THE 7TH INTERNATIONAL CONGRESS ON

FSBM UH2C

BIOHYDROGELS

CASABLANCA, MOROCCO - 2026

SCIENTIFIC PROGRAM & ABSTRACTS

7th International Congress on

BIOHYDROGELS 2026

BIOMATERIALS | DRUG DELIVERY | TISSUE ENGINEERING

REGENERATIVE MEDICINE | WOUND HEALING | BIOFABRICATION

29–31 October 2026 | **Casablanca, MOROCCO**

ICEC Casablanca – International Corporate Events Center



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for Hydrogels

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MSH
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7th INTERNATIONAL CONGRESS ON BIOHYDROGELS

Biohydrogels 2026

Unlocking Innovations in Hydrogels and Emerging Applications

October 29-31, 2026 | International Corporate Events Center | Casablanca, Morocco

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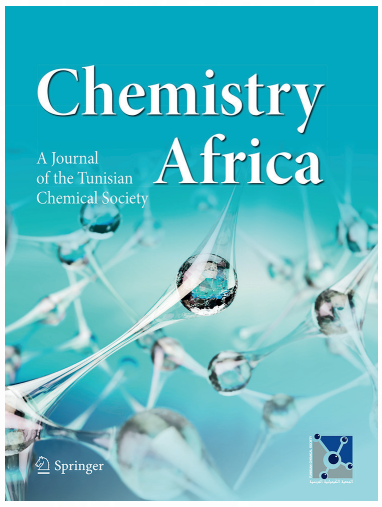
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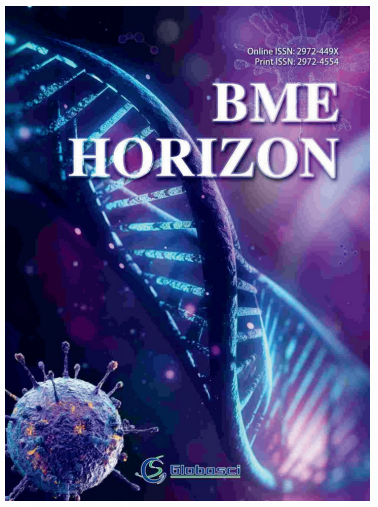
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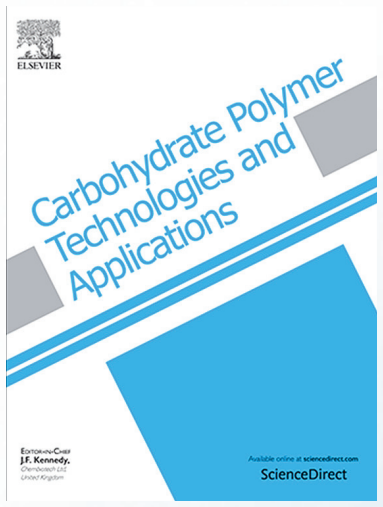
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THE 2ND INTERNATIONAL CONGRESS ON BIOHYDROGELS
FSBM · UH2C · CASABLANCA, MOROCCO · 2026

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RESEARCHERS FROM 25 COUNTRIES WILL PARTICIPATE OFFICIALLY IN OUR CONGRESS!

Morocco · France · Brazil · Kingdom of Bahrain · India · Los Angeles, CA (USA)

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Republic of Serbia · Romania · Jordan · Sweden · Italy · Chile

Canada · Singapore

TOGETHER, ADVANCING BIOHYDROGELS FOR A SUSTAINABLE FUTURE

180+
Expected Participants Worldwide

Keynote Speakers
Leading Experts Internationally

Oral Presentations & Posters
Showcase Your Research

Networking Opportunities
Collaborate. Innovate. Impact.

Advancing Biohydrogels
for a Sustainable Future

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History of Biohydrogels: A Retrospective of Previous Editions



The **Biohydrogels** series began in 2007 under the leadership of the late Prof. Rolando Barbucci (1942–2021) of the University of Siena. Its aim has remained constant: to bring together academic, industrial and clinical communities around the science and applications of hydrogels.

- **2007, Viareggio (Italy).** The first congress, held on 14-18 November, opened the series. It covered hydrogel structure, biomedical and pharmaceutical uses, stem cells and tissue engineering, and drug delivery.
- **2009, Viareggio (Italy).** The second congress (10-15 November) was devoted to industrial applications. Its Industrial Day strengthened exchanges between researchers and companies and encouraged technology transfer.
- **2011, Florence (Italy).** The third congress (8-12 November) concentrated on advanced polymer hydrogels for tissue engineering, including synthesis strategies such as RAFT polymerization and thermoresponsive systems. Poster sessions and prizes recognized emerging contributions.
- **2015, Nantes (France)**. This workshop (5-6 March) gathered around 100 participants from ten European countries. It marked a turning point: the Society for Biohydrogels was officially founded on 6 March 2015, when its statutes were approved and signed.
- **2017, Davos (Switzerland)**. The Society organized two symposia within the TERMIS-EU meeting (28 June), on hydrogel design for regenerative medicine. They were integrated into a conference of more than 1,300 participants, which gave the field wider visibility.
- **2021, Nantes (France)**. Biohydrogels Day, held virtually on 23 April, featured six invited speakers. It covered the path from fundamental science to translational applications in drug delivery and regenerative medicine, and maintained continuity during the pandemic.
- **2026, Casablanca (Morocco)**. The 7th International Congress on Biohydrogels (Biohydrogels 2026) is a leading international forum on recent advances in biohydrogels, polymeric biomaterials and functional soft materials. It will bring together established researchers, academics, industry professionals and early-career scientists from around the world to present high-impact work, exchange expertise and examine the emerging trends shaping this rapidly evolving field.



Biohydrogels 2026: 7th International Congress on Biohydrogels

29-31 October 2026, International Corporate Events Center, Casablanca, Morocco

This seventh edition is the first to be held in **Morocco**, and the first outside Europe. It opens the series to new scientific communities and strengthens collaboration between Europe, Africa and the wider international research landscape.

Over nearly two decades, Biohydrogels has grown from a regional congress into the meeting of an established international society. Biohydrogels 2026 continues this trajectory by extending the network of the Moroccan Society for Hydrogels (Morocco) and the Society for Biohydrogels (France) to new regions and partners.

Welcome Address

Dean of the Faculty of Sciences Ben M'Sick (FSBM)



Dear Colleagues, Distinguished Guests, and Participants. On behalf of the Faculty of Sciences Ben M'Sick, Hassan II University of Casablanca, it is a great honour to welcome you to the 7th International Congress on Biohydrogels (Biohydrogels 2026), held from 29 to 31 October 2026 in Casablanca, Morocco. Bringing together approximately 200 participants from 25 countries, with 180 oral and poster presentations, this congress demonstrates the capacity of scientific research to connect institutions, disciplines, and nations around shared challenges. We are proud to contribute to this international gathering alongside the Moroccan Society for Hydrogels (MSH) and our partner institutions. As a university faculty committed to education, research, and service to society, we attach particular importance to initiatives that connect scientific discovery with practical applications. Biohydrogels offer promising opportunities in healthcare, biotechnology, and environmental sustainability. Their development illustrates how collaboration across chemistry, biology, materials science, and engineering can generate solutions to complex needs. This congress also provides an opportunity to strengthen relationships between universities, research centres, and industry. I hope that the exchanges initiated in Casablanca will lead to joint research projects, academic mobility, and lasting partnerships, while increasing the international visibility of Moroccan and African research. The Book of Abstracts reflects the breadth of the scientific contributions presented during this meeting. It highlights the collective efforts of researchers at different stages of their careers and offers a valuable foundation for discussion and future cooperation. I am especially pleased to acknowledge the participation of doctoral students and young researchers. Providing opportunities for you to present your work, engage with international experts, and develop your scientific networks is central to our university's mission. Your participation is an investment in the future of research and innovation. I extend my sincere appreciation to Prof. Mohammed Berrada, President of the Congress, and to the Scientific and Organizing Committees for their dedication. I also thank our distinguished speakers, institutional partners, sponsors, and all participants for their valuable contributions to this event. I wish you a productive and inspiring congress, fruitful scientific exchanges, and a pleasant stay in Casablanca.

Welcome to Biohydrogels 2026, and welcome to Morocco!

Prof. Abdeslam EL BOUARI

Dean of the Faculty of Sciences Ben M'Sick (FSBM),
UH2C, Casablanca

Welcome Address

Chair of Biohydrogels 2026 and President of the Moroccan Society for Hydrogels (MSH)



Dear Colleagues, Distinguished Guests, and Participants. On behalf of the Organizing Committee and the Moroccan Society for Hydrogels (MSH), it is my great pleasure to welcome you to the 7th International Congress on Biohydrogels (Biohydrogels 2026), taking place from 29 to 31 October 2026 in Casablanca, Morocco. Hosting this congress is a source of great pride for our scientific community. Bringing together approximately 200 participants from 25 countries, with 180 oral and poster presentations, this edition reflects the international reach of hydrogel research and our shared commitment to scientific exchange and cooperation. Biohydrogels represent an exciting field at the intersection of chemistry, polymer science, biology, medicine, and engineering.

Their versatility opens promising avenues in drug delivery, wound healing, tissue engineering, regenerative medicine, biofabrication, and environmental sustainability. Advancing these applications requires dialogue across disciplines and close connections between fundamental research and practical needs. Through plenary lectures, invited talks, oral presentations, poster sessions, and workshops, the scientific programme offers opportunities to discuss emerging challenges and exchange expertise. This Book of Abstracts brings together the contributions presented at the congress, reflecting the diversity of approaches and ideas within our international community. I hope it will serve as a valuable reference and inspire collaborations beyond this meeting. I am particularly pleased to welcome doctoral students and early-career researchers. Your curiosity, creativity, and dedication are essential to the future of hydrogel science. I encourage you to share your ideas, engage in discussions, and build connections with colleagues from around the world. I extend my sincere gratitude to our distinguished speakers, authors, the Scientific and Organizing Committees, institutional partners, sponsors, and volunteers. Their commitment and collective efforts have made this congress possible. I also warmly thank every participant for contributing to the scientific richness of this event. Beyond the scientific programme, I hope you will enjoy the hospitality of Casablanca and the cultural richness of Morocco. May this congress offer you inspiring discussions, productive partnerships, and lasting friendships.

Welcome to Casablanca, and welcome to Biohydrogels 2026!

Prof. Mohammed BERRADA

Congress Chair and President of the Moroccan Society for Hydrogels

Welcome Address

President of the Society for Biohydrogels



On behalf of the Society for Biohydrogels, it is my great pleasure to welcome you to Biohydrogels 2026 in Casablanca, Morocco. Since the first Biohydrogels meeting in Viareggio, Italy, in 2007, our community has progressively developed into an international network of scientists working at the interface of polymer science, materials science, biology, and medicine. The creation of the Society for Biohydrogels in 2015 marked an important milestone in this journey, providing a framework to strengthen scientific exchanges, encourage interdisciplinary collaborations, and support the development of this rapidly evolving field. Our society aims to bring together researchers from diverse backgrounds to advance the understanding, design, and application of hydrogels in biomedical and biotechnological fields. We are particularly committed to fostering interactions between fundamental and applied research, promoting international collaborations, and supporting the next generation of scientists.

Hydrogels offer remarkable opportunities in areas such as tissue engineering, regenerative medicine, drug delivery, biofabrication, and the development of innovative biomaterials. Addressing the scientific challenges in these fields requires interdisciplinary approaches and close collaboration between researchers, clinicians, and industry partners. Biohydrogels 2026 is an opportunity to share new ideas, discuss emerging challenges, and build lasting scientific collaborations. The programme brings together a broad range of topics, from the design and characterization of functional hydrogels to their applications in biomedical engineering, advanced therapies, and sustainable technologies. We are particularly pleased to hold this edition in Casablanca, a vibrant city at the crossroads of Africa, Europe, and the Mediterranean. This meeting provides an excellent opportunity to strengthen international scientific partnerships and to highlight the contribution of Moroccan and African research communities to the development of innovative biomaterials. I would like to express my sincere gratitude to the local organizing committee, our invited speakers, our partners, and all those who have contributed to making this meeting possible. I also warmly welcome our young researchers and students, whose enthusiasm and creativity are essential to the future of our scientific community. I hope that Biohydrogels 2026 will be a stimulating and rewarding experience for all participants, both scientifically and personally, and that the connections established here will lead to new ideas, collaborations, and discoveries.

Welcome to Biohydrogels 2026, and enjoy your time in Casablanca!

Prof. Pierre WEISS

President of the Society for Biohydrogels

Congress Chair

Prof. Mohammed BERRADA
President of the Moroccan Society for Hydrogels (MSH); Vice-Dean of the Faculty of Sciences Ben M'Sick (FSBM), Hassan II University of Casablanca

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Prof. Abdullah Mohamed ASIRI
King Abdulaziz University, Jeddah, Saudi Arabia

Prof. Fathallaah BAZI
Faculty of Sciences Ben M'Sick, Hassan II University of Casablanca, Casablanca, Morocco

Prof. Ayat BOZEYA
Jordan University of Science and Technology, Irbid, Jordan

Prof. Juhaina Abu ERSHAID
Isra University, Amman, Jordan

Prof. Belkheir HAMMOUTI
Euromed University of Fez, Fez, Morocco

Dr. Marya RAJI
Mohammed VI Polytechnic University, Benguerir, Morocco

Prof. Nadia BOUTALEB
Faculty of Science and Technology of Mohammedia, Hassan II University of Casablanca, Mohammedia, Morocco

Dr. Adina Magdalena MUSUC
Ilie Murgulescu Institute of Physical Chemistry, Romanian Academy, Bucharest, Romania

Prof. Nébéwia GRIFFETE
PHENIX Laboratory, Sorbonne University, Paris, France

Prof. Ali Asgar BHAGAT
National University of Singapore, Singapore

Prof. Nabil GRIMI
University of Technology of Compiègne, Department of Process Engineering, Transformations Intégrées de la Matière Renouvelable (TIMR) Laboratory, Compiègne, France

Prof. Dr. Badr Eddine KARTAH
President of the Averroes Foundation for Scientific Research, Innovation and Sustainable Development; Faculty of Sciences, Mohammed V University, Rabat, Morocco

Prof. Gloria GALLEGO-FERRER
Polytechnic University of Valencia, Valencia, Spain

Prof. Nileshkumar DUBEY
University of Maryland School of Dentistry,
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Prof. Idir BENAISSA
Mohammed VI Polytechnic University, Benguerir, Morocco

Prof. Mostapha BOUSMINA
President of the Euro-Mediterranean University of Fez,
Fez, Morocco

Prof. Alireza DOLATSHAHI-PIROUZ
Technical University of Denmark, Kongens Lyngby, Denmark

Prof. Kattesh V. KATTI
University of Missouri, Columbia, Missouri, United States

Prof. Sonia GHOUL
International Faculty of Dental Medicine, International University of Rabat,
Salé, Morocco

Prof. Khalid DRAOUI
Faculty of Sciences, Abdelmalek Essaâdi University,
Tétouan, Morocco

Dr. Soukaina LAMNINI
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Prof. Dounia BEQQOUR
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Prof. Achraf ABDOU
Hassan II University of Casablanca, Casablanca, Morocco

Prof. Najim ITTOBANE
Moulay Ismail University, Meknes, Morocco

Prof. Siham MALLOUK
Sultan Moulay Slimane University, Beni Mellal, Morocco

Prof. Ilham TOUISS
Abdelmalek Essaâdi University, Tétouan, Morocco

Prof. Jihad SEBHAOUI
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Prof. Belkheir HAMMOUTI
Euromed University of Fez, Fez, Morocco

Prof. Adil AKKOUCH
Western Michigan University, Kalamazoo, United States

Prof. Vitaliy KHUTORYANSKIY
University of Reading, Reading, United Kingdom

General Information

CONFERENCE VENUE

The 7th **International Congress on Biohydrogels 2026** will be held from **October 29 to 31, 2026**, at the **International Corporate Events Cente**r (ICEC Casablanca), located in the Aïn Sebaâ district of Casablanca, Kingdom of Morocco.

Conference Venue : International Corporate Events Center (ICEC Casablanca)

Address : 6 Boulevard de Makro, Aïn Sebaâ, Casablanca, Morocco

Conference Dates : October 29 - 31, 2026

Official Website : https://www.biohydrogels2026.com

ICEC Casablanca provides a professional and welcoming environment for international scientific meetings, offering conference facilities suitable for plenary lectures, oral presentations, poster sessions, scientific workshops, exhibitions, and networking activities.

The Congress will bring together distinguished scientists, researchers, academics, industry representatives, and young investigators from Morocco and around the world to exchange knowledge and discuss recent advances in biohydrogels, biomaterials, polymer science, tissue engineering, drug delivery, regenerative medicine, wound healing, and biofabrication.

The conference facilities will include **three scientific conference rooms**, a dedicated **VIP room for the Honorary Committee** and **distinguished guests**, a **registration and information area**, **poster exhibition spaces**, and designated **areas for coffee breaks and networking**.



TRANSPORTATION INFORMATION

Casablanca is one of Morocco's major economic and cultural centers and is accessible through Mohammed V International Airport (CMN), which provides connections to numerous international destinations.

The conference venue is located in the Aïn Sebaâ district and can be reached by taxi, private vehicle, or other available transportation services.

For international invited speakers, the Organizing Committee will coordinate transportation arrangements, including:

- Airport transfers from Mohammed V International Airport to the designated hotel, according to confirmed arrival schedules.
- Daily transportation between the designated hotel and the conference venue during the three days of the Congress.
- Assistance with transportation arrangements related to official Congress activities.

Invited speakers are kindly requested to communicate their flight details, arrival and departure dates, and accommodation information to the Organizing Committee in advance.

Other participants are encouraged to use licensed taxis or reliable transportation services when traveling within Casablanca.

REGISTRATION DESK

The **Conference Registration Desk** will be located at the main entrance of ICEC Casablanca and will serve as the primary reception point for all registered participants, invited speakers, and accompanying guests.

The Registration Desk will be operational throughout the Congress, from **October 29 to 31, 2026**, according to the official conference schedule.

Participants are kindly requested to visit the Registration Desk upon arrival to complete their check-in and collect their conference materials, including:

- Conference identification badge.
- Final Scientific Program.
- Book of Abstracts and conference information.
- Information concerning scientific sessions, workshops, and poster presentations.
- Additional documentation and materials provided by the Organizing Committee.

All participants are requested to wear their conference badges throughout the event to facilitate identification and access to the designated conference areas.

ORGANIZING COMMITTEE INFORMATION DESK

Members of the **Organizing Committee of the 7th International Congress on Biohydrogels 2026** will be available at the Information Desk, located near the main registration area.

The Organizing Committee will be pleased to assist delegates with enquiries regarding the scientific program, conference rooms, presentation schedules, workshops, transportation, accommodation, and other organizational matters.

Participants are encouraged to contact the Information Desk whenever assistance is required.

SCIENTIFIC SESSIONS AND WORKSHOPS

The scientific program will feature plenary and invited lectures, oral communications, poster presentations, and specialized workshops covering emerging developments in biohydrogels and functional biomaterials.

Two specialized workshops are scheduled to begin at **16:00 (04:00 PM)**, according to the Final Scientific Program:

Workshop 1 : 3D Bioprinting

Coordinator : Prof. Adil AKKOUCH

Workshop 2 : From DOI to Scientific Discovery

Coordinator : Prof. Nadia BOUTALEB, Crossref Ambassador for Morocco & MENA

Participants are kindly requested to consult the Final Scientific Program for the exact rooms, dates, and schedules of all scientific activities.

VIP ROOM AND HONORY COMMITTEE

A dedicated **VIP Room** will be available for members of the Honorary Committee, institutional representatives, distinguished invited speakers, and official guests.

This space will provide an appropriate setting for official receptions, institutional exchanges, bilateral meetings, and discussions on future scientific collaborations.

Access to the VIP Room will be coordinated by the Organizing Committee.

GENERAL ASSISTANCE

The Organizing Committee is committed to ensuring a welcoming, productive, and memorable scientific experience for all participants.

Delegates requiring assistance with registration, conference logistics, scientific presentations, transportation, or general information are invited to contact the Conference Information Desk.

We sincerely welcome all participants to **Casablanca, Morocco,** and wish everyone a successful and inspiring **7th International Congress on Biohydrogels 2026**.

BADGES

Official conference name badges will be issued to all registered participants, invited speakers, members of the Scientific and Organizing Committees, sponsors, exhibitors, and distinguished guests upon arrival at the Registration Desk.

All participants are required to wear their conference badges at all times throughout the three days of the Congress. Badges will facilitate identification and access to scientific sessions, workshops, poster exhibitions, coffee breaks, lunches, and other official conference activities.

Participants who **lose their badges** are kindly requested to **contact the Registration Desk** for assistance.

CLOAKROOM AND PERSONAL BELONGINGS

A designated area for personal belongings and luggage storage may be made available at the conference venue, subject to confirmation by the venue management.

Participants requiring assistance with coats, travel bags, or other personal belongings are kindly requested to contact the Registration and Information Desk.

Delegates are advised not to leave valuable items unattended. The Organizing Committee encourages all participants to take appropriate precautions regarding their personal belongings.

CONFERENCE HALLS

The **7th International Congress on Biohydrogels 2026** will take place at the **International Corporate Events Cente**r (ICEC Casablanca), featuring three conference halls equipped to accommodate plenary lectures, invited presentations, parallel scientific sessions, and specialized workshops.

The conference facilities will be organized as follows:

- **Main Conference Hall - Hall 1**

The Main Conference Hall will host the official opening ceremony, keynote and plenary lectures, selected scientific sessions, and the closing ceremony.

- **Parallel Session Hall - Hall 2**

Hall 2 will accommodate parallel oral presentation sessions, invited scientific communications, and thematic discussions covering biohydrogels, biomaterials, polymer science, drug delivery, and related research fields.

- **Parallel Session and Workshop Hall - Hall 3**

Hall 3 will be dedicated to additional parallel scientific sessions, specialized presentations, and interactive workshops, according to the Final Scientific Program.

VIP Room - Honory Committee and Distinguished Guests

A dedicated VIP Room will be reserved for members of the Honorary Committee, institutional representatives, keynote speakers, and distinguished invited guests.

The VIP Room will provide a professional setting for official receptions, institutional meetings, and discussions on international scientific cooperation.

Participants are kindly requested to consult the conference venue maps and on-site signage for the exact locations of all conference halls.

COFFEE BREAKS AND LUNCH AREA

Coffee breaks and lunches will be provided in designated catering and networking areas within the **ICEC Casablanca Conference Center**.

The catering services will include morning and afternoon coffee breaks, according to the official Congress schedule, as well as lunches organized during the event.

Coffee breaks will offer participants an opportunity to enjoy refreshments, Moroccan pastries, and other light snacks while exchanging ideas and establishing professional connections.

Lunches will provide a welcoming environment for networking among researchers, invited speakers, industry representatives, and other conference participants.

Catering arrangements:

- Thursday, October 29, 2026: Morning coffee break, afternoon coffee break, and lunch.
- Friday, October 30, 2026: Social event & Gala dinner between 19h00 and 22h00, according to the final schedule.

Participants are kindly requested to follow the directional signs indicating the catering areas. Volunteers and members of the Organizing Committee will be available to provide assistance.

SPEAKER READY ROOM

A dedicated **Speaker Ready Room / Presentation Preparation Area** will be arranged to assist keynote speakers, invited speakers, and oral presenters in preparing their scientific presentations.

All speakers are kindly requested to submit their presentations in **Microsoft PowerPoint format (.ppt or .pptx)** in advance of their scheduled sessions.

To ensure the smooth running of the scientific program, speakers are strongly encouraged to provide their presentation files **at least half a day before their scheduled presentation time**.

To ensure the smooth running of the scientific program, speakers are strongly encouraged to provide their presentation files at least half a day before their scheduled presentation time.

Speakers should verify that their presentations, embedded videos, animations, fonts, and other multimedia elements function correctly on the conference computers.

The presentation systems will be PC-based. Speakers using Apple Mac computers are therefore advised to ensure compatibility with Microsoft PowerPoint for Windows.

Technical staff and members of the Organizing Committee will be available to assist with presentation uploads and audiovisual requirements.

Important information for speakers:

- Presentations should preferably be submitted using a USB flash drive or another method approved by the Organizing Committee.
- Speakers are requested to arrive at their assigned conference hall at least 15 minutes before the beginning of their session.
- All presentation files should be checked in advance to avoid technical delays.
- Speakers presenting during the morning sessions are encouraged to submit their presentations on the preceding day.
- Speakers scheduled for Saturday, October 31, 2026, are encouraged to upload their presentations by Friday, October 30, 2026.

TECHNICAL ASSISTANCE

Technical support will be available throughout the Congress to assist speakers and session chairs with audiovisual equipment, microphones, projection systems, and presentation-related requirements.

Speakers experiencing technical difficulties are kindly requested to contact the technical staff or the Organizing Committee.

We sincerely appreciate the cooperation of all participants in ensuring the smooth organization and scientific success of the **7th International Congress on Biohydrogels 2026.**

ORAL PRESENTATIONS

To ensure the smooth running of all scientific sessions during the **7th International Congress on Biohydrogels 2026**, oral presenters are kindly requested to follow the instructions below.

- Speakers should carefully consult the Final Scientific Program to confirm their assigned session, presentation time, conference hall, and presentation order.
- All presentations must be prepared in Microsoft PowerPoint format (.ppt or .pptx). Speakers are strongly encouraged to submit their presentation files to the Speaker Ready Room in advance, preferably before 16:00 on the day preceding their scheduled session.
- Speakers are kindly requested to arrive at their assigned conference hall at least **10–15 minutes before the beginning of their session** to introduce themselves to the Session Chairs and become familiar with the audiovisual equipment.

- Each conference hall will be equipped with a projection screen, microphone, and presentation control equipment. Technical assistance will be available throughout the scientific sessions.
- Regular oral presentations are allocated a maximum of 15 minutes, including:
    - ➤ 10 minutes for the scientific presentation.
    - ➤ 3 minutes for questions and discussion.
- Invited and plenary speakers should follow the presentation duration specified in the Final Scientific Program.
- All presenters are kindly requested to respect their allocated presentation times. Session Chairs will monitor timekeeping and may intervene when the maximum duration is exceeded.
- Speakers should ensure that their slides, figures, videos, and animations are clearly visible and compatible with the conference presentation systems.
- In the event of technical difficulties, audiovisual operators and technical staff will provide assistance as quickly as possible.

The Organizing Committee sincerely appreciates the cooperation of all speakers in maintaining the scientific quality and punctuality of the Congress.

DISCUSSION

Scientific discussions represent an essential component of the 7th International Congress on Biohydrogels 2026, encouraging constructive exchanges between researchers, invited speakers, students, and industry representatives.

Following each oral presentation, a discussion period will be organized under the supervision of the Session Chairs.

Delegates wishing to ask questions or provide comments are kindly requested to raise their hands and wait for acknowledgment from the Session Chair.

Microphones will be made available to facilitate clear communication between the audience and the presenters.

Participants are kindly requested to use the microphones when asking questions to ensure that their contributions can be heard by all attendees.

Questions and comments should be concise, relevant to the presentation, and expressed respectfully to encourage productive scientific dialogue.

SHORT ORAL PRESENTATIONS

Short Oral Presentations, where included in the Final Scientific Program, will provide an opportunity for researchers and young scientists to communicate their findings through concise scientific presentations.

Presenters are kindly requested to follow these instructions:

- Carefully consult the Final Scientific Program for the assigned presentation time, hall, and presentation order.
- Prepare presentations in PowerPoint format (.ppt or .pptx).
- Submit presentation files to the Speaker Ready Room in advance.
- Arrive at the assigned conference hall at least 10 minutes before the beginning of the session.
- Respect the presentation duration indicated in the Final Scientific Program.
- Use clear, concise slides highlighting the research objectives, methodology, principal results, and conclusions.

Session Chairs will monitor presentation times to ensure the smooth running of the scientific program.

POSTER SESSIONS

Poster Sessions will be organized in a designated exhibition area within the **ICEC Casablanca Conference Center** during the three days of the Congress, from **October 29 to 31, 2026.**

These sessions will provide an opportunity for researchers, doctoral students, and young investigators to present their scientific work, discuss research findings, and establish new scientific collaborations.

All poster presenters are kindly requested to follow the guidelines below.

Poster Format and Dimensions

- **Poster Size**: A0 (1189 mm high × 841 mm wide).
- **Orientation**: Portrait (vertical).
- **Language**: English.
- **Recommended Format**: Printed scientific poster with clear text, figures, tables, and illustrations.

Each poster should clearly display the title of the scientific contribution, the names of the authors, their institutional affiliations, and the corresponding author's contact information.

Poster content should preferably include an introduction, research objectives, methodology, principal results, discussion, conclusions, and relevant references.

Poster Installation

Poster presenters are requested to install their posters on the designated display panels according to the instructions provided by the Organizing Committee.

Each poster will be assigned a specific identification number corresponding to the number indicated in the Final Scientific Program.

Posters will be organized by scientific topic or thematic session to facilitate discussions and exchanges among participants.

Presenters are kindly requested to check their assigned poster number and location upon arrival at the conference venue.

Poster Display and Presentation

Posters are expected to remain displayed during the designated exhibition period, subject to the final installation schedule.

Poster presenters are strongly encouraged to remain near their posters during the official Poster Sessions to discuss their research with other participants, members of the Scientific Committee, and invited speakers.

The exact poster presentation times will be indicated in the Final Scientific Program.

Poster Removal

Poster presenters are responsible for removing their posters at the end of the Congress on Saturday, October 31, 2026, according to the instructions communicated by the Organizing Committee.

Posters remaining after the designated removal period may be collected by the Organizing Committee.

INVITED SPEAKERS

INNOVATING BIOHYDROGELS FOR HEALTH, ENVIRONMENT AND SUSTAINABLE FUTURE



Prof. Abdelkrim El Kadib
Euromed University of Fez



Prof. Vitaliy Khutoryanskiy
University of Reading



Prof. Pierre Weiss
Nantes University, RMeS



Prof. Nadia Boutaleb
·Hassan II University of Casablanca



Prof. Ali Asgar Bhagat
National University of Singapore (NUS)



Prof. Adil Akkouch
Western Michigan University



Prof. Lalitkumar Vora
Queen's University Belfast



Prof. Khalid DRAOUI
IMED-Lab, Department of Chemistry, Faculty of Sciences, Tetouan



Prof. Beata Kaczmarek-Szczepańska
Nicolaus Copernicus University



Prof. Sophie Lerouge
Ecole de Technologie Supérieure



Prof. Ayat Bozeya
University of Science and Technology (JUST)



Prof. Sidi A. Bencherif
National Center for Scientific Research, CNRS



Prof. Kattesh V. Katti
University of Missouri, Columbia



Dr. Baptise Charbonnier
Nantes University, RMeS



Prof. Alireza Dolatshahi-Pirouz
Technical University of Denmark



Prof. Ajeet Kaushik
Florida Polytechnic University

Invited Speakers



Prof. Abdelkrim EL KADIB

Euromed University of Fes
Fes, Morocco

Title : Chitosan Hydrogels: From Molecular Design and Textural Engineering to Environmental and Biomedical Applications

Thursday, 29th October
10:30 - 11:00, Hall 1

Professor Abdelkrim El Kadib earned his PhD thesis in 2004 from LHFA, Université Paul Sabatier de Toulouse, France. He then completed several postdoctoral fellowships in France at the Université de Pau et des Pays de l'Adour, at the Ecole Nationale Supérieure de Chimie de Montpellier, and later at Total Petrochemical in Belgium. He then spent a year at Queen's University in Kingston, Canada, before joining iNANOTECH, part of the MAScIR Foundation in Morocco, as an associate researcher.

He is currently a Full Professor at the Euromed University of Fez, Morocco, and a corresponding member of the Hassan II Academy of Sciences and Technologies. The research conducted within his group (NanoMAT) bridges sustainable chemistry and nanomaterials science. Their research focuses primarily on surface-functionalized soft gels, mesoporous and nanostructured materials, as well as nanocomposites, particularly those derived from biomass and biowaste, with the aim of introducing the concept of a circular economy to the field of nanotechnology. NanoMAT designs open porous nanostructures for applications in catalysis, energy storage and conversion, water purification, and as biomedical devices. Professor El Kadib has supervised over 40 highly qualified doctoral, postdoctoral, and master's students.

He is the author of 150 publications in high-impact chemistry journals and has also co-filed nearly 20 patents.



Prof. Vitaliy Khutoryanskiy

Reading School of Pharmacy, University of Reading
Reading, United Kingdome

Title : Thermally Induced Cross-linking of Water-Soluble Polymers for Biomedical Hydrogel Development

Thursday, 29th October
11:15 - 11:45, Hall 1

Prof. Vitaliy V. Khutoryanskiy is a Professor of Formulation Science at the University of Reading, School of Pharmacy, and a Royal Society Industry Fellow. His research focuses on pharmaceutical materials, including drug delivery systems, hydrogels, mucoadhesive materials, nanomaterials, and biomaterials. He is internationally recognized for his pioneering work on interpolymer complexes and transmucosal drug delivery. Prof. Khutoryanskiy has been elected Fellow of the Royal Society of Chemistry (FRSC) and Fellow of the Academy of Pharmaceutical Sciences (FAPS).

He has received several prestigious awards for both research excellence and mentorship of early career researchers. He has authored more than 220 scientific publications, with over 16,000 citations. In 2023, he founded and became Director of the PEVITAC Centre at the University of Reading.



Prof. Alireza Dolatshahi-Pirouz

Professor at Technical University of Denmark
Denmark, Denmark

Title : Bioadaptable Hydrogels for Tissue Engineering

Thursday, 29th October
11:45-12:15, Hall 1

Alireza Dolatshahi-Pirouz is a graduate in Physics & Astronomy and he received his Ph.D. in physics from Aarhus University in 2009 and then took on a postdoctoral-research position at the Wyss Institute of Biologically Inspired Engineering and Harvard Medical School. From 2015 he is working as an Assistant Professor at the Technical University of Denmark, Department of Health and Technology.

Furthermore, in 2015 he started his own research group at DTU Nanotech; actually, he is group leader of the Biologically inspired material engineering (BioEngine) Laboratory. Its research lies at the crossroads of biology, engineering, physics, chemistry and biomaterials, where they work in the areas of bone tissue engineering, vascularisation of tissue engineered constructs and microarray studies. Currently he is working on developing new 3D environments for directing stem cells into tissue-like structures and self-healable and stretchable materials with high electrical sensitivity for applications within the emerging fields of flexible electronics, cyborganics, and soft robotics.

To date he has published close to 120 papers, with his citations numbering 9811 and an h-index of 55 according to Google Scholar.



Prof. Beata Kaczmarek-Szczepańska

Nicolaus Copernicus University in Torun
Torun, Poland

Title : Biopolymeric materials based on hyaluronic acid/collagen enriched with ferulic acid

Thursday, 29th October
12:15 - 12:45, Hall 1

Dr. hab. Beata Kaczmarek-Szczepańska, Professor at Nicolaus Copernicus University (NCU), is a University Professor at the Laboratory for Functional Polymeric Materials, Faculty of Chemistry, Nicolaus Copernicus University in Toruń, Poland. She has published over 100 scientific papers in internationally recognized journals and has coordinated several research projects funded by the National Science Centre (NCN) and the National Centre for Research and Development (NCBR).

Her expertise lies in the preparation and characterization of polymer-based materials, primarily dedicated to wound healing applications and innovative cosmetic formulations. Dr. Kaczmarek-Szczepańska has completed numerous research internships in Ireland, Spain, Germany, Switzerland, Portugal, Serbia, and India, and maintains extensive international collaborations. In 2022, she received a scholarship from the Minister of Science and Higher Education (Poland).

She has been listed among the world's top 2% of scientists in her research field and ranked among the top 2% of the most cited scientists worldwide throughout their entire careers.



Prof. Ali Asgar Bhagat

National University of Singapore - NUS
Singapore, Singapore

Title : Catalyzing Healthcare Innovation in Singapore

Thursday, 29th October
13:00 - 13:30, Hall 1

Ali Asgar Bhagat is Director of the Singapore Health Technologies Consortium (HealthTEC.SG), Deputy Director (Translation) at the Institute for Health Innovation and Technology (iHealthtech), and Associate Professor in the Department of Biomedical Engineering at the National University of Singapore (NUS). He leads the translation arm of iHealthtech, overseeing intellectual property strategy, technology development, commercialization, and strategic industry programs. He is also Academic Director of graduate education programmes at NUS Enterprise, where he develops initiatives and programs to train the next generation of deep-tech entrepreneurs.

Prior to NUS, he was Principal Manager at Accelerate Technologies Pte Ltd, the commercialization arm of A*STAR, where he managed evaluation and commercialization of biomedical research outputs across multiple institutes. He previously served as Chief Operating Officer of Clearbridge Biomedics (now Embracing Future Holdings Ltd), an NUS spin-off focused on oncology diagnostics, where he led development of the ClearCell® platform and CTChips®. Earlier, he was a Research Scientist at the Singapore-MIT Alliance for Research and Technology (SMART) Centre.

An inventor on numerous granted patents and author of peer-reviewed publications, his work focuses on translating deep-tech innovations from prototype to market. He received his MS and PhD in Electrical Engineering from the University of Cincinnati and previously held an Associate Scientist position at the Massachusetts Institute of Technology (MIT), USA.



Prof. Sidi A. Bencherif

French National Center for Scientific Research, CNRS
Paris, France

Title :Injectable Cryogels for Biomedical Applications: from Tissue Engineering to Immunotherapy

Thursday, 29th October
15:00 - 15:30, Hall 1

Sidi A. Bencherif, Ph.D., is a senior researcher at the French National Centre for Scientific Research (CNRS) and a faculty-affiliated investigator at the University of Rouen Normandy. He earned his Ph.D. in Chemistry from Carnegie Mellon University and completed postdoctoral training at Harvard University. His research focuses on the design and development of advanced polymeric biomaterials particularly injectable and macroporous cryogels for applications in regenerative medicine, controlled drug delivery, and cancer immunotherapy.

His work bridges fundamental materials science with translational biomedical applications, and he is recognized as a pioneer in injectable cryogel technologies, which have been widely adopted in both academia and industry for diverse biomedical uses. Dr. Bencherif has authored over 100 peer-reviewed publications in leading journals, including Science, Nature Materials, Nature Communications, PNAS, Advanced Science, Bioactive Materials, and Biomaterials. His work has received over 14,000 citations (h-index: 50), and he is an inventor on 15 patents.

He has been recognized among the world's top 2% of most-cited scientists (Stanford/Elsevier) and has received numerous prestigious honors and distinctions, including the U.S. NSF CAREER Award, ACS PMSE Young Investigator Award, ACS I&EC Influential Researcher Award, BMES-CMBE Rising Star Award, and, more recently, the Normandy "Chair of Excellence".

WORKSHOP 1



Prof. Adil Akkouch

Western Michigan University
Kalamazoo (MI), USA

Title :Multifunctional Hydrogels for Antibacterial Activity, microRNA Delivery, and Electrical Stimulation

Thursday, 29th October
15:45 - 16:00, Hall 1

Dr. Adil Akkouch is an Associate Professor at Western Michigan University Homer Stryker M.D. School of Medicine, with appointments in orthopaedic surgery, biomedical engineering, and biological sciences. He obtained his MSc and PhD in Experimental Medicine from Laval University and completed postdoctoral fellowships in additive biomanufacturing and oral health research. Before joining WMed, he served as a Principal Scientist in clean meat research in San Francisco.

His laboratory focuses on 3D bioprinting, biomaterials engineering, and microRNA-based therapeutics for musculoskeletal tissue regeneration. His work is supported by government, industry, and institutional funding. Dr. Akkouch has mentored more than 50 trainees across medical and graduate programs. He holds memberships in numerous international professional societies.

He also serves as a grant reviewer for the NIH and the U.S. Department of Defense.



Prof. Pierre Weiss

Nantes Université
Nantes, France

Title : Silated Polysaccharides and Bone Tissue Regeneration: Calcium Phosphate / Hydrogel Composites

Professor Pierre Weiss, PhD, DDS, is a leading expert in biomaterials and regenerative medicine at the University of Nantes, France, within the Department of Dental Surgery and Hospital Dentistry. He obtained his DDS in 1989, followed by an MSc in Biomaterials in 1993 and a PhD in Biomaterials in 1997, all from the University of Nantes. He previously headed the INSERM–Nantes University Unit UMR-S 791 (LIOAD) focused on osteoarticular and dental tissue engineering, and currently leads the REGOS research team within INSERM Unit UMR-S 1229 RMeS (Regenerative Medicine and Skeleton).

Professor Weiss's research centers on skeletal tissue engineering, hydrogel-based synthetic extracellular matrices, injectable biomaterials, and bone substitutes. His work emphasizes the chemistry and physicochemical characterization of macromolecular solutions and hydrogels to design biomimetic, injectable systems for cartilage and bone regeneration. His research is structured around two major axes: injectable calcium phosphate–based bone substitutes and self-crosslinking polysaccharide hydrogels for tissue engineering and drug delivery. Since 2015, he has led a translational collaboration with HTL on silanized hyaluronic acid for biomedical applications and remains active in clinical odontology research.

He is Scientific Director of the Bioregate regenerative medicine cluster, President of the Society for Biohydrogels, Vice-Dean of the Nantes Dental School, and a member of the University Scientific Council. Professor Weiss has authored over 200 publications, holds 7 patents, and has received more than 6,200 citations (h-index 47).



Dr. Baptiste Charbonnier

Nantes Université
Nantes, France

Title : Hydrogels as the Next Revolution in Cements for Bone Regeneration

Thursday, 29th October
16:30 - 17:00, Hall 1

Dr. Baptiste Charbonnier is an Inserm researcher at the Regenerative Medicine and Skeleton research unit (RMeS, Inserm U1229 / Nantes Université / Oniris) in Nantes, France. At RMeS, he leads the SAMBA research group and serves as co-scientific director of BIO3, an open technology platform dedicated to the synthesis and characterization of materials for biomedical applications. He is particularly interested in decoupling and elucidating the relationships between a scaffold's multiscale architecture and its composition, and their respective influence on the biological response they induce.

A strong advocate of additive manufacturing technologies, he is an active board member of the Nantes MAD4AM cluster and, with colleagues, opened an open space dedicated to additive manufacturing for global health. His work has received substantial funding from the Pays de la Loire Region, the French National Research Agency (ANR), Inserm, and the European Union.



Prof. Sophie Lerouge

École de Technologie Supérieure (ÉTS)
Montréal (GC), Canada

Title : Injectable Macroporous Hydrogels for Cell Delivery and Tissue Engineering

Friday, 30th October
09:00-09:30, Hall 1

Sophie Lerouge is Professor in biomaterials at Ecole de technologie supérieure (ÉTS) since 2007, and associate Professor in radiology at University of Montréal, Quebec, Canada. Elected Fellow of the International Union of Societies for Biomaterials Science and Engineering (IUSBS) in 2016, she was also Canada Research Chair from 2008 to 2018. She is the director of the Biomaterials and Biofabrication Lab at the University of Montreal Hospital research center (CRCHUM) in Montreal, where she is developing and translating injectable hydrogels and scaffolds for vascular diseases, 3D bioprinting and cell therapy, in strong collaboration with clinicians and industry.

Her multidisciplinary work has led to over 100 peer-reviewed papers, 4 patents and several innovation awards such as the Excellence et innovation from the Cardiovascular and Interventional Radiological society of Europe (CIRSE) and the Medal for the 50th anniversary of Université du Québec network



Prof. Kattesh V. Katti

University of Missouri
Columbia (SC), USA

Title : Natural and Unnatural Biohydrogels in Molecular Imaging, Therapy and Theranostics Preclinical and Clinical Investigations

Friday, 30th October
09:45-10:30, Hall 1

Professor Kattesh V. Katti is internationally recognized as the “Father of Green Nanotechnology” and a pioneering scientist whose groundbreaking contributions have transformed the fields of nanotechnology, nanomedicine, molecular imaging, radiopharmaceutical sciences, and biomedical engineering. He currently serves as Distinguished Curators’ Professor of Radiology and Director of the Institute of Green Nanotechnology at the University of Missouri School of Medicine (USA).

Prof. Katti is the founder of the revolutionary field of Nano-Ayurvedic Medicine, integrating Green Nanotechnology with traditional Ayurvedic principles to develop innovative therapeutic and diagnostic approaches. His pioneering discoveries have led to the development of advanced nanomedicines, cancer therapies, antimicrobial and antiviral agents, bio-nanomaterials, and molecular imaging technologies with significant clinical applications. A globally renowned innovator, Prof. Katti has authored more than 300 scientific publications, contributed to numerous books and reviews, and is the principal inventor of over 150 inventions and 50 patents.

His scientific achievements have been recognized through prestigious international distinctions, including the International Hevesy Medal Award, one of the highest honors in Nuclear Medicine and Radiopharmaceutical Sciences. In 2026, he was named Top Innovator of the Year in Healthcare by the International Association of Top Professionals (IAOTP) in recognition of his exceptional contributions to healthcare innovation and translational research. His pioneering work has also received international recognition from leading scientific organizations, including the International Atomic Energy Agency (IAEA), the National Academy of Inventors (USA), and numerous scientific academies worldwide.

Prof. Katti is a Fulbright Global Specialist, Fellow of multiple prestigious academies and professional societies, and has delivered more than 500 plenary, keynote, and invited lectures across the globe. His research continues to shape the future of sustainable nanotechnology, precision medicine, advanced biomaterials, and next-generation biomedical technologies.



Prof. Ayat Bouzieh

Jordan University of Science and Technology (JUST)
Irbid, Jordan

Title : Modeling an injectable poly-γ-glutamic acid–chitosan–rGO hydrogel scaffold for spinal cord tissue regeneration using COMSOL Multiphysics

Friday, 30th October
11:00-11:30, Hall 1

Dr. Ayat Bouzieh is an Assistant Professor at Institute of Nanotechnology in Jordan University of Science and Technology (JORDAN) (Jan. 2019–now). She worked as a researcher at Hamdi Mango Center for Scientific research in The University of Jordan (JORDAN) (Sep. 2013 – Jan. 2019).

She obtained her PhD degree in material science and applied physical chemistry from The University of Jordan in 2018. She is author or coauthors of approximately 40 scientific papers published on international Journals. Adding to that, as a researcher, she was and still involved in many research projects that are funded institutionally, governmentally and internationally. Also she was attended many international and national conferences, workshops and symposiums that were focused on scientific research purposes. At the beginning my research mainly focused on colloid and surface chemistry, started with the Phase diagram, surfactant, emulsion, microemulsion in colloid system, mainly on the descriptive of the behaviors of the three component systems of water oil and surfactant.

Moving forward, she focused more in the application of physical chemistry and nanomaterials. She worked in a multi disciplinary research projects, this includes Characterization and Treatment of Dead Sea Mud, Treatment of olive mill wastewater using colloid and surface chemistry techniques, Conservation of cultural heritage (The Roman Nymphaeum in Amman) using colloid and nanomaterials, Preparation of biodegradable food packaging films, preparation of light weight material with enhanced mechanical properties using nanocomposite concepts. Preparation of Heterogenous nanocatalysis for textile wastewater treatment. Preparation of polymeric nanocomposite membranes and ceramic nanocomposite for water treatments. preparation of Double-Network Hydrogel for Strain Sensing Applications.



Prof. Khalid Draoui

Université Abdelmalek Essaâdi
Tetouan, Morocco

Title : Recent Advances in Clay-Based Biohydrogels and Biohydrogel-Derived Porous Materials for Wastewater Treatment and Environmental Applications

Friday, 30th October
11:45-12:15, Hall 1

Dr. Khalid DRAOUI is a Full Professor at Abdelmalek Essaadi University. He obtained his Ph.D. in Electrochemistry from the University of Aix-Marseille I in 1991, and a Moroccan "State Doctorate" in Thermodynamics and Microcalorimetry from Cadi Ayyad University, Marrakech, in 1998. The latter was conducted in collaboration with the Calorimetry Centre CTM-CNRS Marseille, France.

His research interests include porous materials, clay minerals and clay-polymer nanocomposites, hydrogels, water treatment, energy storage materials, biosensors and corrosion inhibition. He is a member of the Editorial Board of Applied Clay Science and Academic Editor in Minerals. He has coordinated several academic programs, including a Master's degree in Industrial Chemistry and Professional Bachelor's degrees in Clays and Ceramics Industries. He also serves as an Expert Evaluator for the CNRST (Morocco) since 2015. He currently heads the Materials Engineering and Sustainable Energy Laboratory (IMED-Lab-UAE).

He has authored nearly 135 publications (h-index: 38) and has supervised 31 Ph.D. theses, successfully defended and over 150 Master's projects. Additionally, he has led 28 research projects, both national and international. He was an active member of the Erasmus+ INSITES program (Institutionalisation of Structures for Innovation, Transfer, and Knowledge Exploitation) and he is founding member of the Moroccan National Energy Transition Consortium (MNETC-UM6P).

WORKSHOP 2



Prof. Nadia Boutaleb

Hassan II University of Casablanca
Mohammedia, Morocco

Title : Scientific Publishing & Research Visibility : From DOI to Scientific Discovery

Friday, 30th October
15:45-16:30, Hall 1

Dr Nadia Boutaleb is Professor of Agri-Food and Environmental Sciences at Hassan II University of Casablanca (Morocco) and Vice-President of the Moroccan Association for Environmental and Health Sciences and Technologies (AMSTES). She chairs the Editorial Board of a scientific journal where she oversees metadata quality, DOI registration and OJS management.

She believes in open science and research integrity, and provides training on scholarly publishing and metadata structuring. Based in Casablanca, she promotes the adoption of Crossref and open scholarly infrastructures across Morocco and the MENA region.



Prof. Ajeet Kaushik

Florida Polytechnic University
Lakeland (FL), USA

Title : MIP-based electrochemical sensing of microplastics and PFAS for health and environmental management

Friday, 30th October
Room 4

Ajeet Kaushik, Fellow-ICS & Fulbright Specialist, is an Associate Professor of Chemistry at the Department of Chemistry at Florida Polytechnic University, USA, and is exploring nano-enabled technologies for health and environmental monitoring. He is an accomplished scholar (supported by over 350 publications, editorial roles, 14 edited books, 4 patents, and international collaborations) and the recipient of several international awards in support of his credentials.

His research interests include green chemistry, catalysis, drug delivery systems, electrochemistry, sensors, and point-of-care sensing for sustainable health and the environment. To achieve goals, Dr. Kaushik is focused on cutting-edge research and seeking collaborations.



Prof. Lalitkumar Vora

School of Pharmacy, Queen's University Belfast
Belfast, UK

Title : Hydrogels in drug delivery: Recent advances and perspectives

Friday, 30th October
Room 4

Dr Lalitkumar Vora is a Lecturer in Pharmaceutical Sciences at the School of Pharmacy, Queen's University Belfast. He has over 15 years of research experience in advanced drug-delivery technologies, with particular expertise in long-acting formulations, hydrogel systems, and lipid-based delivery platforms. He has secured ~£1 million in research funding as Co-Investigator. He has authored 200+ peer-reviewed publications, 20+ book chapters, and 150+ conference proceedings, with a current h-index of 61 and over 12,000 citations. Dr Vora has edited two academic books and serves on the Editorial Board of The AAPS Journal.

His contributions have been recognized through multiple awards, and he has been listed among the Stanford/Elsevier Top 2% Global Scientists since 2023.

Awards

BEST ORAL & POSTER PRESENTATION AWARDS

To recognize scientific excellence and encourage the participation of young researchers, **the 7th International Congress on Biohydrogels 2026** will present awards for outstanding scientific contributions.

The following distinctions are planned:

- **Best Oral Presentation Award**: €200 and a commemorative trophy.
- **Best Poster Presentation Award**: €200 and a commemorative trophy.

Presentations will be evaluated according to scientific originality, research quality, clarity of communication, relevance of results, and the ability to engage in scientific discussion.

The awards will be announced during the official Closing Ceremony of the Congress on October 31, 2026.

The Organizing and Scientific Committees wish all presenters a successful and enriching scientific experience.



Social Events

DINNER GALA

Le Méridien Casablanca

Ideally located in the northern part of Casablanca, in the Ain Sebaa district – a historical industrial and business district – Le Méridien Casablanca is a Marriott International hotel located 35 km from Mohammed V International Airport, less than 110 km from Rabat International Airport, and just 20 minutes from the main train station.

The hotel features 145 rooms, including 10 suites, two restaurants, a signature bar (the Latitude Bar), a spa, an indoor pool, a fitness center, and over 1,000 sqm of event space for business meetings and special occasions.

Le MERIDIEN
CASABLANCA



DETAILED SCIENTIFIC PROGRAMME

Oral presentations

DAY 1			
ROOM 1 – DAY 1 (CO01 to CO08)			
Moderators:		**Prof. Mouna Latifa BOUAMRANI, Prof. Ali Asgar BHAGAT, Prof. Bahija MOUNIR, Prof. Fathallaah BAZI, Prof. Latifa HAJJI**	
N°	**Room code**	**Nom**	**Talk Title**
1	**R1_CO01**	Khaoula Sebbar	Engineering Multifunctional 3D-Printed Chia Seed Mucilage Biohydrogels Incorporating Rose Bengal and Essential Oils for Advanced Wound Healing
2	**R1_CO02**	Dorota Chmielniak	Biopolymeric materials based on chitosan: the influence of solvent type on film properties
3	**R1_CO03**	Zouhair Elkhlifi	Lanthanum hydroxide engineered sewage sludge biochar for efficient phosphate elimination: Mechanism interpretation using physical modelling
4	**R1_CO04**	Lekbira Zouhri	Influence of Different Culture Media on Secondary Metabolite Production by an Endophytic Fungus Isolated from Globularia alypum L.
5	**R1_CO05**	Yousef Oukahou	Metal–Organic Frameworks for Adsorption Applications
6	**R1_CO06**	Doha Quebouch	Hesperidin-Extract from Citrus reticulata Agro-Industrial By-Products: Antimicrobial and Anti-Biofilm Activities and Food Packaging Film Properties
7	**R1_CO07**	El Mehdi Elgharbaoui	Development of Bioactive Hydrogel-Based Materials Incorporating Functional Molecules for Sustainable Agricultural Applications
8	**R1_CO08**	Houria Hemdani	Amphiphilicity of gum arabic arabinogalactan-proteins in anticancer nanocarriers: a critical analysis of the structure-function evidence

ROOM 2 – DAY 1 (CO09 to CO16)

Moderators:	Prof. Abdelkrim EL KADIB, Prof. Sidi A. BENCHERIF, Prof. Badr Eddine KARTAH, Prof. Hanae EL MONFALOUTI

N°	Room code	Nom	Talk Title
9	**R2_CO09**	Diana Rogel	Extraction and characterization of matrix-bound vesicles of Wharton´s jelly
10	**R2_CO10**	Chaimae Lachhab	Engineering Injectable Polyelectrolyte Complex Hydrogels: Linking Gelation Rheology and Swelling Performance for Drug Delivery
11	**R2_CO11**	Carlo Giovanni Espinoza Maraboli	Engineering wastewater derived extracellular polymeric substances into reusable hybrid biohydrogel adsorbents for cyclic packed bed metal adsorption
12	**R2_CO12**	Aymane Bousfiha	Freeze-Dried Bioactive and Antioxidant Hydrogel Scaffolds Based on Argan Oil and Its Derived Lignin for Wound Management
13	**R2_CO13**	Halima Kerdjoudj	Tannic acid functionalized Wharton's jelly extracellular matrix hydrogel as bioactive and multifunctional platform for tissue engineering
14	**R2_CO14**	Asmae Laaraibi	Development of smart food packaging: a case study on chitosan–clay nanocomposites from Moroccan resources with enhanced thermal and biodegradation properties
15	**R2_CO15**	Snežana Ilić-Stojanović	Thermoanalytical Studies of Inclusion Complexes and Physical Mixtures of Clotrimazole with β-Cyclodextrin and Modified Polyurethane Networks
16	**R2_CO16**	Temsamani Fadoua	The Role of Gelatin Hydrogels in Shaping Mesenchymal Stem Cell Behavior: A Transcriptomics Perspective
17	**R2_CO52**	Fatima-Zahra CHBADI	TiO2/sodium alginate hydrogel as photobiocomposite beads for removal of organic dyes in wastewater

ROOM 3 – DAY 1 (CO17 to CO24)			
Moderators:		**Prof. Hamid EL AMRI, Prof. Mustapha RAIHANE, Prof. Rachid HSISSOU, Prof. Beata KACZMAREK-SZCZEPAŃSKA**	
N°	**Room code**	**Nom**	**Talk Title**
17	**R3_CO17**	Azzeddine Bechar	Development of Electrospun Polylactic Acid/Poly(ethylene glycol)/Silver Nanoparticles Nanocomposite Films with Antimicrobial Properties
18	**R3_CO18**	Safa Nouaa	Competitive Adsorption Mechanisms of Phosphate and Nitrate on Ternary Biopolymer-Bentonite Hydrogel Beads
19	**R3_CO19**	Anouar El Ghazal	Bioactive 3D-Printed Xanthan Gum–PVP–Chia Mucilage Hydrogels Enriched with Phenolic Acids for Advanced Wound Healing Applications
20	**R3_CO20**	DIHAZI Abdelhi	An alginate-derived hydrogel enriched with biochar improves vine resilience to water stress
21	**R3_CO21**	Chaymae Hmimen	Development of Multifunctional Bioactive Electrospun PVDF-Based Membranes Reinforced with Argan-Derived Cellulose and ZnAl-LDHs for Water Treatment Applications
22	**R3_CO22**	Fatima Ezzahra Faridi	Beyond Material Choice in Vital Pulp Treatment: From Calcium Silicate Hydrate Gels to Hydrogel Based Diagnosis and Dentine–Pulp Regeneration
23	**R3_CO23**	Ilham Zerbet	Effect of Vachellia raddiana Gum Arabic-Based Edible Coatings on Postharvest Quality and Biochemical Stability of Fruits
24	**R3_CO24**	Lamyae Dani	Electrospun PLA/ZnAl-LDH-GA Nanofibrous Composites as Multifunctional Wound Dressings with Controlled Gallic Acid Delivery and Enhanced Biological Activities

DAY 2

ROOM 1 – DAY 2 (CO25 to CO32)

Moderators:	Dr. Baptiste CHARBONNIER, Prof. Vitaliy KHUTORYANSKIY, Prof. Alae EL ABED, Prof. Najim ITTOBANE, Prof. Youssef NAIMI

N°	Room code	Nom	Talk Title
25	**R1_CO25**	Didem Demir	Scaffolds Decorated with Bioactive Graphene Quantum Dots for Diabetic Wound Healing
26	**R1_CO26**	Ji Li	Lipopolysaccharides: understanding the ionic hydrogel-forming property of extracellular biopolymers extracted from waste sludge
27	**R1_CO27**	Juan Jairo Vaca-González	Magnetic field–modulated gemcitabine delivery via Fe3O4@SiO2@HAGel nanoplatforms in an in vitro model of pancreatic cancer
28	**R1_CO28**	Khaled Sebakhy	Probing Water Phase Behavior in Alginate Hydrogels: Integrating Quantitative and Structural Insights
29	**R1_CO29**	Hernane Barud	3D Bioprinted Gellan Gum–Clay Hydrogels for Delivery of Trichoderma harzianum for Sustainable Agriculture
30	**R1_CO30**	Safae Er Raouan	Mixture Design Optimization of Plant Secondary Metabolites for Anti-Adhesive Functionalization of 3D-Printed ABS and Nylon Surfaces
31	**R1_CO31**	Aleksandra Mikhailidi	Designing Application-Specific Regenerated Hydrogels through Direct Dissolution of Cellulose from Diverse Sources
32	**R1_CO32**	Housna Amimi	Phytochemical Profiling of Gelidium Sesquipedale for Marine-Derived Biohydrogels: Matrix Interferences and Methodological Considerations

ROOM 2 – DAY 2 (CO33 to CO40)			
Moderators:		**Prof. Soumya EL ABED, Prof. Sophie LEROUGE, Prof. Saad IBNSOUDA, Prof. Kattesh, V. KATTI, Prof. Ayat BOUZIEH**	
N°	**Room code**	**Nom**	**Talk Title**
33	**R2_CO33**	Badre Eddine Halimi	Bacterial Polymer-Based Systems for the Delivery of Therapeutic Agents to Bone Tissue
34	**R2_CO34**	Souha Ben Mahmoud	Formulation and Characterization of a Teucrium polium–Loaded Xanthan–Galactomannan–Hyaluronic Acid Biohydrogel
35	**R2_CO35**	Suzana M. Cakić	Application of Mathematical Models in Clotrimazole Release Kinetics from β-Cyclodextrin Modified Polyurethane Inclusion Complexes
36	**R2_CO36**	Imade Armadi	From Shrimp Waste to 3D-Printed ChitoPatch: Sustainable Production, Characterization and Biomedical Valorization of Chitosan
37	**R2_CO37**	Sarah Bertin	Storage and sustained delivery of mRNA-liposome complexes via Si-HA hydrogels for bone regeneration: toward sequential release
38	**R2_CO38**	Nada El Arrach	Phytoglycogen Nanoparticles as Tunable Polysaccharide Platforms: Linking Surface Chemistry to Functional Applications
39	**R2_CO39**	Abdelilah Ayad	Tuning the self-assembly of quercetin-loaded PEG-b-PLA micelles: a dissipative particle dynamics study
40	**R2_CO40**	Khadija Sikkou	Beyond Conventional PMMA: Self-Healing Polymers and Smart Hydrogel Interfaces for Next-Generation Removable Dental Prostheses

ROOM 3 – DAY 2 (CO41 to CO48)			
Moderators:		**Prof. Mina OUMAM, Prof. Mohamed IDIRI, Prof. Samir CHTITA, Prof. Mohamed MOUMOU, Prof. Soumia BELOUAFA**	
N°	**Room code**	**Nom**	**Talk Title**
41	**R3_CO41**	Assia Ahmimouji	Synthesis and DFT Investigation of Novel Acetophenone-Based 1,2,3-Triazole Derivatives for Potential Corrosion Inhibition
42	**R3_CO42**	Wafaa Zriouel	Biohydrogels as Smart Platforms for Sustainable Corrosion Protection: Stimuli-Responsive Inhibitor Delivery, Self-Healing and Molecular Modeling
43	**R3_CO43**	Kenza Nouwari	In Silico Approaches for Antimicrobial Discovery Against Foodborne Bacterial Pathogens
44	**R3_CO44**	Fatima Ezzahra Ezzaky	Circular Valorization of Medicinal and Aromatic Plant Residues into Functional Biopolymers: Green Extraction, Multi-Scale Characterization, and Emerging Applications
45	**R3_CO45**	Shaimi Taoufik	Application of Response Surface Methodology in Predicting the Leaching Behavior of Rare Earth Elements from Khouribga Phosphate Rock
46	**R3_CO46**	Tarik EL Ouafy	Substituent-Driven Modulation of Electronic Structure and Reactivity in Pyrrole-Based Propanoic Acid Derivatives: A DFT Insight
47	**R3_CO47**	Ighidi Salma	Valorization of Hydroxyapatite-Based Photocatalysts for the Visible-Light Degradation of Organic Textile Pollutants
48	**R3_CO48**	Soukaina BENNIS	In Silico Screening and Optimization of Multi-Target Inhibitors for Neurodegenerative Disorders

ROOM 4 – DAY 2 – (CO49 to CO51)			
Moderators:		**Prof. Taha EL ASSIMI, Prof. Lamia BOURJA, Prof. Adil AKKOUCH, Prof. Abdelkbir ERROUGUI**	
N°	**Room code**	**Nom**	**Talk Title**
49	**R4_SP01**	Lalitkumar Vora	Hydrogels in drug delivery: Recent advances and perspectives
50	**R4_SP02**	Ajeet Kaushik	MIP-based electrochemical sensing of microplastics and PFAS for health and environmental management
51	**R4_CO49**	Asma Munir	The development of natural deep eutectic solvent-mediated rice husk lignin-based hydrogels and biofilms for wound healing applications
52	**R4_CO50**	Houda Hamiach	Eco-Friendly Lignin-Chitosan Hydrogels as Green Coatings for Slow Phosphorus Release Fertilizers and Enhanced Wheat Growth
53	**R4_CO51**	Fatma Zehra Koçak	Natural Polymer-Based Biomimetic and Bioactive Hydrogels for Tissue Engineering and Drug Delivery

Poster presentations

N°	Code	Nom	Poster Title
1	**PC01**	Chaymaa Hachimi Alaoui	Advanced Hydrogel Composites for Bone Additive Manufacturing
2	**PC02**	Lamyae Dani	Multifunctional ZnAl-LDH-GA and MgAl-LDH-GA Bioactive Composites with Controlled Gallic Acid Release and Therapeutic Activities for Advanced Wound Healing
3	**PC03**	Anna Stasiłowicz-Krzemień	Cannabinoid-Loaded Eutectogels Derived from Deep Eutectic Solvents for 3D-Printed Wound Dressing Applications
4	**PC04**	Omayma Aabidi	Design of a Collagen–Alginate Interpenetrating 3D Biomatrix for In Vitro Cell Culture
5	**PC05**	Ali Barazzouq	Elaboration characterization and investigation of advanced composites as some anticorrosion protection coatings for H13 steel surface in 1M HCl solution: Comprehensive approaches
6	**PC06**	Ahmad MAHMUD	A multifunctional hydrogel for integrated regulation of phosphorus release, soil moisture, and thermal buffering in soils
7	**PC07**	SAVIO, L. B	Microbial hyaluronic acid from rice coproducts: a promising biopolymer as hydrogel precursor
8	**PC08**	ABRÃO, M. C	3D PRINTING OF HYALURONIC ACID–GELATIN HYDROGELS FOR DRUG DELIVERY APPLICATIONS
9	**PC09**	Laetitia Florent1	Age-associated remodeling in type I collagen promote the invasion of BRAFV600E mutated melanoma cells and their resistance to targeted therapies within three-dimensional matrix models
10	**PC10**	Khadija Zyani	Biodegradable poly(aspartic acid) superabsorbents with tunable cross-linking for sustainable water management in agricultural soils
11	**PC11**	Raja Saadan	Injectable Silanized Hydroxypropyl Methylcellulose/Lignin Hydrogels for Cutaneous Wound Healing: Physicochemical Characterization and Biological Evaluation
12	**PC12**	J. Attarki	Theoretical Insights into NOx (NO, NO2) Adsorption on NaMgPO4 (033): A DFT and Monte Carlo Study

N°	Code	Nom	Poster Title
13	**PC13**	Loubna Jrhaider	Evaluating plant-derived bioactives and synthetic chemicals for Quality preservation and Microbial safety in processed functional foods
14	**PC14**	Zitouni Youssef	Synthesis and Performance of Dihydro-ar-curcumene and Cadalene as Corrosion Inhibitor for C38 Steel in 1M HCl Medium
15	**PC15**	Ayoub Ait Hfid	Bridging Bio-Based Aerogels and Hydrogels for Fertilizer Applications: Synthesis, Functional Properties, and Agronomic Performance – A Critical Review
16	**PC16**	M. Atanassova	Can sea cucumber peptides be efficient component in cardiac repair hydrogels?
17	**PC17**	Mairim Russo Serafini	Use of a Pectin Hydrogel Containing Passiflora ligularis Extract for Wound Healing in Canine Cutaneous Leishmaniasis: A Case Report
18	**PC18**	Yousra Oudghiri	Natural Polymer-Based Encapsulation Systems for Sustained Antimicrobial Activity in Bio-Based Coatings
19	**PC19**	LOUDILI Chaimae	Hydrogel-Based Smart Interfaces for Dentin-Like Fixed Restorations: Bridging Biomimetic Mechanics and Bioactivity
20	**PC20**	Farah El handour	Electrochemical Behavior of Pyocyanin: Mechanistic Insights, Analytical Strategies, and Emerging Applications
21	**PC21**	Fatima Ezzahra Faridi	Self-Assembling Peptide Hydrogels for Biomimetic Enamel Remineralization: From Concept to Clinical Practice
22	**PC22**	Khadija Sikkou	Smart Biohydrogels for Peri-Implantitis: From Biofilm Control to Exosome-Mediated Immunomodulation and Tissue Regeneration
23	**PC22**	Merieme El Mohazzim	Preliminary Formulation and Characterization of Chitosan Hydrogels for 3D Bioprinting Applications in Tissue Engineering
24	**PC24**	Nayla Munawar	Microbial Dextran Hydrogel as a Smart Platform for Localized Antibiotic Delivery and Infection Control

Keynote Lectures

N°	Code	Nom	Talk Title
1	**KL1**	Prof. Abdelkrim El Kadib	Chitosan Hydrogels: From Molecular Design and Textural Engineering to Environmental and Biomedical Applications
2	**KL2**	Prof. Vitaliy Khutoryanskiy	Thermally Induced Cross-linking of Water-Soluble Polymers for Biomedical Hydrogel Development
3	**KL3**	Prof. Alireza Dolatshahi-Pirouz	Bioadaptable Hydrogels for Tissue Engineering
4	**KL4**	Prof. Beata Kaczmarek-Szczepańska	Biopolymer-based materials enriched with selected phenolic acids
5	**KL5**	Prof. Ali Asgar Bhagat	Catalyzing Healthcare Innovation in Singapore
6	**KL6**	Prof. Sidi A. Bencherif	Injectable Cryogels for Biomedical Applications: from Tissue Engineering to Immunotherapy
7	**KL7**	Prof. Adil Akkouch	Multifunctional Hydrogels for Antibacterial Activity, microRNA Delivery, and Electrical Stimulation
8	**KL8**	Dr. Baptiste Charbonnier	Beyond Brittle: Hydrogels as the Next Revolution in Cements for Bone Regeneration
9	**KL9**	Prof. Sophie Lerouge	Injectable Macroporous Hydrogels for Cell Delivery and Tissue Engineering
10	**KL10**	Prof. Kattesh V. Katti	Natural and Unnatural Biohydrogels in Molecular Imaging, Therapy and Theranostics Preclinical and Clinical Investigations
11	**KL11**	Prof. Ayat Bouzieh	Modeling an injectable poly-γ-glutamic acid–chitosan–rGO hydrogel scaffold for spinal cord tissue regeneration using COMSOL Multiphysics
12	**KL12**	Prof. Khalid Draoui	Recent Advances in Clay-Based Biohydrogels and Biohydrogel-Derived Porous Materials for Wastewater Treatment and Environmental Applications
13	**KL13**	Prof. Lalitkumar Vora	Hydrogels in drug delivery: Recent advances and perspectives
14	**KL14**	Prof. Ajeet Kaushik	MIP-based electrochemical sensing of microplastics and PFAS for health and environmental management

Abstracts
(Keynote lectures)

KL1

Chitosan Hydrogels: From Molecular Design and Textural Engineering to Environmental and Biomedical Applications

Abdelkrime El Kadib

EuroMed University of Fez. Morocco

Abstract

Polysaccharides are among the most abundant natural polymers, exhibiting remarkable structural diversity and functionalities that have positioned them at the forefront of modern materials science and biotechnology. Among them, chitosan, obtained by the deacetylation of chitin, has emerged as one of the most versatile renewable building blocks for advanced materials. Its industrial production has expanded considerably in recent decades, driven by increasing demand for sustainable alternatives to petroleum-derived polymers. The unique combination of reactive amino and hydroxyl groups, excellent film-forming ability, biocompatibility, biodegradability, and tunable gelation properties enables chitosan to fulfill multiple roles in nanomaterial synthesis. It can serve as (i) a structure-directing agent and stabilizer for metal nanoparticles and sol-gel derived nanostructures, (ii) an exfoliating and dispersing matrix for graphene and layered clay minerals, (iii) a confined medium for the controlled growth of metal-organic frameworks (MOFs) and covalent organic frameworks (COFs), and (iv) a renewable carbon and nitrogen precursor for the preparation of nitrogen-doped graphene nanomaterials. Furthermore, the ability of chitosan hydrogels to form films, coatings, membranes, and nanocomposites has enabled the development of multifunctional materials with enhanced mechanical performance, barrier properties, and biological activity.

This presentation will provide an overview of recent advances in the design, synthesis, characterization, and applications of chitosan-based nanomaterials, highlighting representative examples from our research. Particular emphasis will be placed on chitosan-derived hydrogels as sustainable materials, emphasizing their renewability, compatibility with aqueous processing, low environmental impact, and conformity with circular economy principles. Applications in sustainable packaging, biomedical engineering, water purification, heterogeneous catalysis, and energy-related technologies will be discussed, illustrating the broad potential of chitosan as a platform for advanced sustainable functional materials.

KL2

Thermally Induced Cross-linking of Water-Soluble Polymers for Biomedical Hydrogel Development

Vitaliy V. Khutoryanskiy*

Reading School of Pharmacy, University of Reading, Reading, United Kingdom Corresponding author: v.khutoryanskiy@reading.ac.uk

Abstract

Background / Introduction:

This work explores thermal cross-linking of reactive water-soluble polymers using microwave irradiation and autoclaving as a simple route to hydrogels for biomedical applications.

Hydrogels are widely used in biomedicine because of their high water content, tissue-like properties, and biocompatibility. Applications include wound dressings, contact lenses, drug delivery, and tissue-engineering scaffolds. They are commonly prepared by polymerising monomers with cross-linkers or by cross linking pre-formed water-soluble polymers. However, these methods may require extensive purification, costly ionising radiation facilities, or toxic chemical cross linkers, creating concerns over safety, cost, and environmental impact. Here, we propose thermally induced cross-linking of reactive water-soluble polymer mixtures as a safer alternative to potentially toxic chemical cross linkers.

Methods:

Aqueous mixtures of poly(vinyl alcohol) (PVA) with poly(acrylic acid) or poly(methyl vinyl ether-alt-maleic anhydride) were converted into chemically cross-linked hydrogels by microwave irradiation or autoclaving. Alternatively, the mixtures were cast as thin films and heated to form dry cross linked networks that produced hydrogels upon swelling in water.

Results

Microwave irradiation rapidly converted aqueous mixtures of PVA with either poly(acrylic acid) or poly(methyl vinyl ether alt-maleic anhydride) into chemically cross linked hydrogels. Processing at 100–150 °C produced soft, highly swollen materials with equilibrium swelling degrees of approximately 500–1000 g g^{-1}. Their leachable fractions showed low cytotoxicity toward cultured cells, supporting the biocompatibility of the materials. Autoclaving PVA/poly(methyl vinyl ether-alt-maleic anhydride) mixtures similarly produced transparent, stable hydrogels, most likely through ester-bond formation between carboxylic acid and hydroxyl groups. These materials demonstrated high swelling capacity, suitable mechanical properties, and adhesion to porcine skin. They also showed intrinsic antimicrobial activity against Staphylococcus aureus, attributed mainly to their acidic character. Hydrogel extracts maintained greater than 70% fibroblast viability, and direct-contact studies confirmed good cellular compatibility. These findings support their potential as ready-to-use wound dressings. Thermal treatment of solvent-cast films also produced stable networks capable of extensive swelling in water. Autoclaving was further applied to superporous hydrogels, which showed rapid and extensive swelling due to their interconnected porous structure.

Conclusion

Thermal cross-linking provides a simple and effective route to biomedical hydrogels without toxic monomers or additional cross-linking agents. Microwave and autoclave processing can generate highly swellable, biocompatible materials with properties suitable for wound care and other biomedical applications.

Key words: *hydrogels, water-soluble polymers, cross-linking, autoclave*

KL3

Bioadaptable hydrogels for tissue engineering

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Abstract

Hydrogels are highly promising biomaterials for tissue engineering due to their similarity to the native extracellular matrix, which enables them to support cellular activities. However, conventional hydrogels often static, something that limit their capacity to accommodate the dynamic processes associated with tissue growth such cell migration, remodeling, and regeneration. Bioadaptable hydrogels can address due to their native-like properties enabling them to respond to biological and physicochemical changes over time.

This presentation will discuss the design and development of bioadaptable hydrogels with tunable mechanical, biochemical, and degradation properties for tissue engineering applications. Particular emphasis will be given to hydrogels that can sense, respond and adapt to their microenvironment. Finally, the incorporation of bioactive molecules, stimuli-responsive components, and adaptable crosslinking mechanisms will also be discussed as means to control cellular behavior and promoting tissue regeneration.

The approaches highlighted in the presentation could enable next-generation biomimetic biomaterials for tissue engineering, regenerative medicine, and advanced in vitro tissue models.

KL4

Catalyzing Healthcare Innovation in Singapore

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Abstract

Background / Introduction:

Biopolymers are promising biomedical materials due to their biodegradability and biocompatibility, although their properties often require modification. Phenolic acids can improve their structural stability through hydrogen bonding while providing antioxidant and anti-inflammatory activity. Further functionalization with bioactive compounds enables the tailoring of their physicochemical and biological properties. The present study aimed to investigate and compare the physicochemical and biological properties of biopolymer-based scaffolds functionalized with selected phenolic acids and to evaluate their potential for wound dressing applications.

Methods:

The chemical structure and interactions between the polymers and additives were analyzed by FTIR-ATR. Moisture content was determined gravimetrically by drying at 105 °C, while swelling was evaluated in PBS under physiological conditions. Antioxidant activity was assessed using the DPPH assay, and mechanical properties were determined using a universal testing machine. Hemocompatibility was evaluated using anticoagulated human blood, while cytocompatibility was assessed using the MTT assay.

Results

The results showed that scaffold properties depended strongly on the biopolymer type and applied modifications. Hyaluronic acid-based scaffolds exhibited higher water content and porosity but lower stability and faster degradation than collagen-based materials. Collagen-based scaffolds showed a more compact structure and greater stability. Ferulic acid provided over 95% antioxidant activity and improved hemocompatibility, whereas hyaluronic acid-based materials showed excessive hemolysis.

Conclusion

The developed scaffolds showed promising structural, antioxidant, and biological properties, supporting their potential for biomedical applications.

This research was supported by the funds of the Minister of Science and Higher Education under the program "Excellence Initiative – Research University" for the Priority Research Team at Nicolaus Copernicus University in Toruń, "EPIBIOMAT Research Group – Epibiocompatible Materials for Medicine and One Health"

Key words: *biopolymers, biomaterials, phenolic acids, wound dressing*

KL5

Biopolymer-based materials enriched with selected phenolic acids

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Abstract

In this talk, I will delve into the vibrant and rapidly evolving landscape of healthcare innovation in Singapore. Over the past two decades, Singapore has established itself as a global hub for medical advancements, driven by a robust ecosystem that fosters deep collaboration between academia, industry, and government. This unique tripartite model has enabled the nation to punch well above its weight in biomedical research, clinical innovation, and health technology development. This talk will highlight the strategic initiatives and partnerships that have been instrumental in driving innovation and transforming healthcare delivery across the continuum of care — from prevention and diagnostics to treatment and long-term disease management.

I will begin by examining the pivotal roles played by academia, healthcare institutions, and government agencies in catalyzing these innovations. Academic institutions provide the foundational research and knowledge base, training the next generation of clinician-scientists and biomedical engineers while pushing the boundaries of discovery in areas such as genomics, artificial intelligence, and precision medicine. Healthcare institutions, including public hospitals and national specialty centres, offer practical clinical insights, real-world testing environments, and access to diverse patient populations that are critical for validating new technologies and therapies.
Government agencies, in turn, create supportive policies, regulatory frameworks, and substantial funding opportunities that de-risk early-stage research and incentivize private sector participation.

Together, these entities form a synergistic network that drives continuous improvement and innovation in healthcare, ensuring that breakthroughs in the laboratory are translated into tangible benefits for patients and the wider community.

Finally, we will explore the essential considerations that promote the successful translation and commercialization of academic research output. In today's rapidly evolving technological landscape, the ability to swiftly and effectively commercialize academic research is paramount to driving economic growth and societal advancement — especially in the healthcare sector, where the stakes are measured not only in economic terms but in human lives. I will also address common barriers to commercialization, such as the "valley of death" between proof-of-concept and market adoption, and discuss how Singapore's integrated innovation ecosystem is uniquely positioned to bridge this gap.

KL6

Injectable Cryogels for Biomedical Applications: from Tissue Engineering to Immunotherapy

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Abstract

Across cell therapy, regenerative medicine, and immunoengineering, there is a need for advanced three-dimensional (3D) scaffolds that support cells, modulate their behavior, and guide tissue regeneration. Injectable biomaterials have become especially attractive, offering minimally invasive delivery without the risks of open surgery while enabling precise placement within delicate tissues. In this context, we introduced a breakthrough platform: large, preformed macroporous cryogels that can be delivered through a standard needle–syringe system while preserving their structure and function [1].

Our 2012 report of the first injectable cryogel capable of passing through a hypodermic needle while maintaining native-like microenvironmental cues sparked widespread interest and helped redefine the design space of soft biomaterials [2]. These sponge-like constructs, produced through environmentally friendly cryogelation, exhibit unique features—including elasticity, interconnected macroporosity, and shape-memory behavior enabling complete geometric recovery after injection. Over the past decade, injectable cryogels have emerged as a versatile and customizable class of biomaterials aligned with modern research priorities. They hold great promise for various biomedical applications (Fig. 1), including tissue engineering, controlled drug delivery, cell therapies, cancer immunotherapy, and innovative vaccine platforms, including those developed during the COVID-19 era [3–5].

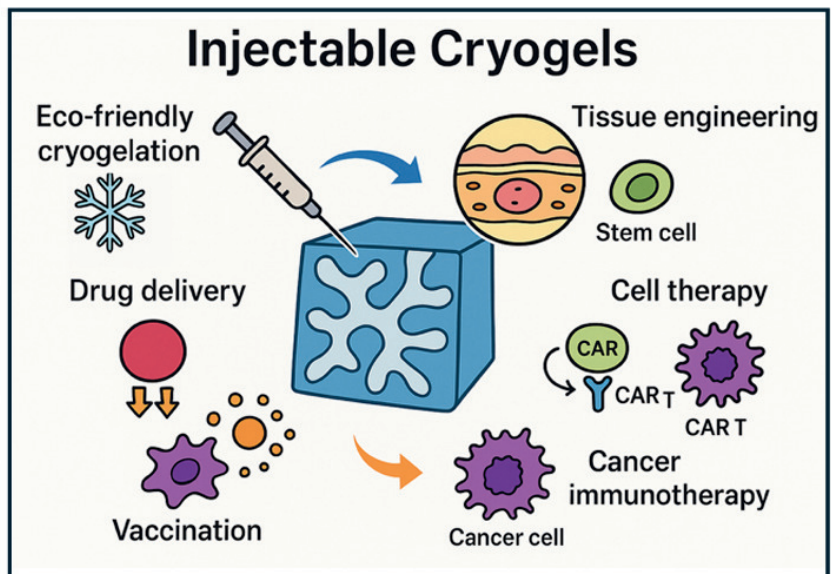


Figure 1. Biomedical applications of injectable cryogels.

Acknowledgemnt: *Together, these strategies provide promising versatile injectable macroporous biohydrogels for cell therapies and tissue engineering.*

references:

[1] L.J. Egremont et al. Trends in Biotechnology 2019, 38:418–431.
[2] S.A. Bencherif et al. PNAS 2012, 109, 19590–19595.
[3] M. Rezaeeyazdi et al. Materials Today Bio 2022, 100207.
[4] S.A. Bencherif et al. Nature Communications 2015, 6:7556.
[5] T. Colombani et al. Advanced Science 2021, 2100316.

KL7

Multifunctional Hydrogels for Antibacterial Activity, microRNA Delivery, and Electrical Stimulation

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Abstract

Multifunctional hydrogels capable of simultaneously modulating infection, molecular signaling, and bioelectrical activity represent an emerging strategy in regenerative medicine. This presentation explores the engineering of hydrogels incorporating functional nanomaterials and conductive polymers to generate biologically active and responsive biomaterial systems.

The integration of conductive polymers, antibacterial agents, and microRNA delivery strategies enables the development of hydrogels with tunable physicochemical, antimicrobial, electrical, and therapeutic properties. These materials may support localized molecular delivery, regulation of cellular behavior, and electrical stimulation of tissue repair.

By combining multiple functions within adaptable hydrogel architectures, this work provides a framework for developing advanced biomaterials for wound healing, bone and cartilage regeneration, and other localized therapeutic applications.

Beyond Brittle: Hydrogels as the Next Revolution in Cements for Bone Regeneration

KL8

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Abstract

Despite decades of research, synthetic bone substitutes still fall short of autografts in demanding clinical situations. Over the past fifteen years, additive manufacturing (AM) has changed this picture by enabling patient-specific scaffolds that precisely fit the defect anatomy, simplify and shorten surgery, and improve aesthetic and functional outcomes. AM also allows scaffold architecture to be controlled from the macro- to the nanoscale, and designs such as triply periodic minimal surfaces have been proposed to enhance bioactivity, guide biodegradation and promote the formation of new vascularized bone.

Although AM first matured for metals and polymers, vat photopolymerization and indirect printing routes now make it possible to produce personalized calcium phosphate bioceramics with biologically relevant architectures. Calcium and magnesium phosphate cements can also be printed into custom macroporous structures, which removes one of the main obstacles to their clinical use, although they still offer less architectural freedom than bioceramics despite promising recent progress. Supported by evolving regulatory and socioeconomic frameworks, such personalized solutions are now reaching patients.

Several issues nonetheless limit their full potential, from maintaining accurate scaffold–defect fit throughout the digital workflow to facilitating implantation in complex sites, from improving biomaterial induced biological response for an optimized regeneration to finely tune biomaterial degradation.

This is where hybrid and composite cements may challenge the dominance of calcium phosphate bioceramics. Already recognized for their superior bioactivity and more suitable biodegradation, cements blended with polymers have recently been developed to improve printability and surgical handling, owing to their elastic and plastic deformability compared with the brittleness of bioceramics. However, the synthetic polymers used so far, such as PCL and PLGA, offer little bioactivity.

Bio-sourced water-soluble macromolecules and hydrogels offer a compelling alternative to these polymers, as they can improve cement printability, handling, flexibility, and mechanical strength while contributing their own biological properties. They may thus pave the way for a new generation of bioactive, printable and patient-specific bone substitutes… which will be illustrated by an example of translational research carried out in Nantes by the RMeS Lab (Inserm UMR 1229), Nantes University Hospital and the Nantes Veterinary School (Oniris).

Key words: *Hydrogels; Cements, Bone tissue engineering.*

KL9

Injectable Macroporous Hydrogels for Cell Delivery and Tissue Engineering

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Abstract

Injectable hydrogels are attractive scaffolds for minimally invasive cell delivery and tissue engineering. However, their limited porosity restricts oxygen and nutrient diffusion, cell proliferation, cell–cell interactions, and cell migration. Our group has developed several strategies to engineer injectable macroporous biohydrogels compatible with cell encapsulation and has demonstrated their potential as platforms for T-cell growth and delivery for local cancer immunotherapy, stem cell delivery, and bioinks for bioprinting.

The first strategy relies on a porogen leaching, in situ gelling hydrogel. Gelatin particles produced by coacervation are used as sacrificial porogens that melt while a chitosan solution undergoes thermally induced gelation at body temperature. This process generates a biodegradable dual-porosity hydrogel with macropores interconnected by the microporous chitosan network formed by phase separation (**Fig.1**).

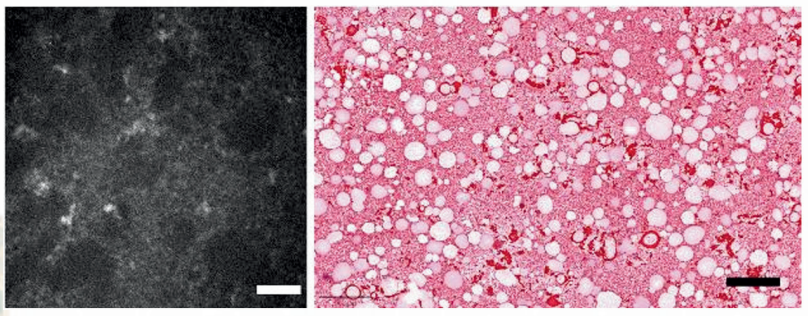


Figure 1*: two-photon microscopy and histology of dual-porosity scaffolds*

Macroporosity significantly enhanced T cell viability, proliferation, and cluster formation, resulting in sustained in vitro antitumor activity for at least three weeks, markedly outperforming conventional microporous chitosan hydrogels ($p < 0.001$).

The therapeutic benefit of this macroporous scaffold is currently being evaluated in a murine tumor model.

The second strategy involves the fabrication of cell-laden granular hydrogels using coaxial air flow and inverse gelation in an alginate bath. This approach enables the production of porous chitosan–gelatin beads surrounded by a thin alginate shell, which can be retained or selectively removed using sodium citrate. Encapsulated mesenchymal stem cells (MSCs) exhibited excellent viability, spreading (Fig.2a), and pro-angiogenic activity, as demonstrated by HUVEC wound-healing and tube-formation assays.

In the third strategy, injectable hydrogel foams based on silk fibroin are developed as cell-laden bioinks, exhibiting excellent stability, injectability and printability (Fig.2b).

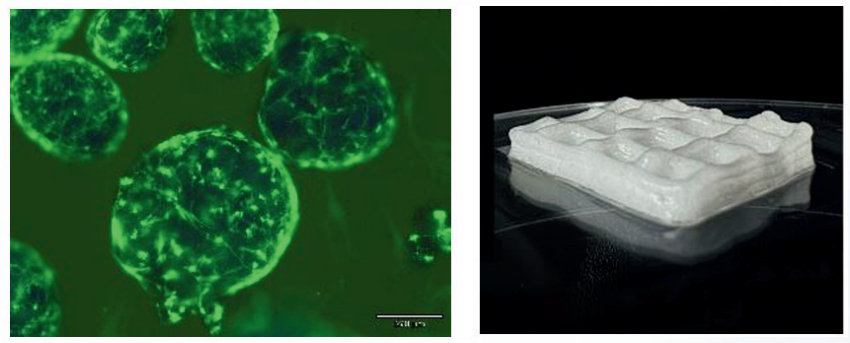


Figure 2*: a) MSC loaded microbeads ; b) Hydrogel foam bioinks*

Together, these strategies provide promising versatile injectable macroporous biohydrogels for cell therapies and tissue engineering.

Key words: *biopolymers, biomaterials, phenolic acids, wound dressing*

Natural and Unnatural Biohydrogels in Molecular Imaging, Therapy and Theranostics Preclinical and Clinical Investigations

KL10

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Abstract

Background / Introduction:

Hydrogels have gained prominence within the health, hygiene and functional food sectors. Both synthetic and natural hydrogels are being used as efficient drug delivery vehicles through encapsulations/embedding diagnostic/therapeutic drugs within various hydrogel matrix. The utility of naturally available plant-based proteins precursors toward the development of hydrogels and their applications in nanomedicine brings about a new paradigm in drug discovery. We have pioneered the development of both natural plant-based hydrogels as well as trimetric amino acid-based hydrogels toward the development of a new generation of nanomedicine agents. This presentation discusses the applications of natural and unnatural hydrogels for the development of diagnostic, therapeutic and theranostic agents for treating cancers and other disease.

Methods:

We have optimized synthetic protocols for the production of plant-based biohydrogels using plant proteins as precursors. We have also optimized, at industrial scales, the development of trimeric amino acids, commonly referred to as 'Katti Peptides', for use as templates for biohydrogels. Diagnostic and therapeutic agents have been developed through encapsulation of these innovative biohydrogels on gold nanoparticles to afford optimal stability and biocompatibility. Diagnostic and therapeutic efficacy of these biohydrogels have been tested in various animal models to elucidate (i) therapeutic efficacy; (ii) evaluate optimum doses and (iii) to gain insights on the mechanism of action.

Results:

Gum Arabic protein-based hydrogels serve as excellent biocompatible corona agents for encapsulating gold nanoparticles (GA AuNPs). Several such GA-AuNPs have shown excellent diagnostic efficacy for detecting tumors through X-ray CT as well as through SPECT imaging. Immunomodulatory properties of a series of various gold nanoparticles using both natural and unnatural hydrogels have demonstrated the following: (i) These new generation of nanomedicine biohydrogel-based agents exert immunomodulatory effects on tumor microenvironment by targeting NF-kB (Nuclear factor kappa-light-chain-enhancer of activated B cells); (ii) These nanomedicine agents suppress pro-tumor M2 macrophages and promote anti-tumor M-1 phenotypes. We have also shown, using both in vitro and in vivo models, that these biohydrogel-based nanomedicine agents promote IL-12 cytokine as a primary pathway to immunomodulate and thus afford unprecedented therapeutic efficacy in treating prostate, breast, pancreatic and other tumors.

Conclusion:

Our innovative approaches toward a new generation of both natural and unnantural biohydrogels have resulted in the discovery of highly effective gold nanoparticles-based nanomedicine agents. Our research, which combines plant-based hydrogels with biocompatible gold nanoparticles, has culminated into the discovery of a new medical modality referred to 'Nano Ayurvedic Medicine'. Clinical trials in human patients have shown excellent efficacy in treating various cancers.

KL11

Modeling an injectable poly-γ-glutamic acid–chitosan–rGO hydrogel scaffold for spinal cord tissue regeneration using COMSOL Multiphysics

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Abstract

Background / Introduction:

Spinal cord injury (SCI) triggers complex primary and secondary damage mechanisms, where excessive extracellular glutamate and subsequent excitotoxicity severely limit intrinsic neural regeneration. Injectable biohydrogel scaffolds that can both modulate the post-injury biochemical microenvironment and provide a permissive matrix for axonal regrowth are emerging as promising strategies, yet design parameters for controlled in vivo release remain poorly defined. In this work, we model an affinity-based, poly-γ-glutamic acid (PGA) chitosan–reduced graphene oxide (rGO) nanocomposite hydrogel scaffold, aiming to couple enzymatically triggered glutamate binding and conversion to GABA with spatially targeted scaffold delivery to injured spinal cord tissue.

Methods:

A COMSOL Multiphysics framework (version 6.0) was developed that integrates (i) fluid-dynamic modeling of extrusion-based 3D printing to validate core–shell scaffold formation (rGO core, chitosan inner hydrogel, PGA outer shell), and (ii) a reaction–diffusion model for scaffold release and neurochemical transport in three coupled domains: astrocyte, extracellular space, and GABAergic neuron. Glutamate glutamine cycling and PGA shell degradation were described using Michaelis–Menten kinetics, while scaffold–peptide binding and dissociation followed affinity-based reaction schemes derived from established protein matrix delivery models. Diffusion coefficients for scaffold species, glutamate, glutamine, GABA, and enzyme were estimated from protein transport in porous hydrogels and implemented in a 2D axisymmetric geometry representing a cylindrical lesion cavity, under physiological conditions (37 °C, pH 7.4)

Results:

Simulations showed that enzymatic degradation of the PGA shell rapidly converts outer-surface glutamate to GABA, driving a sharp decline of extracellular glutamate concentrations below reported excitotoxicity thresholds while sustaining GABA levels within the neuronal domain. Matrix-bound scaffold species (mp, mpSC) progressively decreased over ~16 s, with a concomitant increase in free scaffold complexes (p, pSC) and accumulation of scaffold within the astrocytic region, indicating efficient migration from the extracellular matrix toward neuroprotective sites. Bulk concentration maps revealed that GABA first appears near the scaffold–tissue interface, then spreads along the modeled cylinder, consistent with targeted delivery to the injured zone.

Conclusion:

The COMSOL-based model suggests that an injectable PGA–chitosan–rGO hydrogel scaffold can theoretically lower extracellular glutamate below neurotoxic levels while providing sustained GABA release and spatially controlled scaffold deposition in SCI-like environments.

Key words: *Spinal cord injury, injectable hydrogel, poly-γ-glutamic acid, chitosan, COMSOL Multiphysics*

KL12

Recent Advances in Clay-Based Biohydrogels and Biohydrogel-Derived Porous Materials for Wastewater Treatment and Environmental Applications

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Abstract

The growing contamination of water resources by heavy metals, dyes, pharmaceuticals and other emerging pollutants has led to the development of more sustainable and efficient materials for wastewater treatment. Hydrogels are among the most promising candidates and have attracted considerable attention due to their three-dimensional cross-linked polymeric networks, high water absorption capacity, tunable porosity and abundance of functional groups that can interact with contaminants.

To overcome some limitations of conventional hydrogels, such as their low mechanical strength and limited stability, clay minerals are widely used as reinforcing nanofillers. Incorporating them into polymeric matrices creates hydrogel-clay nanocomposites with enhanced mechanical properties, improved structural stability and increased adsorption performance. The combination of organic biopolymers and inorganic clay nanoparticles creates multifunctional materials that can efficiently remove a wide variety of pollutants from water. Biohydrogels based on natural biopolymers, such as alginate, chitosan, cellulose and starch, combined with clay minerals, have attracted significant interest. These environmentally friendly materials are biodegradable and biocompatible, and have an abundance of active sites for pollutant capture.

Beyond their hydrated state, biohydrogels can be transformed into advanced porous materials through controlled drying processes. These biohydrogel-derived materials have demonstrated exceptional performance in water treatment thanks to their hierarchical pore networks and enhanced accessibility of active sites

This presentation highlights recent advances in the synthesis, characterization and environmental applications of clay-based biohydrogels and biohydrogel-derived materials. Particular attention is given to their application in wastewater treatment, where the combination of biopolymers and clay minerals improves the adsorption of a wide range of inorganic and organic contaminants [1-4].

Key words: *Biopolymers, Clays, Biohydrogels; Wastewater Treatment Adsorption*

References:

[1] Hajar Abara , Jaber Raissouni , Hajar Saadani , Abdelhadi ElHachmi , Mohamed Hadri , Khalid Draoui, Floatable clay-alginate beads for water treatment: Experimental and molecular modeling approaches to Pb(II) and malachite green removal, International Journal of Biological Macromolecules Volume 321, (2025), 146481

[2] I. Barrak, I. Ayouch, Z. Kassab, Y. Abdellaoui, S. Sair, M. El Achaby, A. Barhoun, K. Draoui, The synthesis of low-cost bentonite/biopolymer based composite beads: efficiency for copper ions removal from aqueous solution, International Journal of Environmental Science and Technology, 22, (2025) 16485–16502,

[3] Jaber Raissouni , Khalid Draoui , Ahmed Ait Aghzzaf , Raquel Cela-Dablanca , Ana Barreiro , María J. Fernández-Sanjurjo , Avelino Núñez-Delgado , Esperanza Álvarez-Rodríguez , Sulfadiazine removal with low-cost structured nano and micro-composite hydrogel beads on moroccan clays with alginate–CMC–biochar, Journal of Environmental Management, 374(2025) 123952,

[4] Khadija Achchatar, Sabine Valange, Abdelhak Kherbeche, Hervé Gallard, Khalid Draoui , Cadmium removal using Rhassoul/alginate composite beads: isotherms, kinetics, and thermodynamic study, Adsorption 31, 25 (2025).

Abstracts
(Oral Presentations)

Engineering Multifunctional 3D-Printed Chia Seed Mucilage Biohydrogels Incorporating Rose Bengal and Essential Oils for Advanced Wound Healing

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Abstract

Background / Introduction:

Plant seed mucilages are promising materials for hydrogel development owing to their swelling capacity and potential biocompatibility. This study aimed to develop multifunctional, three-dimensional (3D)-bioprinted hydrogels based on chia seed mucilage (CSM), incorporating essential oils (EOs) and Rose Bengal (RB) for potential wound dressing applications.

Methods:

CSM was extracted using an aqueous method and blended with polyvinylpyrrolidone (PVP) and starch (ST), with tannic acid (TA) serving as a natural cross-linker. Hydrogel scaffolds were fabricated by extrusion-based 3D bioprinting and functionalized with 0.1% RB and 2% or 4% (w/w) EOs from Mentha pulegium (MP), Myrtus communis (MC), and Rosmarinus officinalis (RO). The scaffolds were evaluated for their morphological, physicochemical, thermal, mechanical, antioxidant, and antibacterial properties, alongside cytocompatibility with HaCaT keratinocytes.

Results

Scanning electron microscopy revealed smooth scaffold surfaces, while Fourier-transform infrared spectroscopy and X-ray diffraction showed band shifts and changes in crystallinity consistent with bioactive incorporation and interactions within the matrix. All hydrogels exhibited rapid fluid uptake, reaching swelling ratios of 895-1640% within 15 minutes. RB and EO incorporation modified prolonged hydration behaviour and improved hydrophilicity, as indicated by water contact angle measurements. Mechanical performance varied across formulations, with RB + 2% MC providing the most favourable balance between tensile strength (1.821 ± 0.536 MPa) and elongation at break (79.79 ± 18.65%). Bioactive-loaded formulations exhibited enhanced DPPH radical-scavenging activity, particularly at 4% EO. Unloaded hydrogels showed limited antibacterial activity, whereas RB-EO formulations, particularly those containing 2% EO, produced inhibition zones of up to 22 ± 1.33 mm against Escherichia coli ILP 1428B and 20.83 ± 1.08 mm against Pseudomonas aeruginosa ATCC 27653. HaCaT cell viability depended on formulation composition and concentration. The unloaded matrix maintained 99-100% viability, while the formulation containing 2% MC preserved approximately 90% viability over four days.

Conclusion

3D-bioprinted CSM/PVP/ST hydrogels combine high fluid absorbency with tunable mechanical and biological properties. Incorporating RB and EOs enhances antioxidant and antibacterial activity, although cytocompatibility depends on the selected formulation. The RB + 2% MC system offers a promising balance of mechanical performance, antibacterial activity, and keratinocyte compatibility, supporting further investigation of these hydrogels as multifunctional wound dressings.

Key words: *3D Printing, Hydrogels, Seed Mucilage, Essential Oils, Nature Valorization, Personalized Medicine.*

Biopolymeric materials based on chitosan: the influence of solvent type on film properties

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Abstract

Background / Introduction:

Chitosan is a biodegradable and biocompatible polymer whose applications are limited by its poor solubility under neutral conditions. This study aimed to compare the effect of different organic acid solvents and their concentrations on the physicochemical characteristics of chitosan films.

Methods:

Chitosan (2% w/v) was dissolved in 2% or 3% solutions of acetic acid (AA), citric acid (CA), or lactic acid (LA). The resulting solutions were cast into plastic molds and dried under ambient conditions to obtain thin films. The rheological properties of the chitosan solutions were evaluated, while the chemical structure and intermolecular interactions within the films were analyzed using ATR-FTIR spectroscopy. Film surface wettability, morphology, and topography were characterized, and moisture content was determined gravimetrically. Mechanical properties were evaluated using a universal testing machine, while the water vapor permeation rate (WVPR) was determined gravimetrically.

Results

The type and concentration of organic acid significantly influenced the rheological properties of chitosan solutions and the physicochemical characteristics of the resulting films. ATR-FTIR analysis revealed differences in intermolecular interactions, while contact angle and AFM measurements showed variations in surface wettability and roughness. Moisture content, water vapor permeability, and mechanical properties also depended on solvent composition. Citric acid enhanced intermolecular interactions, lactic acid increased film flexibility, and acetic acid produced homogeneous films with balanced mechanical and barrier properties.

Conclusion

The type of organic acid significantly influences the physicochemical, surface, mechanical, and barrier properties of chitosan films. Acetic, citric, and lactic acids induce distinct intermolecular interactions, enabling the tailoring of film properties for biomedical, cosmetic, and sustainable material applications.

This research was supported by the funds of the Minister of Science and Higher Education under the program "Excellence Initiative – Research University" for the Priority Research Team at Nicolaus Copernicus University in Toruń, "EPIBIOMAT Research Group – Epibiocompatible Materials for Medicine and One Health"

Key words: *biopolymers, biomaterials, chitosan, wound dressings*

Lanthanum hydroxide engineered sewage sludge biochar for efficient phosphate elimination: Mechanism interpretation using physical modelling

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Abstract

Background / Introduction:

Excessive discharge of phosphorus (P) into aquatic ecosystems causes severe eutrophication and threatens global water security. Sewage sludge (SS) represents an abundant urban waste that requires sustainable valorization. In this study, a novel hybrid adsorbent was synthesized by engineering sewage sludge biochar with lanthanum hydroxide ($La(OH)_3$-SSBC) to achieve ultra-high efficiency phosphate capture from aqueous media.

Methods:

Excessive discharge of phosphorus (P) into aquatic ecosystems causes severe eutrophication and threatens global water security. Sewage sludge (SS) represents an abundant urban waste that requires sustainable valorization. In this study, a novel hybrid adsorbent was synthesized by engineering sewage sludge biochar with lanthanum hydroxide ($La(OH)_3$-SSBC) to achieve ultra-high efficiency phosphate capture from aqueous media.

Results

La-SSBC exhibited an exceptional maximum monolayer adsorption capacity of 312.55 mg.P/g at 20 °C, significantly outperforming traditional biochar composites. The adsorption followed pseudo-second-order kinetics and exothermic thermodynamics. The material maintained >97.9% removal efficiency across a wide pH range and in the presence of competing anions (CO_3^{2-}, HCO_3^-, SO_4^{2-}, Cl^-). Statistical physics modeling, along with the schematic representation in Figure 1, revealed a unique double-layered adsorption mechanism. The first layer forms via electrostatic attraction, ligand exchange, and La-O-P inner-sphere complexation on $La(OH)_3$ active sites. The second layer is further stabilized through the interaction of biochar-released cations (Ca^{2+}, Al^{3+}, Si^{4+}), which overcome electrostatic repulsion to form metal-sorbed inner-sphere complexes and induce surface precipitation (Figure 1). Reusability experiments confirmed >97.5% efficiency after 5 cycles.

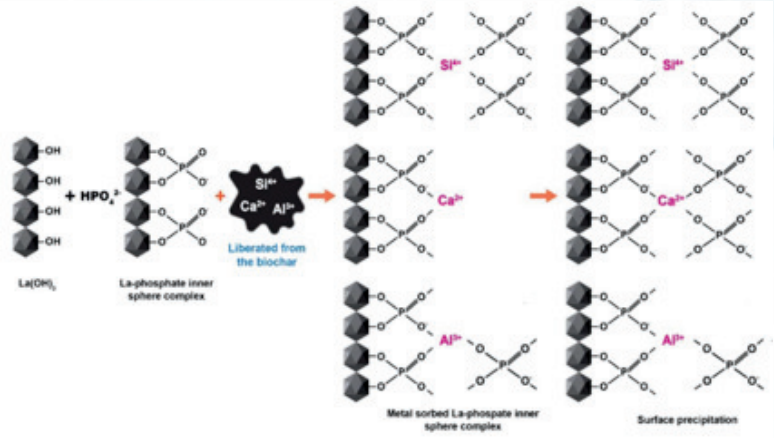


***Figure 1**: A possible mechanism for the adsorption of phosphate onto the La-SSBC composite.*

Conclusion

This work introduces an effective "trash-managed-by-trash" strategy by converting municipal sludge waste into a high-capacity biochar adsorbent. Advanced statistical physics modeling provided atomic-level insights into the double-layered phosphate stabilization, offering a robust approach for eutrophication control and phosphorus recovery.

***Key words:** Adsorption, Sewage sludge, Biochar, Lanthanum hydorxide, Phosphate, Statistical physics modeling*

Influence of Different Culture Media on Secondary Metabolite Production by an Endophytic Fungus Isolated from Globularia alypum L.

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Abstract

Background / Introduction:

Globularia alypum L. is a medicinal plant of the Globulariaceae family known for its diverse biological activities. Endophytic fungi associated with medicinal plants are recognized as a promising source of bioactive secondary metabolites. This study aimed to evaluate the effect of different culture media on the production of antibacterial metabolites by an endophytic fungus isolated from G. alypum L.

Methods:

The endophytic fungus was cultivated on four different solid media: rice (Oryza sativa) (M1), red lentils (Lens culinaris) (M2), broad beans (Vicia faba) (M3), and white beans (Phaseolus vulgaris) (M4). After incubation, fungal metabolites were extracted using ethyl acetate. The obtained extracts were screened for their antibacterial activity against selected bacterial strains.

Results

The antibacterial activity of the fungal extracts varied according to the culture medium used. Extracts obtained from rice (M1) and red lentils (M2) media showed the strongest antibacterial activity, particularly against Bacillus subtilis.

Conclusion

The study highlights the influence of culture medium composition on the production of bioactive metabolites by the endophytic fungus. Rice and red lentils media showed the greatest potential for the production of antibacterial compounds and represent promising substrates for future chemical investigations.

Key words: *gum arabic; arabinogalactan protein; amphiphilicity; nanocarriers cancer.*

Metal–Organic Frameworks for Adsorption Applications.

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Abstract

Background / Introduction:

Metal–Organic Frameworks (MOFs) are a class of crystalline porous materials composed of metal ions or clusters connected by organic linkers. Due to their exceptionally high surface area, tunable pore structures, and chemical versatility, MOFs have attracted considerable attention as advanced adsorbents for environmental and industrial applications. Their ability to selectively capture and remove pollutants makes them promising materials for water purification, gas storage, and separation processes.

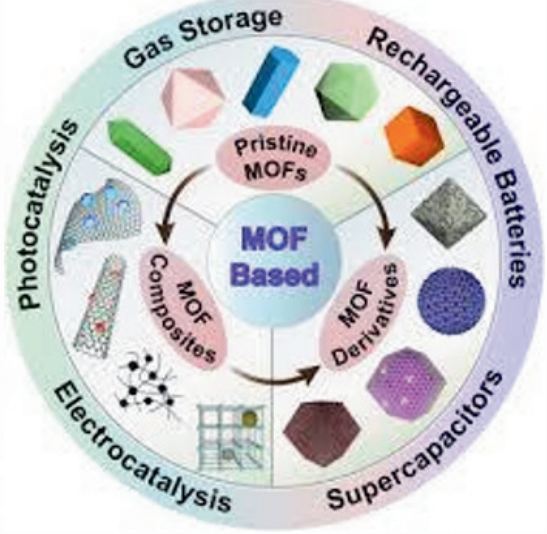


***Figure 1**: A possible mechanism for the adsorption of phosphate onto the La-SSBC composite.*

Methods:

MOFs were synthesized by a solvothermal route using metal salts (such as zinc, copper, iron, cobalt.) and terephthalic acid (BDC) as precursors. The reactants were dissolved in a water–ethanol mixture and heated under controlled conditions. The resulting crystalline product was filtered, washed, and dried. The adsorption properties of the synthesized MOFs were investigated using aqueous dye solutions, and the adsorption efficiency was determined by monitoring the concentration changes before and after treatment.

Results

Numerous MOFs have demonstrated remarkable adsorption capacities owing to their high porosity and functionalizable surfaces. Studies reported efficient removal of contaminants such as methylene blue, rhodamine B, lead ions, and carbon dioxide. The adsorption efficiency was influenced by pore size, surface functionality, and operating conditions. Furthermore, several MOFs exhibited excellent recyclability and stability over multiple adsorption–desorption cycles.

Conclusion

MOFs represent a promising family of adsorbent materials for environmental remediation and separation technologies. Their structural tunability and outstanding adsorption properties provide significant advantages over conventional adsorbents. Future research should focus on improving stability, reducing production costs, and developing scalable synthesis methods for practical applications.

***Key words:** Metal–Organic Frameworks (MOFs), Adsorption, Environmental Remediation, Water Treatment, Porous Materials.*

Hesperidin-Extract from Citrus reticulata Agro-Industrial By-Products: Antimicrobial and Anti-Biofilm Activities and Food Packaging Film Properties

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Abstract

Background / Introduction:

Food spoilage and contamination pose major public health and economic challenges, increasing the demand for sustainable alternatives to synthetic preservatives and conventional plastic packaging Chitosan, a natural polysaccharide widely used in food packaging, has attracted considerable attention due to its promising properties. In parallel, agro-industrial by-products from the stems and leaves of tangerine (Citrus reticulata), are rich in bioactive flavonoids such as hesperidin (HE) and represent an underutilized renewable resource. This study investigated the antimicrobial and anti-biofilm activities of HE extract from tangerine residues and evaluated its incorporation into chitosan-based films as a potential sustainable active food-packaging material.

Methods:

stems and leaves through subcritical water extraction followed by XAD-7 resin purification. Antibacterial activity was evaluated against Pseudomonas aeruginosa, Escherichia coli, Staphylococcus aureus, and Enterococcus hirae using disc diffusion and broth microdilution (MIC/MBC). Anti-biofilm activity on commercial plastic food wrap was assessed using a multi-species bacterial suspension, scanning electron microscopy (SEM), and image analysis. Chitosan–HE films were characterized for thickness, opacity moisture content, swelling, water solubility, and water vapor transmission rate (WVTR).

Results

HE extract exhibited bacteriostatic activity against all tested strains, without bactericidal effects. Gram-positive bacteria were more sensitive, with S. aureus showing the largest inhibition zone (14.7 ± 0.58 mm; MIC: 6.25 mg·mL^{-1}) and E. hirae the lowest MIC (1.56 mg·mL^{-1}). Gram-negative bacteria were comparatively more resistant. The extract strongly inhibited multi-species biofilm formation on plastic packaging, reducing surface colonization to below 5%. Furthermore, the incorporation of HE into chitosan films improved their physicochemical characteristics, enhancing their suitability for active food-packaging application.

Conclusion

HE extract from tangerine residues demonstrated promising bacteriostatic and anti-adhesion activities, supporting its potential as a natural ingredient for active food packaging. Combined with the improved physicochemical properties of chitosan–HE films, these findings highlight the potential of citrus by-product valorization for developing sustainable food-packaging materials.

Key words: *Hesperidin, antimicrobial activity, anti-biofilm, active food films, physicochemical properties.*

Development of Bioactive Film-Based Materials Incorporating Functional Molecules for Sustainable Agricultural Applications

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Abstract

Background / Introduction:

Polymer films are attractive materials for agriculture owing to their high water-retention capacity, biocompatibility and ability to release bioactive compounds in a controlled manner. Incorporating functional molecules into polymeric matrices is a promising route to improve material performance in sustainable production systems, but preserving the activity of these molecules through processing and storage remains a key challenge. This study aimed to develop a bioactive film incorporating different functional components and to evaluate their stability after processing.

Methods:

Films were prepared from a poly(vinyl alcohol) (PVA)–lignin matrix combined with three bioactive components. The formulations were subjected to a preservation process using different protective agents. Physicochemical and morphological characterization was carried out, and the retention of biological functionality was assessed with standard functional and stability assays, comparing formulations with untreated controls.

Results

The functional molecules were successfully incorporated into the PVA–lignin matrix, which remained structurally intact and proved well suited to encapsulating and protecting bioactive compounds. The type of protective agent significantly influenced preservation efficiency and post-processing stability, and several formulations retained biological functionality and stability better than untreated controls.

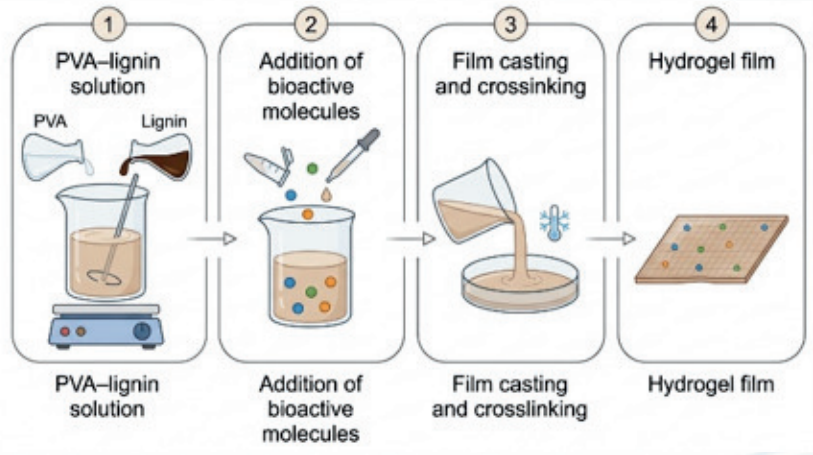


***Figure 1**: Schematic of the protocol for film preparation and incorporation of the bioactive molecules.*

Conclusion

The PVA–lignin film system is a promising carrier for functional bioactive molecules, maintaining their stability after processing. These findings underline the importance of formulation design and protective strategies, and provide a basis for advanced film materials for sustainable agriculture and controlled delivery systems.

***Key words:** Polymer film, PVA, lignin, encapsulation, bioactive molecules, sustainable agriculture*

Amphiphilicity of gum arabic arabinogalactan-proteins in anticancer nanocarriers: a critical analysis of the structure-function evidence

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Abstract

Background / Introduction:

Gum arabic (GA), the exudate of Acacia senegal and Acacia seyal, is used in anticancer nanocarriers mainly for its emulsifying and stabilizing properties. These properties are attributed to its protein-rich arabinogalactan-protein (AGP) fraction. Whether this link is actually demonstrated in cancer studies was examined.

Methods:

Eight primary studies were analyzed: three structural studies of A. senegal gum fractionated by hydrophobic interaction chromatography, and five experimental studies in which GA was used in cancer-related delivery systems. For each application study, the botanical origin of the gum, its characterization, the origin of its amphiphilic behaviour, and any link between gum composition and biological outcome were recorded.

Results

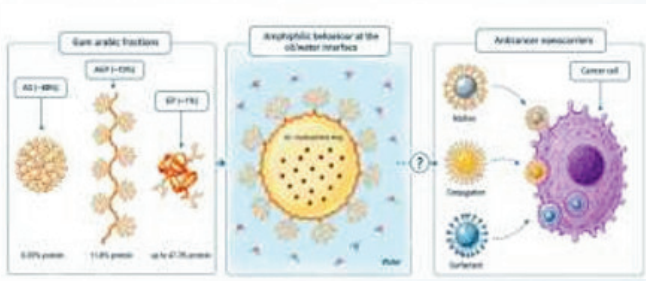
Three fractions have been identified in the gum: an arabinogalactan (~88% of the gum, 0.35 wt% protein), an AGP (~10%, 11.8 wt% protein) and glycoproteins (~1%, up to 47.3 wt% protein). The AGP has been modelled as a block copolymer able to sterically stabilize interfaces. However, in monolayer measurements, a surface pressure higher than that of the whole gum was reported only for the glycoprotein fraction. In the application studies, amphiphilic behaviour was provided by three different sources: native gum properties, covalent conjugation with curcumin, or an added synthetic surfactant (Tween-20). Gum composition (total protein content, A. senegal vs A. seyal) was related to nanoparticle stability and cytotoxicity toward MCF-7 cells in only one study. In none of the studies was the gum fractionated or the AGP contribution isolated.

Conclusion

In the studies analyzed, the contribution of AGP to anticancer activity was not isolated experimentally, and its role therefore remains a hypothesis. The botanical origin and protein content of the gum should be reported, and fractionated gums should be tested directly in future studies.

Key words: *gum arabic; arabinogalactan protein; amphiphilicity; nanocarriers cancer.*

Graphical abstract:



Extraction and characterization of matrix-bound vesicles of Wharton´s jelly

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Abstract

Background / Introduction:

Extracellular vesicles are key mediators of intercellular communication and are commonly isolated from body fluids or conditioned media. However, matrix-bound vesicles (MBV) are a distinct class of extracellular vesicles embedded within the extracellular matrix, where they display specific biochemical and functional properties. Wharton's Jelly (WJ) is an extracellular matrix-rich tissue and a promising source of collagen for the development of hydrogels and bioinks. Thus, it is relevant to determine whether MBV are retained during collagen extraction and hydrogel formation. The aim of this study was to isolate and characterize MBV from decellularized WJ (DWJ) and WJ-derived hydrogels, and to perform a preliminary evaluation of their biological effect.

Methods:

MBV were isolated from DWJ and derived collagen hydrogels by enzymatic digestion with collagenase and papain, followed by filtration and ultracentrifugation. Particle size and concentration were assessed by nanoparticle tracking analysis (NTA). Vesicle morphology was evaluated by transmission electron and atomic force microscopies, and protein content was quantified by NanoDrop and BCA assay. Specific markers were assessed by WB. Cytotoxicity of MBV was evaluated in human dermal fibroblasts using the WST-1 assay after 24 h and 48 h of exposure to increasing MBV/cell ratios.

Results

NTA showed vesicle-like particle populations in both DWJ and hydrogel-derived samples. MBV extracted from WJ displayed a size range of 100–300 nm and a concentration of 1.70×10^{10} MBV/mL, whereas hydrogel-derived MBV showed a narrower distribution of 100–200 nm, and a concentration of 2.63×10^{10} MBV/mL. Protein quantification showed comparable protein content between samples, with 2.5 µg/µL for WJ-derived MBV and 3.1 µg/µL for hydrogel-derived MBV. Western blot analysis revealed the presence of Annexin A6, supporting the presence of vesicles potentially attached to collagen in the ECM. Microscopy confirmed the presence of a rounded shape vesicles with heterogeneous electron-dense profiles and variable internal structures. WST-1 analysis showed no detectable cytotoxicity. Cell metabolic activity remained close to the non-treated condition across all tested ratios.

Conclusion:

This study demonstrates that MBV can be successfully isolated from both DWJ and WJ-derived collagen hydrogels suggesting their retention after collagen extraction and hydrogel formation. The differences in particle size distribution and yield suggest the presence of a vesicle subpopulation associated with the collagen matrix. In addition, the absence of detectable cytotoxicity suggests that these vesicles are well tolerated by cells under the tested conditions, supporting their potential use in biomaterial-based applications. These results provide a first basis for further studies to better understand their biological role in WJ-derived biomaterials.

Key words: *Matrix-bound vesicles, Wharton´s Jelly, Hydrogels*

Engineering Injectable Polyelectrolyte Complex Hydrogels: Linking Gelation Rheology and Swelling Performance for Drug Delivery

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Abstract

Background / Introduction:

Injectable hydrogels are promising platforms for localized and minimally invasive drug delivery because they can be administered as liquids or low-viscosity precursors and subsequently develop a three-dimensional network at the site of administration. Polyelectrolyte complex hydrogels, formed through electrostatic interactions between oppositely charged polymers, offer particular interest because their network architecture can influence mechanical behaviour, water uptake, and ultimately drug-release performance. Rheological characterization and swelling assessment are therefore essential for evaluating their suitability as injectable delivery systems.

Methods:

Polyelectrolyte complex hydrogels were prepared and evaluated through rheological and gravimetric swelling analyses. Oscillatory rheology was used to monitor the viscoelastic response of the hydrogel systems. The gel point was identified at the crossover between the storage modulus (G′) and the loss modulus (G″), corresponding to the transition from viscous-dominant to elastic-dominant behaviour. Swelling capacity was assessed from the dry weight (Wd) and swollen weight (Ws) using the swelling ratio: SR = (Ws − Wd) / Wd. These complementary measurements were used to examine the relationship between network formation, viscoelastic properties, and water uptake.

Results

The investigated systems showed the characteristic evolution expected during hydrogel network formation, with the rheological transition evaluated through the relationship between G′ and G″. The identification of the gel point provides a relevant indicator of the sol–gel transition and of the development of an elastic network, which is particularly important for injectable applications. Swelling analysis demonstrated the capacity of the hydrogels to absorb water, reflecting the accessibility of hydrophilic groups and the balance between polymer–water interactions and network cohesion. Together, rheological and swelling measurements provide a practical basis for comparing formulations and selecting hydrogel systems with properties compatible with injectable drug-delivery applications.

Conclusion:

Rheological monitoring and swelling analysis constitute complementary tools for the characterization of polyelectrolyte complex hydrogels intended for injectable drug delivery. The G′/G″ crossover enables the identification of the gelation transition, while the swelling ratio provides insight into the hydration behaviour of the polymeric network. Further work should quantify the effect of polymer composition, charge ratio, concentration, ionic strength, and environmental conditions on injectability, gelation kinetics, mechanical stability, drug encapsulation, and release behaviour. Such optimization is required to establish robust structure–property relationships and support the development of polyelectrolyte complex hydrogels as controlled drug-delivery platforms.

Key words: *polyelectrolyte complex hydrogels, injectable hydrogels, rheology, gelation, swelling ratio, controlled drug delivery*

Engineering wastewater derived extracellular polymeric substances into reusable hybrid biohydrogel adsorbents for cyclic packed bed metal adsorption

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Abstract

Background / Introduction:

Extracellular polymeric substances (EPS) are microbial biopolymers forming the hydrated matrix in biofilms and abundant in sewage sludge, making them renewable feedstocks for bio-based materials. After extraction, EPS are recovered as soluble biopolymers, but their anionic character enables hydrogel formation via ionic crosslinking with divalent cations. Their composition, including uronic acid polysaccharides, amino sugars, glycoproteins and phenolic compounds, provides functional groups for metal biosorption. However, ionically crosslinked EPS hydrogels lack the mechanical and operational stability required for packed bed adsorption. This work explores covalent immobilization to transform EPS into reusable adsorbents for metal capture.

Methods:

EPS were extracted from sewage sludge via alkaline treatment and recovered as a biopolymeric fraction. They were covalently immobilized using polyethylenimine (PEI) and glutaraldehyde, generating an amine rich crosslinked network suitable for packed bed operation. Batch assays evaluated Cu(II), Pb(II) and Nd(III) adsorption, acid desorption with HCl 0.1 M, alkaline regeneration with NaOH 0.1 M and reuse. Cu(II) adsorption was further assessed in fixed bed columns over five adsorption/desorption cycles.

Results

Covalent crosslinking converted soluble EPS into a separable solid adsorbent, enabling recovery after contact with metal solutions and cyclic operation. After acid desorption and alkaline regeneration, the material retained 90.8%, 98.3% and 79.5% of its initial adsorption capacity for Cu(II), Pb(II) and Nd(III), respectively.

In fixed bed operation, the adsorbent remained functional over five Cu(II) adsorption/desorption cycles, retaining 57.0% of its initial capacity in the fifth cycle despite repeated regeneration.

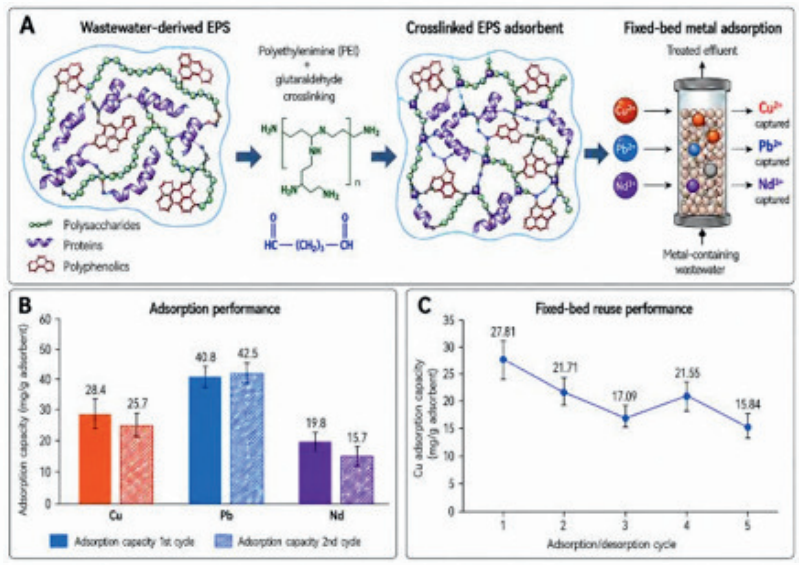


Figure 1: *Covalently immobilized EPS as reusable adsorbents for Cu(II), Pb(II) and Nd(III) capture.*

Conclusion:

PEI/glutaraldehyde crosslinking transformed soluble EPS into a separable and reusable biohydrogel based adsorbent. The crosslinked network enabled packed bed cyclic adsorption/desorption/regeneration operation. These results highlight sewage sludge derived EPS as sustainable precursors for development of metal biosorbents.

Key words: *extracellular polymeric substances, biohydrogels, covalent immobilization, packed bed adsorption, metal recovery.*

Argan Oil and Argan-Derived Lignin in Freeze-Dried Hydrogel Scaffolds for Wound Dressing Applications

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Abstract

Background / Introduction:

The valorization of Moroccan natural resources represents a promising strategy for developing sustainable biomaterials for biomedical applications. Argan oil (Argania spinosa), traditionally used in skin care, is rich in tocopherols, unsaturated fatty acids, and other bioactive compounds that may contribute to skin protection and antioxidant activity. Its incorporation into advanced wound dressings offers an opportunity to explore its potential beyond conventional cosmetic applications. In parallel, lignin extracted from argan shells, an agro-industrial by-product, represents a renewable phenolic polymer with antioxidant potential. Combining these argan-derived resources with poly(vinyl alcohol) (PVA) may enable the development of porous, bioactive materials for wound management.

Methods:

Poly(vinyl alcohol) (PVA)-based hydrogel formulations incorporating argan shell-derived lignin and argan oil were prepared, with and without borax crosslinking, and subsequently freeze-dried to obtain porous, sponge-like scaffolds. The developed materials are being characterized using Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), swelling tests, mechanical testing, antioxidant activity assays, antimicrobial tests, biodegradation studies, and hemocompatibility evaluation.

Results

Freeze-dried hydrogel sponge-like scaffolds were successfully developed, exhibiting different structural and functional properties depending on their composition and crosslinking conditions.

The incorporation of argan oil was associated with increased scaffold porosity, while the addition of lignin contributed to the functional properties of the materials. Comparison of crosslinked and non-crosslinked formulations highlighted the influence of borax crosslinking on scaffold structure and stability. Overall, the results demonstrate the importance of formulation composition and crosslinking in tailoring the properties of these materials for potential wound dressing applications.

Conclusion:

The developed PVA/lignin/argan oil scaffolds offer promising perspectives for the development of natural, bioactive wound dressings intended for closed-wound applications. The natural coloration provided by lignin opens up possibilities for personalizing dressing color through adjustment of lignin concentration to explore different skin-tone shades. In view of the hemocompatibility results, the current formulations require further safety optimization and are not intended for direct blood contacting applications. In parallel, ongoing exploration of 3D bioprinting, supported by the successful optimization of a printable formulation, offers new opportunities to customize dressing geometry and design according to individual needs.

Key words: *Argan oil, argan shell-derived lignin, PVA, porous hydrogel scaffolds, wound dressing*

Tannic acid functionalized Wharton's jelly extracellular matrix hydrogel as bioactive and multifunctional platform for tissue engineering

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Abstract

Background / Introduction:

Tannic acid (TA) has attracted growing interest in biomedical research due to its antioxidant, anticancer, and antibacterial properties. However, its limited bioavailability and short half-life following dietary intake highlight the need for alternative delivery strategies, such as local hydrogel-based systems. Recently, a sustainable hydrogel derived from Wharton's jelly (WJ) extracellular matrix was developed. Compared with rat tail (RT) collagen hydrogels, WJ hydrogels exhibit thinner fibrils, lower permeability, slower deswelling kinetics, and reduced syneresis, suggesting improved interactions with bioactive molecules and enhanced delivery potential. Therefore, this study aimed to investigate TA loading within WJ- and RT-derived hydrogels and to compare their physicochemical and mechanical properties, TA release profiles, and associated antibacterial and antitumoral activities.

Methods:

WJ- and RT-based hydrogels were obtained by inducing fibrillogenesis at neutral pH and 37°C. TA loading was monitored using transparent disk-shaped hydrogels through the evolution of concentric turbidity patterns. Physicochemical and biological functionalities were subsequently assessed.

Results

TA diffusivity was significantly higher in WJ hydrogels than in RT hydrogels (2-times, $p < 0.03$, t-test). Since collagen hydrogels are formed through thermally induced fibrillar self-assembly, resulting in broad pore size distributions, the diffusion of TA molecules (hydrodynamic radius: 2–4 nm) suggests that both hydrogels possess nanoscale porosity larger than 4 nm. The higher apparent diffusivity in WJ hydrogels may therefore be related to their deswelling behavior.

After 24 h, TA loading was similar in WJ and RT hydrogels, although TA distribution appeared more homogeneous in WJ hydrogels, whereas RT hydrogels exhibited peripheral accumulation. Both TA-loaded hydrogels displayed high water-holding capacity (~96%), suitable for tissue regeneration. Mechanical and permeability analyses revealed comparable stiffness and fluid permeability, suggesting similar overall porosity. However, WJ hydrogels exhibited a significantly higher gel fraction (≥1.5-fold, $p < 0.001$) and higher melting temperature (~70 °C vs. 65 °C), indicating distinct collagen–TA interactions. TA release was lower from WJ hydrogels than from RT hydrogels after 24 h ($p < 0.03$). This difference may result from surface erosion and/or swelling of RT hydrogels, promoting TA release from peripheral regions. In biological conditions, TA release may be further enhanced by collagen network remodeling, as ~60% hydrogel degradation was observed in the presence of collagenase.

Conclusion:

In conclusion, WJ-derived hydrogels constitute a promising and sustainable platform for TA delivery. Despite similar loading capacities and overall porosity compared with RT hydrogels, WJ hydrogels exhibited enhanced TA diffusivity, more homogeneous TA distribution, and lower TA release, suggesting distinct collagen–TA interactions and improved retention properties. Combined with their high water-holding capacity and suitable mechanical behavior, these findings highlight the potential of WJ hydrogels for local delivery applications in tissue regeneration and antibacterial or antitumoral therapies.

Key words: *Extracellular matrix, Wharton jelly, hydrogels, tannic acid.*

Development of smart food packaging: a case study on chitosan–clay nanocomposites from Moroccan resources with enhanced thermal and biodegradation properties

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Abstract

Background / Introduction:

The growing demand for sustainable food packaging has encouraged the development of biodegradable materials with enhanced functional properties. Conventional plastic packaging raises significant environmental concerns, highlighting the need for eco-friendly alternatives with effective antimicrobial activity. This study aims to develop antibacterial nanocomposite films based on chitosan and bentonite clay, using locally available and underexploited Moroccan resources, for potential applications in active food packaging.

Methods:

Nanocomposite films were prepared using the solvent-casting technique by incorporating bentonite clay into a chitosan matrix plasticized with glycerol at a concentration of 30% by mass. The resulting materials were characterized using thermogravimetric analysis (TGA) to evaluate their thermal stability and X-ray diffraction (XRD) to investigate their crystalline structure. Biodegradation tests were performed in different media, while antibacterial activity was assessed against Gram-positive and Gram-negative bacteria by measuring inhibition zones.

Results

The nanocomposite films exhibited improved thermal stability compared with pure chitosan, with an increase of 20 °C in the decomposition temperature. XRD analysis revealed enhanced crystallinity, attributed to the combined effects of glycerol and bentonite clay incorporation. Biodegradation tests demonstrated up to 98.3% degradation under controlled conditions within one week. Furthermore, the films showed significant antibacterial activity against both Gram-positive and Gram-negative bacteria, indicating broad-spectrum antimicrobial potential.

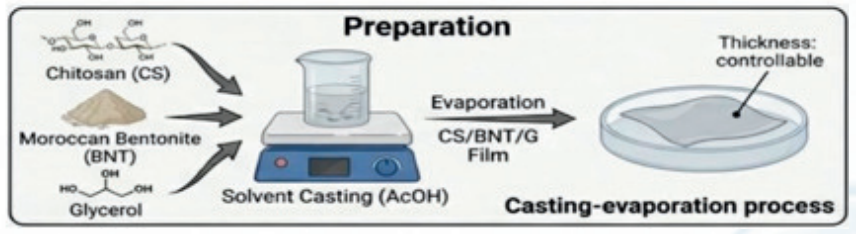


Figure 1: *Figure 1: Schematic representation of the preparation and characterization of chitosan/bentonite nanocomposite films.*

Conclusion:

The developed chitosan/bentonite nanocomposite films exhibited enhanced thermal stability, high biodegradability under the tested conditions, and promising antibacterial properties. These characteristics support their potential application in active and sustainable food packaging. Moreover, the use of underexploited Moroccan resources offers an opportunity to develop cost-effective, environmentally friendly packaging materials while promoting local resource valorisation. Further studies are needed to assess their mechanical properties, food-contact safety, and effectiveness under real food storage conditions.

Key words: *Extracellular matrix, Wharton jelly, hydrogels, tannic acid.*

Thermoanalytical Studies of Inclusion Complexes and Physical Mixtures of Clotrimazole with β-Cyclodextrin and Modified Polyurethane Networks

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Abstract

Background / Introduction:

Cyclodextrins belong to a family of natural cyclic oligosaccharides that resemble a truncated cone with hydrophilic outer surfaces and hydrophobic cavities. They can form reversible host-guest inclusion complexes with numerous molecules, and their structure is increasingly being used to modify various polymers. β-Cyclodextrins (βCD) are suitable as crosslinkers for long-chain polyurethanes (PUR) and result in biodegradable networks with improved mechanical and thermal properties. This study aims to design inclusion complexes between the very poorly soluble antifungal drug clotrimazole and modified βCD-polyurethane networks, as suitable carriers for prolonged drug release, and to investigate the drug interactions with these carriers using thermoanalytical methods.

Methods:

Solid products were prepared by physical mixing and kneading methods in a weight ratio of 1:6 for clotrimazole: βCD–modified PUR networks. Two series of modified PUR networks were obtained using βCD as a cross-linker, an alicyclic isophorone diisocyanate and two polyethylene glycols (PEG2000 and PEG6000), with NCO/OH molar ratios of 4.3 and 6.3, forming urethane links, and confirmed by Fourier transform infrared spectroscopy (FTIR) analysis. These interactions with clotrimazole were studied by differential thermal analysis (DTA), thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), Wide–angle X–ray Diffraction (XRD) and FTIR.

Results

The FTIR results demonstrated the formation of inclusion complexes. The XRD patterns showed specific peaks corresponding to pure clotrimazole only in physical mixtures. In DSC thermograms of the obtained inclusion complexes, the characteristic endothermic peak of the clotrimazole at around 145.90 °C did not appear. This suggests the conversion of the drug from crystalline form to molecularly dispersed or amorphous form inside the crosslinked polyurethane networks modified with βCD. A slight increase in the thermal stability of the prepared complexes was established by TGA analysis, which correlated with their soft-segment molecular weights and NCO/OH molar ratio. The initial degradation depends on the structure of the hard segments, and the urethane bond is first degraded at 220–250°C. The second degradation step is associated with the degradation of the soft segment that started above 300°C. The soft segment length has the greatest influence on the slight increase in thermal stability of both the inclusion complexes and the physical mixture between the crosslinked polyurethane networks and clotrimazole.

Conclusion:

Inclusion complexes of clotrimazole and βCD-modified polyurethane networks based on PEG2000 and PEG6000 polyols were successfully prepared by incorporating the hydrophobic drug clotrimazole through physical bonds. The use of polyols with higher molecular weight and a molar ratio of NCO/OH isocyanates resulted in βCD-based PURs with increased network density and improved thermal stability.

Key words: *β-cyclodextrin, polyurethane, inclusion complex, clotrimazole, thermal properties, XRD.*

Aknowledgement: *The authors acknowledge the financial support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Program No. 451-03-34/2026-03/200133).*

The Role of Gelatin Hydrogels in Shaping Mesenchymal Stem Cell Behavior: A Transcriptomics Perspective

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Abstract

Background / Introduction:

Mesenchymal stem cells (MSCs) play a central role in regenerative medicine due to their self-renewal, multipotency, and sensitivity to environmental cues. Hydrogels offer a promising MSC delivery platform, and collagen, as the main structural protein of the native extracellular matrix, is widely regarded as a reference scaffold material owing to its intrinsic biocompatibility.

As part of an ongoing effort toward collagen-based hydrogel development, gelatin was selected as a preliminary material for this investigation.

This study aimed to investigate how gelatin-based hydrogels of increasing complexity influence MSC behavior using bioinformatics analysis of public datasets.

Methods:

We explored from the Gene Expression Omnibus (GEO) database three public datasets representing gelatin-based hydrogels of increasing complexity: a pure gelatin hydrogel comparing porous versus nonporous architecture, a gelatin methacrylate hydrogel combined with osteoconductive and piezoelectric components under ultrasound stimulation, and a gelatin-alginate hydrogel functionalized with a conductive microfiber network and a gasotransmitter-releasing system. Differential gene expression and pathway enrichment analyses reported in each study were extracted and compared to identify how hydrogel architecture and composition shape MSC transcriptional responses.

Results

Across the three datasets, gelatin hydrogel architecture and composition consistently shaped MSC gene expression.

In the pure gelatin system, porous hydrogels upregulated genes related to integrin binding, actin cytoskeleton organization, and cell-cell connections, while nonporous hydrogels showed elevated matrix degradation-related gene expression, reflecting constrained cell morphology.

In the gelatin-alginate composite, conductive and gasotransmitter-releasing components further modulated genes related to autophagy, calcium signaling, and adhesion.

In the GelMA-based composite, ultrasound stimulation altered microRNA profiles regulating cytoskeletal and calcium-related pathways.

Increasing hydrogel complexity was associated with broader activation of adhesion- and cytoskeleton-related transcriptional programs.

Conclusion:

The architecture and composition of gelatin-based hydrogels critically shape MSC transcriptional behavior, with interconnected porosity and functional cues facilitating cell spreading, adhesion, and intercellular connectivity.

These results support gelatin as a reliable foundational biomaterial for guiding future collagen-based hydrogel design for stem cell delivery platforms.

Key words: *Mesenchymal stem cells, Gelatin hydrogel, Transcriptomics, Cell behavior, Regenerative medicine*

Development of Electrospun Polylactic Acid/Poly(ethylene glycol)/Silver Nanoparticles Nanocomposite Films with Antimicrobial Properties

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Abstract

Background / Introduction:

Electrospinning has emerged as a powerful technique for the fabrication of nanocomposite films with tunable properties for biomedical and sustainable applications. This study aimed to develop polylactic acid (PLA)/polyethylene glycol (PEG)/silver nanoparticles (AgNP) nanocomposite films and evaluate their physicochemical and antimicrobial properties.

Methods:

PLA/PEG/AgNP nanocomposite films were fabricated by electrospinning using different AgNP loadings. The obtained materials were characterized by scanning electron microscopy (SEM) to evaluate morphology and nanofiber diameter, Fourier-transform infrared spectroscopy (FTIR) to investigate chemical interactions, X-ray diffraction (XRD) to determine crystalline structure, and thermogravimetric analysis (TGA) to assess thermal stability. Films were evaluated for their Antimicrobial activity.

Results

SEM analysis confirmed the formation of nanofibrous structures, while FTIR, XRD, and TGA demonstrated the successful incorporation of AgNPs and their influence on the structural and thermal properties of the films. Antimicrobial assays revealed strong inhibitory activity against Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa, and Staphylococcus aureus, with particularly high efficacy against P. aeruginosa and S. aureus.

Conclusion:

The developed PLA/PEG/AgNP nanocomposite films exhibited favorable physicochemical characteristics and broad-spectrum antimicrobial activity. These findings highlight their potential as sustainable antimicrobial materials.

Key words: *Electrospinning, Polylactic acid, Polyethylene glycol, Silver nanoparticles, Nanocomposite films, Antimicrobial activity.*

Bioactive 3D-Printed Xanthan Gum–PVP–Chia Mucilage Hydrogels Enriched with Phenolic Acids for Advanced Wound Healing Applications

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Abstract

Background / Introduction:

Advanced wound care increasingly relies on multifunctional biomaterials that combine moisture retention, antimicrobial protection, antioxidant activity, and controlled release of bioactive compounds to promote an optimal healing environment. In this study, novel 3D-printable hydrogels based on xanthan gum (XG), polyvinylpyrrolidone (PVP), and chia mucilage (CHM) were developed and enriched with gallic acid and tannic acid as natural phenolic bioactive compounds.

Methods:

The hydrogels were successfully fabricated using extrusion-based 3D printing, exhibiting good printability, shape fidelity, and structural stability. The formulations were characterized using FTIR, XRD, SEM, swelling tests, in vitro degradation, sol–gel analysis, water contact angle measurements, and in vitro drug release assays. Antioxidant activity was assessed using the DPPH radical scavenging assay, while antibacterial performance was evaluated through the disk diffusion method and bacterial growth kinetics.

Results

Preliminary results confirmed the successful printing of xanthan gum–PVP–chia mucilage hydrogels, including formulations loaded with gallic and tannic acids. FTIR analysis suggested intermolecular interactions between the polymeric network and phenolic compounds, while XRD indicated a predominantly amorphous structure. SEM observations revealed a porous morphology suitable for fluid uptake and controlled release. Water contact angle measurements confirmed the hydrophilic character of all hydrogel formulations.

The developed hydrogels exhibited remarkable swelling capacity, absorbing more than 400 times their initial weight, while maintaining good structural stability. In vitro degradation studies showed limited mass loss, with less than 25% degradation after 72 h, suggesting suitable stability for wound dressing applications. Antibacterial assays demonstrated enhanced activity in phenolic-loaded hydrogels, with inhibition zones ranging from 11 to 20 mm. The combined incorporation of gallic acid and tannic acid suggested a potential synergistic antibacterial effect. Antioxidant evaluation revealed strong radical scavenging activity in phenolic-loaded formulations, reaching approximately 95.8–97.0%, compared with markedly lower activity in unloaded hydrogels.

Conclusion:

These preliminary findings demonstrate that gallic acid- and tannic acid-enriched 3D-printed xanthan gum–PVP–chia mucilage hydrogels represent promising multifunctional wound dressing platforms, combining printability, hydrophilicity, swelling capacity, antioxidant potential, and antibacterial activity for advanced wound healing applications.

Key words: *3D bioprinting, Xanthan gum, Chia mucilage, Gallic acid, Tannic acid, Wound healing.*

An alginate-derived hydrogel enriched with biochar improves vine resilience to water stress

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Abstract

Background / Introduction:

The Mediterranean climate is characterized by water scarcity and affects negatively the agricultural productions. The purpose of this study was to determine the impact of an enriched biohydrogel (BH) with biochar on grapevine growth, physiological performance, and soil properties under different water stress regimes while monitoring the hydrogel structure in the soil.

Methods:

The physical structure of the hydrogel was characterized using scanning electron microscopy (SEM) while the chemical composition using Fourier-transform infrared spectroscopy (FTIR). The grapevine agronomic and physiological parameters were investigated after application of different water regimes: Control (75% Field Capacity (FC)), Moderate stress (60% FC), sever (50% FC) and very sever (35% FC) water stress. Soil physicochemical parameters were assessed at 240 days post-hydrogel treatment. Growth parameters included root and shoot biomass and length, leaf number, and leaf area while physiological parameters included chlorophyll fluorescence, water content and water potential.

Results

Biohydrogel application in the soil significantly enhanced grapevine growth under water stress conditions. This was accompanied by a progressive degradation of the hydrogel, as revealed by SEM images and confirmed by FTIR spectra after 240 days in the soil. The grapevine biomass increased by 74%, 137%, and 286% under respectively moderate, severe, and very severe stress. Root length increased by 101% at 50% FC and 153% at 35% FC, while shoot length rose by 30%, 119%, and 521% under respectively moderate, severe and very severe stress. Leaf number and leaf area were significantly improved, reaching respectively 738% and 916% at 180 days post-treatment under very severe stress. The physiological parameters were improved by 272.9% for the chlorophyll fluorescence and 91.0% for water content. The water potential recorded a significant increase compared to control. All these changes went along with an improvement in soil properties including cations exchange capacity, total carbon and total nitrogen which increased by respectively 84%, 177% and 243%.

Conclusion:

This study demonstrates that biohydrogel enriched with biochar effectively mitigates the effects of water stress on grapevine plants by enhancing water availability, improving soil fertility, and strengthening plant responses to drought. Hence providing a sustainable strategy to promote grapevine growth under water-limited conditions in Mediterranean regions.

Key words: *Grapevine, Biochar-doped Biohydrogel, Soil properties, Drought mitigation, Sustainable agriculture.*

Development of Multifunctional Bioactive Electrospun PVDF-Based Membranes Reinforced with Argan-Derived Cellulose and ZnAl-LDHs for Water Treatment Applications

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Abstract

Background / Introduction:

Dye-contaminated wastewater and membrane biofouling challenge sustainable water treatment. This study developed a multifunctional hybrid membrane incorporating argan shell-derived cellulose, calcined ZnAl layered double hydroxides (ZnAl-LDH), and activated carbon.

Methods:

A porous polyvinylidene fluoride (PVDF)/cellulose/ZnAl-LDH membrane was fabricated by electrospinning, followed by vacuum filtration deposition of a MgZnAl-activated carbon (MgZnAl-AC) layer. The membranes were characterized using XRD, FTIR, FE-SEM, and TGA. Wettability, swelling, degradation, permeability, antibacterial, antibiofilm, and antioxidant properties were evaluated. Filtration performance was assessed using methylene blue (MB) and methyl orange (MO), individually and in binary mixtures, alongside reusability tests.

Results

Characterization confirmed successful multilayer fabrication and preservation of the nanofibrous structure. Cellulose and inorganic fillers improved hydrophilicity and permeability. The membrane showed no detectable degradation after five months of immersion. It exhibited nearly complete growth inhibition against Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, and Bacillus subtilis, with biofilm inhibition exceeding 60% for all strains. Significant DPPH radical-scavenging activity was also observed.

Dye rejection approached 100% for MB and MO in both single and binary systems, with high performance maintained over successive filtration cycles.

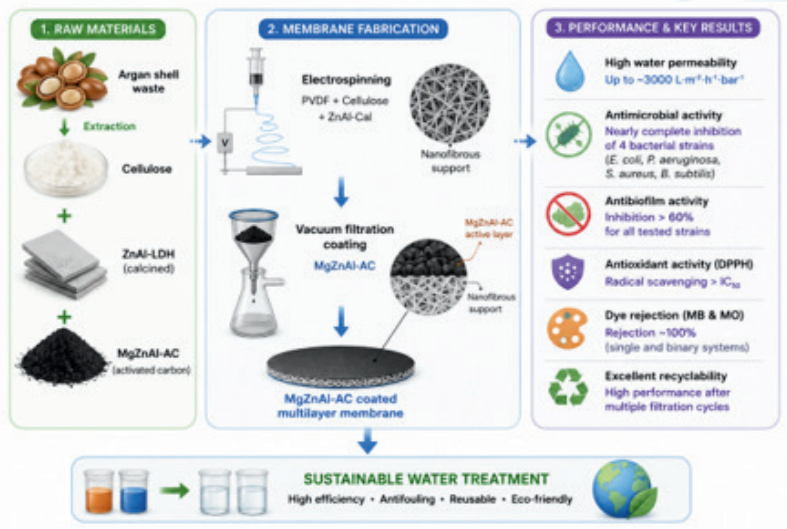


Figure 1: *Design, Fabrication, and Functional Performance of a Multifunctional Hybrid Membrane for Dye Removal and Biofouling Control*

Conclusion:

This bio-inorganic hybrid membrane combines efficient dye removal, permeability, antibacterial, antibiofilm, and antioxidant activities with long-term stability and reusability, demonstrating potential for sustainable wastewater treatment.

Key words: *Electrospun membrane, Activated carbon, LDH, Antibiofouling, Dye removal, Water treatment.*

Beyond Material Choice in Vital Pulp Treatment: From Calcium Silicate Hydrate Gels to Hydrogel-Based Diagnosis and Dentine–Pulp Regeneration

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Abstract

Background / Introduction:

Vital pulp treatment (VPT) has become a mainstream option for deep caries and pulp exposure in permanent teeth, largely because hydraulic calcium silicate cements (HCSCs) such as MTA and Biodentine hydrate to form a calcium silicate hydrate (C-S-H) gel, an alkaline environment, and interfacial apatite. Yet reported success rates still vary widely. This review examines whether VPT outcomes depend on the material or on use conditions, and where gel- and hydrogel-based technologies could address the remaining uncertainty.

Methods:

Narrative review of randomized trials, meta-analyses, human histological studies, and the 2023 ESE S3-level and 2026 EFCD-ESE-ORCA clinical practice guidelines, covering dentine–pulp biology, HCSC composition and bioactivity, and outcomes of pulp capping and pulpotomy.

Results

Both cements release calcium and hydroxyl ions and solubilize dentine-matrix growth factors such as TGF-β1, inducing comparable mineralized barriers. A 2025 meta-analysis (11 studies, 373 teeth) found no significant difference in direct pulp capping success between MTA and Biodentine (RR 0.98; 95% CI 0.94–1.03); differences are confined to setting time, handling, and discoloration. Failure is instead associated with inaccurate pulpal diagnosis, uncontrolled hemostasis, bacterial contamination, and inadequate coronal seal (Figure 1). No inflammatory biomarker (MMPs, interleukins, TNF-α) is yet validated for chairside use.

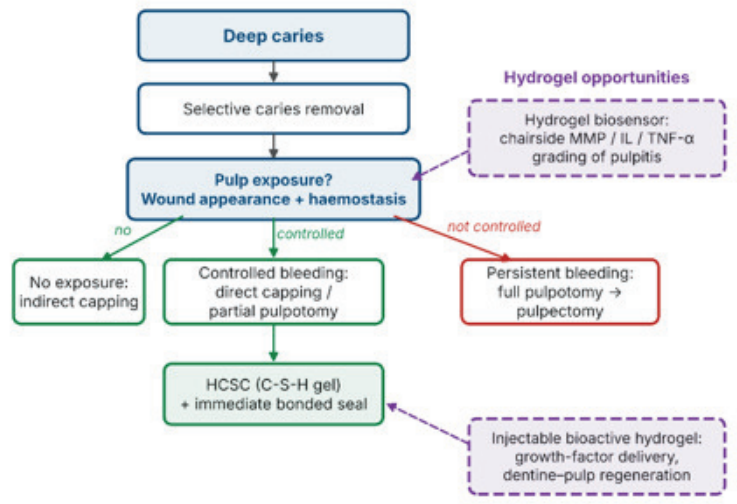


Figure 1: *VPT decision pathway and hydrogel opportunities.*

Conclusion:

Further cement comparison is unlikely to improve VPT outcomes. The next advances will come from hydrogel-based biosensors that can grade pulpal inflammation chairside, and from injectable bioactive hydrogels for controlled growth-factor delivery, moving VPT from reparative barrier formation toward genuine dentine–pulp regeneration.

Key words: *Vital pulp treatment, Calcium silicate cements, Pulpitis diagnosis, Hydrogel biosensors, Dentine–pulp regeneration*

Vachellia raddiana Gum as a Sustainable Edible Coating for Postharvest Fruit Preservation: Effects on Quality, Oxidative Stress and Antioxidant Defense

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Abstract

Background / Introduction:

Postharvest losses of fruits remain a major challenge for food quality preservation and sustainable agriculture. In this context, the development of biodegradable and bio-based coatings offers an eco-friendly alternative to conventional packaging systems. This study investigates the potential of gum extracted from Vachellia raddiana, a native species from southern Morocco, as a natural biopolymer with hydrogel-like properties for edible coating applications.

Methods:

Vegetable gum from Vachellia raddiana was used to formulate edible coatings applied to strawberry, tomato and apple using a dipping technique. Fruits were stored under ambient conditions and evaluated at predefined storage endpoints. A comprehensive set of analyses was performed, including physicochemical parameters (weight loss, pH, total soluble solids), microbiological load, pigment content (carotenoids), phenolic and flavonoid compounds, oxidative stress markers (H_2O_2 and MDA), and antioxidant-related enzyme activities (PPO, POX, CAT and SOD). Statistical analyses were performed using Python to evaluate treatment effects separately for each fruit.

Results

Preliminary observations indicated that gum coating was associated with lower weight loss and favorable changes in selected postharvest quality and biochemical parameters compared with the control. The 5% and 10% gum concentrations appeared to show the most promising overall trends among the tested formulations. Microbiological counts, oxidative stress markers and enzyme activities were also evaluated to characterize the responses associated with gum application. The statistical analyses will establish which treatment differences are significant for each fruit and parameter.

Conclusion:

This work highlights the potential of Vachellia raddiana gum as a sustainable and functional biopolymer for edible coatings, contributing to the development of eco-friendly strategies for postharvest preservation and reinforcing the role of natural hydrogels in sustainable food systems.

Key words: *Vachellia raddiana, vegetable gum, edible coating, postharvest preservation, oxidative stress, antioxidant enzymes, microbiological stability.*

Electrospun PLA/ZnAl-LDH-GA Nanofibrous Composites as Multifunctional Wound Dressings with Controlled Gallic Acid Delivery and Enhanced Biological Activities

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Abstract

Background / Introduction:

The development of multifunctional wound dressings capable of providing structural support while promoting biological healing responses represents a major challenge in advanced wound management. Conventional wound dressings often lack therapeutic functionalities required to control oxidative stress, inflammation, and microbial infections during the healing process. The combination of biodegradable polymers with bioactive inorganic nanomaterials and natural molecules represents a promising strategy for designing advanced biomaterials. In this study, a multifunctional electrospun nanofibrous wound dressing based on poly(lactic acid) (PLA), ZnAl-layered double hydroxides (ZnAl-LDH), and gallic acid (GA) was developed to combine structural properties with antioxidant, antimicrobial, anti-inflammatory, and controlled drug delivery properties.

Methods:

ZnAl-LDH was synthesized with the incorporation of GA through the coprecipitation method under constant pH condition to obtain GA-intercalated ZnAl-LDH nanomaterials. The release behavior of GA from this composite was investigated to evaluate its potential as a controlled delivery system. The synthesized ZnAl-LDH-GA composite was subsequently incorporated into PLA polymeric matrix and composite nanofibrous films were fabricated by electrospinning. The obtained membranes were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), fourier transform infrared spectroscopy (FTIR), and thermogravimetric analysis (TGA). The biological properties of the developed films were evaluated through antioxidants, anti-inflammatory and antimicrobial assays against S. aureus, E. coli, Bacillus sp., and Pseudomonas aeruginosa.

Results

The coprecipitation process at constant pH enabled the successful incorporation of gallic acid into the ZnAl-LDH structure. The ZnAl-LDH host matrix provided a suitable platform for GA loading and controlled release, allowing a gradual liberation of the bioactive molecule. Electrospinning successfully produced PLA/ZnAl-LDH-GA nanofibrous membranes with an interconnected porous morphology appropriate for wound dressing applications. Structural and chemical characterization confirmed the successful integration of ZnAl-LDH-GA within the PLA matrix while maintaining the fibrous architecture of the membranes. The composite films exhibited enhanced antioxidant activity due to GA presence, together with anti-inflammatory effects and antibacterial activity against S. aureus, E. coli, Bacillus sp., and Pseudomonas aeruginosa, demonstrating their potential to reduce oxidative stress, modulate inflammation, and prevent bacterial infection.

Conclusion:

The developed PLA/ZnAl-LDH-GA electrospun nanofibrous films represent promising multifunctional wound dressing materials combining mechanical support, controlled GA delivery, antioxidant, antimicrobial, and anti-inflammatory properties. The incorporation of gallic acid into ZnAl-LDH provides a promising strategy for improving bioactivity and achieving sustained therapeutic effects, highlighting the potential of these composites for advanced wound healing and tissue regeneration applications.

Key words: *Layered double hydroxides, gallic acid, controlled release, electrospinning, antimicrobial activity, wound healing*

Scaffolds Decorated with Bioactive Graphene Quantum Dots for Diabetic Wound Healing

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Abstract

Background / Introduction:

In this study, waste paper-derived graphene quantum dots (GQDs) were combined with curcumin to produce GQD-CurNCs. Physicochemical characterization confirmed successful nanocomposite formation, while antioxidant and antimicrobial assays evaluated their bioactivity. The nanocomposites were subsequently incorporated into chitosan–gelatin cryogels, and the resulting hybrid scaffolds were characterized to assess their potential for diabetic wound healing.

Diabetic wounds are difficult to heal due to prolonged inflammation and increased infection risks, potentially leading to severe complications. Cryogels are promising wound-healing biomaterials with interconnected pores that support cell infiltration, bioactive agent delivery, and tissue regeneration, while their high fluid absorption capacity enables effective wound exudate management.

Methods:

In this study, GQD-CurNCs were synthesized by combining C. longa-derived curcumin nanoparticles with waste paper-derived GQDs and incorporated into an optimized chitosan–gelatin formulation to produce cryogel scaffolds. Their physicochemical and biological properties were evaluated to assess their potential for diabetic wound healing.

Results

CurNPs and GQDs were successfully synthesized and combined to form the nanocomposite illustrated in Figure 1. SEM images revealed irregularly shaped CurNPs distributed across clustered GQD aggregates. Physicochemical analyses confirmed nanocomposite formation, while biological assays demonstrated enhanced antibacterial activity against S. aureus and E. coli. The GQD-CurNCs also inhibited S. aureus biofilm formation by 56.24 ± 1.58% and completely inhibited E. coli biofilm formation.

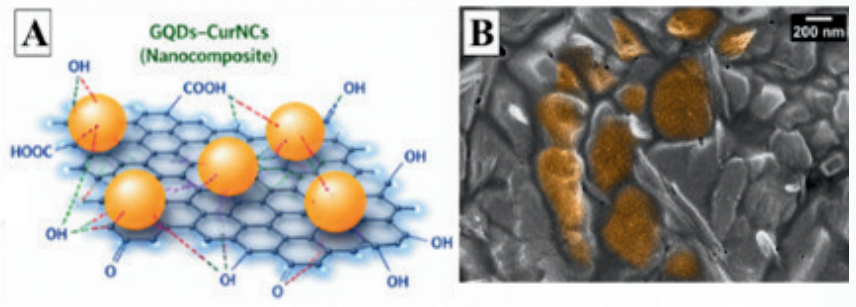


Figure 1: *A) Schematic illustration of biofunctional GQDs-CurNCs and B) SEM images of the composite structure*

GQD-CurNCs were homogeneously dispersed within a chitosan–gelatin matrix, forming cryogels with a sponge-like, interconnected porous structure.

Conclusion:

The developed bioactive cryogel scaffolds exhibited promising physicochemical, antioxidant, and antimicrobial properties. The nanocomposites were homogeneously distributed within the interconnected porous matrix while retaining their bioactivity. These multifunctional scaffolds hold potential for diabetic wound healing by providing antimicrobial protection, regulating oxidative stress, and supporting tissue regeneration.

Key words: *cryogel, curcumin, graphene quantum dot, wound dressing*

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Lipopolysaccharides: understanding the ionic hydrogel-forming property of extracellular biopolymers extracted from waste sludge

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Abstract

Background / Introduction:

IAn interesting and potential property of extracellular biopolymers is the hydrogel formation with calcium ions. Aiming at understanding how biopolymers formed hydrogels and what impacted their properties, a targeted investigation of the lipopolysaccharides (LPS), one of the important components in biopolymers, was performed. The flocculent sludge LPS showed a lower amount of glycans, shorter glycan chain length, lower molecular weight, and higher possibility of containing unsaturated lipids than the granular sludge EPS. The flocculent sludge LPS-Ca aggregates demonstrated invert structures with the water phase in between, contributing to the fluid-like property of the respect EPS-Ca. In contrast, LPS-Ca aggregates from granular sludge displayed bilaminar multilayered morphology, contributing to the solid, self-standing hydrogel of EPS-Ca.

Extracellular biopolymers (also known as EPS) have been considered essential for the biofilm structure. An interesting EPS property is the gel-forming property. How does the LPS and calcium interaction influence the EPS and calcium hydrogel? These are important research questions to be answered for a better understanding of the gel-forming property of the EPS.

Methods:

EPS extraction from sludge by hot alkaline (Na_2CO_3) extraction method. and LPS isolation from sludge using the hot phenol-water method. Interaction of both EPS and LPS samples with 2.5% calcium chloride solution (w/v). Sugar monomers measurement by HPAEC-PAD and glycans visualization by SDS-PAGE and staining with microscopies.

Results:

Although both EPS from flocculent sludge and granular sludge exhibited the ability to form viscous hydrogels, the EPS-Ca hydrogel from flocculent sludge still looked like a fluid and was not able to self-stand at all (Figure 1a). In contrast, the EPS-Ca hydrogel from granular sludge became a solid piece reflecting the shape of the mould and able to self-stand completely.

The phase contrast microscopic images of LPS-Ca aggregates are shown in Figure 1b. LPS-Ca from flocculent sludge displayed the loosely packed inverted structure with water phase (black holes) in between the aggregated structure, while LPS-Ca from granular sludge demonstrated the densely packed structure.

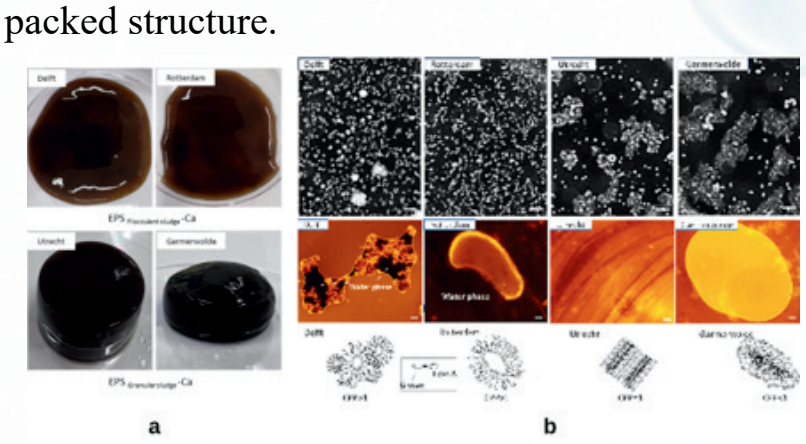


Figure 1: *EPS ionic hydrogel formation test by immerging EPS solution in calcium chloride solution ($CaCl_2$, 2.5%, w/v). a) hydrogel formation. b) microscopies of hydrogel structures.*

Conclusion:

The amount of glycans, glycan chain length, molecular weight and unsaturated lipids in the LPS sludge contributing to the property of the EPS-Ca hydrogels.

Key words: *extracellular polymeric substances (EPS); Lipopolysaccharides (LPS), ionic hydrogel formation, glycans, lipid A, LPS-calcium aggregates*

Magnetic field–modulated gemcitabine delivery via Fe_3O_4@SiO_2@HAGel nanoplatforms in an in vitro model of pancreatic cancer

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Abstract

Background / Introduction:

Pancreatic ductal adenocarcinoma (PDA) faces major therapeutic challenges due to poor gemcitabine (Gem) penetration and drug resistance. We developed Fe_3O_4@SiO_2@HAGel-Gem magnetic nanohydrogels exhibiting mild magnetothermal responsiveness and stimulus-dependent drug release. In BxPC-3 cells, magnetic stimulation enhanced cytotoxicity and late cell death, accompanied by increased BAX and DCK expression and reduced BCL2. These findings support magnetically responsive nanohydrogels as promising platforms for controlled chemotherapy in pancreatic cancer.

PDA is highly aggressive, with poor prognosis, limited drug penetration, and gemcitabine (Gem) resistance. Magnetically responsive nanohydrogels may enable controlled drug delivery and stimulus-responsive release. However, systems combining these capabilities with biological validation in PDA remain limited. This study developed and evaluated magnetic nanohydrogels to enhance controlled chemotherapy in pancreatic cancer cells.

Methods:

Magnetic nanohydrogels were synthesized and characterized morphologically. Magnetothermal response, specific absorption rate, Gem loading, and stimulus-dependent release were evaluated. Cytotoxicity and gene expression (BAX, BCL2, DCK, and ABCB1) were assessed in BxPC-3 pancreatic cancer cells using flow cytometry and quantitative PCR.

Results:

Magnetic nanohydrogels exhibited core–shell morphology, a specific absorption rate of 37.42 W/g, ~50% Gem encapsulation, and ~75% stimulus-dependent release. Magnetic stimulation reduced BxPC-3 cell viability to 1.16%, with 93.2% late apoptotic/secondary dead cells. Gene expression showed increased BAX and DCK and decreased BCL2, supporting enhanced Gem-associated cytotoxicity (Figure 1).

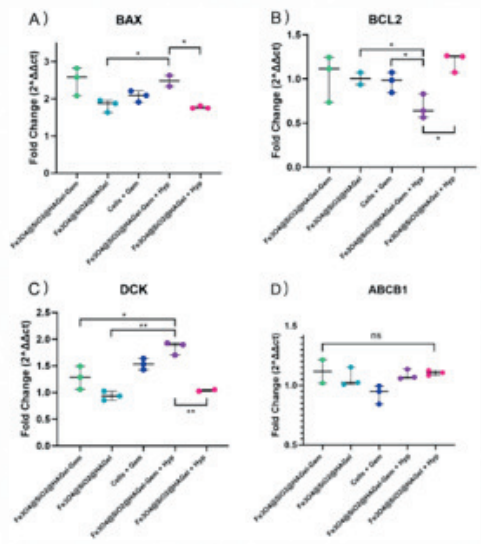


Figure 1: *Relative mRNA expression of apoptosis- and Gem-related genes in BxPC-3.*

Conclusion:

Magnetic nanohydrogels enable magnetically modulated and controlled drug delivery, enhancing Gem efficacy through synergistic physicochemical and biological mechanisms. The integration of magnetic responsiveness, pH-sensitive release, and molecular activation highlights their potential to overcome key therapeutic limitations in an in vitro PDA model.

Key words: *Magneto-responsive nanohydrogels; Gemcitabine delivery; Pancreatic ductal adenocarcinoma*

Probing Water Phase Behavior in Alginate Hydrogels: Integrating Quantitative and Structural Insights

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Abstract

Background / Introduction:

Water distribution within alginate hydrogels strongly influences their structural, mechanical, and functional performance, yet distinguishing and quantifying free and polymer-associated water remains challenging. Here, differential scanning calorimetry (DSC) was combined with cryogenic scanning electron microscopy (Cryo-SEM), small- and wide-angle X-ray scattering (SAXS/WAXS), Fourier-transform infrared spectroscopy (FT-IR), and rheology to examine water-phase behavior and its relationship to hydrogel structure. DSC analysis of aged samples indicated approximately 58% free water and 42% bound water. Complementary measurements showed that increasing Ca^{2+} concentration and aging time altered pore morphology, reduced pore size, increased wall thickness, and promoted a denser network. These structural changes were associated with enhanced mechanical strength and changes in water mobility. The findings demonstrate the value of integrating quantitative thermal analysis with complementary structural, spectroscopic, and mechanical methods to establish links between water populations and hydrogel architecture. This approach can inform the rational design of alginate-based materials for drug delivery, tissue engineering, food structuring, and encapsulation applications.

Alginate hydrogels contain mobile water in macropores and water associated with the polymer network. Because individual methods often provide either quantitative or qualitative information, a combined analytical strategy is needed to relate water populations to structural and functional properties.

Methods:

DSC quantified free and bound water fractions; Cryo-SEM examined pore morphology; SAXS/WAXS probed nanoscale organization; FT-IR assessed polymer–water interactions; and rheology evaluated mechanical behavior. Ca^{2+} concentration and aging time were varied to investigate their effects on hydrogel structure and water distribution.

Results:

Aged samples contained approximately 58% free water and 42% bound water. Higher Ca^{2+} concentration and longer aging were associated with smaller pores, thicker pore walls, greater network density, and enhanced mechanical strength.

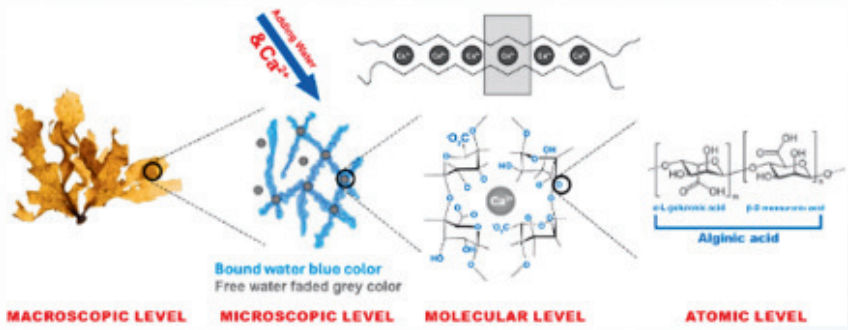


Figure 1: *Relative mRNA expression of apoptosis- and Gem-related genes in BxPC-3.*

Conclusion:

Together, these results highlight the close relationship between hydrogel architecture and water-phase behavior and show that integrating complementary techniques provides a more comprehensive characterization than any single method alone.

Key words: *Alginate hydrogels, Water pools, Macropores, Quantitative analysis, Qualitative analysis, Drug delivery applications*

3D Bioprinted Gellan Gum–Clay Hydrogels for Delivery of Trichoderma harzianum for Sustainable Agriculture

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Abstract

Background / Introduction:

Extrusion-based bioprinting was used to develop gellan gum (GG) and laponite (LP) nanocomposite hydrogels for encapsulating Trichoderma harzianum as a biological control agent. The formulations exhibited typical viscoelastic behavior (G′ > G″) and improved thermal stability due to strong GG-clay interactions. Although processing steps reduced conidial viability, the bioprinted structures successfully maintained fungal germination and mycelial development across different layers. Overall, these hydrogels demonstrate strong potential for sustainable agricultural biodefense and microorganism delivery.

Chemical pesticide overuse causes environmental and health issues, prompting the rise of sustainable biological control agents like Trichoderma harzianum. However, their practical application faces challenges regarding stability, storage, and environmental sensitivity. To overcome this, gellan gum (GG) and laponite (LP) nanocomposite hydrogels provide enhanced mechanical properties and controlled release. Furthermore, combining these biopolymers with 3D bioprinting offers a promising, efficient strategy for encapsulating microorganisms in sustainable agricultural biodefense.

Methods:

DGG/LP composite hydrogels were prepared with 5% (w/w) LP and varying GG (0.5–5.0%) via dispersion, heating, and homogenization. Formulations were selected through rheology, FT-IR, and TGA characterization. Printability was tested, and structures were ionically crosslinked with $CaCl_2$. Trichoderma harzianum conidia (10% w/w) were incorporated to evaluate viability viacounting, germination, and CFU assays after processing. Finally, 1-, 4-, and 8-layer 3D scaffolds were bioprinted to study microorganism release.

Results:

GG and GGLP hydrogels, figure 1, showed viscoelastic behavior (G′ > G″), pseudoplasticity, and increased mechanical strength with laponite. TGA and FT-IR confirmed stable GG-laponite interactions, and the hydrogels exhibited good printability and crosslinking stability. Despite reduced conidia viability during processing, bioprinted structures supported fungal germination and mycelial development across all layers, showing potential for agricultural use.

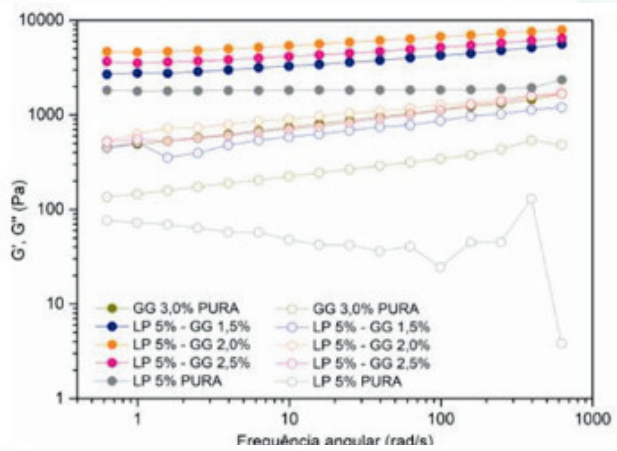


Figure 1: *Frequency sweep curves at 25 °C of GGLP hydrogel samples. (a) Pure GG (dark yellow), pure LP (gray), 5% LP – 1.5% GG (blue), 5% LP – 2.0% GG (orange), and 5% LP – 2.5% GG (pink), showing G' (filled circles) and G'' (open circles)*

Conclusion:

GG/Lp hydrogels showed viscoelasticity (G′ > G″) and good printability. Despite reduced conidial viability, they successfully maintained fungal germination and development, showing agricultural potential.

Key words: *3D bioprinting, gellan gum, composite hydrogel, biological control, biopolymers.*

Acknowledgement: *FAPESP (grants no. 2021/11965-3/CEMASU.*

Mixture Design Optimization of Plant Secondary Metabolites for Anti-Adhesive Functionalization of 3D-Printed ABS and Nylon Surfaces

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Abstract

Background / Introduction:

The growing use of 3D-printed polymers in medical and food applications raises concerns about bacterial adhesion and biofilm formation. This study aimed to optimize natural plant-derived compounds to functionalize ABS and nylon surfaces and reduce adhesion by Staphylococcus aureus and Pseudomonas aeruginosa.

Methods:

Caffeic acid, tannic acid, and coumarin were evaluated individually and in mixtures using a special cubic design. Antibacterial activity was assessed by MIC determination against S. aureus and P. aeruginosa. The optimized mixture was applied to 3D-printed ABS and nylon surfaces, whose physicochemical properties and bacterial adhesion were evaluated through contact angle measurements, surface energy analysis, XDLVO modeling, and SEM.

Results:

Tannic acid showed the strongest individual antibacterial activity. The optimized mixture (16.6% caffeic acid, 66.6% tannic acid, and 16.6% coumarin) achieved MICs of 0.018 mg/mL against S. aureus and 0.10 mg/mL against P. aeruginosa. Model fit was strong (R^2 = 0.99 and 0.91). Surface treatment increased hydrophilicity and reduced bacterial adhesion by up to 96.76% for S. aureus and 97.78% for P. aeruginosa. SEM confirmed reduced bacterial colonization.

Figure 1. Anti-adhesive effect of the optimized plant metabolite mixture on 3D-printed ABS and nylon surfaces against *S. aureus* and *P. aeruginosa*.

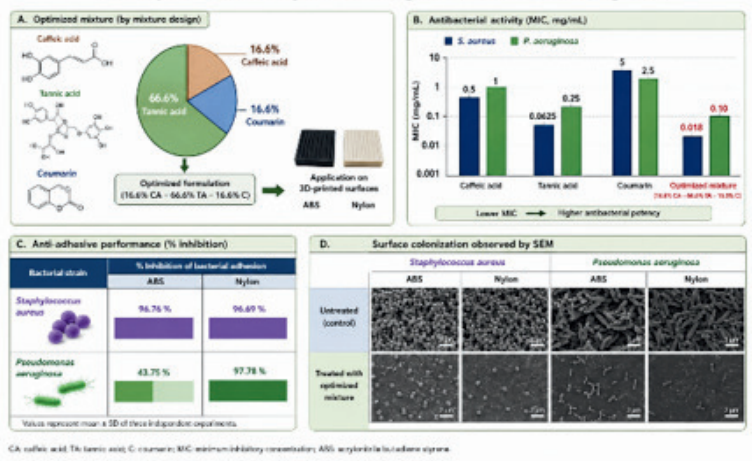


Figure 1: *Anti-adhesive effect of the optimized metabolite mixture on 3D-printed ABS and nylon surfaces against Staphylococcus aureus and Pseudomonas aeruginosa.*

Conclusion:

The optimized natural-compound mixture modified surface properties and reduced bacterial adhesion on 3D-printed ABS and nylon, highlighting its potential as a sustainable strategy to limit microbial contamination and biofilm formation on polymeric materials.

Key words: *3D-printed surfaces, plant secondary metabolites, anti-adhesive activity, biofilm inhibition, mixture design optimization.*

Designing Application-Specific Regenerated Hydrogels through Direct Dissolution of Cellulose from Diverse Sources

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Abstract

Background / Introduction:

Cellulose hydrogels are attractive materials for biomedical and agricultural applications due to their biodegradability, biocompatibility, and high water-retention capacity. Most cellulose-based hydrogels are prepared from cellulose derivatives or chemically crosslinked systems, whereas direct dissolution and regeneration provide a route to physically crosslinked hydrogels without chemical derivatization. However, cellulose feedstocks vary widely in origin and composition, making the development of versatile processing approaches challenging. Therefore, this work evaluated the adaptability of a unified DMAc/LiCl dissolution–regeneration approach for producing cellulose hydrogels from different feedstocks for biomedical and agricultural applications.

Methods:

Hydrogels were prepared by cellulose dissolution in DMAc/LiCl followed by regeneration in water. The obtained materials were characterized by water retention capacity measurements, FTIR spectroscopy, SEM, EDX, and XPS. For biomedical applications, silver nanoparticles were synthesized in situ within regenerated cellulose matrices, and antibacterial activity against Escherichia coli and Staphylococcus aureus was evaluated using the agar diffusion method. Agricultural applications were assessed through water-retention and microgreens cultivation in soil-amended and soilless systems.

Results:

Hydrogels derived from recycled paper fibers exhibited equilibrium water absorption capacities exceeding 50 g/g and improved soil moisture retention during drying. In soil and soilless cultivation systems, the hydrogels promoted microgreen biomass production and increased plant survival under water-limited conditions. In contrast, hydrogels prepared from cotton microcrystalline cellulose and powder celluloses exhibited water absorption capacities of approximately 35–45 g/g and served as matrices for the in situ synthesis of silver nanoparticles, yielding antibacterial cellulose-based composites. Although silver incorporation slightly reduced water retention capacity, the hydrogels retained high water uptake while acquiring antibacterial activity against both Gram-positive and Gram-negative bacteria, with inhibition zones reaching 14 mm for Staphylococcus aureus and 13 mm for Escherichia coli. Structural and compositional analyses confirmed the chemical purity of the regenerated cellulose matrices, supporting their potential as functional biomaterials.

Conclusion:

Cellulose source selection and post-functionalization provided complementary routes for tailoring regenerated hydrogel performance. Recycled paper fibers yielded highly absorbent hydrogels for agricultural applications, whereas silver-functionalized cellulose hydrogels formed antibacterial composites, highlighting the versatility of the dissolution–regeneration approach.

Key words: *regenerated cellulose hydrogel, DMAc/LiCl, silver nanoparticles, agricultural hydrogels, recycled paper fibers, direct dissolution*

Phytochemical Profiling of Gelidium sesquipedale for Marine-Derived Biohydrogels: Matrix Interferences and Methodological Considerations

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Abstract

Background / Introduction:

Marine macroalgae are renewable sources of polysaccharides of growing interest for the development of bio-based hydrogels. Gelidium sesquipedale, a red macroalga and an important source of agar, is therefore particularly relevant for the development of marine-derived biomaterials. However, beyond the polysaccharide fraction, algal biomass contains various non-polysaccharide constituents that may be removed, retained, or co-extracted during agar isolation and may potentially influence the characteristics of the resulting material. Phytochemical screening thus provides an initial approach for identifying the major classes of these constituents prior to biopolymer extraction and purification. However, the complexity of the algal matrix, particularly the presence of pigments, proteins, salts, and polysaccharides, may interfere with conventional phytochemical tests. This study therefore aimed to characterize the phytochemical profile of G. sesquipedale while examining major matrix-related interferences, with a view to its valorization as a source of biopolymers for marine-derived biohydrogels.

Methods:

Samples of G. sesquipedale were collected in April 2026 from Sidi Bouzid (El Jadida) on the Moroccan Atlantic coast. The biomass was washed, dried, and ground prior to characterization. Moisture content, total ash, and acid-insoluble ash were determined. Following hydroalcoholic extraction under controlled conditions, qualitative phytochemical screening was performed using conventional tests based on colorimetric, precipitation, foam, and fluorescence reactions targeting different classes of metabolites. Appropriate controls and methodological precautions were applied to identify and minimize potential interferences associated with the algal matrix.

Results:

The biomass showed a moisture content of 7.2%, a total ash content of 21%, and an acid-insoluble ash content of 1.1%. The relatively low acid-insoluble ash fraction (1.1%) compared with total ash (21%) suggests a limited contribution from acid-insoluble mineral contaminants. Qualitative screening yielded positive reactions in assays targeting alkaloids, phenolic compounds, tannins, flavonoids, saponins, free quinones, coumarins, sterols/triterpenes, cyanogenic compounds, and pH-sensitive pigments, whereas cardiac glycosides and reducing compounds yielded negative responses. Critical examination of the reactions also identified several matrix-related limitations, including masking of some responses by pigments, potential protein interference with Dragendorff's reagent, and a possible contribution of phycobiliproteins to reactions attributed to anthocyanin-like pigments.

Conclusion:

This study provides a preliminary characterization of G. sesquipedale, highlighting both the diversity of phytochemical responses and specific analytical interferences associated with the algal matrix. Further targeted chromatographic and spectrometric analyses are required to confirm the identity of selected metabolite classes, particularly when the observed reactions may be influenced by other constituents of the algal matrix. The presence of non-polysaccharide constituents in this agar-rich biomass raises the question of their fate during biopolymer extraction and purification. Future studies should determine whether these constituents are removed, retained, or coextracted during agar isolation and assess their potential influence on hydrogel formation, physicochemical properties, and functionality. Such knowledge could subsequently help guide extraction and purification strategies for marine biopolymers intended for biohydrogel development.

Key words: *Gelidium sesquipedale, marine-derived biohydrogels, agar, phytochemical screening, marine biomass, matrix interference*

Bacterial Polymer-Based Systems for the Delivery of Therapeutic Agents to Bone Tissue

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Abstract

Background / Introduction:

Bone disorders such as osteoporosis remain a major clinical challenge, motivating the search for drug delivery systems that combine biocompatibility with skeletal specificity. Bacterial glycosaminoglycans (GAGs) have emerged as promising carriers for such applications, owing to their structural versatility and favorable biological properties. The present study investigates the potential of bacterial GAGs, in association with therapeutic compounds, to enable the targeted treatment of bone diseases. Particular attention is given to the Parathyroid Hormone 1 Receptor (PTH1R), a key regulator of bone homeostasis and a validated therapeutic target in bone health.

Methods:

Computational methods were employed to identify novel bacterial GAG species, as well as small molecules and peptides targeting PTH1R. Candidate ligands were selected on the basis of their predicted binding affinity for the receptor. The pharmacokinetic and safety profiles of the selected candidates were subsequently assessed through in silico Absorption, Distribution, Metabolism, Excretion, and Toxicity (ADMET) evaluations.

Results:

Three small molecules and two mutated parathyroid hormone (PTH) peptides exhibiting high affinity for PTH1R were identified. The ADMET analyses indicated favorable pharmacokinetic properties for the selected candidates, supporting their potential suitability for further development. The association of these bone-targeting ligands with bacterial GAGs provides a rational basis for the design of bone-specific drug delivery systems.

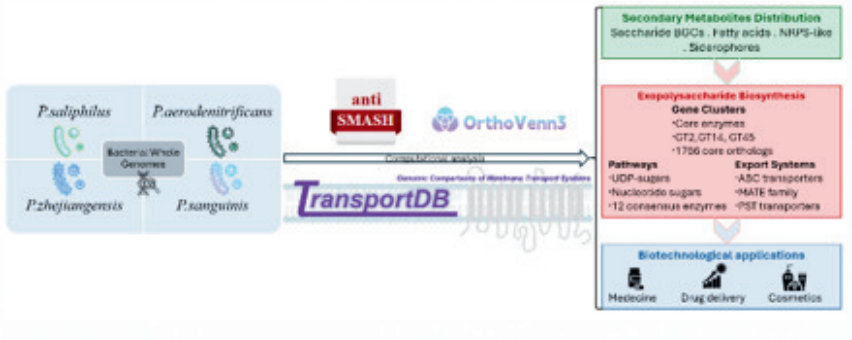


Figure 1: *In silico comparative genomic analysis of four bacterial genomes for the mining of exopolysaccharide biosynthesis gene clusters and their biotechnological potential.*

Conclusion:

By integrating bacterial-derived biopolymers with bone-targeted therapeutics, this work outlines a promising strategy for developing more effective and biocompatible treatments for skeletal disorders. These findings reveal new opportunities for personalized medicine in bone health and contribute to the broader field of biopolymer-based drug delivery systems. Experimental validation of the proposed candidates constitutes a key perspective for future work.

Key words: *regenerated cellulose hydrogel, DMAc/LiCl, silver nanoparticles, agricultural hydrogels, recycled paper fibers, direct dissolution*

Formulation and Characterization of a Teucrium polium–Loaded Xanthan–Galactomannan–Hyaluronic Acid Biohydrogel

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Abstract

Background / Introduction:

In Tunisia, the management of chronic diabetic wounds remains costly because many effective wound-care products are imported. Bio-based hydrogels offer a promising alternative. However, designing a natural hydrogel with both suitable structural properties and biological activity remains challenging.

Methods:

Teucrium polium L. extract was prepared by maceration with 70% ethanol at room temperature. Its phytochemical composition was investigated by UPLC–IMS–QTOF analysis. Antioxidant activity was evaluated. Anti-inflammatory potential was assessed through 13-lipoxygenase inhibition. Hydrogel matrices, with a total polymer concentration of 2%, were prepared using different combinations of xanthan gum, galactomannan, and hyaluronic acid. The final ternary formulation contained 5% T. polium extract. Rheological properties were assessed by oscillatory measurements of the storage and loss moduli. Antibacterial and antifungal activities were evaluated using the agar-well diffusion method.

Results:

UPLC–IMS–QTOF analysis of the Teucrium polium L. extract allowed the tentative identification of 43 compounds. Antioxidant capacities reached 97.6, 22.72, and 220 mg TE/g in the ABTS, DPPH, and FRAP assays, respectively.

Both the extract and the hydrogel reduced 13-lipoxygenase activity. The final hydrogel was homogeneous, and its pH changed only slightly from 5.60 to 5.64 after 30 days. It exhibited antimicrobial activity with inhibition zones ranging from 6.0 to 9.3 mm. It also exhibited shear-thinning behavior.



Figure 1: *Blank and Teucrium polium extract-loaded hydrogels.*

FTIR analysis revealed characteristic polysaccharide bands. The extract-loaded hydrogel showed additional spectral changes in the carbonyl, aromatic, and phenolic C–O regions, consistent with the incorporation of T. polium into the polymeric matrix.

Conclusion:

Further wound-healing studies are required to confirm its therapeutic potential.

Key words: *Teucrium polium, biohydrogel, xanthan gum, galactomannan, hyaluronic acid*

Application of Mathematical Models in Clotrimazole Release Kinetics from β-Cyclodextrin Modified Polyurethane Inclusion Complexes

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Abstract

Background / Introduction:

The aim of present work is to determine and analyse the kinetics of drug release from the polymer matrix by employing various mathematical models. A study was done with clotrimazole, employing a wet kneading technique using β-cyclodextrin (βCD) modified polyurethane networks (PURs) as a biomaterial drug carriers. The drug release data was obtained, quantitatively correlated and interpreted with following mathematical models: zero order, first order, Higuchi, Hixson-Crowell and Korsmeyer-Peppas and evaluated to understand the kinetics of drug release. The criterion for the most suitable model was based on the high degree of correlation coefficient of the drug release profile.

Methods:

A series of polyurethanes for clotrimazole delivery was synthesized from alicyclic isophorone diisocyanate and two polyethylene glycols (mass average molecular weight, $\bar{M}_w$ = 2000 and 6000 $g \cdot mol^{-1}$) by using βCD as a crosslinker, with NCO/OH molar ratio of 4.3 and 6.3. The release of CLOT from PURs was analyzed by reversed-phase high-performance liquid chromatography (HPLC).

Results:

According to the Higuchi model, the drug release from both βCD-modified polyurethane inclusion complexes involves both dissolution and diffusion. Also, the highest values of the correlation coefficients indicate that it best describes the release of clotrimazole from both βCD-modified polyurethane networks (R^2 are 0.99782 and 0.99506). It implies that drug release from the βCD-modified polyurethane networks is the square root of a time–dependent diffusion–controlled process.

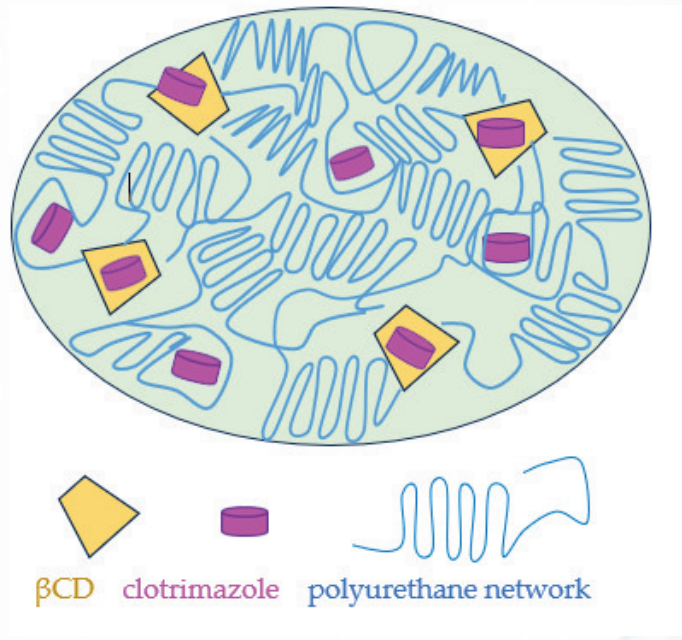


Figure 1: *A probable structure of a segment of the inclusion complexes clotrimazole: βCD-modified polyurethane networks*

Conclusion:

The obtained in vitro results showed surprisingly slow/prolonged clotrimazole release from inclusion complexes clotrimazole: βCD-modified polyurethane networks due to the significant influence of the chosen polyol chain length of soft segments, with potential in vivo applications.

Key words: *β-cyclodextrin, polyurethane biomaterial, inclusion complex, drug release, clotrimazole, HPLC*

Acknowledgement: *The authors acknowledge the financial support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (grants no. 451-03-34/2026-03/200133).*

From Shrimp Waste to 3D-Printed Hydrogels: Sustainable Production, Characterization and Biomedical Application

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Abstract

Background / Introduction:

The increasing demand for sustainable biomaterials has stimulated interest in the valorization of seafood processing waste. Chitosan, obtained by deacetylation of chitin, is a biodegradable, biocompatible and bioactive polysaccharide widely investigated for wound healing and tissue engineering applications. However, the properties of chitosan strongly depend on its biological source and extraction process. In this study, chitosan was produced from three shrimp species and evaluated as a sustainable alternative to commercial chitosan for the development of advanced wound dressing materials.

Methods:

Chitin was extracted from shrimp shell biowaste originating from three shrimp species using an eco-friendly autoclave-assisted process. The extracted chitin was converted into chitosan through alkaline deacetylation. Physicochemical characterization was performed to evaluate extraction yield, degree of deacetylation and structural properties. Chitosan-based formulations were then developed and optimized for film formation and 3D printing of a prototype dressing (ChitoPatch).

Results:

All shrimp-derived chitosans exhibited physicochemical characteristics comparable to those of commercial chitosan, confirming the effectiveness of the extraction process. Spectroscopic analyses confirmed the successful conversion of chitin to chitosan. Cytotoxicity testing demonstrated the good biocompatibility of the materials obtained and validated their potential for biomedical use.

Furthermore, the formulations developed exhibited satisfactory film-forming and printability properties, enabling the successful fabrication of a 3D-printed ChitoPatch prototype with a homogeneous structure and good handling properties.

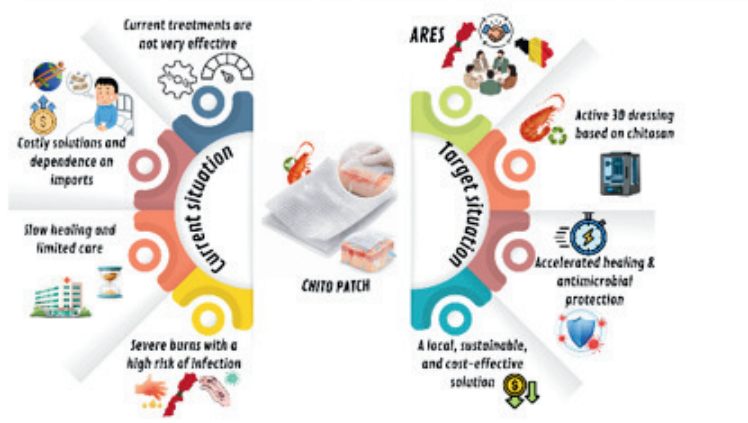


Figure 1: *Conceptual framework of the ChitoPatch project: from current challenges in burn wound management to the development of a sustainable 3D-printed chitosan-based dressing.*

Conclusion:

This work demonstrates the feasibility of transforming shrimp shell biowaste into high-value biomedical materials. The produced chitosans showed performances comparable to commercial chitosan while providing a sustainable and locally available alternative. The successful development of films and a 3D-printed ChitoPatch prototype highlights the potential of these biomaterials for future wound healing and tissue engineering applications. Ongoing studies focus on optimizing bioink formulations and evaluating the biological performance of the final dressing system.

Key words: *Chitosan, Shrimp waste valorization, Biomaterials, 3D bioprinting, Wound dressing, ChitoPatch*

Storage and sustained delivery of mRNA-liposome complexes via Si-HA hydrogels for bone regeneration: toward sequential release

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Abstract

Background / Introduction:

Critical-sized bone defects require interventions promoting revascularization and osteogenesis. While autologous bone grafting remains the gold standard, this solution is limited by donor site morbidity and availability, driving the search for alternatives. To this end, Bone Morphogenetic Protein-2 (BMP-2)-loaded biomaterials offer strong osteogenic potential. However, these systems rely on a bolus delivery of recombinant proteins that fails to replicate the natural physiological healing cascade. Consequently, they require supraphysiological doses, leading to significant side effects. To overcome these limitations, vectorized messenger RNA (mRNA) delivery offers a promising alternative by inducing endogenous BMP-2 expression directly at the injury site, mimicking natural protein synthesis and avoiding exogenous dose-related risks. However, the instability and rapid clearance of mRNA-liposome complexes (lipoplexes) restrict their therapeutic window. Consequently, there is a critical need for delivery systems, such as injectable hydrogels, to stabilize these vectors and ensure sustained local release.

Methods and Results:

In this context, this project aims to incorporate lipoplexes into silanized hyaluronic acid (Si-HA) hydrogels, while ensuring their bioactive delivery. The integrity of Cy5-mRNA and FITC-liposome double-labeled lipoplexes within the hydrogel was assessed by confocal microscopy and, confirmed by the transfection of HEK-293 cells by using mRNA encoding enhanced green fluorescent protein (EGFP) following hydrogel storage for up to 2 weeks. Release assays in physiological conditions using FITC-labeled lipoplexes showed a release profile over 72 hours, suitable for early regenerative stages such as angiogenesis. However, a more prolonged release remains necessary for BMP-2-induced osteogenesis.

Conclusion:

These results demonstrate that Si-HA hydrogels can effectively preserve lipoplex integrity, leading to endogenous protein production. This promising work will pave the way for the development of a biphasic hydrogel designed for the sequential release of mRNAs, aiming to mimic the natural physiological cascade of bone repair by coordinating angiogenesis and subsequent osteogenesis.

Key words: *Bone Tissue Engineering, lipid-based gene delivery, BMP-2, Silanized Hyaluronic Acid, Lipoplexes, mRNA*

Phytoglycogen Nanoparticles as Tunable Polysaccharide Platforms: Linking Surface Chemistry to Functional Applications

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Abstract

Background / Introduction:

Phytoglycogen is a naturally occurring, hyperbranched α-glucan nanoparticle formed in sugary-1 mutant cereal endosperm following impaired isoamylase activity. Its dendrimer-like architecture, hydroxyl-rich surface, high water retention and colloidal behavior provide a distinctive platform for chemical functionalization. This oral presentation focuses on how surface modification strategies transform native phytoglycogen into application-specific nanomaterials.

Methods:

A focused critical synthesis of the review literature was performed, with emphasis on four modification strategies: octenyl succinic anhydride (OSA) esterification, carboxymethylation, cationization, and gas-phase esterification. Their structural effects were considered in relation to reported physicochemical and functional outcomes.

Results:

OSA modification introduces amphiphilic character and enables Pickering emulsions, while OSA/hydroxypropyl dual modification has been reported to markedly improve the solubility and dissolution of poorly water-soluble active pharmaceutical ingredients. Carboxymethylation provides tunable negative charge and supports protein nanocomplexes and pH-responsive hydrogel systems. Cationization introduces positive surface charge, enabling electrostatic complexation with nucleic-acid-based immunostimulants and supporting delivery applications in aquaculture.

Gas-phase esterification has demonstrated spatial control over hydrophobic surface functionalization, offering a route toward defined hydrophobic shells. Together, these approaches illustrate how the same phytoglycogen scaffold can be chemically tuned for distinct delivery, food, biomedical, and advanced-material applications.

Conclusion:

The reviewed evidence shows that phytoglycogen is not only a naturally derived nanoparticle but also a versatile platform whose surface chemistry can be engineered to match specific functional requirements. Linking molecular modification to changes in hydration, charge, amphiphilicity and interfacial behavior provides a rational basis for developing phytoglycogen-based nanomaterials. Remaining challenges include standardized characterization, broader in vivo validation, and regulatory assessment of chemically modified derivatives.

Key words: *Phytoglycogen, Chemical functionalization, Nanocarrier, Bioactive delivery, OSA modification, Advanced materials*

Tuning the self-assembly of quercetin-loaded PEG-b-PLA micelles: a dissipative particle dynamics study

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Abstract

Background / Introduction:

Quercetin is a dietary flavonoid with antioxidant, anti-inflammatory and anticancer activities, but its clinical use is limited by poor aqueous solubility, chemical instability and low bioavailability. Amphiphilic PEG-b-PLA copolymers self-assemble in water into core–shell nanocarriers combining a biodegradable PLA core with a protective PEG corona. However, how copolymer composition and concentration govern the morphology and internal organisation of quercetin-loaded aggregates remains poorly understood at the molecular level.

Methods:

DPD simulations were performed with the Mesocite module of Materials Studio. Quercetin was coarse-grained into two beads, a hydrophobic benzopyrone core (Q1) and a polar catechol ring (Q2); PEG (E), PLA (L) and water (W, three molecules per bead) were single beads (Figure 1a). Flory–Huggins parameters χ_{ij}, derived from MD-computed solubility parameters (COMPASS), were converted into $a_{ij} = 78 + 3.27\chi_{ij}$. PEG_5-b-PLA_{10}, PEG_5-b-PLA_{15} and PEG_5-b-PLA_{20} were simulated with 2 % quercetin and 5–50 % copolymer in a 30 × 30 × 30 r_c^3 box (NVT, $\rho = 3$, $\Delta t = 0.05$, 1×10^6 steps).

Results:

Quercetin and PEG-b-PLA spontaneously formed core–shell micelles with a quercetin core, an intermediate PLA layer and a hydrated PEG shell (Figure 1b). Increasing the PEG_5-b-PLA_{10} concentration drives a transition from spherical to cylindrical micelles and finally to perforated lamellae (Figure 1c). ratios formed well-organised core–shell aggregates encapsulating quercetin.

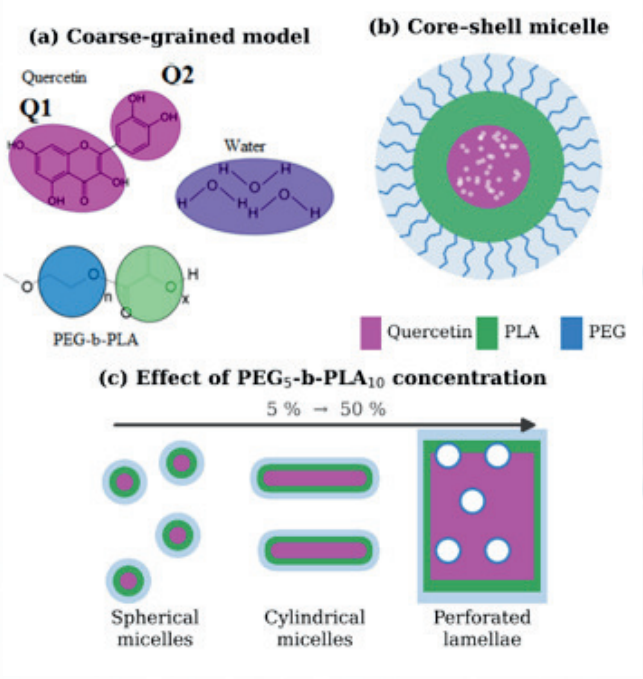


Figure 1: *(a) Coarse-grained model; (b) quercetin-loaded core–shell micelle; (c) morphological evolution with PEG_5-b-PLA_{10} concentration.*

Conclusion:

PEG-b-PLA diblocks efficiently encapsulate quercetin in core–shell micelles whose morphology is tuned by copolymer concentration and block ratio, providing molecular-level guidelines for the design of polymeric nanocarriers. Future work will address release kinetics and experimental validation.

Key words: *Quercetin, delivery systems, dissipative particle dynamics (DPD), PEG-b-PLA diblocks*

Beyond Conventional PMMA: Self-Healing Polymers and Smart Hydrogel Interfaces for Next-Generation Removable Dental Prostheses

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Abstract

Background / Introduction:

Polymethyl methacrylate (PMMA) remains the standard denture-base material despite fatigue fracture, microcrack propagation, microbial colonization, and denture-related mucosal inflammation. Self-healing polymer composites and smart biohydrogels, including self-healing networks built on dynamic bonds, offer an opportunity to design removable prostheses that repair their own damage and actively protect the supporting mucosa.

Methods:

This narrative review critically examines experimental studies (PubMed, Scopus, Web of Science, 2015–2026) on microcapsule-based self-healing 3D-printed denture resins, nanofiber reinforcement, drug-releasing functionalized PMMA surfaces, and hydrogel-based denture liners and coatings. We compare healing mechanisms, mechanical performance, antimicrobial delivery, and translational limitations.

Results:

Recent studies (2025–2026) indicate that healing-agent-loaded microcapsules can repair microcracks and improve fracture toughness in experimental 3D-printed denture resins, although flexural strength and degree of conversion may decrease. Zirconia nanofiber reinforcement introduces further mechanical trade-offs. Functionalized PMMA surfaces have shown sustained antifungal activity in vitro. In parallel, mucoadhesive and self-healing hydrogels (e.g., chitosan, alginate, or hyaluronic acid networks with dynamic Schiff-base or borate-ester bonds) could act as soft interfaces for antifungal delivery and mucosal cushioning (Figure 1). However, combining autonomous base repair with such an interface remains a proposed concept without clinical validation.

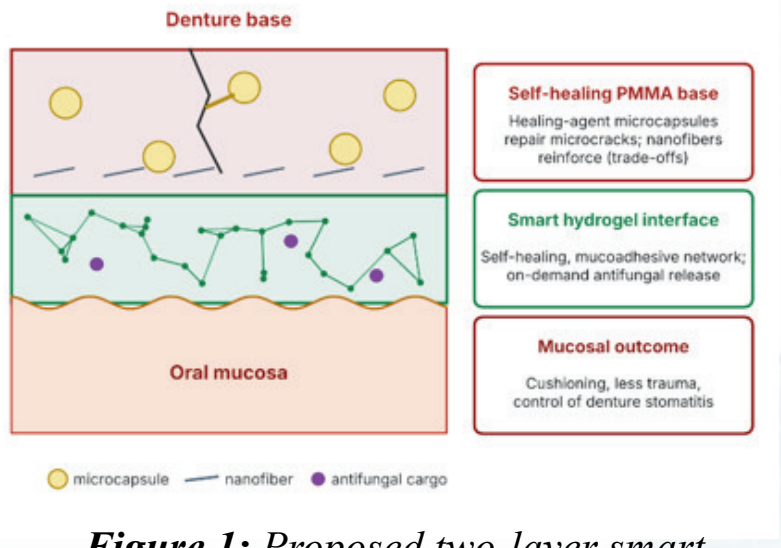


Figure 1: *Proposed two-layer smart removable prosthesis*

Conclusion:

Self-healing resins and smart hydrogel interfaces offer complementary routes towards durable, bioactive removable prostheses: the base repairs its own damage while the interface protects the mucosa. Before clinical translation, researchers must establish long-term mechanical reliability, hydrogel–PMMA adhesion, biocompatibility, antifungal performance, and safety under realistic oral conditions.

Key words: *Self-healing polymers, PMMA, Self-healing hydrogels, Removable prosthodontics, Antifungal delivery, 3D printing*

Synthesis and DFT Investigation of Novel Acetophenone-Based 1,2,3-Triazole Derivatives for Potential Corrosion Inhibition

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Abstract

Background / Introduction:

Herein, a series of acetophenone derivatives bearing a 1,2,3-triazole ring was synthesized through a sequential functionalization strategy.

Methods:

First, the appropriate acetophenone derivatives were alkylated with propargyl bromide to introduce a terminal alkyne. We then subjected the resulting intermediates to a copper-catalyzed azide–alkyne cycloaddition (CuAAC), commonly known as the "click" reaction, with azide-bearing acetamide derivatives to afford target compounds containing the 1,2,3-triazole moiety. We characterized the synthesized compounds using appropriate spectroscopic and analytical techniques.

In addition to the experimental synthesis, a computational study based on density functional theory (DFT) was carried out to examine the electronic properties of the three compound derivatives and to assess their potential as corrosion inhibitors.

Results:

Analysis of the frontier molecular orbitals (HOMO and LUMO), the energy gap, and the electronic distribution allowed us to investigate their molecular reactivity and identify structural features likely to promote interactions with a metal surface. The results indicate that the three derivatives display electronic properties of interest for developing new corrosion inhibitors.

Conclusion:

This study highlights the value of combining click-chemistry synthesis of functionalized acetophenone derivatives with DFT modeling for an initial evaluation of their anticorrosion potential.

Key words: *1,2,3-Triazole, Click chemistry, DFT, Frontier molecular orbitals, Corrosion inhibitors*

References:

[1] M. Hrimla, L. Bahsis, M. R. Laamari, M. Julve, and S.-E. Stiriba, "An overview on the performance of 1,2,3-triazole derivatives as corrosion inhibitors for metal surfaces," Int. J. Mol. Sci., vol. 23, no. 1, Art. no. 16, 2022, DOI: 10.3390/ijms23010016

[2] S. Echihi, N. Benzbiria, M. E. Belghiti, M. El Fal, M. Boudalia, E. M. Essassi, A. Guenbour, A. Bellaouchou, M. Tabyaoui, and M. Azzi, "Corrosion inhibition of copper by pyrazole pyrimidine derivative in synthetic seawater: Experimental and theoretical studies," Mater. Today: Proc., [vol., pp., year], DOI: 10.1016/j.matpr.2020.09.264

[3] K. Belal, A. H. El-Askalany, E. A. Ghaith, and A. F. S. Molouk, "Novel pyrazole-clubbed triazole scaffolds as promising inhibitors for carbon steel corrosion in sulfuric acid and as antibacterial agents: Electrochemical and computational evaluation," BMC Chem., [vol., Art. no.], Jan. 2026, DOI: 10.1186/s13065-025-01704-x.

Biohydrogels as Smart Platforms for Sustainable Corrosion Protection: Stimuli-Responsive Inhibitor Delivery, Self-Healing and Molecular Modeling

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Abstract

Corrosion of metallic materials remains a major technological and economic challenge, motivating the development of sustainable, adaptive, and multifunctional protection strategies. Biohydrogels, owing to their biodegradability, biocompatibility, high water-retention capacity, tunable network structure, and ability to incorporate active compounds, are emerging as promising platforms for advanced corrosion protection. This review critically examines their potential as smart systems for controlled and stimuli-responsive delivery of environmentally friendly corrosion inhibitors.

Particular attention is given to biohydrogels derived from natural polymers, including chitosan, alginate, cellulose, gelatin, and starch, as well as their hybrid and nanocomposite architectures. The influence of pH, ionic species, redox conditions, temperature, and local damage on hydrogel swelling, network rearrangement, and inhibitor release is discussed in relation to corrosion-relevant environments. The integration of self-healing functionality is further considered as an approach for restoring protective performance following coating damage and prolonging service life.

The review also highlights the potential of molecular modeling, including density functional theory and molecular dynamics simulations, to elucidate inhibitor–hydrogel interactions, diffusion processes, adsorption on metallic surfaces, and structure–property relationships.

Emerging opportunities for artificial intelligence and machine learning are discussed for predicting inhibitor performance and guiding the rational design of responsive biohydrogel systems. Overall, biohydrogels represent a promising bridge between green chemistry, smart materials, and corrosion science, offering new opportunities for adaptive and sustainable corrosion protection.

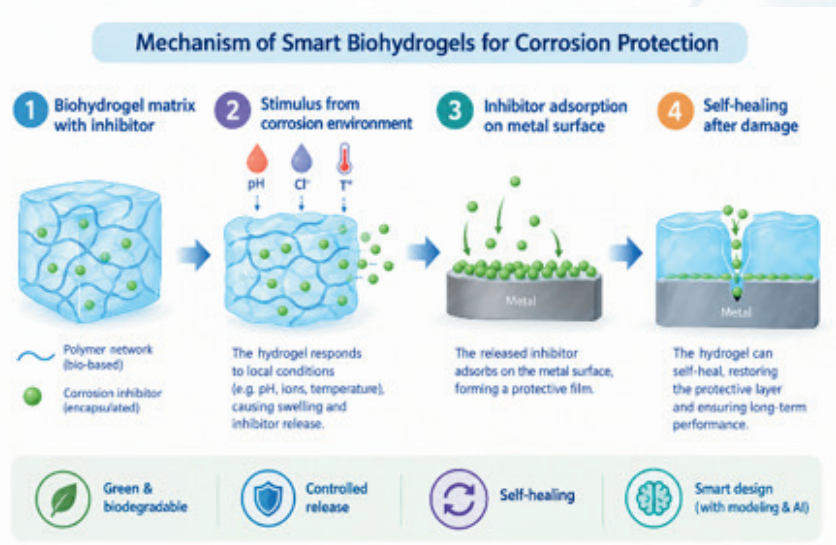


Figure 1: *Mechanism of Smart Biohydrogels for Corrosion Protection*

Key words: *Biohydrogels, Smart corrosion inhibitors, Stimuli-responsive materials, Self-healing, Green corrosion protection, Molecular modeling, Artificial intelligence.*

In Silico Approaches for Antimicrobial Discovery Against Foodborne Bacterial Pathogens

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Abstract

Background / Introduction:

Antimicrobial resistance (AMR) among foodborne bacterial pathogens poses an increasing threat to public health, reducing the effectiveness of existing treatments and emphasizing the urgent need to identify novel antimicrobial agents. In this context, computational approaches provide valuable tools for exploring structure-activity relationships and identifying promising compounds targeting bacterial virulence-associated proteins.

Methods:

In this study, an integrated computational workflow combining three-dimensional quantitative structure-activity relationship (3D-QSAR) modeling, molecular docking, molecular dynamics (MD) simulations, and absorption, distribution, metabolism, excretion, and toxicity (ADMET) predictions was employed to identify and prioritize potential antimicrobial candidates. The 3D-QSAR model was developed to investigate the relationship between molecular structural features and biological activity, and its predictive performance was evaluated through statistical validation. Molecular docking was subsequently performed to characterize the predicted binding interactions between selected compounds and the target protein. MD simulations were conducted to assess the dynamic stability of the resulting protein-ligand complexes, while ADMET analysis was used to evaluate the predicted pharmacokinetic and toxicity profiles of the selected candidates.

Results:

The developed 3D-QSAR model exhibited satisfactory statistical performance and predictive potential, supporting the identification of promising compounds. Molecular docking predicted favorable binding interactions with the target protein, while MD simulations provided further insights into the stability of the protein–ligand complexes. Additionally, ADMET predictions indicated favorable pharmacokinetic properties, with no major toxicity alerts identified by the computational models.

Conclusion:

Overall, these findings highlight the value of integrating complementary computational approaches for the identification and prioritization of potential antimicrobial agents targeting bacterial virulence-associated proteins. Nevertheless, further experimental investigations are essential to validate the predicted biological activities and assess the therapeutic potential of the identified candidates against foodborne bacterial pathogens.

Key words: *Antimicrobial resistance, Foodborne bacterial pathogens, 3D-QSAR, Molecular docking, Molecular dynamics simulations, ADMET prediction.*

References:

Moussaoui, M., Baammi, S., Baassi, M., Kerraj, S., Soufi, H., Rachdi, Y., El Idrissi, M., Salah, M., Belghiti, M.E., Rachid, D. and Belaaouad, S. (2026). International Journal of Molecular Sciences, 27(2), p. 1050. https://doi.org/10.3390/ijms27021050

Circular Valorization of Medicinal and Aromatic Plant Residues into Functional Biopolymers: Green Extraction, Multi-Scale Characterization, and Emerging Applications

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Abstract

Background / Introduction:

There is global interest in aromatic and medicinal plants due to their richness in bioactive compounds; however, their processing, particularly after essential-oil extraction generates a quantity of solid and liquid residues, which are considered waste. The recycling and valorization of these residues represent a promising approach for recovering valuable biomolecules and producing high-value-added natural polymers.

This study focuses on recent developments in innovative green extraction techniques, characterizations, and transformation of medicinal and aromatic plant residues into value-added biopolymers, with particular emphasis on circular valorization strategies.

Methods:

Scientific articles were collected from major databases: Scopus, ScienceDirect, and Google Scholar.

Keywords used included: “Aromatique and medicinal plant residues”, “biopolymers extraction”, “green extraction”, “microwave-assisted extraction”, “ultrasound-assisted extraction”, “enzyme-assisted extraction”, and “pressurized liquid extraction”.

Recent peer-reviewed articles published mainly between 2016-2026 were selected.

Articles were screened based on: relevance to aromatic and medicinal plant residues and biopolymer extraction, extraction efficiency, environmental sustainability, and industrial applicability.

Results:

The reviewed studies show that residues from medicinal and aromatic plants can be effectively converted from underutilized by-products into high-value biopolymer resources.

Green extraction techniques offer the potential to recover functional compounds while improving the utilization of lignocellulosic fractions. Particular attention is given to multi-scale characterization of the structure, mechanical properties, and functionality of derived biopolymers, which will be optimized for different applications including packaging, biomedical, and electronic sectors.

Conclusion:

The study highlights the potential of aromatic and medicinal plant residues as valuable resources through the integration of green extraction, advanced characterization, and the development of biopolymers for applications in various sectors.

Key words: *Aromatic and medicinal plant residues, biopolymers, green extraction, multi-scale characterization, Circular Bioeconomy.*

Graphical Abstract



Substituent-Driven Modulation of Electronic Structure and Reactivity in Pyrrole-Based Propanoic Acid Derivatives: A DFT Insight

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Abstract

Background / Introduction:

Understanding how substituent groups influence molecular electronic structure is essential for designing functional organic materials. Pyrrole-based propanoic acid derivatives represent promising candidates for molecular electronics due to their tunable electronic properties. This study aims to elucidate the role of substituent effects on the physicochemical and reactive behavior of these systems using a theoretical approach.

Methods:

Density Functional Theory (DFT) calculations were performed at the B3LYP/6-311++G(d.p) level. Frontier molecular orbitals (HOMO–LUMO), global reactivity descriptors (chemical hardness, softness, and electrophilicity), and electronic structure analyses were used to evaluate substituent influence.

Results:

The results reveal a strong dependence of electronic properties on substituent nature. The P3YPP-PA derivative exhibits the lowest HOMO–LUMO gap (5.80 eV), indicating higher chemical reactivity and enhanced intramolecular charge transfer. Conceptual DFT descriptors confirm that electron-donating and electron-withdrawing groups significantly modulate molecular stability and reactivity.

Conclusion:

This study demonstrates that substituent engineering is an effective strategy for tuning electronic properties in pyrrole-based systems. The findings highlight their potential applications in molecular electronics and advanced functional materials.

Key words: *Density Functional Theory, HOMO–LUMO Gap, Chemical Reactivity, Substituent Effects, Molecular Electronics.*

Valorization of Hydroxyapatite-Based Photocatalysts for the Visible-Light Degradation of Organic Textile Pollutants

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Abstract

Background / Introduction:

The valorization of waste into high-value materials is an attractive approach for developing sustainable solutions to environmental challenges. In this context, hydroxyapatite has gained interest due to its potential for environmental applications. This study investigates the valorization of waste-derived hydroxyapatite and its potential application in the photocatalytic degradation of organic pollutants generated by the textile industry.

Methods:

The obtained hydroxyapatite was characterized by X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), Raman spectroscopy, and scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDX). Photoluminescence (PL) analysis was also performed to investigate its optical properties. The photocatalytic activity of the hydroxyapatite was evaluated through the degradation of representative textile dyes under light irradiation.

Results:

The characterization analyses confirmed the structural, morphological, chemical, and optical properties of the hydroxyapatite. XRD confirmed its crystalline structure, while FTIR and Raman spectroscopy revealed its characteristic chemical bonds. SEM-EDX provided information on the morphology and elemental composition of the material. The photocatalytic tests demonstrated that the valorized hydroxyapatite exhibits promising activity toward the degradation of organic textile pollutants.

Conclusion:

The results highlight the potential of waste-derived hydroxyapatite as a valorized material for environmental applications. Its photocatalytic performance demonstrates its potential for the treatment of water contaminated with organic pollutants from the textile industry, contributing to the development of sustainable wastewater treatment approaches.

Key words: *Hydroxyapatite, Waste valorization, Photocatalysis, Textile pollutants, Organic dyes, Wastewater treatment.*

In Silico Screening and Optimization of Multi-Target Inhibitors for Neurodegenerative Disorders

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Abstract

Background / Introduction:

Neurodegenerative disorders are progressive conditions characterized by neuronal loss and neurotransmitter imbalance, in which cholinesterases are established therapeutic targets. The limited efficacy of single-target agents has intensified interest in multi-target strategies. This study assessed a focused library of hybrid derivatives as dual-target inhibitors.

Methods:

3D-QSAR models were built using Comparative Molecular Field Analysis (CoMFA) and Comparative Molecular Similarity Indices Analysis (CoMSIA), with molecules aligned to the lowest-energy conformer of the most active compound. Contour maps, molecular docking and molecular dynamics simulations were used to identify key binding interactions and conformational stability. Sixteen newly designed candidates were evaluated for drug-likeness and ADMET properties.

Results:

The optimized models showed strong statistical performance: R^2 = 0.984 and 0.988 (CoMFA) and 0.979 and 0.982 (CoMSIA), Q^2 = 0.712 and 0.734, and external R^2pred = 0.941 and 0.956. Contour maps revealed the key structural determinants of target affinity, while docking and dynamics clarified critical binding interactions under physiological conditions. A lead compound emerged with markedly enhanced dual-target potency and favorable brain penetration.

Conclusion:

This integrated framework accelerates the rational design of multi-target compounds for neurodegenerative disorders. The computational insights also provide a basis for incorporating optimized candidates into biomaterial-based delivery systems, such as hydrogel platforms, to enhance targeted therapeutic performance.

Key words: *3D-QSAR, CoMFA, CoMSIA, cholinesterase inhibitors, molecular docking, ADMET*

The development of natural deep eutectic solvent-mediated rice husk lignin-based hydrogels and biofilms for wound healing applications

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Abstract

Background / Introduction:

Lignin is a renewable biopolymer with antioxidant and antimicrobial properties, making it promising for biomedical applications. Rice husk, an agricultural abundant by-product, represents a valuable source of lignin. However, its poor solubility and limited processability restrict its use in hydrogels and biofilms. Natural deep eutectic solvents (NADES) offer a sustainable approach to improving lignin solubility and facilitating the development of functional biomaterials for wound healing.

Methods:

Lignin was extracted from rice husk using a two-step process involving alkaline and mild hydrogen peroxide treatments. Different NADES formulations and concentrations were investigated to improve lignin solubility. Sodium carboxymethyl cellulose (CMC-Na, 2-3 wt%) was used for biofilms, while polyvinyl alcohol (PVA, 8 wt%) was employed for hydrogels. NADES functioned as a plasticizer and cross-linking agent. The resulting materials were evaluated for their structural, thermal, swelling, surface, and mechanical properties.

Results:

NADES incorporation improved lignin solubility to approximately 20 mg/mL, enabling the preparation of homogeneous hydrogels and biofilms. The resulting materials exhibited enhanced flexibility, improved mechanical stability, and water stability for up to 24 hours compared with untreated lignin formulations. They also showed promising antioxidant properties and approximately 70% bacterial inhibition, supporting their potential for wound dressing applications.

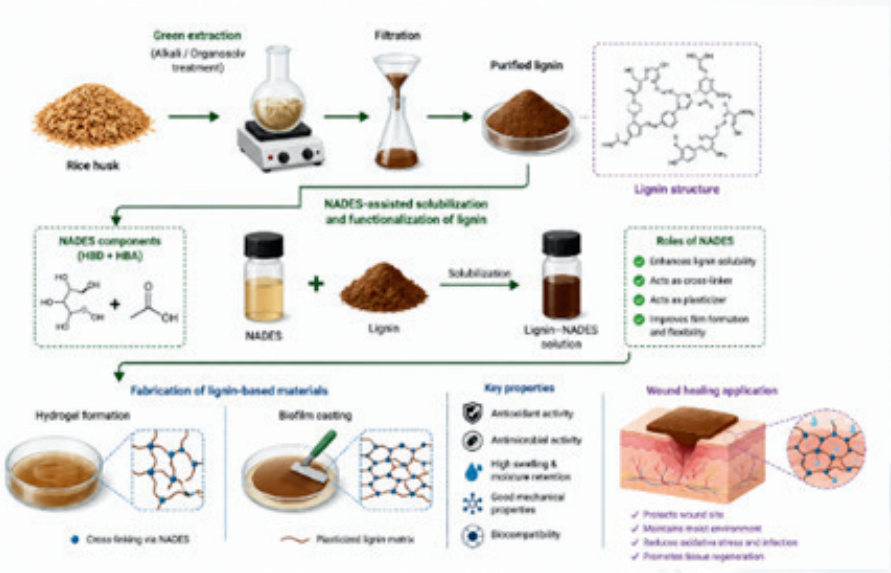


Figure 1: *Schematic diagram of rice husk lignin extraction and NADES-assisted fabrication of hydrogels and biofilms for wound healing.*

Conclusion:

NADES-assisted processing provides a promising green process for incorporating rice husk-derived lignin into functional hydrogels and biofilms. The improved solubility, mechanical properties, and antioxidant and antibacterial performance highlight the potential of these agricultural waste-derived materials for sustainable wound dressings. Further biocompatibility and wound healing studies are needed to assess their practical biomedical applications.

Key words: *Rice husk lignin, Natural Deep Eutectic Solvents (NADES), Hydrogels, Biofilms, Wound healing, Biomedical applications.*

Eco-Friendly Lignin-Chitosan Hydrogels as Green Coatings for Slow Phosphorus Release Fertilizers and Enhanced Wheat Growth

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Abstract

Background / Introduction:

Conventional phosphorus (P) fertilizers dissolve rapidly, causing nutrient losses and low uptake. Eco-friendly hydrogel coatings were developed by physical crosslinking (electrostatic interactions and hydrogen bonding, no chemical crosslinker) of lignosulfonate (SLS, a lignin by-product), chitosan (Cs) and polyvinyl alcohol (PVA) to slow P release from triple superphosphate (TSP). Formulations with different SLS contents were characterized, and P release in water and soil and wheat growth were evaluated.

Plants absorb only 10-20% of fertilizer P; the rest is lost through soil fixation, leaching and runoff, harming ecosystems. Slow-release fertilizers (SRFs) coated with biodegradable; biomass-derived polymers are a promising solution. Hydrogels are effective coatings thanks to their water-retaining 3D networks, but chemical crosslinking relies on fossil-based reagents; physical crosslinking is a simpler, non-toxic, waterborne alternative. This work investigates Cs/SLS/PVA hydrogels as TSP coatings.

Methods:

Hydrogels were prepared from Cs, PVA and SLS (12, 25 and 50 wt% relative to Cs; CsxSLS). Films were characterized (FTIR, XRD, SEM-EDX, contact angle, zeta potential, TGA, mechanics) and the solutions used to coat TSP granules. P release in water and soil (UV-Vis), water retention, biodegradability and wheat growth were assessed.

Results:

Hydrogels form through electrostatic complexation between Cs NH_3^+ and SLS SO_3^- groups, reinforced by hydrogen bonding with PVA. Incorporating SLS stabilise the hydrogel network, reduced hydrophobicity, and swelling (323 to 11 g/g).

In soil, coatings reduced P release by 33-53% (Figure 1), and increased water retention by up to 8%. After 60 days of wheat cultivation, coated TSP improved wheat performance compared with uncoated TSP, doubling chlorophyll content, increasing leaf area by 54% and shoot dry weight by 23%, while enhancing available soil P by 55%. Moderate SLS contents (12-25%) provided the best overall balance, whereas 50% SLS achieved the slowest P release but resulted in a less favorable agronomic response.

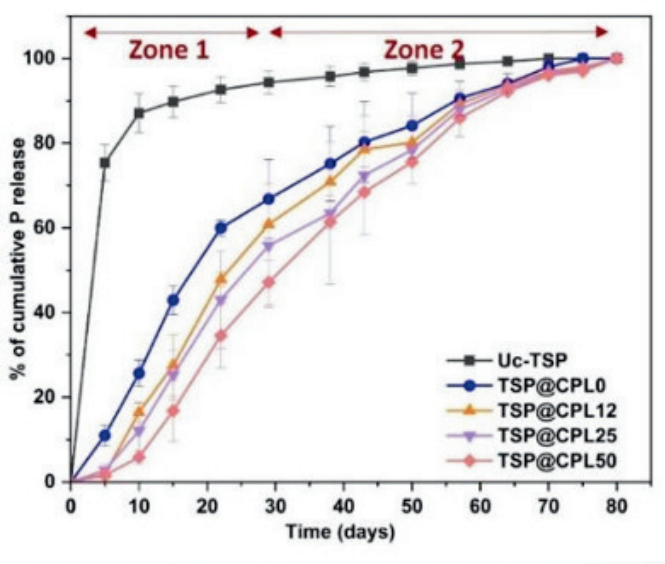


Figure 1: *The cumulative P released in soil*

Conclusion:

Physically crosslinked Cs/SLS/PVA hydrogels valorizing lignin are effective biodegradable coatings for slow-release P fertilizers. Moderate SLS contents (12-25%) improved P availability, water retention and wheat growth, whereas 50% was detrimental, probably due to the sodium counterion.

Key words: *Sodium lignin sulfonate, biopolymers, physical hydrogel, slow release, water retention, Wheat growth.*

Natural Polymer-Based Biomimetic and Bioactive Hydrogels for Tissue Engineering and Drug Delivery

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Abstract

Background / Introduction:

There is a significant need for the development of functional biomimetic and bioactive scaffolds in Tissue Engineering (TE). Natural polymers mimic the natural extracellular matrix (ECM) of tissues. Therefore, there is an increasing demand to explore them in the Tissue Engineering and Regenerative Medicine fields. Natural materials primarily offer lightness, strength, and flexibility. Natural materials share a hybrid structure, comprising soft and hard portions, ordered hierarchically, as in pearls, bone, and silk. In biomimetic TE scaffolds, natural polymers are integrated with bioactive ceramics and nanoparticles.

Hydrogels are crosslinked polymers resembling ECM with a water-abundant porous structure and elasticity. High swelling capacity and biodegradation properties of natural polymer-based hydrogels make them great candidates for drug delivery systems. The functionally designed bioinspired composite hydrogels with drug delivery systems in TE not only provide structural integrity but also combat bacterial infections for treatment efficiency.

Methods:

The main objective of this study is to elucidate studies on various natural polymer-based hydrogels made of dual combinations of alginate, chitosan, silk fibroin and sericin. The crosslinking of hydrogels is mainly based on freeze gelation and freeze thawing techniques, leading to porous scaffolds.

Results:

Alginate-matrixed hydrogels integrated with pumice-enriched hydroxyapatite bioceramics and loaded with an antibiotic showed improved biomineralization, in-vitro cytocompatibility and bioactivity with antibacterial properties for bone regeneration.

Alginate and sericin-based hydrogel scaffolds loaded with nanoparticles possessed porous, elastic properties and supported wound healing in-vitro.

Silk fibroin and chitosan-based hydrogel scaffolds loaded with an antibiotic were investigated as wound dressings. They showed high cell viability and proliferation, and wound healing capacity in-vitro. The potential pro-angiogenic properties are being investigated.

Conclusion:

In conclusion, the biomimetic design of TE scaffolds based on natural polymers integrated with bioactive ceramics and drugs provides significant potential in terms of high biocompatibility, wound healing capacity and antibacterial properties for regeneration of tissues.

Key words: *biomaterials, biomimetic, hydrogels, natural polymers, drug delivery, Tissue Engineering*

TiO_2/sodium alginate hydrogel as photobiocomposite beads for removal of organic dyes in wastewater

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Abstract

This study reports the preparation and detailed characterization of eco-friendly photobiocomposite beads, titanium (IV) oxide/iron alginate (TiO_2/FeAlg), and examines their effectiveness for Rhodamine B photocatalytic degradation using sunlight as a renewable energy source. Chemical and physical characteristics of pure TiO_2, FeAlg, and FeAlg@TiO_2 beads were investigated using UV–visible diffuse reflectance spectra (UV–Vis DRS), scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR), photoluminescence spectroscopy (PL), thermogravimetry (TGA), derivative thermogravimetry (DTG), and differential scanning calorimetry (DSC) analysis. In this study, the emphasis on immobilizing TiO_2 photocatalyst into an alginate biopolymer matrix and the photobiocomposite beads, exhibits a porous structure, an exceptional surface area, and a smaller band gap due to the presence of iron nanoparticles that could also maintain e−/hole separation for better photocatalytic activity under visible light.

Background / Introduction:

Wastewater treatment is considered an important environmental issue due to climate change and the growth of population. Renewable solar energy to promote organic pollutant degradation technology, especially is a promising when combining semiconductor and solar energy, known as photocatalysis. However, photocatalyst powder recovery is considered a major challenge. Immobilizing photocatalysts within a biopolymer matrix provides a potential solution. This study investigates Fe-crosslinked alginate beads and photobiocomposite beads, FeAlg@TiO_2, for the degradation of RhB as a model dye under sunlight.

Methods:

FeAlg and FeAlg@TiO_2 beads were prepared using a physical ionic crosslinking method using sodium alginate as a green support for incorporation of TiO_2 and iron as crosslinked agent to obtain photobiocomposite beads .

Results:

The FeAlg beads achieved approximately 72% RhB removal after 210 min, whereas the FeAlg@TiO_2 photobiocomposite beads achieved approximately 69% removal after 90 min under the investigated experimental conditions. These results demonstrate the potential of alginate-based materials for solarassisted dye removal and highlight the promise of TiO_2 immobilization for developing recoverable photocatalytic systems. Further investigation of degradation kinetics and material reusability would help establish their potential for practical wastewater treatment

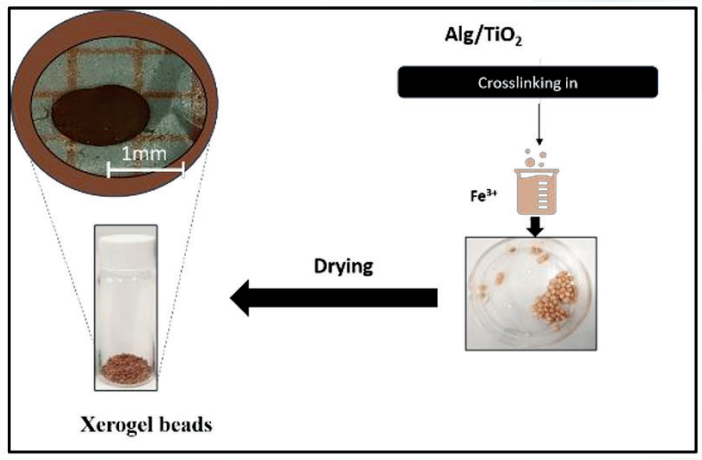


Figure 1: *Synthesis procedure for FeAlg and FeAlg@TiO_2 beads*

Conclusion:

FeAlg and photobiocomposite FeAlg@TiO_2 xerogel and hydrogel beads demonstrate promise for RhB degradation under sunlight. The incorporation of TiO_2 oxide into the alginate biopolymer matrix. These findings are considered sustainable and eco-friendly for wastewater applications.

Key words: *FeAlg beads; TiO_2 immobilization; Solar photocatalysis; Wastewater treatment.*

Abstracts
(Poster Presentations)

Advanced Hydrogel Composites for Bone Additive Manufacturing

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Abstract

Background / Introduction:

Critical bone defects resulting from surgical resection, trauma, or congenital malformations remain a major clinical challenge. Conventional autologous bone grafts are associated with complications, including donor-site morbidity and limited availability, highlighting the need for biocompatible, resorbable, and personalized implants.

Three-dimensional (3D) printing has emerged as a promising strategy for fabricating biomimetic constructs owing to its controllability, versatility, and reproducibility. Compared with conventional processing approaches such as direct injection, extrusion-based 3D printing enables the production of scaffolds with controlled porosity and pore interconnectivity, thereby supporting bioactive-molecule diffusion, in vivo cell attachment, and angiogenesis. It also permits tuning of scaffold mechanical properties, such as stiffness and elasticity, to match bone-regeneration requirements. Hydrogel composites are increasingly recognized as a new generation of biomaterials for bone tissue engineering because they combine the hydrated, flexible polymeric network of hydrogels with the mechanical reinforcement and biological activity provided by inorganic phases, typically calcium phosphate ceramics.

In this study, composites combining a dual-network hydrogel with biphasic calcium phosphate (BCP) particles were developed and characterized as biomaterial-inks for 3D printing and bone tissue engineering.

Methods:

The hydrogel formulation comprised a physically crosslinked chitosan-based hydrogel, providing shear-thinning behavior and printability, mixed with a chemically crosslinked silanized hydroxypropyl methylcellulose (Si-HPMC) hydrogel, ensuring post-printing stability and structural integrity. Various architectures were fabricated by extrusion-based 3D printing to evaluate printability and structural fidelity. Mechanical performance was assessed by measuring flexural stress and strain at fracture and determining the elastic modulus. Composite stability and cytocompatibility were also evaluated to determine their functional suitability for bone-defect regeneration.

Results

The developed BCP-reinforced dual-network hydrogels demonstrated printability and the ability to maintain structural fidelity after extrusion-based printing. Mechanical characterization provided quantitative information on flexural stress, strain at fracture, and elastic modulus, reflecting the resistance of the composites under load. Stability and cytocompatibility analyses further supported the potential of these materials for use in bone tissue engineering.

Conclusion:

This study presents BCP-reinforced dual-network hydrogel composites as promising biomaterial-inks for extrusion-based 3D printing. By integrating printability, structural stability, tunable mechanical performance, and cytocompatibility, these composites may facilitate the development of personalized scaffolds for bone-defect regeneration.

Key words: *Bone regeneration, 3D printing, hydrogels, biocomposites*

Multifunctional ZnAl-LDH-GA and MgAl-LDH-GA Bioactive Composites with Controlled Gallic Acid Release and Therapeutic Activities for Advanced Wound Healing

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Abstract

Background / Introduction:

Layered double hydroxides (LDHs) have gained significant attention in biomedical applications due to their tunable layered structure, biocompatibility, and ability to incorporate and protect bioactive molecules. In wound healing, oxidative stress, inflammation, and microbial infections are major factors that can delay tissue regeneration, highlighting the need for multifunctional biomaterials with antioxidant, anti-inflammatory, antimicrobial, and controlled drug delivery properties. Gallic acid (GA), a natural phenolic compound, was selected as an active molecule due to its well-established antioxidant, antimicrobial, and anti-inflammatory properties. This study aims to develop ZnAl-LDH and MgAl-LDH systems intercalated with gallic acid as potential multifunctional materials for wound healing applications, providing both biological activity and controlled GA release.

Methods

ZnAl-LDH-GA and MgAl-LDH-GA composites were synthesized by incorporating gallic acid into LDH matrices through a coprecipitation method at constant pH. The obtained materials were characterized using X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), and scanning electron microscopy (SEM) to confirm structural formation, chemical interactions, thermal stability, and morphology. The release behavior of gallic acid from LDH matrices was evaluated to investigate their drug delivery potential. Biological properties were assessed through antioxidant, antimicrobial, and anti-inflammatory activity assays.

Results

XRD, FTIR, TGA, and SEM analyses confirmed the successful formation of ZnAl-LDH and MgAl-LDH structures and the incorporation of gallic acid within the layered matrices. Morphological analysis revealed characteristic organized layered structures of LDH materials, while thermal analysis demonstrated the stability of the synthesized composites. The ZnAl-LDH-GA and MgAl-LDH-GA systems exhibited controlled release of gallic acid, demonstrating their potential as bioactive delivery platforms. The composites showed significant antioxidant activity, antimicrobial effects against pathogenic microorganisms, and anti-inflammatory potential, attributed to the presence of gallic acid and the properties of the LDH carriers.

Conclusion:

The developed ZnAl-LDH-GA and MgAl-LDH-GA composites represent promising multifunctional biomaterials combining controlled bioactive molecule delivery with antioxidant, antimicrobial, and anti-inflammatory activities. Their physicochemical stability and biological performance support their potential application in advanced wound dressings and regenerative medicine strategies. Further investigations involving cytocompatibility studies and integration into polymeric scaffolds will contribute to their translation toward clinically relevant wound healing systems.

Key words: *Layered double hydroxides, gallic acid, controlled drug release, antioxidant activity, antimicrobial activity, wound healing*

Cannabinoid-Loaded Eutectogels Derived from Deep Eutectic Solvents for 3D-Printed Wound Dressing Applications

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Abstract

Background / Introduction:

Natural deep eutectic solvents (DES) are increasingly recognized as multifunctional systems that can serve both as extraction media and as integral components of soft biomaterials. Concurrently, bioactive compounds from Cannabis sativa, particularly cannabinoids, are being investigated for their antioxidant and regenerative effects in wound healing. Combining these approaches enables the development of advanced therapeutic materials with enhanced functionality.

Methods

In this work, a choline chloride–allantoin DES was employed for the extraction of cannabinoids and subsequently utilized in the preparation of eutectogel-based wound dressings. Process parameters were optimized using a Design of Experiment (DoE) strategy, applying a Box–Behnken model to evaluate the influence of extraction time, temperature, and water content. Cannabinoid content was determined by high-performance liquid chromatography (HPLC).

Results

The optimized extraction system provided effective recovery of cannabinoids while maintaining the environmentally favorable profile of the DES. The obtained extracts exhibited strong antioxidant activity across multiple assays (DPPH, ABTS, CUPRAC, FRAP). Notably, in vitro scratch assays demonstrated that extracts obtained using the DES significantly enhanced wound closure compared to both untreated controls and the DES system alone, indicating a synergistic effect of the extracted bioactive compounds.

The DES-based extract was directly incorporated into a polymer network to form eutectogels, yielding homogeneous materials with suitable viscoelastic properties for extrusion-based 3D printing. The resulting constructs showed high structural fidelity and reproducibility. Drug release studies performed using Franz diffusion cells revealed distinct release profiles depending on the formulation.

Conclusion:

This study demonstrates a dual-function approach in which DES acts as both an extraction medium and a structural component of eutectogels. The integration of sustainable extraction, bioactive performance, and tunable release behavior highlights the potential of these systems as next-generation, customizable wound dressing materials.

Key words: *Natural deep eutectic solvents, Cannabinoids, Eutectogels, Wound healing, 3D printing*

Design of a Collagen–Alginate Interpenetrating 3D Biomatrix for In Vitro Cell Culture

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Abstract

Three-dimensional (3D) biomatrices are promising platforms for in vitro cell culture because they reproduce mimic key features of the native extracellular matrix (ECM) and provide a supportive microenvironment for cellular functions. However, single-polymer hydrogels rarely combine bioactivity with mechanical stability. Collagen offers cell-adhesive motifs and structural similarity to the native ECM, but it is mechanically weak and prone to degradation and contraction in culture, whereas alginate offers tunable ionic gelation and structural support but lacks intrinsic cell-adhesion sites. This work proposes a literature-guided design for a collagen–alginate interpenetrating polymer network (IPN) intended for in vitro 3D cell culture, in which each component compensates for the limitations of the other. The design is based on a critical analysis of the literature and focuses on biomaterial selection, hydrogel formulation, and scaffold architecture, considering key parameters such as mechanical properties, porosity, and biocompatibility. These parameters will guide the future optimization of the biomatrix to support cellular viability and functionality. This conceptual approach provides a foundation for subsequent experimental fabrication and characterization.

Background / Introduction :

Three-dimensional (3D) biomatrices are promising platforms for in vitro cell culture because they mimic key features of the native extracellular matrix (ECM) and support cellular functions. Natural polymers are particularly attractive for this purpose because of their biocompatibility and tunable physicochemical properties. However, single-polymer hydrogels rarely combine bioactivity with mechanical stability. Collagen provides cell-adhesive motifs but is mechanically weak, whereas alginate provides tunable gelation and structural support but lacks cell-adhesion sites. Combining them in an interpenetrating network is therefore a rational strategy, which this work examines through a literature-guided design.

Approach:

A literature-guided approach was used to define the design of a collagen–alginate interpenetrating 3D biomatrix for in vitro cell culture. Published studies on collagen, alginate and their composite hydrogels were analyzed to guide biomaterial selectuion, .hydrogel formulation, and the design of a 3D scaffold architecture suitable for cellular encapsulation and culture.

Collagen was selected for its cell-adhesive motifs and ECM-like properties, while alginate was selected to provide structural stability and controllable gelation. Mechanical properties, porosity, and biocompatibility were considered as key design parameters to ensure a physiologically relevant microenvironment.

Proposed design:

The analysis supports a design in which collagen and alginate form complementary networks, expected to balance bioactivity and mechanical integrity. This proposed system is intended to provide a stable and biologically relevant microenvironment for 3D cell culture. These expected properties remain to be confirmed experimentally.

Conclusion:

This work outlines a rational, literature-based design for a collagen–alginate interpenetrating 3D biomatrix for in vitro cell culture. It defines the framework for future experimental fabrication, characterization and optimization of the biomatrix.

Key words: *Collagen, Alginate, 3D Biomatrix, Hydrogel, Interpenetrating Polymer Network, Extracellular Matrix, In Vitro Cell Culture*

Elaboration characterization and investigation of advanced composites as some anticorrosion protection coatings for H13 steel surface in 1M HCl solution: Comprehensive approaches

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Abstract

Background / Introduction:

H13 steel surface material occupies an important place in various industrial fields, including petrochemicals, power generation and transportation, chemical processing, automobile, construction, and maritime. The cured epoxy composite coatings are the one of the most frequently employed methods of protection, characterization by ease of use, relatively low cost, and the reduction of corrosion rate. Besides, the properties of three-dimensional network cured composite coatings and its derivatives are interesting due to the presence of several heteroatoms in their structures, these heteroatoms can be associate with electrons on the metallic substrates area, by creating a stable covalent bond that prevent corrosion processes.

Methods

Two composite coatings were elaborated based trifunctional epoxy resin (ERT) as a matrix, diaminobiphenyl (DABP) as a curing agent, and titanium dioxide (TiO_2) as a reinforcing filler. These composites were characterized by using FTIR, XRD, SEM, EDS, and AFM.

Results

The anticorrosion protection efficiencies of 95.93% (PDP), and 95.44% (EIS) was recorded for composite formulated by TiO_2 (ERT/DABP/TiO_2). The main findings of the incorporation of TiO_2 in the elaborated composite is considered responsible for the best adherence protective coating formed onto H13 steel surface. Electrochemical studies showed that the incorporation of TiO_2 significantly reduced the corrosion current density from 2330.507 (H13 steel alone) to 94.799 µA/cm². SEM investigation was involved to outline the degradation of H13 steel surface when subjected to elaborated composites.

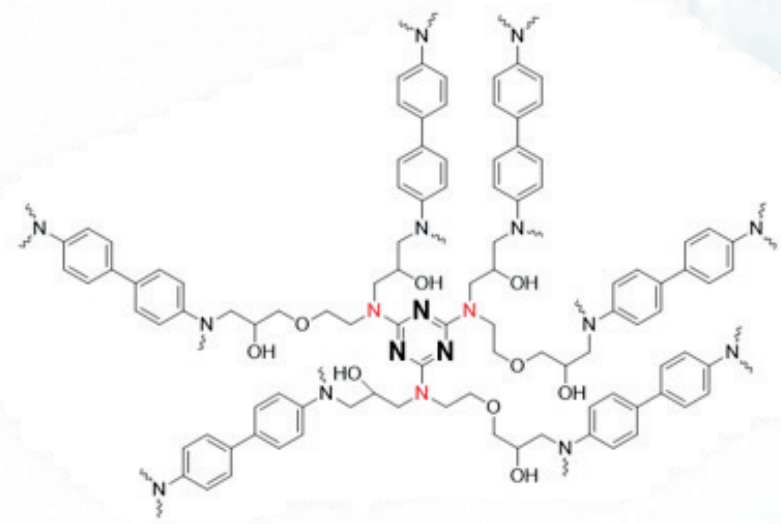


Figure 1: *Structure of cured epoxy composite ERT/DABP*

Conclusion:

This study demonstrates a dual-function approach in which DES acts as both an extraction medium and a structural component of eutectogels. The integration of sustainable extraction, bioactive performance, and tunable release behavior highlights the potential of these systems as next-generation, customizable wound dressing materials.

Key words: *Natural deep eutectic solvents, Cannabinoids, Eutectogels, Wound healing, 3D printing*

A multifunctional hydrogel for integrated regulation of phosphorus release, soil moisture, and thermal buffering in soils

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Abstract

Background / Introduction:

Approximately 70% of global freshwater is consumed in agricultural activities, yet 40-60% of applied irrigation water is lost through evaporation, deep percolation, or surface runoff before reaching the root zone. These inefficiencies occur amid intensifying global water scarcity, with an estimated 1.8 billion people living under conditions of absolute water stress. Climate change further exacerbates these challenges by increasing drought frequency, altering precipitation patterns, and reducing the reliability of conventional water supplies.

Across diverse regions in Africa, these constraints are further compounded by soil phosphorus (P) deficiency, resulting in less than 10% of applied fertilizer P becoming plant available. Climate-induced heat stress additionally disrupts root-zone nutrient uptake and microbial activity, further reducing fertilizer use efficiency.

While numerous soil amendments have been developed to improve either water retention or nutrient delivery, few technologies simultaneously address water, nutrient, and thermal limitations within a single system. This study proposes a multifunctional hydrogel platform designed to integrate controlled P delivery, soil moisture regulation, and thermal buffering for climate-resilient agriculture.

Methods

A multifunctional hydrogel composite was synthesized using a hybrid polymer network. P was incorporated directly into the matrix as a slow-release nutrient source. In addition, mineral-supported phase change materials (PCMs) were embedded to provide thermal buffering through latent heat storage and release. Preliminary characterization focused on evaluating material formation, swelling behavior as indicator of water absorption and thermal regulation capacity.

Results:

The hydrogel composite was successfully synthesized, demonstrating the feasibility of integrating P components and thermal-regulating PCMs within a single hydrogel architecture. Swelling analyses revealed a high water absorption capacity, confirming the material's strong hydration potential and suitability for soil water management applications. The successful development of this multifunctional system establishes a foundation for simultaneously targeting P availability, water conservation, and temperature regulation in agricultural soils.

Conclusion:

This work presents a novel multifunctional hydrogel designed to address three major and interconnected constraints to agricultural productivity: P limitation, water stress, and thermal stress. The successful synthesis and favorable swelling properties demonstrate the potential of this integrated approach as a next-generation soil amendment. Future studies will focus on quantifying P-release kinetics, evaluating thermal-buffering efficiency under fluctuating temperature regimes, and assessing soil-plant responses under controlled and field-relevant conditions to determine the hydrogel's capacity to enhance nutrient-use efficiency, soil resilience, and crop performance.

Key words: *Hydrogel, Phosphorus release, Water retention, Phase change materials, Soil fertility*

Microbial hyaluronic acid from rice coproducts: a promising biopolymer as hydrogel precursor

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Abstract

Background / Introduction:

To reduce Hyaluronic Acid (HA) production costs, this study validated the use of enzymatic rice syrup (XARHE), an agro-industrial coproduct, as a substitute for commercial culture media. Cultivation using ERS exclusively not only yielded the highest HA output but also maintained structural and rheological quality comparable to commercial standards, establishing it as a sustainable and highly viable alternative for biohydrogel formulation.

Biohydrogel formulation drives innovation in fields such as tissue engineering and cosmetics, creating a demand for high-performance biopolymers like microbial hyaluronic acid (mHA). While mHA offers exceptional biocompatibility and water-retention capabilities, its production is hindered by the high cost of commercial culture media, such as Brain Heart Infusion (BHI). This study aims to develop a sustainable, cost-effective synthesis strategy using XARHE as a partial or total substitute for BHI, while validating the resulting polymer's efficacy as a precursor for biohydrogels.

Methods

Following the cultivation of S. zooepidemicus, hyaluronic acid was extracted, purified, and lyophilized. To validate its application, the polymer was formulated into biohydrogels (3% w/v) and evaluated via rheological tests to confirm its structural integrity.

Results:

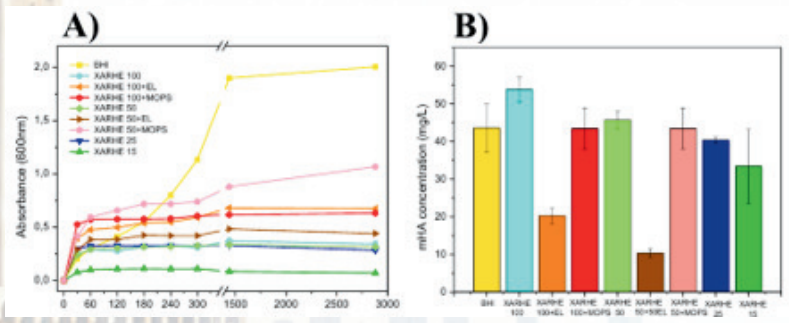


Figure 1: *(A) Growth curve of strain ATCC 39920 and (B) Hyaluronic acid quantification.*

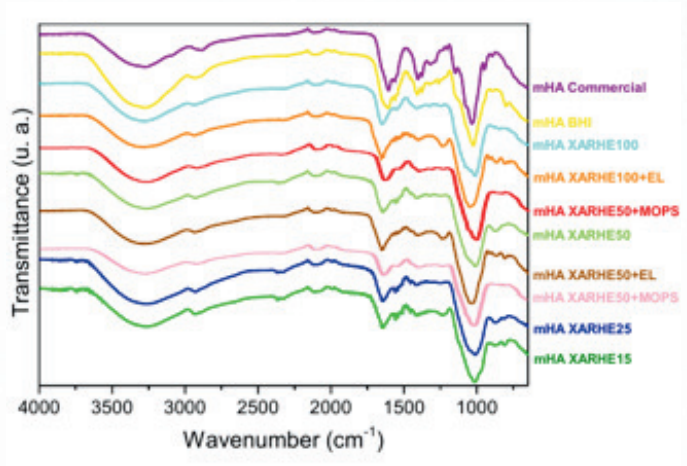


Figure 2: *FTIR spectra of the commercial HA and the synthesized samples.*

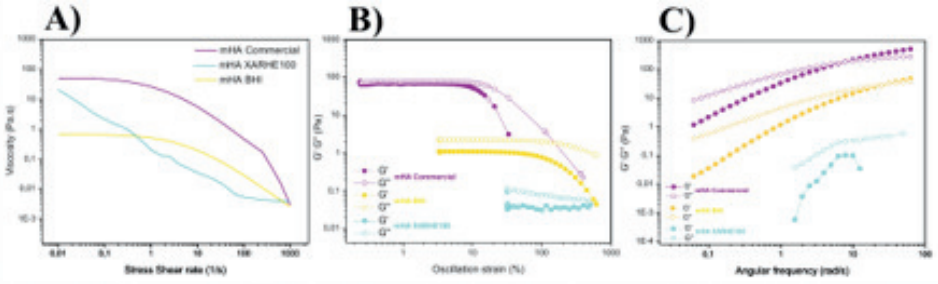


Figure 3: *(A) Viscosity profile, (B) Amplitude sweep and (C) Frequency of mHA biohydrogels.*

Conclusion:

The study concludes that XARHE is a highly effective alternative for mHA production. Formulations containing 100% and 50% XARHE yielded the highest results, outperforming the control medium. Furthermore, FTIR and rheological analyses confirmed that the synthesized material possesses a structure and performance equivalent to commercial standards, establishing the use of this agricultural by-product as a sustainable and promising strategy for creating biohydrogels.

Key words: *Streptococcus zooepidemicus hyaluronic acid, coproducts, biohydrogel.*

3D printing of hyaluronic acid–gelatin hydrogels for drug delivery applications

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Abstract

Background / Introduction:

3D printing enables personalized drug delivery through hydrogels made from natural polymers. This study developed a printable hydrogel based on hyaluronic acid, gelatin, and cellulose nanocrystals, demonstrating suitable rheological properties, accurate printability, and pseudoplastic and thixotropic behavior. Cross-linking improved the hydrogel's rheological properties and thixotropic recovery, while giving it a characteristic blue colour.
Personalized medicine and 3D printing enable customized drug delivery systems that improve treatment efficacy, safety, and adherence. Hydrogels made from hyaluronic acid and gelatin offer biocompatibility and controlled drug release but require reinforcement to improve their mechanical strength. This study aims to develop a 3D-printed drug delivery system using hyaluronic acid, gelatin, and cellulose nanocrystals, crosslinked with genipin, a natural and low-toxicity agent.

Methods



Figure 1: *Hydrogel preparation.*

Results:

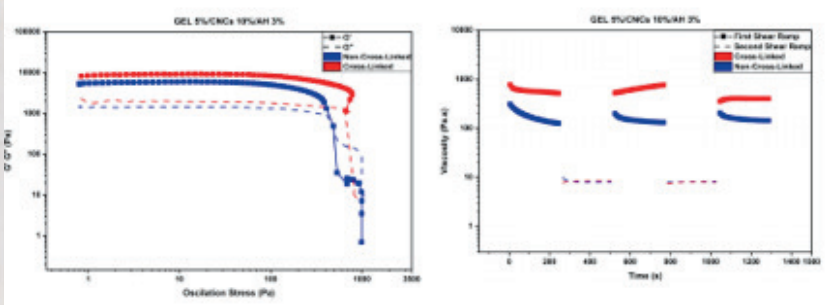


Figure 2: *Amplitude sweep and thixotropy assay of the hydrogel.*

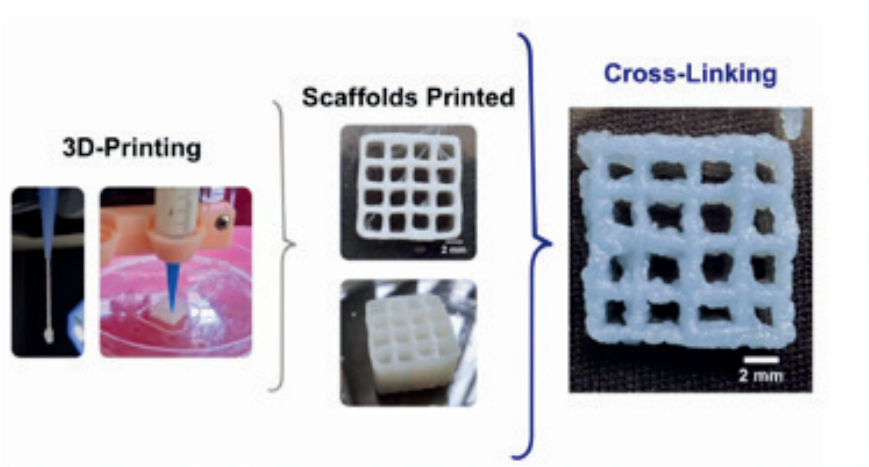


Figure 3: *Hydrogel GEL 5%/CNCs 10%/HA 3% in the 3D printing process and cross-linked*

Conclusion:

In conclusion, the factorial design identified the hydrogel formulation containing 5% GEL, 10% CNCs, and 3% HA (w/v) as the most suitable for 3D printing applications. This formulation exhibited favorable rheological properties, including a module crossover between 350 and 500 Pa and an elastic modulus (G′) above 5700 Pa. The non-crosslinked hydrogel showed a G′ of 5716.48 Pa and a yield point of 487 Pa, while crosslinking further improved its mechanical performance. Both formulations displayed pseudoplastic viscosity and thixotropic behavior, although the crosslinked hydrogel demonstrated superior structural recovery.

Key words: *3D-printing, hydrogel, cellulose nanocrystals, biopolymers, drug delivery system.*

Acknowledgement: FAPESP (grants 2024/23271-4) and FAPESP-BEPE (grants 2025/25180-9).

Age-associated remodeling in type I collagen promote the invasion of BRAF^{V600E} mutated melanoma cells and their resistance to targeted therapies within three-dimensional matrix models

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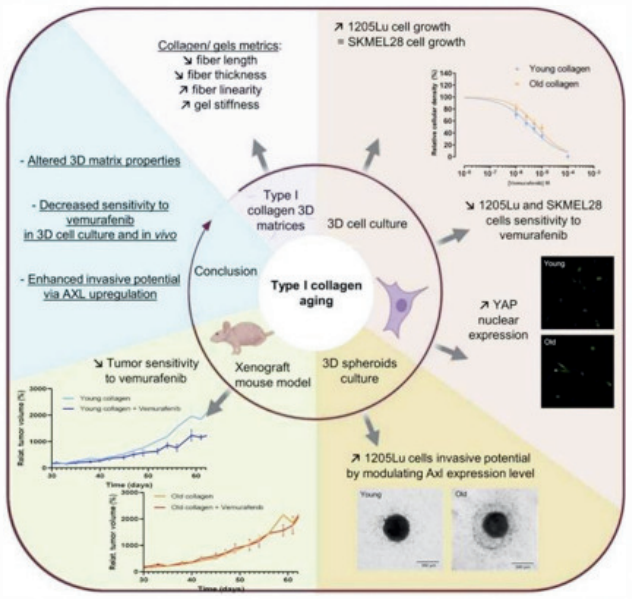
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Abstract

Background / Introduction:

Targeted therapies against mutated BRAF^{V600E} therapies, such as vemurafenib, has improved the prognosis for melanoma patients; however, resistance to these targeted therapies frequently emerges. Type I collagen-a key element of the tumor microenvironment-contributes to tumor progression and therapeutic resistance. With aging, type I collagen undergoes remodeling that alters its fibrillar organization and mechanical properties. Although these changes have been documented, their impacts on BRAF^{V600E}-mutated melanoma cell behavior and drug response remain unclear.

Methods



In this study, we used both in vitro and in vivo models to investigate how collagen age-remodeling modulates BRAF^{V600E}-mutated melanoma response to vemurafenib.

Results:

Our findings indicate that in vitro—using a 3D culture matrix model—old collagen promotes increased proliferation of 1205Lu cells and protects both 1205Lu and SKMEL28 cells from vemurafenib effects. This was associated with elevated YAP expression, suggesting a role for mechano-transduction in drug resistance. The 3D collagen matrix spheroid model revealed that aged collagen enhances the invasive properties of 1205Lu cells, which correlated with an upregulation of the AXL receptor. In vivo, vemurafenib reduced tumor growth in athymic mice xenografted with melanoma cells embedded in young collagen matrices, but not in those with aged collagen.

Conclusion:

Age-related alterations in type I collagen contribute to reduced efficacy of anti-BRAF^{V600E} therapies in BRAF^{V600E}-mutated melanoma (Florent et al., Biomed Pharmacother, 2025).

Key words: *Type I collagen, Age-related modifications, BRAF^{V600E} melanoma, Targeted therapy, Resistance, Invasion.*

Biodegradable poly(aspartic acid) superabsorbents with tunable cross-linking for sustainable water management in agricultural soils

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Abstract

Background / Introduction:

Most commercial superabsorbents used to retain water in soil are polyacrylates that persist for years. Poly(aspartic acid) (PASP), obtained from polysuccinimide (PSI), offers the same water-binding carboxylate groups on a biodegradable backbone. We studied how the pre-polymer and the cross-linker shape the properties of PASP superabsorbents for soil use.

Methods:

Within the I-WALAMAR project (UMI – FH Aachen), PSI was synthesised by thermal polycondensation of L-aspartic acid with H_3PO_4 (0–34 wt%), alone or with glutamic acid or lysine, then cross-linked with hexamethylenediamine (HMD, 5–20 mol%), tartaric acid dihydrazide, bis(glycine) (di)ethylene glycol esters, lysine or its Cu^{2+}/Zn^{2+} complexes and ring-opened with NaOH, KOH or ethanolamine. Pre-polymers were characterised by yield, GPC (molar mass) and FTIR (branching), and the new cross-linkers by ^1H NMR. The superabsorbents were assessed for soluble fraction, swelling kinetics (Qmax, k, t_{63}), absorbency under load (AUL, 0.1 and 0.3 psi), nutrient release (N, PO_4^{3-}-P, K) and biodegradation by manometric respirometry (BOD) in activated sludge, against three commercial products. Selected samples were tested in pot experiments.

Results:

All cross-linkers gave stable superabsorbents (Fig. 1a,b). HMD at 5 mol% gave the highest uptake (121 g g^{-1}), matched by the glutamic acid copolymer; tartaric dihydrazide and the glycine esters reached 83–108 g g^{-1} and lysine-based networks 46–65 g g^{-1} (Fig. 1c), the latter bringing amine and Cu/Zn sites for nutrient binding.

Raising HMD to 20 mol% lowered swelling to 23 g g^{-1}. PSI made at 31–34 wt% H_3PO_4 gave networks with less than 10% soluble fraction that kept up to 81% of their free swelling under 0.3 psi, against about 12% for Stockosorb. After 5 days in activated sludge, the BOD of clPASP-HMD5 reached 400 mg O_2 L^{-1} versus about 50 for the polyacrylate (BOD/COD ≈ 0.5).

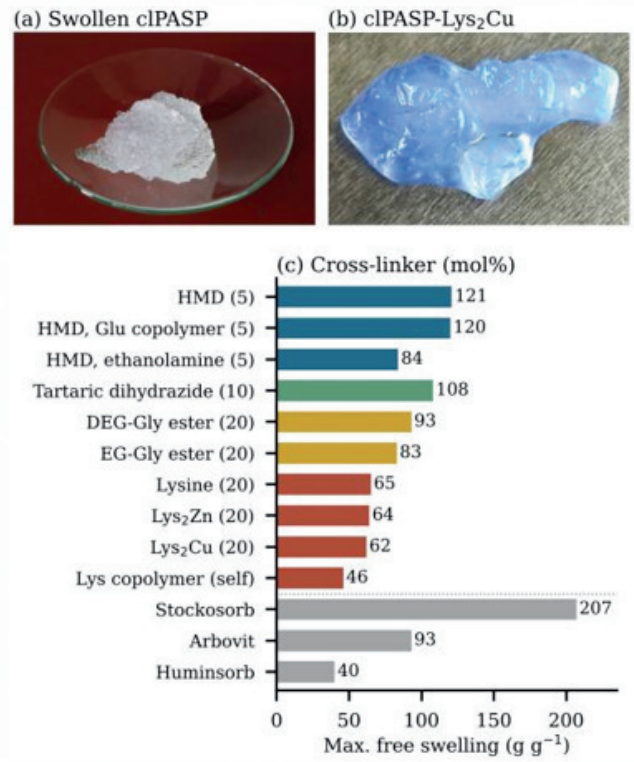


Figure 1: *(a, b) Swollen PASP superabsorbents; (c) maximum free swelling for different cross-linkers compared with commercial products (grey).*

Conclusion:

PSI/PASP chemistry works as a toolbox: the choice of pre-polymer and cross-linker sets the capacity, swelling rate and load resistance, and can add nutrient-binding functions, while the materials degrade far faster than polyacrylate. Degradation studies in soil are the next step.

Key words: *Superabsorbent, Poly(aspartic acid), Cross-linker, Biodegradation, Water retention*

Injectable Silanized Hydroxypropyl Methylcellulose/Lignin Hydrogels for Cutaneous Wound Healing: Physicochemical Characterization and Biological Evaluation

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Abstract

Background / Introduction:

Injectable hydrogels provide a favorable environment for cutaneous wound healing through their ability to conform to irregular wound geometries and maintain a hydrated environment conducive to tissue repair. Developing formulations that combine suitable mechanical properties and ease of administration with biological functionality is therefore an important objective for wound-care applications. This study investigated hydrogels combining silanized hydroxypropyl methylcellulose (Si-HPMC) with lignin, a natural plant-derived biopolymer, as injectable materials for skin wound healing. The formulation strategy aimed to associate the gel-forming properties of Si-HPMC with the antioxidant and antibacterial activities of lignin, while preserving injectability and cytocompatibility.

Methods:

Si-HPMC hydrogels with different lignin concentrations were characterized for rheological, mechanical, and injection properties, antioxidant and antibacterial activity, and cytocompatibility. In vivo wound healing was evaluated by monitoring wound diameter on days 1, 3, 6, 9, and 12 in lignin-containing, lignin-free, and control groups.

Results:

Lignin incorporation improved the mechanical properties of Si-HPMC hydrogels while preserving injectability and cytocompatibility. The formulations also exhibited antioxidant and antibacterial activities. In vivo, wound diameter decreased progressively, with faster closure in lignin-containing groups. Initial diameters were approximately 5.5–6.0 mm. By day 3, diameters decreased to approximately 3.0 and 2.7 mm for 0.5% and 1% lignin hydrogels, respectively, compared with 4.5 mm for lignin-free Si-HPMC and 5.5 mm for the negative control. By day 6, the corresponding values were approximately 2.3, 1.8, 3.5, and 4.3 mm. Near-complete closure occurred by day 9 with 1% lignin. On day 12, both lignin-containing groups reached approximately zero wound diameter, whereas residual diameters of 0.5 and 1.0 mm remained in the lignin-free and control groups, respectively (Fig. 1). These trends suggest enhanced wound closure with lignin, particularly at 1% concentration.

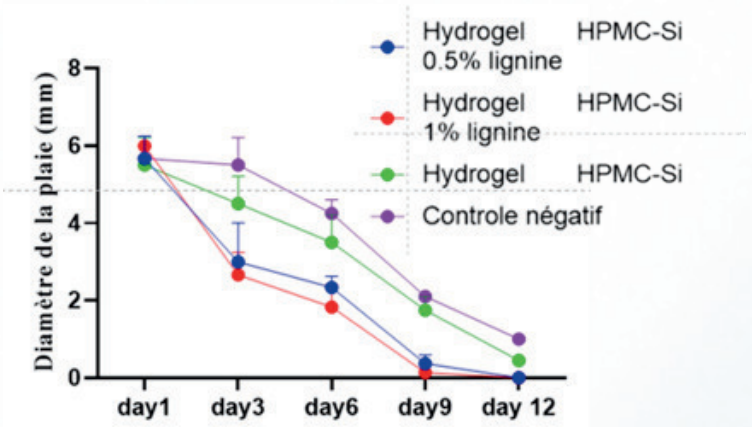


Figure 1: *Evolution of wound diameter over 12 days in groups treated with Si-HPMC hydrogels containing 0.5% or 1% lignin, lignin-free Si-HPMC hydrogels, and a negative control.*

Conclusion:

Si-HPMC/lignin hydrogels show potential for wound healing, combining improved mechanical properties, injectability, cytocompatibility, antioxidant and antibacterial activities. The 1% lignin formulation showed promising wound-closure trends, pending statistical validation.

Key words: *Injectable hydrogels, Si-HPMC, lignin, antioxidant activity, antibacterial activity, wound healing.*

Theoretical Insights into NOx (NO, NO_2) Adsorption on $NaMgPO_4$ (033): A DFT and Monte Carlo Study

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Abstract

Background / Introduction:

Nitrogen oxides (NO and NO_2) are major air pollutants responsible for respiratory diseases, photochemical smog, and environmental degradation. This work aims to investigate the adsorption mechanism of NO and NO_2 on the $NaMgPO_4$ surface using density functional theory (DFT).

Methods:

The Gaussian 09 package was implemented to undertake full DFT calculations.

To conduct an investigation the adsorption characteristics of NO and NO_2, compounds on the $NaMgPO_4$ (033) surface, MCDs computations were carried out using the Material Studio 8.0 Software (Accelrys; BIOVIA, Dassault Systems, USA).

Results:

possesses the smallest energy gap (0.363 eV) among the investigated gaseous species, suggesting higher chemical reactivity and a greater tendency to interact with the $NaMgPO_4$ (033) surface. In addition, NO_2 exhibits the lowest global hardness value (0.181 eV) in aqueous medium. The MCDS calculations yielded adsorption energies of −874.03 and −819.94 kcal/mol for NO and NO_2, respectively The negative values of these adsorption energies demonstrate that the adsorption processes are thermodynamically favorable and occur spontaneously. Furthermore, the theoretical findings demonstrate strong interactions between the investigated gaseous molecules and the $NaMgPO_4$ (033) surface.

RDF analyses showed that the dominant interaction distances for all adsorption complexes are below 3.5 Å, confirming the chemisorptive nature of the adsorption process. The negative values of these adsorption energies demonstrate that the adsorption processes are favorable and spontaneous. NO and NO_2 molecules preferentially adsorb in a parallel orientation relative to the $NaMgPO_4$ surface.

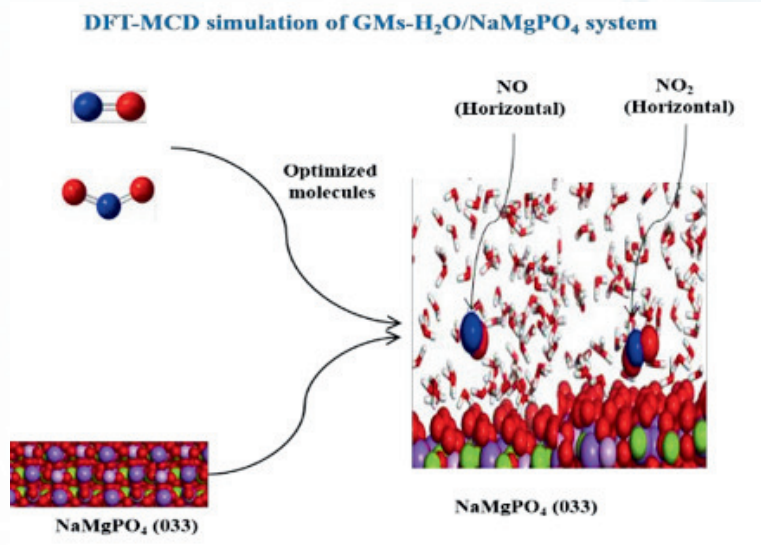


Figure 1: *adsorption mechanism of NO_x onto $NaMgPO_4$ (033)*

Conclusion:

The strong adsorption energies, favorable adsorption configurations, and chemisorptive interactions predicted by DFT and MCDS confirm the effectiveness of $NaMgPO_4$ (033) for NO and NO_2 removal. Therefore, $NaMgPO_4$ emerges as a promising candidate for the development of advanced technologies aimed at controlling atmospheric NOx pollution.

Key words: *Gaz adsorption, Sodium Magnesium phosphate, DFT, Monte Carlo simulation.*

Evaluating plant-derived bioactives and synthetic chemicals for Quality preservation and Microbial safety in processed functional foods

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Abstract

Background / Introduction:

The search for eco-friendly and health-promoting food preservation strategies has driven extensive research into natural bioactive compounds. Plant essential oils, rich in polyphenols and volatile bioactive fractions, represent promising natural alternatives to synthetic chemical preservatives commonly used to prevent oxidative degradation and microbial spoilage in processed foods. This study aims to evaluate and compare the bio-protective potential of selected plant essential oils with conventional synthetic additives.

Methods:

The phytochemical profile was determined, followed by in vitro assessment of antioxidant capacity and antimicrobial activity against common foodborne pathogens and spoilage organisms. Furthermore, the incorporation of these natural extracts into a functional food model was evaluated over a storage period to monitor changes in physicochemical properties (pH, color, lipid oxidation) and microbial growth.

Results:

The results demonstrated strong antioxidant and broad-spectrum antimicrobial properties of the natural botanical extracts, effectively slowing down lipid oxidation and inhibiting microbial proliferation. The bio-preservative effect was found to be comparable to synthetic reference additives, without adversely affecting the quality traits of the food matrix (Figure 1).

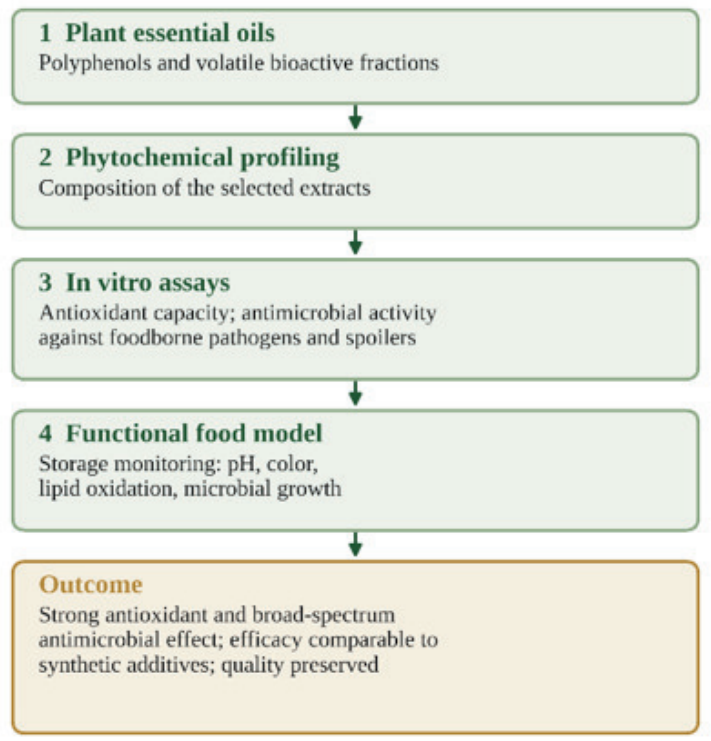


Figure 1: *Overview of the study design and main outcomes.*

Conclusion:

These findings support the sustainable valorization of plant bioresources as effective biopreservatives for cleaner-label functional food formulation.

Key words: *Essential oils, Bio-preservation, Natural antioxidants, Synthetic additives, Physicochemical stability, Functional foods*

Synthesis and Performance of Dihydro-ar-curcumene and Cadalene as Corrosion Inhibitor for C38 Steel in 1M HCl Medium

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Abstract

Background / Introduction:

In this study, we report the synthesis of dihydro-ar-curcumene and cadalene via an iodine-mediated cleavage of arylhimachalene. Cadalene showed higher corrosion inhibition (85.7%) than ar-curcumene (80%) on C38 steel, forming a protective physiosorbed film. Experimental results were supported by surface characterization and theoretical calculations.

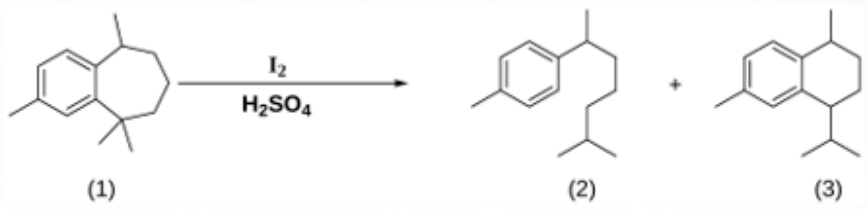
Aromatic compounds with a bisabolan carbon skeleton and saturated side chain, including the dihydro-ar-curcumene are natural compounds valued for their wide range of applications such as flavoring, cosmetics, and biological activities. This study focuses on the synthesis of cadalene and dihydro-ar-curcumene from arylhimachalene an Atlas cedar oil derivative and explores their potential as green corrosion inhibitors for steel in acidic environments.

Methods:

The isolated products were characterized using NMR and mass spectrometry. SEM and EDS analysis were used to display the surface of C38 steel immerged in 1.0 M HCl in the absence and presence of cadalene and ar-curcumene. The reactivity of cadalene and ar-curcumene with the C38 steel surface was investigated utilising DFT approach.

Results:

The treatment of arylhimachalene (1) with 2 equivalents of H_2SO_4 in combination with 2 equivalents of I_2 leads to a total conversion of the substrate and the selective formation of dihydro-ar-curcumene (2).



The SEM image of C38 steel submerged in 1.0 M HCl alone reveals extensive surface degradation, characterized by severe pitting and irregular features, indicative of substantial corrosion. In contrast, the C38 steel immersed in 1.0 M HCl in the presence of two studied inhibitors cadalene and ar-curcumene at 10^{-3} M displays a markedly smoother and more uniform surface.

Conclusion:

EIS studies indicated that both compounds are efficient inhibitors, with inhibition efficiencies of 80% for ar-curcumene and 85.7% for cadalene at 10^{-3} M, underscoring their robust protective properties. Polarisation investigations validated that both chemicals function as mixed-type inhibitors, influencing both anodic and cathodic processes. Moreover, the DFT computational and MC approaches agree with experimental findings, demonstrating advantageous adsorption of the inhibitors on the metallic sample area.

Key words: *Sesquiterpenes, synthesis, catalysis, corrosion, Cedar oil, DFT.*

Bridging Bio-Based Aerogels and Hydrogels for Fertilizer Applications: Synthesis, Functional Properties, and Agronomic Performance – A Critical Review

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Abstract

Background / Introduction:

Conventional mineral fertilizers are constrained by low nutrient-use efficiency, with substantial N, P and K losses through leaching, volatilization, runoff and fixation. These losses reduce crop productivity and intensify environmental pressure, while water scarcity further limits fertilizer performance in dryland systems. Slow-release carriers enable sustainable fertilization, but most rely on petroleum-based polymers. Bio-based hydrogels and aerogels offer biodegradable alternatives, yet they are reviewed separately despite shared compositions, crosslinking chemistries and nutrient/water transport mechanisms.

Methods:

This review synthesizes recent primary studies retrieved from Scopus, Web of Science, ScienceDirect and Google Scholar. It compares cellulose, lignin, alginate, chitosan, starch and protein matrices and their composites in terms of crosslinking, nutrient loading, drying route, swelling, soil water retention, release kinetics and agronomic response.

Results:

Bio-based hydrogel and aerogel fertilizer systems share similar biopolymer matrices, crosslinking methods and nutrient loading routes; their main structural difference is created by the drying step. Freeze-drying, commonly used in aerogel fertilizer studies, preserves an open porous network, whereas ambient drying causes collapse into denser xerogel-like structures (Figure 1). Nutrient release is mainly controlled by swelling, diffusion, pH, ionic strength and crosslink density, but the test medium outweighs most formulation variables: a cellulose/tamarind gum hydrogel released 95 % of its urea within 8 days in water but only after 34 days in soil [1]. Water uptake ranges from about 13 to 390 g g^{-1} [2,3], and soil amended with 0.1 wt% of this hydrogel retained water for 56 days versus 15 days for the control [1]. In a wheat pot experiment, a sodium alginate/gelatin/polyacrylamide hydrogel increased root length by up to 43% under extreme drought stress and shoot dry weight by up to 51% under well-watered conditions [2]. Plant responses depend on dose [4], nutrient-use efficiency is rarely measured, and no study has compared aerogel and hydrogel forms of the same formulation.

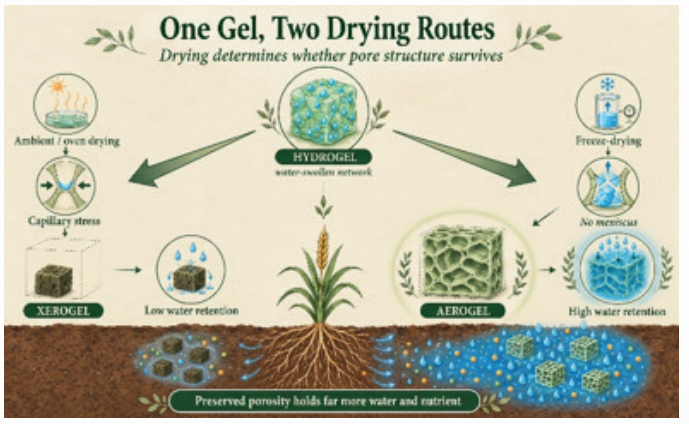


***Figure 1**: Effect of the drying route on the architecture of a Hydrogel.*

Conclusion:

Bio-based aerogel and hydrogel fertilizers are promising dual nutrient–water carriers for drylands that return agricultural residues to the soil. Further progress now depends on comparable evidence: carriers described by drying route and pore structure, release tested in water and soil, biodegradation measured as mineralization, and multi-season field trials against matched-nutrient controls.

***Key words:** Bio-based aerogel, hydrogel, drying route, water retention, slow-release, circular economy*

Can sea cucumber peptides be efficient component in cardiac repair hydrogels?

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Abstract

Background / Introduction:

Post myocardial infarction (MI), oxidative stress and insufficient blood supply contribute to impaired cardiac repair, while the subsequent formation of fibrotic scar tissue, characterized by poor electrical conductivity, further exacerbates cardiac dysfunction. Peptide-based hydrogels from different non-sea-cucumber sources have already demonstrated preclinical efficacy in cardiac repair, establishing a medical translational precedent. Self-assembling peptide hydrogels with pro-angiogenic and anti-fibrotic motifs improved left ventricular ejection fraction and reduced fibrotic tissue formation in rat MI models (Firoozi, 2020). Vascular Endothelial Growth Factor (VEGF)-mimetic and mitochondria-targeted peptide hydrogels promoted vascular regeneration and attenuated apoptosis in mouse MI models (Xu, 2025). Conductive peptide co-assembly hydrogels integrating ROS scavengers shortened Q wave, R wave and S wave intervals and enhanced tissue electrical integration in infarcted hearts in vitro (Luo, 2025; Zhan, 2022). These results collectively demonstrate that bioactive peptide hydrogels can address the core pathological features of MI — oxidative stress, insufficient angiogenesis, fibrosis, and electrical discontinuity — providing a validated framework into which sea cucumber-derived peptides could be integrated. No direct ex vivo or in vivo cardiac studies of sea cucumber peptide hydrogels have been published; the cardiac-relevant benefits described are inferred from the peptides' demonstrated bioactivities and the proven efficacy of analogous peptide-hydrogel systems in MI models.

Methods:

For exploring the bio functional capacity of peptides from a library of more than 700 sea cucumber Parastichopus tremulus body wall peptide sequences we have established previously, we have used in silico approaches (PepAnno; BIOPEP-UWM; AlphaFold). Beta sheet formation was a main network stiffness parameter explored for the peptides and their combinations (AlphaFold, Warren et al., 2023). Next, we have validated the cytotoxicity and haemolytic capacities of 13 of the most promising peptides to prepare formulations of these with other established hydrogel components such as gelatin, chitosan or PEG. A protocol for peptide loading capacity biochemical evaluation for the hydrogels, containing the additional compounds with desirable properties was prepared.

Conclusion:

Previously, 13 single peptide sequences were predicted to have suitable hydrogel assembly properties: combinations of net charge/pI, amphipathicity/hydrophobicity, secondary structure, fibril formation, and response to pH, salt, and calcium (Mildenberger et al., 2021). The first 5 sequences among these 13 have been thoroughly studied after custom synthesis (Atanassova et al., 2025). Here we have studied in silico the resting 8 peptide sequences and their combinations and compared these to the initial 5. Since we have previously observed that after gel formation many of the bioactive properties of the integrated peptides can be either lost or drastically reduced, we have tried to address this issue by predicting and designing combinations of peptides for the hydrogel composition, which will ensure the active sites are not involved in the structural interactions during gel formation. Our hydrogel compositional predictions will be validated in vitro/ex vivo, in 3D tissue models such as hiPSC-derived 3D Engineered Heart Tissue (EHT) in the future.

Key words: *sea cucumber, collagen, peptides, bioactivity, hydrogel formulation, heart repair*

Use of a Pectin Hydrogel Containing Passiflora ligularis Extract for Wound Healing in Canine Cutaneous Leishmaniasis: A Case Report

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Abstract

Background / Introduction:

Canine cutaneous leishmaniasis (CL) is a disease that is difficult to manage clinically, associated with chronic wounds that heal slowly, compromising animal welfare and potentially favouring secondary infections. Therefore, topical therapeutic strategies with bioactive natural compounds emerge as promising alternatives to aid the tissue repair process. In this sense, the extract from the leaves of Passiflora ligularis shows promise in wound treatment due to its antibacterial, anti-inflammatory, and healing properties. Thus, the objective of this study was to evaluate the healing potential of a pectin hydrogel containing P. ligularis extract in the treatment of a wound in a dog with CL.

Methods:

This is an experimental case study, approved by the Ethics Committee on the Use of Animals (no. 2460180825), in which a dog diagnosed with cutaneous leishmaniasis was treated topically, once a day, with 500 mg of pectin hydrogel containing 5% P. ligularis extract for 21 days. The animal was evaluated on days 0, 7, 14, and 21. Wound area was measured using ImageJ software, and percentage wound contraction was calculated relative to baseline.

Results:

Throughout the treatment period, progressive improvement in the clinical appearance of the wound was observed, with a clear reduction in exudate, better organization of granulation tissue, and a continuous decrease in the lesion area. The lesion area decreased from 15.43 cm² on day 0 to 3.69 cm² on day 21, which corresponds to a 76% wound contraction. Figure 1 demonstrates the healing effect of the formulation from the 14th day of treatment.

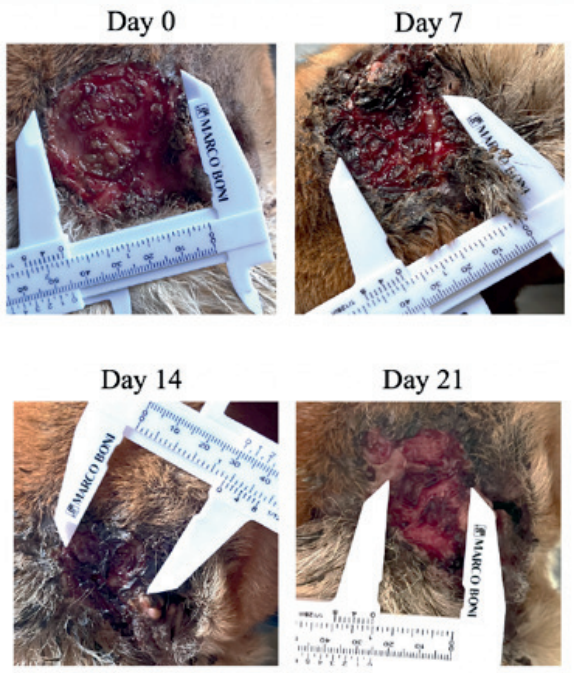


***Figure 1**: Evolution of cutaneous leishmaniasis wound in a dog treated with P. ligularis extract hydrogel for 21 days, showing progressive reduction of the lesion and advancement of healing process on days 0, 7, 14, and 21.*

Conclusion:

In this single-animal case, the pectin hydrogel containing P. ligularis extract was associated with progressive wound contraction and improved clinical appearance. These preliminary findings support controlled studies in larger cohorts to assess its efficacy and safety as a topical adjunct for CL-associated wounds.

Key words: *Pectin Hydrogel, Leishmaniasis, Isoquercetin, Wound healing.*

Natural Polymer-Based Encapsulation Systems for Sustained Antimicrobial Activity in Bio-Based Coatings

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Abstract

Background / Introduction:

The growing demand for sustainable antimicrobial materials has stimulated the development of bio-based systems incorporating natural active compounds. However, the high volatility and limited stability of many natural antimicrobial agents restrict their long-term effectiveness. Encapsulation using natural polymers offers a promising strategy to protect bioactive compounds and ensure their controlled release. This study investigates the incorporation of encapsulated natural antimicrobial agents into water-based coatings and evaluates their antibacterial performance and stability over time.

Methods:

The antibacterial activity of four naturally derived compounds and two essential oils was first screened by determining their minimum inhibitory concentrations (MIC) using a microdilution broth assay (resazurin indicator) against five target bacterial strains (E. coli, S. aureus, P. aeruginosa, B. subtilis, and E. faecalis). Subsequently, these active agents were encapsulated within three types of bio-based polymer matrices (polysaccharide, cellulosic, and hybrid protein/polysaccharide systems) utilizing probe sonication and complex coacervation techniques. Both raw and encapsulated formulations were then incorporated into a water-based varnish, applied onto solid supports ($1cm^2$) and dried. The antibacterial efficacy of the bio-functionalized coatings was quantified via spectrophotometry (OD_{600}) after 24 h of incubation. Finally, the long-term stability of the antimicrobial properties was evaluated after a one-month storage period at room temperature.

Results

Initial screening of raw natural compounds and crude essential oils revealed varying potencies, with the most effective agents exhibiting low Minimum Inhibitory Concentrations (MIC) down to 0.25% (v/v) against Staphylococcus aureus and 1% (v/v) against Pseudomonas aeruginosa. However, direct incorporation of these unencapsulated crude agents into the coating matrix yielded limited and short-lived antibacterial effects.

To overcome this, microencapsulation within bio-hydrogel matrices was deployed.

This encapsulation strategy significantly enhanced long-term antimicrobial efficiency and stabilized release kinetics. The highest antibacterial performance was achieved by Pure Compound 2 encapsulated in Matrix A-B blend, reaching a remarkable inhibition rate of 93.96% against Enterococcus faecalis. Furthermore, systems using Pure Compound 1 encapsulated in Matrix A maintained stable and potent activity against E. faecalis (70%) Formulations based on Pure Compound 3 within Matrix A and Matrix C also exhibited robust and prolonged bioactivity, sustaining inhibition values between 55% and 75% against P. aeruginosa and Escherichia coli. These comparative findings confirm that transitioning from crude compounds to hydrogel-encapsulated systems successfully prevents premature degradation and ensures long-lasting surface protection.

Conclusion:

In conclusion, this study successfully demonstrates that natural polymer-based encapsulation significantly improves the antimicrobial performance and long-term stability of bioactive compounds. Due to ongoing patenting and intellectual property protection processes, the exact identities of these compounds and matrices remain confidential. Notably, the developed systems maintained exceptional stability and sustained antibacterial activity against both Gram-positive and Gram-negative bacteria throughout a one-month continuous cycle. These findings highlight the significant potential of these eco-friendly formulations as protective coatings for biomedical, food packaging, or hygienic surface applications, offering a sustainable alternative to conventional chemical agents while directing future work toward evaluation under real operational conditions.

Hydrogel-Based Smart Interfaces for Dentin-Like Fixed Restorations: Bridging Biomimetic Mechanics and Bioactivity

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Abstract

Background / Introduction:

Dentin is a natural hydrogel-based composite: a hydrated collagen matrix reinforced with carbonated apatite, combining stiffness, toughness and biological responsiveness. Conventional fixed restorations (zirconia, lithium disilicate) are biologically inert and far stiffer than dentin. This mismatch concentrates stress at the tooth–restoration interface and offers no protection against secondary caries or interface degradation. This work aims to review strategies combining dentin-like mechanical behaviour with hydrogel-based smart functionality in fixed restorative dentistry.

Methods:

A narrative review of the literature was conducted in Scopus and PubMed (2015–2026) using the keywords “biomimetic restorative materials”, “polymer-infiltrated ceramic network”, “smart dental materials”, “stimuli-responsive hydrogels” and “dentin remineralization”. In vitro, in vivo and clinical studies relevant to crowns, onlays, luting cements and the dentin–restoration interface were selected.

Results:

Polymer-infiltrated ceramic networks, CAD/CAM resin composites, functionally graded and nacre-inspired ceramic–polymer composites show elastic moduli close to dentin and better damage tolerance than conventional ceramics. At the interface, hydrogel-based systems add biological function: self-assembling peptide and collagen-mimetic hydrogels promote biomimetic remineralization of the hybrid layer; pH-responsive hydrogels release calcium, phosphate, fluoride or antibacterial agents during acid challenge; self-healing and protein-repellent networks limit microcrack propagation and biofilm formation (Figure 1). However, most evidence is in vitro and long-term clinical data remain scarce.

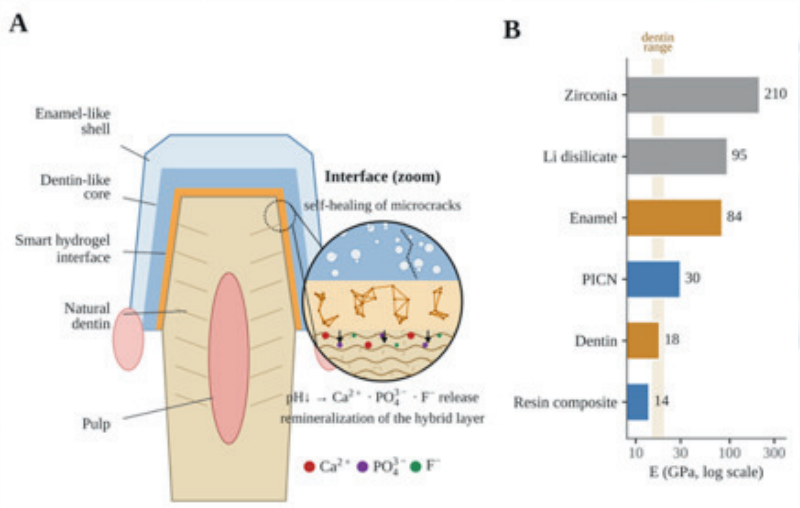


***Figure 1**: (A) Biomimetic fixed restoration with a smart hydrogel interface (zoom). (B) Elastic modulus of restorative materials vs dental tissues.*

Conclusion:

Combining dentin-like restorative materials with smart hydrogel interfaces is a promising route toward fixed restorations that are both mechanically and biologically biomimetic. Future work should focus on graded hydrogel–ceramic hybrids, 3D-printable formulations and well-designed clinical trials.

***Key words:** smart biomaterials, hydrogels, biomimetic dentistry, dentin-like materials, fixed restorations, remineralization*

Electrochemical Behavior of Pyocyanin: Mechanistic Insights, Analytical Strategies, and Emerging Applications

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Abstract

Background / Introduction:

Pyocyanin (PYO) is a redox-active phenazine produced by Pseudomonas aeruginosa that plays important roles in bacterial physiology, oxidative stress, extracellular electron transfer, and biofilm-associated processes. Its reversible redox behavior and electrochemical activity make it a promising target for analytical detection and a potential mediator in bioelectrochemical and environmental applications. However, its electrochemical behavior depends on experimental conditions, electrode materials, pH, and the composition of the sample matrix. Understanding the relationship between pyocyanin biosynthesis, molecular properties, and electrochemical responses is therefore essential for developing reliable detection strategies and exploring its broader technological applications.

Methods:

This review critically examines the scientific literature on pyocyanin biosynthesis, regulatory mechanisms, physicochemical characteristics, and electrochemical properties. Particular attention is given to electrochemical techniques, including cyclic voltammetry (CV), differential pulse voltammetry (DPV), square-wave voltammetry (SWV), and chronoamperometry. Electrode materials, surface modifications, analytical performance, sample preparation, and applications in environmental monitoring and bioelectrochemical systems are also considered.

Results:

The literature highlights the importance of pyocyanin's reversible redox activity in electrochemical sensing and electron-transfer processes. Voltammetric techniques offer complementary approaches for characterizing and quantifying pyocyanin, while electrode surface engineering can improve sensitivity and analytical performance. Beyond detection, pyocyanin has potential applications in microbial fuel cells, electrocatalytic processes, and selected environmental remediation strategies. Nevertheless, differences in experimental conditions, electrode configurations, sample matrices, and reporting practices complicate direct comparisons between published studies. Moreover, electrochemical detection of pyocyanin does not, by itself, establish its biological signaling function or demonstrate a specific environmental benefit.

Conclusion:

Pyocyanin represents a valuable link between bacterial metabolism and electrochemical technology. Integrating knowledge of its biosynthesis, redox behavior, and analytical detection could support more reliable sensors and guide the development of bioelectrochemical applications. Future research should prioritize standardized measurement protocols, improved selectivity in complex samples, and experimental validation of proposed environmental applications.

Key words: *Pyocyanin, Pseudomonas aeruginosa, electrochemical detection, redox properties, biosynthesis, environmental applications.*

Self-Assembling Peptide Hydrogels for Biomimetic Enamel Remineralization: From Concept to Clinical Practice

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Abstract

Background / Introduction:

Fluoride, the standard non-invasive treatment of early enamel caries, mainly remineralizes the lesion surface without restoring its depth. The self-assembling peptide P11-4 forms in situ, triggered by acidic pH and calcium ions, a fibrillar β-sheet hydrogel whose anionic residues bind calcium and template hydroxyapatite formation, mimicking amelogenin.

To summarize the mechanism of action of P11-4 and the evidence supporting its use in restorative dentistry.

Methods:

A narrative review of the literature was conducted. PubMed was searched up to October 2026 for in vitro studies, clinical trials and systematic reviews evaluating P11-4 on non-cavitated enamel and dentin caries lesions. Key findings were synthesized qualitatively.

Results:

Applied as monomers after etching, P11-4 diffuses into the lesion body down to about 70 µm before assembling into a three-dimensional hydrogel. Most in vitro studies report gains in microhardness and mineral content, enhanced by combination with fluoride or CPP-ACPF. Clinically, randomized trials and meta-analyses report more frequent arrest of initial lesions (RR 1.82; 95% CI 1.32–2.50), reduced lesion size and favourable outcomes on post-orthodontic white spot lesions, with the P11-4 + fluoride varnish combination performing best. Laboratory data also suggest remineralization of demineralized dentin.

Certainty of evidence remains low to moderate: small, mostly single-centre trials, short follow-up (6–12 months), heterogeneous outcome measures and high statistical heterogeneity. Mineral gain detected by fluorescence is not always visible clinically (ICDAS), and the same limited pool of trials underlies most reviews.

Conclusion:

P11-4 illustrates the transition of a self-assembling biohydrogel from concept to practice in minimally invasive restorative dentistry. Standardized long-term trials, extension to dentin lesions and hybrid hydrogels (peptide/fluoride, peptide/bioactive glass) are priorities.

Key words: *Self-assembling hydrogel, P11-4, Remineralization, Enamel, Minimally invasive dentistry*

Smart Biohydrogels for Peri-Implantitis: From Biofilm Control to Exosome-Mediated Immunomodulation and Tissue Regeneration

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Abstract

Background / Introduction:

Peri-implantitis is a biofilm-associated inflammatory disease characterized by progressive loss of supporting bone. Current decontamination and surgical approaches do not consistently resolve the disease or predictably regenerate bone. Smart injectable biohydrogels can respond to cues of the inflamed pocket (acidic pH, reactive oxygen species (ROS), matrix metalloproteinases (MMPs), and body temperature) to release cargo on demand. Loading these hydrogels with extracellular vesicles, notably exosomes, could combine local biofilm control with host modulation and tissue repair.

Methods:

This narrative review synthesizes consensus reports and preclinical studies from PubMed, Scopus, and Web of Science (2015–2026) on stimuli-responsive and thermosensitive hydrogels, antibacterial hydrogel systems, hydrogel-mediated extracellular vesicle delivery, immunomodulation, and peri-implant regeneration. It critically examines mechanisms, biomaterial design, translational barriers, and research gaps.

Results:

Injectable hydrogels, mainly based on chitosan, hyaluronic acid, gelatin methacryloyl (GelMA), or poloxamer, improve local retention and sustained release of therapeutic cargo. Antibacterial activity relies on chitosan or on pH- or enzyme-triggered release of antiseptics, antibiotics, or antimicrobial peptides. Exosomes derived from bone marrow or dental pulp mesenchymal stem cells and from M2 macrophages have been associated with M1-to-M2 macrophage polarisation, reduced IL-1β and TNF-α, and enhanced osteogenic and angiogenic markers in experimental models (Figure 1). However, evidence specific to peri-implantitis remains limited: most data come from periodontitis or bone-defect models, few studies use biofilm-contaminated titanium surfaces, dosing and release kinetics are reported inconsistently, and vesicle characterization rarely follows MISEV guidelines. Clinical efficacy has not yet been established.

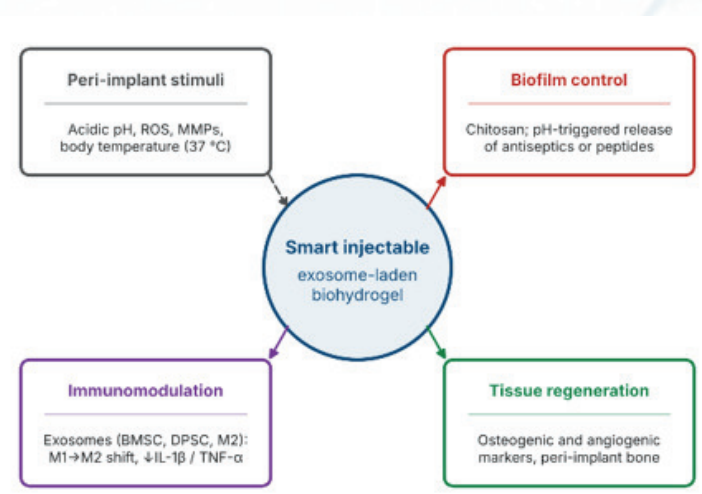


Figure 1: *Multifunctional smart exosome-laden biohydrogel for peri-implantitis*

Conclusion:

Smart biohydrogels combined with exosome-based delivery may provide a multifunctional platform linking local biofilm management, immune modulation, and tissue regeneration. Before routine clinical use, peri-implantitis-specific models, standardized vesicle characterization, reproducible manufacturing, safety assessment, and controlled clinical trials are required.

Key words: *Peri-implantitis, Smart biohydrogels, Exosomes, Immunomodulation, Local drug delivery, Tissue regeneration*

Preliminary Formulation and Characterization of Chitosan Hydrogels for 3D Bioprinting Applications in Tissue Engineering

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Abstract

Background / Introduction:

The advent of 3D bioprinting has revolutionized tissue engineering by enabling the fabrication of complex, patient-specific scaffolds with precise control over architecture and cell distribution. Chitosan hydrogels are considered attractive candidates for bioinks in 3D bioprinting due to their favorable biological properties. Chitosan has become a promising biopolymer in the biomedical field due to its mucoadesiveness, antibacterial properties, and capacity to form physically crosslinked hydrogels. However, their application is hindered by inherent limitations, notably slow gelation rates and weak mechanical properties, which compromise printability and structural integrity of the printed constructs.

Methods:

The investigation focused on assessing their rheological behavior and mechanical performance, critical factors influencing printability and scaffold stability (Fig. 1).

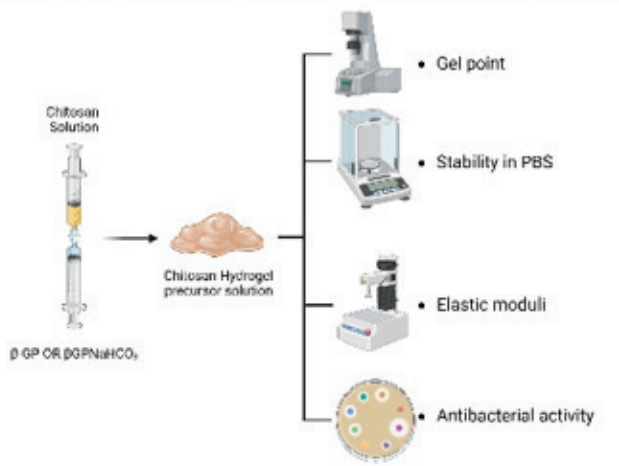


Figure 1: *Methods used in this study.*

We determined the gelation time of each hydrogel and assessed their linear equilibrium modulus plateau through frequency sweep tests. Additionally, the compressive strength of the hydrogels was measured to evaluate their structural integrity under mechanical stress. Beyond these mechanical properties, we examined other essential characteristics, swelling capacity, and antibacterial activity to provide a comprehensive understanding of their functional performance through a comparative analysis.

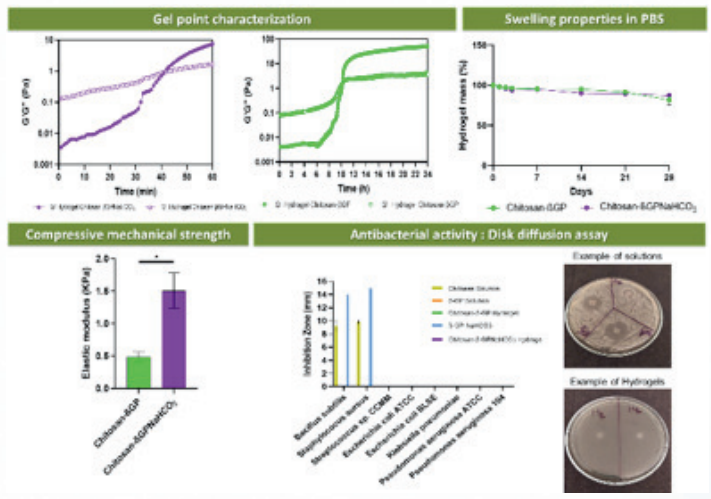


Figure 2: *Results of gelation time, compressive strength, swelling capacity, and antibacterial activity of different chitosan studied.*

Conclusion:

Our findings aim to inform the development of chitosan-based bioinks with enhanced properties, facilitating their application in 3D bioprinting for tissue engineering.

Key words: *Chitosan, hydrogel, tissue engineering, thermosensitive scaffolds, 3D bioprinting.*

Microbial Dextran Hydrogel as a Smart Platform for Localized Antibiotic Delivery and Infection Control

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Abstract

Background / Introduction:

Bacterial wound infections remain a major healthcare challenge, while conventional systemic antibiotic therapy is often associated with repeated dosing, limited drug retention at the target site, and undesirable side effects. Biodegradable polysaccharide-based hydrogels have emerged as attractive biomaterials because of their excellent biocompatibility, moisture retention, and controlled drug release capabilities. Among these materials, microbial dextran possesses unique physicochemical properties that make it a promising candidate for biomedical applications. This study aimed to develop a simple and cost-effective microbial dextran hydrogel capable of efficiently encapsulating clindamycin and providing controlled local drug release with enhanced antibacterial activity for potential wound healing applications.

Methods:

A three-dimensional dextran hydrogel was synthesized by alkaline polymerization using N,N′-methylenebisacrylamide as the crosslinking agent. The optimized hydrogel was characterized by swelling kinetics, pH- and temperature-responsive behavior, water retention, degradation analysis, scanning electron microscopy (SEM), and Fourier transform infrared spectroscopy (FTIR). Clindamycin was incorporated into the hydrogel to evaluate drug loading efficiency, in vitro release kinetics, and antibacterial activity against Bacillus subtilis and Staphylococcus gallinarum.

Results:

The optimized hydrogel exhibited a maximum equilibrium swelling ratio of 73 ± 1% within 120 min, demonstrating excellent water absorption and responsiveness to pH and temperature. The material retained moisture for approximately 18 h and remained structurally stable for 7–8 days. SEM analysis revealed a porous interconnected network, while FTIR confirmed successful crosslinking and drug incorporation. The hydrogel achieved a clindamycin loading efficiency of 70 ± 2% and released approximately 65 ± 2% of the encapsulated drug within 10 h under physiological conditions. Antibacterial evaluation demonstrated significant inhibition against Gram-positive bacteria, producing inhibition zones of 37 ± 1 mm for Bacillus subtilis and 26 ± 1 mm for Staphylococcus gallinarum, whereas the unloaded hydrogel showed no antimicrobial activity.

Conclusion:

This study demonstrated that microbial dextran hydrogel enables efficient clindamycin loading with sustained and controlled drug release. The hydrogel exhibited excellent swelling behavior, structural stability, and significant antibacterial activity against Gram-positive pathogens. Shows strong potential as a biodegradable platform for localized drug delivery and advanced wound dressing applications.

Key words: *Hydrogel, Dextran, Biomaterial, Drug release, Antimicrobial therapy, Wound healing.*

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