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Application of laser-based methods for the development of new coatings

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Abstract :Implant materials play a pivotal role in modern medicine, with applications ranging from joint replacements to dental fixtures and cardiovascular stents. The longevity and efficacy of these implants are often contingent upon the biocompatibility and functional properties of their surface coatings. Matrix Assisted Pulsed Laser Evaporation (MAPLE) emerges as a promising technique in the field of biomaterials science, offering precise control over the deposition of functional coatings on implant surfaces.

This abstract outlines the significance of MAPLE as a cutting-edge technology for the development of new coatings tailored to meet the specific requirements of implant materials. MAPLE is characterized by its ability to deposit a wide range of materials, including polymers, ceramics, and biomolecules, onto implant surfaces with exceptional precision. The technique utilizes a laser beam to ablate a frozen matrix containing the desired coating material, resulting in the transfer of a well-defined layer onto the implant substrate.

In this context, we review the current state of research and innovation in MAPLE technology as applied to implant coatings. We delve into the advantages offered by MAPLE, such as the preservation of material integrity and the ability to create multifunctional coatings with controlled thickness and composition. Furthermore, we explore the potential for incorporating bioactive agents, antimicrobial compounds, and growth factors into MAPLE-coated implants, enhancing their performance and biocompatibility.

To sum up, Matrix Assisted Pulsed Laser Evaporation is a versatile and innovative technology with the potential to revolutionize the field of implant materials and coatings. By enabling precise control over coating composition and structure, MAPLE offers opportunities for the development of next-generation implants that not only extend lifespan but also enhance the quality of life for patients. This abstract underscore the growing significance of MAPLE in the development of new coatings for implants, emphasizing its potential to drive advancements in the field of biomaterials science.

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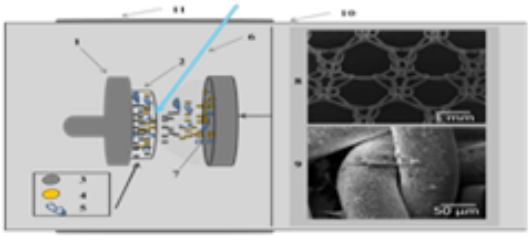

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MARIANA IONITA AND ALIN GEORGIAN TOADER

Polysulfone/crown ethers immobilized onto graphene oxide composite membranes for hemodialysis

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Abstract: Polymeric membranes are widely used for various biomedical applications like proteins concentration [1], osseointegration [2] or substitutes as technological solutions for various organs, like artificial lung – oxygenator [3] or artificial kidney – haemodialysis [4]. This work presents the principle for synthesis of a new generation of composite polymeric membranes with functionalized graphene for haemodialysis.
First, crown ethers are covalent immobilized on graphene in order to increase to selectivity and specificity for removing targeted compounds (like cations of heavy metals) for specific medical conditions associated with chronic renal disease. Crown ethers were immobilized covalently using cyanuric chloride as linker onto amino functionalized graphene oxide.
In the second stage of synthesis, functionalized graphene was used for obtaining composite polymeric membranes with controlled porosity for hemodialysis. Fully structural and morphological characterization of synthesized materials is presented and hydrodynamic and separation properties were evaluated. Also, haemotoxicity tests were performed in order to study and prove the non-cytotoxic character of synthesized membranes.

Acknowledgement: This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS – UEFISCDI, project number TE 110/2022

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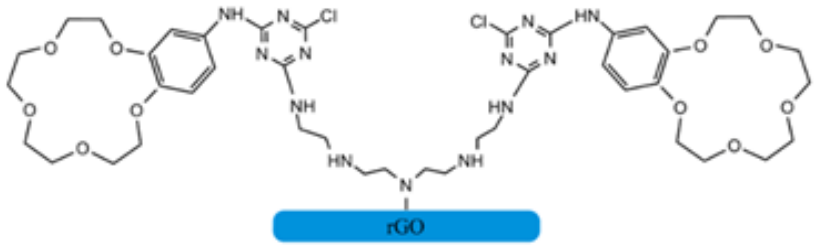
Figures



Functional polymeric membranes for hemodialysis and osseointegration

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Abstract: Polymeric membranes are selective materials used in a wide range of applications that require separation processes, from water filtration and purification to industrial separations. Because of these materials' remarkable property, selectivity, membranes are also used in a wide range of biomedical applications that require separations. Considering the fact that most organs (apart from the heart and brain) have separation processes associated with the physiological function (kidneys, lungs, intestines, stomach, etc.), technological solutions have been developed to replace the function of these organs with the help of polymer membranes. This presentation is focused on the latest developments in the field of membrane materials for biomedical applications. A short introduction to the field of membrane materials will open this fascinating journey, the main subject being the applications of these materials in hemodialysis, osseointegration, artificial lungs, liver and pancreas, controlled drug delivery, proteins separations and other related separations with the biomedical sciences (antibiotics removal from environment or retention of compounds used un clinical imaging techniques). Surface treatment (chemical reactions, plasma or laser treatment) of membranes to increase separation properties, hemocompatibility, reduce toxicity or achieve desired physical properties will be presented and discussed. Some future trends and actual scientific projects will end this presentation.

Acknowledgement: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS/CCCDI – UEFISCDI, project number PN-III-P4-ID-PCE-2020 -1154, Hemodialysis combined with stimuli responsive drug delivery - a new generation of polymeric membranes for advanced biomedical applications within PNCDI III.

Super-Resolved Non-linear Optical Microscopy: Architectures and Perspectives

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Abstract:Non-linear optical microscopy techniques (NLO) exploit processes upon which a sample emits light in the visible when excited with infrared photons. Second Harmonic Generation Microscopy (SHG) and Two-Photon Excited Fluorescence Microscopy (TPEF) stand as the most prominent NLO techniques, having been demonstrated as powerful tools for the 3D visualization of tissues and advanced materials in a wide palette of high-impact studies. Here, we discuss three architectures for super-resolved non-linear optical microscopy. First, we present how the contrast mechanisms of SHG and TPEF imaging can be harnessed to provide resolutions beyond the diffraction barrier, when combined with the re-scan concept, previously introduced in the context of re-scan confocal microscopy. Considering the current high need for techniques capable to characterize non-fluorescent samples at sub-diffraction resolution, we place special focus on showcasing the resolution advantage of Re-Scan Second Harmonic Generation Microscopy (rSHG). Second, we turn our attention to super-resolved non-linear optical microscopy based on image scanning microscopy concepts. Third, we discuss generic concepts for tip-enhanced two-photon excited fluorescence and tip-enhanced second harmonic generation, and current efforts that we devote to the development of multimodal nanoscope featuring diverse far-field and near-field imaging modalities. In the final part we discuss perspectives on combining super-resolved NLO imaging with trending artificial intelligence methods. In this context, we first discuss avenues that we are exploring for virtual super-resolved NLO based on Generative Adversarial Networks, and then switch focus towards automated diagnostics perspectives building on the combined use of complementary Deep Learning models.

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Complex architecture encapsulation systems for therapeutic principle release control

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The purpose of this scientific work is to develop a controlled release system for an active substance in inflammation management. The chosen design is a transdermal patch based on chitosan (CHT) functionalized with 3-(trimethoxysilyl)propyl methacrylate (TSP) through the EDC-NHS coupling mechanism. Chitosan is considered a natural antioxidant and an excellent hemostatic agent, making it suitable for the production of high-performance dressings [1]. The anti-inflammatory agent encapsulated in the polymeric material is vitamin K, which, in addition to its anti-inflammatory properties, promotes tissue regeneration.The material synthesis involved preparing two solutions, one of chitosan and one of the modifying agent, which were subsequently mixed. To form the active intermediate ester, EDC was added, and NHS was added for system stabilization. The modified chitosan was lyophilized, and the unreacted excess of TSP was removed through repeated ethanol rinsing, resulting in four materials with different degrees of modification. Creating a patch involved layering the four synthesized materials for characterization analysis.The contact angle was studied to highlight the wetting properties of all CHT and TSP-based formulations, as well as unmodified chitosan. It was observed that the hydrophilicity of the synthesized samples decreased directly with the increase in the degree of modification with TSP.Subsequently, vitamin K release studies were conducted using UV absorption. The release of vitamin K was carried out in a PBS solution, with minor differences between the system configurations, most of them showing a release of approximately 100% in the first four hours. The multilayer assembly demonstrated the fastest release, which may be attributed to the lower stability of the multilayer sample due to non-uniformity and imperfect adhesion between layers. It is worth considering the production of complex samples in which the layers are chemically bonded for better structural integrity.

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Graphene oxide/Nitrocellulose non-covalent hybrid as solid phase for oligoDNA/miRNA extraction from complex medium.

by Georgian A. Toader[1], **Florentin R. Nitu** [2], Lorand Savu[2], and Mariana Ionita[1,3,4,*]
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The surfaces of commercially available nitrocellulose membrane filter was non-covalent modified by graphene oxide (GO) microparticles dispersion. The modification of NC membrane was confirmed by Fourier Transform Infrared Spectroscopy (FTIR), which highlighted the principal absorption bands of both the NC membrane at 1641, 1276, and 835 cm^{-1} (NO2) and of GO in the range of 3450 cm^{-1} (CH2-OH). The scanning electron microscope (SEM) analysis shows uniform coverage of NC membrane with GO sheets.
The NC–GO hybrid membranes were used to separate oligonucleotides that had fewer than 50 nucleotides (nt) from complex biological solutions, containing alpha- Eagle's minimal essential medium (α-MEM), fetal bovine serum (FBS), bovine serum albumin (BSA), anionic detergent sodium dodecyl sulfate (SDS), and sodium chloride.
The oligonucleotides were desorbed from the surface of the NC–GO hybrid membrane using Tris-HCl buffer with a pH of 8.0. With a final amount of 2 µg GO per NC disc (~1.1 mg/NC disc), we recover approximately 0.33 – 0.37 ng (~7%) of the initial oligo-DNA dissolved in 100 µL complex biological sample.
NC membranes have a limited capacity for immobilizing oligo ssDNA. Our results indicate that modifying NC membranes with GO greatly enhances their interaction with oligo ssDNA, leading to much higher binding affinity.
We propose the use of NC-GO solid phase as a promising alternative or complementary approach to commercially available magnetic particle kits for increased oligonucleotide extraction. Our experiments indicate that this hybrid membrane is able to detect oligo DNA in both complex solutions and human plasma-like media.

Surface-functionalized cellulose acetate membranes with enhanced biomineralization ability

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Abstract

From all the existing membrane modification techniques, surface functionalization by covalent immobilization is the most convenient one because it allows a highly selective binding and prevents the leeching of the immobilized compound into the surrounding aqueous environment. During covalent immobilization, stable bonds are formed between the functional groups of the substrate and the functional groups of the active compound [1]. In this study, the surface of commercial cellulose acetate membranes was functionalized with 4'-aminobenzo-15-crown-5 ether, using a covalent bonding approach. The purpose of this study was to develop a novel generation of cellulose-based membranes with applications in the biomedical field, particularly in osseointegration, by functionalizing the surface of cellulose acetate with 4'-aminobenzo-15-crown-5-ether (AB15C5) using ethanolamine (EA) as modification agent and glutaraldehyde (GA) as linker molecule. Crown ethers are macrocyclic polyethers containing a central cavity lined with oxygen atoms where they can accommodate positive metal ions or a variety of neutral and ionic organic species. The metallic cations are stabilized by the interactions with the lone pairs of electrons on the surrounding oxygen atoms forming a host-guest complex [2]. The proposed reaction mechanism was confirmed by XPS analysis while the presence of the functionalization agents in the membranes structure was showed by ATR FT-IR spectra. The effects of the functionalization process on the morphology, thermal and mechanical properties of the membranes were studied by SEM, TGA and tensile tests. The obtained results revealed that the cellulose acetate membranes were successfully functionalized with crown ether and provided a good understanding of the interactions that took place between the polymer and the functionalization agents. Moreover, promising results were obtained during the Taguchi biomineralization studies. SEM images, EDX mapping and XRD spectra indicating that the CA-AB15C5 membranes have a superior Ca2+ ions retention ability, this causing an accentuated calcium phosphate deposition on the modified polymeric fibers, compared to the neat CA membrane.

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Calorimetry and Langmuir-Blodgett Monolayers Biophysical Studies on the Interaction between Synthesized Peptides and Lipids with Model Membranes.

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Abstract: Biophysical techniques can be used to shed light on the interactions between peptides and lipids with model membranes that mimic a cellular membrane. Synthesized peptides represent a source of potential anticancer and theragnostic drugs and it is an important strategy to study their interaction with model membranes in order to eventually improve drug/substrate interactions. One of the simplest models of cellular membrane is made of a single phospholipid but models that are more complex than simple phospholipids can be made of mixtures containing cholesterol, other phospholipids, gangliosides, etc. Calorimetry (DSC) and Langmuir-Blodgett monolayers biophysical studies allows us to investigate the peptide interaction with different model membranes (e.g. monolayers and multi-lamellar vesicles) varying for example the peptide molar fraction and temperature. On the other hand, the investigation on the lipids extracted from a fungus cell wall can help to understand the possible interaction between anti-fungal molecules - used for treatments - and the cell wall for fungal pathogens in general. These preliminary studies together with further investigations could reveal the complex mechanisms underlying the interaction of peptides and lipids with model membranes and other molecules. Regarding the studies of the interaction between a synthesized peptide (potential drug) and the model membrane, the desirable endpoint would be the thorough design of peptide-based targeting carriers for theragnostic applications.

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Exploring bioabsorbable Zn-ZnO composites consolidated by room-temperature-extrusion

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Abstract: Motivated by the growing demand for bioabsorbable materials in tissue repair [1], this research investigated Zn-based composites for potential medical applications. These composites are produced using high-purity atomized Zn powder, consolidated by room-temperature extrusion, with no sintering step. This process leads to an ultra-fine grain structure stabilized by ZnO dispersoids, which originate from passivating films on Zn powder and are introduced in situ during powder deformation and consolidation [2, 3]. The stabilization by fine dispersoids is crucial to address the intrinsic instability of Zn, marked by its strain-softening and strain-rate sensitivity, which affects the functionality of biomedical devices, i.e., endovascular stents [4]. Comprehensive microstructural investigations using LM, SEM, and TEM show a significant grain refinement in the extruded composite compared to cast Zn. The average grain size of the Zn matrix in the composite was smaller than 1 µm, and fine clusters of nanometric ZnO particles are homogeneously spread along Zn grain boundaries, providing structural stability even after annealing [5]. The mechanical strength of the composites surpasses traditional pure Zn standards [2]. Corrosion test and mass loss measurements reveal that the composites and cast Zn degrade at a similar rate when immersed in DMEM at body temperature for 14 days. XRD and EDS analysis of their byproducts show similar composition for all materials. However, SEM surface analyses reveal distinct corrosion patterns between the Zn-ZnO composites and cast Zn; the composite displays a smoother surface and localized, shallow pitting, in contrast to the deeper, widespread pitting observed in cast Zn (illustrated below). This difference is attributed to their distinct microstructures. In-vitro biological tests revealed comparable biocompatibility between cast Zn and extruded composite, but the last displayed slightly superior bacteriostatic activity due to the ZnO dispersoids [6]. Notably, while the composite exhibited similar biocompatibility results against different sterilization processes, cast Zn was significantly sensitive, with autoclaving resulting in intensified corrosion and Zn+ release, leading to a toxic response when using concentrated extracts for MTT and comet assays, which was not the case for UV sterilized samples. For all materials, using diluted extracts (25% and 10%) in biological assays give a non-toxic response, regardless of the sterilization method. In summary, powder consolidation is a promising method for developing UFG Zn-ZnO composites for bioabsorbable medical devices.

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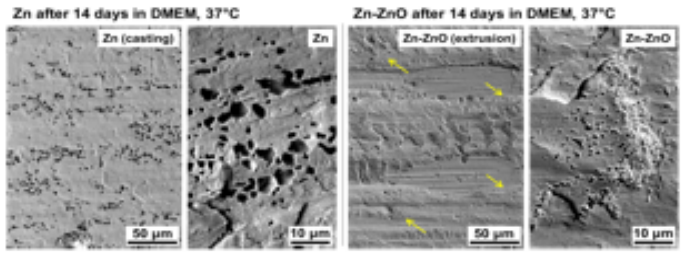
Figures

Functionalized graphene oxide with crown ethers



Targeted Intracellular Treatment for Anti-cancer Therapy using Nanoparticles.

Roxana Cristina Popescu[1,2], Diana Savu2, Adela Banciu[1], Daniel Dumitru Banciu[1], Sorin Ion Jinga[1]

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Abstract: The clinically available treatment options in cancer therapy lack of specificity and give severe adverse effects. Thus, finding more efficient methods in terms of targeting cancer cells and reducing the adverse effects of the oncologic treatment must be urged. Solutions based on nanoparticles can cross biological barriers in order to reach cancer cells, and can be done by modulating their properties, like dimension and surface properties. Such systems gather in the tumor area and are internalized by cancer cells to deliver small quantities of chemotherapeutic drugs, directly into the target, at an efficient concentration and with minimal systemic toxic effects. Moreover, radiosensitization using nanoparticles aims to enhance the local dose at the tumor level, though the production of secondary effects, following the interaction of ionizing radiation and nanoparticles, while the healthy tissue is spared. Nevertheless, in designing an efficient anti-cancer strategy using nanoparticles it is important to know and to modulate the phenomena taking place at the interaction of the nanoparticles and the tumor cells, such as: (1) the internalization mechanism of the nanoparticles in the tumor cells, as well as (2) the intracellular trafficking of the nanoparticles, these phenomena determining the efficiency of treatment.

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Quantitative virtual profiles for an advanced monitoring of 3d in vitro bone extracellular matrix mineralization

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Abstract

I Bone tissue engineering (TE)-based products are beginning to be used in clinical practice. However, although significant progress has been made, evaluating when the tissue construct has reached a suitable level of maturity, is still a challenge. Moreover, such an assessment is prevalently obtained via destructive analyses that slow down the pipeline and increase costs. A quantitative virtual profile (qVP) based on non-destructive techniques was then developed for an advanced monitoring of 3D in vitro bone extracellular matrix (ECM) mineralization. A series of parameters were extracted and correlated to develop the qVP, allowing to compute an unambiguous dynamic index, working as "off/on sensor" to identify the occurred bone ECM mineralization.

This index is expected to produce a significant impact on current TE strategies. In particular, suggested qVP would represent a future valuable tool to: monitor in time the very same sample, perform clean analysis of the outcome, reduce sample number and cost, reduce the number of animals in in vivo studies, and increase the safety of use of TE constructs. This concept will allow to move towards novel standards to effectively share and compare different strategies within the TE community. Moreover, the potential variability of the autologous cell used to product bone TE constructs could be overcame, reducing the gap in the translation process from bench to bedside.

Rational design of peptoid molecules with antibiotic complexation properties

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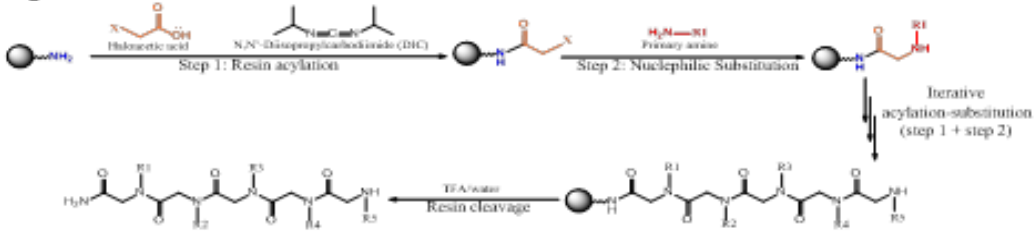
Abstract: Food quality assurance is a topic of great interest for the European Union, one of the four main domains of protection in the EU food safety policy and action being represented by contaminants and residues. This work focuses on the synthesis of N-substituted polyglycine oligomers, known as peptoids, which were rationally designed to have antibiotic complexation properties. Peptoids are a class of peptido-mimetic molecules, where the side chain is linked to the N atom, instead of the C atom of the amide bond. This characteristic makes peptoid molecules less sensitive to enzyme degradation[1] and allows a great diversity of the side-chain residues. Peptoids are chemically synthesized using solid phase synthesis (SPS) protocols. SPS follows an iterative acylation-nucleophilic substitution protocol, as shown in the reaction pathway presented in the figure below, in which the amine selected for the substitution steps introduces the side chain in the oligomeric sequence. In this work we have developed original peptoid structures which were rationally designed to interact with tetracycline and its interferents (naproxen and diclofenac sodium salt). Their sequence was inspired from ssDNA oligonucleotides which have been previously shown to give specific complexes with deoxytetracycline[2]. Mass spectrometry and tandem mass spectrometry analysis of these novel molecules has shown that indeed they give complexes with tetracycline and its interferents. These preliminary results indicate the possibility to develop sensing platforms for the detection of tetracycline, one of the most frequently used antibiotics worldwide, surpassing most of the other antibiotics used in agriculture[3].

Figure:



General reaction pathway of solid phase synthesis of N-substituted polyglycine oligomers.

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POLYMERIC FIXED PARTIAL PROSTHESES EVALUATION RELATED TO BACTERIAL LOAD

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Abstract: Partial edentulousness is one of the most common health problems and occurs in 75% of the world population. There are few studies in the literature that use exfoliative cytology to evaluate the effects of different dental prostheses on the oral mucosa. Our study aimed to evaluate the correlation of lesions that may occur at the level of the edentulous ridge compared to the design of fixed partial denture intermediates. Provisional dentures have experienced a sharp development due to the evolution of polymers and the various technologies used. A number of 15 provisional polymer fixed partial prostheses were evaluated after provisional cementation in the oral cavity. The samples were grouped into three groups according to the manufacturing process: traditional (self-polymerizing chemoplastic polymers), milled (milled PMMA) and printing (photopolymerizable PMMA). The sampling of cells from the mucosal surface of the intermediates and from the surface of the oral mucosa was done by scraping, the material was spread on glass slides to obtain the smear. ATP-Dragan and Babeș-Papanicolau stainings were performed for cytodiagnosis. Cytodiagnosis allowed the identification of cellular lesions of an inflammatory and/or reactive nature. Specific and non-specific inflammatory lesions, the presence of squamous epithelial cells, cells of the immune response and bacterial flora could be recognized. The material used, the processing technology and the finish of the prosthesis are factors that influence the development of the microbial flora, but its type is determined by the quality of the hygiene of the oral cavity and the design of the intermediates. The cytological method is fast and non-invasive, it provides an informative analysis that allows the identification of etiological risk factors for the occurrence of inflammatory diseases Temporary prostheses correctly finished and adapted to the prosthetic field allow guiding the healing of the oral mucosa, which is demonstrated by the presence of cellular changes associated with repair / reepithelialization.

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Nanocomposite Coatings for Military Textiles

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Abstract: The threats to national security call for developing advanced materials that increase combat capability in chemically, biologically, or radiologically contaminated environments or on the battlefield.This study aimed to develop new types of active polymeric nanocomposites that can be applied to military textiles, by emerging coating technologies, and to investigate their 'self-decontamination' abilitiestogether with their barrier properties for chemicalwarfare agents (CWA). Active polyurea-based coatings comprising photoactive compounds were developed to function as an active substrate with potential'self-decontamination' abilities when exposed to CWA.When exposed to light, these'self-detoxifying'coatings should be able to photothermally degradeCWA. The nanocomposite coatings synthesized were characterized via scanning electron microscopy coupled with energy dispersive X-ray spectroscopy, Fouriertransform infrared spectroscopy, tensile and shear tests,dynamic mechanical analysis in single cantilever mode,solid-state ultraviolet-visible spectroscopy, and were submitted to specific decontamination assays (mustard gas permeation tests, decontamination survey with CWA simulants).

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Assessment of Chrysin's Protective Potential in Nanoformulations Containing Calixarene 0118 (OTX008) and Sulfobutylether-β-cyclodextrin (SBEβCD) against Cardiac Fibrosis in Diabetes: Insights from In Vitro and In Vivo Investigation

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Abstract: Cardiac fibrosis is a pathophysiological consequence of chronic hyperglycemia in diabetes. There are still many knowledge gaps in understanding the processes involved in cardiac fibrosis. While TGFβ inhibitors show promise as a potential treatment for cardiac fibrosis, there is a need for more targeted therapies that can specifically inhibit scarring without affecting other physiological processes.

Galectin-1 (Gal-1) is a β galactoside-binding lectin that emerged as a regulator of cardiac inflammation, hypertrophy and neovascularization. However, Gal-1 role in diabetes-induced cardiac fibrosis has never been explored.

Therefore, we aimed to investigate the protective effects of a new nanoformulation of chrysin (CHR) in calixarene 0118 (OTX008) and sulfobutylether-β-cyclodextrin (SBEβCD) on cardiac fibrosis, as a consequence of chronic diabetes, by *in vitro* and *in vivo* studies. Through complexation, we intended to increase the solubility and bioavailability of chrysin, known for its anti-fibrotic activity, and to add a new molecular target, given by OTX008, an inhibitor of galectin-1, a key player of fibrogenesis.

In our experimental design, H9c2 cells were exposed to normal and high glucose for 48 hours and then treated for 6 days with chrysin, SBEβCD, SBEβCD polymer, SBEβCD+ CHR, SBEβCD + CHR, OTX008, OTX008- SBEβCD, OTX008- SBEβCD, OTX008- SBEβCD -CHR, OTX008- SBEβCD-CHR. The *in vivo* experiment was performed on streptozotocin-induced chronic diabetes to mice. Treatments were administered 2 times/week for 2 weeks to 20-week chronic diabetes animals by intraperitoneal (i.p.) injections.

Our *in vitro* and *in vivo* data showed a significant increase of gene and protein Gal-1 expression in cardiomyocytes exposed to high glucose and cardiac tissue. The CHR/OTX- SBEβCD treatments induced inhibition of Gal-1 and reduced cell death and cardiac fibrosis, respectively. These effects were associated with the downregulation of TGFβ pathway.

The new proposed nanocomplex could be further investigated as a possible candidate to prevent and manage diabetes-induced cardiac fibrosis.

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Photocrosslinkable Hydrogel Films for Chemical Warfare Agents Decontamination Applications

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Abstract
Often utilized in acts of terror and conflict, chemical warfare agents (CWAs) are extremely hazardous substances. In the event of a chemical warfare attack, the decontamination of CWAs is of utmost importance because they have the potential to cause widespread harm and even death, resulting in a significant number of casualties. This can put immense pressure on the already burdened medical and health facilities in the affected region. Therefore, decontamination measures must be taken promptly and efficiently to minimize the impact of such an attack. The development and application of photocrosslinkable interpenetrated network hydrogel peelable films, intended for the safe removal from contaminated surfaces, of two of the most prevalent and extremely hazardous real chemical warfare agents, the blistering agent mustard gas (HD) and the nerve agent soman (GD), were considered for this research. The objective of this study was to provide a novel approach to CWA decontamination that would enable quick and effective remediation of CWA contaminated sites by trapping harmful compounds inside the hydrogel polymeric matrix while using a dual pathway to effectively degrade them: hydrolytic and photocatalytic. The exceptional ability of these materials to neutralize CWA, as well as their appropriateness for decontamination, was demonstrated using specific analytical methods: scanning electron microscopy, micro-CT, Fourier transform infrared spectroscopy, thermogravimetric analysis, dynamic mechanical analysis, shear, tensile, and compression tests, swelling investigations, and gas chromatography–mass spectrometry for evaluating the decontamination efficacy against two real warfare agents (HD and GD) and one chemical warfare simulant (dimethyl methyl phosphonate, a simulant for G series nerve agents). After peeling the hydrogels from the surfaces contaminated with CWA, the decontamination efficiency obtained varied from 99.35 to 99.98%.

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Biomaterials used in prosthetic structures on dental implants

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Abstract: In the field of dental implantology, the design of interface esthetics not only affects the esthetic coutcome, but also affects the health and long-term stability of the tissue around dental implant.
Establishing and maintaining a soft-tissue seal around transmucosal abutments on bone-level implants or on the collar of one-stage tissue-level implants is paramount to maintaining crestal bone height, and failing to do so will result in apical migration of the soft tissue onto the implant
The emergence profile located at the junction of these four components is an important form of oral esthetics.
Using different types of dental materials in guiding soft tissue healing, correct transmission of information at the dental officel level, using different types of prosthetic abutments, in order to finally achieve a properly done work from a clinical and technical point of view, this is only a part of the conditions imposed for the proper completion of this type of prosthetic works.

Nanocomposite Hydrogel Films Based on Sequential Interpenetrating Polymeric Networks as Drug Delivery Platforms

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Abstract The present work describes novel materials synthesized via a dual covalent and ionic crosslinking strategies, leading to the formation of a fully interpenetrated nanocomposite hydrogels. The polymeric network was obtained by the free-radical photopolymerization of N-vinylpyrrolidone using tri(ethyleneglycol) divinyl ether as crosslinker in the presence of sodium alginate (1%, weight%). The ionic crosslinking was achieved by the addition of Zn2+, ions which were coordinated by the alginate chains. Bentonite nanoclay was incorporated in hydrogel formulations to capitalize on its mechanical reinforcement and adsorptive capacity. TiO2 and ZnO nanoparticles were also included in two of the samples to evaluate their influence on the morphology, mechanical properties and/or the antimicrobial activity of the hydrogels. The double-crosslinked nanocomposite hydrogels presented a good tensile resistance (1.5 MPa at 70% strain) and compression resistance (12.5 MPa at a strain of 70%). Nafcillin was loaded into nanocomposite hydrogel films with a loading efficiency of up to 30%. The drug release characteristics were evaluated, and the profile was fitted by mathematical models that describe the physical processes taking place during the drug transfer from the polymer to a PBS (phosphate-buffered saline) solution. Depending on the design of the polymeric network and the nanofillers included, it was demonstrated that the nafcillin loaded into the nanocomposite hydrogel films ensured a high to moderate activity against *S. aureus* and no activity against *E. coli*. Furthermore, it was demonstrated that the presence of zinc ions in these polymeric matrices can be correlated with the inactivation of *E. coli*.

Hyaluronic Acid-Based Hydrogels as Potential Scaffolds for Tissue Engineering Applications

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Biocompatible and biodegradable hydrogels with biomimetic properties are increasingly interesting for biomedical applications, particularly when they can be printed or in situ formed to mimic extracellular matrix or as personalized implantable devices in tissue regeneration or drug delivery [1].Hyaluronic acid (HA) is a linear anionic polysaccharide which is well known to be a primary component of the extracellular matrix which possess excellent moisturizing properties, biocompatibility and biodegradability, and also has a variety of essential physiological functions. Moreover, HA can bind to several receptors on the surface of cells and regulate cell activities, such as proliferation, survival, migration, and differentiation. Among the many natural biomaterials found in the body, HA is a promising candidate for a broad range of biomedical applications such as fabrication of bioengineered scaffolds for cartilage, nerve, and skin tissues in addition to drug delivery systems. Notable concentrations of HA are present in synovial fluid, the vitreous body of the eye, cartilage, skin, the nervous system, and other tissues. Apart from its numerous biological properties, HA also has a generous chemical structure that makes it an attractive biomaterial. The presence of a variety of functional groups such as carboxyl, hydroxyl and amide groups on HA backbone allow of ease of chemical modifications through which various mechanical and chemical properties can be tailored [2,3].The aim of the present study was the chemical modification of hyaluronic acid with methacrylic anhydride in order to synthesize hydrogels with potential applicability in tissue engineering. The methacrylation reaction was confirmed through FTIR and 1HNMR. Hydrogel properties such as mechanical behavior, swelling as well as 3D bio printability were the main subjects of investigation.

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new generation of polymeric membranes for advanced biomedical applications within PNCDI III.

Bridging the Gap: The Evolution of a Biomedical Engineer through Computer-Aided Design

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In the realm of biomedical engineering, the practical application of knowledge is paramount, culminating in the creation of tangible products that have a profound impact on healthcare and science. Computer-Aided Design (CAD) has a pivotal role as a catalyst for innovation and bridging the gap between theoretical concepts and real-world solutions. Moreover, as a foundational technology, has revolutionized the field of biomedical engineering by providing a powerful platform for conceptualization, design, and analysis. Three distinct facets of CAD will be presented.
*Design Optimization & Innovation – Designing, optimizing, and modeling customized hip implants [1].*The emphasis of this section centers on how CAD enables biomedical engineers to expand the horizons of design. It explores the intricate process of tailoring hip implants to individual patient needs, emphasizing the significance of CAD in achieving precision, innovation, and improved patient outcomes. *Medical Research & Physiological Anticipation – Personalized hemodynamic modeling of arteriovenous grafts (AVG) for prediction of vascular access stenosis and thrombosis (Patient – specific modeling of venous AVG stenosis) [2]* Highlighting the role of CAD in medical research, this section explores its application in anticipating physiological responses. Using this case study, as well as patient-specific modeling of venous arteriovenous graft stenosis, it underscores CAD's contribution to cutting-edge research, early detection, and proactive healthcare interventions. *Unified Clinical and Technical Perspective – Mapping Complex Ventricular Tachycardia [3]and Atypical Left Atrial Flutter [4].*Three-dimensional (3D) reconstructions of the heart utilizing electromagnetic fields, sensors, and CAD's effectiveness as a potent instrument for diagnosing, simultaneously addressing intricate cardiac conditions enfold the nurturing cross-disciplinary cooperation between clinicians and biomedical engineers. This comprehensive exploration of CAD's diverse roles in biomedical engineering underscores how CAD enhances design innovation, supports groundbreaking medical research, and unifies clinical and technical viewpoints, ultimately advancing the biomedical engineer's capabilities in improving healthcare outcomes.

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Solid Phase Oligo-DNA Extraction from Complex Medium Using an Aminated Graphene/Nitrocellulose Membrane Hybrid

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Abstract: A nitrocellulose–amino-polyethylene glycol modified reduced graphene oxide hybrid that consists of a commercially nitrocellulose (NC) membrane non-covalently modified with amino-polyethylene glycol modified reduced graphene oxide (NH_2-PEG-rGO) microparticles was successfully prepared for oligonucleotide extraction. The modification of NC membrane was confirmed by Fourier Transform Infrared Spectroscopy (FTIR), which highlighted the principal absorption bands of both the NC membrane at 1648, 1279, and 839 cm^{-1} (NO_2) and of NH_2-PEG-rGO in the range of 2950-2850 cm^{-1} (C-H) and 3306 cm^{-1} (-OH). The SEM analysis underlined the well-dispersed and uniform coverage of NC membrane with NH_2-PEG-rGO. The wettability assay indicated that the NC–NH_2-PEG-rGO hybrid membrane exhibited a higher hydrophobic behavior, with a water contact angle of 91.7°, compared to the 16.5° contact angle of the NC control membrane. The NC– NH_2-PEG-rGO hybrid membranes were used to separate oligonucleotides that had fewer than 50 nucleotides (nt) from complex solutions. The features of the NC–NH_2-PEG-rGO hybrid membranes were tested for an extraction period of 60 min in different complex solutions based on $MnCl_2$, another with $MgCl_2$, and a third one containing a combination of both. The oligonucleotides were desorbed from the surface of the NC–NH_2-PEG-rGO hybrid membrane using Tris-HCl buffer with a pH of 8.0. Out of the three complex media with different salts utilized, the best results were achieved with $MgCl_2$, as evidenced by the highest fluorescence emission of 525 relative fluorescence units (r.f.u.). This value corresponded to the extraction of approximately 600-630 pg (≈14%) of the total oligo-DNA. This method is an efficient and effortless way to purify short oligonucleotides from complex solutions.

Ultrasensitive assay of atrazine in food and water samples

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Abstract : Atrazine is the pesticide that is found in surface water sources more frequently than any other pesticide, therefore, the paper describes ultrasensitive detection of atrazine from fruit and water samples, using an on-site screening platforms incorporating stochastic microsensors based on graphite powder modified with 4-tert-butylcalix [4] arene and calix[4]arene-25,26,27,28-tetrol. Limits of determination of 0.1 mol/L were recorded while the sensors could have been used on wide concentration ranges. Recoveries higher than 95,00% were recorded when used for the assay of atrazine in water, fruits and vegetables.

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Fast screening of biological and food samples using miniplatforms based on 3D stochastic microsensors

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Abstract: Enantioanalysis of aspartic acid is of high importance for metabolomics in colon cancer, as well as for the quality of food. Therefore, we proposed two miniplatforms based on incorporation of 3D stochastic microsensors for fast screening tests of biological and food samples. The 3D stochastic microsensors were designed using nanographene paste decorated with spheroidal Cu, and CuO, respectively, and modified with a solution of beta-cyclodextrin. Different values for the signatures of L- and D-aspartic acid were recorded making possible its enantioanalysis in biological samples and in food samples. The miniplatforms, and fast screening tests (6minutes/screening test) were validated using real samples.

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Stochastic sensors as new tools for the assay of CA72-4, CA19-9, CA12-5 and CEA in biological samples

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Abstract

Three diagnostic biomarkers, namely carcinoembryonic antigen (CEA), carbohydrate antigen 19-9 (CA19-9), and carbohydrate antigen 72-4 (CA72-4), are utilized for the diagnosis of gastric cancer (GC) [1]. The correlation between the elevation and the incidence, reappearance, and spread of GC has been extensively studied. Recent research has demonstrated that serum tumor markers, particularly CA12-5, possess significant clinical value in the identification of GC. According to a recent study, the combination of CEA, CA19-9, CA72-4, and other biomarkers may offer enhanced precision in the diagnosis of GC patients [2]. Stochastic sensors have been employed in the field of biomedical research due to their ability to accurately and quantitatively analysis a variety of biological samples [3].

Therefore, this paper proposes the utilization of two stochastic sensors based on graphenes decorated with heteroatoms used for the simultaneous determination of CA72-4, CA19-9, CA12-5 and CEA in various biological samples. The conductivity of the matrix material, specifically graphene, was enhanced through the selection of N- and S-doped graphene. The utilization of graphene material was found to be more convenient due to its high signal stability and greater reproducibility of measurements when compared to graphite pastes. Oleamides (used as modifiers for the design of the stochastic sensors) are a novel class of materials that exhibit a three-dimensional "V" conformation, resembling the required pores essential for the stochastic sensor design. The proposed sensors exhibited high sensitivities, low limits of quantification, and wide working concentration ranges, enabling the simultaneous assay of CA72-4, CA19-9, CA12-5 and CEA despite the stage of gastric cancer.

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3D stochastic microsensor based on graphene for simultaneous determination of p53, HER-3, and HER-4

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Abstract: The present study reports on the characterization and validation of a 3D stochastic microsensor that utilizes nitrogen, boron co-doped graphene for the simultaneous determination of p53, HER-3, and HER-4 in biological samples. The synthesis and morphological characterization of nitrogen, boron co-doped graphene powder was conducted through the utilization of scanning electron microscopy and X-r ay powder diffraction techniques. The utilization of the 3D stochastic microsensor based on nitrogen, boron co-doped graphene for the assay of p53 demonstrated an increased sensitivity and an extended linear concentration range. The limits of quantification for all biomarkers tested were observed to be at the magnitude order of attogram mL-1. The outcomes demonstrated a significant association with biological samples, indicating the prospective dependability of this for screening examinations employed in the molecular identification and quantification of p53, HER-3, and HER-4 in samples of whole blood, gastric tissue tumors, saliva, and urine. The signatures of other biomarkers or substances found in biological samples were found to be higher than those of p53, HER-3, and HER-4, suggesting that the latter do not impede the measurements. The biomarkers demonstrate accurate identification in biological samples, achieving recoveries greater than 98.00% and RSD% values less than 0.05.

Acknowledgments

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Simultaneous determination of vitamins B5, B7 and B9 using stochastic sensors as tools

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Abstract: Vitamins play a vital role in supporting daily physiological functions and are integral to metabolic processes, including the prevention of vascular events and the postponement of diabetic nephropathy progression. Accurate evaluation of food quality necessitates the ultrasensitive assessment of vitamins B5, B7, and B9. Hence, a prompt screening assay for multivitamin tablets, pharmaceutical tablets, water, and biological fluids such as urine is essential to ensure their accurate detection and quantification. The present research proposes a miniplatform that employs a 2D sensor based on Cobalt-Phthalocyanine/Carbon for detecting vitamins B5, B7, and B9 in various samples, such as multivitamin tablets, pharmaceutical tablets, water, and biological samples like urine. The utilization of stochastic sensors and the stochastic mode was chosen as the screening method for the diverse samples, given the complex structure of the matrix. Additionally, the stochastic sensors are capable of performing reliable qualitative and quantitative analyses. The identification and quantification of vitamins B5, B7, and B9 were achieved by determining their specific signatures and utilizing them to identify their signals in the diagrams obtained during the rapid screening of the samples. The sensor proposed in this research provided high sensitivities and low determination limits. The validation process involved the utilization of pharmaceutical tablets, supplement tablets, water samples, and biological samples, specifically urine. The sensor under consideration exhibits cost-effectiveness and can be employed for rapid screening tests, with a duration of 6 minutes, across a variety of samples, with over 150 measurements possible, and a lifespan of up to one month.

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Nanodiamond-driven potential modulation of cellular response through local (nano)mechanical reinforcement of 3D printed gellan gum scaffolds

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Abstract: Nanoparticles manifest their intricate role in guiding cellular interactions through a complex and multifaceted interplay of mechanical forces, biochemical signaling, and cellular responses, yet the underlying mechanisms need further understanding. Previous work within our research group has suggested enhanced interactions of various cell types, including hASCs, fibroblasts, osteoblasts, and neural precursors, with nanodiamond nanoparticles (NDs) at low concentrations (<1%) embedded within gelatin nanofibers [1-4]. Scanning electron microscopy suggested intensified cellular adhesion contacts on locally exposed NDs in gelatin nanofibers (Fig.1a), while nanoindentation indicated local stiffness increase [2]. This study aims to investigate the underlying mechanism driving localized cell adhesion - whether it is composition-driven, nanomechanically-driven, or a combination of both. Our research extends to exploring if such cell-instructive behavior is replicated in 3D printed scaffolds with low ND concentrations (Fig. 1d). To achieve this, we developed acellular inks suitable for 3D printing, using a gellan gum polysaccharide matrix loaded with varying weight percentages of NDs (0%, 0.5%, 1%, 2%, and 3%). The rheological behavior of the formulations was evaluated, along with their injectability and printability. The morpho-structural characterization of the 3D printed scaffolds was performed through SEM and micro-CT. The reinforcing effect of the nanoparticle loading was investigated through compression tests, using a texture analyzer, while nanoindentation was used to explore local mechanical effects. Murine preosteoblasts (MC3T3-E1) were used to assess scaffolds' biocompatibility, cytoskeleton investigation and ability to support osteogenic differentiation in vitro, revealing the effect of low concentration NDs to promote cell interactions.

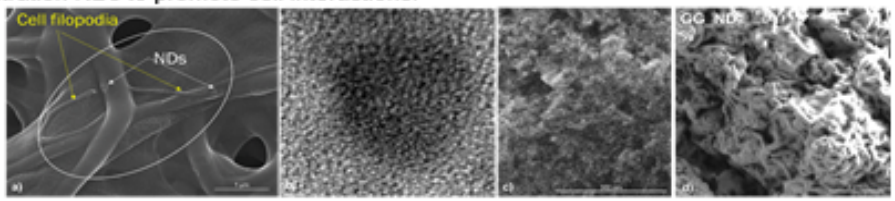

Figure 1. a) NDs improved the innate cell-instructive character of electrospun gelatin scaffolds, cell filopodia oriented towards NDs aggregates; microstructural details: b) single ND particle (TEM), c) SEM image of NDs; d) GG_ND1% nanocomposite appearance by SEM.

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The synergistic effect between Brønsted and Lewis acid sites of Re-TiO_2 catalyst in one-pot synthesis of levulinic acid from glucose

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Abstract: The levulinic acid (LA) shows anti-inflammatory and anti-acne properties and is used in the synthesis of pharmaceutical products, plastic production, polymer resins and antimicrobial foods. Its synthesis from glucose involves two steps: 1) the izomerisation of glucose into fructose over Lewis acid sites, then a combination of Brønsted and Lewis acid sites will improve the dehydration of fructose to hydroxymethylfurfural (HMF), and 2) the rehydration of HMF, in the presence of Brønsted acids sites will lead to levulinic acid formation. Therefore the presence both of Brønsted and Lewis acid sites in the Levulinic acid formation from biomass is absolutely necessary.In these conditions, the doping of TiO2 with different percent of rhenium in order to the increase of its Brønsted acidity as well as the evaluation of its catalytic performances in the hydrolysis of glucose to levulinic acid were the aims of this research study.The insertion of different amount of rhenium into structure of TiO2 anatase was carried out by sol-gel method, after preparation the materials were calcined at 500 °C, 1h. The materials prepared: TiO2, 2%Re-TiO2 and 10%Re-TiO2 were characterized by Py-FTIR, adsorption-desorption isotherms of N2 and XRD techniques. The conversion of glucose to levulinic acid was carried out at 210 °C for 24h under autoclave conditions and reaction products were analysed by GC-MS technique using the calibration curves.The insertion of rhenium into TiO2 structure led to diminution of surface area from 86 m2 /g to 67 m2 /g but not to a phases segregation corresponding to TiO2 and ReOx neither for 10%Re-TiO2. The XRD diffraction lines at 2θ = 25.3°, 37°, 48°, and 55° characteristic of the (101), (004), (200), and (105) crystal planes confirmed the anatase structure of TiO2(Fig.1). The absence of diffraction lines specific for rhenium oxides showed the success of the rhenium insertion into structure of anatase TiO_2. An interesting thing noticed was that an increase the amount of rhenium introduced into TiO_2 structure led to an increase of Ti^{3+} concentration, therefore a decrease of Lewis acidity. This thing was highlighted by Pyr-FTIR, where the Brønsted/ Lewis (B/L) acidity ratio increased from 0 (for TiO_2) to 1.36 (for 10%Re-TiO_2) which also led to an increase of levulinic acid yield from 30.5% (over TiO_2) to 60.5 (over 10%ReTiO_2) at 210 °C. Moreover, 10%Re-TiO_2 catalyst was recycled for four times without significat loss of its catalytic activity. In summary, the present study described the production of levulinic acid from glucose over Re-TiO_2 material. The incorporation of rhenium into structure of anatase TiO_2 was confirmed by tehniques: XRD and adsorption-desorption isotherms of N_2. The presence of rhenium led to an increase of Brønsted acidity of Re-TiO_2 material which favored the increase of levulinic acid yield.

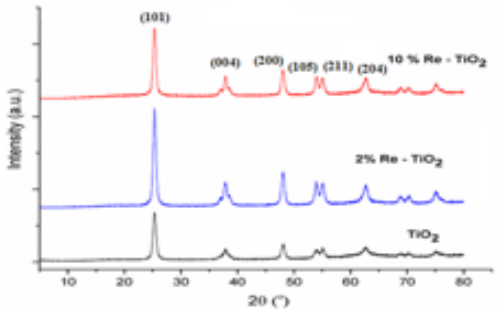

Fig. 1. X-ray powder diffraction patterns of the prepared catalysts

Prostate on a chip as a new predictive model

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Abstract: The project stems from two unique perspectives: one focused on the limitations of animal research, and the other on the lack of information regarding prostate carcinogenesis. According to the first point of view, researchers have looked for viable alternatives to animal testing in order to give more support and more relevant findings when changing human cells. According to the report, the adoption of organ-on-a-chip technologies has surpassed academic laboratories, owing to a desire to better understand the physiology of health and disease, as well as to seek innovative ways to enhance the human situation. Furthermore, the development of these microfluidic devices known as "organs on a chip" should provide us with cellular activity outcomes similar to those seen in human bodies when subjected to various stimuli, which excites the scientific community for a variety of reasons, particularly the potential future certainty in any illness treatment that could be tested on them. Regarding the second point, while this new technology has been tested on numerous organs in the body, there has been little application to the prostate, with the single study focusing on the metastatic phase of cancer. Finally, given the reasons indicated above, the purpose of this effort is to induce comparable cellular activity to that observed in the human prostate using organ-on-a-chip technology.

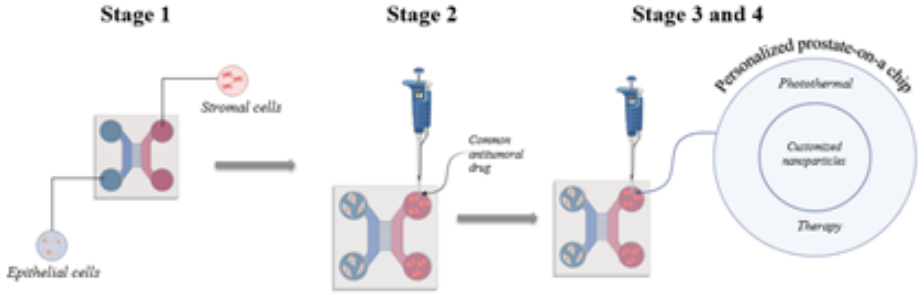

Figure 1. Schematic representation of the step-by-step approach.

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Aspects regarding the characterization of the profile of the finished of somme non - metalic materials used in direct dental restoration

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Abstract: Choosing dental restorative materials implies surface quality assessment. To determine the best materials for dental practice, nine direct coronal restorative materials were used to evaluate the variations in roughness . The purpose of this research was to examine the roughness of the polished surfaces of nine direct coronal restorative materials.These materials used in this study included two self-polymerizing composites (Charisma -Hereus Kulzer Germany } and Simulate{ Kerr, Germany), four light-curing composites (Herculite XRV Ultra, Synergy D6, Brilliant - nanohybrid composite, and Latelux - microhybrid composite), and three glass ionomer cements (Kavitan Plus, Ketac Molar EasyMix, and Fuji II LC). This study aimed to identify the materials with the best surface quality for dental applications.The class of light-curing diacrylic resin composites exhibited the lowest roughness values. Materials such as Herculite XRV Ultra, Synergy D6, Brilliant, and Latelux showed superior surface quality after mechanical polishing. This suggests that these materials are highly suitable for dental applications. The roughness measurements of Herculite XRV Ultra, Synergy D6, Brilliant, and Latelux were significantly lower compared to other materials in the study. This indicates that these light-curing diacrylic resin composites have smoother surfaces, reducing the likelihood of absorption and enhancing their performance in dental restorations. The self-polymerizing diacrylic resin composite, Simulate II, exhibited high roughness values after mechanical polishing. Example: The roughness measurements of Simulate II were notably higher compared to other materials in the study. This suggests that the surface quality of Simulate II may not be as favorable for dental applications. The increased roughness can lead to a larger specific surface area, increasing the likelihood of absorption and promoting stronger physico-chemical interactions with biological fluids. The investigations on the surface quality of nine direct coronal restorative materials revealed variations in roughness after mechanical polishing. The light-curing diacrylic resin composites, including Herculite XRV Ultra, Synergy D6, Brilliant, and Latelux, exhibited the lowest roughness values, indicating their suitability for dental applications. However, the self-polymerizing diacrylic resin composite, Simulate II, demonstrated higher roughness values, suggesting that its surface quality may not be as desirable. These findings provide valuable insights for future research on the influence of chemical composition and roughness on the adhesion of Streptococcus mutans, a bacterium associated with dental caries. By selecting materials with optimal surface quality, dental practitioners can enhance the longevity and performance of restorations in clinical practice.

DNA Nanostructure: an efficient drug delivery platform

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Abstract: In the past decade, significant progress has been made in integrating nanotechnology into various biomedical domains such as bioimaging, biodetection, and drug delivery. DNA nanotechnology, an emerging field, offers simple yet powerful design techniques for self-assembly of nanostructures with unique advantages and high potential in enhancing drug targeting and reducing drug toxicity. Various sequence programming and optimization approaches have been developed to design DNA nanostructures with precisely engineered, controllable size, shape, surface chemistry, and function. Notably, potent anticancer drugs like Doxorubicin and CpG oligonucleotides have been effectively loaded onto DNA nanostructures, augmenting their uptake efficiency by cells. These advances have implicated the bright future of DNA nanotechnology-enabled nanomedicine.

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Gelatin Methacryloyl-polysaccharide based bioink with potential in 3D bioprinting applications

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Abstract: 3D bioprinting is seen as a promising method for obtaining scaffolds which may be adapted perfectly at the defect of each patient. The biomaterial or the combination of biomaterials which are used as bioink must be similar with extracellular matrix of the tissue, which is formed by a complex composition of fibrous protein and polysaccharide. [1]. Gelatin is a fibrous protein, obtained by partial hydrolysis of collagen, which is present in its structure the tripeptide Arginine-Glycine-Aspartic Acid (RGD), a sequence that promotes cell attachment. At body temperature, gelatin is liquid which makes it unusable as a scaffold. Thus, in order to stabilize the scaffold is necessary to chemically modify gelatin in order to obtain photocrosslinkable gelatin which is known as Gelatin methacryloyl (GelMA). Unfortunately, GelMA presents low viscosity which leads to the collapse of the layers and limits its application as bioink at room temperature. In order to improve viscosity, it was proposed to use a natural thickening agent: guar gum, a non-ionic polysaccharide. More than that, guar gum presents antibacterial activity [2]. Also, the use of a composition based on a protein and polysaccharide has the role to mimic natural extracellular matrix of the tissue. Rheological properties of the bioink are very important. It is known that high viscosity ensures a good print fidelity, but high pressures are necessary to be used which may lead to cell damage. For extrusion based bioprinting, shear-thinning behavior is an essential factor governing printability, which means that with the increase of shear rate the viscosity decreases. More than that, in order to have a good print fidelity it is important that after the shear stress is removed, the viscosity of the bioink to recover showing thixotropy behavior [3].

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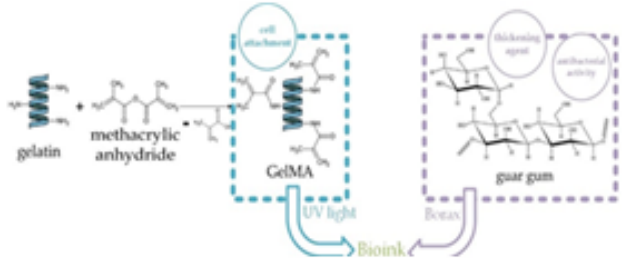

Design of Electrospun and 3D-printed Scaffold co-loaded with Therapeutic Agents for Antibacterial Wound Dressings

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Abstract: The research work presents an efficient solution for antibacterial wound dressings by engineering a drug and prodrug-co-loaded bicomponent scaffold, using the strategy of combining electrospinning and 3D-printing technologies [1-3]. The outer component was constituted by a chitosan (CS) electrospun membrane loaded with indomethacin-based prodrug (pIMC), which served as support for printing the inner component, a gelatin methacryloyl (GM)/ sodium alginate (SA) 3D hydrogel loaded with tetracycline hydrochloride (TCH). In order to obtain the bicomponent scaffold, firstly it was necessary the design of pIMC-containing CS nanofibrous membrane (F/pIMC) by electrospinning as outer component, and secondly, the design of TCH-loaded GM/SA hydrogel (H/TCH) by 3D-printing and its double crosslinking (GM photopolymerization and ionic crosslinking of SA), as inner component. The assembling of the two components was achieved by printing the hydrogel onto the surface of nanofibrous membrane. SEM micrographs underlined both the nanofibrous architecture of non-crosslinked and crosslinked electrospun membranes, and the porous microstructure of 3D-printed scaffolds, as well as the joining of the two components in the final bicomponent scaffold. The study of drugs release profiles revealed that both F/pIMC and H/TCH released the therapeutics in a controlled and sustained manner when they were in the presence of enzymes. According to in vitro cytocompatibility evaluation (MTT assay), the HeLa cell culture exhibited a good viability in the presence of bicomponent scaffold, which suggests that this could promote HeLa cells adhesion and proliferation. The bicomponent scaffold also manifested an excellent antimicrobial activity against E. coli and S. aureus bacterial strains.

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Electrochemical label-free biosensor based on reduced graphene oxide and gold nanoparticles for DNA hybridization detection

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Abstract: We designed an electrochemical biosensor to detect DNA molecules using as the basis of our platform screen printed carbon electrodes (SPCEs) that were further modified by us with reduced graphene oxide (RGO) and gold nanoparticles (AuNPs). Both the reduction of graphene oxide and the AuNPs grafting were performed by a simple electrochemical procedure through cyclic voltammetry (CV). A single-stranded DNA probe (the bioreceptor) was attached to the electrode surface by physical adsorption, then the hybridization was performed by incubating the functionalized SPCEs with complementary DNA target, that was detected by electrochemical methods, like CV and electrochemical impedance spectroscopy (EIS), and confirmed by chronocoulometry.Each step of the electrode modification was investigated by morphological and structural characterization, by scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy, respectively, in addition to CV and EIS. The findings indicated that incorporating AuNPs into RGO/SPCEs improved surface conductivity, enhancing detection sensitivity. Detecting changes in the electrochemical signal, resulting from the binding of target DNA to the bioreceptor, was based on recording the modifications in the charge transfer resistance of the $[Fe(CN)_6]^{4-/3-}$ redox system introduced into the electrolyte solution.

Acknowledgements

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Alginate-Salecan-Nanoclay hydrogel composites as ink formulations for additive manufacturing processes

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Abstract: The purpose of this work was to create 3D printable nanocomposite hydrogels with potential biomedical applications using two different marine-sourced polysaccharides. The preparation of the polysaccharide bicomponent hydrogel formulations is examined in the first section of the study, which is followed by the choice of the ideal ratio of polysaccharide concentrations to guarantee proper stability of the 3D printed samples. The second stage was to produce 3D scaffolds with high printing-fidelity by varying the amount of nanoclay doped in the previously chosen biopolymer ink. The 1:1 alginate-salecan hydrogels supplemented with the highest nanofiller concentrations according to the additive manufacturing studies showed the highest appropriateness for 3D printing process. The capacity of the nanocomposite formulations to effectively create porous 3D printed constructions with high fidelity was proven by the morphological and structural studies. The obtained results highlighted the importance of selecting the right partner ratio (biopolymers, nanoclay), as they have a significant impact on the functionality of printing formulations and ensuing 3D printed structures. These unique hydrogel nanocomposites inks could therefore be regarded as valuable biomaterials with adequate properties for applications in the additive manufacturing of 3D structures with customized shape for individualized regenerative therapy.

Acknowledgements
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Development of gelatin/gelan scaffolds for tissue substitutes

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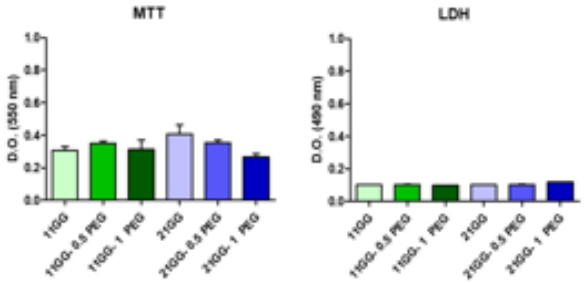
Abstract: Hybrid materials based on different polymers are widely used in biomedical engineering, especially for tissue regeneration to compensate the functional and physiological deficits of the wounded tissue. These hybrid materials have great potential in tissue engineering due to their suitable mechanical properties, biocompatibility, and the ability to sustain cell proliferation, differentiation, and adhesion, promoting the regeneration of new tissue to replace an old wounded one. [1]

The main goal of the current study was to obtain polymer-based hydrogels using gellan and gelatin, integrating hydrophilic PEG with NH_2 groups for soft tissue applications. The obtained mixtures were crosslinked using two consecutive methods: microbial transglutaminase (mTG) and $CaCl_2$. mTG method is involved in the formation of covalent bonds between free amine groups (both from protein and/or the used PEG). To generate enhanced systems, CaCl2 was supplementary used to crosslink the polysaccharide gellan. The final materials were freeze-dried to fabricate scaffolds with interconnected porosity.

Morphological and chemical properties of the obtained hydrogels are analyzed by SEM and FTIR. The swelling behavior of the scaffolds in PBS was also investigated and was proved that the addition of PEG-NH_2 into the bio-based matrix efficiently decreased the swelling percentage of the scaffolds. The LDH and MTT assays were employed for quantifying cell death (Fig. 1).



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Innovative bio-hybrid structures for hard tissue engineering

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Abstract: Bone regeneration is one of the impressive abilities of the human body. However, severe bone defects require external intervention and the conventional approaches, based on the use of autografts and allografts, raise limitations related to availability. The use of scaffolds for bone regeneration is an effective strategy to overcome the problems caused by standard treatment measures and the need for developing novel approaches for tissue engineering is emphasized[1].In this study we present the synthesis of scaffolds based on natural polymers and silicon compounds as a solution to the mentioned issue. Two natural polymers were used to obtain the scaffolds; in addition, the samples were reinforced with inorganic polyhedral oligomeric silsesquioxane (POSS) nanostructures. All the samples were in situ cross-linked with 3-glycidoxypropyl-trimethoxysilan (GPMTS) and half of them were supplementary set through a bioinspired sugar-acid gelation process.The results of the swelling study showed a higher swelling degree for the samples cross-linked only with GPTMS compared to those double cross-linked, proving that the second gelation process was efficient and formed numerous interactions between the polymer chains. Scanning electron microscopy (SEM) images indicated that all the samples showed uniform and interconnected porosity, with pore diameters that allows the access of osteoblast cells. In addition, the energy dispersive X-ray analysis (EDAX) indicated that all samples reinforced with POSS exhibit a high concentration of silicon. The uniform distribution of the silicon in the polymeric matrix was confirmed by the EDAX mapping images proving the effectiveness of the dispersion process.The MTT results exhibit higher cell viability for the double cross-linked samples, the highest viability being recorded for the double-crosslinked sample reinforced with POSS with no functional groups. Additionally, the LDH assay confirmed the biocompatibility of the samples. The obtained samples displayed a morphology that allowed the diffusion and attachment of osteoblasts (Fig 1), thus being suitable for use in the regeneration of bone tissue.

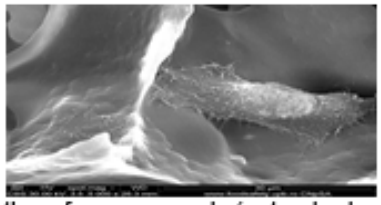

Fig. 1. Osteoblast attached to the reference sample (natural polymers crosslinked with GPTMS)

Acknowledgement: Part of this research work was supported by ARUT national grant 56/2023.

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Materials and Technologies approach for provisional restauration.

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Abstract:

Introduction:

Provisional prostheses are mandatory step in prostheses,made of materials and tehnologies ,they restore for a short period the disturbed functions of the stomatognatic system.The first use of polymethyl methacrylate(PMMA) as a dental device was for the fabrications of complete denture bases.

Experimental:

It s important to know about the effect of the type of splint material,heart-cured PMMA or chemical-cured PMMA on the wear of opposing tooth surfaces.For example,if provisional restauration is made , it must be taken into account that there are component elements such as: pillar and intermediate teeth.3D printed resins for provisional restaurations have become popular with the emergence of new tehnologies.

Results and Discussion:

In this study,we evaluated three different commercially available resins for provisional restaurations and one new experimental resin.Provisional prosheses can be: provisional restaurations made of acrylic resin made by the direct technique,provisional restauration printed on a 3D printer and provisional restaurations printed on a 3D printer reinforced with glass fiber between the post teeth.

Conclusions:

Fiberglass reinforced 3D printed prostheses are not reliable because they are not as compact as printed or direct technique restaurations.

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Designing self-assembling systems for targeted release of bioactive factors

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The aim of the study was to bind single-stranded DNA sequences to create a system for controlled release of bioactive factors. Due to their high levels of structural programmability, permeability, and biocompatibility, DNA nanostructures are among the most promising candidates for the delivery of active agents. They are constructed through self-assembly into cage-like shapes, can tightly hold drug molecules within the structure, and based on environmental stimuli, can be disassembled and reassembled [1]. In this scientific approach, a DNA cage was synthesized from four DNA strands after conducting molecular dynamics simulations to observe the interactions between DNA molecules in Figure 1.

1)ACATTCCTAAGTCTGAAACATTACAGCTTGCTACACGAGAAGAGCCGCCATAGTA

2)TATCACCAGGCAGTTGACAGTGTAGCAAGCTGTAATAGATGCGAGGGTCCAATAC

3)TCAACAGGCAGTTGATAAAACGACACTACGTGGGAATCTACTATGGCCGGCTCTC

4)TTCAGACTTAGGAATGTGCTTCCCACGTAGTGTCGTTTGTATTGGACCCTCGCAT

Following the actual synthesis, the result was characterized using the conventional agarose gel electrophoresis method, where with the help of known base pair standards, it was demonstrated that the binding of the DNA cage was successfully achieved, with the number of base pairs falling between the two selected standards. Additionally, specific nanomaterial methods were employed, where through Dynamic Light Scattering analysis and Zeta potential measurements, the positive electric potential was confirmed, reinforcing the idea of binding single-stranded DNA strands within a DNA cage, and the hydrodynamic diameter was calculated.

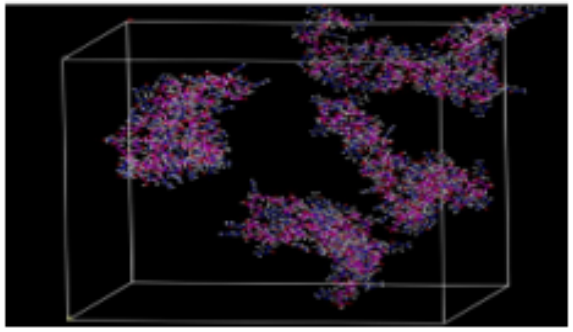

Figure 1 - Periodic cell depicting the four single DNA strands interacting in the Molecular Dynamic simulation

Isolation of natural extracellular matrices and optimization of morphostructural characteristics for targeted applications

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Abstract: Since there is a rising need for reliable bone substitutes, it is very important that we develop new performant materials which can possess characteristics as similar as possible to the tissue that is to be replaced. Given the fact that the current solutions come with different disadvantages and the resources are limited, natural scaffolds represent a promising alternative. [1,2] Therefore, the aim of this study was to achieve a composite biomimetic scaffold that can be used for the regeneration of osteochondral tissue by using the materials obtained from the decellularization and demineralization processes. Using a chemical decellularization technique, an extracellular matrix (ECM) resulted, and it was then used for obtaining a hydrogel and a hydrogel cross-linked with genipin. The FT-IR spectra of both of the hydrogels showed specific peaks of collagen, which confirm the collagenic structure of the materials. Bone samples were demineralized in an acid solution. The solution in which the bone samples were demineralized was dialyzed and used as a precursor for calcium phosphates, by adapting a standard method. The FT-IR spectra peaks for phosphate and hydroxyl were identified, similar to phosphates obtained through conventional methods. The elemental structure of the powders was shown with XPS. Scanning Electron Microscopy (SEM) was used to investigate the morphology of the powders, which is entirely different from the particles which are found in scientific literature. The size and shape of the particles isn't uniform. The bigger particles have irregular platelet shape and the rest of them are fine powders. Composite films were obtained by immersing the collagenic gel in a solution containing the calcium phosphates. The SEM images of the composite films reveal crystalline agglomerations on the surface of the films. Through EDX the elemental composition of these agglomerations was determined. The platelet shaped calcium phosphates can cover significant areas near the surfaces of the films, which can generate topographic changes. The increased surface roughness can be beneficial for populating it with cells since it provides better adherence to the substrate. Surprisingly, in section, the films show a multilayer lamellar morphology. This is probably due to the tendency of the particles to settle in a more orderly manner. Micro-CT was used to study the internal morphology of the composite material and to highlight the distribution of the mineral phase in the volume of the material. Also, it can be observed that the film has a multilayer structure, and that the pores seem to be in parallel layers, comparable to the SEM images of the film. In conclusion, with a few improvements the material could be used for biomimetic scaffolds with the purpose of osteochondral tissue regeneration.

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