining biocompatible polymers and metallic nanoparticles offer promising strategies for inhibiting microbial growth, biofilm formation, and virulence without inducing cytotoxicity.

Methods: Gold nanoparticles were synthesized using maltol as a reducing agent and subsequently coated with fish gelatin to produce Mal-AuNPs-Gel. Different tools like UV-Vis spectroscopy, FTIR, XRD, FE-TEM, SAED, EDS, zeta potential analysis, and dynamic light scattering were used. Antimicrobial activity was evaluated against bacterial and fungal pathogens by determining MICs. Crystal violet and the CFU method were employed to quantify the single- and mixed-species biofilm. Antivirulence activity was assessed by analyzing hemolysis, siderophore production, protease activity, and motility. RT-PCR was used to check the gene expression, whereas in vitro cytotoxicity and in vivo phytotoxicity assays were used to check the biocompatibility.

Results: Physicochemical analysis confirmed successful NP synthesis with a distinct UV-Vis absorption peak at 555 nm, spherical-to-irregular crystalline morphology, and an average particle size of 111–113 nm. Gelatin coating reduced the zeta potential from –27.68 mV to –2.3 mV, indicating effective surface functionalization. Long-term stability studies showed only a slight increase in particle size after two months. The Mal-AuNPs-Gel demonstrated enhanced antimicrobial activity against *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Listeria monocytogenes*, *Escherichia coli*, and *Candida albicans*. Mal-AuNPs-Gel significantly inhibited biofilm formation and suppressed virulence traits of *P. aeruginosa*, accompanied by the downregulation of genes involved in multiple virulence factors. Cytotoxicity/phytotoxicity assays confirmed good biocompatibility at effective concentrations.

Conclusion: This work highlights fish gelatin-based nanobiomaterials as multifunctional antimicrobial agents with strong potential for biomedical and surface-related applications to combat biofilm-forming antibiotic-resistant pathogens.

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sciforum-179437: Functionalized surface of a ceramic carbonated apatite substrate with an antibacterial α -tocopheryl phosphate organic layer

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Carbonated apatite (CA) is a bioresorbable calcium phosphate ceramic widely regarded as the closest synthetic analog to the mineral phase of biological bone. Due to this close chemical similarity, CA is an attractive candidate for the treatment of skeletal defects. In parallel, the promising bioactive molecule α -tocopheryl phosphate (α -TP), a phosphorylated derivative of vitamin E, has recently gained significant attention due to its reported antibacterial potential and favorable interactions with biomaterial surfaces. Here, we investigate the feasibility of developing a hybrid material consisting of a ceramic CA substrate coated with a functional α -TP organic layer. The aim is to determine whether α -TP can be deposited and retained on the CA ceramic surface in a controllable and measurable manner, while preserving the key characteristics of the substrate. Particular attention is given to the chemical features of the modified surface, as well as changes in topographical and mechanical behavior following the functionalization. The central hypothesis of this study is that the calcium-phosphate rich surface of CA can suitably support α -TP immobilization without compromising the intrinsic properties that make CA a clinically relevant bone substitute. Establishing this interface would provide the basis for a monolithic hybrid grafting material that combines the bioresorbable and osteoconductive character of CA with the added antibacterial functionality from a bioactive surface layer imparted by α -TP. This work, therefore, represents an initial step toward the development of advanced bioresorbable synthetic bone grafts with enhanced surface-driven biological performance.



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sciforum-180072: Gentamicin-Eluting TiO₂ Nanotubes on Ti-24Zr-10Nb-2Sn Alloy for Enhanced Antibacterial Performance Against *Staphylococcus aureus*

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Postoperative infections associated with orthopedic and biomedical implants represent a major clinical challenge, leading to prolonged recovery times, implant failure, and increased healthcare costs. These complications are largely driven by bacterial adhesion and biofilm formation on implant surfaces, which significantly reduces the effectiveness of conventional antibiotic treatments. Among the most clinically relevant pathogens, *Staphylococcus aureus* is a major concern due to its high affinity for metallic implants and its ability to form resistant biofilms.

Although titanium-based alloys exhibit excellent biocompatibility and corrosion resistance, they lack intrinsic antibacterial functionality. In this context, TiO₂ nanotubes have emerged as promising platforms for localized drug delivery; however, their performance depends strongly on nanotube architecture and release behavior. This study demonstrates the functionalization of TiO₂ nanotubes on a Ti-24Zr-10Nb-2Sn alloy, a low-modulus Ti-based alloy designed for biomedical applications, to achieve localized antibacterial activity.

TiO₂ nanotubes were fabricated via electrochemical anodization (30 V for 30 min) and evaluated as a gentamicin delivery system. The nanotubes exhibited an average length of 9.92 µm, a diameter of 80.67 nm, and a high surface density (~195 nanotubes/µm²), enabling efficient drug loading.

Drug release analysis revealed a biphasic profile, with an initial release of 54.47% within 40 min, followed by complete release at 120 min, suggesting diffusion-mediated release from the nanotubular structure. Antibacterial assays showed a significant reduction in viable bacteria (~17 CFU/mL) compared to untreated controls (>300 CFU/mL) (p < 0.05). Additionally, agar diffusion tests revealed a large inhibition zone of 49.6 mm, confirming effective antibiotic release and diffusion.

These findings demonstrate that anodized TiO₂ nanotubes provide an effective localized antibiotic delivery system, offering a promising strategy to mitigate implant-associated infections through rapid antibacterial action.



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sciforum-182202: Manufacturing of tear resistant probiotic loaded membrane patches for application on eardrums in chronic otitis media treatment

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Introduction:

Bioactive tympanic membrane patches currently incorporate antibiotics and growth factors to facilitate healing. However, due to the increasing issue of antibiotic resistance and the insufficient structural integrity of existing patches, tear-resistant membranes loaded with probiotics present an excellent alternative. These membranes can replace antibiotics while ensuring surgical manipulability.

Methods:

Sodium alginate $M_w = 100\text{--}200$ kDa (3% w/v) served as the polymeric matrix, while gum Arabic (0.8% w/v) acted as an interpenetrating agent, alpha-lactalbumin (1.5%) improved probiotic survival, and sucrose (2% w/v) served multiple roles as a cryoprotectant, osmotic balancer, and porogen agent with water. Probiotics (10^9 CFU/mL) were incorporated before 3D bioprinting. A D-optimal mixture design was used to optimize the formulation ratios. The PyRheo Python package predicted printability through simulations, modeling shear stress and filament stability. The 3D-printed patches were cross-linked with 1% (w/v) CaCl_2 water solution for 15 minutes. Optical microscopy was used to assess encapsulation post-printing, and a simulated middle ear effusion at various intervals evaluated polymeric network swelling and the ability of probiotics to withstand infection conditions, while Resazurin assay measured metabolic activity.

Results:

Optical microscopy images showed successful probiotic encapsulation with a homogeneous distribution over the membrane, ensuring adequate release of bioactive probiotic metabolites. Swelling test results in simulated middle ear fluid showed a slow increase, reaching approximately 30% after 24 h, leading to a more controlled, sustained release, confirming previous observations. Resazurin assay showed metabolic activity of released probiotics post-printing and after 24 hours.

Conclusion:

This study demonstrates the fabrication of probiotic-loaded patches with mucoadhesive properties as a novel platform for otitis media delivery and sustained release of viable probiotics. Future research should evaluate antibacterial efficacy, long-term viability, membrane mucoadhesive and tear resistance properties.

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sciforum-175211: Multifunctional Rhenium and Iridium Flavonoid Complexes for Antibacterial Biomaterials and Green Therapeutic Platforms

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Introduction: The development of multifunctional biomaterials integrating therapeutic and antimicrobial functions represents a major challenge. The MET-EFFECT project aimed to design novel rhenium and iridium flavonoid-based complexes with dual biological and catalytic activity, while incorporating them into sustainable drug delivery systems suitable for advanced antibacterial surfaces and personalized therapies.

Methods: New O,O-bidentate flavonoid-derived ligands were synthesized and optimized to enhance water tolerance and enable green synthetic methodologies. A water-soluble apg-type ligand was developed, allowing the preparation of a series of Re(V)-oxo complexes, including structurally characterized monosubstituted species. Ongoing efforts target disubstituted derivatives and modified ligands for Ir(III) coordination. The complexes were evaluated through cytotoxicity assays in cancer cell lines, supported by bioinformatics-based structure-activity relationship (SAR) analysis and molecular docking studies. Catalytic activity was assessed in olefin epoxidation under environmentally friendly conditions. Selected compounds are being incorporated into biocompatible microcapsules using green valorization approaches.

Results: Re(V) complexes exhibited moderate to significant cytotoxicity, particularly against Jurkat leukemia cells. In silico studies predicted interactions with multiple biologically relevant targets. The complexes demonstrated catalytic activity in green olefin epoxidation, marking the first application of flavonoid-type O,O-bidentate rhenium complexes in this reaction. Preliminary formulation studies indicate improved stability and controlled release potential upon microencapsulation.

Conclusions: The integration of multifunctional metal-flavonoid complexes into sustainable delivery platforms provides a promising route toward next-generation antibacterial biomaterials with combined therapeutic and catalytic functionality.



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sciforum-181241: Neat Chitosan Films that Release Polyhexanide for Use in Antibacterial Wound Dressings

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Introduction

Chronic, non-healing wounds, including diabetic foot and venous ulcers, affect ~2% of people in developed countries and their prevalence is expected to rise with population ageing and rising obesity and diabetes. As these wounds are frequently infected, antimicrobial dressings (AMDs) are commonly used to aid healing. Here, we produced sustainable antimicrobial films composed solely of chitosan and loaded them with polyhexanide (poly(hexamethylene biguanide); PHMB), an antiseptic used in wound care. The drug loading and sterilization steps were merged to reduce production steps. All assays were conducted on sterilized films, ensuring that sterilization-related effects were reflected in the results. Film performance was benchmarked against a commercial PHMB-releasing AMD.

Methods

Chitosan films were produced by cryogelation without plasticizers or crosslinkers, yielding porous matrices made solely of chitosan. PHMB was loaded by immersing films in PHMB solutions during autoclave sterilization. The films were characterized for dissolution, water uptake, vapor transmission and antioxidant activity. PHMB release kinetics was studied under wound-relevant conditions and benchmarked against a commercial PHMB-releasing AMD assayed in parallel. Antibacterial activity duration and interactions with blood were also evaluated and compared to the commercial AMD.

Results

The films exhibited high porosity, high water uptake, high moisture vapor transmission and high antioxidant activity, along with low dissolution. Higher PHMB loading led to higher PHMB release. Films loaded with a 1 mg/mL PHMB solution exhibited a release profile most similar to a commercial PHMB-releasing AMD assayed in parallel, while releasing more PHMB over a longer period. These films inhibited and killed *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa* for at least 24 h. They also promoted blood coagulation and showed hemolysis levels comparable to the commercial AMD.

Conclusions

The results indicate that PHMB-loaded chitosan cryogel films are promising candidates for use in AMDs.



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sciforum-174270: Peptoids impart antibiofilm and cell protective actions to an etched titanium surface

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There is an urgent need for biocompatible and antimicrobial surfaces for biomedical devices to face the rapid spread of antibiotic resistance, the high risk of infection, and the formation of biofilms on implants. Antimicrobial peptides are promising candidates due to their broad spectrum of activity and cytocompatibility; however, they are limited by rapid enzymatic degradation. Peptoids are synthetic oligomers structurally similar to peptides, but have intrinsic resistance to proteolysis. In this work, the peptoid GN2-Npm9 was employed to functionalize a chemically pre-treated (CT) Ti6Al4V surface intended for bone-contact dental or orthopedic implants. Physicochemical characterization was performed through contact angle measurements, zeta potential titration, XPS analysis, and fluorescence microscopy. Based on chemical–physical characterisation, the peptoid adsorbed layer on CT was confirmed to be stable and homogeneous, mediated by electrostatic interactions. The modified surfaces were highly hydrophilic (contact angle $\approx 30^\circ$) and demonstrated sustained peptoid delivery over at least nine days. Based on the biological characterization, functionalized samples significantly inhibited colonization and biofilm formation by *Escherichia coli*, *Staphylococcus epidermidis*, oral plaque pathogens, and *Pseudomonas aeruginosa*. Antibacterial action was shown to be selective with both direct and quorum-sensing-mediated effects. Cytocompatibility with human mesenchymal stem cells was preserved, and co-culture models confirmed the protection ability of the functionalized surfaces on cells in the presence of bacteria.



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sciforum-179221: Rapid and Broad-Spectrum Antimicrobial Behavior of Laser-Cladded Copper Surfaces for Infection-Resistant Biomaterials

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The development of antimicrobial dental materials with rapid bactericidal activity is essential for preventing early-stage bacterial colonization and biofilm formation in the oral environment. Copper (Cu) is widely recognized for its strong antibacterial properties; however, its effectiveness in rapidly inactivating different types of oral bacteria upon initial contact remains insufficiently understood. In addition, the fabrication of pure Cu structures using conventional additive manufacturing techniques is challenging due to its intrinsic material properties. Laser cladding provides a promising approach to overcome these limitations, enabling the fabrication of functional Cu-coated surfaces for customized dental applications.

In this study, Cu-coated SUS304 surfaces were fabricated via a laser cladding process, and their fast-acting antimicrobial performance was evaluated. Antibacterial activity was assessed using a modified film adhesion method. *Escherichia coli* and *Staphylococcus aureus* were selected as representative Gram-negative and Gram-positive bacteria, respectively, to simulate different bacterial responses relevant to oral environments. Short exposure times (3–15 min) were investigated to capture early-stage antimicrobial behavior. Bacterial viability was quantified by colony counting, and fluorescence staining was used to visualize bacterial membrane integrity.

The Cu-coated surfaces exhibited rapid and broad-spectrum antimicrobial activity against both bacterial species. Within 3 min of contact, a noticeable reduction in bacterial viability was observed (75% reduction), followed by a substantial decrease after 5 min (90% reduction), indicating a fast bactericidal response. Nearly complete bacterial inactivation (>99%) was achieved after 15 min. Consistent antimicrobial performance was observed for both Gram-negative and Gram-positive bacteria, suggesting that the Cu surface effectively overcomes differences in bacterial cell wall structures. Fluorescence observations revealed a time-dependent increase in membrane damage, supporting a contact-based antibacterial mechanism.

These findings demonstrate that laser-cladded Cu surfaces function as rapid-response and broad-spectrum antimicrobial interfaces. This study highlights the potential of Cu-coated surfaces for the development of infection-resistant and customizable dental biomaterials.



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sciforum-182859: Surface modification strategies for mitigating biofilm adhesion on glaucoma drainage devices in the intraocular environment: a systematic review

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Background: Despite their proven clinical efficacy in lowering intraocular pressure, glaucoma drainage devices (GDDs) remain highly susceptible to biofilm-related complications and subsequent surgical failure. This systematic review critically evaluates current surface modification strategies designed to inhibit microbial colonization and modulate the host tissue response within the complex intraocular environment.

Methods: A comprehensive systematic search was conducted across PubMed, Scopus, and Google Scholar databases for peer-reviewed studies published between 2016 and 2026. Studies focusing on chemical, physical, and biological surface modifications of GDDs were screened and analyzed according to the PRISMA guidelines to ensure methodological rigor.

Results: Key strategies identified include the grafting of hydrophilic polymers (such as PEG and zwitterionic coatings), the controlled elution of antimicrobial agents (silver nanoparticles, antibiotics), and the application of topographical nano-patterning. The evidence suggests that while these functionalized surfaces significantly reduce in vitro bacterial adhesion by up to 90%, achieving long-term in vivo stability and maintaining hemocompatibility remain critical challenges. Furthermore, the interplay between biofilm prevention and the suppression of excessive subconjunctival fibrosis emerged as a pivotal factor in device longevity.

Conclusion: Surface engineering represents a robust and evolving field that significantly enhances GDD safety. Nevertheless, there is a pressing need for standardized in vivo models and longitudinal clinical trials to better predict the long-term efficacy and biocompatibility of these biofilm-resistant coatings in human patients.

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sciforum-175090: Water-Stable Electrospun PVA Nanofibers via Vapor Crosslinking and Controlled In Situ Silver Nanoparticle Incorporation for Antimicrobial Applications

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Polyvinyl alcohol (PVA) nanofibers produced by electrospinning are attractive for biomedical and antimicrobial applications due to their biocompatibility and ease of processing in aqueous systems. However, their inherent water solubility and lack of intrinsic antimicrobial activity limit practical use. This study reports the fabrication of water-stable electrospun PVA nanofibers via glutaraldehyde (GA) vapor crosslinking, followed by in situ incorporation of silver nanoparticles (Ag NPs) to enhance antimicrobial functionality. In this study a 10 wt % PVA solution was electrospun under controlled parameters (10 kV, 0.27 mL/h, 7 cm tip-to-collector distance, 70 % of relative humidity). Crosslinking was performed using GA/HCl vapor treatment for 24 h. Ag NPs were deposited onto crosslinked PVA nanofibers (cPVA) through chemical reduction using AgNO₃ as precursor and NaBH₄ as reductant agent. Morphological, structural, and chemical characterization was carried out using SEM, EDX, FTIR, and Raman spectroscopy. Nanoparticle size distribution was analyzed with ImageJ software. Electrospun PVA nanofibers exhibited an average diameter of approximately 140 nm, which increased to ~170 nm after crosslinking, confirming successful structural modification. FTIR and Raman spectra verified acetal bridge formation between PVA and GA. Ag NPs with size distributions between 12–20 nm were homogeneously deposited using the chemical reduction method, showing reduced agglomeration compared to Tollens-based synthesis. The modified nanofibers demonstrated structural stability in water and surface chemical interactions between silver and acetal groups. In this manner, GA vapor crosslinking effectively rendered PVA nanofibers water-insoluble while preserving morphology. Controlled in situ reduction enabled uniform Ag NPs incorporation, producing nanofibrous composites with potential for antimicrobial biomedical applications.



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Session 4. Biomaterials for Tissue Engineering and Regenerative Medicine

sciforum-175102: Hybrid 3D-Printed/Electrospun Honeycomb PCL Scaffolds Improve Mechanical Stability and Promote Osteoblast Colonization

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Introduction:

The fabrication of biomimetic scaffolds that simultaneously provide structural support and microenvironmental cues remains a central challenge in bone tissue engineering. Electrospinning enables the production of nanofibrous matrices that resemble the extracellular matrix but lacks control over macroscopic geometry and mechanical robustness. In contrast, 3D printing allows precise architectural design but does not replicate the nanoscale features required for optimal cell-material interactions. This study proposes a hierarchical strategy that integrates both techniques to generate honeycomb-shaped biologically functional scaffolds.

Methods:

Poly(ϵ -caprolactone) scaffolds with hexagonal geometry were fabricated by combining 3D-printed collectors with electrospinning deposition. The resulting constructs were characterized by Fourier-transform infrared spectroscopy to confirm chemical integrity, scanning electron microscopy to evaluate fiber distribution and scaffold architecture, and mechanical testing to determine tensile properties. Swelling behavior and enzymatic degradation were assessed to analyze physicochemical stability. *In vitro* biological performance was evaluated using MTT assays of human fetal osteoblasts and fluorescence microscopy to determine cell viability, proliferation, and scaffold colonization.

Results:

This fabrication approach produced scaffolds with hierarchical organization, integrating defined hexagonal macroporosity with nanofibrous surfaces. Structural design influenced mechanical response and fluid interaction, yielding improved stability compared to randomly deposited meshes. *In vitro* assays demonstrated sustained and enhanced cell viability and progressive colonization along the hexagonal architecture.

Conclusions:

The integration of 3D printing and electrospinning enabled the fabrication of hierarchical PCL scaffolds that combine controlled macroscopic architecture with biomimetic nanofibrous features. The hexagonal design influenced mechanical behavior, physicochemical stability, and cellular response, promoting scaffold colonization while maintaining structural integrity. This dual-fabrication strategy addresses the individual limitations of each technique and represents a promising approach for the development of structurally guided platforms for bone tissue engineering applications.



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sciforum-177654: From Spontaneous Differentiation to Functional Synaptic Networks: Neurogenic Modulation of SH-SY5Y Cells by Semiconductive P3HT Interfaces

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Introduction: Neurodegenerative diseases affect millions worldwide and remain without effective regenerative treatments. Advances in neuroprosthetics and bioelectronic medicine increasingly rely on materials capable of interfacing with neural tissue and supporting functional recovery. Semiconductive polymers offer bioelectrical and structural cues that can modulate neuronal behavior without exogenous stimulation, making them promising candidates for regenerative strategies. This study investigated the ability of poly(3-hexylthiophene) (P3HT)-coated substrates to promote spontaneous neuronal differentiation, maturation, and synaptic network formation in human SH-SY5Y neuroblastoma cells cultured under non-inductive conditions.

Methods: The surface potential of P3HT films was characterized using PeakForce Kelvin Probe Force Microscopy (PF-KPFM), with Δ CPD values calculated relative to highly oriented pyrolytic graphite to ensure tip-independent measurements. SH-SY5Y cells were seeded on P3HT-coated or uncoated control slides and maintained for 15 days. Cell viability and proliferation were assessed using MTS assays and DAPI-based nuclear quantification. Neuronal differentiation was evaluated through qPCR analysis of cytoskeletal and synaptic genes (SOX2, NES, TUBB3, SYN, SYP), complemented by immunofluorescence staining for TUBB3, MAP2, and NFH. Neurite outgrowth was quantified using NeuronJ, and functional relationships among neuronal markers were explored using STRING-based protein-protein interaction analysis.

Results: P3HT substrates demonstrated excellent biocompatibility and significantly enhanced SH-SY5Y viability and proliferation over time. Gene expression and immunofluorescence analyses revealed increased levels of neuronal cytoskeletal and synaptic markers, accompanied by pronounced neurite elongation and branching. These findings indicate that P3HT promotes spontaneous neuronal differentiation and supports the emergence of early synaptic networks even in the absence of chemical inducers.

Conclusions: P3HT-based interfaces act as potent modulators of neuronal maturation and network formation, highlighting their potential for next-generation neural interfaces and regenerative bioelectronic applications.



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sciforum-179479: Gelatin–Chitosan Scaffolds from *Mugil cephalus* Skin: Enhanced Fibroblast Proliferation, Migration, and Anti-Inflammatory Activity for Wound Healing

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The fishing and aquaculture industries consistently produce substantial amounts of waste, from which collagen (Col.), gelatin (Gel.), and chitosan (Ch.) can be extracted. These biomolecules can subsequently be used as raw materials in the production of biomaterials, particularly in the fabrication of scaffolds designed for wound healing applications. Understanding how Gel:Ch ratio influences their physicochemical characteristics, and especially their biological properties, is essential to ensure the development of a safe product with validated *in vitro* properties. In this study, we developed novel scaffold formulations, named FGS-1, FGS-2 and FGS-3, using, for the first time, gelatin isolated from the skin of *Mugil cephalus*, with different Gel-Ch. ratios: (1:1), (2:1), and (1:2), respectively. The hydroxyproline content was higher in the raw material (Gel.) and decreased in the scaffold formulations after crosslinking with EDC/NHS, showing a positive correlation with increasing Gel:Ch ratio (FGS-2>FGS-1>FGS-3). FTIR spectroscopy confirmed crosslinking between the components of Gel:Ch. All formulations exhibited high biocompatibility after 24 h with L929 fibroblast and RAW 264.7 macrophage cell lines, as determined by the MTT colorimetric assay. No significant differences were observed among the formulations regarding nitric oxide inhibition; however, a significant inhibitory effect on superoxide anion production was observed in lipopolysaccharide (LPS)-stimulated RAW264.7 macrophages cells, indicating positive anti-inflammatory activity. Likewise, the BrdU cell proliferation assay revealed that FGS-2 formulation showed a favorable proliferative effect compared to the control group. Finally, fibroblast migration showed a significant positive effect especially in FGS-2 scaffolds, as evidenced by the *in vitro* scratch assay after 14 h of incubation. These results highlight the potential of scaffolds prepared from *Mugil cephalus* skin gelatin for tissue repair and regeneration and support further *in vivo* studies.



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sciforum-178926: Microenvironment-Responsive Polyethylene Glycol-Based Hydrogel Scaffolds for Vascularized Tissue Engineering.

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Introduction: A common limitation of hydrogel-based tissue engineering scaffolds is poor vascularization, mainly because oxygen and nutrient diffusion is restricted to about 100–200 μm . As a result, cells in thicker constructs often become hypoxic. Current approaches, such as microchannel-based designs or the use of growth factors like VEGF, have shown some benefit, but they are largely static and do not reflect the dynamic nature of the extracellular matrix (ECM). In this work, attention is placed on polyethylene glycol (PEG)-based hydrogels that can respond to their surrounding microenvironment.

Methods: An ECM-inspired PEG hydrogel scaffold was designed incorporating matrix metalloproteinase (MMP)-sensitive peptide crosslinkers and oxygen-responsive elements. The system introduces a dual-responsive mechanism in which cell-secreted enzymes trigger localized degradation, while hypoxic conditions promote further structural loosening. This response increases scaffold porosity and exposes embedded pro-angiogenic cues. The framework considers how these combined responses regulate pore size, permeability, and endothelial cell infiltration during tissue regeneration.

Results: Previous experimental studies on PEG-based hydrogels show that matrix stiffness and degradability influence vascularization. Compressive modulus values ranging from approximately 30 to 110 kPa, depending on PEG concentration, have been linked to differences in cell migration, with intermediate formulations supporting more stable endothelial networks. Endothelial structures have been reported to reach lengths of up to $\sim 700\ \mu\text{m}$ and penetrate beyond 1 mm into the scaffold, although fully lumenized vessels remain limited. Enzymatically degradable hydrogels consistently demonstrate improved cell infiltration compared to non-degradable PEG systems. These findings support the rationale for combining enzyme-sensitive degradation with additional environmental responsiveness.

Conclusion: PEG hydrogels that respond to both enzymatic activity and oxygen levels offer a more adaptable way to improve vascularization. By allowing the scaffold to change in response to local conditions, this approach supports increased permeability and better endothelial infiltration, providing a practical direction for future scaffold design.



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sciforum-174260: Polylactide/Nanohydroxyapatite Composite Films: Physicochemical Properties and Biocompatibility for Regenerative Medicine Applications

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Introduction: Piezoelectric biomaterials are of significant interest for regenerative medicine due to their ability to stimulate cell proliferation and differentiation. Polylactide (PLA) is a bioresorbable piezoelectric polymer classified by the FDA as GRAS, but its bioactivity is limited. Nanohydroxyapatite (nHA) has excellent osteoinductivity and biocompatibility. The aim of the study was to develop a PLA/nHA composite and comprehensively evaluate the effect of nHA addition on physico-chemical properties and biocompatibility.

Methods: nHA particles were synthesized by chemical precipitation at pH 9-11. The precipitate was washed and dried at 120°C. Composite materials in the form of films were obtained by irrigation from a solution. Granules of PLA weighing 0.5 g were dissolved in 14.3 ml of methylene chloride, 10 wt.% nHA was added, and the resulting suspension was poured into a Petri dish and naturally dried. The obtained films were characterized by FTIR, XPS, and DSC methods, and the wetting angle was measured. Biocompatibility was assessed using a resazurin test on osteosarcoma MG-63 cells for 24, 48, and 72 hours.

Results: FTIR spectra confirmed the successful incorporation of nHA into the PLA matrix by the characteristic bands of phosphate groups at 560, 600, and 1020 cm⁻¹. The DSC analysis showed that the addition of nHA slightly changes the thermophysical properties. XPS analysis revealed C-O, C=O, C-C, and O=C-O bonds in pure PLA, while Ca and P were not detected on the surface of PLA/nHA. With the introduction of nHA, the wetting angle decreased from 84.9° to 71.2°. The resazurin test demonstrated the biocompatibility of PLA and PLA/nHA, with the viability of MG-63 cells > 70% at all time points.

Conclusions: PLA/nHA composite films have been successfully obtained. The addition of nHA improves the hydrophilicity of the surface and provides high biocompatibility, which is of interest for use in tissue engineering.



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sciforum-179505: Assessment of In Vitro Degradation of 3D Bioreabsorbable Scaffolds for Bone Regeneration

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Introduction: Bone regeneration using bioresorbable scaffolds requires understanding their degradation mechanisms. This study evaluates the effect of filler content on microstructure and mechanical properties during in vitro degradation. Three-dimensional printing enables the fabrication of complex geometries that mimic natural bone architecture and patient anatomy. Polymers such as PHBV (polyhydroxybutyrate-co-hydroxyvalerate) are widely studied due to their biocompatibility, biodegradability (~ 2 years), and mechanical properties (0.2 - 1.5 GPa) comparable to trabecular bone. PHBV combined with bioactive glasses (BGs) can result in composites with enhanced stiffness, hydroxyapatite formation, and osteoconductive properties.

Methods: In vitro degradation experiments were conducted to evaluate structural changes in polymeric composites with BGs of different reactivity. PHBV and PHBV + BG (2 and 4 wt%, 1393 and 45S5 compositions) filaments were produced by extrusion and 3D-printed. Scaffolds were immersed in simulated body fluid for 30 days. Before and after soaking, scaffolds were characterized by microcomputed tomography, scanning electron microscopy, X-ray diffraction (SAXS-WAXS), and weight loss and swelling measurements. Mechanical behaviour was tested under bending and compression.

Results: Scaffolds showed good adhesion between layers, a smooth surface, and interconnected pores with pore size that promotes osteogenesis (100–500 µm). BG particles significantly enhanced the bioactivity of the composite, leading to the formation of a hydroxyapatite-like layer on the surface. 3D-printed rasters exhibited a porous internal structure, a sign of internal degradation. After 30 days, PHBV-BG composites exhibited weight loss and swelling below 1.5%. Mechanical tests confirmed the structural integrity of the fabricated scaffolds. Degradation decreased the maximum strength (12 MPa vs 4 MPa at 30 days), elongation at break (4% vs 3% at 30 days) and the elastic modulus (600 MPa vs 300 MPa at 30 days).

Conclusions: This study demonstrates that bioactive glass particles influence degradation kinetics in polymer-bioactive glass composites, with potential applications in bone regeneration.



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sciforum-175074: Characterization of Cellular and Molecular Responses to Platelet-Rich Plasma (PRP) from Elderly Patients with Acute Inflammatory Conditions in Cell Culture

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Introduction: Chronic illness treatment limitations drive the research on regeneration of damaged tissues and organs. Inflammation delays recovery in elders. PRP therapy offers promise with high bioavailability, regenerative power, and low immunity risks. Optimizing PRP's therapeutic use can improve treatment strategies for patients.

Methods: This study enrolled 20 participants divided into two groups: conditionally healthy donors aged 60–70 (G1) and patients with acute appendicitis in the same age range (G2). PRP was prepared using a two-step centrifugation technique. Cell metabolic activity was evaluated using the resazurin test on days 1–3 of the experiment. The oxidation level of 2',7'-dichlorodihydrofluorescein diacetate characterized the production of active oxygen species. The study of the cell's senescent phenotype was conducted using the Aging Cell β -galactosidase Staining Kit. The production level of biologically active substances was determined using the ELISA method: IL6, IL10, TGFB1, PAI-1, PDGF, VEGF.

Results: In G2, IL6 levels and TGF β levels exceeded the ones in G1 by 42 and 13.7 times consecutively. and groups did not differ in the concentration of PAI-1, VEGF-1, or PDGF. The concentration of IL10 in G2 exceeded G1 by 5 times ($p=0.037$). After 72 hours, proliferative and metabolic activities increased: G2 showed a 2.42-fold higher stimulatory effect compared to G1 ($p0.05$). The antioxidant effect of G2's PRP was less pronounced than that of G1's. Statistically significant differences in senescent protein marker accumulation were absent. Addition of G2's PRP tended to increase the proportion of senescent cells in culture.

Conclusions: The study of PRP in G2 showed significant differences in its effects compared to G1. After 72 hours, there was increased cell proliferation in the PRP series of G2. Stimulation of PRP in G2 led to increased production of reactive oxygen species, which correlated with the levels of IL6 and IL10 in the PRP and the percentage of senescent cells.



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sciforum-175379: Evaluation of a Biomimetic and Electroactive 3D Bioprinted Cardiac Patch: From Bioink Optimization to Functional Regeneration in a Perfusion System

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The escalating demand for functional myocardial tissue following ischemic injury has catalyzed the development of biomimetic and electroactive 3D cardiac patches. In this study, a hybrid bioink—comprising decellularized bovine pericardium (dECM), silk fibroin (SF), alginate, and gold nanoparticles (AuNPs)—was developed and systematically optimized for extrusion-based 3D bioprinting to fabricate structurally robust and electrophysiologically active constructs. The bioink was engineered to recapitulate the biochemical complexity of the native extracellular matrix (ECM) while providing essential mechanical reinforcement and conductive properties to facilitate synchronized cardiac tissue regeneration. In the subsequent phase, the biodegradability, biocompatibility, and regenerative efficacy of the 3D-bioprinted patches were evaluated within a dynamic 3D perfusion culture system. Under physiologically relevant flow conditions, the constructs were assessed for their capacity to support cellular adhesion, proliferation, and hierarchical tissue organization. The functional role of the patches in cardiac reconstruction was evaluated through a multi-parametric approach, including biochemical assays, histological assessments, and immunofluorescence analyses of cardiac-specific biomarkers and ECM remodelling. Furthermore, the safety profile of the construct was rigorously established through ISO-standardized cell viability assays, in vitro irritation/corrosion tests, and in vitro skin sensitization assessments. The degradation kinetics and structural integrity were systematically monitored to ensure controlled biodegradability. Our findings demonstrate that this hybrid 3D cardiac patch offers a biomimetic microenvironment with favorable mechanical–electroactive properties and high biosafety, supporting cardiac maturation within a perfusion environment. This study provides a comprehensive framework for the development of multifunctional cardiac constructs and underscores their translational potential in regenerative cardiovascular medicine.



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sciforum-175030: Injectable and bioprintable RGD-functionalized hydrogels support chondrogenic differentiation of adipose mesenchymal stromal cells

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Objective: Articular cartilage lesions represent a major clinical challenge due to limited regenerative capacity, particularly in osteoarthritis (OA), and tissue engineering approaches combining a range of biomaterials, cells and growth factors may offer promising alternatives. Hydrogels, by mimicking the extracellular matrix (ECM), may influence cell behavior. Therefore, we aimed to evaluate whether injectable and bioprintable hydrogels contribute differently to the in vitro chondrogenic differentiation of human adipose-derived stromal cells (hASCs).

Materials and Methods: Two commercial hydrogels functionalized with arginine-glycine-aspartic acid (RGD) motifs, VG-RGD (injectable) and VINK-RGD (bioprintable) were evaluated using human adipose-derived stromal cells. Rheological and mechanical properties, printability, and cytocompatibility were assessed. Printing parameters were chosen to print 3D cell-embedded construct (Discovery 3D, RegenHu) with interconnected pores to guarantee nutrient permeability using extrusion technology. Chondrogenic differentiation was evaluated at multiple time points (day 2, 10, 28) via real-time PCR, immunohistochemistry, transmission electron microscopy (TEM) and attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR).

Results: ATR-FTIR showed that RGD-functionalized hydrogels exhibit the characteristic bands of sodium alginate. Rheological analysis revealed shear-thinning behavior in both VG-RGD and VINK-RGD, with stiffness range from 1.30 to 3.66 kPa, respectively. VINK-RGD exhibited superior shear-thinning behavior and structural fidelity post-printing. Both hydrogels effectively supported hASC viability and did not show cytotoxic effects. VG-RGD and VINK-RGD supported the expression of key chondrogenic markers COL2A1, SOX9 and ACAN, which significantly increased over time, while COL1A1 expression decreased in VINK-RGD by day 28. ATR-FTIR confirmed the formation of collagen type II in both hydrogels, while TEM revealed more organized fibrillar collagen structures in VG-RGD.

Conclusions: VG-RGD and VINK-RGD hydrogels both effectively support chondrogenic differentiation and extracellular matrix remodeling. This study provides the first direct comparison of injectable and bioprintable RGD-modified hydrogels under identical cell and culture conditions, offering critical insights for the rationale selection of materials in cartilage tissue engineering.



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sciforum-178363: Macromolecular crowding in tissue engineering and regenerative medicine

Dimitrios Zeugolis

UCD

Macromolecular crowding, by reducing diffusion, promotes molecular association and accelerates biological processes by several orders of magnitude. The effectiveness of macromolecular crowding to exclude volume has been shown to depend on the physicochemical properties (e.g. charge, dispersity) of the macromolecular crowding agents. Despite the well-established history of macromolecular crowding in biochemical reactions, only recently it has become the subject of investigation in eukaryotic cell cultures. We have conducted macromolecular crowding experiments in permanently differentiated (e.g. human dermal fibroblasts, human tendon cells, human corneal fibroblasts) and mesenchymal stromal (e.g. human bone marrow, human adipose derived, human umbilical cord) cell cultures for the development of tissue engineered medicines, drug discovery models and cell-derived matrices. Cell cultures were conducted in xenogeneic and allogeneic media without and with scaffolds, as appropriate. The experimental work used to validate macromolecular crowding in eukaryotic cell culture, includes, but not limited to basic cell function (e.g. morphology, viability, proliferation, metabolic activity), protein deposition (e.g. electrophoresis, immunofluorescence), gene expression (e.g. reverse transcription polymerase chain reaction) analyses. The dispersity and the hydrodynamic radius of the macromolecular crowding agents were assessed with dynamic light scattering. The charge of the macromolecular crowding agents was assessed with electrophoretic light scattering. The viscosity of the macromolecularly crowded solutions was assessed with rheology. Our work clearly illustrates the transformative potential of macromolecular in eukaryotic cell culture.



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sciforum-179172: Mechanistic Study of Ion-Exchange Strategy for Regulating Multi-Metal Homeostasis to Ameliorate Mitochondrial Dysfunction in Radiation-Induced Oral Mucositis

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Radiation-induced oral mucositis (RIOM) is a common and severe complication of radiotherapy for head and neck cancers. Preliminary studies by the applicant revealed that RIOM is not merely characterized by isolated iron overload, but rather exhibits a novel pathological feature of multi-metal dyshomeostasis, specifically "iron overload accompanied by zinc/magnesium depletion." Accordingly, we propose the hypothesis that this multi-metal dyshomeostasis serves as a critical upstream mechanism driving RIOM repair failure by activating ferroptosis and inducing mitochondrial dysfunction. Consequently, the targeted reconstruction of local metal homeostasis is expected to achieve synergistic tissue repair. Based on the competitive displacement principle of coordination chemistry, this project proposes the design and synthesis of a magnesium/zinc-curcumin complex (MgZn-Cur), which is further integrated with a γ -polyglutamic acid/polylysine network to formulate an in situ hydrogel spray (MgZn-Cur@PP). Exploiting the high stability constant between iron and curcumin, this system competitively displaces Mg and Zn within the iron-overloaded microenvironment. This enables a sophisticated ion-exchange regulation strategy that simultaneously chelates excessive iron and supplements depleted magnesium and zinc. Specifically, this study will: (1) systematically characterize the physicochemical properties and the ion-exchange mechanism of the MgZn-Cur@PP hydrogel; (2) elucidate the underlying mechanisms by which multi-metal dyshomeostasis triggers ferroptosis and mitochondrial damage; and (3) evaluate the in vivo repair efficacy and biosafety of the hydrogel spray using animal models. By interpreting the pathogenesis of RIOM from the unprecedented perspective of multi-metal dyshomeostasis, this study is expected to provide novel insights and a solid theoretical foundation for the clinical treatment of RIOM.



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sciforum-173438: Mineralised Biopolymer-Based Scaffolds Containing Bioactive Compounds from *Cissus quadrangularis* for Bone Tissue Regeneration

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Introduction

Large bone defects remain a significant clinical challenge due to the limited intrinsic regenerative capacity of bone tissue and the insufficient bioactivity of conventional scaffolds. This study aims to develop a multifunctional biomimetically mineralised scaffold integrating natural polymer networks, bacterial cellulose reinforcement, in situ-formed hydroxyapatite (HAp), and phytochemical bioactive compounds to enhance bone regeneration.

Methods

A porous scaffold composed of gellan gum (GG), carboxymethyl chitosan (CMCs), and bacterial cellulose (BC) was fabricated via freeze-drying. Biomimetic mineralization was performed by immersing the scaffold in fivefold concentrated SBF supplemented with *Cissus quadrangularis* extract. The formation and distribution of HAp were characterized using SEM, EDS, FTIR, and XRD. Physicochemical properties of scaffold were evaluated through swelling behavior, porosity, and compressive strength testing. Biological performance was assessed via hemolysis assay, cell viability assay, and Alizarin Red S staining for osteogenic differentiation.

Results

Uniform HAp deposition on the scaffold surface was confirmed by SEM imaging and further validated by FTIR and XRD analyses. The composite matrix preserved its interconnected and homogeneous porous architecture after mineralization. Excellent hemocompatibility was observed, with a hemolysis rate of 1.9%. Cell viability exceeded 100% relative to the control group, indicating favorable cytocompatibility and potential proliferative stimulation. Osteogenic differentiation was markedly enhanced, as quantified by Alizarin Red S staining, with mineral deposition levels reaching 0.794 ± 0.128 , nearly six-fold higher than the control group (0.1457 ± 0.0031).

Conclusions

The synergistic integration of natural polymer networks, bacterial cellulose reinforcement, biomimetic mineralization, and plant-derived bioactive molecules resulted in a multifunctional scaffold with enhanced osteogenic potential. This strategy provides a promising platform for advanced functional biomaterials in bone tissue engineering applications.



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sciforum-174602: New Silk Fibroin-based Dual-crosslinked Hydrogel Inks for 3D Printing of Lung Tissue Engineering Scaffolds

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Respiratory diseases, e.g., idiopathic pulmonary fibrosis, are increasing the expanding healthcare burden globally. To develop effective treatments, lung tissue engineering (LungTE) provides a promising approach. The mechanical characteristics of human lungs change from elastic and compliant alveolar regions to stiffer and stronger bronchial and pleural regions. This progressive change in mechanical microenvironment plays an important role in lung recovery from disease to the healthy state after medical intervention. In scaffold-based tissue engineering (TE), TE scaffolds provide a conducive microenvironment for cells and for new tissue formation. Compared to other technologies, many 3D printing technologies have distinctive advantages of producing complex TE scaffolds with gradients (structural, mechanical, chemical, and/or biological). Current research on LungTE mainly uses hydrogels with non-variable mechanical properties. In this study, new hydrogel printing inks comprising sodium alginate, carboxylated cellulose nanofibers and methacrylic acid-modified silk fibroin (MeSF) were formulated and assessed for extrusion-based 3D printing into novel LungTE scaffolds. They could have controlled dual-crosslinking, thus enabling 3D printing of LungTE scaffolds with programmable mechanical gradients. A physically crosslinked primary network, controlled by polymer chain entanglement and ionic interaction, was formed by sodium alginate and cellulose nanofibers, while MeSF enabled formation of a second covalent network via post-printing photopolymerization. Concentrations of the three components in new hydrogels could be changed, adding another factor for controlling mechanical properties of scaffolds. Rheological analysis was conducted for hydrogel inks to achieve good printability. Printing parameters were optimized. Even for intricate alveolar-like porous designs, hydrogel scaffolds showed no collapse or filament fusion after 3D printing and retained structural integrity during mechanical deformation. Dual-crosslinking enabled high scaffold fidelity and spatially adjustable mechanical property, which could lead to creation of mechanically distinct peripheral, alveolar, and bronchial sections within a single 3D printed scaffold. An in vitro biological study revealed good biocompatibility of printed scaffolds.



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sciforum-172005: Photodynamic Therapy: A Promising Strategy for Alveolar Bone Regeneration

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Introduction: Alveolar bone loss can result from multiple dental conditions or systemic pathologies, with functional and aesthetic consequences. The treatment of such defects remains a major clinical challenge, largely due to the limited regenerative capacity of alveolar bone. Photodynamic therapy (PDT) represents a promising approach to bone regeneration by modulating cellular activity through photochemical processes. Thus, the main objective of this study was to investigate the effects of Porphyrin 1a (meso-tetraphenylporphyrin with Pt (II)) on the function of bone cells and on the osteogenic differentiation of rat bone marrow stem cells (BM-MSCs). Additionally, this study intended to optimise the therapeutic protocol regarding the photosensitiser concentration and light exposure regimens.

Materials and Methods: The effect of the photosensitiser on the SaOS-2 cell line was assessed by testing 3 and 5 J irradiation regimens and a range of concentrations from 1 to 100 nM. The protein content (SRB assay), cell cycle (flow cytometry), *Ki-67* expression (RT-PCR), and formation of mineralised deposits (Alizarin Red staining) were evaluated 24 and 72 hours after treatment. Additionally, the subcellular localisation of Porphyrin 1a was determined using confocal microscopy on BM-MSCs, and the impact of PDT on the proliferation and formation of mineralised deposits was evaluated in these cells 72 hours after treatment.

Results: Porphyrin 1a promoted a significant increase in protein content of SaOS-2 cells and BM-MSCs after irradiation at 5 J. After PDT, the cell populations were mainly in the G₀/G₁ phase of the cell cycle. Furthermore, increased *Ki-67* expression and more mineralised deposits were observed in SaOS-2 cells. Additionally, it was demonstrated that Porphyrin 1a colocalises with the nucleus, mitochondria, plasma membrane, and endoplasmic reticulum of BM-MSCs.

Conclusions: Overall, PDT promoted cellular proliferation, with the most pronounced effects observed under 5 J and at low photosensitiser concentrations. Additional studies are required to elucidate the specific cellular mechanisms behind PDT-induced proliferation and differentiation.



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sciforum-172402: Synthesis and characterization of type I collagen-based scaffolds cross-linked with natural polyphenols extracted from green tea

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Collagen, thanks to its high biocompatibility, low immunogenicity, and ability to mimic the extracellular matrix (ECM), is a promising candidate for soft tissue repair. However, its poor mechanical properties and rapid in vivo degradation limit its use in high-stress environments. This study focused on the cross-linking of type I collagen-based scaffolds with a natural extract from green tea (TPHs). This extract can provide collagen cross-linking and additional anti-inflammatory and antioxidant properties.

Type I collagen scaffolds obtained through the lyophilization of type I collagen hydrogels were immersed in TPHs-PBS solutions at different concentrations. Samples were characterized by several techniques (ATR-FTIR, FE-SEM, DSC, XRD, swelling and compression tests, UV-VIS spectroscopy, release tests, and zeta potential measurements) to investigate if the cross-linking process caused collagen denaturation, how different concentrations of TPHs affected the physico-chemical properties of the hydrogel, and the dynamics of TPHs release in a physiological solution.

Results confirmed TPHs as an effective cross-linking agent without causing collagen denaturation. Samples cross-linked with TPHs registered elastic moduli as high as 7 kPa with an increment of 180 %. Release tests evidenced a slow release of a fraction of the TPHs after an initial (1 h) burst release, making these constructs suitable for a sustained action up to 14 days.



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sciforum-174831: Synthesis of Functional Silk Fibroin/Chitosan Composite Hydrogel for Wound Healing

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Introduction: The aim of this work was to develop a functional composite hydrogel mainly composed of silk fibroin (a protein polymer) and chitosan (a polysaccharide polymer) and to evaluate its properties as a potential scaffold for wound healing dressings. Each component of the composite has well-confirmed properties that are effective in the injury healing process. Silk fibroin was extracted using Ajisawa's method, and a commercial chitosan. **Methods:** A combined method involving cyclic freeze-thawing and freeze-gelation (by using NaOH) was used to synthesize the SF:CS hydrogel at a ratio of 1:1 (v/v) and a porous scaffold was fabricated upon lyophilization. The developed composite scaffold was analyzed using FTIR analysis, porosity estimation, and swelling test (fluid uptake). **Results:** FTIR analysis revealed the chemical nature and molecular conformation of the developed composite scaffold-based hydrogel. Porosity evaluation showed that the composite had 65–80% porosity. The fluid uptake evaluation was conducted for 24 hours, and it confirmed that the synthesized composite hydrogel had a high capacity of solvent uptake, which was stabilized after 6h. To conclude, the synthesized functional composite-based hydrogel prepared using the combined method showed porous structure and a high degree of swelling, indicating that it is a promising biomaterial with integrated drug delivery systems to preventing inflammation and enhancing angiogenesis during wound healing process.



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sciforum-179301: Technological possibilities and limitations of microscopic examinations of H&E-stained mammalian cells

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Microscopic investigation of cell cultures is one of the most commonly used methods in cell biology. It is used to evaluate cell morphology, growth and structural changes. For such examinations, suitable staining methods are often investigated. Several dyes, however, have proven problematic for use on cells grown on nanofibrous or 3D-printed biomaterials because they stain the substrate in a similar way to the cells. This suggests optimization of the staining protocol.

An aspect often neglected in such microscopic evaluations is the choice of filters and similar optical modifications of the microscope. The microscopic setup, however, can significantly affect the image quality for diverse fluorescent and other dyes.

Here we provide an overview of the influence of diverse microscopic setups, using 3T3-Swiss albino mouse embryonic fibroblasts stained with hematoxylin and eosin (H&E), one of the most commonly used standard histological staining techniques. While hematoxylin stains basophilic structures such as cell nuclei blue-violet, eosin stains acidophilic parts of the cells pink, especially the cytoplasm.

A fluorescence microscope Axio Observer 7 (Zeiss) was used to examine the cells in transmitted light, comparing the usual transmitted light brightfield images with photographs taken using different phase contrast modes, differential interference contrasts (DIC), crossed polarizers, etc. In addition, different exposure times, condenser positions, and white balances were compared.

The results show how important it is to carefully select the microscopic setup in order to optimize the quality of images of stained mammalian cells.



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sciforum-180768: Theravex Technology: A Systematic Review and Meta-Analysis of Its Effectiveness in Oral Surgical Procedures.

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Objective: This systematic review aims to synthesize the current evidence from preclinical and clinical studies on the application of Theravex Technology (TTech) (formerly known as bone bioactive liquid “BBL”) in improving postoperative outcomes in dentistry.

Methods: A comprehensive literature search was conducted across PubMed, Scopus, ScienceDirect, Cochrane Library, and Google Scholar for studies published up to March 2026. Eligible studies were selected according to predefined PICOS criteria. The outcomes were analyzed using the random-effects model on Rstudio with results reported as risk ratios (RRs) and 95% confidence intervals (CIs), and a p-value of less than 0.05 was set as a significant result. Trial Sequential Analysis (TSA) was conducted using TSA software to evaluate the required information size (RIS) and control for random errors.

Results: Four studies encompassing 526 treated sites were included in this review. Meta-analysis results of postoperative healing demonstrated a significant benefit of TTech, with a RR of 7.19 (95% CI: 2.24; 23.13; p = 0.0009). These findings were further validated by TSA, which confirmed robustness by crossing the TSA boundaries, but the cumulative number of subjects did not reach the RIS. Narrative synthesis results from a preclinical study consistently showed that BBL-treated implant surfaces achieved significantly greater bone-to-implant contact, increased inter-thread bone area, and reduced crestal bone loss compared with conventional surfaces. Clinically, TTech was associated with improved implant stability, enhanced osseointegration on CBCT, and accelerated soft tissue healing. Compared to chlorhexidine mouthwash, TTech promoted earlier pain relief and superior early wound healing, highlighting its potential to optimize both hard and soft tissue recovery following implant therapy.

Conclusion: Current evidence positions TTech as a promising bioactive agent in dentistry, with beneficial effects on osseointegration, soft tissue healing, and postoperative pain reduction. Further long-term clinical studies are crucial to confirm its sustained effectiveness and establish standardized treatment protocols.



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Session 5. Biomaterials for Drug Delivery and Therapy

sciforum-175251: Linking Neuroproteomics to Predictive Brain Drug Delivery: A Physicochemically-Informed Modeling Framework for Silver Nanocarriers in Alzheimer's and Parkinson's Disease

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Neurodegenerative disorders such as Alzheimer's disease (AD) and Parkinson's disease (PD) are characterized by region-specific molecular dysregulation, progressive neuronal loss, and impaired brain clearance mechanisms, collectively limiting the efficacy of regenerative therapeutics. In parallel, biomaterial-based drug delivery systems face critical challenges in achieving stable, targeted, and safe transport across the blood-brain barrier (BBB). Here, we propose a physicochemically informed computational framework that systematically links neuroproteomics to predictive brain drug delivery using silver nanocarriers. Public cerebrospinal fluid (CSF) proteomics and brain-region transcriptomics datasets are integrated to derive disease-specific molecular signatures, enabling classification of AD versus PD and prioritization of affected brain regions and signaling pathways associated with neurodegeneration and impaired clearance. These biological outputs are coupled to a reduced pharmacokinetic model incorporating blood-brain transport, interstitial exposure, and a parameterized ISF-CSF exchange term serving as a proxy for glymphatic function. This structure enables scenario-based simulations reflecting preserved versus impaired clearance dynamics. To ensure translational relevance, experimentally determined physicochemical properties of ready-made silver nanoparticles—including hydrodynamic size, polydispersity index, ζ -potential, optical stability, and stability in physiological media—are embedded as feasibility constraints within the modeling space. This integration enables stability-aware optimization of dose and release kinetics for a model regenerative factor under predefined safety boundaries. The resulting framework establishes a quantitative bridge between disease-specific molecular dysregulation and rational nanocarrier design, providing a scalable and data-driven blueprint for optimizing brain-directed regenerative therapies in AD and PD.



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sciforum-179780: Effect of pore size on physical properties of self-agglomerated and ultrasonicated lyogels

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Introduction:

Silk fibroin (SF) lyogels are promising biomaterials for tissue engineering and drug delivery; however, their performance is strongly influenced by pore architecture and degradation behavior. Understanding how processing routes affect these properties is essential for designing application-specific systems.

Methods:

Lyogels were prepared from regenerated aqueous SF derived from *Bombyx mori* silk using two gelation approaches: storage-induced self-agglomeration (5% w/v) and ultrasonication (7% w/v). The gels were subsequently freeze-dried to obtain porous lyogels. The materials were characterized for pore morphology, swelling kinetics, hydrophilicity, in vitro enzymatic degradation (Protease XIV, 1 U/mL), and drug release behavior.

Results:

Self-agglomerated lyogels exhibited smaller and more uniform pores, slower swelling, and prolonged structural integrity. In contrast, ultrasonicated lyogels showed larger, more heterogeneous pores and rapid water uptake, absorbing up to ~1800% of their dry weight within 1 h, whereas self-agglomerated lyogels absorbed less than 1000% but continued swelling for over one week. Under enzymatic conditions, ultrasonicated lyogels degraded completely within 48–72 h, while self-agglomerated lyogels retained their structure beyond 4 days. Drug release studies indicated faster release from ultrasonicated lyogels ($T_{50\%} \approx 0.68$ h) compared to self-agglomerated lyogels ($T_{50\%} \approx 1.03$ h).

Conclusions:

These findings demonstrate that modulation of SF gelation provides an effective strategy to tailor pore structure, swelling behavior, degradation rate, and drug release kinetics. This enables the rational design of lyogels for burst or sustained drug delivery and tissue engineering applications.



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sciforum-179556: Dual-Ion Crosslinked Alginate Hydrogels for Combined Antioxidant and Anti-Inflammatory Delivery in Colon-Targeted Therapy

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Chronic psychological stress disrupts gut homeostasis via activation of the hypothalamic-pituitary-adrenal (HPA) axis, leading to oxidative stress, epithelial damage, and persistent intestinal inflammation. Targeted strategies capable of simultaneously modulating oxidative stress and inflammatory responses are therefore highly desirable for colon-related disorders.

Here, we developed a dual-ion crosslinked sodium alginate (SA) hydrogel for the sustained release of antioxidant mineral-tannic acid nanoparticles (mTNs) under colon-mimicking conditions.

Mannuronic-rich, low molecular weight SA (50–80 kDa; M/G ratio 1.56) was selected to ensure homogeneous nanoparticle incorporation. A controlled pre-gelation step with Ca²⁺ and Zn²⁺ ions was introduced to promote uniform crosslinking and enhance network stability, with Zn²⁺ additionally contributing to epithelial repair and redox regulation.

Composite hydrogels containing 2, 3, and 4 % (w/v) SA and 1 % (w/v) mTNs were prepared and characterized in terms of encapsulation efficiency, mechanical properties, swelling, degradation, and release kinetics in simulated colon fluid. Anti-inflammatory activity was evaluated in LPS-stimulated macrophages by quantifying TNF- α gene expression, while cytocompatibility was assessed in Caco-2 cells.

Encapsulation efficiencies exceeded 80%, and dual ion crosslinking provided tunable mechanical properties comparable to native colon tissue. The composite hydrogels exhibited sustained nanoparticles release over 72 h, while preserving antioxidant activity. Notably, mTN-loaded hydrogels significantly reduced TNF- α expression compared to SA-only controls, confirming an anti-inflammatory effect, with excellent cytocompatibility observed in Caco-2 cells.

Overall, this dual-crosslinked hydrogel platform represents a promising strategy for controlled antioxidant delivery and modulation of stress-related colon inflammation, supporting its potential for colon-targeted therapy.



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sciforum-173305: Macroheterocycle-Functionalized Bentonite Nanohybrids for Antimicrobial Biomaterial Coatings

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Bentonite is an abundant montmorillonite clay widely explored in biomedical applications due to its high surface area, cation-exchange capacity, and inherent antibacterial adsorption properties (Aliyev et al. 2025). Its layered structure enables intercalation of organic molecules, and chemical modification is routinely employed to tailor surface chemistry and functionality (Aliyev et al., 2026). In this study, we investigate the immobilization of synthetic macroheterocycle (MHC) ligands onto bentonite to develop multifunctional antimicrobial nanohybrids. This approach extends our previous work on bentonite-based antibacterial nanocoatings by introducing purely organic MHC units as active agents.

Bentonite was non-covalently functionalized with newly synthesized MHC compounds, and the hybrids were characterized by FTIR, XRD, and electron microscopy. Spectroscopic analysis revealed new functional bands consistent with MHC incorporation, while XRD indicated slight interlayer expansion. SEM/TEM observations demonstrated coated and partially exfoliated clay sheets, confirming successful modification.

Preliminary antimicrobial assays against *Staphylococcus aureus* and *Escherichia coli* suggest enhanced activity of MHC-bentonite compared to unmodified clay. Ongoing studies include biofilm inhibition analysis, ROS quantification, membrane integrity testing, and cytocompatibility assessment. Polymer-clay composite coatings are also being fabricated to evaluate their applicability in biomaterial systems.

These findings indicate that MHC-bentonite hybrids may act through dual mechanisms—sustained release from the clay matrix and direct antimicrobial interaction of macroheterocycles—supporting their potential use in infection-resistant biomaterials.

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sciforum-180013: Angiogenic Peptide Hydrogels Delivering Neuronal Differentiators for Treatment of Traumatic Brain Injury

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Introduction: Traumatic brain injury (TBI) remains a major global cause of injury-related mortality and long-term neurological disability. However, significant advances in therapeutic strategies have been limited in recent years.

Methods: Herein, we developed a supramolecular hydrogel based on amphiphilically modified angiopoietin-1 (Ang-1) mimetic peptide. Retinoic acid (RA) was subsequently encapsulated into the hydrogel system to achieve sustained co-delivery of angiogenic and neurogenic cues. The formation and structural properties of the fabricated hydrogels were characterized by transmission electron microscopy (TEM) and circular dichroism (CD) spectroscopy, while the critical micelle concentration (CMC) was determined by fluorescence spectroscopy with Nile red as a fluorescent probe. The biological performance of the hydrogel system was evaluated using cell scratch assays, tube formation assays, and *in vitro* RA release studies. To assess therapeutic efficacy, TBI was induced in mice via controlled cortical impact, followed by intracerebral injection of the RA-loaded hydrogels.

Results: *In vitro* assays demonstrated that the supramolecular hydrogels not only significantly promoted angiogenesis, but also enhanced the differentiation of neural stem cells into neurons. Furthermore, the Cell Counting Kit-8 (CCK-8) assay in a nerve cell co-culture system confirmed the neuroprotective effect. These findings were further corroborated in a mouse TBI model, where treatment with hydrogels significantly improved neuronal survival and reduced brain tissue loss.

Conclusions: In this study, supramolecular hydrogels loaded with RA were successfully constructed. These hydrogels enable the slow, continuous, and low-dose co-delivery of angiogenic growth factors and RA to local brain tissue, thereby demonstrating their potential for clinical translation in TBI treatment.



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sciforum-182148: Bioactivity-Guided Assembly of Fucoidan from *Turbinaria decurrens* for Enhanced Anticancer Performance

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Fucoidan has emerged as a promising multifunctional biomaterial due to its diverse biological activities and inherent bioactivity. With low toxicity, excellent biocompatibility, and biodegradability, fucoidan has been widely explored as a bioactive polymer for drug delivery, particularly in targeted cancer therapy. However, its functional contribution within biomaterial systems and its role in modulating therapeutic efficacy remain poorly understood. This study aims to elucidate the structure of fucoidan extracted from *Turbinaria decurrens* and to evaluate its potential role as a bioactive component in enhancing anticancer efficacy. Its intrinsic bioactivity and ability to interact with therapeutic compounds suggest a functional contribution beyond that of a passive carrier.

The isolated fucoidan was identified as a sulfated galactofucan composed of alternating (1→3)/(1→4)-linked α -L-fucopyranose residues, with sulfate groups located at the C-2, C-3, and C-4 positions. Small-angle X-ray scattering (SAXS) analysis provided insight into its conformation. Fucoidan from *T. decurrens* exhibited multiple biological activities, including immunomodulatory and lipid-regulating effects. Notably, its anticancer activity against HT-29 cells suggests that this activity can be enhanced through structural modulation.

Fucoidan was assembled with chitosan via electrostatic interactions between sulfate ($-\text{SO}_3^-$) and protonated amino ($-\text{NH}_3^+$) groups to form FC complexes, which were loaded with curcumin to generate FCC systems. Characterization confirmed the formation of amorphous nanostructures. The FCC system exhibited enhanced anticancer activity compared to free curcumin in both MCF-7 and A549 cancer cell lines, indicating improved bioavailability.

Overall, these findings demonstrate that fucoidan from *T. decurrens* functions not only as a structurally defined polysaccharide but also as an active contributor to therapeutic performance. By integrating intrinsic bioactivity with rational assembly, this study highlights a bioactivity-guided approach for the development of fucoidan-based systems, providing a foundation for the future design of bioactive nanomaterials in cancer therapy.



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sciforum-174449: Biodegradable PHB–Alginate Composite Matrix for Controlled Endolysin Release

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Introduction

Infection control and efficient local delivery of antimicrobial proteins remain key challenges for advanced wound dressings. This work presents a fully biodegradable composite wound dressing that combines an electrospun poly(3-hydroxybutyrate) (PHB) fibrous mat with a Ca²⁺-crosslinked alginate hydrogel layer acting as a reservoir for therapeutic proteins (endolysins).

Methods

The composite was fabricated in three stages. First, a porous PHB fibrous mat was produced by electrospinning PHB from 6–8% (w/v) solutions in a hexafluoroisopropanol/chloroform system, with parameters adjusted to obtain fibers of 1–4 µm in diameter. Second, a 2% (w/v) aqueous sodium alginate solution was prepared and the protein was introduced at room temperature. Third, the electrospun PHB mat was placed into the alginate solution prior to gel formation, so that during subsequent crosslinking it became fully submerged/embedded within the gel layer; gelation was achieved by Ca²⁺ diffusion crosslinking through a dialysis membrane (5% CaCl₂, 20 min). Morphology was evaluated by scanning electron microscopy, mechanical properties by tensile testing, and protein content by the Bradford assay (595 nm; BSA calibration). Encapsulation efficiency was calculated as the ratio of experimentally loaded to theoretically introduced protein.

Results

The approach yields a porous, mechanically supportive PHB scaffold fully integrated within a biocompatible alginate hydrogel coating, enabling homogeneous protein distribution in a biodegradable composite structure.

Conclusions

The proposed fully biodegradable PHB/alginate composite dressing provides a mechanically robust, porous framework embedded within a protein-loaded hydrogel layer, offering a promising platform for local delivery of endolysins and other therapeutic proteins in wound care.



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sciforum-174422: Can Biobased Ionic Liquids act as Cryoprotectants?

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Biomaterials research increasingly relies on multifunctional platforms that integrate structural performance with biological activity. In this context, transfersomes have attracted considerable attention due to their adaptability, biocompatibility, and potential for controlled delivery of bioactive compounds. Additionally, ionic liquids (ILs) have been explored as functional compounds in biomaterial design due to their tunable physicochemical properties, low volatility, and capacity to modulate interfacial interactions. When incorporated into nanovesicular systems, they give rise to TransfersomILs, an advanced hybrid nanosystem that combines membrane flexibility with enhanced colloidal stability.

A critical challenge in the development of vesicular biomaterials is ensuring structural integrity and functional preservation during storage. Freeze–thawing and freeze–drying are widely employed stabilization strategies; however, they may induce membrane disruption, aggregation, and loss of encapsulated compounds. Therefore, identifying effective cryo- and lyoprotective agents is essential to maintain nanosystem performance and extend shelf life.

Within this framework, the present study explores biobased ILs as multifunctional excipients in unloaded and loaded TransfersomILs, evaluating their role in preserving physicochemical stability and antioxidant functionality after lyophilization.

Two ILs, (2-hydroxyethyl)-trimethylammonium-L-phenylalaninate [Cho][Phe] and (2-hydroxyethyl)-trimethylammonium glycinate [Cho][Gly], were synthesized and incorporated at 0.2% (v/v). Physicochemical properties of all produced nanoparticles, as well as association and retention efficiencies of caffeic acid-loaded systems, were assessed before and after the freezing strategies. Antioxidant activity was also determined using the DPPH radical scavenging assay.

Results demonstrated that both produced TransfersomILs maintained suitable particle size distribution and colloidal stability after freeze–thawing, demonstrating that biobased ILs exhibited cryoprotective performance comparable to conventional cryoprotectants. In freeze–drying studies, although retention efficiency was lower than that achieved with classical lyoprotectants, structural integrity and antioxidant activity were preserved.

Overall, biobased ILs show potential as alternative cryoprotective compounds for nanovesicular systems, warranting further optimization to enhance their lyoprotective capacity.



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sciforum-167756: Cardiomyocyte-Loaded Polymeric Microsphere Design For Treatment Of Cardiac Regeneration After Myocardial Ischemia And in vitro Evaluation

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Cardiovascular disease (CVD) is the leading cause of mortality and disability worldwide, with 17.9 million annual deaths, including myocardial infarction caused by atherosclerosis [1]. Atherosclerosis is a complicated cardiovascular disease caused by multiple factors, including aging, inflammation, coronary artery blockage, oxidative stress, and plaque rupture, which causes myocardial ischemia (MI) and damages the heart muscle [2]. Current clinical strategies face limitations such as a lack of regeneration of damaged muscle and residual heart failure progression (e.g., pharmacological treatments and reperfusion therapies), leading to death [3]. Targeted drug delivery systems, including nanomedicine, nanoparticles and microsphere therapies, are being investigated to improve cardiomyocyte renewal. In this study, we designed a cardiomyocyte-loaded Gelatin-Alginate (GA) microsphere conjugated with LA (lipoic acid) and CMP (WLSEAGPVVTVRALRGTSW) peptide to treat damaged heart tissue by using the electrostatic spray drying technique. We determined the chemical groups and morphological analyses of the microsphere using FT-IR, ¹H NMR, and EDS-SEM. Dose-dependent cytotoxicity of drug and peptide conjugation on cell-loaded microspheres was obtained on days 4, 8, and 12 of incubation using the CCK-8 assay and live-dead assay. The cytotoxicity results showed the cell viability increased from 72% to 100% on day 12, indicating that drug and peptide conjugation increased cell regeneration. Thus, this treatment method may be part of a promising next-generation cellular therapy in the future.



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sciforum-157045: Doxorubicin-loaded Cholesterol-Glycopolymer Nanomicelles with Autophagy Activator Rapamycin for Synergistic Glioblastoma Cell Inhibition

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In a recent work, we developed a pH-responsive diblock glycopolymer (PMagala₁₈-*b*-P(MAA₂₄-*co*-MACHol₆)) for the controllable delivery of doxorubicin (DOX); the glycopolymer nanomicelles have high DOX loading efficiency, caveolae-/clathrin-mediated endocytosis pathways, endosome-lysosome localization, and pH-responsive DOX release properties in the Human Glioblastoma Carcinoma (H4) cell line. Herein, we prepared the DOX-loaded glycopolymer micelles. The physico-chemical properties of these DOX-loaded micelles, including particle size, polydispersity (PDI), surface zeta potential, drug loading content (DLC, wt.%), drug loading efficiency (DLE, wt.%), number of loaded DOX, and relative colloidal stability (%), were investigated. In the cell biological study, we utilized the H4 and H4-GFP-LC3 cell lines (stably over-expresses green fluorescent protein (GFP)-tagged microtubule-associated autophagy marker protein 1 light chain 3 (LC3)) as model cell lines. The co-incubation/co-delivery of MAGala₁₈-*b*-P(MAA₂₄-*co*-MACHol₆)/DOX nanomicelles with autophagy activator rapamycin (RAPA) could lead to an obviously enhanced tumor cell proliferation inhibitory effect, which might be due to the synergistic effect of DOX (the Topoisomerase II inhibition and DNA intercalation) and RAPA (autophagy process activation and LC3-II protein degradation). The synergistic effect of MAGala₁₈-*b*-P(MAA₂₄-*co*-MACHol₆)/DOX nanomicelles and RAPA was further quantified by Bliss independence analysis. This work showed a preliminary study on the glycopolymer-based (DOX-RAPA) drug co-delivery nanosystem, which might inspire the future development of “anticancer agent-autophagy regulator co-delivery nanotherapeutics” toward clinical cancer chemotherapy.



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sciforum-182263: Dual-Loaded Curcumin and Phenformin Copolymer Micelles for Targeted Colorectal Cancer Therapy via Mitochondrial Stress and Metabolic Modulation

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Curcumin, a natural polyphenol from *Curcuma longa*, exhibits potent anti-cancer properties against colorectal cancer (CRC), yet its poor solubility and rapid systemic clearance severely limit clinical translation and overall therapeutic efficacy in patients. To overcome these challenges, curcumin-loaded copolymer micelles were rationally engineered, significantly improving solubility, pharmacokinetic stability, tumor-specific accumulation, and efficient cellular uptake in CRC cells. Phenformin, a mitochondrial complex I inhibitor with reported chemopreventive activity in CRC, was co-encapsulated to develop a dual-targeting nanomedicine with enhanced precision, specificity, and potential synergistic anti-cancer effects. In vitro, curcumin micelles alone moderately inhibited proliferation and migration of HCT116 cells, whereas curcumin/phenformin co-loaded micelles were required to elicit comparable effects in CT26 cells, reflecting distinct cell line-specific metabolic dependencies on glycolysis and oxidative phosphorylation. Mechanistically, the dual-loaded formulation induced overproduction of reactive oxygen species and pronounced mitochondrial dysfunction, highlighting markedly enhanced oxidative and energetic stress. In subcutaneous CRC models, curcumin/phenformin micelles exhibited significantly superior anti-tumor efficacy compared with single-agent or unloaded treatments. Taken together, this dual-targeting nanomedicine not only enhances curcumin bioavailability, systemic stability, and tumor-specific delivery but also selectively modulates tumor metabolism and triggers mitochondrial stress, providing a highly promising, versatile, and translationally relevant therapeutic strategy for colorectal cancer treatment.



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sciforum-179134: Effect of Gelation Route on Pore Architecture, Swelling, and Degradation of Silk Fibroin Lyogels

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Silk fibroin (SF) lyogels are promising biomaterials for tissue engineering and drug delivery, but their performance depends strongly on pore architecture and degradation behavior. In this study, we compared lyogels prepared from naturally self-agglomerated SF and ultrasonicated SF to determine how gelation route influences pore morphology and related physical properties such as swelling and degradation. Regenerated aqueous SF was prepared from *Bombyx mori* silk, gelled either by storage-induced self-agglomeration (5% w/v) or ultrasonication (7% w/v), and then freeze-dried to obtain porous lyogels. The materials were evaluated for swelling kinetics, pore morphology, hydrophilicity, in vitro degradation and release kinetics. Self-agglomerated lyogels exhibited smaller and more uniform pores, slower swelling, and prolonged structural integrity, whereas ultrasonicated lyogels showed larger, less homogeneous pores and rapid water uptake. Ultrasonicated lyogels absorbed up to ~1800% of their dry weight within 1 h, while self-agglomerated lyogels absorbed 1000% but continued swelling for more than one week. Under enzymatic degradation with Protease XIV (1 U/mL), ultrasonicated lyogels degraded completely within 48–72 h, while self-agglomerated lyogels retained their shape beyond 4 days. Additionally ultrasonicated sponges showed faster release ($T_{50\%} \approx 0.68 \pm 0.01$ hr), i.e., 41 mins, whereas self-agglomerated sponges exhibited slower release ($T_{50\%} \approx 1.03 \pm 0.04$ hr), i.e., 64 mins. These findings show that controlling SF gelation is an effective strategy to tune pore size, swelling, and degradation, enabling rational selection of lyogels for burst-release versus sustained-release systems and for tissue engineering applications.



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sciforum-179371: Functional Nanomaterials for Tumor Immunotherapy

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Malignant tumors pose a significant threat to human health, with over 90% of tumor-related deaths attributed to metastasis. How to overcome the immunosuppressive tumor microenvironment and tumor metastasis is the main challenge. In this context, we have designed a range of nanocomposites to address the aforementioned challenges. (1) Various biodegradable pyroptosis inducers have been developed. And the systematic mechanisms of different nano-pyroptosis inducers-induced pyroptosis and cuproptosis as well as their potential in anti-tumor immunotherapy and inhibition of tumor metastasis have been investigated. (2) A synergistic strategy combining immunotherapy and inhibition of circulating tumor cells (CTCs) formation was proposed. Au nanoparticles with a large pore size were utilized as carriers for delivering anti-CD24 antibodies, which not only blocked the CD24/SIG-C10 signaling pathway but also alleviated its inhibitory effect on macrophages, thereby enhancing immune response. (3) A "metal chelation therapy" method has been proposed. The copper chelating agent D-penicillamine coordinated with Zn^{2+} to form a nanotherapeutic agent (Zn-PEN), which depletes copper in tumor cells and promotes the proliferation of Zn^{2+} , ultimately achieving synergistic anti-tumor, antibacterial, and anti-metastasis therapy. Furthermore, we proposed a strategy of artificially mimicking EMT, integrating ferroptosis and immunotherapy to inhibit tumor growth and metastasis by EDTA-Mg nanochelator.

References

- [1] Xie, Y. L.; Li, C. X. et al. *Adv. Mater.* **2026**, *38*, e15904.
- [2] Xie, Y. L.; Lin, J.; Li, C. X. et al. *Angew. Chem. Int. Ed.* **2025**, *64*, e202411976.
- [3] Xie, Y. L.; Li, C. X. et al. *Angew. Chem. Int. Ed.* **2025**, *64*, e202506126.
- [4] Zhu, G. Q.; Li, C. X. et al. *Adv. Mater.* **2024**, *36*, 2409066.
- [5] Qiao, L. Q.; Li, C. X. et al. *Adv. Mater.* **2024**, *36*, 2308241.



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sciforum-174179: Functional performance and biocompatibility of PEDOT:GABA neurotransmitter-loaded coatings

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Neurological disorders are among the leading causes of disability and premature mortality in Europe and are frequently associated with impaired neurotransmission involving glutamate, γ -aminobutyric acid (GABA), dopamine, or acetylcholine (1). Current therapeutic strategies rely predominantly on systemic drug administration, which often results in non-specific distribution, limited targeting precision, and adverse side effects (2). Conducting polymer microelectrode coatings capable of incorporating and releasing neurotransmitters offer an alternative strategy for localised neuromodulation. Such biointerfaces aim to replicate aspects of synaptic regulation while reducing systemic exposure (3,4).

This study investigated poly(3,4-ethylenedioxythiophene) (PEDOT) coatings incorporating GABA as electrically responsive neural interfaces designed to combine biocompatibility with electrically controlled neurotransmitter release. PEDOT:GABA coatings were fabricated via electrochemical deposition onto electrode substrates (5). Cytocompatibility was evaluated *in vitro* using resazurin-based metabolic assays and morphological assessment of SH-SY5Y neuroblastoma and U87 glioblastoma cultures. The ability of the coatings to modulate cellular signalling was assessed by fluorescence calcium imaging to quantify intracellular Ca^{2+} transients following electrically triggered GABA release.

Cells cultured on PEDOT:GABA coatings displayed a moderate reduction in metabolic activity compared with PEDOT controls, while preserving normal morphology and viability. No morphological features indicative of cytotoxicity were observed. Calcium imaging of U87 cultures revealed reproducible, stimulus-dependent intracellular Ca^{2+} fluctuations following electrical stimulation, confirming their capacity to modulate cellular signalling pathways. Calcium transients were detected only upon electrical stimulation and were absent under non-stimulated conditions.

PEDOT:GABA coatings demonstrate a combination of cytocompatibility and electrically controllable bioactivity at the neural interface. While slightly modulating cellular metabolic activity, the coatings do not induce cytotoxic effects and retain the capacity to evoke receptor-mediated calcium signalling. Collectively, these results support the potential of neurotransmitter-loaded conducting polymers as multifunctional biomaterials for spatially and temporally controlled drug delivery and localised neuromodulation.

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sciforum-179376: Influence of Mucoadhesive Polymer Interactions with Lipid and Mucin on Adhesion: Implications for Drug Delivery Systems

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Mucoadhesive polymers are crucial in drug delivery, as their adhesion to mucosal surfaces directly affects bioavailability and therapeutic efficacy. Although macroscopic properties such as wettability and swelling influence retention, linking these effects to molecular mechanisms remains challenging [1,2].

In this study, HPMC, Kollidon, and Carbopol were examined under varying levels of pH to evaluate both macroscopic and molecular aspects of mucoadhesion. Polymer swelling and surface expansion were monitored in real-time using surface dissolution imaging, providing insights into hydration dynamics and deformation. Surface energy calculations using the OWRK model revealed differences in interfacial interactions that may govern adhesion.

At the molecular level, Langmuir–Blodgett trough experiments with model lipid and mucin layers simulated key mucosal components [3]. Polymers were introduced beneath these layers, and changes in surface pressure and layer organization were tracked to assess adsorption kinetics and dominant interactions, including hydrogen bonding and hydrophobic forces.

Results demonstrated a correlation between macroscopic retention and molecular interactions. Polymers with optimal wettability and surface energy showed the strongest binding, while layer reorganization suggested a mechanistic basis for retention. Variations between polymers and pH conditions indicate that both intrinsic material properties and environmental factors modulate mucoadhesive performance.

Integrating macroscopic and molecular analyses provides a comprehensive understanding of polymer–mucosal interactions. These findings offer a rational framework for designing mucoadhesive polymers in advanced drug delivery systems, with the potential to enhance therapeutic outcomes.

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References:[1] Jawadi, Z., Yang, C., Haidar, Z. S., Santa Maria, P. L., Massa, S. (2022). Bio-Inspired Muco-Adhesive Polymers for Drug Delivery Applications. *Polymers*, 14(24), 5459. [2] Subramanian, P. (2021). *Mucoadhesive Delivery System: A Smart Way to Improve Bioavailability of Nutraceuticals*. *Foods*, 10(6), 1362. [3] Alp, G., Aydogan, N. (2020). Lipid-based mucus penetrating nanoparticles and their biophysical interactions with pulmonary mucus layer. *European Journal of Pharmaceutics and Biopharmaceutics*, 149, 45–57.



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sciforum-173646: Layered Double Hydroxide-Engineered Oxidized Hyaluronic Acid/Gelatin/Carboxymethyl Chitosan Injectable Hydrogel Incorporating Salvianolic Acid B and Dexamethasone for Cartilage Regeneration

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Introduction

Articular cartilage defects remain a major clinical challenge due to the limited intrinsic regenerative capacity, frequently leading to osteoarthritis and joint dysfunction. Current treatments provide only temporary symptomatic relief without restoring cartilage structure and function. This study aims to develop an injectable hydrogel system capable of localized drug delivery and structural support to promote cartilage regeneration.

Methods

An injectable Schiff-base crosslinked hydrogel composed of oxidized hyaluronic acid (OHA), gelatin (GEL), and carboxymethyl chitosan (CMCs) was prepared, with layered double hydroxide nanoparticles (LDHs) incorporated to enhance stability of the hydrogel and enable controlled release of salvianolic acid B (SalB) and dexamethasone (DEX). The chemical change of OHA were determined using titration method and FT-IR analysis. The morphology of LDHs and hydrogel was characterized by SEM and TEM. Gelation behavior, *in vitro* injectability, self-healing ability, and tissue adhesion were comprehensively evaluated. Biocompatibility was assessed via the CAM assay and *in vivo* subcutaneous injection in mice. The angiogenic activity of the SalB-loaded hydrogel was examined using scratch wound-healing assay.

Results

FT-IR analysis confirmed oxidation of OHA $\approx 70\%$ and formation of imine bonds within the hydrogel network. SEM and TEM revealed the nanoscale size and hexagonal morphology of LDHs, as well as homogeneous porous microstructure of the hydrogel. The hydrogel exhibited controlled *in situ* gelation, excellent injectability, self-healing capability, and strong tissue adhesion. Sustained release of SalB and DEX was achieved over 14 days. The incorporation of LDHs significantly improved structural stability and drug-release behavior compared to LDH-free systems. *In vivo* studies demonstrated stable gel formation without signs of adverse tissue reactions. Additionally, the hydrogel did not affect chick embryo development and significantly promoted angiogenesis.

Conclusions

The synthesized hydrogel integrates *in situ* gelation, sustained dual-drug delivery, and excellent biocompatibility, offering a promising minimally invasive platform for cartilage regeneration.



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sciforum-182050: Microstructural and Mechanical Characterization of PVA-Based Drug Delivery Films Containing Menthol: Correlation Between SEM Morphology and Texture Analysis Across Three Manufacturing Methods

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Introduction: Menthol, a naturally occurring terpene alcohol from *Mentha piperita* L., is incorporated into polyvinyl alcohol (PVA)-based pharmaceutical films for topical analgesia. Its high vapour pressure creates manufacturing challenges, inducing microstructural defects that compromise film mechanical performance. Characterizing the relationship between manufacturing-induced surface morphology and film mechanical properties is essential for rational biomaterial design in drug delivery applications.

Methods: PVA-based films (PVA 10%, glycerol 3%) containing menthol (5% w/w) and benzocaine (5% w/w) were manufactured by three methods: semi-solid extrusion 3D printing, solvent casting, and DOBOT MG400 robotic arm-assisted electrospinning (15 kV, 1 mL/h, 10 cm tip-to-collector distance). Blank excipient-only controls were prepared in parallel. Surface microstructure was characterized by scanning electron microscopy (SEM) at $\times 1,000$ magnification. Mechanical properties were assessed by texture profile analysis: compression force, resilience, film burst strength (HDP/FSR probe), and rib seal strength (N/mm). The coefficient of variation (CV%) was calculated for all parameters.

Results: SEM revealed distinct method-dependent microstructural profiles correlating directly with mechanical performance. Solvent casting produced large irregular surface pores (up to 50 μm) from menthol volatility, corresponding to reduced burst strength (1202 ± 435 g, CV: 36.2%). 3D printing generated uniformly distributed controlled microporosity, yielding superior burst strength reproducibility (2369 ± 99 g, CV: 4.2%)—a 10-fold improvement over casting. Electrospun films preserved the intact nanofibrous architecture even with active compounds, demonstrating the highest compression resistance (37.5 ± 2.2 N, CV: 5.9%) and optimal rib seal strength (3.09 N/mm, CV: 7.7%). Menthol incorporation significantly reduced compression force in all methods compared to blank films, confirming matrix plasticization.

Conclusions: Manufacturing method critically determines microstructural and mechanical quality of menthol-containing PVA biomaterial films for drug delivery. 3D printing provides superior dimensional reproducibility; electrospinning preserves nanofibrous integrity; and solvent casting is most vulnerable to volatile compound-induced defect formation. SEM morphology directly predicts mechanical performance, supporting its use as a quality screening tool in pharmaceutical biomaterial development.



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sciforum-175412: Multifunctional Collagen Corneal Shields Enabling Sustained Drug Delivery and Regeneration for Ocular Surface Therapy

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Regenerative medicine in ophthalmology offers a novel approach to overcoming the limited healing capacity of ocular tissues and the challenges of conventional therapies. Ocular drug delivery remains hindered by physiological barriers, including tear turnover and the protective corneal epithelium, resulting in the loss of up to 95% of topically administered therapeutics through conventional eye drops. In this context, collagen-based corneal shields have emerged as a promising multifunctional drug delivery platform biomimetically resembling the native corneal extracellular matrix, capable of providing mechanical protection, hydration, and sustained therapeutic release while supporting tissue healing. The present study investigated the development and physicochemical characterization of therapeutic chemically crosslinked collagen corneal shields using custom-designed 3D-printed molds. This methodology enabled control of shield geometry and surface quality, indispensable for maintaining optical performance. Optical analysis confirmed high transparency, with visible transmittance values between 92% and 98%, exceeding ISO standards for ophthalmic biomaterials. Dissolution studies showed controlled biodegradation, with in vitro dissolution rates between 5% and 25%, expected to increase under in vivo enzymatic conditions. Rheological evaluations showed that collagen concentration and crosslinking density affect viscoelastic properties and mechanical integrity. The shields also effectively incorporated water-soluble drugs, enabling prolonged diffusion, while tobramycin-loaded shields demonstrated sustained antimicrobial activity over 72 hours, validating successful drug loading and controlled release. Overall, the results affirm that collagen corneal shields fabricated using 3D-printed molds achieve a combination of controlled biodegradation, sustained drug delivery, and high optical clarity. These attributes underscore their viability as multifunctional scaffolds for next-generation regenerative ophthalmic therapies.



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sciforum-179434: Optimization of Rutin- and Quercetin-Loaded Chitosan Nanoparticles for Enhanced Anti-Inflammatory Delivery

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Introduction: Flavonoids such as rutin (R) and quercetin (Q) are natural polyphenolic compounds with significant pharmacological activities and a key role in disease prevention. They exhibit strong anti-inflammatory, antioxidant, and vasoprotective properties. However, their poor aqueous solubility markedly limits their bioavailability and therapeutic efficacy [1]. Herein, Chitosan-based nanoparticles (CS-NPs) encapsulating R and Q were developed using electrofluid dynamic (EFD) and ionotropic gelation (IG) techniques, resulting in enhanced controlled release profiles suitable for mitigating vascular inflammation.

Method: R and Q were preliminarily subjected to physicochemical characterization, including phase solubility studies, melting point determination, and FTIR spectroscopy. CS-NPs singularly loaded with R or Q were optimized adapting the preparation methods reported in previous studies [2,3], in order to improve drug loading and stability. Different formulations were characterized in terms of particle size, polydispersity index (PDI), zeta potential (ZP), and morphology (SEM, TEM). Encapsulation efficiency (EE %) was determined and in vitro release kinetics were evaluated and fitted using mathematical models.

Results: The CS-NPs exhibited a mean diameter of 200–350 nm, depending on the preparation method and processing parameters. The PDI was approximately 0.22, indicating good formulation homogeneity, while the ZP was around +28 mV, reflecting the characteristic positive surface charge of chitosan and ensuring colloidal stability. All samples showed high encapsulation efficiency (EE ≈ 95%). R- and Q-loaded CS-NPs prepared by EFD showed greater drug release compared to those obtained *via* IG. In vitro release profiles were best fitted by the Korsmeyer-Peppas model, suggesting a diffusion-controlled mechanism, involving both R and Q diffusion and polymer relaxation.

Conclusion: R- and Q-loaded CS-NPs showed favorable physicochemical properties, high entrapment efficiency, and controlled, diffusion-driven release. In vitro studies in inflammatory cell models are ongoing to assess their anti-inflammatory activity and potential as bioavailable nanocarriers for preventing and targeting vascular inflammation.



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sciforum-182261: Prodigiosin-loaded microvesicles as a novel anticancer drug

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Cancer is a complex, multifactorial disease, making the development of new drugs with a targeted mechanism of action crucial. Prodigiosin, a pigment with antitumor, anti-inflammatory, and antioxidant activity, is attracting attention as a potential active component for drug delivery systems. One promising delivery method is microvesicles (MVs), which can transport active substances to target tissues.

The aim of this study was to produce and characterize microvesicles induced in HEK 293 cells and MSCs, as well as to confirm the presence of prodigiosin in them for further use in therapeutic systems. Methods: Vesicles were obtained by incubation with cytochalasin, followed by prodigiosin loading using sonication, as well as by direct incubation of cells with prodigiosin. Protein concentration was analyzed using BCA protein quantification. Microvesicle size and concentration were measured using nanotracking analysis. Structure and morphology were examined using dark-field microscopy with hyperspectral analysis.

Results: Microvesicles were obtained from HEK 293 cells and MSCs, which had similar protein levels and abundance, and their stability was demonstrated. The MV sizes were within the range suitable for drug transport, ranging from 100–200 nm. Hyperspectral analysis confirmed the presence of prodigiosin in the loaded vesicles; the reflectance spectra matched those characteristic of this pigment.

Conclusions: Microvesicles from various cell lines were obtained and characterized, demonstrating their stability and the possibility of loading active substances, such as prodigiosin. The results demonstrate the potential of using MV as a delivery system for therapeutic agents directly to tumor tissue, facilitating the development of new approaches to cancer therapy.

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sciforum-182063: Semi-Solid Extrusion 3D Printing Enhances Epidermal Accumulation of Menthol from PVA-Based Transdermal Biomaterial Films: An Ex Vivo Comparative Permeation Study

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Introduction: Menthol, a bioactive terpene alcohol from *Mentha piperita* L., activates epidermal TRPM8 cold receptors, so epidermal drug concentration is the most relevant pharmacological endpoint for topical analgesic applications. Semi-solid extrusion 3D printing enables precise layer-by-layer PVA matrix construction, potentially creating more homogeneous drug distribution than conventional solvent casting.

Methods: PVA-based films (PVA 10%, glycerol 3%) containing menthol (5% w/w), benzocaine (5% w/w), and capsaicin (0–1% w/w) were manufactured by 3D printing (n=12) and solvent casting (n=12) using matched formulations. Ex vivo permeation studies used human abdominal skin from 10 donors in flow-through diffusion cells at 32°C over 24 hours (ethics: Kaunas Regional Biomedical Research Ethics Committee, BE-2-42). Menthol was quantified by validated GC/FID ($R^2=0.99996$). Statistics: Mann-Whitney U test; Cohen's d.

Results: 3D printing produced a 4.4-fold higher epidermal menthol accumulation versus casting (22.0 vs 5.0 µg/mL; $p=0.0004$; Cohen's $d=1.79$). The epidermal-to-dermal ratio was markedly higher for 3D printing (0.230 vs 0.066), indicating preferential epidermal drug retention. Thickness uniformity CV was 7.3% for 3D printing versus 19.7% for casting; drug content RSD was 4.7% versus 9.5%. SEM of blank cast films showed smooth homogeneous surfaces, confirming that inferior precision in active formulations is attributable to menthol volatility during bulk drying rather than procedural deficiencies in the casting method itself.

Conclusions: Taken together, these results suggest 3D printing warrants further investigation as a manufacturing platform for natural terpene-based transdermal biomaterials, offering superior epidermal drug retention and manufacturing reproducibility.



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sciforum-182192: Streamlined Nanodrug Delivery Systems for Localized Cancer Therapy via Electrospinning and Electrospray

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Introduction

Localized drug delivery systems offer targeted therapeutic administration but remain limited by poor release efficiency and control. Hybrid nanostructures that combine fibers and nanoparticles represent a promising strategy to enhance local drug delivery. We developed a nanofibrous patch based on poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP) fibres and Fluorescein sodium salt (Flu)-loaded poly(lactic-co-glycolic acid) (PLGA) nanoparticles, using electrospinning to enable localized cancer therapy. PVDF-HFP was selected for its chemical stability and piezoelectric properties, enabling stimuli-responsive drug release and mimicking the electromechanical behavior of some native tissues.

Methods

PVDF-HFP (18% w/v) was dissolved in dimethylformamide/acetone (70/30 v/v) and was electrospun at a flow rate of 0.6 mL/h, with a 12 cm needle-to-collector distance and a voltage of 15 kV. PLGA (2% w/v) was dissolved in hexafluoro-2-propanol, and Flu (10% w/w, Flu/PLGA) was added. The solution was electrosprayed onto nanoparticles at 0.008 mL/min, 12 cm needle-to-collector distance, and 15 kV. The morphology of samples was analyzed by a field emission scanning electron microscope. Average nanoparticle and fiber diameters were measured from SEM images using ImageJ (n = 50). Release studies of Flu-loaded PLGA nanoparticles (free and fiber-bound) were conducted in PBS (pH 7.4) at 37 °C for 4 h and 24 h (n = 3).

Results

Flu-loaded PLGA nanoparticles with homogeneous size (d: $0.83 \pm 0.28 \mu\text{m}$) and morphology were uniformly distributed on the surface of electrospun PVDF-HFP nanofibers with a diameter of $0.74 \pm 0.14 \mu\text{m}$. Approximately more than 50% of Flu was released from PLGA nanoparticles in 30 min, and 90% in 4 h. The amount of Flu released was decreased after 24 h when PLGA nanoparticles were located on the surface of PVDF-HFP fibers.

Conclusion

The results highlight the potential of this hybrid fiber/nanoparticle platform for controlled and localized drug delivery, particularly as implantable or stimuli-responsive systems for cancer therapy.

Acknowledgements

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sciforum-182079: Supercritical-Assisted Design of SiO₂-TiO₂ Functionalized PLGA Scaffolds for Controlled Drug Delivery Applications

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The development of multifunctional biomaterials with finely controlled structural and functional characteristics remains a major challenge in drug delivery and tissue engineering. In this study, SiO₂-TiO₂ composite particles were synthesized via the Supercritical Anti-Solvent (SAS) process and subsequently incorporated into poly(lactic-co-glycolic acid) (PLGA) matrices through supercritical CO₂-assisted foaming. A systematic investigation of key operational parameters, including pressure (90–150 bar), temperature (40–65 °C), and solution flow rate (4–8 mL/min), was carried out to determine their influence on particle formation, composition, and scaffold architecture. SEM-EDX analyses confirmed successful co-precipitation and formation of SiO₂-TiO₂ hybrid particles under specific processing conditions, and revealed significant variations in particle size distribution and structural organization as functions of the operating parameters. The findings highlight a complex interplay between thermodynamic and mass-transfer phenomena governing particle precipitation and deposition. Distinct transitions in particle morphology and spatial distribution within the reactor were observed for specific parameter combinations. In parallel, the supercritical foaming of PLGA produced porous scaffolds with markedly different architectures, ranging from uniform pore networks to heterogeneous structures exhibiting localized defects. The structural features obtained suggest a notable correlation between processing conditions and the potential performance of the resulting systems in controlled-release applications. Overall, this work underscores the versatility of supercritical fluid technologies for fabricating advanced composite biomaterials. The capacity to tailor microstructure through precise control of processing parameters opens new opportunities for designing next-generation scaffolds with customized properties for biomedical applications.



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Session 6. Biomaterials and Implantable Devices for Healthcare

sciforum-174850: Biomaterial-Enabled Wearables in Sport: Closing the Validity Gap from Lab to Field

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Introduction: Biomaterial-enabled wearables (smart-textile ECG garments and skin-conformal/microfluidic sweat patches) are increasingly proposed for athlete monitoring during training and competition. However, field translation remains constrained by sport-specific stressors (e.g. multidirectional motion, high sweat rates, and interface instability) and by inconsistent reporting of signal processing and data quality, sustaining a validity gap from lab to field.

Methods: We performed a targeted evidence map restricted to athletes and training/competition contexts, including primary studies evaluating biomaterial-enabled wearables against an in-use reference during sport tasks. Studies were categorized by device type (smart textiles vs skin-adhesive/microfluidic patches) and classified by validation domain: physiological/biological validity, analytical validation (signal quality, drift, adhesion/washability, data loss), and decision validity (actionable sport endpoints, e.g., thresholds or hydration indices).

Results: Eight studies met the inclusion criteria, including works on smart textiles representing 50.0% (4/8) and skin-adhesive/microfluidic patches representing 50.0% (4/8) (hybrid systems 0%). All studies assessed physiological/biological validity 100% (8/8), typically via agreement against team systems/standard patches/blood lactate or via feasibility of interpretable biosignals during sport tasks. Explicit analytical validation metrics (quantified artefact burden, interface stability under sweat shear, washability, or data-loss rates) were reported in 25.0% (2/8), despite frequent mention of motion/sweat as key limitations. Decision validity was addressed in 37.5% (3/8) through performance- or practice-relevant endpoints, including sweat lactate threshold during swimming and sweat electrolyte/sweat-rate metrics during elite team-sport practice. Across contexts, a recurring field failure mode was degradation of signal interpretability during vigorous, multidirectional movement and prolonged sweating, with limited transparency on preprocessing and artefact handling.

Conclusions: Athlete-context studies show promising physiological agreement, but the dominant gap is field robustness and decision readiness, driven by motion/sweat challenges and under-reporting of analytical and preprocessing details. Standardized artefact reporting and explicit decision-level validation are needed to accelerate reliable adoption in training and competition.



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sciforum-178389: Micro and Nano- Structuring of Hydroxyapatite-MMT LoadedHydrogels for Bone Regeneration Applications

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Bone regeneration focuses on creating functional tissue to repair bone defects. Creating a biodegradable scaffold hydrogel that combines a hemostatic agent with bioactive ceramics can afford the biological and mechanical benefits of both components. In the present study, we developed an injectable gelatin-alginate dual composite hydrogel, i.e. loaded with two functional fillers, hydroxyapatite (HA) and the hemostatic agent montmorillonite (MMT). HA (Microparticles and nanoparticles) was incorporated at concentrations of 10-30 mg/mL, with and without MMT at 20 mg/mL. The effects of functional fillers and their concentration on the microstructure and resulting physical and mechanical properties were studied, and a qualitative model summarizing these effects was developed. All formulations exhibited clinically appropriate gelation times (5-29 seconds). n-HA significantly prolonged gelation time, reaching 29 ± 3 s at 30 mg/mL, while MMT reduced gelation time at all concentrations. The tensile strength of the unloaded hydrogel reached 20 kPa and increased to 57 kPa with 30 mg/mL of n-HA. The tensile strength even increased further with the addition of MMT (77 kPa). The results indicate that the combination of HA and MMT produced dual micro-composite hydrogels with moderate reinforcement, whereas the combination of n-HA and MMT generated dual nano-micro composites with synergistic effects. The latter exhibited the highest strength and sealing ability, while maintaining clinically relevant gelation times and controlled swelling behavior. In conclusion, the combination of MMT with n-HA or HA enables the creation of functional hydrogels with controlled properties, tailored to specific applications in bone regeneration.



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sciforum-175231: Multifunctional Bioactive Coatings for Metallic Veterinary Implants

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Veterinary implants, including bone implants, are composed of various metals and alloys, such as titanium and stainless steel. However, metallic implants are vulnerable to bacterial infections and potentially can escalate the foreign body response due to the mechanical mismatch between implants and host tissues. Therefore, there is an urgent need for the development of modifications that either reduce bacterial adhesion or exhibit antibacterial properties while maintaining or increasing the biocompatibility of implants.

In this study, 316L stainless steel and titanium grade 2 surfaces are electrochemically coated with a mixture of diazonium, sulphonium, and iodonium salts. The modified surfaces are characterized using Optical Profilometry and Atomic Force Microscopy (AFM) to evaluate roughness, while Scanning Electrochemical Microscopy (SECM) is employed to assess coating uniformity. The biological performance is evaluated via Scanning Electron Microscopy (SEM) imaging after incubation with *E. coli* (antibacterial activity) and osteoblasts (cell adhesion). Additionally, corrosion resistance is investigated using Electrochemical Impedance Spectroscopy (EIS).

The proposed electrochemical deposition is expected to result in a homogeneous organic layer. Preliminary assumptions suggest that the modified surfaces will exhibit a significant reduction in bacterial counts compared to unmodified samples, as visualized by SEM. Furthermore, EIS analysis is anticipated to demonstrate an enhanced corrosion resistance, with a predicted increase of at least 20 % in the time to the first signs of corrosion. AFM and SECM analyses are expected to confirm that the salt deposition maintains controlled surface roughness, which is conducive to cell integration.

The results obtained in this study demonstrate that electrochemical deposition of an appropriate mixture of diazonium, sulfonium and iodonium salts is an effective strategy for creating a homogeneous layer, which simultaneously protects implants from bacterial adhesion and corrosion while promoting bone cell adhesion. This approach has the potential to enhance the clinical success rate of veterinary implantations.



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sciforum-175277: Optimization of Carbon Nanotube Morphology in Self-Supporting Buckypapers for Bioelectronic Interfaces

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Bioelectronics requires advanced conducting materials to interface with biological systems without triggering inflammatory responses. Conventional metal electrodes often suffer from mechanical and chemical mismatches with living tissue, a challenge that can be addressed using flexible, self-supporting carbon nanotube (CNT) films known as buckypapers (BPs). This study focuses on the optimization of CNT morphology, specifically length and thickness, to enhance the electrochemical performance and porosity of these interfaces.

The fabrication process involved the vacuum filtration of various multi-walled CNT types dispersed in DMF through sonication, followed by overnight drying to produce mechanically stable, self-supporting films. The electrochemical properties were evaluated using cyclic voltammetry and electrochemical impedance spectroscopy, comparing different nanotube morphologies against commercial references. The results demonstrate that nanotube dimensions dictate electrode efficiency. Short and thin nanotubes provided the highest current density and capacitance due to their superior accessible surface area, while maintaining the lowest total impedance and nearly zero charge transfer resistance. In contrast, longer and wider nanotubes exhibited high stability but lower energy storage capacity. Furthermore, long nanotubes with medium thickness created continuous electrical pathways that minimized ion entry barriers. Optimized in-house samples consistently exhibited better kinetic efficiency and lower series resistance compared to standard commercial BPs.

In conclusion, precise control over nanotube morphology is essential for creating efficient bio-derived interfaces. These optimized BPs provide a robust platform for further modification with bioactive hydrogel layers designed to mimic natural tissue structures. Subsequent research will evaluate these materials *in vitro* with human-derived cell lines (SH-SY5Y, U87) and *ex vivo* with embryonic co-cultures to confirm their biocompatibility and ability to stimulate neural activity.

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sciforum-179298: Tantalum-Doped 58S Bioactive Glass Coatings for Corrosion-Resistant CoCrMo Implants

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This work investigates the electrodeposition of tantalum-doped 58S bioactive glass onto porous CoCrMo alloy substrates to improve the material's compatibility with orthopedic implant systems. The evaporation-induced self-assembly (EISA) method was used in order to produce tantalum-doped 58S bioactive glass. This method ensured that the structural organization was under control. The addition of tantalum greatly enhances the bioactivity and osteoconductive properties of the coatings, thereby promoting rapid tissue healing and strong osseointegration at the implant interface. The 58S and 58S-0.6Ta bioactive glass coatings were shown to clearly improve cell survival and proliferation, as demonstrated by comparative in vitro investigations, thereby reinforcing their critical role in promoting favorable biological responses and enhancing implant integration. This finding highlights the significance that surface modification plays in enhancing cell-material interactions and overall biological performance. Electrochemical analysis, performed using potentiodynamic polarization (PDP) and electrochemical impedance spectroscopy (EIS), revealed that coated substrates showed improved resistance to corrosion in simulated bodily fluid (SBF) compared to uncoated control substrates. The findings presented here shed light on the potential of tantalum-doped bioactive glass coatings as a viable and innovative approach to enhance the functionality, biological performance, corrosion resistance, and long-term durability of CoCrMo orthopedic implants under demanding physiological conditions.



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sciforum-180861: Validation of clinical CT-based volumetric analysis using Ti implants for *in vivo* monitoring of Mg-based orthopaedic devices

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INTRODUCTION: *In situ* quantification of residual implant volume is desirable in long-term Mg implant studies where repeated *ex vivo* measurements require euthanising animals. Although clinical X-ray computed tomography (CT) is commonly used for *in vivo* imaging, its accuracy for measuring implant volumes against CAD models or *ex vivo* micro-CT is still lacking. The study represents a preliminary methodological validation of CT-based volumetric analysis using Ti implants and CAD reference before application to degrading Mg-based devices.

METHODS: Unstable zygomatic arch fractures were created in three farm pigs and stabilised with craniofacial plate-screw systems. One animal received the Ti-6Al-4V system on the right arch and the ZX10 Mg device on the left, while others received ZX10 devices on both sides. CT scans were acquired at 1, 3, 6, and 12 months, with *ex vivo* micro-CT performed after one year following euthanasia. Implant segmentation was performed in 3D Slicer using modality-specific intensity thresholds, optimised and applied consistently within each modality. Volumetric analysis of the combined Ti plate-screw system at one year was performed by a single observer.

RESULTS: *Ex vivo* micro-CT data were highly accurate, with a mean error of 0.944 %, whereas clinical CT showed a higher deviation with a mean error of 9.107 %. The mean clinical CT error may still be acceptable for longitudinal monitoring depending on the magnitude of implant degradation over time. The coefficient of variation was 0.212 % for micro-CT and 1.054 % for clinical CT, indicating good reproducibility for both modalities. The deviation in clinical CT measurements is attributed to partial-volume effects and limited spatial resolution.

CONCLUSIONS: CT-based volumetric analysis of Ti implants demonstrated good reproducibility but lower accuracy than micro-CT. Despite systematic deviation, CT-based analysis is reliable for longitudinal *in vivo* monitoring when measurement bias is considered. Further studies are underway to assess ZX10 implants which may behave differently due to gradual *in vivo* degradation altering their volume and geometry.



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Session 7. Bioprinting and Bio-Fabrication

sciforum-174740: New Natural Polymer-based Bioinks and their 3D Bioprinting for Liver Tissue Engineering

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Liver failures caused by disease or injury are a growing medical problem globally. Currently, liver transplantation is the only viable treatment for severely compromised liver. But the scarcity of donor organs heavily limits liver transplantation. Liver tissue engineering (LTE) emerges and has shown great potential for treating liver failure. 3D bioprinting, a powerful biomanufacturing platform, can create complex cell-laden living structures for functional liver tissue regeneration, and developing new bioinks underpins advances of bioprinting in LTE. In this study, new dual-photocrosslinkable hydrogel bioinks were formulated and evaluated for LTE bioprinting. The bioinks combined glycidyl methacrylate-modified hyaluronic acid (HA-GMA), gelatin methacryloyl (GelMA) and gelatin and leveraged the synergy of these three polymer constituents for the hydrogels. HA-GMA and GelMA are UV-curable and allow mimicry of liver extracellular matrix and also precise adjustment of hydrogel modulus via photocrosslinking, thereby ensuring structural stability of bioprinted LTE constructs. GelMA provides good printability, while HA-GMA's high degree of functionalization allows incorporation of bioactive molecules. Gelatin has dual roles: promoting cell adhesion and serving as a thermosensitive component that dissolves during service to create porous struts, thus facilitating cell infiltration, nutrient diffusion, and waste removal in a conducive cell growth microenvironment. Using tri-component hydrogel based-bioinks containing NCTC1469 mouse hepatocytes, 3D cell-scaffold constructs of the designed grid structure with square pores were fabricated via extrusion-based 3D bioprinting. By systematically varying concentrations of HA-GMA, GelMA and gelatin in hydrogel printing inks, the rheological behaviour, printability and crosslinking of inks were optimized and consequently high scaffold fidelity was attained. Additionally, mechanical properties and biodegradation behaviour of 3D printed structures could be tuned. The 3D bioprinted constructs maintained structural integrity over extended culture periods and supported high cell viability and proliferation. Importantly, the constructs promoted the expression of mature hepatic markers and sustained key liver-specific functions *in vitro*.



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sciforum-175417: 3D bioprinted scaffold for dermal tissue imitation in burn treatment: physicochemical characterization.

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The need for personalized scaffolds for skin replacement has led us to explore technologies such as three-dimensional bioprinting, which has become a promising alternative in regenerative medicine, enabling the fabrication of customized scaffolds that mimic the architecture and function of native skin tissue.

This project focuses on the development of preliminary 3D-bioprinted scaffolds for dermal tissue regeneration in first- and second-degree burns using extrusion-based bioprinting. The methodology included the segmentation of clinical burn images to define the geometry of the area of interest , the formulation of bioinks combining natural polymers (type I collagen extracted from bovine Achilles tendon) and synthetic polymers (polylactic acid), and scaffold fabrication.

This hybrid approach leverages the biocompatibility of collagen and its properties similar to those of the extracellular matrix, while incorporating PLA to improve mechanical strength and structural stability. Physicochemical characterization through mechanical testing was used to assess the performance of the developed formulations , where the scaffold showed hydrogel retention at different porosities, leading to the selection of a specific porosity type.

The obtained results include optimized bioink formulations that provide adequate mechanical properties and create a favorable microenvironment for their potential application as a scaffold. In addition, the printed constructs exhibited sufficient structural stability for handling .

This research contributes to the development of dermal substitutes, addressing current therapeutic limitations in burn care by establishing a personalized bioprinting strategy and identifying promising scaffold design parameters for dermal regeneration.



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sciforum-174961: Data-Driven Inverse Design of Electrospun Biomaterials with Controlled Fibre-Diameter Distributions for Tissue Regeneration

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Electrospun nanofibrous scaffolds are widely used in tissue engineering because their fibrous architectures closely resemble the extracellular matrix (ECM), providing structural and biochemical cues that regulate cell adhesion, proliferation, and tissue regeneration. However, designing electrospun biomaterials with targeted structural features remains largely empirical. In particular, biological performance is strongly influenced by the full fibre-diameter distribution, which governs pore size, mechanical behaviour, and cell infiltration, yet most optimisation strategies rely only on mean fibre diameter.

This work presents a data-driven framework for the inverse design of electrospun biomaterials with tailored fibre-diameter distributions relevant to regenerative applications. Using a curated meta-dataset containing more than 68,000 fibre-diameter measurements extracted from 1,778 datasets across 16 polymers commonly used in biomaterials, we develop predictive models capable of reconstructing complete fibre-diameter distributions from experimentally controllable electrospinning parameters, including polymer composition, solvent system, and electrohydrodynamic conditions. Model performance is rigorously evaluated computationally and empirically to ensure robust generalisation across different experimental sources.

To enable scaffold design, the predictive models are embedded within a chemically constrained and Inverse Monte Carlo framework that generates feasible polymer-solvent-process combinations capable of achieving user-defined fibre-diameter distributions while respecting experimentally validated compatibility constraints. This inverse design approach allows researchers to computationally explore process conditions that produce biomimetic architectures, including bimodal fibre distributions known to enhance cell infiltration and tissue integration.

By integrating interpretable machine learning, chemically informed constraints, and distribution-aware modelling, this framework provides a new pathway for the rational design of electrospun biomaterials for tissue regeneration. The approach reduces trial-and-error experimentation, accelerates scaffold optimisation, and supports the development of next-generation electrospun constructs with tunable structural properties tailored to specific regenerative medicine applications.



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sciforum-182060: DOBOT MG400 Robotic Arm-Assisted Electrospinning: A Novel Hybrid Biofabrication Platform for Precise Manufacturing of PVA-Based Drug Delivery Films Containing Natural Active Compounds

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Introduction: Conventional stationary electrospinning systems lack precise control over nanofibre deposition geometry and collector positioning, limiting film thickness uniformity. Integration of a programmable robotic arm with electrospinning represents a novel biofabrication approach enabling precise X-Y positioning control during fibre deposition. This hybrid system may improve manufacturing reproducibility for pharmaceutical films containing volatile natural compounds such as menthol (*Mentha piperita* L.) and capsaicin (*Capsicum annuum* L.).

Methods: A custom-built hybrid electrospinning system was constructed using a DOBOT MG400 robotic arm (Shenzhen Yuejiang Technology Co., China) with programmable X-Y positioning, a syringe pump (LSP02-1B, Longer Precision Pump, China), Gamma High Voltage power supply (USA), and grounded aluminium collector (85 mm). Processing parameters included 15 kV, tip-to-collector distance 10 cm, flow rate 1 mL/h and duration 1 hour. PVA-based formulations (PVA 10%, glycerol 3%) containing menthol (5% w/w), benzocaine (5% w/w), and capsaicin (0–1% w/w) were electrospun onto PTFE substrates. Manufacturing quality was assessed by mechanical CV%, thickness uniformity (USP 731>), rib seal strength, and scanning electron microscopy.

Results: The DOBOT MG400 robotic arm-assisted system produced reproducible nanofibrous PVA films confirmed by SEM (×1,000 magnification) across all formulation variants. Optimized films (menthol-benzocaine-capsaicin) achieved rib seal strength CV of 7.65%, superior to stationary casting (CV: 26.8%). Moisture content was optimally controlled at 5.6% – lowest across all three manufacturing methods – attributable to the high surface-area-to-volume ratio of the nanofibrous matrix. Programmable X-Y robotic movement reduced edge-effect variability inherent to stationary electrospinning, enabling uniform collector coverage and consistent film thickness.

Conclusions: The custom-built DOBOT MG400 robotic arm-electrospinning hybrid platform represents a cost-effective and scalable biofabrication approach combining robotic precision positioning with electrospinning nanostructuring capability. The system successfully produces pharmaceutical-grade nanofibrous films containing volatile natural compounds, achieving superior moisture control and mechanical reproducibility. This novel platform addresses a critical limitation of conventional electrospinning and offers a promising basis for precision biofabrication of natural compound-based transdermal biomaterials.



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sciforum-178349: Organoid Bioprinting

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Over the past 10 years, organoids have emerged as a transformative platform in stem cell biology and translational medicine. These three-dimensional (3D) miniaturized versions of tissues or organs exhibit self-organization into multicellular architectures that recapitulate structural and functional features of native organs. By preserving cell-cell interactions and tissue-specific microenvironment cues, organoids derived from patient-specific or genetically engineered cells have exceptional potential for applications across multiple biomedical domains. Given their critical role in biomedicine, advancing organoid innovations has become a top priority in current biomedical research. 3D bioprinting, first appeared in 1988 and based on the powerful additive manufacturing platform, now enables unprecedented strategies for achieving living structures effectively and efficiently. It has the unmatched capability to engineer complex and biologically relevant architectures for different purposes. It provides precise deposition/placement of biomaterials, live cells, and other necessary substances to form carefully designed, spatially organized living structures, offering revolutionary potential for fabricating organoid-incorporated products. A key feature of 3D bioprinting is its programmable control over biomechanical and biochemical cues (matrix stiffness, growth factor gradient, etc.), which directly modulate cellular processes such as migration, lineage specification, and functional maturation: the critical determinants of organoid fidelity. Furthermore, 3D bioprinting facilitates hierarchical patterning of cells into pre-defined geometries, thereby enhancing the recapitulation of tissue-specific cytoarchitecture. It also presents unprecedented opportunities to scale up organoid biofabrication to produce macroscale tissue constructs. This talk will provide a concise review of recent developments of organoid bioprinting and its translational applications in biomedicine, focusing on four areas - developmental biology research, cancer research, drug discovery, and regenerative medicine and precision medicine, and introduce our current research on organoid bioprinting. Challenges and future perspective of organoid bioprinting will be pointed out, including bioink formulation and biomaterials for bioinks, bioprinting technologies, bioprinting scale-up, and artificial intelligence-assisted bioprinting.



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sciforum-174852: Three-Dimensional Bioprinting of New Hydrogel-based Bioinks into Cell-scaffold Constructs for Articular Cartilage Repair

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Articular cartilage exhibits excellent load-bearing capacity and minimal friction that enables essential articulation in human diarthrodial joints. Following disease or injury, its self-repair ability for defects over a critical size diminishes. Tissue engineering strategies involving seeding chondrocytes onto artificial porous scaffolds have shown their efficacy for repairing cartilage defects but have their own limitations including cell penetration and distribution in scaffolds. Three-dimensional bioprinting uses bioinks comprising live cells, extracellular matrix (ECM)-analogous biomaterials and possibly bioactive biomolecules to fabricate living structure with potential high cell viability and with precisely controlled cell distributions for effective body tissue regeneration, and hydrogels based on natural polymers, which may replicate physicochemical and mechanical characteristics of native ECM, are often utilized to create bioinks. In this study, new hydrogel-based printing inks consisting of methacrylate-modified chitosan (CSMA), methacrylate-modified gelatin (GelMA) and hyaluronic acid (HA), with an added photoinitiator, were formulated and with the incorporation of ADTC5 murine chondrogenic cells or rat bone marrow-derived mesenchymal stem cells (rBMSCs), new bioinks were created for bioprinting for cartilage regeneration. Extrusion-based 3D printing or bioprinting was conducted on a bioprinter. Optimal printing allowed inks/bioinks to be extruded smoothly as continuous fine filaments. After printing, printed structures underwent crosslinking by UV light. CSMA, GelMA and HA concentrations were optimized for printing inks via rheological analysis. Results showed GelMA and HA improved printability of CSMA-based hydrogels. Printing parameters such as printing speed, layer height, and nozzle diameter were investigated and optimized, achieving multilayered hydrogel scaffolds with high resolution and fidelity. The morphology, mechanical properties, biodegradation and biocompatibility of 3D printed scaffolds were also assessed. In 3D bioprinted structures, ADTC5 or rBMSC displayed high cell viability after 14-day culture. Overall, 3D bioprinted cell-scaffold constructs showed robust structural integrity, adequate mechanical properties and favorable cellular responses, indicating their potential for cartilage tissue engineering.



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sciforum-173040: Top-Down and Bottom-Up Biofabrication of Biomimetic Cartilage Scaffolds for Regenerative Applications

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Articular cartilage (AC) is a highly specialized, load-bearing tissue whose extracellular matrix (ECM) composition and zonal organization are essential for its exceptional biomechanical performance. However, due to its avascular and aneural nature, AC possesses very limited intrinsic repair capacity, making functional regeneration a longstanding clinical challenge. Although current biomaterials and scaffold-based strategies can reproduce aspects of gross architecture and mechanical properties, they often fail to replicate the anisotropic collagen type II organization and biochemical complexity required for durable joint function [1].

To address these limitations, we present a biofabrication strategy that combines advanced 3D printing technologies, genetically engineered cells with enhanced cartilage-like ECM production capacity and devitalization methods. Two complementary fabrication approaches were employed: digital light processing (DLP) printing for rapid, high-resolution construct generation, and coaxial extrusion printing to deposit multi-material core-shell filaments integrating structural and bioactive components.

To enhance biochemical fidelity, bioinks were supplemented with devitalized ECM (dECM) derived from CRISPRa-edited adipose-derived stem/stromal cells engineered to upregulate proliferation as well as aggrecan and collagen type II expression, key structural components of cartilage [2]. This strategy provides a scalable and reproducible source of cartilage-specific ECM without exogenous growth factors while maintaining bioactivity through mild devitalization [3].

Poly(ethylenglycol)-diacrylate-Gelatine-Methacryloyl (PEGDA-GelMA)-based bioinks enriched with lyophilized dECM were processed using both printing techniques to generate anisotropic scaffolds replicating the different zones of cartilage, especially in regard to collagen type II organization. Thorough characterization demonstrated high print fidelity, suitable mechanical properties, and improved support for synovial mesenchymal stem/stromal cell (sMSC) viability and function (Figure 1).

By integrating top-down (DLP) and bottom-up (coaxial extrusion printing) fabrication with engineered dECM, this approach advances the development of biomimetic scaffolds that more closely recapitulate the hierarchical organization of native AC, offering a promising translational pathway for functional cartilage regeneration.

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Session 8. Reactive/Smart Biomaterials

sciforum-182164: Multiscale Design of Piezoelectric PLA/BaTiO₃ Composites for Electrically Active Bone Grafts

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Introduction

Piezoelectric polymer-ceramic composites based on poly(lactic acid) (PLA) and barium titanate (BT) are promising candidates for bioactive structures capable of enhancing bone regeneration through electromechanical stimulation. In this work, we present a multiphysics computational homogenization framework to evaluate the effective electromechanical response of PLA/BT composites as a function of microstructural parameters.

Methods

A periodic representative volume element (RVE), consisting of a BT inclusion embedded in a PLA matrix, was implemented using a multiphysics finite element framework within structural mechanics and piezoelectric formulations to account for mechano-electrical coupling. The full set of homogenized elastic tensors, piezoelectric stress-charge coefficients, and dielectric properties was derived. The analysis systematically investigates the influence of key microstructural parameters, namely inclusion volume fraction and mechanical contrast between matrix and filler, on the effective composite response.

Results

The homogenization framework provides stable and consistent predictions of the effective electromechanical properties of PLA/BT composites. The results indicate a non-linear dependence of both electromechanical coupling and individual components of the mechanical tensor on BT content, with a marked sensitivity of shear-related terms. This aspect is particularly relevant for bending-dominated structures, where shear contributions can significantly influence strain distribution and, consequently, the generated electrical potential.

Conclusions

The proposed finite element-based framework enables the preliminary design of piezoelectric composites by identifying trade-offs between electromechanical performance and the full mechanical tensor response, supporting the fine-tuning of voltage generation in load-bearing bone grafts to modulate cellular activity. Overall, we establish a first multiscale homogenization approach for PLA/BT systems, capturing non-linear composition effects while emphasizing the importance of rigorous model validation.



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sciforum-176005: Biomimetic Patch for Vascular Repair and Patency Diagnosis

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As the crucial final step in cardiovascular surgery, vascular suturing often comes with risks such as vascular stenosis and occlusion, which pose threats to the patient's health. Currently, drug therapy and instrument-assisted diagnosis are used to prevent complications. However, the best solution for real-time monitoring and suppression of these situations has not yet been found. In view of the mechanical deformation caused by vascular dilation and contraction, this study prepared a biomimetic collagen substrate through electrospinning and the photopolymerization of gelatin methacrylate (GelMA). Tartaric acid (TA) and MXene modification respectively endowed it with the biological functions of promoting cell growth and anti-inflammation, as well as excellent sensing performance, aiming to promote vascular repair while monitoring vascular health signals. The results showed that the biomimetic piezoresistive nanofibers had excellent conductivity (8.1 S/m) and excellent sensing performance, including high sensitivity ($S = 0.03 \text{ kPa}^{-1}$), rapid response/recovery (36.5 ms/42.4 ms), and good stability (> 8000 cycles), capable of monitoring micro physiological signals such as pulse and wrist bending. *In vitro* experiments showed that this biomimetic fiber patch not only had good biocompatibility, promoting cell adhesion and spreading, and anti-inflammatory and antioxidant biological functions, but also had the sensing function of real-time monitoring of vascular health status. In subsequent *in vivo* experiments, the biomimetic fiber patch was combined with the flexible PCB and machine learning algorithms to construct an intelligent wireless integrated diagnostic and therapeutic platform. This platform enabled real-time monitoring and analysis of different health conditions of vascular patency, occlusion and repair, successfully preventing vascular thrombosis formation and accelerating healing. In conclusion, this study successfully proves the potential of the biomimetic piezoresistive nanofiber system for integrated diagnosis and treatment through *in vitro* simulation and *in vivo* experiments, providing a promising example for vascular repair management.



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sciforum-181418: Glucose-Responsive G-quartet/Protein hydrogels for Smart Insulin Delivery

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The rising global burden of diabetes necessitates the development of advanced therapeutic strategies beyond conventional insulin therapies, which often fail to achieve precise glycemic control and are associated with pain and inconvenience to patients. This limitation is predominantly observed in Type 1 diabetes, an autoimmune disease that destroys insulin-producing β cells, leading to a lifelong dependence on exogenous insulin administration. These challenges underscore the critical need for glucose-responsive systems capable of autonomous and precise insulin delivery. In an effort to address this challenge, we have designed an injectable, glucose-responsive G-quartet/protein hydrogel (GPHG) engineered via supramolecular self-assembly and dynamic iminoboronate chemistry for smart insulin delivery. The system involves a supramolecular interaction (such as π - π interaction) as well as dynamic iminoboronate ester chemistry to enable selective insulin release under hyperglycemic conditions, as evidenced by an insulin release assay/self-regulated pulsatile release pattern under cyclic glucose concentration. GPHGs demonstrate tunable viscoelasticity ranging from 10 to 50 kPa depending on the phenyl boronic acid-based crosslinkers. The developed system exhibits injectability, shear thinning behavior, non-cytotoxicity, mechanical flexibility, and controlled insulin release under physiologically relevant conditions. Furthermore, in vivo studies and histological investigations demonstrate effective glycemic regulation without adverse effects, highlighting its potential as a minimally invasive, translational platform for smart insulin delivery.



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sciforum-178920: Innovations in Injectable Conductive Hydrogels for Neural Regeneration and Biointerface Compatibility

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Background:

The nervous system's restricted ability to regenerate represents a therapeutic gap in the treatment of neural injuries and degenerative disorders. Conventional therapies, including pharmacological treatments, surgical interventions, electrical stimulation therapies, and neurorehabilitation, rarely lead to full recovery, especially in cases involving impaired neural signaling. Injectable conductive hydrogels have become potential candidates for therapeutic applications in neural tissue engineering. Hydrogels are ideal due to their biocompatibility, tunable mechanics, and injectability, allowing for minimally invasive delivery. Their high water content facilitates rapid nutrient diffusion while their electrical conductivity enhances neuronal signaling, and their mechanical properties allow for controllable drug release. Hydrogels promote a compatible interface with existing neural tissue, enabling integration and supporting efficient interaction.

Aim:

The aim of this manuscript is to investigate the potential of utilizing injectable conductive hydrogels as biomimetic materials that can support neural biointerface integration and facilitate neural tissue regeneration.

Methods:

Gelatin methacrylate will be combined with conductive materials to create injectable conductive hydrogels. Characterization tests will assess the hydrogel's mechanical properties, electrical conductivity, porosity, and injectability. In vitro function testing will follow; neural stem cells will be embedded within the hydrogel to evaluate cell growth and mimicry of the neural microenvironment. Cell proliferation will be measured using MTT assays, while immunostaining for β -III tubulin will be done to examine neurite extension and network formation. Multielectrode arrays will confirm signal transmission. Statistical analysis will evaluate validity.

Expected Results:

The hydrogel is expected to demonstrate mechanical and electrical properties similar to native neural tissue. Neural stem cells are expected to demonstrate cellular proliferation, interconnected networks with extended neurites, and measurable electrical activity indicative of functional signal propagation.

Conclusion:

Injectable conductive hydrogels have successfully demonstrated in vitro the ability to serve as biomimetic scaffolds for neural tissue engineering. Further in vivo studies are needed to validate their therapeutic effects.



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sciforum-175702: Investigation of carbon dots for toxic metal chelation therapy employing red blood cell membranes as a biomimetic model

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Heavy metal poisoning is a global health concern due to rapid industrialisation, urbanisation and environmental contamination. In recent years, nanotechnology-based chelation therapy has emerged as a transformative approach in biomedical sciences. Mercury is toxic to red blood cells (RBCs) by interacting with the sulfhydryl group of the membrane proteins and alteration in the membrane phosphatidyl serine, resulting in the formation of echinocytes, leading to hemolysis. This study involves the synthesis of sulphur-functionalised garlic-derived carbon dots (GD CDs) using the hydrothermal method followed by evaluating the haemolysis properties of mercury in their presence and establishing the membrane protection action of GD CDs against mercury ions using RBCs as the biomimetic membrane model.

Characterization techniques utilized include UV-visible and fluorescence spectroscopy, transmission electron microscopy and zeta potential measurements of the GD CDs. Additionally, hemocompatibility and protection against damage from mercury exposure for GD CD were evaluated using hemolysis assays, hemolysis inhibition assays and analysis of RBC morphology using microscopy. Measurements of lactate dehydrogenase (LDH) activity were also part of the evaluations.

Fluorescence spectra of GD CDs indicated an emission peak of approximately 475 nm and reduced fluorescence intensity when exposed to Hg(II) ions, indicating strong interactions between Hg(II) and the sulfur on the thiol group of GD CD. In hemolysis assays, GD CDs had good hemocompatibility (less than 5% hemolysis up to 150 µg/mL); GD CDs were an effective inhibitor of Hg(II)-induced hemolysis, with as much as 98% protection observed when GD CDs were present at a 1:1 molar ratio with Hg(II). Imaging data showed that normal RBC morphology was restored in the presence of GD CD, and cytotoxicity was reduced as evidenced by LDH assays demonstrating lower levels of membrane damage when GD CD was included in assays with Hg(II). These findings highlight GD CD as a promising, biocompatible nanoplatform for heavy metal detoxification and nanomedicine-based chelation therapy.



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sciforum-177696: Microfluidic-Synthesized pH-Responsive Nanoparticle–Hydrogel Composites for Targeted Osteoarthritis Drug Delivery

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Osteoarthritis (OA) demands localized, on-demand drug delivery due to the limited efficacy of systemic or standard intra-articular therapies, which suffer from rapid clearance and poor targeting. We present a novel stimuli-responsive nanocomposite system comprising amphiphilic core–shell polymer nanoparticles (NPs) embedded in a hydroxypropyl methylcellulose- C_{12} (HPMC- C_{12}) hydrogel matrix. Crucially, the NPs are produced via a microfluidic chip process, yielding highly uniform sizes with polydispersity index (PDI) 0.1. This microfluidic approach overcomes the drastic polydispersity and batch-to-batch inconsistencies of conventional nanoparticle synthesis, ensuring reproducible NP characteristics and enhanced drug loading capacity. The NPs polymer architecture has been rationally tuned for pH-responsiveness: they remain stable at physiological pH, yet rapidly trigger payload release at pH 6.5, mimicking the acidic microenvironment of inflamed OA joints. This precise pH-triggered behavior targets drug release to diseased tissue while minimizing off-target leakage. In vitro studies of the NP-hydrogel composite in buffered media demonstrated sharply differential release profiles: at pH 7.4 the composite showed negligible drug release, whereas at pH 6.5 it achieved sustained release of encapsulated payloads over days. Notably, the hydrogel's porous network allows co-loading of large biologics, while the NP cores carry hydrophobic small-molecule drugs. Using doxorubicin as a model drug and relevant OA therapeutic candidates, we confirm that the system can concurrently deliver a small molecule and a high-molecular-weight protein with distinct release kinetics. Such dual delivery leverages the hydrogel for slow protein release and the NPs for controlled small-drug release, addressing the need for combination therapy in OA. Co-delivery of small and macromolecular therapeutics is increasingly recognized for synergistic treatment efficacy, and our composite provides a single injectable platform to achieve this. Preliminary in vivo evaluations in rat OA models indicate excellent biocompatibility and localization of the composite, with ongoing studies to quantify its therapeutic impact.



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sciforum-176397: Piezoelectric 3D-Printed Scaffolds Coupled with Ultrasound Stimulation for Improved Bone Tissue Engineering Strategies

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The increasing incidence of trauma- and osteoporosis-related non-union fractures in the aging population has intensified the clinical demand for bone substitutes, prompting growing interest in bone tissue engineering (BTE) strategies. A promising BTE approach is the development of biomimetic scaffolds capable of providing structural support while promoting bone tissue regeneration. Bone homeostasis and repair rely considerably on the piezoelectric properties of bone tissue, derived mainly from its type I collagen fibers and hydroxyapatite-rich extracellular matrix[1]. Additionally, additive manufacturing technologies (Fused Deposition Modelling (FDM)) have been widely adopted in BTE, as they enable the reproducible and scalable fabrication of scaffolds with precise control over their structural architecture, microporosity, and mechanical properties. Thus, combining piezoelectric scaffolds with ultrasound (US) wireless mechanical stimulation offers a novel strategy to deliver targeted electrical stimuli to enhance bone regeneration. In this work, 3D-printed porous cylindrical scaffolds made from different piezoelectric filaments—poly-L-lactic acid (PLLA), polyvinylidene fluoride (PVDF), and conductive PVDF—were developed to compare their physicochemical properties and osteogenic performance. SEM and micro-CT analysis showed that all scaffolds presented homogeneous morphology and a high printing fidelity with low defects and pore sizes matching the CAD model. All constructs except PLLA were hydrophobic, and PLLA exhibited mechanical properties closest to native trabecular bone. Conductive PVDF scaffolds had a significantly higher piezoelectric charge coefficient. Notably, a previously optimized US stimulation protocol [2] (intensity=250 mW/cm²; freq=3MHz; duty cycle=20%; duration per scaffold=3 mins (every 2 days) for 3 weeks) promoted the osteogenic differentiation of human bone-marrow mesenchymal stem/stromal cells(hBMSCs), especially for PLLA scaffolds, as evidenced by increased ALP activity and up-regulated osteogenic markers (*Runx2/COL1A1*). Overall, our results highlight a clear synergy between the 3D scaffolds' piezoelectric features and US stimulation on the enhancement of the osteogenic differentiation of hBMSCs, highlighting this strategy potential for improved BTE clinical applications.



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sciforum-173965: Sustainable biomaterials for smart multifunctional active wound dressings

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Introduction: The main requirements for active wound dressings are the ability to absorb exudate, reduce bleeding, and prevent infections. In reality, commercially available active wound dressings do not meet all these needs and are very expensive. The aim of this work is to obtain sustainable and low-cost materials with multifunctional action as antibacterial, antioxidant and anti-inflammatory agents, together with the ability to detect infection by color change.

Methods: Keratin was extracted from discarded wool and electrospun to obtain nanofiber mats. Polyphenols were extracted from grape pomaces and pomegranate peels and seeds. keratin dressings were functionalized with natural polyphenols and fully characterized from physical, chemical and biological standpoints.

Results: Stable dressings of randomly oriented keratin nanofibers were obtained and functionalized, with grape and pomegranate extracts maintaining polyphenol activity. Samples were biocompatible and possessed effective antioxidant activity. Functionalized fibers were able to change color upon acidification (typical of bacterial contamination), offering a smart solution for rapid infection detection. Pomegranate functionalized materials also exhibit significant antibacterial action against *S. epidermidis*.

Conclusions: The combination of keratin obtained from discarded wool and polyphenols from agri-food byproducts is a promising strategy for obtaining sustainable biomaterials for smart multifunctional active wound dressings.

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