The 1st International Online Conference on Functional Biomaterials

The 1st International Online Conference on Functional Biomaterials

10–12 July 2024 | Online

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Welcome from the Chair

Dear Colleagues,

It is my pleasure to announce the **1st International Online Conference on Functional Biomaterials (IOCFB2024)**. The conference is organized by the MDPI open access *Journal of Functional Biomaterials* (ISSN 2079-4983, Impact Factor 5.0) and will be held **online** from **10 to 12 July 2024**.

The conference will provide an opportunity for scientists in the field to present their latest research and to participate in discussions about implantable biomaterials development more widely. The main themes of the conference are:

1. Dental Biomaterials;
2. Bone Biomaterials;
3. Antibacterial Biomaterials;
4. Biomaterials for Tissue Engineering;
5. Biomaterials for Drug Delivery;
6. Biomaterials for Diagnostics, Therapy and Healthcare;
7. Bio-fabricated and 3D Printed Biomaterials.

The conference will provide new opportunities for biomaterials researchers to exchange ideas and to expand scientific horizons of the field. The conference will be organised to make it easier for researchers from disparate backgrounds to come together and to share their specialist perspectives in new ways, augmenting the trans-disciplinarity of the field. With a greater sharing of new strategies to overcome bottlenecks and the highlighting of nascent approaches, new routes for the creation of clinical biomaterials will be promoted. Ultimately, it is the free sharing of ideas that will secure a global-scale effort for the field, thereby underpinning its growing role as a key modality for medical interventions.

With an open forum concept, the conference will be a platform for both technically conventional and unconventional approaches. At the organisational level, its virtual nature will promote interactions free of geographic and travel constraints and so place delegates in the same interactive 'space' with the possible creation of new research community linkages and, with this, new scientific directions for the future.

During the conference, there will be two types of live broadcasts: oral presentations and poster presentations. Through the Zoom platform, participants have the opportunity to engage in interactive sessions, freely share comments and engage in discussions with fellow researchers. Arguably, a virtual conference is also less physically demanding, allowing full focus on the material presented throughout the conference period without the risk of low audience engagement, as can happen sometimes at the start and end of in-person conferences when delagates may be constrained by travel arrangements.

All accepted abstracts will be available online in open access form on Sciforum.net during and after the conference.

Prof. Dr. Pankaj Vadgama
Conference Chair
School of Engineering and Materials Science, Queen Mary University of London, London, UK

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

Journal Webpage: https://www.mdpi.com/journal/jfb.

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Prof. Dr. Xiao Chen
Key Laboratory of Tissue Engineering and Regenerative, Medicine of Zhejiang Province, School of Medicine, Zhejiang University, Hangzhou, China

Speakers

Keynote Speakers

Prof. Dr. Daniel X.B. Chen
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Prof. Dr. Shuilin Wu
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Prof. Dr. Davide Deganello
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Dr. Junjie Li
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Prof. Dr. Federico Carpi
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Prof. Dr. John G. Hardy
Department of Chemistry, Lancaster University, Lancaster, UK

Dr. Sara M. Soto
Barcelona Institute for Global Health (ISGlobal), Barcelona, Spain

Dr. Hannah Donnelly
College of Medical, Veterinary and Life Sciences, University of Glasgow, Glasgow, UK

Dr. Piergiorgio Gentile
School of Engineering, Newcastle University, Newcastle upon Tyne, UK

Program at a Glance

The 1st International Online Conference on Functional Biomaterials
10–12 Jul 2024, Online

DAY 1 Morning	DAY 2 Morning	DAY 3 Morning
Session B. Bone Biomaterials	**Session D.** Biomaterials for Tissue Engineering	**Session A.** Dental Biomaterials
DAY 1 Afternoon	**DAY 2 Afternoon**	**DAY 3 Afternoon**
Session C. Antibacterial Biomaterials	**Session E.** Biomaterials for Drug Delivery **Session F.** Biomaterials for Diagnostics, Therapy and Healthcare	**Session G.** Bio-fabricated and 3D Printed Biomaterials **Poster Session**

IOCFB 2024 Program

10 Jul 2024 (Wednesday)
Opening Ceremony
Session B. Bone Biomaterials

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
9:30–9:35	15:30–15:35	Welcome from the conference chair—Prof. Dr. Pankaj Vadgama	
9:35–9:40	15:35–15:40	Welcome from the session chairs—Dr. Zhidao Xia and Prof. Dr. James Triffitt	
9:40–10:00	15:40–16:00	Keynote Speaker **Prof. Dr. Davide Deganello**	Additive manufacturing and the application for functional biomaterials
10:00–10:20	16:00–16:20	Keynote Speaker **Dr. Gianluca Cidonio**	Reimagining 3D bioprinting to pattern hierarchical features for skeletal regeneration
10:20–10:40	16:20–16:40	Invited Speaker **Dr. Hannah Donnelly**	A bioengineered bone marrow niche model to support long-term HSCs/in vitro
10:40–10:50	16:40–16:50	Selected Speaker **Mikhail Shlykov**	Mathematical and experimental modeling of calcium phosphates resorption in physiological conditions
10:50–11:00	16:50–17:00	Selected Speaker **Magdalena Górecka**	Poly (vinyl alcohol) as a functionality modifier of magnesium phosphate-based bone cement
11:00–11:10	17:00–17:10	Selected Speaker **Geetha Balasubramani**	Bio-ceramic based bone implant coating for better stability and functional metabolism between bone tissues & metals implants
11:10–11:20	17:10–17:20	Selected Speaker **Sara Ferraris**	Polyphenol-based coatings to control the degradation of magnesium alloys
11:20–11:30	17:20–17:30	Selected Speaker **Polina Kachalina**	Changing of mechanical properties of PLA-based materials during biodegradation
11:30–11:40	17:30–17:40	Selected Speaker **Meenal Agrawal**	Antibacterial poly (ε-caprolactone) scaffold for bone tissue regeneration
11:40–11:50	17:40–17:50	Selected Speaker **Reza Samiee**	Fabrication of a hydroxyapatite coating reinforced with Functionalized graphene oxide deposited on NiTi implant alloy: A bioactivity and electrochemical properties analysis
11:50–12:00	17:50–18:00	Selected Speaker **Marcin Wekwejt**	Advancements in biofunctional dual-setting bone cements: The potential of pHEMA hydrogel enhancement for magnesium phosphate cement

Session C. Antibacterial Biomaterials

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
14:00–14:05	20:00–20:05	Welcome from the session chair—Prof. Dr. John H.T. Luong	
14:05–14:35	20:05–20:35	Keynote Speaker **Prof. Dr. Shuilin Wu**	Photo-responsive antibacterial Biomaterials
14:35–14:55	20:35–20:55	Invited Speaker **Dr. Sara M. Soto**	Antibiofilm materials
14:55–15:10	20:55–21:10	Selected Speaker **Rukudzo Chihota**	Bactericidal coatings based on elastomers
15:10–15:25	21:10–21:25	Selected Speaker **Aleksei Demakov**	Development of smart polymer nanomaterials that generate nitric oxide for the antibacterial application.
15:25–15:40	21:25–21:40	Selected Speaker **Abay Maksumova**	Antibacterial-coated surgical sutures by ALD of titanium oxide doped with vanadium for the treatment of the surgical site infection
15:40–15:55	21:40–21:55	Selected Speaker **Jiayang Xie**	Addressing MRSA infection and antibacterial resistance with peptoid polymers
15:55–16:10	21:55–22:10	Selected Speaker **Weinan Jiang**	Peptide-mimicking antifungal polymers possessing BBB penetrating property to treat fungal infections and meningitis
16:10–16:25	22:10–22:25	Selected Speaker **Haodong Zhang**	Switching from membrane disrupting to membrane crossing, an effective strategy in designing antibacterial polypeptide

11 Jul 2024 (Thursday)
Session D. Biomaterials for Tissue Engineering

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
9:30–9:35	15:30–15:35	Welcome from the session chair—Prof. Dr. Li Ren	
9:35–9:55	15:35–15:55	Invited Speaker **Dr. Piergiorgio Gentile**	Nano-engineered multilayered systems to release targeted therapeutics
9:55–10:10	15:55–16:10	Selected Speaker **Rui Wang**	Multifunctional metal–organic cages accelerate tissue regeneration via regulating microenvironment and mediating endogenous growth factor production
10:10–10:25	16:10–16:25	Selected Speaker **Najoia Aribou**	Dielectric relaxation behavior of composite based on polyester matrix reinforced with argan nutshell powder biofiller
10:25–10:40	16:25–16:40	Selected Speaker **Pooja Ajit Jain**	3D printed nanocomposite scaffold for bone tissue regeneration
10:40–10:55	16:40–16:55	Selected Speaker **Yang yang**	Tracing immune cells around biomaterials with spatial anchors during large-scale wound regeneration
10:55–11:10	16:55–17:10	Selected Speaker **Nourhan Hassan**	Magnesium as a tissue engineering material in plastic surgery: In-vitro biocompatibility studies with human dermal fibroblasts
11:10–11:25	17:10–17:25	Selected Speaker **Sreypich Say**	Fibroblast and THP-1 cells response to the multi-arm PEGNHS-modified decellularized porcine pericardium

Session E. Biomaterials for Drug Delivery
Session F. Biomaterials for Diagnostics, Therapy and Healthcare

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
14:00–14:10	20:00–20:10	Welcome from the session chairs—Prof. Dr. Alexander K. Andrianov and Dr. Ian Teasdale	
14:10–14:30	20:10–20:30	Keynote Speaker **Dr. Junjie Li**	Activable polymersome-based nanoreactors for targeted cancer therapy
14:30–14:45	20:30–20:45	Selected Speaker **John Hardy**	Exogenous stimuli-responsive materials for drug delivery
14:45–15:00	20:45–21:00	Selected Speaker **Angelika Sabina Banas**	Conducting polymer microspheres for targeting neuroblastoma
15:00–15:15	21:00–21:15	Selected Speaker **Filippo Rossi**	Decorated nanogels as promising tools for selective drug delivery in spinal cord injury
15:15–15:20	21:15–21:20	Welcome from the session chair—Dr Serena Danti	
15:20–15:40	21:20–21:40	Invited Speaker **Prof. Dr. John G. Hardy**	Stimuli-responsive materials for drug delivery, neuromodulation, tissue engineering and regenerative medicine
15:40–15:55	21:40–21:55	Selected Speaker **Alex G. Kuchumov**	Influence of aortic valve leaflet material model on hemodynamic features in healthy and pathological states
15:55–16:10	21:55–22:10	Selected Speaker **Sara Abdulhadi Hasan**	Shining hope for future applications in oncology: BSA-coated silver nanoparticles targeting triple negative breast cancer cells
16:10–16:25	22:10–22:25	Selected Speaker **Nica Simona Luminita**	Polymer/carbon nanotubes composites for biomedical applications
16:25–16:40	22:25–22:40	Selected Speaker **Gianluca Ciarleglio**	Fabrication of pH-responsive multilayer hydrogel patches for enhanced burn wound treatment

12 Jul 2024 (Friday)
Session A. Dental Biomaterials

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
9:30–9:35	15:30–15:35	Welcome from the session chair—Prof. Dr. Gianrico Spagnuolo	
9:35–9:55	15:35–15:55	Session chair **Prof. Dr. Gianrico Spagnuolo**	Effects of ormocer-based and nanohybrid composite resins on viability and differentiation of human dental pulp stem cells
9:55-10:15	15:55-16:15	Invited Speaker **Prof. Dr. Magdalena Ziąbka**	ZrO2 composites modified with different ceramics additives in the aspect of mechanical and biological properties as potential dental biomaterials
10:15-10:30	16:15-16:30	Selected Speaker **Ermelinda Silvana Junckes**	Incorporation of N-acetylcysteine into an experimental resin-based sealer
10:30-10:45	16:30-16:45	Selected Speaker **Massimo Barbieri**	Graphene and its derivatives in dental implants: a patent landscape study
10:45-11:00	16:45-17:00	Selected Speaker **Rasha M. Abdelraouf**	An innovative surface treatment technique for coating 3D printed polyamide 12 by hydroxyapatite
11:00-11:15	17:00-17:15	Selected Speaker **Tamer M. Hamdy**	Compressive strength, microhardness, and solubility of zinc-oxide eugenol cement modified with e-glass fiber fillers
11:15-11:30	17:15-17:30	Selected Speaker **Rafaela Pilecco**	Does the restorative design and material affect marginal, internal fit, interfacial volume, and fatigue behavior of indirect restorations
11:30-11:45	17:30-17:45	Selected Speaker **Claudio Cirrincione**	Three-dimensionally printed polycaprolactone shows more physiological stiffness compared with titanium alloy

Session G. Bio-Fabricated and 3D Printed Biomaterials
Poster Session

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
14:00–14:05	20:00–20:05	Welcome from the session chair—Dr. Lidy Fratila-Apachitei	
14:05-14:35	20:05-20:35	Keynote Speaker **Prof. Dr. Daniel X.B. Chen**	Advance in biomaterials, bioink, and extrusion bioprinting
14:35-14:50	20:35-20:50	Selected Speaker **Yuqing Lu**	Effect of printing layer orientation and finishing protocol on the fracture behavior of 5Y-PSZ ceramic by 3D printing
14:50-15:05	20:50-21:05	Selected Speaker **Parul Chaurasia**	3D printing of alkali dissolved chitosan bioink and structural evaluation of bioprinted constructs for biomedical application
15:05-15:20	21:05-21:20	Selected Speaker **Daniela Vaquero Hernández**	Synthesis and characterization of 3D-based alginate-gelatin bioprinted scaffolds for bone tissue applications
15:20-15:40	21:20-21:40	**Break**	
15:40-16:40	21:40-22:40	**Poster Session**	The Poster Sessions will take place in Zoom break-out rooms. The list of names and titles of the posters can be found here

Poster List

Poster Session	
Name	**Title**
Edyta Kosińska	Biomaterials based on Ti6Al4V and hydroxyapatite obtained using 3D Binder Jet printing
Ekaterina Sergeevna Chikanova	New composite materials based on chitosan, carboxymethylcellulose, hydroxyapatite and wollastonite for bone regeneration
Teng Wan	Surface decoration of PEEK implants with IGF-1 via polydopamine enhances osseointegration and osteogenic differentiation
Sara Abdulhadi Hasan	Towards Sustainability and Waste-to-Wealth Approach: Development of Metallic Nanoparticles for Biomedical Applications using Local Palm Tree Waste
Felipe Cordova Lozano	Enhancing Antimicrobial Efficacy: Glutaraldehyde Crosslinking of Electrospun PVA Nanofibers Embedded with Ag Nanoparticles
Ihtisham Ul Haq	Antimicrobial activity of polymers-functionalized urinary catheters against Staphylococcus aureus
Monika Rojewska	Physicochemical study of mucoadhesive polymers and their interactions with mucin
Ana Júlio	Enhancing solid lipid nanoparticles performance: combining commercial lipids with biobased ionic liquids
Yannis Paulus	Silicon nanoneedles for sustained treatment of choroidal angiogenesis
Shadi keihankhadiv	ATRP-Synthesized Linear Copolymer Conjugates from Pharmaceutically Functionalized Choline Ionic Liquid Monomers for Ampicillin Delivery
Carmela Del Giudice	Biocompatibility on Human Dental Pulp stem cells (hDPSCs) of experimental fluoride-doped calcium phosphates as promising remineralising materials
Beatriz Serralheiro da Cruz	Impact Strength of Composite Materials on Different Thicknesses
Alex Kuchumov	In silico model of CoCr stent performance in multi-layered artery using 2-way fluid-structure interaction: influence of boundary conditions and vessel length
Luis Fernando Andrade da Silva	Iron Oxide Nanoparticles Coated with Alginate: Potential Contrast Agent for Magnetic Resonance Imaging
Ekaterina Brodovskaya	In vitro study of polyelectrolyte microcapsules loaded with chlorin E6 and iron oxide nanoparticles for photodynamic therapy
Darya Kalugina	A new strategy based on methylene blue and boron nitride for local photodynamic therapy
Rebeca Muniz de Melo	Development of theranostic nanoplatforms based on colloidal silver nanoprisms and paramagnetic chelates
Nancy Nelly Zurita-Méndez	Development of Galatite-Eggshell membranes and bioactive glass scaffolds for their use in bone tissue engineering
Gustavo Henrique Doná Rodrigues Almeida	Production and Characterization of Biological Grafts Derived from a Decellularized Uterus Aiming for Tissue-Engineering Applications
Cristian Enrique Torres-Salcido	Gelatin-Based Coaxial Nanofibers as a Coating of 3D Poly(Lactic Acid) Printed Scaffolds for Bone Tissue Engineering
Sahra Fonseca	Effect of mechanical and chemical process variation on antibacterial activity of polydopamine coating.

About Us

Launched in 2009 by MDPI, Sciforum is an event management platform that supports open science by offering the opportunity to participate in, as well as to organize, academic events. Having hosted hundreds of events (be it in-person events, virtual events, or webinars), Sciforum helps organizers reduce their administrative efforts by providing a comprehensive set of tools to successfully manage academic events.

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Abstracts

Session A. Dental Biomaterials

sciforum-090168: Graphene and Its Derivatives in Dental Implants: A Patent Landscape Study

Massimo Barbieri

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Carbon allotropes, including graphene, graphene oxide (**GO**), and reduced graphene oxide (r**-GO**), have potential as coating nanomaterials to improve the performance of dental implants.

Furthermore, graphene has demonstrated strong antibacterial activity and enhanced biocompatibility in comparison to other types of carbon nanoscale structures.

Several bibliometric studies have been published on the use of graphene-based materials, but they only focus on scientific articles and not patents.

A few articles report on a patent study of dental implants but without focusing on carbon allotropes.

The objective of this study is to provide the patent landscape analysis of graphene and its derivatives in relation to dental implants.

The search for relevant information was conducted on Espacenet (`https://worldwide.espacenet.com`, provided by the EPO—European Patent Office), using keywords and classification codes, specifically, the IPC (International Patent Classification) and CPC (Cooperative Patent Classification).

Dental implants are primarily classified in the A61C13/00 and A61C8/00 subgroups, while the classification symbol for graphene and its derivatives, such as graphene oxide, is C01B32/182 and its lower subgroups.

By combining the abovemention symbols with keywords, a total of 68 patents/patent applications were obtained.

After reading the title, abstract, and claims, 16 documents were excluded as they were off-topic and not related to the use of graphene or its derivatives in dental implants.

The Orbit Intelligence platform (`https://www.orbit.com`) was used to analyze the 52 relevant results obtained. Of these, 55.8% are granted patents, 26.9% are pending patent applications, 5.8% were revoked, and 11.5% lapsed.

The first patent application was filed in 2010.

China has the highest number of applications with 20, followed by the USA with 7 and South Korea with 6.

Graphene oxide is the most commonly claimed carbon allotrope, while titanium and its alloys are among the most frequently used materials.

sciforum-088349: Acrylic Bone Cement Reinforced with Halloysite Clay Nanotubes

Tamer M. Hamdy

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Background

In the disciplines of orthopedics and dentistry, acrylic bone cement is frequently utilized for treating bone defects, securing prosthetic implants, remodeling osteoporotic deformities, and repairing fractures. Traditional acrylic bone cement has been found to have several disadvantages, such as prosthesis loosening, heat generation, inferior mechanical characteristics, and weak interface integrity. There was a strong need to improve its qualities; as such, recent research has shown that adding halloysite clay nanotubes (HNTs) to materials based on polymers can enhance their mechanical and thermal qualities.

Objectives

We sought to assess the impact of adding 10 weight percent of HNT fillers to traditional acrylic bone cements in order to modify their compressive strength, flexural strength, and exothermic heat generation.

Methods

The monomer liquid was combined with acrylic powder to create the control group. The creatively reinforced group was made by combining the acrylic powder with liquid before adding 10 weight percent of HNT fillers. XRF was used to carry out the chemical characterization of the fillers that were used. Measurements were made of the setting temperature, compressive strength, and flexural strength. Independent sample *t*-tests were used to statistically analyze the data and compare the mean values (p 0.05).

Results

The results showed that when compared to the traditional acrylic bone cement control group, the novel modified acrylic bone cement with 10 weight % HNT fillers had greater mean compressive strength, greater flexural strength, and lower setting temperatures ($p \leq 0.05$).

Conclusions

It was possible to employ the modified reinforced acrylic bone cement with 10% HNT fillers as an alternative to acrylic bone cement.

sciforum-089937: An Innovative Surface Treatment Technique for Coating 3D-Printed Polyamide 12 Using Hydroxyapatite

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Introduction

Polymer 3D printing has gained wide applications in the medical field. Polyamide 12 has been used to reconstruct bony defects. Coating its surface with calcium phosphate compounds, as hydroxyapatite, could enhance its bonding with bone. In this study, a simple innovative surface treatment was introduced by applying light-cured cement to coat 3D-printed polyamide 12 specimens with hydroxyapatite.

Methods

Polyamide 12 powder was printed by selective laser sintering to produce 40 disc-shaped specimens (15 mm diameter $\times$ 1.5 mm thickness). The specimens were divided randomly into two main groups: (1) a control (untreated) group, where the surface of the specimens was left without any modifications; and (2) a treated group, where the surface of the specimens was coated with hydroxyapatite by a new method using a light-cured dental cement. Each group was further subdivided into two subgroups according to the immersion in simulated body fluid (SBF). The first subgroup was not immersed in SBF and was left as printed, while the second subgroup was immersed in SBF for 15 days (n = 10/subgroup). The surfaces of the control and treated specimens were examined using an environmental scanning electron microscope (SEM) and energy-dispersive X-ray analysis (EDXA) before and after immersion in SBF.

Results

The SEM micrographs of the control 3D-printed polyamide 12 specimens illustrated the agglomerated 3D-printed particles with minimal porosity. Their EDXA revealed the presence of carbon, nitrogen, and oxygen. This surface was not affected by immersion in SBF, as detected by SEM and EDXA. The microstructure of the coated specimens showed deposited clusters of calcium and phosphorus on the surface, in addition to carbon, nitrogen, and oxygen. This coat was stable after immersion, as detected by SEM and EDXA.

Conclusions

Using light-cured cement could be considered a simple method to coat the 3D-printed polyamide 12 with hydroxyapatite.

sciforum-089792: Biocompatibility Study on Human Dental Pulp Stem Cells (hDPSCs) of Experimental Fluoride-Doped Calcium Phosphates as Promising Remineralising Materials

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Introduction

Innovative fluoride-doped calcium phosphates attract great interest as potential remineralising materials for dental applications, which may be able to react with body fluid and be converted into fluorapatite (FA) and/or fluor-hydroxyapatite (FHA). Hence, this in vitro study aimed to assess the cytotoxicity, self-renewal, and migratory properties of these experimental materials.

Methods

Five specimens containing 0, 5, 10 and 20% fluoride on hDPSCs were tested at different dilutions (undiluted, from 1:5 to 1:100), and the eluates were prepared according to ISO 10993-12. Viability assays were conducted using the MTT test. Furthermore, we analysed self-renewal by observing colony formation and migration activity with scratch tests.

Results

Our results demonstrated that the powders with greatest toxicity on hDPSCs are those without fluoride and with 20% fluoride when diluted 1:1. Exclusively using the 1:50 dilution, which is non-cytotoxic, we observed that the powder containing 20% fluoride caused a significant decrease in clonogenic capacity. Furthermore, the results obtained from the scratch test did not highlight significant differences in terms of the migratory capacity of the cells when treated with different percentages of fluoride, leaving us to hypothesise that the different percentages of fluorine do not act at the level of the cytoskeleton.

Conclusions

The results obtained confirm that the experimental fluoride-doped calcium phosphates are cytotoxic for hDPSCs regardless of the percentages of fluorine tested, but the effects of their dilutions indicate that controlled doses could be able to promote cell proliferation. Therefore, the data obtained represent a starting point for future studies that will focus on the most appropriate concentrations of fluoride to be used in order to obtain non-cytotoxic and osteoinductive effects so that these experimental materials can be used clinically for beneficial and preventive purposes.

sciforum-089335: Compressive Strength, Microhardness, and Solubility of Zinc-Oxide Eugenol Cement Modified with E-Glass Fiber Fillers

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Background

In restorative dentistry, zinc oxide eugenol (ZOE) cements are among the most commonly used temporary materials. Eugenol has several therapeutic benefits, including sedative, anti-inflammatory, bacteriostatic, and pain-relieving properties. It is also advantageous because of its low cost and ease of application and removal. Researchers are trying to strengthen ZOE because, despite its benefits over other temporary fillers, including varnish, zinc polycarboxylate, and calcium hydroxide, it has a lower mechanical strength. Recently, E-glass fibers have shown great promise as reinforcing fibers because of their excellent mechanical behavior, sufficient bonding, and acceptable aesthetics.

Objectives

To assess ZOE cements and those reinforced with manual incorporation of 10% E-glass fibers in terms of compressive strength, surface microhardness, and solubility.

Methods

The control group was prepared by mixing dental ZOE powders with their liquid. The innovatively reinforced dental ZOE group was prepared by incorporating 10 wt.% E-glass fibers into the ZOE powder prior to liquid mixing. Particle size distribution (PSD), scanning electron microscopy (SEM), and X-ray fluorescence (XRF) were used to characterize the E-glass fibers. Evaluations of the modified group were conducted on its compressive strength, surface microhardness, and solubility. Independent-sample *t*-tests were used to statistically analyze the data and compare mean values (p 0.05).

Results

The findings demonstrated that, in comparison to the unmodified ZOE, the modified ZOE had a significantly lower mean value of solubility and a significantly higher mean value of compressive strength and surface microhardness ($p \leq 0.05$).

Conclusions

The modified ZOE cements with 10 wt.% E-glass fibers provide enhanced compressive strength, surface microhardness, and reduced solubility, which encourages their use as permanent dental restorative materials.

sciforum-090354: Development of New Dental Compositions for Early Treatment of Dental Caries

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Introduction

Dental caries remains the most common dental problem. Due to the high cost of treatment, there is a growing interest in the use of more preventive and minimally invasive biotechnological methods. Hydroxyapatite (HA), due to its excellent biocompatibility, finds wide application in dentistry as a remineralizing component. The use of enzymes is promising for the destruction of cariesogenic bacterial biofilms. The low resistance of bacteria to the action of enzymes is a great advantage of this approach. Thus, this work is devoted to the development of new composite dental materials of prolonged action based on hydroxyapatite, enzyme-destructors and biodegradable polymers for caries treatment.

Methods

The compositions were prepared by mixing gelatin, HA and enzymes (glucoamylase, glucose oxidase, lysozyme) in aqueous solution in a given ratio. The suspensions were poured into molds, frozen and subjected to lyophilic drying. Structural and morphological characteristics of the obtained biomaterials in the form of plates were analyzed using SEM with EDS analysis system. The absorbance and degradation kinetics of the plates were measured in PBS medium at 37 °C. Antibacterial properties were studied against microorganisms found in the oral cavity.

Results

In the course of the study, new biomaterials in the form of plates were obtained, which can be active against pathogenic microflora of the oral cavity and have a mineralizing effect in the processes of restoration of damaged enamel. The plates have a slightly hydrophobic surface and their dissolution in PBS starts only after 30 min, which are positive factors for prolonged action in the composition of active components. The addition of enzymes accelerates the dissolution of the plates.

Conclusions

Based on the results, the obtained biomaterials are suitable for the treatment and prevention of dental caries, indicating the potential for their further in vivo study.

sciforum-089259: Does the Restorative Design and Material Affect Marginal, Internal Fit, Interfacial Volume, and Fatigue Behavior of Indirect Restorations?

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Introduction

Prosthodontists must select the restoration design and material to achieve long-lasting oral rehabilitations when restoring endodontically treated teeth. Few studies compare those factors in terms of fit, interfacial volume, and fatigue behavior. Thus, this study aims to evaluate the fatigue behavior, marginal and internal fit, and interfacial volume of CAD-CAM restorations with different designs (endocrowns and crowns) made from different materials (lithium disilicate ceramic, LD, IPS e.max CAD; and resin composite, RC, Tetric CAD).

Methods

Simplified crowns and endocrowns (n = 10) were produced using CAD-CAM technology through scanning by an intraoral scanner (Primescan), followed by milling in a 4-axis machine (CEREC MC XL), and then bonded to fiberglass-reinforced epoxy resin dies. After the restorations' finishing, surface treatment procedures, and bonding, a computed microtomography was used to assess fit and interfacial volume. A cyclic fatigue test (20 Hz, initial load = 100 N/5000 cycles; step-size = 50 N/10,000 cycles until 1500 N, if specimens survived, the step-size = 100 N/10,000 cycles until failure) was performed. Topography and fractography analysis were also performed. Two-way ANOVA and Kaplan-Meier with log-rank (Mantel-Cox) test were run ($\alpha = 0.05$).

Results

Endocrowns presented a superior axio-occlusal fit, while crowns presented a better cervical-axial and occlusal fit. LD restorations had a superior occlusal fit, while RC had a better marginal fit. The interfacial volume was similar among the tested groups. Fatigue behavior was superior for RC restorations compared to LD ones, independently of the restoration design. LD restorations presented a softer topography compared to RC.

Conclusions

The restoration design affected the cervical-axial, axio-occlusal, and occlusal fit. The marginal gap was similar between designs, but it was impacted by the restorative material, as well as the occlusal fit. The fatigue behavior was not influenced by the restoration design, meanwhile RC restorations showed superior performance compared to LD ones.

sciforum-090031: Effects of Ormocer-Based and Nanohybrid Composite Resins on Viability and Differentiation of Human Dental Pulp Stem Cells

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Introduction

Conventional nanohybrid (CeramX) and ormocer-based (Admira fusion) dental composite resins were compared investigating their effects on human dental pulp stem cells (hDPSCs) in terms of cytotoxicity, migration and osteogenic differentiation.

Methods

The samples and the eluates were prepared according to ISO 10993-12. hDPSCs were treated with different dilutions (undiluted, from 1:2 to 1:100) of CeramX and Admira fusion eluates. Viability assays were conducted in standard or osteogenic conditions using the MTT test. Furthermore, we analysed the migration activity with scratch test. Osteogenic differentiation potential was evaluated exclusively at dilution of 1:50 by Alkaline Phosphatase Activity and Alizarin Red Staining assay.

Results

Admira Fusion demonstrated to be highly biocompatible and positively influenced the proliferation of hDPSCs; on the contrary, CeramX showed to be more cytotoxic. The ormocer-based eluate exhibited osteo-inductive effects on hDPSCs when diluted at ratio of 1:50; conversely, conventional nanohybrid composite did not show any notable effect on stem cells differentiation.

Conclusions

The lower cytotoxicity observed with Admira Fusion compared to the conventional nanohybrid composite could be attributed to a reduced monomers release in the oral environment. This evidence supports the hypothesis of limited adverse effect and enhanced healing potential, particularly when the material is positioned in close contact with pulp tissue.

sciforum-089700: Impact Strength of Composite Materials on Different Thicknesses

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Knowledge about the strength of restorative materials is crucial to a proper decision-making process on oral rehabilitation. Various test set-ups can determine the strength of materials under different circumstances, however, not much is known about materials' behavior under higher or more abrupt loads, such as in an impact situation. This study aimed to investigate the effect of different consistencies of resin composite materials (Conventional and Flowable) commonly used for dental restorations on their impact strength. Specimens of two light-cured composites (Flow - Clearfil Majesty ES Flow, Kuraray Noritake; Conv - Clearfil AP-X PLT, Kuraray Noritake) were produced with two different thicknesses (1.0 or 1.5 mm; n = 15) to be tested under impact. The impact strength was measured within the Dynstat method. Data were analyzed by one-way ANOVA. The statistical significance was set to p 0.05. The results showed a significant difference between Flow and Conv for 1.0 mm thickness (Flow [11.61 $\pm$ 2.66 kJ/m^2]; Conv [5.06 $\pm$ 0.98 kJ/m^2]), but no significant difference was found between materials with 1.5 mm thickness (Flow [6.53 $\pm$ 1.04 kJ/m^2]; Conv [6.75 $\pm$ 1.01 kJ/m^2]). Considering thicknesses in the same materials, higher impact strength values were found for the Flow composite with 1.0 mm thickness. This finding can point to a higher population of defects in larger volumes of composite materials. Given the results, it can be concluded that the evaluated flowable resin composite behaved similarly to a regular composite in thicker constructions and that inner defects and residual polymerization shrinkage stresses can make larger pieces more fragile.

sciforum-092057: Incorporation of N-Acetylcysteine into an Experimental Resin-Based Sealer

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The most common root canal sealers are bioceramic, which release hydroxyl anions and demonstrate bactericidal activity against microorganisms. However, because of its high solubility, this has an impact on sealing capacity as well. Another option is a resin-based sealer, which has a high sealing capacity but is inert to microorganisms. Thus, in this work, an experimental sealer was developed with both features: low solubility and bioactivity due to the use of a polymeric system, and release of the drug N-acetylcysteine (NAC) absorbed onto hydroxyapatite (HAp) nanoparticles incorporated in an epoxy polymer system. Thiol bond interactions allow NAC molecules to disrupt bacterial membranes. Because HAp is soluble in acidic pH, it is expected to release NAC molecules when exposed to a low pH environment.

The sealers were produced by incorporating the particles of interest with a radiopacifier in a mix of resin monomers to form epoxy sealers by chemical polymerization. Physical-chemical properties were determined and compared with a commercial sealer (AH Plus).

As expected, AH Plus demonstrated low sorption in the immersion media and a constant pH. After 28 days, only the Epoxy/NAC and Epoxy/HApNAC groups lost weight in water and PBS, indicating that NAC had been released. However, Epoxy/HApNAC showed lower pH variation across all media, which could be attributed to Epoxy/NAC's lower drug content or particle dimensions. The weight loss in water of Epoxy/NAC ($30.23 \pm 5.12\%$ w/w) and Epoxy/HApNAC ($1.67 \pm 0.16\%$) corroborates with the NAC release profile. Epoxy/HApNAC samples released 49 μmol/L (0.09% mm) of NAC into water. DC data show that the interaction of NAC molecules with epoxy resin polymer chains improves particle compatibility in comparison the Epoxy/HAp group.

The Epoxy/HApNAC group showed similar behavior to the AH Plus group and potential bioactive property by NAC-released content, without compromising the degree of conversion.

sciforum-088500: Three-Dimensionally Printed Polycaprolactone Shows More Physiological Stiffness Compared with Titanium Alloy

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Introduction

Intraoral bone regeneration requires the use of meshes made of titanium alloy (Ti6Al4V) placed under the oral mucosa as space maintainers and with adequate stiffness to withstand chewing loads. However, excessive load resistance could damage the mucosa with the exposure of meshes and infectious problems. Also, polycaprolactone (PCL), a resorbable polymer, is used as a mesh because it has high hardness at physiological temperatures. Both Ti6Al4V and PCL need to be sterilized before use. The objectives of this study are to compare the response to mechanical load between sterile PCL (SPCL), virgin PCL (VPCL) and Ti6Al4V meshes.

Methods

Fifteen meshes with dimensions of 10 mm $\times$ 30 mm were designed with free CAD software; thickness was 0.2 mm for five Ti6Al4V meshes and 0.8 mm for ten PCL meshes. The meshes were produced with selective laser melting for Ti6Al4V and a fused deposition modeling for PCL. Before loading, five PCL meshes were sterilized in a laminar flow hood using ethanol solution (70%) for 30 min, washed in distilled water for 10 min and then left to air-dry. All meshes were fixed at four points at the ends and loaded centrally with a universal testing machine (MTS 810) running at 130N and a 10 mm/min speed using a spherical point measuring 10 mm in diameter until the first failure.

Results

The first failure of VPCL and SPCL appeared at 46 $\pm$ 1.74 N and 36 $\pm$ 3.83 N, respectively, while it appeared at 83.1 $\pm$ 19.97 N for Ti6Al4V. PCL showed low stiffness compared with Ti6Al4V (2.8 $\pm$ 0.67, 2.0 $\pm$ 0.19 and 9.4 $\pm$ 2.11 N/mm for VPCL, SPCL, and Ti6Al4V, respectively).

Conclusions

Ti6Al4V displays higher stiffness compared with PCL, but the latter is more than adequate for withstanding physiological chewing loads and as a space maintainer. Furthermore, the PCL stiffness values are similar to those of keratinized mucosa reported in the literature.

sciforum-088643: ZrO_2 Composites Modified with Different Ceramics Additives in the Aspect of Mechanical and Biological Properties as Potential Dental Biomaterials

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Zirconia is in well known as a dental biomaterial and has been applied as structural material for implants, dental bridges, crowns or inserts due to its biocompatibility, high fracture toughness, and radiopacity. On the other hand oxide ceramics can undergo subcritical cracking which is crucial parameter in the case of a long-term loading in a humid environment (such as human body). Pure zirconium oxide stabilized with yttrium oxide is considered also as an inert material. To improve bioactive properties, modifying additives are used to induce a specific biological response. One of the most common bioactive filler, which enhances early and late bone-to-implant integration; is represented by hydroxyapatite. Another example of a material that has the effect of enhancing osteointegration is bioglass. Bioactivity can also be understood in the context of providing dental materials with antibacterial function. Among the most commonly used antibacterial materials are silver and copper nanoparticles. In the present work we tried to consider 3 aspects simultaneously. First of all determination of slow crack growth parameters and then lifetime estimation of biocomposites made of ZrO_2 and hydroxyapatite (HAp), where zirconia powder was obtained by hydrothermal method. Secondly, comparison of biological properties such as antibacterial efficacy and biocompatibility of ZrO_2/HAp in respect of ZrO_2 composites modified with hexagonal boron nitride (hBN), bioglass (BG), and bioglass containing copper (BGCu). Thirdly, demonstration of bioactive properties that promote the formation of an apatite layer on the biocomposite surface in contact with SBF.

Our findings indicated that all materials demonstrated a high degree of biocompatibility. However, it is noteworthy that a slight cytotoxicity was observed in the composites modified with HAp and hBN. Furthermore, the same composite materials exhibited notable antibacterial properties against Gram-positive bacteria and some Gram-negative strains. Moreover, the mechanical tests showed that ZrO_2/HAp biocomposites revealed susceptibility to subritical cracking.

Abstracts

Session B. Bone Biomaterials

sciforum-093546: A Bioengineered Bone Marrow Niche Model to Support Long-Term HSCs In Vitro

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A bioengineered bone marrow niche model to support long-term HSCs in vitro Long-term reconstituting haematopoietic stem cells (LT-HSCs) are used to treat blood disorders via bone marrow transplantation to engraft and repopulate the blood system. The very low abundance of LT-HSCs and their rapid differentiation once removed from their niche in the bone marrow hinders their clinical utility. Previous developments using stromal feeder layers, defined media cocktails, and bioengineering have enabled HSC expansion in culture, but of mostly short-term HSCs (ST-HSC) and progenitor populations at the expense of naïve LT-HSCs. Here, we report the creation of a bioengineered LT-HSC maintenance niche that recreates physiological extracellular matrix organisation, using soft collagen type-I hydrogels to drive nestin expression in perivascular stromal cells (PerSCs or pericytes). We demonstrate that nestin, which is expressed by HSC-supportive bone marrow stromal cells, is cytoprotective and, via regulation of metabolism, is important for HIF-1α expression in PerSCs. When CD34+ve HSCs were added to the bioengineered niches comprising nestin/HIF-1α expressing PerSCs, LT-HSC numbers were maintained with normal clonal and in vivo reconstitution potential, without media supplementation. We provide proof-of-concept that our bioengineered niches can support the survival of CRISPR edited HSCs. Successful editing of LT-HSCs ex vivo can have potential impact on the treatment of blood disorders.

sciforum-090073: Advancements in Biofunctional Dual-Setting Bone Cements: The Potential of pHEMA Hydrogel Enhancement for Magnesium Phosphate Cement

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Bone regeneration capabilities are inherent to skeletal tissue. However, the integration of specialized biomaterials is frequently necessary, enhancing and sometimes being crucial to the bone healing process. Bone cements are particularly notable within this context as they exhibit biofunctionality. Specifically, magnesium phosphate cement (MPC) is recognized for its quick setting, high mechanical strength, and osteogenic benefits, despite issues like brittleness and injection complications. This study presents a novel MPC-based cement enhanced with poly(2-hydroxyethyl methacrylate) (HEMA) hydrogel, aimed at overcoming these limitations.

The novel cement formulation includes a powder mix of tri-magnesium phosphate and di-ammonium hydrogen phosphate at a 4:1 ratio, combined with HEMA solutions (15–25%). Polymerization, initiated by APS/TEMED, with different premixing times, facilitates hydrogel formation. Specimen preparation involved mixing the above components at a 2.5 g/mL ratio, subsequently putting the obtained paste into molds, and curing them (24 h, 37 °C, >90% humidity). Evaluations covered setting time, SEM microstructure, XRD and FTIR analyses, mechanical strengths, porosity, degradation rate, and cytocompatibility with human osteoblasts.

Key findings indicate that incorporating HEMA hydrogel markedly impacts the primary properties of MPC. Specifically, alterations in the concentration of HEMA and the duration of premixing significantly influence the creation of hydrogel aggregates within the cement matrix, contributing to enhanced mechanical properties and facilitating controlled degradation. Importantly, although the modified cement demonstrated advantageous functional and mechanical properties, future research should prioritize exploring alternative hydrogel formulations or modifications to the HEMA polymerization process.

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sciforum-091682: Antibacterial Poly (ε-Caprolactone) Scaffold for Bone Tissue Regeneration

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Over the past few decades, there has been significant progress in the field of biomaterials, specifically in addressing the challenges associated with tissue regeneration. By selecting the appropriate biomaterials and fabrication techniques, one can achieve tissue-specific architectures and structural properties for scaffolds. These scaffolds have also been modified with site-specific functionalities to facilitate optimal tissue regeneration. Despite these advancements, challenges like large-sized defects and infection-prone implant sites hinder the success of these scaffolds. To address these challenges, a highly porous poly (ε-caprolactone) (PCL) scaffold was developed utilizing high-internal-phase emulsion (HIPE, dispersed phase volume > 74%) templating, which was further functionalized to impart antimicrobial properties. A single-step methodology was employed to create nanocomposite scaffolds made of crosslinked PCL. This was achieved by the polymerization of Pickering HIPEs of ε-caprolactone (CL) that were stabilized using hydrophobic silica nanoparticles (mSiNPs) at low concentrations. The developed scaffolds demonstrated cyclic compressional stability for multiple cycles. Further, the PCL nanocomposite scaffolds were functionalized using an antimicrobial therapeutic agent that could effectively prohibit the growth and formation of biofilm in the case of both *S. aureus* and *E. coli*. The developed nanocomposite scaffolds had no adverse effect on MG-63 cells, allowing their growth and surface adherence. The developed antimicrobial scaffolds of PCL demonstrated promising capability to not only allow regeneration at large defect sites but also avoidpossible implant-site infections.

sciforum-091525: Bio-Ceramic-Based Bone Implant Coating for Better Stability and Functional Metabolism between Bone Tissues and Metal Implants

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Background

Bone Replacement is suggested for a patient when the patient's knee/limb bone region starts to be painful/swollen around the joint part due to osteoarthritis and other bone-related diseases; during surgery, a new bone implant made of metal on metal (titanium, cobalt-chromium) or a polymer on metal (polyethylene on titanium) is used. A huge disadvantage of this kind of bone implant is that it causes inflammation and infections due to the metal or polymer debris generated on the implant. Infections or inflammation caused by bacterium adherence to an implant surface, a biofilm formation occurring at the implantation site, and infections caused by metal debris generated from friction and movement of the knee joint are referred to as implant-associated infections.

Method

So, in this research work, we have developed a bio-ceramic-based composite coating on a metal implant comprising beta-Tricalcium phosphate, pectin, gelatin, and (PVP) polyvinylpyrrolidone on a titanium screw to increase biocompatibility, antibacterial activities, and anti-inflammatory activities of the implant. Composite coating on a bone implant will enhance cell growth around the implant and it gives a viable environment for the implanted site.

Results

The primary characterization of the composite coating materials is conducted by (SEM) Scanning Electron Microscopy with (EDX) Energy Dispersive X-ray, a (FTIR) Fourier Infrared Spectroscopy analysis, in vitro antibacterial testing, and anti-inflammatory testing and the in vitro degradation study is conducted for the determination of stability of the coating.

Conclusions

In the above tests, it is concluded that our novel composite coating materials have an increased antibacterial effect and biocompatibility in nature. However, further research is needed for the in vivo testing process to confirm the use of synthesized bio-ceramic-based composite coating for bone tissue engineering or bone defects.

sciforum-090370: Biomaterials Based on Ti6V4Al4 and Hydroxyapatite Obtained Using 3D Binder Jet Printing

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Currently, there is an increasing discussion on the topic of the aging population and the associated problems. As the issue becomes more pressing, there is a rising need for surgical implants that meet specific requirements. Metal-based implants are being phased out due to their tendency to cause abnormal tissue growth. A more effective solution is to combine metal with ceramics, particularly hydroxyapatite, which has a structure similar to natural bone and can facilitate tissue regeneration. Surgical implants are designed to serve as bone replacements for as long as possible. The ideal implant should be characterized by its ability to integrate with the bone through osteointegration, mitigate inflammation, and promote bone regeneration.

In order to improve the durability and biocompatibility of a bone implant, a composite material based on the titanium alloy Ti6Al4V and hydroxyapatite can be designed. The process of obtaining the Ti-HAp composite involves several important elements, including the synthesis of hydroxyapatite particles with a specific morphology, 3D binder ket printing, and the sintering of materials.

Binder jetting is a 3D printing technology used for producing biomaterials. It allows for the production of components designed in a computer-aided design program, such as CAD. The binder jet method has several advantages, including the ability to produce multiple components in a single process and achieve high porosity for bone implants.

The binder jet 3D printing method can produce a composite biomaterial based on Ti6Al4V and HAp, which may serve as an alternative to conventional methods for obtaining bone implants. However, further research is necessary in order to improve production parameters and determine the final properties of Ti-HAp biocomposites.

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sciforum-089941: Bismuth Apatites as the Basis of Biomaterials for Bone Tissue Regeneration

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Compounds with apatite structures containing bismuth, of the compositions $Ca_{10-2x}Bi_xNa_x(PO_4)_6F_2$ (x = 1, 2, 3, 4), $Ca_8BiNa(PO_4)_6O$ and $Ca_8BiNa(PO_4)_{5.5}(VO_4)_{0.5}O$, were synthesized by a solid-phase reaction for the first time. The phase identity and crystal structure features of the substances were studied by X-ray diffraction analysis (Rietveld method) and IR spectroscopy. It was found that calcium, bismuth and sodium ions are distributed on cationic positions of the apatite crystal structure, not statistically, but taking into account coordination possibilities. Thus, sodium ions, possessing high values of coordination numbers, are located in the centers of three-caped triangular bipyramids (CN = 9, Wyckoff position 4*f*), and bismuth ions are located in in the centers of two-caped triangular bipyramids (CN = 8, Wyckoff position 6*h*). Calcium is distributed uniformly over the positions. Such peculiarity of the crystal structure of substances causes strong binding of bismuth ions, and, therefore, prevents their exit from the structure. The phase stability (stability) of the substances in water, phosphate-salt buffer and trypsin was confirmed by X-ray phase and elemental analyses, which confirmed the prediction of behavior made on the basis of structural data. The absence of cytotoxicity of the materials was confirmed directly in the standard MTT test. For the $Ca_8BiNa(PO_4)_6F_2$ and $Ca_6Bi_2Na_2(PO_4)_6F_2$ compositions, an increase in cell proliferation was observed. This phenomenon can be explained by the fact that these substances are formed as spheroidal particles during synthesis, which facilitates their penetration through the cell membrane. In addition, it was found that $Ca_8BiNa(PO_4)_6O$ and $Ca_8BiNa(PO_4)_{5.5}(VO_4)_{0.5}O$ do not possess bactericidal activity against *S. aureus* and *E. coli* cultures, which also agrees with the previously mentioned conclusions. Thus, new non-cytotoxic materials based on bismuth apatite were obtained.

sciforum-090148: Changing of Mechanical Properties of PLA-Based Materials during Biodegradation

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Arthrodesis is a surgical procedure which aim is to fix an affected joint to compensate the lost function of the limb. Nowadays the common materials for these purposes are medical steel and titanium alloys. However, metal alloys have high mechanical characteristics compered to natural bone. That leads to stress shielding at the place of bone and implant contact. Also these implants cannot provide joint fixation at a physiological angle for patients under anesthesia.

Current problems can be solved by development a self-positioning individualized implant made of composite material with shape memory effect. The materials presented in this research are polylactic acid (PLA) filled with bioinert (SiO_2) and bioactive (hydroxyapatite) particles. Mechanical properties of the composites are close to natural bone's. Also, PLA is a biodegradable material, which means that implant can gradually dissolve inside the body. This peculiarity leads to changing mechanical properties during time, but also helps to avoid repeated surgery. This research is focused on how different conditions of biodegradation affect mechanical characteristics of PLA- SiO_2 and PLA-HAp composites.

Composites with 10, 15 and 20% mass of fillers and pure PLA were produced by extrusion. The process of degradation was observed on flat samples (ISO 14125:1998) to determine flexural properties of materials. The samples were immersed in phosphate-buffered saline, blood serum and cell solution to compare differences in biodegradation mechanism. The samples were kept in solutions at 37 °C for 1, 2, 4 and 8 weeks. Then they were tested by mass change, SEM of surface and three-point bending.

The results demonstrated change in the degree of crystallinity and a significant decrease in the mechanical properties of samples during the process of biodegradation. It caused by the paramount destruction of the amorphous phase of the polymer.

Study was performed with a support of Grant RNF № 24-23-00442.

sciforum-090726: Development of Multifunctional Synthetic Peptide with Pro-Regenerative, Antibacterial, and Anti-Inflammatory Properties as an Additive to Biocomposites Promoting Bone Regeneration

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Trauma, cancer, infections, and degenerative and inflammatory diseases are all contributing to an increase in the prevalence of bone problems and deformities. Bone repair and replacement options are evolving as a result of advances in orthopedic technology and high-quality biomaterials. Biomaterials based on polymer scaffolds, such as chitosan, are making a substantial contribution to the rapid expansion of bone tissue engineering. New additives are constantly being developed in response to the rising need for increased bioactivity in biocomposites used for bone regeneration.

Here, we present the design and synthesis of a multifunctional, synthetic bioactive peptide composed of a fragment of human Cystatin C (CystC) and anoplin. By combining these two bioactive proteins, we aim to combine pro-regenerative and anti-inflammatory capabilities with antibacterial properties to effectively assist bone regeneration and wound healing while also preventing or treating bacterial infections throughout the healing process. The biological activity of the ug46 peptide and the chitosan-ug46 (CH-ug46) biocomposite was examined in vitro, and the results suggest improved regenerative properties of the CH-ug46 biocomposite, which is dose-dependent. Furthermore, while the ug46 peptide demonstrated limited antibacterial activity at low doses, the antibacterial capabilities of the biocomposites releasing high doses of peptide were able to suppress the growth of the selected bacteria strains that are commonly found infecting healed wounds.

Our findings indicate that synthetic peptides can be utilized to provide specific activities required to promote regeneration processes and prevent negative effects frequently associated with wound healing, such as microbiological infections or severe inflammation. Designed bioactive peptides show promise as additions to enhance porous scaffolds and may help to advance the development of specialized, custom-tailored biocomposites.

sciforum-090191: Evaluation of Biofunctional Composite Cement: Integrating Magnesium Phosphate and Alginate Hydrogel

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The characteristic of injectability is crucial within the realm of biofunctional materials, enhancing their application in minimally invasive surgical procedures. In this context, bone cements, particularly magnesium phosphate cement (MPC), are prominently utilized due to their excellent resorption rates, high mechanical strength, and quick curing times, positioning them as strong competitors against traditional ceramic cements. Nonetheless, MPC is not without its challenges, including issues of brittleness, paste susceptibility to washout, and difficulties with injectability. This investigation focuses on the advantages of integrating alginate hydrogel into MPC, with the goal of improving its operational effectiveness and overall performance characteristics.

The synthesis of ceramic cement was executed through the combination of magnesium oxide and potassium dihydrogen phosphate (4:1 Mg/P molar ratio), incorporating varying concentrations of sodium alginate (SA) solutions as the liquid phases and adjusting powder-to-liquid ratios accordingly. The hydrogel was formed through a delayed cross-linking reaction using $CaCO_3$/GDL. Subsequently, the cement pastes were shaped and incubated under standardized conditions. Comprehensive assessments were performed, including evaluations of setting time and temperature, microstructure, chemical and phase composition, mechanical strengths, injectability, biodegradation, and cytocompatibility.

A novel dual-setting biocomposite cement was effectively created. The production of well-crystallized k-struvite crystals, showing significant variances in size and growth patterns, in conjunction with the cross-linked SA, was confirmed. Our analyses demonstrate numerous advantages of these new cements, such as decreased setting times, diverse microstructural configurations, improved biodegradability, and enhanced paste cohesion and injectability. Nevertheless, these advancements negatively impacted the composite's mechanical strength. Notwithstanding elevated bioreactivity, the cements retained cytocompatibility across most evaluated groups.

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sciforum-088324: Fabrication of a Hydroxyapatite Coating Reinforced with Functionalized Graphene Oxide Deposited on a NiTi Implant Alloy: A Bioactivity and Electrochemical Property Analysis

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The majority of the challenges within the broad application of titanium alloys used as biomedical implants are related to their interfacial properties; thus, surface modification represents a proper solution to overcome these issues. Surface functionalization by coating deposition is an appropriate choice for metallic implant surface modification [1]. In particular, inorganic ceramic coatings such as hydroxyapatite (HAp, $Ca_{10}(PO_4)_6(OH)_2$) have been widely employed to improve this incompatibility [2]. Nevertheless, the brittle nature and poor strength of HAp coatings are a problem, especially when the implant needs to work under load-bearing conditions. Therefore, the incorporation of nanoparticles as secondary bioactive fillers enhances their characteristics [3]. This work aims to investigate the effect of graphene oxide (GO) nanolayers functionalized with therapeutic cations as an active/passive filler to increase the bioactivity of an HAp coating and hinder the access of corrosive species to the metallic substrate. The release ability of functionalized graphene oxide (FGO) makes it a desirable candidate as a bioactive additive for bone regeneration. The flake morphology of these nanoparticles can enhance the barrier performance and the toughness of the HAp coating [4].

For this purpose, GO nanoparticles have been synthesized via the modified Hummer method and have been functionalized through absorption of strontium and gallium cations. Then, an HAp coating loaded with Sr/Ga-functionalized GO nanoparticles was deposited on nitinol samples. The effect of FGO incorporation on the anticorrosion behaviour of HAp-coated nitinol samples was studied via polarization and electrochemical impedance spectroscopy (EIS). Furthermore, the bioactivity and antibacterial performance of the composite coatings applied on implant samples have also been investigated.

sciforum-090157: Formation of Calcium Phosphate Coatings on Titanium and Polymer Substrates Using Gas-Detonation Deposition

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The use of medical implants is becoming more widespread, which is attracting great interest in the development of new technologies for their production. Titanium-based implants are the most common now, but the polymer polyetheretherketone (PEEK) is studied as a substitute. Despite the biotolerance to titanium and PEEK, their implantation in the human body is often accompanied by some negative effects. This problem is solved by depositing biocompatible coatings on the implant's surface, in particular, calcium phosphates (CPs). CP coatings on implants are produced by different techniques, each of which has its own disadvantages related to both the quality of the formed coatings and their cost.

Biocompatible coatings based on hydroxyapatite (HAP) on metal and polymer implants were obtained by gas-detonation deposition (GDD). This method consists ofthe acceleration of HAP powder by a detonation wave resulting from the explosion of a mixture of acetylene and oxygen. HAP powder particles are introduced into the detonation wave and accelerate to high speeds and form a coating on the implants. Among the main advantages of GDD are its high productivity, the ability to form layers of different thickness on large-area substrates in a few minutes, the possibility of varying the coating composition, the high adhesion with low energy consumption of the process and, accordingly, the low cost.

HAP coatings with a thickness ~ 200 microns on titanium and PEEK substrates were studied by Raman spectroscopy, XRD and microscopic analysis. This study showed the formation of a porous coating on the titanium substrate, which consisted of crystalline and partially amorphous HAP. The latter was transformed into a crystalline one during annealing at 600 °C. The HAP coating on PEEK was shown to consist of HAP with a small admixture of tricalcium phosphate. The appearance of the latter is explained by the partial transformation of HAP microparticles into tricalcium phosphate when they collide with the surface.

sciforum-090301: Low Concentration Hematology Behaviour of NIR—Sensitive Silver Nanoplates: Isotropic against Anisotropic Morphologies

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Introduction

Understanding the hematological behavior of near-infrared (NIR) responsive plasmonic nanoparticles is crucial for their medical applications. Despite low concentrations, their nature may cause toxicity in biological environments through interactions with biomolecules. Especially interactions with plasma proteins have implications for hemostasis, thrombosis, and inflammatory responses. This study focuses on isotropic and anisotropic silver nanoparticles's (AgNPs) interactions with bovine serum albumin (BSA) and effects on red blood cells (RBCs) and clotting time.

Method

Specific localized resonant surface plasmon AgNPs were synthesized and exposed to protein. Protein solution was prepared within normal blood plasma limits (35–50 mg mL^{-1}). UV-Vis and fluorescence spectroscopy studied interaction, while transmission electron microscopy (TEM) analyzed changes in particle size and morphology. Fresh blood incubated with AgNPs assessed cell morphology changes. RBCs content release, specifically lactate dehydrogenase (LDH) activity, was measured using UV–vis-NIR spectrophotometry to indicate membrane rupture. AgNPs' impact on blood coagulation times was investigated using test kit after incubation.

Results

UV-Vis studied the chemical environment of interface AgNPs/BSA. The results not showed changes to prism-shaped with different concentrations, but sphere-shaped showed decreases intensity. Fluorescence reveled that nanoparticles can induce the enhancement and quenching of protein emission, possibly due to conformational changes in protein structure. By TEM, aggregation state of systems AgNPs/BSA was confirm. AgNPs showed minimal impact RBCs morphology and LDH release. Isotropic AgNPs increased LDH release compared to anisotropic. Interaction with BSA may activate the coagulation cascade, but AgNPs showed no impact on coagulation time.

Conclusions

AgNPs interacted with BSA at lower than reported. Isotropic nanosilver distributes throughout the protein network, exerting reactivity. In addition to the effect on BSA organization, isotropic nanoparticles caused some RBCs disruption compared to the NIR-sensitive anisotropic AgNPs, which showed no negative effects on hemocompatibility. These results aid in developing devices loaded with NIR- light responsive nanosilver, ensuring safe use.

sciforum-090371: Mathematical and Experimental Modeling of Calcium Phosphates Resorption in Physiological Conditions

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The successful osseointegration of the implant depends on numerous factors, both material-related (phase composition, mechanical properties, implant morphology, presence of doping agents) and recipient-related (health status, nature of inflammation, material's influence on immunostimulation and reparative histogenesis). Modeling each stage of regeneration separately and combining stages gradually to form a comprehensive model appears to be an appropriate approach for identifying relationships between these factors.

This study aims to assess the contribution of the resorption rate of the osteoplastic material to the process of bone defect regeneration. Dicalcium phosphate dihydrate (DCPD), octacalcium phosphate (OCP), hydroxyapatite (HA), obtained by the hydrolysis of precursors, were used. Resorption kinetics were evaluated using isotonic buffer solutions SBF and PBS in stationary and dynamic closed systems (up to 28 days; t = 37 °C; without solution replacement). In the stationary system, a phase transformation of DCPD to OCP was observed for both solutions, which was quantitatively described by a theoretical model based on first principles of chemical kinetics. Equilibrium between material and saturated solution was observed for OCP and HA samples.

For experiments in the dynamic system, a bioreactor was developed to mimic physiological fluid flow. Under these conditions, no phase transformation of DCPD to OCP occurred in either solution, and equilibrium between material and saturated solution was observed. This was explained within the previously obtained theoretical model, taking into account Fick's second law.

Similar experiments were conducted using a mixture of culture medium DMEM and bovine blood serum. It was found that serum albumin adsorbs as a monolayer on the surface of calcium phosphates (Langmuir-type I isotherm), significantly inhibiting the dissolution rate of DCPD and the crystallization rate of OCP.

All obtained data were described within a unified theoretical model, further development of which is the focus of future research.

sciforum-090361: New Composite Materials Based on Chitosan, Carboxymethylcellulose, Hydroxyapatite and Wollastonite for Bone Regeneration

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Introduction

Composite materials are used in medicine for a wide range of practical tasks to improve human health. In traumatology and orthopedics, materials are used that combine biodegradable polymers with inorganic salts, most often calcium phosphates. Currently, the selection of multicomponent compositions of inorganic fillers that perform different functions and improve the characteristics of transplants is considered promising. In particular, the combination of phosphates and calcium silicates is of interest.

Methods

In this work, porous materials were made from powders containing synthetic hydroxyapatite (HA, $Ca_{10}(PO_4)_6(OH)_2$) and wollastonite (WT, β-$CaCiO_3$) in the ratios 0/100, 20/80, 40/60, 60/40, 80/20 and 100/0; chitosan gel (200 kDa, 90%); and carboxymethylcellulose. Granules were produced in various shapes—cylinders, spheres and hemispheres with a diameter of 4 mm. All samples were examined by XRD, FTIR, XPS, SEM and EDS analysis systems. The Vickers microhardness at HV0.2 load, the density and the porosity of the granules were studied. Their dissolution in tris-buffer, an isotonic solution, was studied. Their cytotoxicity was determined using the MTT test.

Results

The resulting materials are porous, rough and hydrophilic. The pore sizes are mainly 0.2–1.0 microns. The density of the samples ranges from 2.76 to 3.48 g/cm^3, depending on the composition. The microhardness of the granules varies from 3.04 to 5.38 0.2HV. According to XRD and FTIR data, it was determined that no structural phase transitions of inorganic powders occur during the synthesis process. It was found that the highest rate of dissolution is observed in the tris-buffer, where samples of HA/W 60/40 degrade faster. It was determined that the granules do not have a cytotoxic effect.

Conclusions

Based on the results obtained, the new materials obtained are suitable for bone regeneration and can be studied in vivo.

sciforum-091717: Obtaining Hydroxyapatite as a Calcium Phosphate with High Potential in Bone Tissue Engineering

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As the main mineral component of bone tissue, hydroxyapatite (HAp) shows promising potential in bone tissue engineering due to its similarity to the natural component of bone tissue and its ability to stimulate tissue regeneration. Understanding the processes for obtaining hydroxyapatite and its properties is key to the further development of modern bone tissue engineering techniques to improve the effectiveness of regenerative therapies for trauma and osteoarticular diseases. The wet precipitation method is an effective technique for obtaining hydroxyapatite (HAp) in bone tissue engineering. The process is simple, scalable and allows precise control of parameters such as temperature and pH. The advantage of this method is that HAp with different morphologies and microstructures can be obtained by modifying the process conditions. In addition, it is an economically attractive technique due to the low cost of raw materials and the simplicity of the process. The conclusion is that the wet precipitation method is a promising option for producing HAp for bone tissue engineering applications. The presented work presents a method for the synthesis of hydroxyapatite and its detailed characterization. The chemical composition and morphological properties were determined using the following research techniques: Fourier transform infrared spectroscopy, particle size analysis, electron microscopy observations, and X-ray diffraction analysis. The results indicate great potential for the application of bioceramics in medical applications.

The novelty of the presented work is the combination of selected calcium phosphates with titanium alloy via sintering. As a result of this work, porous gradient structures were obtained, which were then evaluated for physicochemical properties using techniques such as X-ray diffraction, XRD.

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sciforum-090443: Poly(Vinyl Alcohol) as a Functionality Modifier of Magnesium Phosphate-Based Bone Cement

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Within the biomedical field, alternatives to natural bone are essential for repairing significant bone breaks that require rebuilding. Injectible, self-hardening bone cements like magnesium phosphate (MPC) are integral to orthopedic operations with minimal invasiveness. These biomaterials are valued for their biodegradable qualities, quick setting, and good mechanical strength, equating them with traditional bone substitutes such as calcium phosphates. However, there is a noted deficiency in the cohesion and ease of injection of MPC paste. This research delves into creating a novel functional biocement based on MPC enhanced with a poly(vinyl alcohol) (PVA) hydrogel to improve its application.

This biocomposite cement results from combining magnesium oxide with potassium dihydrogen phosphate in a PVA-based matrix. The study examines hydrogel's impact by varying its concentrations and different content of cross-linking agent. The evaluation encompasses assessments of setting time and temperature, microstructural examination, identification of phases and chemical composition, static strength testing, injectability potential, and a cytocompatibility evaluation with human osteoblasts.

This research has culminated in the creation of a unique dual-setting bone cement, which merges magnesium phosphate cement with poly(vinyl alcohol) hydrogel. This novel biocomposite is characterized by exceptional attributes such as superior biocompatibility, proper biodegradation and improved functional qualities, reducing negative physiological responses and enhancing safety for clinical use. Furthermore, the material demonstrates a reduced setting temperature, good porosity and enhanced injectability - allowing for more precise and minimally invasive surgical procedures. Consequently, this innovative biocement holds great potential for advancing orthopedic and trauma treatments.

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sciforum-090238: Polyphenol-Based Coatings to Control the Degradation of Magnesium Alloys

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Introduction

Magnesium alloys are promising for implants because of their biocompatibility and biodegradability. However, they are still poorly applied in clinics due to too rapid degradation, which does not match with tissue regeneration and is often associated with inflammation due to a pH rise and hydrogen development. The aim of this work is the development of natural organic coatings that can modulate the degradation rate of the substrates.

Methods

Plane samples (AZ31-AZ91) and porous 3D structures (AZ91) obtained by 3D printing combined with investment casting were considered as substrates. Natural organic coatings, tannic acid (TA) or polyphenols extracted from green tea leaves (TPH) were obtained by immersion in aqueous solutions of the selected molecules without the addition of toxic chemicals. The functionalization conditions were optimized in order to obtain homogeneous coatings that were free of cracks.

Results

Coating formation by soaking allowed for the treatment of complex geometries and porous structures. TA uniformly covered the surface of magnesium alloys, maintaining its redox activity after grafting, as well as the micro-topography, but it presented several micro-cracks (more evident in AZ31). The TA coating allowed us to keep the pH at the physiological level during AZ91 soaking in PBS. The result was less effective on AZ31. TA-coated AZ91 was poorly corroded after 14 days of soaking in PBS, and TA was still present on it. However, electrochemical tests did not evidence the effects of the coating improvements in terms of corrosion potential and rate. This effect was probably due to the presence of cracks. The use of TPH and surface pre-treatment allowed for the development of more homogeneous and crack-free coatings on both AZ91 and AZ31 surfaces. These coatings presented improved corrosion resistance (electrochemical tests) and biocompatibility.

Conclusions

Natural organic coatings represent a promising green and sustainable strategy for the modulation of the degradation rate of magnesium alloys for biomedical applications.

sciforum-090470: Sintering of Titanium-Ceramic Composites

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Bone diseases are still a great bane among patients. Researchers are looking for a material for bone implants so that it meets all conditions and stimulates cells to grow rapidly. There are various possibilities for the consolidation of ceramic-metal alloys. In the present study, sintering in high vacuum was undertaken. The materials consist of a titanium alloy (Ti6Al4V), which is of course responsible for the strength, then the bioactivity-stimulating agent is hydroxyapatite so that the bone cells are stimulated to proliferate and form new apatite layers.

The aim of this study was to select sintering process parameters for titanium alloy and hydroxyapatite composite materials. The obtained matrices were sintered in a vacuum furnace. The materials were subjected to various tests to confirm the correctness of the selected values. Characterization was carried out using various test methods, including XRF, SEM, and microhardness testing. The results so far for the materials obtained show promising possibilities in the biomedical field. The choice of components and the methods of combining them were appropriate, which prevented the degradation of the samples.

The authors gratefully acknowledge financial support of the project “New Generation of Bioactive Laser Textured Ti/Hap Implants” under acronym “BiLaTex” carried out within M-ERA.NET 3 Call 2022 programme in the National Centre for Research and Development (ERA.NET3/2022/48/BiLaTex/2023).

sciforum-083334: Surface Decoration of PEEK Implants with IGF-1 via Polydopamine Enhances Osseointegration and Osteogenic Differentiation

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Polyetheretherketone (PEEK) is a promising biomedical material in orthopedic and dental applications owing to its excellent mechanical properties, near absent immune toxicity, and X-radiolucency, but suffers from bio-inertness and inferior osteoconduction. Surface modification of PEEK can effectively solve this problem, retaining most of its advantageous properties. In this study, porous structures were fabricated using concentrated sulfuric acid, and the interface was bio-functionalized by IGF-1 immobilization on the porous surface via a polydopamine coating. The surface characteristics of modified PEEK were evaluated via scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS). The pore size was generally distributed between 0.3 and 0.8 μm and was evaluated using ImageJ software. The hydrophilicity and BSA protein adsorption capacity were significantly enhanced after dopamine coating. IGF-1 was successfully immobilized onto the porous surface via the polydopamine coating and the immobilization efficiency was determined via ELISA. The tensile mechanics study showed that although the surface porous structure maintained a Young's modulus similar to that of human bone, the elongation at break and the maximum yield strength decreased. The in vitro studies revealed that PEEK immobilized with IGF-1 could remarkably improve the attachment, spreading, proliferation, extracellular matrix secretion, and alkaline phosphatase (ALP) activity of MC3T3-E1 pro-osteoblasts. These findings indicate that IGF-1 modification on the surface of PEEK implants using pDA as an intermediate layer can significantly enhance the osseointegration and osteogenic differentiation potential of PEEK, which has great potential for clinical applications.

sciforum-091918: The Preparation of Calcium Phosphate Coatings on a 3D-Printed Titanium Alloy (Ti 6Al-4V) by Means of Plasma Electrolytic Oxidation (PEO)

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Research provides results on the preparation of calcium phosphate coatings using plasma electrolytic oxidation. Calcium phosphate coatings are applied to titanium substrates measuring 20 × 30 × 2 mm. These substrates are produced using selective laser melting (SLM). Most implants are made of titanium and its alloys because of their excellent biocompatibility. However, they have disadvantages, including limited biological activity, wear, and corrosion resistance. Thus, to investigate the impact of the PEO method and the voltage on the coating characteristics, three different voltages, 200, 250, and 300 V, were used. This study utilized a JSM-6390LV scanning electron microscope (SEM) with an INCA Energy Penta FET X3 system. X-ray diffraction analysis was performed using a PANalytical X'Pert PRO diffractometer. Friction and wear tests were performed with a "ball–disk" setup on a TRB^3 tribometer. The surface morphology shows that an increase in applied voltage leads to an increase in the size of the pores. At an applied voltage of 300 V, the PEO coating layer cracked and the surface became uncommonly rough. An elemental analysis of the sample cross-sections reveals the formation of TiO_2 layers enriched with Ca and P at voltages between 200 and 250 V. At 300 V, calcium phosphate layers are observed predominantly on the outer surface. XRD analysis shows the presence of hydroxyapatite and titanium oxide phases. The coefficient of friction and the wear rate largely depend on the morphology, pore size, and density of a layer of the titanium dioxide. Therefore, the sample at 250 V exhibits better wear resistance compared to the other two coated samples. The PEO method shows promise for manufacturing implants with calcium phosphate coatings for traumatology and orthopedics. Titanium implants with these coatings are expected to enhance osseointegration and reduce the risk of implant failure.

Abstracts

Session C. Antibacterial Biomaterials

sciforum-089852: Addressing MRSA Infection and Antibacterial Resistance with Peptoid Polymers

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Introduction

The continued emergence and rapid spread of drug-resistant bacteria, coupled with the lack of novel antibiotics, imply the urgent need for new antimicrobial agents. Host defense peptides (HDPs) have been extensively studied as promising drugs against drug-resistant bacterial infections due to their broad-spectrum antimicrobial activity and insusceptibility to drug resistance. However, their application is limited by inherent shortcomings such as low stability upon proteolysis, cumbersome and time-consuming synthesis, and high cost. Therefore, the development of HDP mimetics that are resistant to proteolysis, easy to synthesize, and possess in vivo antimicrobial capability is of great significance.

Methods

The peptoid polymer was tested against drug-resistant Gram-positive bacteria, persister cells, and biofilms. In vitro and in vivo toxicity tests confirmed the high biocompatibility of the polymer. Confocal characterization, ROS test and DNA binding experiment were used to demonstrate the antimicrobial mechanism. Finally, mouse models were used to confirm the in vivo antibacterial efficacy of the peptoid polymer.

Results

In this study, we synthesized a library of antibacterial peptoid polymers with various C-terminal functional groups via one-pot ring-opening polymerization of *N*-substituted *N*-carboxyanhydrides (α-NNCAs). The optimal peptoid polymer showed potent activity against methicillin-resistant *Staphylococcus aureus* (MRSA) planktonic bacteria, persister cells, and biofilm. It's noteworthy that bacteria are unable to acquire resistance against the peptoid polymer owing to the antibacterial mechanism including the generation of reactive oxygen species and DNA binding. The preferred molecule exhibited effective in vivo anti-infectious performance in the mouse wound model, the mouse keratitis model, and the mouse peritonitis model induced by MRSA. In addition, the polymer also displayed potent in vitro and in vivo antibacterial activity against various other drug-resistant Gram-positive bacteria.

Conclusions

This study demonstrates the potential of peptoid polymers mimicking HDP in the treatment of drug-resistant microbial infections, mitigation of antibiotic resistance and development of antibacterial materials.

sciforum-090224: Antibacterial-Coated Surgical Sutures by Atomic Layer Deposition of Titanium Oxide Doped with Vanadium for the Treatment of the Surgical Site Infection

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Suture-associated surgical site infection causes bacterial pathogens to colonize the suture surface and biofilms that are highly resistant to antibiotic treatment. Surgical suture materials with antibacterial coating are becoming increasingly common in surgical practice. Traditional materials used in clinical settings often cause secondary complications such as infection, foreign body reaction, or chronic inflammation. Surgical sutures combining antibacterial nanomaterials possess a more promising efficacy. The application of antibacterial coatings to suture materials can make a significant contribution to prevention of the suture-associated surgical site infection. The most widely used and proven antimicrobial agent is the broad-spectrum antiseptic triclosan. However, due to the ecotoxicity of its oxidation products, there is currently a tendency to create suture materials with low or no triclosan content. This work provided a new approach to the development of antibacterial sutures based on the atomic layer deposition (ALD) technique. We have proposed applying a titanium–vanadium oxide nanofilm that is 12 nm thick on surgical sutures with an enhanced antibacterial property. The ALD process was carried out at a temperature of 80 °C. The ALD process was performed using supercycles consisting of repeated surface self-saturating hydrolysis reactions between $TiCl_4$ and H_2O, $VOCl_3$ and H_2O. The obtained surgical sutures showed high antibacterial effectiveness against strains of microorganisms *E. coli* and *S. aureus*. We are currently conducting animal tests.

The work was carried out within the framework of the State Assignment 1023022800054-7-3.4.4.

sciforum-090314: Antimicrobial Activity of Polymers-Functionalized Urinary Catheters against *Staphylococcus aureus*

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Introduction

Approximately 40% of nosocomial infections are catheter-associated urinary tract infections. Various surface modification methods are under consideration, with the potential to prevent bacterial colonization on the urinary catheter (UC).

Objectives

Herein, we aimed to coat the UC with a coating of polyvinyl alcohol (PVA) and ε-polylysine (PLL) and to check their antimicrobial effects against *Staphylococcus aureus*.

Methodology

A 10% PVA solution was prepared by mixing 10 g of PVA in 90 mL deionized water and stirring at 90 °C for two hours. Subsequently, 0.15 mL of 2% glutaraldehyde was added to the PVA solution. Next, the 20 mL of PVA/GA solution was shifted to small beakers to prepare PVA/GA/ε-PL solution in different ratios such as 1 mL ε-PL (PVA/GA/ε-PL-1), 0.75 mL ε-PL (PVA/GA/ε-PL-2), 0. 5 mL ε-PL (PVA/GA/ε-PL-3), 0. 25 mL ε-PL (PVA/GA/ε-PL-4). Pure PVA was used as a control. The solution of PVA/GA/ε-PL was coated on the UC by plasma-induced surface treatment to ensure optimal coating adhesion. The chemical analysis of the polymer-modified UC was performed by Fourier-Transform Infrared Spectroscopy (FTIR). The antimicrobial activity of modified UC was tested by a disc diffusion method and a colony forming unit/mL method against *S. aureus*.

Results

The disc diffusion method confirmed the antimicrobial activity of polymer-coated UCs through a zones on the plates. The colony-forming unit/mL showed that polymer-coated UCs caused a 4-log reduction compared to the control. The four tested polymer-coated UCs restricted bacterial growth until three dilutions. Confocal microscopy was performed for further confirmation of the antimicrobial properties of the polymer-modified UCs. Sample 1 caused the death of 74% of cells, followed by sample 4 (69%), sample 2 (49%), and sample 3 (43%), whereas in control samples, only 29% of dead bacterial cells were found.

Conclusions

Polymer-coated UCs showed promising antimicrobial effects against *S. aureus.*

Keywords: PVA; PLL; catheter; antimicrobial coatings; *Staphylococcus aureus*.

sciforum-090254: Antimicrobial Activity of Viscose–Polyester Non-Woven Fabric Functionalized with ZnO and Cu Nanoparticles

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Abstract

The global coronavirus epidemic increased awareness of infectious diseases and the need of developing hygienic textile materials with antimicrobial properties [1].

Considering bioactive textiles, which can kill microorganisms or inhibit their growth, various materials, modifiers, and modification methods have to be tested. The complex process of designing antimicrobial textiles includes, among others, selecting: the structure and composition of the textile material, a compatible bioactive modifier and an effective method of its application. Non-woven structures offer great potential for use in filtration systems, protective systems and covering materials. The modifiers, such as zinc oxide (ZnO) and copper (Cu) nanoparticles, have a high ability to change the biological and physicochemical properties of textile structures [2].

We developed the multifunctional non-woven fabric composed of hydrophobic (polyester) and hydrophilic (viscose) fibers, two nanomodifiers (2.5% of ZnO or/and Cu) and vinyltrimethoxysilane (VIN) applied by dip-coating method.

The modification effects were rated based on the complex analysis: SEM/EDS microscopy, AAS, Raman and FTIR spectroscopy and DSC and TG/DTG techniques. The wettability and surface free energy were determined using the goniometric method. The bioactive properties were studied against Gram-positive (Staphylococcus aureus) and Gram-negative (Klebsiella pneumoniae) bacteria and HCoV 229E human coronavirus. The new functional non-woven fabric with antibacterial and antiviral activity is non-toxic against non-tumorigenic, immortalized human keratinocyte cells (HaCat) and human lung adenocarcinoma cells (A549).

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References

1. Ivanoska-Dacikj, A.; Oguz-Gouillart, Y.; Hossain, G.; Kaplan, M.; Sivri, Ç.; Ros-Lis, J.V.; Mikucioniene, D.; Munir, M.U.; Kizildag, N.; Unal, S.; et al. Advanced and Smart Textiles during and after the COVID-19 Pandemic: Issues, Challenges, and Innovations. *Healthcare* **2023**, *11*, 1115. `https://doi.org/10.3390/healthcare11081115`.
2. Cieślak, M.; Kowalczyk, D.; Krzyżowska, M.; Janicka, M.; Witczak, E.; Kamińska, I. Effect of Cu Modified Textile Structures on Antibacterial and Antiviral Protection. *Materials* **2022**, *15*, 6164. `https://doi.org/10.3390/ma15176164`.

sciforum-092132: Bactericidal Coatings Based on Elastomers

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The rapid evolution of medical device technologies has provided effective solutions to several health challenges, ranging from artificial heart valves to hip replacement prostheses. Despite advancements in medical device technologies, infections remain a critical concern, posing risks such as tissue damage and organ failure. To address this, biomaterials with enhanced bactericidal properties are crucial.

This study examined the effectiveness of the produced elastomeric coatings containing bactericidal additives, in preventing bacterial infections on the surfaces of materials used in medicine. The influence of various additives, including silver, turmeric, graphene, cloves, and black cumin seeds, was tested on the bactericidal properties of silicone coatings. The bactericidal tests carried out showed an effect dependent on their concentration, and samples containing silver and black cumin seeds showed the strongest bactericidal properties. However, optimal concentrations must balance bactericidal effectiveness with potential cytotoxicity concerns. The material tests carried out focused on understanding the impact of additives such as silver, turmeric, graphene and cloves on the properties of the elastomer, revealing their diverse impact on the chemical structure, surface morphology, hardness, and hydrophobicity. The analysis of the surface adhesion of polymer coatings to glass proved that the use of additives improves their adhesion to the substrate used. The strongest effect was visible when turmeric was added to the silicone matrix.

sciforum-092150: Biocompatible Biodegradable Materials Based on Chitosan Modified with Nanostructured Titanium Dioxide

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In light of current trends to reduce the ecological load, much attention is being paid to biopolymer-based materials - from the development of biomedical drugs, membranes for purification and packaging materials. Large-scale research in this direction is carried out using chitosan (CTS) due to its biocompatibility, biodegradability, and antimicrobial properties. The CTS limiting factor is its low physical-mechanical characteristics and thermal stability. The actual task is CTS modification by combining it with materials that are also biocompatible and non-toxic. One of the promising compounds is TiO_2, which has a pronounced antimicrobial and photocatalytic activity. At the same time, the strengthening of useful properties of the composite material should be expected when TiO_2 in nanostructured form is used.

The research aims to obtain CTS based materials modified with TiO_2 nanoparticles (NPs); and study their biodegradation, physical-mechanical, thermal-physical and antibacterial properties. TiO_2 NPs with average sizes ranging from 20 to 920 nm were prepared from $Ti(OPr^i)_4$ by sol-gel technology. TiO_2 NPs were incorporated into solutions of 3 wt.% CTS in acetic acid. The TiO_2 concentration was varied from 0.5 to 10 wt.% (relative to CTS mass), acetic acid—from 1.2 to 6 wt.%. Transparent homogeneous materials with high physical-mechanical properties were obtained. The highest tensile strength and deformation—up to 100 MPa and 30%—are possessed by films containing up to 2 wt.% of TiO_2 (50 nm). The effect decreases when the TiO_2 NPs size and concentration increase. Thermal-physical characteristics of CTS with 2 wt.% of TiO_2 NPs were studied by differential scanning calorimetry and dynamic mechanical analysis methods. It was found that the materials are degraded by *Aspergillus niger* by 50% within 4 weeks and exhibit antibacterial activity against *Staphylococcus Aureus*.

The work was financially supported by the Russian Science Foundation (project No. 23-74-10069).

sciforum-092160: Chitosan as a Biomaterial with Antimicrobial Properties: Revalorizing By-Products from the Food Industry

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Due to society's growing concern for the environment, there is an increasing demand for developing biomaterials in different industrial sectors. At the governmental level, the application of a circular economy is being promoted, based on the revaluation of by-products produced during manufacturing, which can serve as raw material for the manufacturing of another. In the past few years, chitosan has come into focus as a potential biomaterial for both the biomedical and the food sectors, as it possesses inherent antibacterial and antifungal properties, antioxidant activity, good film-forming abilities, biocompatibility, non-antigenicity, and analgesic, anti-inflammatory and hemostatic activities. Chitosan is a biodegradable polycationic polysaccharide whose main components are glucosamine and *N*-acetylglucosamine monomers disposed randomly and connected by β-1,4-glycosidic bonds (Du et al., 2024; Yin et al., 2024). This biopolymer has been studied in different forms, such as nanoemulsions, hydrogels or composites, obtaining favorable results for its application as edible packaging to help extend the shelf life of perishable foods such as fruits and vegetables, as well as in biomedicine as materials that help wound healing (Du et al., 2024; Gritsch et al., 2018; Káčerová et al., 2024). Thus, this systematic review aims to present the available information on the formation of antibacterial biomaterials from chitosan with potential applications in biomedicine and food packaging, from a circular economy point of view, since this compound is highly present in the skeleton of crustaceans and is a by-product of the food industry.

sciforum-090069: Development of Antibacterial Wound Healing Materials Using Polycaprolactone Fibers and ZnO Nanoparticles

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Introduction

Traditional dressings are inadequate for effective wound healing due to their restricted qualities; however, there is a growing global demand for wound treatment. The occurrence of problems in wound healing is primarily attributed to inflammatory processes triggered by infection with diverse microorganisms. This study involved the development of an antibacterial dressing using electroformed polycaprolactone (PCL) fibers that incorporated zinc oxide nanoparticles (ZnO NPs).

Materials and Methods

The nanofibers were obtained in a mixture of acetic and formic acids with a concentration of PCL 25%. ZnO NPs, prepared by autoclave synthesis, were added to the acid mixture in varying amounts of 1, 3, and 5 wt.%. The structure and chemical composition of the ZnO NPs and PCL composite fibers were analyzed using SEM, EDX, and FTIR spectroscopy. The antibacterial activity was assessed against multiple strains of bacteria and fungus. The biocompatibility of the samples was assessed using the Lonza human dermal fibroblast cell line.

Results

The size of the produced ZnO NPs varied between 10 and 12 nanometers. The composite fibers have a size that varies between 300 nm and 1 μm. The EDX examination verifies that the primary constituents of the fibers consist of carbon, oxygen, and zinc. Furthermore, it is demonstrated that with an increase in the wt.% of ZnO, the atomic concentration likewise increases to 1.1%, 2.7%, and 3.9%, respectively. The successful implementation of ZnO nanoparticles was confirmed by the use of FTIR spectroscopy. The materials showed 100% antibacterial activity. When cell survival was evaluated, samples with 1% and 3% were shown to have low cytotoxicity in contrast to 5%.

Conclusions

A novel composite fiber material with high potential for wound healing has been created. This platform exhibits enhanced bactericidal and proliferative activities. This study demonstrates the potential of utilizing the composite material in wound healing applications.

Funding: This research was funded by the Russian Science Foundation (20-19-00120-P).

sciforum-090444: Development of Smart Polymer Nanomaterials That Generate Nitric Oxide Forantibacterial Application

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Introduction

Modern scientific and clinical data indicate that 60% of chronic wounds contain microbial biofilms, which are associated with the main pathophysiological processes and contribute to the prolongation of infection. The nitric oxide (NO) radical, depending on application time and concentration, has been shown to cause the dissolution of biofilms and sensitization of bacteria to antibiotics without causing resistance. In nanomolar concentrations, NO stimulates vasodilation, enhances the proliferation of endothelial cells, reduces thrombus formation, and promotes angiogenesis and wound healing. Therefore, research and development of the immobilization of nitric oxide precursors on carriers for local delivery of controlled amounts of NO for specific medical purposes is relevant.

Methods

The deposition of plasma polymers was carried out using a ZP-COVANCE-RFPE-3MP vacuum system equipped with an oil diffusion pump providing the residual pressure in a vacuum chamber below 30 Pa. Isopentyl nitrite (99.995%) and C2H4 (99.95%) were used as precursors to deposit thin films on silicon wafers and polycaprolactone nanofibers at a discharge power of 30 W. The obtained plasma-deposited polymer films were studied by SEM, EDX analysis, XPS, FTIR spectroscopy, and WCA. The films were tested against different pathogens.

Results

Plasma deposition resulted in homogeneous and well-bonded layers. SEM micrographs showed no pinholes, cracks, or other damage in the deposited layers. According to FTIR and XPS, the obtained spectra indicated the presence of nitroxyl compounds on the surface of samples. It was shown that nitroxyl-containing films prevented the formation of biofilms.

Conclusions

We developed an approach to deposit nitroxyl-containing films from a mixture of isopentyl nitrite/C2H4 and demonstrated antibacterial effects against Gram-positive and Gram-negative pathogens.

Funding: This work was supported by the Russian Science Foundation (grant №20-19- 00120-P).

sciforum-091060: Effect of Mechanical and Chemical Process Variation on Antibacterial Activity of Polydopamine Coating

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Low bacterial load and adhered biofilms are challenges to current tests and prophylactic measures, and can result in healthcare-associated infections (HAIs). It has been shown that the risk of HAIs can be reduced when antibacterial coatings are applied to the surface of medical devices. This study aims to optimize the antibacterial efficacy of polydopamine coating as a potential material for the prevention of HAIs.

Polydopamine coatings were characterized after varying the coating process. Modifications included the concentration of dopamine monomers, the sample position (horizontal vs vertical), the stirring speed (0–90 RPM) and the reaction time (0.5–24 h). The results were monitored via UV-visible, wettability and atomic force microscopy. The dopamine cytotoxicity was evaluated on the L929 cell line, in accordance with the ISO 10993-5 standard, and the antibacterial properties of polydopamine coatings were assessed using ISO 22196 standardization against *Staphylococcus aureus* and *Escherichia coli*.

Surface wettability, and therefore bacterial adhesion, are affected by the thickness and roughness of the polydopamine coating, playing a role in its antibacterial activity. Thicker and rough coatings had a better antibacterial effect against *S. aureus* (1.6 ± 0.4 log reduction), but not against *E. coli* (0.05 log reduction). The viability of L929 cells was $\geq$94% in the presence of the polydopamine coating.

These results demonstrate that polydopamine is a promising non-toxic material for antibacterial coatings on medical devices. However, further tests are required to enhance its antibacterial properties.

sciforum-091732: Enhancing Antimicrobial Efficacy: Glutaraldehyde Crosslinking of Electrospun PVA Nanofibers Embedded with Ag Nanoparticles

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This work presents a comprehensive investigation into the synthesis and characterization of polyvinyl alcohol (PVA) nanofibers modified to enhance antimicrobial efficacy through glutaraldehyde crosslinking and the incorporation of silver nanoparticles. The nanofibers were synthesized using the electrospinning technique, followed by a crosslinking process employing the vapor chamber method with glutaraldehyde/HCl solvent evaporation for 24 h, resulting in a nanofiber mat resistant to water. The introduction of silver nanoparticles was achieved via the chemical reduction method using $NaBH_4$ as a reducing agent, yielding nanoparticles with a size distribution ranging from 5 to 9 nm and uniformly dispersed within the crosslinked nanofiber matrix. The antimicrobial activity of the resulting composite nanofiber mat was thoroughly evaluated, revealing significantly improved efficacy against a range of microbial pathogens. The mechanisms underlying the enhanced antimicrobial activity, attributed to the synergistic effects of crosslinking and silver nanoparticle incorporation, are discussed in detail. Moreover, the physicochemical properties of the nanofiber mat, including morphology, structure, and composition, were analyzed using various characterization techniques such as SEM, STEM, FTIR, Raman, and EDS. The findings elucidate the potential of this approach for developing advanced antimicrobial materials applicable in diverse fields, including biomedical textiles, wound dressings, and medical devices. This study contributes to the ongoing efforts to combat antimicrobial resistance and improve infection control strategies in healthcare and other relevant sectors.

sciforum-091152: Fabrication of Herbal Loaded Antimicrobial Hemostatic Dressing

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Introduction

Excessive blood loss is a major issue during injuries which accounts for 10% of mortality and exerts an economic burden on public health. An ideal hemostatic dressing must contain clotting efficiency, antimicrobial activity, and antioxidant properties. Cotton gauze is most commonly used first aid material. However, it lacks inherent antimicrobial and hemostatic activity, limiting its widespread application. This study was carried out to functionalize cotton surfaces with natural ingredients such as sodium alginate (SA) and tannic acid (TA). SA is a natural biopolymer with high absorption capacity, hemostatic activity, and rapid wound healing properties, making it suitable for various biomedical applications. TA, an FDA-approved plant polyphenol, is known for its antimicrobial and mucoadhesive properties. Combining both agents may result in the fabrication of multifunctional hemostatic material.

Methods

SA-based blend membranes were prepared with varying concentrations of glycerol and optimised with different physicochemical characterisations, such as contact angle, SEM, XRD, and mechanical studies. Further, different concentrations of TA were added to the optimised SA:Gly blend to impart hemostatic and antimicrobial activity. These blends were coated on cotton fabric using a dip-coating method.

Results

The prepared membranes exhibited an exponential increase in flexibility with an increase in glycerol content due to the plasticisation effect. An increase in the amorphous nature of the membranes was observed due to the polymer chain relaxation upon glycerol incorporation. Antimicrobial analysis revealed more than 95% viable colony reduction. Furthermore, fabricated dressings showed a significant deposition of blood components on the surface and over 85% cell viability, suggesting their excellent hemostatic and biocompatible nature.

Conclusions

This study revealed that the fabricated dressings hold great potential for utilisation in hemostatic activity with infection-resistant properties in the near future.

sciforum-089797: Functional Metal Nanoparticles and Their Composites for Antimicrobial Applications

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With pronounced optical absorption and scattering, metal nanoparticles (MetNPs), such as gold (Au), silver (Ag), and copper (Cu), have found their way into a wide spectrum of applications, from biological to electrochemical. The effects that are the most important characteristics of these particles—the localized surface plasmon resonance (SPR) and high surface reactivity—are closely related to their physico-chemical features (size, shape, high percentage of unsaturated surface atoms, surface charge, medium, etc.), allowing researchers to design nanostructures tailored to specific biomedical applications based on a variety of biological processes occurring on the nanometer scale. The goal of this work is to present the abovementioned NPs with different sizes and shapes as free-standing or functionalized (by polymers—polyaniline and polypyrrole—or mesoporous silica) NPs, presenting an interesting and useful antimicrobial activity as one of their many beneficial features for application in biological systems. Besides NPs' incorporation into polymers/silica protecting them from agglomeration and oxidation, their functionalization also improves their properties, making them, among other things, biocompatible and water-soluble materials that are easily synthesized with an excellent yield. Considering these antimicrobial biomaterials, additional attention should be paid to their cytotoxicity, environmental impact, and long-term stability, as well as potential microbial resistance development.

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sciforum-092043: Green Synthesis of Ag or Au Nanoparticles for Antimicrobial Applications Using Wild Consortia of SCOBY-Based Membranes

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The green synthesis of bioactive nanoparticles (NPs) is biologically safe, cost-effective, and environment-friendly, and is becoming more attractive in various fields: the food industry, biotechnology, materials science, pharmaceuticals, and cosmeceuticals. Kombucha culture (named SCOBY—*Symbiotic Culture of Bacteria and Yeasts*) is a wild consortium of microorganisms naturally immobilized in a nanocellulose membrane. In this study, SCOBY-based membranes decorated with gold NPs (AuNPs) or silver NPs (AgNPs) were produced through an eco-friendly process. In the first stage, the microbial consortium immobilized in a nanocellulose membrane was grown by the fermentation of a black tea-based medium. AgNP and AuNP deposition on the SCOBY nanocellulose membrane (SNM) was achieved using only the washed, dried, and finely ground SNM and metal precursors. The biosynthesized AuNPs/SNM and AgNPs/SNM were characterized by Scanning Electron Microscopy (SEM) coupled with Energy-Dispersive Spectroscopy (EDS), X-ray diffraction (XRD), and Fourier-Transform Infrared (FTIR) Spectroscopy. SEM images show cellulose fibrils and the successful incorporation of Ag nanoparticles with an average size of 50 nm and Au nanoparticles (30 nm) into SNM. In XRD, the characteristic diffractograms of Iα and Iβ cellulose allomorphs appear and the representative patterns confirm the formation of AgNPs and AuNPs. The antimicrobial potential of the SNM enriched with nanoparticles was evaluated by the well-diffusion technique against the Gram-negative bacteria *Escherichia coli* and the Gram-positive bacteria *Staphylococcus aureus.* The metal-decorated SNM showed good antimicrobial potential, and the results highlight the increased antimicrobial performance of AuNPs/SNM and AgNPs/SNM compared to raw SNM. The results recommend Ag-decorated SNM (Ag-SNMs) and Au-decorated SNM (Au-SNMs) for multiple practical applications such as medical and food packaging fields. The antioxidant effect was determined by DPPH and ABTS tests. In the DPPH assay, the Au-NPs and Ag-NPs showed a higher antioxidant activity.

sciforum-091896: In Vivo Management of *Salmonella gallinarum* Infection Using CuO and ZnO Nanoparticles as Antibacterial Agents

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Introduction

The poultry industry is a major contributor to global food security, providing a huge amount of dietary protein. Its rapid expansion has played a crucial role in addressing food shortages worldwide. However, infectious diseases remain a significant challenge in the poultry industry, leading to reduced production and an increased economic burden. Antibiotics are widely used to overcome the problem of infectious diseases, which leads to antimicrobial resistance. Developing new antimicrobial drugs is crucial to combating antimicrobial resistance. CuO and ZnO nanoparticles exhibit promising antimicrobial activity against bacteria. This study aimed to assess the antimicrobial activity of CuO and ZnO nanoparticles against *Salmonella gallinarum*.

Methods

Ninety one-day-old chicks were divided equally into six groups: negative control, positive control, FLOR-A, CZNP-1, CZNP-2, and CZNP-3. On the 19th day, all the groups except the negative control group were challenged with *S. gallinarum*. Following the onset of clinical signs, treatment consisting of Florfenicol (50mg/L) for group FLOR-A and CuO and ZnO nanoparticles for groups CZNP-1, CZNP-2, and CZNP-3 was administered at varying doses: 10 + 25, 15 + 37.5, and 20 + 50 mg/kg/d, respectively. Live body weight, carcass weight, relative organ weight, and the ALT, AST, urea, and creatinine levels were determined. The collected data were analyzed using an ANOVA technique with a completely randomized design.

Results

The results revealed that the feed conversion ratio improved (p 0.001), the live body weight and carcass weight increased (p 0.001), and the relative organ weight and serum concentrations of ALT, AST, creatinine, and urea decreased (p 0.001) after treatment with CuO and ZnO nanoparticles in the treatment groups.

Conclusions

The study concluded that CuO and ZnO nanoparticles exhibit antibacterial activity against *S. gallinarum* and can serve as a substitute for Florfenicol. Optimal efficacy was observed with CuO and ZnO nanoparticles at a dose level of 15 + 37.5 mg/kg/d.

sciforum-092156: Metal Complexes of a Naturally Inspired Framework Functionalized for Antibacterial Biomaterials Development

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In the realm of combating antimicrobial resistance (AMR) and tackling infections triggered by priority pathogens outlined in the ESKAPE acronym by WHO, the development of innovative antibacterial biomaterials through novel multifunctional rhenium and iridium flavonoid complexes holds significant promise. In the MET-EFFECT project (funded MSCA-SE, Horizon Europe, `https://met-effect.com`) groundbreaking concept of using novel multifunctional rhenium and iridium flavonoid complexes as both metallodrugs and homogeneous catalysts is proposed. By leveraging the synergistic potential of these complexes, which act both as metallodrugs and homogeneous catalysts, advanced solutions for countering ESKAPE pathogen infections can be crafted. These biomaterials represent a beacon of hope in addressing the pressing challenges posed by antimicrobial resistance, thus bolstering patient outcomes within healthcare environments. Integration of rhenium and iridium flavonoid complexes into composite biomaterials, such as hydrogels, films, or coatings, stands as a pivotal strategy for antimicrobial applications. Within these biomaterial matrices, these complexes serve dual roles as both antimicrobial agents and catalysts, effectively combating infections brought about by ESKAPE pathogens. By incorporating flavonoid ligands renowned for their antimicrobial properties, such complexes disrupt bacterial cell membranes or impede crucial metabolic pathways, ultimately leading to bacterial demise. Furthermore, these multifunctional complexes can be tailored to selectively target specific bacterial species within the ESKAPE group, such as *Staphylococcus aureus* or *Klebsiella pneumoniae*, while mitigating adverse effects on commensal bacteria or host cells. This targeted approach significantly enhances the efficacy and safety profile of the metallodrugs. Emphasis on the design of antibacterial biomaterials incorporating rhenium and iridium complexes prioritizes biocompatibility and safety. Formulations are meticulously optimized to minimize cytotoxicity and immunogenicity, thereby ensuring seamless compatibility with host tissues and cells.

sciforum-091748: Natural Inspired Antibacterial Biomaterials Designed to Target the *Staphylococcus aureus* Pathogen

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In the context of the WHO's list of priority pathogens and the growing concern over antimicrobial resistance (AMR), the development of antibacterial biomaterials presents a promising avenue for combating drug-resistant bacteria. Antibacterial biomaterials can be designed specifically to target the pathogens listed in the ESKAPE acronym, such as *Staphylococcus aureus*. There is a huge potential for natural extract-based biomaterials (such as chitosan, starch, and alginate) to combat infections caused by drug-resistant strains of *S. aureus* by leveraging the antimicrobial properties of medicinal plant-derived compounds (e.g., essential oils, phenolic-rich extracts from herbs). Incorporating these extracts into biomaterials offers innovative strategies for developing effective antimicrobial formulations for medical and healthcare applications. Nanocomposite materials composed of biodegradable polymers and antimicrobial nanoparticles were functionalized with natural extracts to target *S. aureus* infections. Electrospun nanofibers composed of biocompatible polymers were loaded with antimicrobial plant extracts. Surfaces of medical devices, implants, or catheters can be coated with antibacterial coatings containing natural extracts to prevent colonization and biofilm formation by *S. aureus*. Hydrocolloid-based dressings or cryotropic gels, commonly known as cryogels, containing antimicrobial plant extracts have been developed for wound care applications. Nanocomposites are utilized for various biomedical applications, including tissue engineering scaffolds, wound dressings, and implant coatings, to prevent and treat *S. aureus* infections. Consideration is given also to the sustainability and environmental impact of antibacterial biomaterials. Sustainable sourcing of raw materials, eco-friendly manufacturing processes, and biodegradable materials are minimizing the environmental footprint associated with their production and disposal.

sciforum-089838: Peptide-Mimicking Antifungal Polymers Possessing BBB Penetrating Property to Treat Fungal Infections and Meningitis

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Introduction

Currently, the high mortality rate of invasive fungal diseases worldwide poses a significant threat to human life and health. However, the antifungal resistance and the blood-brain barrier (BBB) severely limit the treatment options and success rate of clinical management for fungal infections, especially meningitis. Host defense peptides are an ideal class of antibiotic alternatives, but the poor proteolytic stability, difficult synthesis, and expensiveness hinder their applications. It is also difficult to find highly selective antifungal and BBB-penetrating HDP mimics because fungi and mammalian cells are both eukaryotic cells. Inspired by cell-penetrating peptides (CPP), which could penetrate the cell membrane and BBB, we hypothesize that the mimics of both HDP and CPP could penetrate the fungal cell membrane and BBB to realize potent antifungal activity against meningitis.

Methods

A series of guanylated poly(2-oxazoline)s were synthesized by mimicking HDP and CPP. The in vitro and in vivo studies were conducted to realize therapeutic effects against invasive fungal infections and fungal meningitis.

Results

The guanylated poly(2-oxazoline)s $PGOx_{10}$ displayed efficient and selective antifungal properties against drug-resistant fungi by penetrating the fungal membrane to induce fungal organelle decomposition (***Angew. Chem. Int. Ed.***, 2022, 61, e202200778). $PGOx_{10}$ also demonstrated potent therapeutic potential in several infection models, including the skin abrasion infection, model, keratitis model, and systemic infection model. By adjusting the side-chain spacers, we found that guanylated poly(2-oxazoline)s $PGMeOx_{10}$ with methyl spacer group showed more potent antifungal activity, as well as BBB-penetrating property (***J. Am. Chem. Soc.*** 2023, 145, 25753–25765). Therefore, $PGMeOx_{10}$ displayed anti-infectious activity against fungal meningitis.

Conclusions

This study proposes a novel strategy for designing highly effective and selective antifungal agents and offers potential candidate compounds for combating invasive fungal infections and meningitis.

sciforum-090353: Polyethylene Glycol (PEG)-Silver Nanoparticles for Efficient Antibacterial Strategies

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Silver nanoparticles, due to their ability to inhibit bacterial proliferation, are highly attractive for medical antibacterial applications. The development of nanotechnology in biomaterials production allows for the fabrication of alternatives to traditional treatment strategies. Therefore, silver nanoparticles hold promise as an antibacterial strategy in tissue engineering.

The preparation conditions are crucial for achieving optimal results with silver nanoparticles. Particle size is a key property, and the use of water-soluble, mild reagents along with proper temperature control promotes the fabrication of particles within the desired nanoscale range. Poly(ethylene glycol) (PEG), a non-toxic and inert polymer, is often used to stabilize nanoparticles during synthesis due to its mild properties. This study investigated the involvement of PEG in the synthesis process.

In this work, PEGylated silver nanoparticles were synthesized via a chemical route using silver nitrate ($AgNO_3$) as a starting material. Their size and efficacy were evaluated using physical-chemical characterization and in vitro antimicrobial activity test.

UV-VIS and FT-IR spectroscopy confirmed the formation of silver nanoparticles. Particle size and the influence of synthesis parameters were determined using DLS and AFM techniques. The results showed that the prepared PEGylated silver nanoparticles exhibit a monodisperse distribution with sizes below 100 nm. We can therefore conclude that this type of PEG-synthesized nanoparticle has the potential to be an effective antibacterial agent.

sciforum-089815: Switching from Membrane Disrupting to Membrane Crossing, an Effective Strategy in Designing Antibacterial Polypeptide

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The extensive utilization of antibiotics has precipitated the emergence of antibiotic-resistant bacteria in recent years. The revelation of Host Defense Peptides (HDPs) has provided a promising avenue for addressing antibiotic-resistant infections. Nevertheless, the practical application of these natural peptides has been impeded by their constrained stability, intricate synthesis process, and elevated cost. Consequently, designing and discovering antimicrobial compounds, including peptide polymers, that mimic HDPs has become a promising solution. A structural design approach has emerged as a classical strategy for developing HDP mimetics. By altering the chemical structure of main chains and side chains, various types of HDP mimetics have been developed, such as α-peptide polymers, β-peptide polymers, polyoxazolines, etc. with high efficacy against antibiotic-resistant bacteria. Furthermore, a mechanism-guided approach is proposed for the design of antimicrobial peptide polymers, taking into account the potential variations in antimicrobial mechanisms associated with chiral and enantiomeric peptides. Helical β-peptide polymers forming α-helical structures upon interaction with bacterial membranes are more effective in disrupting the bacterial membrane, whereas heterochiral β-peptide polymers demonstrate attenuated interactions with cell membranes, thereby facilitating their penetration of bacterial membranes for internal action. This finding has spurred the development of peptide polymers tailored from modifying antimicrobial mechanisms. Additionally, by incorporating biocompatible amino acid residues into the peptide polymers, a class of β-peptide polymers with high efficacy against antibiotic-resistant bacteria and excellent biocompatibility has been identified, offering a promising approach for addressing antibiotic resistance.

sciforum-092241: Synergistic Enhancement of Electrospun Keratin Mats with Medicinal Plants and Green-Synthesized Silver Nanoparticles for Biomedical Applications

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Keratin, a versatile polymer rich in cysteine and disulfide bonds, exhibits strength and elasticity, making it crucial for tissue engineering. Its biocompatibility and biodegradability foster the development of advanced biomaterials. Incorporating medicinal plant extracts enhances keratin's therapeutic potential. Additionally, green-synthesized silver nanoparticles (AgNPs) provide antimicrobial properties. Electrospun keratin-based mats may be promising materials for medical applications since electrospinning enables the fabrication of nanofibrous scaffolds with high surface area-to-volume ratios, mimicking the extracellular matrix's structure. This research aims to develop electrospun keratin mats enhanced with medical plants and green-synthesized AgNPs for medical dressings.

To prepare keratin-based electrospun solutions keratin hydrolysate and polyethylene oxide (PEO) were used. *Matricaria chamomilla* as a medicinal plant for extract and AgNPs preparation and *Sodium Alginate* as an additive were chosen. The UV-Vis analysis was conducted to characterize the green-synthesized AgNPs. The structure of electrospun mats micro-nanofibers was analyzed by SEM.

The UV-Vis exhibited an absorption peak spanning 400-450 nm, indicating the presence of surface plasmon resonance characteristic of AgNPs. This observation confirms the successful synthesis of AgNPs.

Furthermore, the electrospun fibers displayed homogeneity. Analysis of fiber diameters revealed that 88% of keratin hydrolysate and PEO fibers fell within the 100–200 nm range. The addition of the herbal extract led to an increase in fiber diameters, with 50% of measured fibers ranging from 100–200 nm and 44% from 201–300 nm, while the incorporation of biosynthesized AgNPs had no significant impact on fiber diameters. The addition of *Sodium Alginate* (c = 3%) resulted in a notable increase in fiber diameters, with 84–95% of fibers falling within the 100–300 nm range.

The findings indicate that keratin-based compositions enriched with *M.chamomilla* extract and green-synthesized AgNPs can be effectively electrospun. Incorporating Sodium Alginate enhances the versatility of the electrospun mats for medical applications. Nevertheless, further in-depth investigation is required.

sciforum-090227: Towards Sustainability and Waste-to-Wealth Approach: The Development of Metallic Nanoparticles for Biomedical Applications using Local Palm Tree Waste

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Introduction & Significance

Nanoparticles are small particles that range in nanoscale less than 100 nm, which is equivalent to one billionth 10^{-9} [1]. The development of nanoparticles by green methods has gained considerable research attention in medical applications such as cancer therapy, tissue engineering, and target-specific drug delivery due to their non-toxicity, surface functionality, and stability. This approach reduces environmental pollution and provides benign materials with desired properties (antibacterial, antibiofilm, antimalarial, and anticancer) for advanced biomedical applications. Palm trees are rich in polyphenols, which can act as both reducing and stabilizing agents [2].

Methods

In this study, silver and selenium nanoparticles were synthesized using a variety of local palm tree waste and products such as date palm leaves, date buds, and homemade date syrup. The formation of nanoparticles was confirmed by measuring the surface plasmon resonance peak using a UV-VIS spectrophotometer. The antibacterial properties of the silver nanoparticles on three different types of bacteria were studied using the Hinton–Broth method.

Results

UV-Vis Spectroscopy confirmed the presence of nanoparticles in all prepared solutions. Additionally, the antibacterial effect was assessed using the disc diffusion method. The greatest antibacterial activity was seen against *Escherichia coli*, which was evidenced by the large clear zone of inhibition. Moreover, the growth of *Staphylococcus aureus* was disturbed by the silver nanoparticles.

Conclusions

Using palm leaves, buds, and date syrup, a successful synthesis of silver, selenium, and gold nanoparticles was achieved. Bacterial studies showed disruption of bacterial growth in Gram-positive staphylococcus aureus and significant antibacterial effect against Gram-negative Escherichia coli. Next, we aim to examine the effect of the synthesized nanoparticles on cancer cell lines and fibroblasts as well as investigate their ability to enhance wound healing stimuli response using hydrogels. Material sustainability and the conversion of waste to advanced materials were successfully demonstrated in this project.

sciforum-089808: ZnO NP-Based Advanced Materials and Their Potential Bioapplications

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Zinc oxide (ZnO) is considered one of the most versatile oxide nanoparticles, mainly because of its particularities regarding its biocompatibility, photosolubility, and low toxicity, and is listed by the USFDA as a generally recognized as safe (GRAS) material. The applicative capacity of ZnO is strongly influenced by the synthesis method (with both large-scale chemical and physical methods being reported), which involves polluting reagents, toxic solvents, and surfactants, which have an influence on the size, morphology, and physicochemical properties.

In this context, our research aimed to find alternative ways to synthesize ZnO particles via green methods (biosynthesis) using active constituents from plant extracts (i.e., aqueous solutions of *Hibiscus*, *Green Tea*, *Sea buckthorn*, etc.) with reducing, capping, and stabilizing effects. These synthesized ZnO NPs have demonstrated their effectiveness in inhibiting bacterial growth and their better bioactivity and biocompatibility as a result of the functional groups derived from the phytochemical substances present on their surface according to the FTIR results, which highlighted the formation of reactive oxygen species and the direct interaction of the particles with bacterial surfaces. Also, a morphological analysis showed that the particles have a predominantly spherical shape, with particle sizes below 50 nm.

The decrease in toxicity through the use of eco-friendly methods and the multifunctional properties make these particles ideal candidates for applications in biomedical fields, such as targeted drug/gene delivery systems, antimicrobial coatings, antioxidant and anti-inflammatory activities, bioimaging, tissue engineering, skin protection applications, development of cancer therapies, biosensors, etc.

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Abstracts

Session D. Biomaterials for Tissue Engineering

sciforum-094985: Reimagining 3D Bioprinting to Pattern Hierarchical Features for Skeletal Regeneration

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Over the past twenty years, the field of tissue engineering and regenerative medicine (TERM) has been significantly impacted by the emergence of 3D bioprinting technology. This advancement has enabled the precise printing of tissues composed of a single cell type, with remarkable resolution and fidelity. Nevertheless, achieving the desired functionality of tissues has remained a challenge due to the absence of diverse cell populations and variations in microenvironment distribution. Traditional 3D bioprinting methods have struggled to provide an effective approach for incorporating multiple cells and biomaterials in a controlled manner. The use of interchangeable syringe-based systems has often led to issues such as delamination between interfaces, particularly hindering the fabrication of interconnected constructs like cartilage and bone tissue. In this study, we introduce a new approached based on the possibility of compartmentalization of biomaterials and cells, controlling density over a gradient architecture to closely mimic osteochondral defects. By incorporating flow-focusing and passive mixer printhead modules, we achieved rapid and dynamic modulation of fiber diameter and material composition, driving compartmentalization of human bone marrow stromal cells (HBMSCs) into distinct three-dimensional layers with defined density patterns, demonstrating functional responses based on final concentration. Experiments conducted ex vivo and in vivo confirmed the functionality of 3D Bioprinted constructs containing patterned growth factors and cellular components. Consequently, this approach enables the simulation of diverse cellular environments and proliferation pathways within the same construct, a capability not achievable with conventional bioprinting techniques. These findings present new opportunities for fabricating functionally graded materials and physiologically relevant skeletal tissue substitutes, for the support in TERM applications for an ageing population.

sciforum-090425: 3D-Printed Nanocomposite Scaffolds for Bone Tissue Regeneration

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Three-dimensional (3D) printing technology has revolutionized the field of tissue engineering, particularly in the development of scaffolds for craniomaxillofacial (CMF) bone regeneration. Till today, a question remains regarding the use of 3D-printed nanocomposite scaffolds incorporating metallic or gold nanoparticles for craniomaxillofacial bone regeneration. In this research study, we aim to develop 3D-printed nanocomposite scaffolds tailored with various bioactive materials and nanotechnologies, offering a significant advancement in the field of CMF bone regeneration. Gelatin methacryloyl (GelMA) was selected as a bioink candidate for its biocompatibility and tunable mechanical properties. Surface-engineered gold nanoparticles (AuNPs) were incorporated to enhance the rheological properties, conductivity, and printability of the bioink. The integration of bioactive molecules, such as small-chain amino acids conjugated to gold nanoparticles (AuNPs), had the potential to contribute to bone healing and regeneration. The improvements in biological, electrical, and rheological characteristics facilitated enhanced differentiation of encapsulated stem cells and enabled the fabrication of highly viable and stable constructs. These findings hold significant potential to advance 3D bioprinting capabilities, offering a promising avenue for the fabrication of precise and biologically relevant tissue constructs for applications in regenerative medicine and personalized therapeutic interventions. These scaffolds can be customized to the specific needs of the defect site, thereby improving the outcomes of bone regeneration therapies.

sciforum-090373: Application of PH-Responsive Multifunctional Hydrogel in Rapid Hemostasis and Repair of Infected Wounds

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Objective

To construct a multi-functional Ph-responsive hydrogel loaded with tannic acid, and explore its hemostatic function and promoting the repair of infected wounds, and initially explore the related mechanism of hydrogel promoting the repair of infected wounds.

Method

Ph-responsive multifunctional hydrogels were composed of carboxymethyl chitosan (CMCS), Konjac oxide (OKGM) and tannic acid (TA). CMCS and OKGM were able to form Ph-responsive hydrogels with dynamic covalent bonds through Schiff base reaction. TA could enhance the antibacterial and mechanical properties of the hydrogels. The biocompatibility, blood compatibility and functional evaluation (antioxidant, antibacterial and hemostatic properties) of CMCS-OKGM@TA hydrogel were tested in vitro. Meanwhile, cellular function experiments related to wound healing were performed. The effects of CMCS-OKGM@TA hydrogel on inflammation regulation, vascularization and epithelialization of infected wounds in BALB/C mice were investigated under in vivo conditions. Transcriptomic sequencing was performed on skin tissues of infected wounds in mice to screen relevant pathways for mechanism study, providing new ideas for treatment of infected wounds.

Results

Due to Schiff base reaction and hydrogen bonding, the compound could rapidly absorb liquid components, form gel and adhere to the tear, showing rapid liver hemostasis and tail hemostasis. The polyphenol groups of TA make the hydrogel have good antibacterial and scavenging properties of active oxygen free radicals. In addition, the hydrogel has good biocompatibility in vitro cytotoxicity, blood compatibility test and in vivo toxicity test. Finally, in vivo experiments showed that the hydrogel showed significant bacteriostasis and promoting wound healing. Conclusion: The multifunctional hydrogel has the ability of rapid hemostasis and bacteriostasis, and can be widely used in acute bleeding caused by trauma and as wound dressing to prevent bacterial infection.

sciforum-088842: Borate Influence on Acellular Bioactivity of Mesoporous Borosilicate Bioactive Glasses for Tissue Engineering

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The goal of the third generation of biomaterials, which includes bioactive glasses (BGs), is to improve tissue regeneration and repair. By interacting with the biological environment, these materials promote tissue regeneration. When BGs come into contact with physiological fluids, they readily connect with the host bone tissue, simulating hard tissue. The natural equilibrium of bone remodeling may be upset, and therapeutic ion release may be impacted by the breakdown of silicon-based glasses over time. Borosilicate bioactive glasses (BBG) are a solution to this problem since they improve the quality of bioactive glass disintegration.

Using a modified Stober sol–gel approach, we synthesized a range of BBGs in this study by substituting boron into the base BG at varying ratios. To describe the BBGs' physicochemical and in vitro acellular bioactivity characteristics, several methods were used, including Thermogravimetric analysis, inductively coupled plasma atomic emission spectroscopy, Fourier-Transform Infrared Spectroscopy, X-ray diffraction, Brunauer–Emmet–Teller and Barrett–Joyner–Halenda theories, nuclear magnetic resonance, and Scanning Electron Microscopy attached with energy-dispersive X-ray spectroscopy. Additionally, the rate of BG breakdown in a simulated bodily fluid over a range of durations up to 21 days was measured using a Seven Compact pH/Ion S220 pH meter.

Based on our research, the BGs' pH values upsurged and their dissolution ability was increased when the boron concentration was raised. The boron-induced structural modifications appear to have improved the kinetics of dissolution, allowing for faster ion release into the surrounding fluid. These results provide prospects for the controlled release of therapeutic ions in BBG systems. Furthermore, the rate of hydroxyapatite precipitation was slower in the BGs with higher boron concentrations. This is connected to how the BGs' decreased pore volume and specific surface area impacted the bioactivity of the glass. This finding advances knowledge of the apatite formation and dissolution behavior of BBG.

sciforum-090561: Development of Galatite-Eggshell Membranes and Bioactive Glass Scaffolds for Their Use in Bone Tissue Engineering

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Treatment of large bone defects is one of the most challenging tasks in orthopedics, an estimated of 2.2 million bone grafting procedures are performed worldwide per year. Bone tissue engineering has an increasing interest in the development and construction of analogous bone grafts with osteoconductive, bioactive, biodegradation, and mechanical properties. Bioactive glasses (BG) are being utilized as biocompatible, biodegradable materials and collagen (Col) represents more than 90% of the bone organic matrix, both materials have shown excellent properties in bone repair. The galatite is frequently named artificial bone and is a thermostable polymer obtained with casein-formaldehyde.

The current study involves the fabrication of novel 3D scaffolds conformed by galatite (Gal) obtained from goat milk-casein, bioactive glass (BG) synthesized by sol-gel technique, and as a source of collagen (Col), they were used eggshell inner membranes. Scaffolds were elaborated by the solvent-casting technique and each phase was characterized by FTIR, XRD, and SEM evaluations; also bioactivity and biodegradability of the composites were in-vitro evaluated by immersion into simulated body fluid (SBF) and phosphate-buffered saline solution (PBS). Mechanical characterization under compression forces was taken in the CellScale Univert (R) equipment to observe the strain-stress curves. Obtained results, make the materials valuable in various biomedical applications, including bone tissue engineering, drug delivery systems, and implants.

sciforum-091783: Dielectric Relaxation Behavior of Composite Based on Polyester Matrix Reinforced with Argan Nutshell Powder Biofiller

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This study investigates the dielectric relaxations of an unsaturated polyester matrix (PS) reinforced with varying weight fractions of argan nutshell powder (ANS) as a biofiller across temperatures ranging from 303 K to 453 K and frequencies from 0.1 Hz to 1 MHz. At low temperatures and high frequencies, dielectric relaxations are primarily attributed to the dipolar polarization of water associated with argan nutshell powder (ANS) charges. As temperatures increase and within the intermediate frequency range, dielectric relaxations are attributed to the α-relaxation process resulting from the rubbery glass transition of the polyester matrix (PS). Beyond the glass transition temperature and at low frequencies, dielectric relaxations are associated with the interfacial polarization effect, arising from the accumulation of charges at the interfaces between the filler and the matrix. Filler/matrix interactions are further examined in terms of the interfacial polarization effect, with consideration given to the increase in the weight fraction of the argan nutshell powder (ANS). Additionally, this study elucidates the impact of filler/matrix interactions on the dielectric properties of the composite system, offering valuable insights into the role of argan nutshell powder (ANS) as a biofiller in enhancing the performance and functionality of an unsaturated polyester matrix (PS) for potential applications in materials engineering.

sciforum-088600: Fibroblast and THP-1 Cell Response to the Multi-Arm PEGNHS-Modified Decellularized Porcine Pericardium

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In the early stage of transplantation, macrophage cells play an important role in reacting with the transplantation materials. Minimizing the reaction by maintaining the low inflammation of the original decellularized porcine pericardium (dPPC) after the modification process is necessary to avoid rejection. Over the healing process, the fibroblast is the key cell to form the adhesion between the membrane and the wound site. Repelling the fibroblast to adhere to the membrane surface is important to achieve good wound healing and ensure that no adhesion forms. Therefore, we investigated the repose of the fibroblast and THP-1 cells to the multi-arm PEGNHS-modified dPPC.

In this study, dPPC was prepared by the high-hydrostatic-pressure method and confirmed by means of H&E staining and residual DNA quantification. It was then modified with α-succinimidyloxyglutaryl-ω-succinimidyloxyglutaryloxy-polyoxyethylene (2-arm PEGNHS), pentaerythritol tetra (succinimidyloxyglutaryl) polyoxyethylene (4-arm PEGNHS), and hexaglycerol octa(succinimidyloxyglutaryl) polyoxyethylene (8-arm PEGNHS) and confirmed by ATR-FTIR, anti-PEG antibodies, and ninhydrin assay. The modification was carried out over the amine bond between the NH_2 of dPPC and the NHS functional group of PEG with molar ratios of 1:1 and 1:2. The prediction of the inflammation levels and fibroblast repelling in vitro was performed by using THP-1 cells and NIH3T3 cells, respectively.

The dPPC was confirmed by the loss of cellular nuclei and the residual DNA. The modification was confirmed by increasing the C-O-C bond and by the the brown color of the anti-PEG antibodies. The free amine group was significantly reduced after the introduction of the PEG molecules. Among all conditions, 8-arm PEG-modified dPPC in a molar ratio 1:2 was significantly repelling the fibroblasts, and then, cells started to restore on day 7 of culture. The THP-1cells were also repelling and exhitibed a low inflammation secretion level. With these observations, the technology of cell-repelling surfaces was developed and could be used to fabricate anti-adhesion membranes.

sciforum-090310: Gelatin-Based Coaxial Nanofibers as a Coating of 3D Poly(Lactic Acid) Printed Scaffolds for Bone Tissue Engineering

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Bone tissue engineering (BTE) has emerged as an option for creating new bone substitutes for application in bone tissue defects. The materials used for making the scaffolds have been based on FDA-approved synthetic polymers such as poly(ε-caprolactone) (PCL) and poly(lactic acid) (PLA) for their biodegradable, biocompatible, and mechanical properties. Moreover, a biopolymer such as gelatin (Gt) has been used as a functional coating for its biological properties. In BTE, a combination of techniques has emerged for developing different microarchitectures that could imitate the extracellular matrix (ECM) of native bone. In this work, we try to combine electrospinning and 3D printing to create a bone scaffold with improved topological properties. We produce coaxial nanofibers (CNF) of PCL/Gt and PLA/Gt for coating a circular porous 3D printing scaffolds using electrospinning. The characterization by SEM showed the fibrillar structures with interconnected pores with random alignment, and TEM indicates the formation of the core-shell structure. FTIR and Thermal analysis show the characteristic signals of each component and no apparent effect on the decomposition stages of each material, respectively. The biological characterization of the coating 3D scaffolds showed an improved adhesion in 24 h and good biocompatibility and bioactivity of human fetal osteoblasts over the 21 days of culture. In conclusion, our results showed that CNF-coated scaffolds have improved topological properties by functionalizing Gt-based coaxial electrospun nanofibers with potential use in BTE. The authors want to thank the financial support by CONAHCYT for the scholarship granted for the doctoral study of CETS with CVU 1009583 and the financial support given by DGAPA-UNAM-PAPIIT IN202924, IN106624, and PAIP 5000-9222 projects.

sciforum-090385: Gradient Ti/HAp Composite Biomaterials Fabricated by Controlled Thermodynamic Powder Metallurgy

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The reliability of hard tissue engineering processes is crucial in a variety of application such as knee or hip joint replacement. For a successful integration of any implant, bone regeneration, osseointegration at the interface bone and implant as well as mitigating inflammatory events are essential aspects.

The objective of this work is to extend the biocompatibility, osteoconductivity and mechanical performance associated with a lifetime of biomaterials based on Titanium (Ti). The hypothesis state that the bioactivity of titanium alloy biomaterials can be increased by the addition of hydroxyapatite (HAp) and further boosted by porosity. Designing the gradient bio composite starting with preparation of materials mixture of Ti6Al4V powder, synthetized HAp powder (5 and 10% wt.) and a foaming agent cabroxymethylocelulose (CMC) (5 and 10% wt.) milled to a very uniform density by ZrO_2 ball miller. In a step next the powders mixtures were cascaded in a press die the first layer was Ti6Al4V + 5%Hap + 5%CMC and upper layer was Ti6Al4V + 10%Hap + 10%CMC, and next pressed by the cold isostatic pressing (CIP). Sintering of the composites was performed on a Yttria-stabilized zirconia plate with air channels in a vacuum furnace at 1300 °C under Ar protective atmosphere. The results show high potential of this methodology for preparation of gradient structure, with lower layer hardness reaching 10 GPa and elastic modulus 154 GPa and upper layer containing HAP and porosity reaching 10%.

The authors gratefully acknowledge financial support of the project “New Generation of Bioactive Laser Textured Ti/Hap Implants” under acronym “BiLaTex” carried out within M-ERA.NET 3 Call 2022 programme in the National Centre for Research and Development (ERA.NET3/2022/48/BiLaTex/2023).

sciforum-092012: Investigation of Gelatin-Based Nanofibers for Tissue Regeneration: Degradation and Water Absorption Properties

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Nanofibers exhibit considerable potential as materials for tissue regeneration, owing to their adjustable characteristics and compatibility with biological systems. In the present investigation, nanofibers were prepared by dissolving 27% gelatin in a solvent combination consisting of 70% acetic acid (AcA) and 9% dimethyl sulfoxide (DMSO) in a ratio of 95:5. After that, the obtained gelatin scaffolds were crosslinked with 25% glutaraldehyde (GA) due to the poor mechanical properties of gelatin in a physiological environment.

The nanofiber's water absorption capacity and degradation rate were assessed to determine its suitability for prospective application in the field of wound healing. The degradation rate of the nanofibers was monitored for a duration of 21 days, during which degradation rates were evaluated at regular intervals of 7 days. Furthermore, an assessment of the capacity for water uptake was conducted for a duration of 7 days. The results showed that the degradation rate increased from 34.27% after 7 days to 74.39% by day 21, showing a progressive process of disintegration. In addition, the nanofibers demonstrated a notable capacity for water absorption, with absorption rates peaking at 437.38% on the initial day and thereafter stabilizing at 286.43% over a period of 7 days. The results of this study highlight the promise of crosslinked gelatin-based nanofibers as a viable option for tissue engineering purposes, specifically in the context of wound healing. This is due to their ability to exhibit controlled degradation and high water absorption, which are highly favorable characteristics. Additional research is necessary to examine the biocompatibility and in vivo performance of nanofibers to confirm their effectiveness and safety for use in clinical applications.

sciforum-090143: Investigation of the Corrosion Mechanism of Bifunctional FeMnSi-Based Alloys for Medical Applications

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In the past few decades, researchers have investigated Fe-based biodegradable alloys for various purposes such as biocompatibility, tissue healing control over degradation rate, and the shape memory effect (SME) for specific medical applications. Within this study, the authors proposed bifunctional Fe–Mn–Si-based alloys with additions of Ag and Cu as potential biodegradable materials with a SME. In vitro studies were conducted by immersing the samples in physiological solutions, Ringer's and simulated body fluid (SBF), for different time intervals at 37 °C. Corrosion rates were determined according to the mass loss, via cyclic and linear potentiometry, and electrochemical impedance spectroscopy (EIS). Microstructural analyses were performed using optical microscopy (OM) and scanning electron microscopy (SEM). Initial and post-immersion chemical analyses were performed using energy-dispersive spectroscopy (EDS), aiming to investigate the formation of salts, chlorides, and carbonates. The samples were subjected to dynamic mechanical analysis (DMA) and were evaluated before and after immersion at different applied frequencies. The surface morphology was examined using atomic force microscopy (AFM) for the initial samples and those subjected to DMA experiments. Fourier transform infrared spectroscopy (FT-IR) and nano-FTIR experiments were performed to identify and confirm the corrosion compounds formed on the surface. A generalized type of corrosion was identified, and an increase in mass was observed in the first 3-5 days due to the compounds formed due to metal–solution contact. A phase change in the solid state was observed using differential scanning calorimetry (DSC) during cooling, which was associated with a martensitic transformation. Its critical start temperature (M_s) was similar to the human body temperature, indicating that this material has potential for medical applications. The results suggested that a shape memory Fe-based biodegradable alloy has the potential to be used in the medical industry, with a suitable thermomechanical treatment to adjust the transition temperatures.

sciforum-090286: Investigation of the Influence of α-Tricalcium Phosphate on the Structure of Poly-3-hydroxybutyrate Matrix in Nonwoven Materials Obtained by Electrospinning

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This study explores the impact of α-tricalcium phosphate (α-TCP) on a poly-3-hydroxybutyrate (PHB) matrix via electrospinning (ES) to produce composite materials. The ES method allows for the production nonwoven fibrous materials with a high content of functional additives. The ES method ensures the uniform distribution of the additive, which is important for applications in regenerative medicine. Scanning electron microscopy (SEM) analysis of materials based on PHB-α-TCP shows a reduction in surface defects with the addition of α-TCP; however, at higher concentrations, larger inclusions appear. Additionally, morphology analysis indicates changes in fiber diameters and a decrease in surface density with the introduction of α-TCP, highlighting increased porosity and surface development.

Mechanical testing illustrates the deformation process of PHB-based nonwoven materials, with the rupture mechanism influenced by the presence of α-TCP. SEM images reveal the impact of α-TCP on the mechanism of the rupture, showcasing accumulations of the calcium source within the fibrous material.

Thermal properties were analyzed using differential scanning calorimetry. The impact of the additive on the thermal properties was insignificant during the first round of heating. The second round of heating showed a decrease in crystallinity, but X-ray diffraction analysis indicated changes in the supramolecular structure, with the crystallites themselves increasing in number.

The obtained materials were characterized by high porosity and surface development, which are crucial for effective tissue regeneration and restoration. The unique combination of properties in the PHB-α-TCP composite material holds promise for revolutionizing multiple industries, particularly those in the fields of regenerative medicine, dentistry, and environmental sustainability. However, further research is required to optimize the material's properties for specific applications, ensuring its safe and effective utilization.

sciforum-089690: Magnesium as a Tissue Engineering Material in Plastic Surgery: In-Vitro Biocompatibility Studies with Human Dermal Fibroblasts

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Introduction

Magnesium-based metallic alloys have recently gained significant attention in scientific research due to their unique mechanical stability and biodegradability characteristics, making them promising candidates for various applications in tissue engineering, particularly as scaffolds to support cell growth. While magnesium alloys are already employed in clinical settings, such as osteosynthesis screws in hand surgery, previous studies have predominantly focused on their bone-specific biocompatibility, with limited understanding of their interaction with skin and connective tissue. Therefore, the development of functional and biocompatible cell carriers based on magnesium, aimed at promoting skin and connective tissue regeneration, represents a logical next step towards establishing magnesium as a versatile biomaterial.

Methods

Our study aimed to assess the impact of bioabsorbable magnesium alloys, specifically Mg-Y-RE-Zr, on human dermal fibroblasts in vitro. To achieve this objective, we conducted a series of biocompatibility tests following ISO 10993-5 guidelines, encompassing both direct and indirect cell contact scenarios. Key parameters evaluated included cytotoxicity, cell proliferation via XTT, LDH assays, and vital fluorescence staining, along with observations of cell morphology, migration, and colonization under light microscopy. It was particularly noteworthy that the investigation of these cellular responses correlated with the degradation of the metallic material and the development of corrosion products.

Results

Our findings indicate that resorbable magnesium alloys can serve as carrier materials in tissue engineering, interacting positively with human dermal fibroblasts. Notably, a controlled degradation process observed with coated magnesium surfaces demonstrated significant added value in terms of cell-specific biocompatibility compared to rapid degradation.

Conclusions

Our results hold promise for optimizing the design and application of magnesium-based materials in regenerative medicine contexts. They also offer initial insights into the interaction of magnesium alloys with skin and connective tissue, paving the way for a new class of materials in tissue engineering for plastic surgery applications.

sciforum-092148: Mechanical and Biological Assessments of Braided Artificial Tendons Functionalized with Cork Extract

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The incidence of tendon ruptures has increased over the years, and represents one of the main causes of musculoskeletal injuries that occur annually due to high mechanical loads, degenerative processes, trauma, stretching, chronic overuse, inflammation, etc. In this investigation, a new approach using braids of different materials, namely biodegradable (lyocell and biodegradable polyester) and non-biodegradable (polyethylene terephthalate (PET)) materials functionalized with natural cork extract was explored. The cork extract was selected due to its biocompatibility and its properties of interest (antioxidants, antimicrobials, anti-inflammatory, antifungals, cell affinity, etc.). The mechanical characterization of the braids was carried out, and lyocell presented properties closer to accepted ranges: extension less than 10%, and tensile strength between 19 and 100 MPa. Loading of the cork extract into the bradding systems was evaluated in three ways: (1) dip coating; (2) surface activation with UV light followed by dip coating; and (3) binding through dopamine coating. The cork extract was found effective in preventing bacterial action and in promoting antioxidant activity. Collected data deemed the proposed strategy as promising for treating tendon lesions, thus improving the quality of life of affected patients. This innovative approach has the potential to revolutionize existing treatment methods, offering solutions for patients with tendon injuries.

sciforum-092049: Multifunctional Metal–Organic Cages Accelerate Tissue Regeneration via Regulating Microenvironment and Mediating Endogenous Growth Factor Production

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Objective

The repair of large-size skin and bone defects remains an important clinical challenge. On one hand, the microenvironment of trauma is complicated and affects the tissue regeneration. On the other hand, using exogenous growth factors is limited by poor stability, high cost, and dysfunction in a harmful microenvironment. Recently, a great deal of attention has been paid to the development of metal–organic frameworks (MOF) as alternative biomaterials. However, creating MOF with negligible cytotoxicity, excellent chemical stability, ROS scavenging ability, and functions regulating endogenous growth factor production remains challenging.

Results

We synthetized magnesium-seamed and zinc-seamed C-propylpyrogallol[4]arene (PgC_3Mg and PgC_3Zn, separately). These two kinds of metal–organic cages both exhibited excellent stability, biocompatibility, and efficient antioxidant properties. Afterward, we investigated the function of PgC_3Mg in bone regeneration and PgC_3Zn in wound healing. PgC_3Mg promoted osteogenic differentiation of bone-marrow-derived mesenchymal stem cells. In vivo results indicated that PgC_3Mg significantly accelerated cranial bone regeneration. PgC_3Mg functionalized GelMA hydrogel exhibited a better effect than commercial Bio-Gide membranes. Immunostaining showed that PgC_3Mg increased the formation of type H vessels and the expression of platelet-derived growth factor BB. For soft tissue repair, PgC_3Zn exerted a bacteriostatic effect against *S. aureus* and *E. coli*, and more significantly promoted proliferation and migration of L929 fibroblast cells compared with $ZnCl_2$. Animal experiments suggested that PgC_3Zn accelerated acute and that *S. aureus* infected skin defect healing. Histological staining revealed a high level of collagen deposition, epithelialization, and vascularization after PgC_3Zn treatment. Immunostaining revealed that PgC_3Zn remarkably increased the expression of TGF-β, EGF and VEGF growth factors.

Conclusions

All these results demonstrated that PgC_3Mg and PgC_3Zn are promising treatment strategies in tissue engineering, and have become potential alternative materials for multiple growth factors.

sciforum-089981: Production and Characterization of Biological Grafts Derived from a Decellularized Uterus Aiming for Tissue-Engineering Applications

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Decellularized reproductive tissues have been used to generate biomaterials for several applications, not restricted to reproduction due to their enriched ECM and capacity to be modulated and applied for other tissues. This study aimed to produce and characterize grafts derived from decellularized uterine tissue to be used in tissue engineering approaches. Porcine uterine fragments (n = 10) were decellularized in 1% SDS and 0.5% Triton X-100, followed by three cycles of ultrasonic bath. To evaluate the decellularization efficiency, HE and DAPI staining and total DNA quantification were performed. Histological analysis of ECM components was performed as well. SEM was used for ultrastructural characterization. For biomechanical characterization, native and decellularized samples were attached to a computerized mechanical testing machine and submitted to a traction charge. FTIR-ATR and Raman spectroscopy were used to perform a physical–chemical evaluation of ECM. For the cytocompatibility assay, 3T3 and canine yolk-sac-derived cells were cultured on the scaffolds for 10 days. DAPI and HE staining revealed absence of nuclei in decellularized samples; moreover, DNA quantification revealed a decrease of 95%. Regarding ultrastructure, 3D structure was maintained, conserving the original stratification and preserving thin and dense collagen bundles. Histological analyses showed that main ECM components remained preserved with a similar organization as found in the native tissue. Biomechanical results demonstrated significate difference only for the maximum pulling force between the groups, but there was no difference for maximum elongation and stiffness. Spectroscopic results also corroborated the structural findings, with no difference in the main analyzed band between the samples. In vitro assays revealed that cells were able to attach to the scaffolds, which allowed their survival and proliferation. Our data revealed that the decellularization was efficient, which preserved 3D structure, composition and biomechanical properties and presented satisfactory cytocompatibility, demonstrating the generated biomaterial can be used tissue-engineering applications.

sciforum-088332: The Impact of Binary Bioglass on the Biodegradation and Bio-Mineralization of PCL Electrospun Fibers for Guided Bone Regeneration

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In this study, we produced Poly(ε-caprolactone) (PCL) electrospun fibers with varying concentrations (5%, 10%, 15%, and 20% wt.%) of binary bioactive glass 63S-37C (BG, 63% SiO_2-37% CaO). These membranes showed good acellular bioactivity, biocompatibility, and reasonable biodegradability. Apatite formation in SBF was assessed using SEM-EDS analysis, indicating enhanced bioactivity with increased BG content. We also examined the effects of BG incorporation on membrane morphology, composition, fiber diameters, biodegradability, and bioactivity. Our findings demonstrate well-dispersed BG within the PCL matrix, maintaining thermal stability. Although PCL membranes were more hydrophobic than BG-filled ones, PCL/BG membranes displayed improved degradability, wettability, and enhanced apatite formation, especially with higher BG concentrations (10% and 20% wt.%). These results suggest that PCL/BG membranes hold promise for guided bone regeneration.

We focused on developing guided bone regeneration (GBR) membranes with enhanced bioactivity, biocompatibility, and proper degradation ability. By incorporating binary bioactive glass "63% SiO_2-37% CaO" produced via a hydrothermal method into Poly(ε-caprolactone) (PCL) electrospun membranes, we aim to investigate their properties. The membranes aim to isolate bone defects from surrounding soft tissue, promoting bone tissue growth while preventing interference from non-osteogenic tissues. The impact of bioactive glass content on membrane properties, including wettability, biodegradation, and bio-mineralization, is examined to assess their potential applications in biomedical fields, particularly for guided bone regeneration.

sciforum-083256: Tracing Immune Cells Around Biomaterials with Spatial Anchors during Large-Scale Wound Regeneration

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Introduction

After severe skin damage, the resulting scar usually contains dense extracellular matrix (ECM) fibers devoid of the hair follicle, which lack sensation and endocrine function as well as the flexibility of normal skin. The immune system plays a varying role in driving scar fibrosis or hair follicle regeneration upon different environmental stimuli. Recently, tissue regeneration mediated by immunoregulatory biomaterials is emerging as a prospective strategy in tissue engineering. The biomaterials' topographical properties, such as pattern and diameter, play important roles in influencing cell activities and manipulating the related immune response during wound regeneration. As a result, there is an urgent need to explore the immunoregulatory mechanisms stimulating hair follicle regeneration in skin repair.

Methods

Here we present a method for skin wound regeneration using biodegradable aligned ECM scaffolds with different diameters: A300 (319 $\pm$ 100 nm), A600 (588 $\pm$ 132 nm), and A1000 (1048 $\pm$ 130 nm). Currently, development in single-cell RNA sequencing (scRNA-seq) and spatial transcriptomics (ST) has enabled the assessment of gene expression at spatial resolution, which has been applied to detect regional cellular communication. The large-scale wound healing model with implanted biomaterials provides an ideal method to understand and probe the role of the immune system in tissue regeneration.

Conclusions

We show that the implantation of A300 scaffolds accelerates wound coverage and enhances hair follicle neogenesis. Multimodal profiles highlight the potential role of regulatory T cells in mitigating tissue fibrous by suppressing excessive type 2 inflammation. We find that immunodeficient mice lacking mature T lymphocytes show the typical characteristic of tissue fibrous driven by type 2 macrophage inflammation, validating the potential therapeutic effect of the adaptive immune system activated by biomaterials. These findings contribute to our understanding of the coordination of immune systems in wound regeneration and facilitate the design of immunoregulatory biomaterials in the future.

sciforum-092055: Ultrasonic Synthesis and Properties of Chitosan and Collagen Block Copolymers for Tissue Engineering

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Materials for tissue bioengineering must have a set of properties, such as biocompatibility when interacting with cells in vitro and in vivo, adhesion, proliferation and differentiation of cells in the material. One of the most important requirements for this kind of materials is satisfactory physical and mechanical characteristics that are not inferior to the actual regenerated tissue in a given area of the body. The strength of collagen and chitosan-based materials meet all the requirements when used as matrices for tissue engineering. Block copolymers based on fish collagen and chitosan were obtained 0via ultrasonic irradiation of a mixture of homopolymers. Under the influence of ultrasonic irradiation, two effects— mechanochemical and radical—contribute to the breaking of chains (degradation of macromolecules). As a result, macroradicals are formed that randomly combine with each other. If there are two homopolymers in a solution, then under the influence of ultrasound the chains of both polymers are broken, the resulting macroradicals of different natures recombine and a block copolymer is formed. Films based on the obtained block copolymers of chitosan and collagen are characterized by a tensile strength of up to 120 MPa and are biocompatible with hTert-BJ5ta fibroblast cells. The properties of the material can be controlled by changing the ratio of components, the time of ultrasonic treatment, the molecular weight characteristics of the original homopolymers and the introduction of plasticizers that have a positive effect on the properties of the matrix. The totality of the results obtained shows that compositions based on block copolymers are superior to films made from homopolymers and their mechanical mixtures in terms of mechanical properties, adhesion and proliferation of fibroblast cells. This work was supported by grant of the Russian Science Foundation (project No. 23-13-00342, `https://rscf.ru/project/23-13-00342/`).

Abstracts

Session E. Biomaterials for Drug Delivery

sciforum-092085: Development of Targeted Combined Structures Based on Phospholipid Nanosystems for Lung Cancer Therapy

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Introduction

The development of targeted delivery systems (DSs), including DSs with controlled release, e.g., photoinduced release, is considered to be one of the most promising directions of antitumour therapy development. The increasing morbidity of patients with non-small cell lung cancer makes it urgent to improve the therapy of this disease. One of the effective drugs in the treatment of this disease is Gefitinib (Gef); however, Gef is used in the form of tablets, and its bioavailability is about 50%. In this regard, the development of DSs with photoinduced release for Gefitinib is very promising, and their use will improve the safety profile of the drug and reduce undesirable effects.

Methods

The combined DSs were prepared by the following methods: 1. liposomes were obtained by the lipid film; 2. micelles were emulsified by inert gas bubbling. The created model formulations were evaluated according to the particle size, ζ-potential, and content of active substances. The cytotoxic activity of the nanoconstructions was studied on the lung carcinoma cell line A549.

Results

In the process work, model formulations of DSs with different morphologies were created. From the proposed formulations, the most promising ones were selected according to the criteria of particle size (<200 nm) and active substance inclusion (85–90%). The leader models were also tested for cytotoxic activity on A549 cells. It turned out that only in the micellar model did the toxicity index for irradiated and non-irradiated cells exceed 50%. This indicates the promising application of this model for further research.

Conclusions

In the course of this work, biopharmaceutical studies were carried out to substantiate the composition and technology of targeted DSs with photoinduced release of Gefitinib and to study the antitumour activity in vitro.

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sciforum-090285: Green Nanotechnology: Effect of Proteins on the Synthesis of Gold Nanoparticles

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Over the last decade, the field of green nanotechnology has received a great deal of research attention due to its cost-effectiveness and environmental friendliness. The green approach has been successfully used to develop metallic nanoparticles of various sizes and morphologies for various biomedical applications and has resulted in the successful development of these particles. By combining two different types of proteins in this work and synthesizing them in a balanced manner, we have been able to synthesize spherical gold nanoparticles with low polydispersity. peptone and whey. Because of the presence of a large number of chemical functional moieties, proteins have a great deal of variety and can act in a variety of ways such as reducing and stabilizing. The formation of gold nanoparticles was studied by UV-Vis absorption spectroscopy, and a strong surface plasmon resonance peak centered at 520 nm confirmed the presence of the nanoparticles in solution. The size and morphology was studied using Transmission electron microscopy. The particles were spherical and contained an organic protein coat which offered stability against aggregation in solution. It is currently being studied whether these nanoparticles can produce fluorescence and antibacterial properties in order to broaden the range of biomedical applications of these colloidal materials.

sciforum-092145: Universal Drug Delivery Platform for Anticancer Theranostics Based on Dumbbell-like Fe_3O_4-Au Nanoparticles

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Anticancer therapy is a significant challenge today. The use of nanocarriers as a promising method can influence the pharmacokinetics and biodistribution of drugs, as well as reduce side effects. Combinations of drugs such as doxorubicin and paclitaxel in certain ratios have been shown to exhibit a synergistic effect, while using drugs simultaneously can reduce the development of resistance and the total administered dose. However, delivering combinations of drugs to tumor cells at a given molar ratio is difficult due to differences in the chemical structure and properties of anticancer drugs (hydrophobicity and charge). In this work, magnetic dumbbell-like Fe_3O_4-Au nanoparticles (MDNPs) are proposed. Firstly, due to their magnetic properties, MDNPs can be used for magneto-resonance imaging. Secondly, the presence of two chemical surfaces (Fe_3O_4 and Au) allows us to modify MDNPs with different molecules in order to load two different types of drugs at given ratios. MDNPs were produced through the thermal decomposition of $Fe(CO)_5$ and $HAuCl_4$ in octadecene-1. The size was 14 ± 1 nm for Fe_3O_4 and 4 ± 1 nm for Au. After that, the Fe_3O_4 surface of the MDNPs was sequentially coated with 3,4-hydroxyphenylacetic acid, FAM-maleimide modified human serum albumin (HSA), and NH_2-PEG-COOH. These nanoparticles were stable in both water and PBS for 30 days and allowed for the loading of cisplatin (cPt, 0,3mg/1mg Fe), doxorubicin (DOX, 0.45 mg/1 mg Fe), and paclitaxel (PTX, 0.35 mg/1 mg Fe). The Au surface was modified with HSA that had previously been loaded with a drug to obtain a system with two drugs. As a result, two systems were produced (MDNP-cPt-DOX, with a molar ratio of cPt/DOX 1:1, and MDNP-PTX-DOX, with a molar ratio of PTX/DOX: 1:3). These proved to be comparable with free drugs' synergistic results in terms of their toxicity against the CT26 cell line. To summarize, modified MDNPs can be loaded with different types of drugs, and the Au surface allows for the addition of another drug to achieve a synergistic effect in therapy.

sciforum-089892: ATRP-Synthesized Linear Copolymer Conjugates from Pharmaceutically Functionalized Choline Ionic Liquid Monomers for Ampicillin Delivery

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Introduction

Linear polymer drug delivery through ATRP (Atom Transfer Radical Polymerization) stands as a breakthrough in medical science, offering exceptional advantages. The controlled and predictable structure of linear polymers ensures a precisely regulated drug release, optimizing therapeutic outcomes. This method allows for tailored drug delivery, enabling the targeting of specific cells or tissues with minimal side effects.

Methods

This study involved the synthesis of monomeric ionic liquids by substituting the chloride counterion in [2-(methacryloyloxy)ethyl]trimethylammonium chloride (TMAMA/Cl) with the ampicillin anion from its sodium salt (AMPNa), resulting in the formation of [2-(methacryloyloxy)ethyl]trimethylammonium ampicillin (TMAMA/AMP). Subsequently, methyl methacrylate (MMA) was copolymerized with TMAMA/AMP using the ATRP method, producing copolymers based on AMP, denoted as P(TMAMA/AMP-*co*-MMA). The drug release mechanism was facilitated by ion exchange with phosphate anions in PBS, which is mimicking the natural environment of physiological fluids with a pH of 3.7 at 37°C.

Results

The drug carriers exhibited 61–76% of the AMP contents in the copolymers. The polymeric chain lengths were determined by assessing the total monomer conversion (27–47%), leading to a degree of polymerization (DPn = 131-363). Utilizing dynamic light scattering (DLS), the hydrodynamic diameters (Dh = 190–328 nm) of polymer nanoparticles and their polydispersity index (PDI = 0.01-0.06) in an aqueous solution were determined. In addition, in vitro studies demonstrated the release of 72–100% (11.1–19.5 μg/mL) of drug within 26 h.

Conclusions

Our study explored the well-defined linear copolymers, P(TMAMA/AMP-*co*-MMA)s, with varying ionic contents, showcasing their promise as carriers in drug delivery systems (DDS). The findings affirm the efficacy of the trimethylammonium-based IL monomer carrying AMP in designing polymeric carriers with precise amounts of therapeutically active anion. This DDS holds potential for preventing and treating diverse bacterial infections, including respiratory tract infections.

sciforum-092157: Biomaterial-Based Nanoencapsulation for Drug Delivery for Treating Eating Disorders, Overcoming Challenges, and Enhancing Therapeutic Efficacy

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Introduction

Eating disorders (EDs) have evolved into severe, complex, and life-threatening conditions, impacting individuals of all ages and inflicting significant physical and psychological repercussions. These disorders, including binge eating, restrictive eating, compulsive eating, irregular eating patterns, anorexia, bulimia, and orthorexia nervosa, pose an increased risk of suicide attempts, mortality, and comorbid conditions. Despite advances in therapeutic interventions, limited treatment effectiveness and high rates of relapse persist.

Methods

The methodology for this study involves conducting a literature review on EDs and biomaterial-based nanoencapsulation (BBNE), identifying suitable drug therapies, evaluating BBNE methods, developing personalized treatment strategies, assessing their efficacy through clinical trials, performing statistical analysis, and discussing findings and future directions.

Results

BBNE offers precise drug delivery (DD), controlled release, and compatibility with combination therapies, promoting personalized and safe treatment strategies. This approach enhances drug bioavailability and stability, potentially improving therapeutic success while minimizing systemic adverse effects and increasing treatment adherence. Its personalized nature enables the tailoring of treatment regimens to address the unique biological and psychological factors of EDs.

Conclusions

However, challenges such as scalability, regulatory approval, and long-term safety need to be addressed to facilitate the widespread adoption of BBNE in clinical practice. In conclusion, the progress in BBNE offers transformative possibilities for treating EDs. Hence, this research endeavors to investigate innovative strategies utilizing DD biomaterials to meet the treatment requirements of EDs and enhance the therapeutic efficacy.

sciforum-090280: Conducting Polymer Microspheres for Targeting Neuroblastoma

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Introduction

Neuroblastoma is a type of cancer that develops in young children from immature nerve cells. Traditional treatments include surgery, chemotherapy and radiotherapy. However, these treatments can cause significant side effects, especially in children, potentially affecting their development and long-term health. A novel approach of direct drug delivery to the tumour site has been proposed, using conductive polymer-based microspheres that carry the anti-cancer, anti-inflammatory and antioxidant agent, curcumin.

Methodology

Conducting polymer microspheres (CPMS) were formed by the chemical polymerization of hydroxymethyl-3,4-ethylenedioxythiophene around polystyrene beads, with their further removal with the use of toluene. After incubation in the solution of curcumin, CPMS were characterized by means of electron microscopy, UV-Vis spectroscopy, and infrared spectroscopy. Curcumin release was monitored under both static (no stimulation) and electrically triggered conditions. Cytotoxic effect of CPMS was tested against neuroblastoma (SH-SY5Y) cell line.

Results

Infrared spectroscopy confirmed the incorporation of curcumin within CPMS, while release studies indicated a consistent, low-dose release of drug, applicable to both electrically stimulated and spontaneous release scenarios. Cytotoxicity measurements proved the efficiency of curcumin-loaded CPMS against a neuroblastoma cell line.

Conclusions

We showed that CPMS possess the capacity to efficiently encapsulate and release curcumin, demonstrating suitable release kinetics. CPMS proved to be effective in both spontaneous and electrically induced release scenarios. Future research will focus on assessing the biocompatibility of these carriers and evaluating their efficacy with various model drugs. The research suggests that CPMS hold significant promise and practical utility as an innovative approach to anti-cancer treatment, especially for combating neuroblastoma.

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sciforum-082905: Decorated Nanogels as Promising Tools for Selective Drug Delivery in Spinal Cord Injury

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Introduction

Spinal cord injury (SCI) is characterized by a primary SCI that is the consequence of a traumatic event, and by the subsequent inflammatory response, characterized by the activation of microglia/macrophages/astrocytes, that leads to an aggravation of the pathology and to neurodegeneration [1,2]. A possible therapeutic approach is represented by the possibility to modulate the inflammatory response through the release of drugs in the damaged zone selectively within different cell lines. Recent advances in polymer science and nanotechnologies showed increased interest for nanogels (NGs), a new class of colloidal systems that can be used as carriers to treat SCI.

Material and Methods

Nanogels were synthesized using polyethylene glycol (PEG) and polyethylenimine linear (PEI), after having functionalized PEI with a chromophore [3,4]. This PEI functionalization was essential to constantly trace the nanogels during the biological assays. Many different coating strategies of the nanogels were analyzed; in fact, surface functionalization is essential to tune the characteristics and the biological behavior of the final system.

Results and discussion

Biological tests proved that functionalized nanogels were able to be selectively internalized in mouse microglia or astrocytes depending on their surface decoration, that their degradation promoted drug release, and that the use of anti-inflammatory molecules as a delivered drug were able to mitigate the pain state [5,6]. Subsequent in vivo assays on diseased mice confirmed the result obtained in vitro and the potentiality of this kind of surface functionalization.

Conclusions

Nanogels are, for sure, effective devices in drug delivery, and here, we showed their potentialities as targeted drug delivery systems in SCI.

References

1. Thuret, S.; Moon, L.D.; Gage, F.H. Therapeutic interventions after spinal cord injury. *Nat. Rev. Neurosci.* **2006**, *7*, 628–643.
2. Papa, S.; Veneruso, V.; Mauri, E.; Cremonesi, G.; Mingaj, X.; Mariani, A.; De Paola, M.; Rossetti, A.; Sacchetti, A.; Rossi, F.; et al. Functionalized nanogel for treating activated astrocytes in spinal cord injury. *J. Control. Release* **2021**, *330*, 218–228.
3. Pinelli, F.; Pizzetti, F.; Rossetti, A.; Posel, Z.; Masi, M.; Sacchetti, A.; Posocco, P.; Rossi, F. Effect of surface decoration on properties and drug release ability of nanogels. *Coll. Surf. A* **2021**, *614*, 126164.
4. Pinelli, F.; Saadati, M.; Rossetti, A.; Rossi, F.; Sacchetti, A. On the influence of polyethyleneimine modification in nanogel-driven drug delivery. *Coll. Surf. A* **2023**, *658*, 130623.
5. Vismara, I.; Papa, S.; Veneruso, V.; Mauri, E.; Mariani, A.; De Paola, M.; Affatato, R.; Rossetti, A.; Sponchioni, M.; Moscatelli, D.; et al. Selective modulation of A1 astrocytes by drug-loaded nano-structured gel in spinal cord injury. *ACS Nano* **2020**, *14*, 360–371.

6. Papa, S.; Rossi, F.; Ferrari, R.; Mariani, A.; De Paola, M.; Caron, I.; Fiordaliso, F.; Bisighini, C.; Sammali, E.; Colombo, C. Selective nanovector mediated treatment of activated proinflammatory microglia/macrophages in spinal cord injury. *ACS Nano* **2013**, *7*, 9881–9895.

sciforum-091979: Enhancing Solid Lipid Nanoparticle Performance: Combining Commercial Lipids with Biobased Ionic Liquids

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The exploration of biocompatible and sustainable materials for nanotechnology-based formulations with pharmaceutical and cosmetic applications is rapidly expanding. Among these formulations, solid lipid nanoparticles (SLNs) have garnered significant attention due to their biocompatibility and potential to enhance transcutaneous penetration, rendering them suitable for skin applications [1]. However, they present some issues, such as low stability. On the other hand, biobased ionic liquids (ILs) are versatile compounds, known to improve the incorporation of sparingly soluble compounds, improve stability, or enhancepermeation across the skin barrier [2]. Therefore, their incorporation in nanodelivery systems has the potential to improve the overall properties of nanoparticles. This work aimed to produce and evaluate the performance of SLNs incorporating choline-based ILs.

Different SLNs were prepared using two commercial lipids, Gelucire® 43/01 and Precirol ATO® 5. Moreover, (2-hydroxyethyl)trimethylammonium phenylalaninate – [Cho][Phe] was incorporated in both types of SLNs. The nanosystems were characterized concerning size, polydispersity index, and zeta potential. Stability studies were conducted for 90 days. Additionally, the impact of the nanoparticles on cell viability was also evaluated using the HaCaT cell line via the MTT assay.

The results showed that ILs improve the colloidal stability of the nanoparticles and the physicochemical properties towards a topical application. The data also showed that the impact of ILs is dependent on the solid lipid used to prepare the SLNs. In conclusion, the production of innovative lipid nanocarriers combined with biobased ILs seems to open a new paradigm for skin delivery.

sciforum-090382: Injectable Hydrogel Based on Carboxymethyl Chitosan/Oxidized Agarose for Potential Application in Local Drug Delivery

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An injectable hydrogel based on oxidized agarose (OA) and carboxymethyl chitosan (CMCh) was developed with OA:CMCh variable proportions (60:40, 50:50, and 40:60) were evaluated, and its characterization was carried out through time gelation, injectability, syringeability, compression mechanical properties, swelling, and degradation. For all proportions, it was found that the hydrogel gelled before reaching 37 °C, and it proved to be suitable for injection through a 21 G gauge needle. Also, a direct relationship was identified between the CMCh amount added to the mixture and the evaluated properties of the hydrogel. The injectability (maximum injection force) for the 60:40 ratio was 12.84 N and increased by 62% in the 40:60 ratio. Nevertheless, these were less than 30 N, which is the maximum force accepted for manual injection. Likewise, the 60:40 proportion presented a compressive strength of 26.92 kPa and increased by 72% in the 40:60 proportion. Likewise, the swelling capacity increased from 1972% to 3102% for the same proportions, respectively. Furthermore, the increase in CMCh percentage was also associated with a decrease in the degradation rate; for example, the 40:60 ratio (14.28%) was 32% lower than the 60:40 ratio. In conclusion, for mixtures with higher CMCh content, the hydrogel's injectability, compressive strength, and swelling capacity increased. These results suggest that changing the proportion of OA:CMCh can modulate the material's properties, indicating its versatility and adaptability. It is a promising option for biomedical applications such as the local administration of active ingredients.

sciforum-091766: Local Chemotherapy Platform with Controlled and Prolonged Drug Release for the Prevention of Local Tumor Recurrence

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Introduction

Local recurrence in oncology is a significant issue, often due to chemotherapy limitations like drug concentration fluctuations in the tumor localization and non-specific action, leading to unstable therapeutic effects and reduced effectiveness. This research aimed to develop a biodegradable local chemotherapy platform for multi-month, controlled drug release.

Methods

A polycaprolactone (PCL) substrate was prepared using the solvent casting method followed by aminolysis on one side for the subsequent deposition of a multilayer coating containing doxorubicin (DOX). The substrate was analyzed using FTIR spectroscopy, SEM, colorimetric and wetting angle measurements. To stabilize the release of DOX, an ionic complex between poly-γ-glutamic acid (PGA) and DOX was formed. A coating was applied to the platform by layer-by-layer assembly of polyelectrolytes. Various coating deposition methods, different polycations, and the presence of empty polyelectrolyte bilayers were tested. The platform was analyzed using SEM, AFM and DSC. The empty platform was also tested for cytotoxicity and cytocompatibility using ovarian cancer cells (SKOV-3) and primary human fibroblasts. The *in vitro* activity of the released DOX was assessed using SKOV-3 cells.

Results

The amount of amino groups on the substrate surface after aminolysis was 118.1 μg/mL. The ionic complex between DOX and PGA was obtained with 99% efficiency and contained 99 μg/mg DOX. The total load of DOX in the platforms was 570 ng/cm^2. The release of DOX from the resulting platforms lasted for more than 5 months and was characterized by minimal explosive kinetics and uniformity. According to the results of in vitro studies, the platform showed no cytotoxicity, was characterized by good cytocompatibility and did not interfere with the antitumor activity of DOX.

Conclusions

This work is promising for drug delivery systems and therapeutics, as it compensates for the explosive nature of antineoplastic agents release in similar studies and has the highest prolonged release.

sciforum-092149: Nanoscale Cyclodextrin Systems for the Delivery of Tetrapyrrole Photosensitizers

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Introduction

Application of pharmacological forms based on nanomaterials is a promising methodological approach to increase the therapeutic efficacy of nonpolar drugs by increasing their bioavailability. One of the most important parameters that makes it possible to assess the effectiveness of the use of pharmacological forms is the release profile of the drug from the nanocarrier. The role of the kinetic characteristics of drug liberation from nanocarriers has not been sufficiently studied due to the existing limitations of the analysis of mass transfer in complex biological systems.

The aim of this work is to compare the equilibrium and kinetic characteristics of the distribution of the photosensitizer Temoporfin when the photosensitizer is bound to monomeric or polymeric forms of β-cyclodextrin derivatives.

Materials

Temoporfin was provided by Biolitec® (Germany). The cyclodextrin methyl-β-cyclodextrin was purchased from AraChem (Netherlands). β-cyclodextrin polymer and carboxymethyl-β-cyclodextrin were purchased from Cyclolab (Hungary).

Results

The fluorescence features of Temoporfin in complexes with β-cyclodextrin derivatives were studied, and the binding constants were determined. According to the results obtained, all cyclodextrin derivatives exhibit a high affinity for the sensitizer. Using the developed spectral techniques, the kinetics of Temoporfin release from complexes with cyclodextrins in the presence of model biological membranes or serum proteins were analyzed. The processes of association and dissociation of photosensitizer molecules from nanocarriers strongly depend on both the physicochemical properties of cyclodextrin molecules and their structure. Despite their lower affinity, polymeric cyclodextrins are able to delay sensitizer molecules for a significantly longer period of time.

Conclusions

Our results show that fluorescent techniques are highly informative in studying the processes of sensitizer redistribution between nanostructures. According to the data obtained, the rate of drug release from complexes with nanomaterials varies in a wide range, which should be taken into account when analyzing the pharmacokinetics of drugs introduced as part of complexes with a nanocarrier.

sciforum-092040: Physicochemical Study of Mucoadhesive Polymers and Their Interactions with Mucin

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Solid drug dosage forms applied directly to the mucous membrane are becoming very popular because they allow to prolong the drug release for several hours and ensure maintainance of the optimal therapeutic level. This effect is possible due to the presence of mucoadhesive polymers. The mutual entanglement of polymer and mucin chains leads to form a gel structure which is a reservoir for the drug. Generally, the mucoadhesive forms contain hydrophilic polymers, such as polycarbophil, carbomer, chitosan, or cellulose derivatives (HPMC, HEC, etc.).

Scientific papers indicate that selecting the appropriate ratio of the polymers can extend the drug release, enhance the repeatability of the release profiles, improve the mucoadhesive properties of the material surface, and improve drug transport to the mucosa. Therefore, it is important to look for a correlation between the composition of the mucoadhesive carrier and its surface properties. Consequently, the wettability of polymer matrices, the degree of their swelling, the SFE value, and the mucoadhesion force are crucial for designing oral carriers and predicting their effectiveness in vivo. In our research, we measured the swelling and the contact angle on the polymer surface by the sessile drop method using various simulated biological fluids, water, and diiodomethane. The correlation between the physicochemical properties and release profiles obtained for antifungal drugs were evaluated.

Moreover, to explore the interactions between the polymer and mucin in the cell membrane environment, studies were carried out using the Langmuir monolayer technique. The obtained results allowed to better understand the mucoadhesion process and confirm the existence of interactions between mucin, mucoadhesive polymers, and model biological membranes. We have shown that these interactions depend on the type of mucoadhesive polymers, pH, and presence of mucin.

sciforum-092186: Preparation and Evaluation of Niosomal Formulation for Solubility Enhancement of Anti-fungal Agent for the Treatment of Oral Candidiasis

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The human fungal pathogen Candida albicans is notorious for causing oral infectious diseases, notably oral thrush, particularly in immunocompromised individuals with conditions such as hyposalivation, diabetes mellitus, and prolonged use of antibiotics or immunosuppressive medications, often compounded by poor oral hygiene practices. Addressing such infections often involves anti-fungal medications, with Clotrimazole being a prominent choice. However, Clotrimazole, classified as a BCS class II drug, poses challenges due to its high permeability coupled with low solubility in water.

Traditionally available in lozenge form, Clotrimazole's efficacy is hindered by its uneven distribution within saliva, necessitating frequent dosing and potentially compromising patient compliance. To overcome these limitations, this study proposes a novel approach: a niosomal-based subgingival film formulation of Clotrimazole. By leveraging the advantages of niosomes, including enhanced drug solubilization capacity and prolonged release kinetics, this formulation aims to improve drug efficacy while simultaneously enhancing patient compliance by reducing dosing frequency.

Initial findings from the study are promising. The prepared niosomal film demonstrates favorable characteristics, including high entrapment efficiency and potent anti-fungal activity. Moreover, the release profile of the drug from the niosomal film exhibits superior performance compared to conventional drug-loaded films. These results suggest that the niosomal-based formulation holds significant potential for enhancing the therapeutic outcomes of Clotrimazole in the treatment of oral fungal infections.

By addressing the limitations of conventional Clotrimazole formulations through innovative niosomal technology, this study offers a promising avenue for improving the management of oral fungal infections. Further research and clinical trials are warranted to validate these findings and pave the way for the development of effective, patient-friendly treatments in this important area of healthcare.

sciforum-088742: Rutin-Loaded Hybrid Nanoparticles for Controlled Delivery: Technological and In Vitro Anti-Inflammatory Properties

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Anthracyclines are crucial in treating neoplastic diseases but can cause cardiomyopathy and brain damage. Rutin, a bioflavonoid, improves brain damage induced by doxorubicin but has limitations. Hybrid nanoparticles (H-NPs) were developed to enhance rutin's effectiveness and protect brain cells. The H-NPs were formulated using phosphatidylcholine, palmitoylethanolamide (PEA), cholesterol, poloxamers (LP and LPR) and hyaluronic acid (HA) (LPHA, LicpHA and LPHAR and LicpHAR) via the nanoprecipitation technique. PEA reduces inflammation, while HA aids in mucoadhesion and absorption enhancement. The mean size, stability size, zeta potential (ZP), morphology, thermal properties, encapsulation efficiency, drug content, and in vitro drug release and permeation were studied. The cellular uptake of LPP and LPH was investigated in cell lines. Cytotoxicity and anti-inflammatory activity were evaluated in cells. HA and PEA influenced the size of H-NPs. The mean size increased from 118 nm for LPP to 179 nm for LicpHA and further to 247 nm for LPHR. The size also increased after rutin loading, ranging from 171 nm for LPPR to 255 nm for LPHR. HA's addition influenced the ZP, shifting from -17.3 mV for LPP to -29.9 mV for LPH and finally to -35 mV for LicpHA. TEM images showed spherical shapes with irregular surfaces for all N-HPs. The total amount of rutin in the dispersion was approximately 97%, with an encapsulation efficiency of 68%. Thermal analysis indicated the presence of HA on the LPH surface. In vitro, studies demonstrated significantly improved drug permeation with both systems, higher than rutin-free solutions. LPP and LPH showed rapid cellular uptake within three hours. LPPR and LPHR significantly reduced cell death and induced inflammation. All H-NPs resulted in a greater anti-inflammatory effect compared to H-NPs without PEA.

In summary, LPH and LicpHA show potential for rutin encapsulation for different delivery routes. Additionally, rutin-loaded PEA H-NPs exhibit enhanced vasculoprotective effects.

sciforum-091250: Silicon Nanoneedles for Sustained Treatment of Choroidal Angiogenesis

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Purpose

Choroidal neovascularization (CNV) is a major cause of vision loss and blindness in wet macular degeneration. To treat CNV, intravitreal anti-vascular endothelial growth factor therapy (VEGF) such as bevacizumab (BEV) are often utilized, but these treatments require frequent invasive administration and can carry a risk of eye infection. To improve the treatment efficiency, reduce the treatment burden, and reduce side-effects and invasiveness, the current study describes a novel treatment of CNV using miniature biodegradable silicon nanoneedles (SiNNs) fabricated on a tear-soluble contact lens.

Methods

The SiNNs were encapsulated with BEV (BEV@SiNNs) and used as drug carriers for long-term, sustained drug delivery. BEV@SiNNs were evaluated on a New Zealand rabbit CNV model (n = 7) after approval from the University of Michigan IACUC. To generate CNV, subretinal injection of Matrigel (20 μL) and VEGF (7.5 μL, 100 μg/mL) was performed using a 30G Hamilton needle. A contact lens was inserted subconjunctivally on the posterior sclera 3 days after CNV creation and monitored by color fundus photography, OCT, and fluorescein angiography (FA) before and at 1, 3, 7, 14, and 28 days and then monthly for up to 1 year post-treatment.

Results

BEV@SiNNs resulted in long-term, sustained reduction in mean FA CNV leakage intensity for at least 1 year. There was a rapid 45% reduction in CNV within 1 week. CNV continued to gradually reduce further to an 80% reduction in CNV by 4 months that was persistent to 12 months. Control CNV did not have a significant change in CNV over 1 year. Rabbits were comfortable on the grimace scale, and no complications occurred with treatment in any animals. OCT showed normal retinal morphology and layers.

Conclusions

SiNNs are an efficient drug delivery platform technology for long-term (at least 1 year), sustained treatment of CNV in this rabbit model.

sciforum-091555: Stimuli-Responsive Materials for Drug Delivery, Neuromodulation, Tissue Engineering and Regenerative Medicine

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Introduction

The development/application of novel drug delivery systems capable of precisely controlling the delivery of their payloads is an area of intense current research interest as the importance of personalized medicine has been understood. Such systems potentially enable spatiotemporally controlled delivery, for example, maintaining a therapeutically effective level of a drug, minimizing unwanted side effects, and thereby enhancing treatment efficiency. Stimuli-responsive materials (SRMs) have significant potential for the development of smart biomaterials capable of drug delivery with defined release profiles. We are interested in the design, synthesis, and characterization of biomaterials capable of responding to one or more stimuli, and their use in various paradigms.

Methods

An interdisciplinary approach combining chemistry (synthesis), materials science and engineering was employed to prepare and characterize SRMs and their composites (e.g., mechanics, microscopy and spectroscopy). SRMs and their composites were exposed to stimuli (electricity, light and magnetism), and the release profiles of their payloads (e.g., drugs) was quantified spectroscopically.

Results

Electricity, light and magnetism are capable of triggering the delivery of drugs or biologics of various molecular weights from SRMs and their composites in vitro and ex vivo as demonstrated spectroscopically.

Conclusions

SRMs can deliver a variety of clinically relevant payloads of various molecular weights in response to triggers, and can potentially be used to control the chronopharmacology of their payloads in line with the chronobiology of the condition needing treatment. The bioactivities of the bioactive molecules includes antimicrobial, anti-cancer, anti-inflammatory and growth factors. The stimulation paradigms are either designed to be adaptable to integration in existing medical devices or technologies (e.g., catheter balloons inserted via minimally invasive surgery, medical electronics such as bionic eyes, cochlear implants, electrodes for deep brain stimulation, etc.).

sciforum-092152: Synthesis and Characterization of Mesoporous Silica Nanoparticles for Delivery of Anticancer Drugs

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Mesoporous silica nanoparticles (MSN) are a promising drug delivery system due to their unique morphology, tunable particle size (50–300 nm), controlled pore size, high surface area, and biocompatibility. The use of MSN as carriers can improve the effectiveness of anticancer drugs by targeted delivery to the tumor, controlled release, and reduced side effects. Currently, the possibility of delivery of such classes of anticancer drugs as cytostatics, photosensitizers, and radiopharmaceuticals using MSN is being actively studied.

The aim of this work is to synthesize and evaluate the morphology of MSN.

The research objectives were to obtain mesoporous nanoparticles, to estimate their size, to measure the specific surface area of the particles, to analyze the adsorption capacity of the particles, the efficiency of encapsulation, and the release kinetics of the drug.

MSN were synthesized by the modified Stober method, in which tetraethoxysilane is the source of silicon, and the nanoparticles are obtained by using the CTAB surfactant. The particle size analysis was carried out by scanning electron microscopy, and the specific surface area of the particles was also estimated by the BET method. The loading and release kinetics of doxorubicin from MSN were studied spectrophotometrically using a Varioscan LUX multifunction plate reader daily for 20 days. Doxorubicin fluorescence was measured at an excitation wavelength of 470 nm and an emission wavelength of 590 nm. The release kinetics of doxorubicin were studied at room temperature in phosphate-buffered saline (PBS) with pH 7.4.

As a result, the average particle size of MSN was 100 nm, and the pore diameter was 3 nm. The specific surface area of MSN was 644 m^2/g. Doxorubicin loading was carried out by adsorption from a solution with a concentration of 2 μg/mL. The doxorubicin loading efficiency was 19.13%

sciforum-090049: The Development of Doxorubicin Delivery Systems Specifically Designed to Target Cancer Cells Using Magnetic Fe_3O_4 Nanoparticles

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Introduction

Drug carriers made of magnetic nanoparticles (Fe_3O_4) have become increasingly popular. Iron nanoparticles possess distinct magnetic characteristics and can be transported to the desired location by the manipulation of a magnetic field. The medicine utilized in the study is doxorubicin. The issue with magnetic nanoparticles is in their tendency to form agglomerates when suspended in physiological solutions. To enhance particle stability and ensure safe application, it is necessary to apply a biocompatible polymer coating on the surface of the particles. Lysozyme is a biopolymer that possesses both anticancer and anti-inflammatory effects, which can stabilize nanoparticles and enhance therapeutical effects.

Methods

The magnetic nanoparticles were generated using three different methods: hydrothermal, annealing, and coprecipitation. The produced particles were analyzed by SEM, EDX analysis, FTIR spectroscopy, and BET. The surface charge of the nanoparticles was determined by measuring their zeta potential. The magnetic characteristics of the Fe_3O_4 particles were analyzed using a vibrating sample magnetometer. Experiments involving the loading and release of doxorubicin were conducted at various pH levels. In vitro cytotoxicity studies were conducted on the created nanosystem utilizing the Emt6 cell line and a healthy cell line.

Results

A comparative analysis of three distinct approaches for producing magnetic nanoparticles facilitated the determination of the most pertinent method for synthesizing Fe_3O_4 nanoparticles. The nanoparticles possess an ideal size of approximately 20 nm and exhibit magnetic properties of 68.4 emu/g. Additionally, they have greater specific surface area values of 62 m^2/g. The particles obtained exhibited a significant capacity for loading doxorubicin. The incorporation of a lysozyme shell resulted in an extended duration of drug release from the created systems, in contrast to the uncoated nanoparticles.

Conclusions

Based on the findings of this study, the drug-loaded nanoparticles are suitable for cancer treatment and have potential for further in vivo investigations.

Abstracts

Session F. Biomaterials for Diagnostics, Therapy and Healthcare

sciforum-089740: Nanocomposites Synthesized by Decorating Reduced Graphene Oxide with Zinc Oxide for Electrochemical Applications

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In 2004, the World Health Organization recommended the development of miniaturized diagnostic devices that are accessible, easy to use, selective, specific, economical, etc. By using nanotechnology to create sensors, the analytical electrochemistry field has made great progress in terms of expanding their application range, improving their reproducibility, decreasing their detection limits, and improving the ease of detection of the analyte of interest. The conductivity of nanocomposites is determined by the concentration, size, and dispersion of nanoparticles in the carbon matrix. The compatibility of carbon materials with different media is generally moderated by their strong interactions and high surface energy. In this paper, we investigated the possibility of obtaining zinc oxide quantum dots (ZnO QDs) for the creation of nanocomposites based on transitional oxides and carbon materials made from reduced graphene oxide (RGO) for electrochemical applications. We used the precipitation process to generate ZnO QDs. The Hummer process was utilized to synthesize RGO. The ZnO-RGO nanocomposites were produced via an ex situ technique. A range of analytical techniques were used to assess the shape, size, structural phase purity, functional groups, wettability, and other characteristics of the samples. Through the use of spectroscopic analysis, the structural aspects of the oxide, carbon material, and composite were investigated. The surface morphology, particle size, and distribution of nanoparticles in the carbon material were examined using a field-emission scanning electron microscope. Goniometric studies followed the percolation and wetting capacity studies of the nanocomposites. The application capacity of the ZnO-RGO nanocomposite was evaluated via cyclic voltammetry.

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sciforum-092035: A New Strategy Based on Methylene Blue and Boron Nitride for Local Photodynamic Therapy

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Introduction

The application of the photosensitizer methylene blue (MB) in photodynamic therapy (PDT) is limited by the high risk of side effects. This restricts the possibility of using MB for highly effective PDT. This study presents the development of a new strategy for local PDT based on MB adsorbed on a photocatalyst—hexagonal boron nitride nanoparticles (h-BN).

Materials and Methods

h-BN/n•MB heterostructures with a specified concentration (n) of MB were obtained by immobilizing MB on h-BN NPs using a controlled adsorption method. Characterization of h-BN/n•MB heterostructures was carried out using SEM, EDX, UV-Vis spectrophotometry, fluorescence and FTIR spectroscopy. The level of ROS mediated by h-BN/n•MB heterostructures was determined by amperometric method. The cytotoxicity of the material was assessed on human skin melanoma (A-375) and human fibroblast (Wi-38) cell lines.

Results

h-BN/MB heterostructures with MB concentrations of 100, 200, and 300 mg/g were fabricated. The results of fluorescence and FTIR spectroscopy indicate π-π stacking of MB and h-BN in heterostructures. According to spectrophotometry, the desorption of MB is no more than 7 mass. %, which confirms the high stability of the heterostructures. All h-BN/n•MB heterostructures generated a high level of ROS—up to $3.8 \times 10^{-2} \pm 0.3 \times 10^{-2}$ μM/μg within 24 h after exposureto sunlight. Biological studies indicate the presence of pronounced antitumor activity of the material, as well as its selective cytotoxicity to normal and cancer cells.

Conclusions

A new sunlight-activated platform for local PDT has been developed. h-BN/n•MB heterostructures demonstrate high therapeutic potential due to their strong oxidative activity. The presented data confirm the feasibility of using heterostructures to enhance the photoefficiency of low doses of MB.

Funding: The research was funded by the Russian Science Foundation (20-19-00120-P).

sciforum-092127: Chitosan Nanoparticle-Loaded Essential Oils Electrosprayed onto Polycaprolactone Microfibers: A Novel Antifungal Therapy for Diabetic Foot Ulcers

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Diabetic foot ulcers (DFUs) represent a significant healthcare challenge due to their susceptibility to fungal infections, which can exacerbate the already compromised healing process and limit treatment strategies. Here, we present a novel approach based on chitosan (Ch) nanoparticles loaded with commercial essential oils (EOs; citral, geraniol and cinnamaldehyde) and electrosprayed onto polycaprolactone (PCL) electrospun microfibers. The combination of chitosan, known for its antimicrobial properties and biocompatibility, with EOs possessing potent antifungal activity, offers a promising strategy for enhanced therapeutic efficacy. The electrospraying technique facilitates the uniform distribution of Ch nanoparticle-embedded EOs onto PCL microfibers, ensuring controlled release and prolonged retention at the wound site. Chitosan nanoparticles were synthesized using a specific 2.5:1 ratio of Ch-Sodium triphosphate (TPP) and Tween 80 as a surfactant, and loaded with the EOs known for their potent antifungal properties. Subsequently, these nanoparticles were dispersed onto PCL fibers using the electrospraying technique. The resulting composite material exhibited excellent antifungal efficacy against common fungal pathogens implicated in DFUs, namely *Candida* spp. Moreover, the synergistic effect of Ch, EOs, and PCL provided sustained release of the bioactive compounds, prolonging the antifungal effect. Data confirmed this innovative approach as a promising strategy for combating fungal infections in DFUs, potentially improving clinical outcomes and quality of life in diabetic patients.

sciforum-092048: Optical Responses in Biofunctionalized Spherical Semiconductor Quantum Dots

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Given the optoelectronic properties of gallium arsenide (GaAs), it is currently a promising candidate for the development of optimal platforms for optical biosensing devices. The biofunctionalization of this semiconductor can be achieved using biomaterials extensively explored in life sciences for diagnostics. In this study, we investigate the synergistic impact of a functional biomaterial shell and a diatomic confining potential on the electronic and optical properties of GaAs/AlGaAs/bioshell spherical quantum dots. Calculations were conducted within the framework of effective mass and parabolic band approximations, solving the Schrödinger equation for a confined electron using the finite element method (FEM). Our findings reveal that alterations in the sizes of the GaAs core, AlGaAs shell, biomaterial shell, and confinement potential parameters result in significant variations in the energies of electron quantum dots and the optical absorption spectrum. We conclude that the diatomic confinement potential parameters enable adjustment of both ground and excited state energies, thereby modulating the amplitudes and positions of peaks in the obtained optical properties. This nuanced control over the quantum dot properties holds promise for tailoring device performance in optical biosensing applications. By enhancing sensitivity and specificity in detecting biomolecules, such devices could revolutionize biomedical diagnostics, offering rapid and accurate detection of diseases or biomarkers.

sciforum-089822: Phytosynthesis of Core-Shell Nanoparticles of Selenium and Silver for Biomedical and Environmental Applications

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Introduction

Bimetallic nanoparticles synthesized by non-toxic methods have gained considerable spotlight in applications such as cancer therapy, and target-specific drug delivery this being due to material specific properties provided by the shell, like metal specific catalytic and electronic properties and core associated stability, making them highly customizable. In this project, we successfully synthesized stable bimetallic core-shell particles of silver/selenium for potential applications in drug delivery/antimicrobial use.

Methods

Bimetallic nanoparticles of silver core-selenium shell, and vice versa synthesized by a two-step bottom-up approach, using cinnamon, curcumin and hibiscus plant extracts as part of green synthesis protocol. Nanoparticles were characterized for size and morphology by UV-Vis spectroscopy, TEM, SEM, and Infrared spectroscopy.

Results

Nanoparticles and raw materials were analysed for nanoparticle formation at each step of synthesis using UV spectroscopy, Absorption spectra of extracts was obtained to exclude. Initial plasmon resonance peaks were seen at 285 nm in line with range of 200–350 nm expected for selenium indicating formation of selenium core. UV spectrometry was repeated once silver shell was synthesized encapsulating core, and a peak was observed at 446 nm in addition to a preexisting peak at 285 nm, inline with expected peaks for silver in 400–800 nm range, indicating formation of silver shell. Results were further confirmed with SEM/TEM imaging.

Conclusions

Stable bimetallic core-shell nanoparticles were synthesized using plant extracts that acted not only as catalytic compounds but also simultaneous reducing and stabilising agents within the synthesis process, were successfully prepared using inexpensive and ecofriendly methods, as evidenced by UV spectrometry and SEM/TEM imaging showing presence of spherical nanoparticles measuring under 100 nm. Antimicrobial sensitivity testing and further stability testing is currently underway.

sciforum-092114: A mediator Biosensor for Glucose Detection Based on Glucose Oxidase, Bovine Serum Albumin Covalently bound with Neutral Red, and Single-Walled Carbon Nanotubes

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Currently, mediator biosensors make it possible to determine the glucose content in biological fluids, food products and other complex samples, and the urgent task today is to develop the most convenient and accurate online biosensor for determining glucose levels. The developed biosensor includes a portable potentiostat, a 5 mL measuring cell and a screen-printed electrode. The working surface of the screen-printed electrode is modified with single-walled carbon nanotubes, bovine serum albumin covalently bound wuth neutral red and a glucose oxidase enzyme. Modification of bovine serum albumin with neutral red was carried out using glutaraldehyde. All measurements were carried out at pH = 7.0 (phosphate buffer solution, buffer solution salt concentration of 33 mM) and at an applied potential of -0.7 V. Modification of the working electrode with a biocomposite makes it possible to analyze glucose in the range of 0.1–60 mM. The functioning time of the system is 29 days. This range allows us to carry out online glucose monitoring of human blood samples, as well as of tear fluid, where glucose levels should average 0.1–0.3 mM for non-invasive measurements. The biosensor was tested on three samples of physiological fluids; a comparison of the results obtained with the data from the standard method using the Student's statistical test and Welch approximation showed a statistically insignificant difference in the results obtained via the different methods of analysis. Thus, the developed system may become an alternative analytical system for non-invasive monitoring of glucose levels in the future.

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sciforum-092151: Development of Nanocapillary Electrochemical Biosensors for Glucose Detection

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This work considers the possibility of the fabrication of a nanocapillary electrochemical biosensor for glucose determination. The principle of glucose determination is based on the reaction of glucose decomposition into glucolactone and hydrogen peroxide. Glucose oxidase is used as an enzyme. Electrodes based on glass nanocapillaries are used as biosensors for the determination of various analytes due to their ease of fabrication, high sensitivity, selectivity and small size.

Before the fabrication of the nanocapillary sensor, the technique of enzyme immobilization on the mica surface was reproduced. Freshly pierced mica sheets were silanized with 0.33% APS diluted in water and ethanol. The silanized mica was washed in distilled water and immersed for 12 h in 2.5% GA solution in PBS, then washed with distilled water and dried under an Ar atmosphere. The mica samples were then immersed in GOx in PBS solution (2 mg/mL) overnight at room temperature. At each modification step, the surface topography was examined via AFM. Evaluation of the surface topography showed that irregularities in the topography appear during the enzyme immobilization process, which change as the mica surface is modified.

This technique was reproduced to functionalize the inner surface of the nanopipette. At each modification step, cyclic voltammetry waveforms were recorded in HBSS from -800 to 800 mV (400 mV/s) relative to Ag/AgCl. After the reaction of quartz with APS, terminal amino groups were formed on the surface and protonated in the electrolyte solution, and the ionic current at positive potentials increased significantly. Upon crosslinking with glutaric aldehyde, the ionic current decreased as the carbonyl groups were bound to the positively charged groups of APS. After functionalization with glucose oxidase, cyclic voltammetry showed the negative rectification of the current as GOx contains a negative charge.

Conclusions

The possibility of immobilizing glucose oxidase on the nanocapillary surface for glucose detection was demonstrated.

sciforum-090095: Development of Theranostic Nanoplatforms Based on Colloidal Silver Nanoprisms and Paramagnetic Chelates

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There is growing interest in the development of nanomaterials that facilitate the high-precision detection of cancer cells with the least possible invasion of the body. The association of drugs and contrast agents for concomitant therapy and diagnostic is extremely important to follow the evolution of treatment. However, cancer drugs can often cause collateral damage to non-cancer cells and a promising alternative to these treatments is plasmonic photothermal therapy (PTT) [1]. The use of silver nanoparticles (AgNPs) present advantages over other metals, as it combines good qualities in terms of plasmonic feature, synthesis with high control over size and morphology, and cost-effectiveness. AgNPs also have the versatility to modify their surface, providing higher specificity and/or even a signal for a diagnostic technique, like magnetic resonance imaging (MRI). MRI is a non-invasive diagnostic tool that allows the differentiation between healthy and tumoral tissues. However, this technique commonly requires the use of contrast agents (ACs) to enhance the image contrast. Gd^{3+} chelates are the systems most used clinically as ACs and their conjugation with NPs allows a greater concentration of paramagnetic ions, generating a greater contrast without increasing their dosage. Bifunctional nanosystems based on AgNPs and Gd^{3+} chelates present the promising possibility to achieve theranostic nanoplatforms, combining the photothermal property of AgNPs with the relaxometric efficiency of Gd^{3+} chelates. Thus, AgNPs, with good chemical and colloidal stability and a prismatic shape, and DOTA-Gd complexes containing a thiol group were prepared. The obtained bifunctional nanosystems maintained the optical properties of AgNPs and showed longitudinal relativities for Gd^{3+} similar to the AC used clinically (at 20 MHz and 37 °C) [2]. Therefore, the results are promising for the preparation of theranostic systems for MRI and PTT.

sciforum-092124: In Silico Model of CoCr Stent Performance in Multi-Layered Arteries Using Two-Way Fluid–Structure Interaction: Influence of Boundary Conditions and Vessel Length

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The qualitative and rapid assessment of atherosclerotic lesions is still a challenging task. The primary therapy for this pathology involves implanting coronary stents, which help restore blood flow in atherosclerosis-prone arteries. In-stent restenosis is a stenting procedure complication detected in about 10–40% of patients. A numerical study using two-way fluid–solid interaction (FSI) assessed the effectiveness of stenting and was able to reduce the number of complications. Nevertheless, the boundary conditions (BCs) used in the simulation play a crucial role in the implementation of an adequate computational analysis. Three CoCr stent designs were modeled with the suggested approach. The artery–plaque system was modeled as a multi-layer structure with anisotropic hyperelastic mechanical properties. Two kinds of boundary conditions for the solid domain were examined—fixed support (FS) and remote displacement (RD)—to assess their impact on hemodynamic parameters to predict restenosis. Additionally, the influence of artery elongation (short-artery model vs. long-artery model) on the numerical results with the FS boundary conditions was analyzed. A comparison of the FS and RD boundary conditions demonstrated that the variation in the hemodynamic parameter values did not exceed 2%. An analysis of the short-artery and long-artery models revealed that the difference in hemodynamic parameters was less than 5.1%, and in most cases, it did not exceed 2.5%. The RD boundary conditions were found to reduce the computation time by up to 1.7–2.0 times compared to the FS boundary conditions. This study revealed that the stent design significantly affected hemodynamic parameters as restenosis predictors. Moreover, the stress–strain state of the artery–plaque–stent system also depends on the proper choice of boundary conditions.

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sciforum-090951: In Vitro Study of Polyelectrolyte Microcapsules Loaded with Chlorin E6 and Iron Oxide Nanoparticles for Photodynamic Therapy

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The goal of the research was to investigate the photocytotoxicity effect and target delivery of polyelectrolyte microcapsules loaded with the photosensitizer chlorin E6 (ClE6) and iron oxide nanoparticles on mouse hepatoma cells (Mh22a). Microcapsules were made by layer by layer (caps-ClE6). Polyelectrolyte layers (PAH and PSS) and iron oxide nanoparticles were alternately deposited on the spherical cores loaded with ClE6. After 24 h incubation of Mh22a with caps-ClE6 (20 caps/cell) and free ClE6 (11.2 μg/mL), the cells were irradiated by red light (660 nm and 60 W) for 15 min (RL). The photocytotoxicity was evaluated using MTT colometric tests. The targeting in vitro was determined in a Petri dish after 24 h incubation of cells with caps-CLE6 on a permanent magnet and RL 15 min. The cell death was assessed using double staining (acridine orange and ethidium bromide). For caps-CLE6, the cell viability without RL was more than 70%. In the case of free ClE6, the viability was only 26%. After RL, cell death was 92% and 95% for caps-ClE6 and ClE6, respectively. ROS generation by caps-ClE6 was 2-fold higher compared to free ClE6. After incubation of Mh22a with caps-CLE6 on a permanent magnet and RL, fluorescence microscopy showed almost complete cell death by necrosis and apoptosis and no cell death outside the magnet. Thus, Caps-CLE6 had less dark cytotoxicity with the phototoxicity effect via RL, and could be concentrated with magnets.

sciforum-090177: Iron Oxide Nanoparticles Coated with Alginate: Potential Contrast Agent for Magnetic Resonance Imaging

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Magnetic resonance imaging (MRI) contrast can be enhanced through the use of magnetic nanoparticles. These nanoparticles alter the relaxation time of ^{1}H nuclei in water molecules present in tissues, providing sharper and more detailed images. The use of natural polymers such as sodium alginate, in addition to being biocompatible and non-toxic, will ensure greater colloidal stability of the suspension, allowing its use as a contrast agent for MRI. Therefore, this study aimed to prepare and analyze the behavior of iron oxide nanoparticles (FeNPs) to assess their potential application as a contrast agent for MRI diagnosis. FeNPs were prepared in an aqueous medium using the co-precipitation method. Subsequently, the surface of the nanoparticles was coated with different concentrations of sodium alginate (2.5, 5.0, 7.5, and 10.0 mg·mL^{-1}), to make FeNPs stable in an aqueous environment and biocompatible. The efficiency of FeNPs (with and without alginate) as contrast agents was evaluated through relaxivity measurements (20 MHz at 25 °C). The obtained results showed that with the addition of alginate, FeNPs showed a decrease in transverse relaxation time (T_2) compared to NPs without the polymer. These results may indicate that the incorporation of the stabilizer led to a change in the mobility of water molecules, thereby altering the diffusion time of water molecules near the superparamagnetic center and increasing the colloidal stability of iron oxide nanoparticles in suspension. Thus, based on the obtained results, FeNPs-alginate show potential for use as biocompatible contrast agents for diagnostic imaging.

sciforum-090162: Multimodal Nanosensors Comprising Hydrophilic Silver-Based Quantum Dots and Gd-DOTA Complexes

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Magnetic resonance imaging (MRI) is a non-invasive technique that offers advantages compared to others diagnostic methods. Due their low sensitivity, contrast agents (CAs) are employed to improve image contrast by reducing the relaxation times of water molecules within the medium. The main commercial CAs are Gd-based complexes, due to the presence of seven unpaired pairs of electrons in Gd^{3+} ion. Among them, those composed by the DOTA ligand are notable for their high thermodynamic and kinetic stability. Despite the efficiency of the Gd-DOTA complexes in enhancing contrast, nanoparticulate CAs have been used to further amplify the MRI signal. Gd-complexes have been attached to Quantum Dots (QDs), offering a secondary signal for optical imaging, combining the advantages of both techniques into a single system [1]. QDs are semiconductor nanocrystals characterized by a size range from 2 to 10 nm, possessing size-tunable optical properties and an active surface. These properties make them interesting for multiple fields of application, such as nanoprobes for diagnostic imaging. However, the majority of works published so far with this aim use Cd-based QDs or material that is synthesized via organic methods [2]. In order to utilize the material in biological applications, in this work, we synthesized Ag_2Se QDs in aqueous medium, and conjugated them to Gd-DOTA complexes through thiol–metal binding. The optical characterization showed an increase up to 43% of the emission intensity of the QDs after the conjugation procedures. Moreover, relaxometric studies showed an relaxivity values improvement of these nanosensors, compared with the clinical Gd-DOTA complex. These results demonstrated the potential of the systems based on Ag_2Se QDs and Gd-DOTA complex to serve as non-toxic optical probes in biomedical applications.

References

1. Albuquerque, G.M.; Souza-Sobrinha, I.; Coiado, S.D.; Santos, B.S.; Fontes, A.; Pereira, G.A.; Pereira, G. Quantum dots and Gd 3+ chelates: advances and challenges towards bimodal nanoprobes for magnetic resonance and optical imaging. *Top. Curr. Chem.* **2021**, *379*, 12, 1–35.
2. Viegas, I.M.; Gonçalves, I.W.; Santos, B.S.; Fontes, A.; Pereira, M.G.C.; Pereira, C.F.; Pereira, G.A. Synthesis of hydrophilic Ag 2 Se quantum dots optically optimized by multivariate strategies: an easy one-pot approach. *New J. Chem.* **2022**, *46*, 21864–21874.

sciforum-087748: Noble Metal Nanomaterial-Based Biosensors: New Analytical Model and Discrete Dipole Approximation Method

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Introduction

Noble metal nanoparticles (NPs), such as gold and silver, have been studied extensively in various scientific fields due to their peculiar properties. Researchers have used NPs to fabricate biosensors. The demand for biosensors for virus detection has increased, and research is focusing on ways to fabricate small, portable devices enabling rapid and accurate detection. İn this work, noble metal NPs of different shapes and sizes, including nanospheres, nanowires, nanocubes, and nanocylinders, were dispersed in surrounding media to simulate, using the discrete dipole approximation (DDA) method, their plasmonic properties. For this, a new model was proposed to calculate the response of the surface plasmon peaks of the NPs considered, and new analytical formulas were presented. The RISs of oxide-coated metal nanocubes were studied here, too. RISs were found to depend on the shape, size, core material, shell thickness, and shell composition of the NPs.

Methods

-DDA is a general technique for calculating the scattering and absorption of electromagnetic radiations by particles of arbitrary shapes and compositions.

-The polarizability of the NPs considered can be written as follows:

$$\alpha(\omega) = V\varepsilon_m(\varepsilon(\omega) - \varepsilon_m)/(\varepsilon_m + F(\varepsilon(\omega) - \varepsilon_m))$$

where V represents the volume of the NP. F defines the depolarization factor.

-The properties of the NPs considered are quantified, in this work, in terms of absorption (C_{abs}) and scattering (C_{sca}) cross-sections:

$$Cabs = kIm[\alpha]$$

$$Csca = (k^4/6\pi)|\alpha|^2$$

-Sensitivity is

$$S = (\Delta\lambda LSPR[nm])/(\Delta n[RIU])$$

Results

-A shift in plasmon wavelength with the shell thickness for X-SiO_2 (X = Au, Ag, and Al) was found.

-A shift in the peak wavelength with the refractive index of medium for coated metallic nanocubes was found.

-A variation in sensitivity with particle size was found.

Conclusions

A new model was proposed and developed to model and control the plasmon peak position and intensity according to the particle size, core material, shell thickness, and shell composition. The RIS factor increased with an increasing thickness of the oxide layer.

sciforum-090552: Polymer/Carbon Nanotubes Composites for Biomedical Applications

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The fabrication of composites based on different fillers has gained numerous considerations in the past decades in different areas of biomedical research. It is necessary for the chosen polymeric material as a continuous phase to have good compatibility with the fillers to form a unique biomedical system. Interfacial interactions between components of the system are also important for establishing characteristics of the resulting biomedical material. In this work, one polymer based on modified polysulfone (PSF) was considered a host matrix where modified carbon nanotubes with hydroxyl groups were added for the scope of fabricating a biocompatible material. A chlorometilation reaction was used to create aldehyde groups linked to PSF, which was further cross-linked by an oxidation reaction and acetilization of poly(vinyl alcohol) (PVA) to obtain a new modified PSF with side PVA groups. For comparison only, the new material was analyzed with another system containing PVA as a matrix where different concentrations of modified carbon nanotubes were added. The content ratio of modified carbon nanotubes varied between 0.5 to 5 wt.%. Each prepared composite system was investigated by contact angle measurements. The compatibility with blood was determined by theoretical calculation and experimental analysis such as hemocompatibility. Materials were proved to be biocompatible, which leads to their recommendation as blood-contacting materials.

sciforum-089268: Reuseable and Efficient Catalytic Alginate Beads Encapsulated with Silver Nanoclusters Synthesized Using Mangosteen Peel

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In recent years, phytosynthesis of metallic nanoparticles using aqueous extracts of plants and plant products has become considerably important in biomedical and environmental applications due to its non-toxicity and the fact that it is an environmentally friendly approach.

In this study, we developed stable silver nanoparticles using the peels of mangosteen fruit. This fruit peel contains several phytochemicals including flavonoids and polyphenols (phenolic compounds). These phytochemicals possess anti-aging, antioxidant and cytoprotective properties. The formation of nanoparticles was confirmed by the characteristic surface plasmon resonance peak at around 400 nm.

The synthesized nanoparticles were encapsulated in sodium alginate beads with a single-step method via ionotropic crosslinking using calcium chloride (5 wt.%). The resulting beads were compact and porous. The photocatalytic properties of the beads were evaluated using various toxic dyes such as Congo red, methylene blue, Alizarin yellow and methyl orange both in the presence and absence of solar radiation.

The nanoclusters acted as catalytic sites for the degradation process, while alginate provided a stable matrix for the immobilization of the nanoclusters and facilitated the mass transfer of the pollutants to the catalytic sites. The study highlights the effectiveness of silver-nanocluster-loaded alginate beads as a promising and eco-friendly material for the treatment of medical waste and contaminated water in the future.

sciforum-091886: Shining Hope for Future Applications in Oncology: BSA-Coated Silver Nanoparticles Targeting Triple-Negative Breast Cancer Cells

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Introduction

Nanoparticles have gained significant attention in various scientific domains, especially medicine. Their applications span a wide range of fields including diagnostics, drug delivery antimicrobials, and cancer therapy [1]. The green synthesis of nanoparticles is favored over traditional physical and chemical methods as it is cost-effective, simple, and eco-friendly [2]. Silver nanoparticles (AgNPs) have been safely utilized in medicine. Previous studies have shown that bovine serum albumin (BSA) can be used as a capping agent for AgNPs for optimum drug delivery. Triple-negative breast cancer is an aggressive breast cancer subtype associated with poor prognosis due to a lack of targeted therapy. In this study, BSA-coated AgNPs were synthesized to examine their anti-cancer effects on triple-negative breast cancer cells (MDA-MB-231).

Methods

Using the green approach, BSA solution was added to silver salts to produce the BSA-coated silver nanoparticles with different concentrations. The presence of silver nanoparticles was examined using UV-Vis absorption spectra and transmission electron microscopy (TEM). Triple-negative breast cancer cells were treated with BSA-AgNPs. Untreated MDA-MB-23 cells were used as controls. Cell proliferation and morphology were assessed using light microscopy.

Preliminary Results

UV-Vis absorption spectra and TEM confirm the presence of AgNP nanoparticles in the size range of 15–16.50 nm. Through assessing the effect on breast cancer cells, silver nanoparticles exhibit dose-dependent toxicity against the MDA-MB-231 breast cancer cell line, which was evidenced by the typical signs of apoptosis including cell shrinkage and membrane blebbing 24 h post-treatment.

Conclusions and Future Perspective

BSA-coated silver nanoparticles were successfully synthesized. The early findings indicate that the efficacy of protein-decorated silver nanoparticles against breast cancer cells is directly proportional to the dosage, primarily through the induction of apoptosis. BSA-coated silver nanoparticles have great potential in future cancer therapies. Nevertheless, future studies need to be conducted to examine their drug selectivity and in vivo effects.

sciforum-089958: Spinach-Mediated Synthesis of Silver Nanoparticles/Nanoclusters and Fabrication of Reuseable Polymer Beads and Membranes for Antimicrobial and Photocatalytic Applications

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Recently, the phytosynthesis of metallic nanoparticles using extracts of plants and plant products has gained considerable importance in biomedical applications due to its environmentally friendly approach. In this study, we developed stable silver nanoparticles and silver nanoclusters using the extract of green spinach as a chemical reducing and stabilizing agent. Upon the addition of the extract to a silver nitrate solution, silver nanoparticles formed immediately, as evidenced by a color change in the solution. A characteristic surface plasmon resonance peak at around 400 nm confirmed the formation of silver nanoparticles.

The silver nanoparticles were encapsulated in alginate beads through a single-step method involving ionotropic crosslinking using calcium chloride (5 wt.%). The resulting beads were compact and black in color. The beads were porous and contained plate-like silver nanoclusters, as revealed by Scanning Electron Microscopy studies. The photocatalytic characteristics of the beads were evaluated using two important organic molecules/pollutants, namely 2-nitrophenol and methyl orange. The beads exhibited excellent photocatalytic properties by degrading the pollutants into non-toxic substances in less than 30 min. The enhanced degradation performance was attributed to the synergistic effects of silver nanoclusters and alginate. The nanoclusters acted as catalytic sites for the degradation process, while alginate provided a stable matrix for the immobilization of the nanoclusters and facilitated the mass transfer of the pollutants to the catalytic sites. This study highlights the effectiveness of silver nanocluster-loaded alginate beads as a promising and eco-friendly material for the treatment of medical waste in the future.

Reuseable polymer films of alginate and polyvinyl alcohol containing silver nanoparticles were also developed using a spray method. The films were robust and exhibited excellent antibacterial properties against various strains of bacteria. This research project paves the way for the development of sustainable and effective nanomaterial-based solutions for biomedical and environmental remediation.

sciforum-090172: The Fabrication of pH-Responsive Multilayer Hydrogel Patches for Enhanced Burn Wound Treatment

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Introduction

Burns represent one of the most serious and painful skin injuries, with a significant impact on patients' quality of life and vital functions. The management of burns requires timely treatment and the use of innovative materials that promote effective wound healing. In this context, hydrogels are emerging as a promising therapeutic option due to their high hydrophilicity, good biocompatibility, and ability to provide an optimal environment for the regeneration of damaged skin tissue.

In this work, a new protocol was developed to fabricate a pH-responsive multilayer hydrogel patch based on biocompatible alginate (ALG) and containing different bioactive principles, such as manuka honey (MH), for its antibacterial properties.

Methods

The multiple layers of the patch were assembled by ionic crosslinking with a calcium chloride solution. The swelling ratio, water content, and porosity were evaluated to assess the hydrophilicity of the hydrogels and their ability to absorb exudate from the wound to promote healing and prevent infection. FTIR analysis was used to investigate the chemical composition of the patch layers, and DSC analysis was employed to evaluate the thermal stability in the physiological range. Water vapor transmission rates (WVTRs) were calculated to quantify the water vapor transmission through the patches. The degradation at different pH values was studied to establish the pH-responsive nature.

Results and Conclusions

Multilayer hydrogels were successfully prepared using ionic gelation. The samples showed a high water content (>85%) and high porosity. They also showed good water vapor permeability, which demonstrates their potential use for the treatment of burns. The DSC analysis showed thermal stability in the physiological range. In conclusion, this work presents a promising innovation in the field of burn care, offering a new approach for improving burn management and healing.

sciforum-092130: The Influence of Aortic Valve Leaflet Material Models on Hemodynamic Features in Healthy and Pathological States

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Cardiac blood outflow restriction is caused by calcific aortic stenosis, a gradual thickening of the aortic valve leaflets, and long-term fiber tissue remodeling. Surgeons have several options when replacing an aortic valve: they can employ minimally invasive techniques like transcatheter aortic valve implantation (TAVI) or perform open-heart surgery, which requires making an incision in the chest. There are several benefits and drawbacks to these kinds of surgeries. The Ozaki procedure, which replaces the aortic valve with tissue from an autologous pericardium, has been proposed recently. Although this approach shows promise in treating aortic valve disease, it lacks long-term outcomes and appropriate leaflet sizing selection. Surgeons can anticipate the results of each patient's operation with the use of numerical fluid simulations.

However, a question remains unanswered in the explanation of material models for leaflet mechanics. It can be challenging to choose the best model to explain various aortic valve diseases. We analyzed aortic valve leaflet material models numerically using 3D FSI simulation in order to characterize the hemodynamics in diseased, normal, and Ozaki situations. Furthermore, we disclose the displacement distributions, von Mises stress, and wall shear stress. We analyzed the isotropic hyperelastic model, the anisotropic hyperelastic model, and the elastic model in this study. Velocity, pressure, OSI, and TAWSS were also evaluated. We discovered that the proper model for leaflet simulation in the Ozaki case and the healthy state case involves the Holzapfel–Gasser–Ogden constitutive equation. In the case of pathology (calcification), it is better to adopt the elastic model.

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Abstracts

Session G. Bio-fabricated and 3D Printed Biomaterials

sciforum-084796: Silylation of Cellulose Using a Cyclotetrasiloxane and Its Polymerization

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Microfibrillated cellulose (MFC) is a natural material that can be extracted from the plant cell wall. It has attractive properties such as high strength, excellent stiffness, and high surface area, but its hydroxylated surface is often pointed out as a limiting factor for its use in commercial applications. MFC cannot be ideally dispersed in non-polar solvents, monomers, or polymers since the hydrophilic surface of MFC is incompatible with hydrophobic environments. The complete dissolution of cellulose in a solvent system is complex. A cyclotetrasiloxane was synthesized via hydrosilylation of 1,3,5,7-tetramethylcyclotetrasiloxane (D_4H) with Trimethoxyvinylsilane (TMVS). The structure of tetramethylcyclotetrasiloxane modified with Trimethoxyvinylsilane (D_4H– TMVS) was characterized by Fourier-transform infrared (FT-IR) and 1H nuclear magnetic resonance (^{1}H-NMR). This cyclotetrasiloxane bound to cellulose and then polymerized it by ring-opening polymerizations (ROPs) with an initiator in a second step. Polysiloxanes are useful for conferring chain flexibility, biointegrity, radiation resistance, thermal stability, and hydrophobicity. With an appropriate degree of silylation, cellulose will disperse efficiently in organic solvents such as acetone, chloroform, and tetrahydrofuran. As a result, the possibility of using cellulose is increased in a number of different disciplines, such as antioxidants, bio-composites, biomedicine, carbon fiber, photo-catalysts and photovoltaics, the adsorption of heavy metal ions, and wood adhesives.

sciforum-092038: Effect of Printing Layer Orientation and Finishing Protocol on the Fracture Behavior of 5Y-PSZ Ceramic by 3D Printing

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Introduction

3D printing has emerged as a promising technique for fabricating permanent dental ceramic restorations. However, there is limited literature regarding aesthetic ceramics for monolithic restorations, such as 5 mol% yttria partially stabilized zirconia (5Y-PSZ). Therefore, the aim of this study was to investigate the influence of printing layer orientation and finishing protocol on the fracture behavior of 5Y-PSZ by stereolithography (SLA) 3D printing.

Materials and Methods

Bar-shaped 5Y-PSZ specimens were 3D-printed via SLA, followed by debinding and sintering. The dimension of the as-sintered specimens was 1.0 mm $\times$ 1.0 mm $\times$ 12.0 mm. The specimens were randomly divided into two groups according to printing layer orientations: parallel or perpendicular to the tensile surface in the following bending test. The specimens of each printing layer orientation were subsequently submitted to different surface finishing protocols: as-sintered, polished, and glazed. The fracture strength of each group was determined using a ball-in-hole device. The fractured specimens were examined under a scanning electron microscope to identify the fracture origin.

Results

Two-way analyses of variance showed significant effects of printing layer orientation (p 0.001) and finishing protocol (p 0.001), while the interaction of factors was not significant (p = 0.195). The parallel orientation (639.9 $\pm$ 98.6 MPa) was stronger than the perpendicular (506.9 $\pm$ 47.9 MPa) for the as-sintered specimens. Polishing significantly improved the strength for both parallel (782.0 $\pm$ 134.0 MPa)^{A} and perpendicular (644.6 $\pm$ 159.8 MPa)^{B} orientations. While glazing did not have a significant effect on the strength for both orientations, the glazed perpendicular specimen (622.8 $\pm$ 96.7 MPa)^{B} presented similar strength to the glazed parallel specimens (580.9 $\pm$ 116.9 MPa)^{B}.

Conclusions

Both printing layer orientation and finishing protocol affect the fracture strength of 3D-printed 5Y-PSZ. Despite some differences, polishing and glazing are acceptable surface finishing protocols for 3D-printed ceramic restorations in terms of strength.

sciforum-089664: Nanocellulose Reinforced Polyacrylamide/Sodium Alginate Double Crosslinked Network Composite Hydrogels: Mechanical Behaviour and FEM Analysis

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For many load bearing biomedical applications, development of mechanically strong hydrogels are needed to act as supporting structures. Due to their extreme strength and toughness, Double-network (DN) composite hydrogels have emerged as a hot research topic. Herein, we prepared cellulose nanofiber (CNF) reinforced poly(acrylamide-co-Alginate) (P(AAm-co-Alg)) double network composite hydrogel via in situ polymerization. Based on the double-network P(AAm-co-Alg)/CNF-Fe^{3+} composite hydrogel structure formed by the covalently cross-linked acrylamide network and non-covalently $COO-$-Fe^{3+} ionic coordination act as a secondary crosslinking network. The development of Cellulose nanofibril (CNF) and Fe3+-based anisotropic functional tough composite hydrogel construct, presenting the development and physical characterisation (shape morphing, swelling potential and rheology) of the composite structure. By incorporating CNF and Fe^{3+}, the tensile properties such as tensile strength and toughness of the P(AAm-co-Alg) composite hydrogel were improved by 300% and 250%, respectively. The loading of FE^{3+} also enhanced the energy dissipation in loading and unloading tests.

Here, we also proposed the 3D printed multilayer composites, printed in nature inspire hierarchical laminate fashion, to fabricate a functional porous composite construct. We implement the finite element (FE) modelling to analysis the pre-programmed anisotropic functional composite structure with the computer simulation. It shows how the improved physical, mechanical and biological functionality of the hydrogel fiber reinforced composite printed scaffold can be programmed by varying cellulose fibers/fibrils orientation and matrix compliance, making it suitable for load-bearing biomedical applications. Our novel design approach, based on DN composite hydrogel with enhanced anisotropic mechanical, physical and antibacterial properties of the printed construct, offers new perspectives for application in the area of electronic skin,, drug delivery and tissue engineering.

sciforum-090412: Production of Hydrogel Inks for Fresh 3D Printing Based on Esterified Pectin

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Fresh 3D printing allows prototyping tissue and organ equivalents for biomedical applications by extruding hydrogel "ink" into a bath with a supportive gel containing an active crosslinking component. The aim of the work is to select the conditions for the formation of a supportive gelatin matrix, to obtain hydrogel inks and functional products based on esterified pectin.

The following research objects were selected: aqueous solutions of thermally reversible gelatin protein (2.5–3 wt.%) and UP (2–6 wt.%), as well as solutions of $CaCl_2$, an ion-type crosslinking agent for UP, selected in a molar ratio.

As a result of the research work, cooling curves of gelatin and UP solutions were obtained, presented in Arrhenius coordinates, on the basis of which the values of the activation energy of the viscous flow and the gelation process were obtained. The concentration dependences of the gelation temperature and dynamic viscosity are obtained, and the effect of concentration on the mechanism of structure formation is studied. The concentration dependences of dynamic viscosity indices on pH for equiviscid and equiconcentrated solutions are investigated. The working concentrations of a gelatin-based hydrogel bath and UP ink have been established. The effect of the molar content of calcium chloride on the mechanism and rate of Ca^{2+}-induced gelation of unipectin working solutions has been studied. The strength characteristics of gel systems and frame-type products based on them were determined using a rupture testing machine (RKM X.1.01 PS, Russia). A complex of biological tests of the hydrogel components of the system for cytocompatibility and hemocompatibility was carried out.

Based on the conducted research, it was found that the implemented approach to the adaptation of hydrogels based on esterified pectin opens up new opportunities for the production of carcass structures using the technology of fresh printing on a 3D bioprinter (Fabion, Russia).

sciforum-090175: Synthesis and Characterization of 3D-Based Alginate–Gelatin Bioprinted Scaffolds for Bone Tissue Applications

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Bone tissue regeneration has become increasingly important due to the challenges posed by critical-sized injuries, pathology, or disease. Tissue engineering offers a promising approach to repair and regenerate damaged bone tissue. To achieve this, emerging technologies such as 3D bioprinting have been proposed for designing microarchitectures through layer-by-layer extrusion using different biopolymers or hydrogels such as alginate and gelatin, which, due to their malleability and biocompatibility, facilitate the generation of cell-laden scaffolds that could restore bone defect functionality.

This work aimed to synthesize a 3D bioprinting scaffold with a bioink combination of alginate–gelatin with and without fetal osteoblasts. The scaffold's characterization by FTIR showed the characteristic signals of the bioink components, while SEM analysis showed the porous structure morphology of the 3D-printed scaffold and the cell–material interaction.

The biological response when osteoblasts were seeded over the surface and use as part of the bioink showed good adhesion and biocompatibility over the 21 days of culture. Moreover, alizarin red staining showed that osteogenic factors improved the quantity of calcium deposits in both assays for calcium deposit evaluation.

In conclusion, our results showed that the bioink based on alginate and gelatin allows for a stable 3D-printed scaffold, supporting the osteoblasts' viability and cell growth and bone extracellular matrix deposition. The authors want to thank the financial support of CONAHCYT for the scholarship granted for the master study of DVH with CVU: 1190428, and the financial support given by the DGAPA-UNAM-PAPIIT IN202924 project.

sciforum-092088: Thermoplastic and Biocompatible Materials Based on Block Copolymers of Chitosan and Polycaprolactone

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The relevance of this study is related to the demand for biocompatible and thermoplastic polymer materials suitable for use in personalized regenerative medicine. Materials based on polycaprolactone and chitosan are recognized as promising candidates for the development of biodegradable materials that successfully combine the properties of synthetic and natural components. The basic idea is that polycaprolactone is convenient from a processing properties perspective, since materials based on it are thermoplastic and have good mechanical properties, but high hydrophobicity and low cellular adhesion limit the use for solving certain medical problems. This can be solved by combining it with chitosan in one composition.

The copolymerization was performed in solution using ultrasonic irradiation. To obtain homogenous solution of chitosan with polycaprolactone, they were dissolved in DMSO and chloroform, respectively, after which both solutions were mixed and irradiated by ultrasonic treatment for 30 min at 25 °C. The structure and properties of the synthesized block copolymers were studied by XRD analysis, gel-permeation chromatography (GPC) and differential scanning calorimetry (DSC). The study of samples by XRD analysis showed the amorphous structure of copolymers, in contrast to the original crystalline homopolymers. The results of DSC study showed a decrease in the melting point of polyester blocks and a decrease in the glass transition temperature of chitosan blocks in the copolymer. The fermentative depolymerization of chitosan blocks in the samples was performed, which made it possible to determine the molecular weight characteristics of the polycaprolactone blocks by GPC study. Films were obtained from block copolymer solutions by the solvent casting method, drying them at 65 °C to a constant mass. The film samples were characterized by high mechanical properties (tensile strength ~ 70 MPa, with elongation at break ~ 35%). The biocompatibility of the composition was investigated and proven by the MTT assay.

This research was funded by the Russian Science Foundation, grant number 23-13-00342.

sciforum-092039: Three-Dimensional (3D) Printing of Alkali-Dissolved Chitosan Bioink and Structural Evaluation of Bioprinted Constructs for Biomedical Application

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Three-dimensional (3D) bioprinting has been proven to be the chosen method of fabricating tissue implants and organ models because it can replicate the desired intricate geometries with great accuracy and precision. However, it faces unique challenges distinct from other 3D printing methods, particularly concerning the viscosity of bioink and the multidimensionality of biological structures. There are three fundamental challenges to bioprint any functional tissue, namely (1) achieving shape fidelity for structures in the biological dimensional range with native mechanical properties, (2) ensuring dense vascularization, and (3) attaining cell density akin to native tissue. Despite exploring diverse combinations of bioink materials, achieving consistent success and reproducibility remains challenging. We focused on attaining shape fidelity; here, we have described a 3D printing methodology where chitosan was dissolved in an alkaline solvent, enabling crosslinking with water. Rheological assessment of the bioink using the Power law model illustrated its shear-thinning properties, which is essential for extrusion-based 3D bioprinting. Printing parameters were optimized. The 3D bioprinting was carried out within a support hydrogel comprising thermoresponsive gelatin showing Bingham rheology. This supportive material prevented the collapse of the printed structures. Post-printing, the structures were crosslinked by pouring 40 °C water into the print container, simultaneously melting the support medium, and facilitating the recovery of the 3D bioprinted complex structure like a tri-leaflet heart valve, etc. The printed dimensional accuracy was in the range of .stl file dimensions. The mechanical properties of the printed structures fall in the range of native human soft tissue, i.e., 0.1 KPa–1 MPa. The degradation study described the variation in stability of the 3D bioprinted construct at different incubation conditions. Utilizing chitosan-based bioink and support-driven 3D bioprinting presents a promising avenue for creating intricate vascular structures, propelling advancements in tissue engineering and diverse biomedical applications.

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