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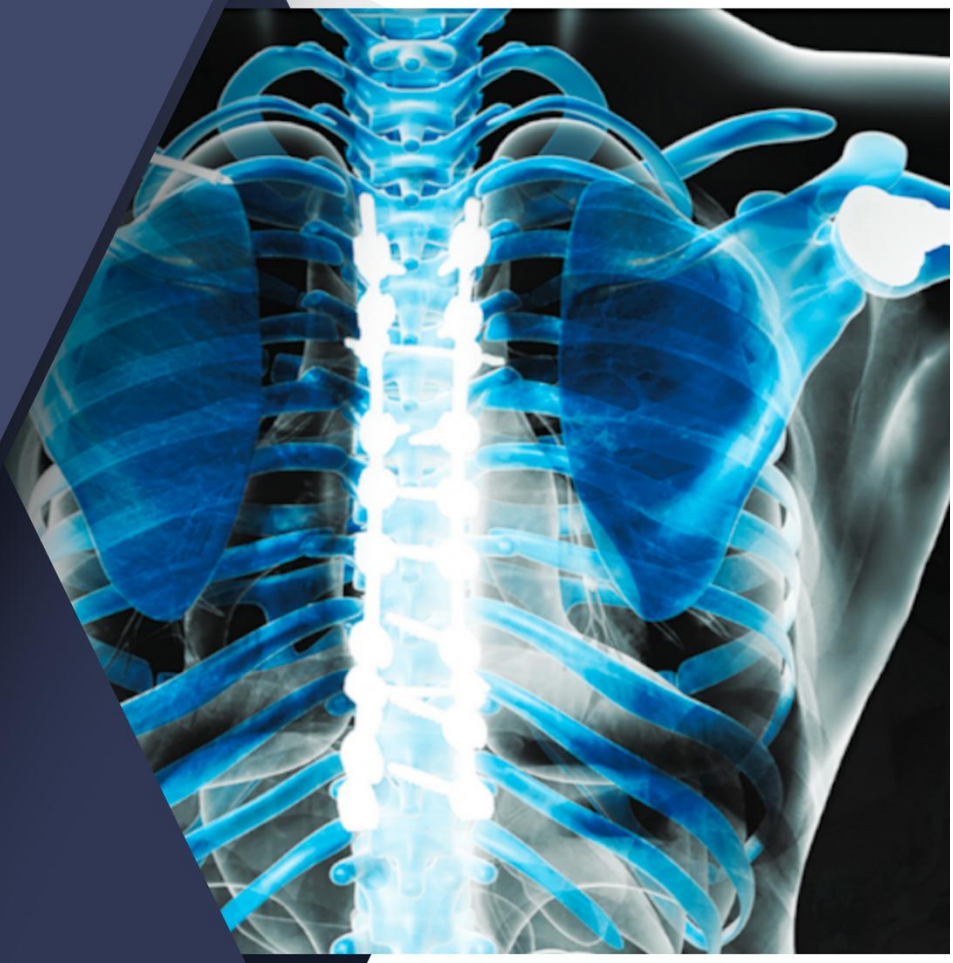

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Dr. Magdalena Jażdżewska, EngD
Dr. Justyna Sawicka

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INAUGURAL LECTURE

3D BIOPRINTING AS A REAL DISRUPTIVE INNOVATION IN THE MODERN MEDICINE

Michał Wszoła

Polbionica S.A.

3D-bioprinting has recently emerged as a highly promising method for personalized treatment in regenerative medicine and chronic diseases. Another key application is its use as an alternative to animal models in preclinical drug testing. Significant efforts are underway to develop bioprinted tissue and organoid-based platforms for drug discovery and toxicity screening. However, clinical application of 3D-bioprinting still faces several scientific, administrative, and regulatory challenges. Recent changes in U.S. legislation allow the use of alternative nonclinical methods—such as organ-on-a-chip, bioprinting, and AI-based models—for preclinical drug testing, reducing reliance on animal models. The aim of this study presents the outcomes of 3D-bioprinting of: (i) vascular structures, (ii) a bionic pancreas, (iii) liver organoids, (iv) pancreatic cancer organoids, and (v) hepatocellular carcinoma organoids—as functional platforms for drug development and therapeutic evaluation. Methods: Over the past 12 years, we have conducted comprehensive research on biomaterials, bioprinting techniques, and the development of perfusable models of vessels, pancreatic and liver organoids, as well as tumor-bearing constructs. In parallel, we engineered a proprietary bioreactor system to support the viability and functional maturation of the bioprinted tissues, including the bionic pancreas. Results: A complete ecosystem for drug testing has been developed, consisting of novel bioinks, vascularized organoids (pancreas and liver), cancer organoids, and a perfusion bioreactor platform. Importantly, the 3D-bioprinted Bionic Pancreas-ATMP® has successfully completed preclinical studies in large animals and is ready for first-in-human transplantation. Conclusion: The 3D-bioprinted Bionic Pancreas-ATMP® is ready to enter the regulatory pathway toward clinical trials, with the goal of obtaining Market Authorization from EMA and Biologics License Authorization from FDA. Continuous innovation in 3D-bioprinting is expected to significantly reduce or even replace animal testing, while providing more predictive and human-relevant models.

PLENARY LECTURES

ADVANCED MATERIALS AND BIOINSPIRED SURFACES FOR THE NEXT GENERATION OF IMPLANTS FOR REPARATIVE AND REGENERATIVE MEDICINE

Pascale Chevallier, Francesco Copes, Carlo Paternoster, Andranik Sarkissian, Diego Mantovani

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Over the last 50 years, biomaterials, prostheses and implants saved and prolonged the life of millions of humans around the globe. Today, nano-biotechnology, nanomaterials and surface modifications provides a new insight to the current problem of biomaterial complications, and even allows us to envisage strategies for the organ shortage. In this talk, creative strategies for addressing functional nanocoatings, new metals for tunable degradable metals for a new class of implants and mixing vascular cells and collagen-based materials for physiologically relevant models will be targeted with the overall aim to envisage today how far innovation can bring tomorrow solutions for reparative and regenerative medicine. The overall take home message of this talk is aimed to show how advanced nanostructured coatings, degradable metals and 3D human cell models represent the today bottleneck in reparative and regenerative medicine, and which are few of the strategies that have to be investigated to push forward innovation in the field, for the benefit of patients and Humans.

PERMANENT AND TEMPORARY IMPLANTS: STABILITY AND DEGRADATION CHALLENGES

Endzhe Matykina

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The electrochemical stability defines the service life of permanent implants and temporary, biodegradable devices. Ti and Mg alloys used for such applications face drastically different corrosion challenges, further affected by the processing route, be it wrought, cast or additive manufacturing. Importantly, in drug-eluting devices, the drugs may act as corrosion inhibitors or accelerators, which imposes an additional challenge for a controlled degradation rate of temporary implants. This lecture addresses i) the effect of inflammatory process and hygiene routines on the stability of wrought Ti alloys without and with bioactive plasma electrolytic oxidation (PEO) coating systems; ii) localized corrosion control of additively manufactured (AM) Ti alloys, and iii) the role of drugs that form part of smart surface functionalization in biodegradation of Mg alloys. To this effect, techniques such as EIS, FTIR, EIS, ICP-OES, SVET, SIET and H2 evolution tests are implemented in order to establish the degradation mechanisms of the coating/alloy systems and their interaction with drugs. Metal ion release (Ti4+, Al3+ and V5+) from bare and PEO coated alloys during their short- and long-term in vitro immersion is correlated with the electrochemical AC and DC measurements in artificial saliva and inflammatory simulated body fluid [1, 2]. The lecture offers an understanding of the effect of laser or electron-beam induced microstructural changes in AM and surface textured Ti6Al4V alloys on their corrosion resistance [3]. The role of bioactive flash-PEO coatings in development of multi-scale topography and successful prevention of localized corrosion of these alloys is underpinned. Stand-alone ceramic and hybrid ceramic-polymeric drug-loaded coating systems for temporary implants based on high purity Mg, Mg-Zn-Ca and Mg-RE alloys are discussed. It is shown that hybrid coating systems protect against the drug's corrosion accelerating effect, help maintaining an adequate degradation rate, avoid burst release and ensure gradual drug elution [4]. Some pharmaceutical agents loaded into hybrid coatings can offer over 70% inhibition efficiency. The corrosion inhibition or acceleration effect of the eluted drug is discussed in terms of the formation of insoluble drug-Me (Meº Mg, Ca) complexes, that can participate in active protection mechanism by interacting with the defects in the coating system and impede the access of corrosive species.

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BONE REGENERATION CAPACITY OF MAGNESIUM PHOSPHATE MINERALS

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Bone defects exceeding a critical size require filling with autologous bone grafts or synthetic materials to prevent fibrous tissue ingrowth. Current synthetic bone substitutes, mainly based on calcium phosphate phases like hydroxyapatite or ß-tricalcium phosphate, have limitations, including insufficient mechanical properties and slow resorption, particularly for hydroxyapatite. Magnesium phosphate (MgP) minerals offer a promising alternative due to their higher solubility and demonstrated bone regeneration capacity [1]. This lecture provides an overview of MgP for bone replacement, covering MgP chemistry, clinical applications such as self-setting cements, granules, and macroporous scaffolds, and their impact on bone healing in animal models. MgP minerals are typically processed via low-temperature wet synthesis routes like precipitation from aqueous solutions or cement setting reactions. The latter can produce minerals such as struvite ($MgNH_4PO_4 \cdot 6H_2O$), K-struvite ($MgKPO_4 \cdot 6H_2O$), and newberyite ($MgHPO_4 \cdot 3H_2O$), depending on cement composition and reaction conditions. Struvite cements have shown excellent bone regeneration in a sheep model, with nearly complete degradation after ten months [2]. Faster degradation can be achieved through potassium substitution, forming K-struvite, which resorbs within two months and is replaced by bone after four months [3]. Since aqueous cement pastes require manual mixing and have a short processing window, a glycerol-based ‘ready-to-use’ MgP cement paste was developed. This allows direct application without time constraints, as the cement hardens by replacing glycerol with tissue water, reducing contamination risks and operator influence. In vivo studies in sheep demonstrated similar bone regeneration to conventional aqueous MgP cements. Another MgP application is mineral bone adhesives, achieved by modifying MgP cements with organophosphate compounds like phytic acid or ortho-phosphoserine, which form chelate complexes with Mg^{2+} ions. Recent studies demonstrated adhesive strengths of up to 8 MPa on wet bone surfaces, comparable to cyanoacrylate adhesives [4].

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PSEUDO-PROTEINS: BIODEGRADABLE POLYMERS FOR VERSATILE MEDICAL APPLICATIONS

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In recent years, the development of biodegradable polymers has emerged as a leading frontier in the construction of new biomaterials for sophisticated medical applications. Among the naturally occurring biodegradable polymers, proteins occupy a major position due to their innate affinity for tissues, enzymatic biodegradability, and the release of α-amino acids (α-AAs) that can be assimilated by the organism, thereby promoting tissue regeneration [1]. However, proteins possess significant drawbacks when considered as biomaterials, including immunogenicity resulting from their molecular architecture. A new generation of α-AA based biodegradable polymers, known as 'Pseudo-Proteins' (PPs), has been developed [2]. PPs are synthetic (artificial) polymers designed to mimic the structure and function of natural proteins. Unlike traditional proteins, which consist of α-AAs linked by peptide bonds in a head-to-tail orientation, PPs have alternative linkages, such as tail-to-tail or head-to-head connections of α-AAs. Due to their unique molecular architecture, PPs are less recognizable by the immune systems of living organisms, making them valuable for various biomedical applications [2,3]. The key monomers for synthesizing PPs are diamine-diesters made of α-AAs and diols [4]. Several classes of PPs both regular and functional types have been developed exhibiting a broad spectrum of material properties. PPs contain various chemical linkages along with peptide bonds that extend the properties of these materials for biomedical applications [2-8]. It has to be underlined that PPs retain the most valuable properties of proteins such as high tissue compatibility and nutritional potential through releasing α-AAs upon biodegradation. PPs are highly promising as resorbable materials for both versatile surgical applications and drug delivery vehicles.

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BIOCOMPATIBILITY OF SILICONE BREAST IMPLANTS CALLED INTO QUESTION

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Silicone breast implants are among the most used medical devices. They consist of a silicone shell with a smooth or textured surface containing a filler (saline, silicone gel or hydrogel). Breast implants trigger a Foreign Body Reaction (FBR) leading to the formation of a capsule that becomes the first recipient of silicone released by the implant. Three sources of silicone are distinguished: (a) silicone debris eroded from the surface texture of the shell, (b) permeation of the silicone gel filler and (c) massive exposure to silicone gel after rupture. We previously defined a new classification of implant textures based on a rigorous metrological analysis of textures. Using this classification, we showed by transcriptomic analysis of explanted capsules that the expression of certain inflammation genes was significantly higher in capsules formed around macrotextured implants (1). To understand the origin of this persistent inflammation, we carried out a topographical analysis of the implants after implantation that confirmed significant wear of the macrotextures generating surface debris (2). These debris could therefore be responsible for maintaining inflammation and triggering pathologies in certain patients. More recently, we studied the inflammation due to silicone gel filler after permeation or rupture of the breast implants. We collected clinical explants of periprosthetic tissues and focused on changes in (i) tissue organization and (ii) transcriptomic signatures of periprosthetic tissues exposed to different sources of silicone with respect to implant integrity, surface texturing and implant filling (3). Silicone exposure from breast implants induces tissue remodeling, immunogenic response and autoimmune markers in periprosthetic tissues. Our results challenge the view of FBR as a stable and innate immune response. FBR is generally considered to be complete with the formation of the fibrous capsule, 3 to 6 months after implantation. However, the continuous and recurrent release of silicone due to implant ageing, coupled with the inability to clear it, leads to a chronic state of FBR, promoting a persistent inflammatory infiltrate and an adaptive immune response, which may ultimately lead to the activation of pathological immune pathways. Overall, this work provides new insights into the immunological mechanisms triggered by silicone, the associated chronic FBR and once again challenges the concept of silicone safety.

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CAPACITIVE STIMULATION-SENSING SYSTEM FOR EMERGING ACTIVE BONE IMPLANTS

Antonio Ramos

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Active bone implants are recognized as a promising adaptable technology for personalized implants. The rate of the orthopaedic implants as intramedullary prosthesis are related with the bone interface as the main cause of revision was the aseptic loosening [1]. That active implant concepts are based on the ability to be adaptable and controlling the interface behaviour [2,3]. The sensing using capacitive patterns are one possibility to sensing and stimulate the interface. The present study analyses the possibility to use that technology to evaluate the potential application in bone interface implant. Materials and methods: Was developed an in-silico model to study the implant bone interface stimulation and sensing. Using the Finite element model of a trabecular bone acquired by micro CT scan to represent the implant interface [4] in the trabecular bone. The sensor was implemented and the interface contact between bone and implant was analysed, considering the frequency of stimulation and interface gap. Experimentally, an ex vivo model was developed, an innovative low-power miniaturized electronic system with ability to provide both therapeutic stimulation and bone/implant interface monitoring using network-architecture capacitive interdigitated patterns was implemented. It comprises five modules: sensing, electric stimulation, processing, communication and power management [5]. Results: The results in the fixation scenario, the electric field stimuli decreased 85% from the sensor interface to a parallel plane 2 mm apart from such interface. A significant influence of the bone-stimulator distance on the electric stimuli was found: the electric stimuli magnitudes varied in the range between 0.38 V/mm (fixation scenario) and 4.8 mV/mm (massive loosening scenario) for voltages up to 10 V. Strong frequency-dependent behaviours were also observed in the electric stimuli: their magnitudes can reach 106-fold decreases when the excitation frequency is decreased from 32 kHz to 14 Hz. The ex vivo models validate the technology concerning the sensing system, its ability to detect bone-implant interface changes in target regions. Conclusion: The work provides an impactful contribution to the way for the development of the new generation of orthopaedic. The results highlight that co-surface stimulators can deliver osteogenic electric stimuli along trabecular bone structures, ensuring low electric power excitation and can detect the interface bone changes.

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ENGINEERING THE FUTURE OF MEDICINE: NOVEL BIOMATERIALS FOR DRUG DELIVERY AND BONE REGENERATION

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The engineering of advanced biomaterials is changing the landscape of modern medicine, offering innovative solutions for targeted delivery of active substances and tissue regeneration. A particularly promising area of research is the development of multifunctional composite materials designed to meet the complex structural and biological requirements associated with bone and osteochondral tissue repair. This project focuses on novel biomaterials that integrate polysaccharides, such as pullulan, with biodegradable polymers and calcium phosphate-based ceramics, including hydroxyapatite and tricalcium phosphate. These hybrid systems combine the beneficial biological properties of natural polymers with the mechanical strength and osteoconductivity of inorganic phases, enabling the creation of bioactive scaffolds and drug delivery platforms tailored to specific patient needs [1]. A major challenge in osteochondral regeneration is reproducing the natural gradient between soft cartilage and rigid bone. To address this, gradient biomaterials have been developed to provide spatial differences in composition, porosity, mechanical properties and bioactivity [2]. These structures support site-specific cell differentiation and promote seamless tissue integration, closely mimicking the hierarchical organization of native tissue. Conducted studies have confirmed the biocompatibility and safety of pullulan- and calcium phosphate-based systems through incubation and in vitro tests, demonstrating no cytotoxicity as well as appropriate degradation behavior. Incubation in SBF fluid demonstrated support for mineralization of new apatite layers on the surface. These findings validate their potential for safe clinical use and lay a strong foundation for future translational applications in regenerative medicine.

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LECTURES

INTEGRATING BIOENGINEERED HUMAN SKIN WITH BIOPRINTED CARTILAGE FOR EAR RECONSTRUCTION

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Introduction: Microtia is a congenital disorder characterized by the malformation of the external ear, which can lead to significant psychosocial challenges for affected children [1-2]. This study aims to explore a novel tissue-engineered treatment approach that integrates bioprinted autologous auricular cartilage and bioengineered skin substitutes to address the aesthetic and functional deficits associated with microtia [3]. Materials and Methods: We developed a bioprinted autologous auricular cartilage construct, termed EarCartilage, and a bioengineered human pigmented and prevascularized dermo-epidermal skin substitute, referred to as EarSkin [4]. These constructs were tested in immunocompromised rat models to evaluate their integration, functionality, and aesthetic outcomes [4]. The primary focus was to assess the vascularization of EarSkin, the maturation of the epidermis, and the mechanical stability of EarCartilage in short- and long-term in vivo studies. Results: Results indicate that the human-engineered blood capillaries within EarSkin successfully connected to the vasculature of the recipient rats within one week, facilitating rapid blood perfusion and supporting epidermal maturation [5]. Histological analysis revealed that the bioengineered EarSkin exhibited a stratified epidermis populated with mature keratinocytes and melanocytes [6]. The presence of melanocytes in the basal layer was particularly noteworthy, as it contributed to the restoration of skin pigmentation. Additionally, in vivo assessments demonstrated that EarCartilage maintained favorable mechanical stability and promoted enhanced extracellular matrix deposition, essential for structural integrity [7]. Conclusions: This study presents a pioneering approach for the treatment of microtia through the combination of EarCartilage and EarSkin, addressing both the functional and aesthetic limitations of current reconstructive techniques. The rapid vascularization and successful integration of engineered tissues underscore the potential of this method to improve outcomes for children with microtia, offering a promising alternative to traditional surgical interventions. The findings contribute valuable insights into the field of tissue engineering and regenerative medicine, highlighting the importance of integrating multiple tissue types for complex reconstructive challenges.

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BIOPRINTING WITH MENISCUS DECM, COLLAGEN-BASED NUTRACEUTICALS, AND SINGLE-CELL TRANSCRIPTOMICS: NEW PERSPECTIVES FOR BIOMATERIALS AND REGENERATIVE MEDICINE

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Collagen-based biomaterials have gained increasing attention in regenerative medicine and nutraceutical applications. This study integrates three complementary approaches: the investigation of collagenous biopolymers from marine spongin, the development of bioinks derived from decellularized collagen-rich extracellular matrix (dECM) of the porcine meniscus for 3D bioprinting, and the creation of a single-cell transcriptome atlas of the meniscus to support tissue engineering strategies. Our research confirms the presence of collagen types I and III as primary structural components of spongin, with proteomics, solid-state NMR, and Raman spectroscopy demonstrating its compositional similarity to mammalian collagen. Additionally, HPLC-MS analysis identified halogenated di- and tri-tyrosine crosslinking agents, revealing a complex molecular interplay within this ancient biocomposite [1]. In parallel, we present an efficient, scalable method for extracting and processing porcine meniscus dECM for bioink formulation. Given the meniscus's cartilage-like properties and structural robustness, we developed a novel protocol combining homogenization, hydrolysis, supercritical CO_2 extraction, and lyophilization. This method retains native biomolecules while ensuring good printability and cell-supportive properties. Despite DNA content exceeding conventional thresholds, in vitro studies confirmed excellent biocompatibility, challenging current decellularization efficacy standards [2]. Furthermore, we introduce a comprehensive single-cell transcriptome atlas of the porcine meniscus, highlighting four major cell types—chondrocytes, endothelial cells, smooth muscle cells, and immune cells—along with five distinct chondrocyte subclusters (Ch0-Ch4). Notably, chondrocyte subclusters in the red zone exhibit mesenchymal stem cell-like properties, contributing to tissue remodeling, endothelial proliferation, and vascularization, whereas those in the white zone specialize in cartilage matrix deposition and microenvironmental protection. The cellular similarity between porcine and human menisci reinforces the pig model’s relevance for orthopaedic research and regenerative medicine [3]. By integrating biomaterial innovations with cellular and molecular insights, our findings open new avenues for advanced therapies in tissue engineering, meniscal repair, and collagen-based nutraceuticals.

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POLYHYDROXYALKANOATES IN BIOMEDICAL APPLICATIONS FROM WOUND DRESSINGS TO BONE REGENERATION

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Polyhydroxyalkanoates (PHAs) are bacterially synthesized biopolymers that have gained significant attention due to their biodegradability, biocompatibility, and tunable physicochemical properties. These features make PHAs highly promising for biomedical applications, including wound dressings, tissue scaffolds, and implantable materials [1]. Medium-chain-length PHAs (mcl-PHAs) such as polyhydroxyoctanoate (P(3HO)) demonstrate elastomeric properties suitable for soft tissue engineering and regenerative medicine. Recent research in my group has explored the fabrication of P(3HO)-based materials using two primary approaches: solvent casting with porogen leaching and electrospinning. Porous foams produced via salt-leaching exhibited high porosity, making them suitable for cell growth and nutrient diffusion. Electrospinning, assisted by liquid nitrogen cooling, enabled the formation of nanofibers, although process optimization remains necessary to eliminate bead formation. These advancements position P(3HO) as a promising candidate for next-generation wound dressings. In the field of orthopedic implants, the development of composite materials integrating P(3HO) with calcium phosphate ceramics has led to scaffolds that mimic the structure and mechanical properties of bone tissue [2]. Tricalcium phosphate (TCP) scaffolds coated with P(3HO) maintained structural integrity under compression while exhibiting enhanced bioactivity. Incubation in simulated body fluid resulted in the formation of apatite layers, confirming their bioactive potential. In vitro studies with preosteoblasts (MC3T3-E1) demonstrated improved early-stage cell proliferation on P(3HO)-coated scaffolds compared to uncoated TCP. A novel functionalization strategy has been explored to integrate anti-inflammatory agents into implantable materials. By chemically modifying P(3HO) oligomers with diclofenac, controlled drug release was achieved, reducing local inflammation at the implantation site [3]. While higher concentrations of diclofenac-functionalized polymers exhibited cytotoxic effects, optimized formulations maintained cell viability and promoted osteogenic differentiation. In conclusion, PHAs, particularly P(3HO), demonstrate significant potential in medical applications, offering versatile solutions for tissue engineering and controlled drug delivery.

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SYNTHESIS AND CHARACTERIZATION OF HYDROXYAPATITE COATINGS ON BIOCOMPATIBLE OXIDE INTERLAYERS INTEGRATED WITH THE TI6AL4V ALLOY IMPLANT SURFACE

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Progress in medicine is associated with the wide use of new technologies. An example is the rapidly developing implantology, which requires the use of increasingly complex and multifunctional materials that enable the reproduction of tissue functions, e.g. bone. In order to obtain a permanent implant-bone connection, materials are sought that, in addition to the appropriate physicochemical, mechanical and tribological properties, will stimulate and accelerate the regeneration of bone tissue and stimulate osteogenic cells. Among the materials used to produce orthopedic and dental implants, metal materials, especially titanium and its alloys, play a special role. Despite many beneficial properties of titanium materials, such as low specific gravity, high corrosion resistance and good biocompatibility in the environment of tissues and body fluids, these materials exhibit poor osteoconductive properties, necessary to obtain a permanent and stable connection between the implant and bone tissue. One of the factors limiting their use is the high modulus of elasticity, which significantly exceeds the modulus of the cortical layer, which can lead to bone loss around the implant. A good solution seems to be the production of a hydroxyapatite coating on the surface of metal implants. Currently, the obstacle to the wider use of these coatings is their very low adhesion to the titanium substrate. The aim of the presented research was to modify the surface of Ti6Al4V alloy implants, which can be produced, among others, in 3D technology (laser sintering of titanium powders intended for medical devices). In the first stage, the surface of Ti6Al4V alloy samples was modified, obtaining titanium oxide layers with diverse morphology, structure, and mechanical and biological properties [1,2,3]. In the second stage, highly biocompatible oxide nanolayers were used as intermediate layers (IL) and Ti6Al4V/IL/HA type systems were produced. The intermediate layers were a link between the hydroxyapatite coating and the Ti6Al4V alloy substrate [4,5]. Their task was to improve the bond strength between the metal substrate and the hydroxyapatite coating while maintaining the appropriate physicochemical and biological properties of the system. Physicochemical, mechanical and biological characterization was performed for the obtained systems.

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SURFACE CHEMISTRY OF IMPLANTS: FROM THEORY TO APPLICATIONS

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Cutting-edge investigations on new implant materials in both academic and industrial centers emphasize the importance of understanding the implant–tissue interface. In this presentation, I would like to focus on the surface chemistry of implant materials and demonstrate how tailoring surface properties can optimize their functionalities — ranging from corrosion protection and enhanced biocompatibility to reduced infection risks and improved therapeutic effects [1]. By controlling chemical composition, structural configuration, surface topography, functional group coverage, and even electron density, we can significantly improve the performance of implant surfaces [2]. Our approach integrates experimental techniques (microscopy, spectroscopy, and biological assays) with computational methods (quantum chemical modeling and molecular dynamics). This integrated research strategy allows for a comprehensive description of the interactions taking place at the implant–cell interface, bridging molecular understanding and macroscopic properties. The key message is that the rational and chemical knowledge-based design is essential for developing next-generation implant materials. Tailoring surface chemistry allows for the functionality of biomaterial surfaces but in a broader perspective is necessary for facing the dynamically growing demands of modern functional biomaterials and healthcare.

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BIOLOGICAL AND ELECTROCHEMICAL PERFORMANCE OF POLYMER-COATED MAGNESIUM ALLOYS FOR BIOMEDICAL APPLICATIONS

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Introduction Due to their good mechanical properties, magnesium and its alloys have been widely used in various industries for years. Magnesium alloys are used in implantology, which are characterised by good biocompatibility and the ability to degrade, eliminating the need for additional surgeries to remove the implant from the human body. For this reason, they present a promising alternative to traditional metallic implants [1]. However, magnesium alloys also have several drawbacks, the biggest problem with their use is related to too rapid degradation in the body fluid environment, which is associated with a decrease in mechanical properties and reduced functionality of the implant [2]. Modifications of the chemical composition and various coating deposition techniques are employed to prevent rapid corrosion. Polymer coatings improve magnesium alloys by enhancing corrosion resistance, mechanical properties, and cell adhesion and growth [3]. Material and Methods This study aimed to investigate the properties of the biodegradable polymer coating on a WE43 magnesium alloy. Polymer coatings made of P(L/G/TMC) – a copolymer of lactide, glycolide, and trimethylene carbonate were applied using ultrasonic spraying. Comprehensive testing was conducted, encompassing microscopic observations, potentiodynamic polarisation test, electrochemical impedance spectroscopy (EIS) and cytotoxicity test. The study was conducted for samples in their initial state and with the applied surface modification. Results and conclusion The obtained results indicated a positive effect of the applied polymer coating on the corrosion behaviour of the magnesium alloy. However, there is a need for further research for a more detailed analysis of the long-term corrosion behaviour of polymer-modified Mg alloy.

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THE REGULATORY EFFECTS OF CU IONS ON CITRATE METABOLISM IN THE DIFFERENTIATION OF OSTEOBLASTIC CELLS

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The novel modifications of bone implants are trying to accomplish the osteointegration of the implant with bone that improves tissue regeneration. To induce this process the differentiation of osteoblasts needs to be tightly regulated. This regulation in all the phases of their differentiation guarantee proper skeletal development. Moreover numerous studies are underway to create implant surface modifications to be antibacterial. The use of two charged ions such as copper has antimicrobial properties, so it has become a potential opportunity to use it to improve the implant surface. However, there are studies that show that high concentrations of copper ions lead to inhibition of cellular energy metabolism. The aim of this study was to test whether copper ions induce a cytotoxic effect in osteoblastic cells by inhibiting the activity of energy metabolism. The model for the study was a culture of human hFOB 1.19 osteoblasts and primary osteoblastic cells POB. Cells were cultured under control conditions and in medium to which $CuCl_2$ was added at concentrations of 100-300μmol/L. Subsequently, cell survival was examined after 24 h and enzyme activities of energy metabolism, alkaline phosphatase activity were measured. Finally the ability of mineralization was measured by Alizarin Red staining. In addition, the survival of cells growing on titanium samples on which copper ions were deposited at concentrations of 100 and 300μmol/L was examined. Adding $CuCl_2$ to cell cultures at a concentration of 200μmol/L resulted in a 52% decrease in mitochondrial enzyme activity for aconitase, 27% lactate dehydrogenase and 70% isocitrate dehydrogenase, and alkaline phosphatase activity decreased by 65%. Reducing the Cu concentration to 150μmol/L led to a reduction in the total number by about 34% and about 15% inhibition of mitochondrial enzyme activity. In these conditions the Ca mineralization was significantly increased. Under the same conditions, alkaline phosphatase activity was not changed. Surface modifications of titanium samples using high, above 300μmol/L copper concentrations led to 85% cell death. Cu^{2+} ions at concentrations above 250μmol/L lead to increased mortality of the osteoblasts tested. This is caused by direct inhibition of mitochondrial enzyme activity and aerobic metabolism. However 150μmol/L Cu2+ aggravated cellular mineralization.

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FUNCTIONALIZATION OF GRAPHENIC BIOMATERIALS VIA OXYGEN PLASMA

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Graphenic materials have gained huge attention due to their outstanding properties, making them widely applicable, i.a., components of biomaterials. Surface properties of graphene-based materials, mainly electronic and wettability, play crucial role for biomedical applications. However, due to their hydrophobic nature, the surfaces need to be functionalized to improve wettability and biocompatibility. In this study, we investigate the effect of oxygen and ammonia plasma treatment on the surface properties (electronic, wettability and biological response) of graphenic surface [1-2]. The microscopic and spectroscopic (SEM, AFM, RS, XPS, LDI-MS) results indicated generation of surface functional groups which substantially modify surface chemistry while preserving the topography and bulk properties of the graphenic material. The measured water contact angle decreases significantly after oxygen plasma treatment from 99° to ca. 5°, making the surface hydrophilic [1]. Finally, the biological role of functional groups on graphenic surfaces was examined in terms of cell adhesion using the mouse fibroblast cell line (NIH/3T3). The results showed enhanced cell adhesion and spreading on the plasma-modified surface. In contrast, bacterial adhesion test suggested that the altered electronic properties, particularly the lowered work function, do not promote bacterial attachment [3]. The obtained results provide the guidelines for designing carbon-based biomaterial and illustrate the importance of tailoring the surface functional groups (chemical nature and coverage) for optimal biological response.

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FUNCTIONALIZED SILSESQUIOXANES WITH A CAGE-LIKE ARCHITECTURE AS VERSATILE BUILDING BLOCKS FOR BIOMATERIALS ENGINEERING

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Double-decker silsesquioxanes (DDSQs) and polyhedral oligomeric silsesquioxanes (POSSs) occupy an indisputable place among the group of functionalized siloxane-based compounds and find the applications in various fields, including hybrid materials [1], coordination chemistry [2], catalysis [3], etc. They throw light on the development of molecular and macromolecular organosilicon chemistry concepts. While the use of POSS in medicine has been known for years, DDSQ has not been widely exploited in this context so far. DDSQs can be used as building blocks for composited with polyvinyl alcohol (PVA) creating potential biomaterials applied for skin regeneration. The method of preparation and characterization of the hybrid biocomposites based on double-decker silsesquioxanes (DDSQs) functionalized by methacrylate derivatives and polyvinyl alcohol (PVA) will be presented. The resulting biomaterials fulfill the requirements for potential skin regeneration applications. Human fibroblasts growing on prepared hybrid composites are characterized by proper spindle-shaped morphology, proliferation and activation status similar to control conditions (cells cultured on PVA), as well as increased adhesion and migration abilities. The obtained results suggest that the prepared biomaterials could serve as an artificial skin substitute [4, 5]. The synthesized silsesquioxane-based components were characterized using ^{1}H, ^{13}C, and ^{29}Si NMR, FT-IR, HR-MS, ESI-MS, and X-ray analysis. Similarly, the obtained DDSQ/PVA biomaterials were analyzed using SEM and mechanical testing. For biological studies, we conducted cytotoxicity and proliferation assessments, immunofluorescence and cell morphology analyses, cell adhesion tests, 2D scratch assays, gelatin zymography, fibroblast activation status evaluation, and statistical analysis.

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SMART IMPLANTABLE SCAFFOLDS: BIODEGRADABLE PIEZOELECTRIC PLATFORMS FOR ENHANCED TISSUE REGENERATION

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Electric stimulation is a proven strategy for enhancing tissue regeneration and wound healing, promoting cell proliferation, migration, and differentiation [1]. Piezoelectric materials generate electric potential from internal mechanical deformation without additional wiring or electrodes, enabling localized activation. Traditional bulk ceramic piezoelectrics pose challenges due to non-biocompatibility and excessive piezoelectric properties, while micro- or nanoparticles can trigger immune responses [2]. In contrast, piezoelectric polymers like Poly-L-lactic acid (PLLA) offer a biocompatible alternative, with voltage output range mimicking natural bioelectric signals in the human body. PLLA is widely used in medical applications due to its biodegradability, biocompatibility, and favorable mechanical properties. When properly processed, PLLA exhibits piezoelectricity, making it a suitable candidate for electroactive biomaterials [3]. Experimental: PLLA was fabricated in various forms, such as tensile drawn films, electrospun nano-fibers, nanotubes on substrate via template wetting using anodized aluminum oxide (AAO). Samples were analyzed for bacterial and cell interactions, physicochemical characteristics, microstructure, and piezoelectric properties using various methodology. Results and Discussion: Our research optimized PLLA-based scaffolds by tailoring crystallinity and molecular orientation to enhance piezoelectric response. We successfully fabricated drawn [3], electrospun, and nanotextured PLLA films [4] and confirmed their piezoelectric properties. Notably, nano-texturing supports good cellular growth while also exhibiting antibacterial effect through observed enhanced piezoelectric properties [4]. These films generate insufficient potential to induce reactive oxygen species (ROS) in the liquid, ensuring their safety. Piezoelectric properties can be tuned by incorporating anisotropic biocompatible or bioactive nano-fillers, improving internal orientation and crystallinity [5]. Incorporating antimicrobial nanoparticles would add functionality to these films. Conclusion: Our results indicate that piezoelectric PLLA piezoelectric materials facilitate tissue regeneration and offer a safe implantable scaffold, making them promising candidates for biomedical applications. To further advance the field, we explore new fabrication methods to develop complex, safe and multifunctional piezoelectric scaffolds.

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MAGNESIUM PHOSPHATE-BASED DUAL-SETTING BONE CEMENT MODIFIED WITH PVA HYDROGEL FOR ADVANCED ORTHOPEDIC APPLICATIONS

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Bone cements based on magnesium phosphate (MPC) are promising materials in minimally invasive orthopedic procedures due to their bioresorbability, fast setting time, and favorable mechanical strength [1], but are limited by poor cohesion and injectability [2]. This study presents a novel MPC formulation incorporating poly(vinyl alcohol) (PVA) hydrogel and borax as a cross-linking agent to enhance clinical handling [3]. The composite cement was synthesized by mixing magnesium oxide and potassium dihydrogen phosphate (4:1 molar ratio), using aqueous PVA (1–3 wt.%) and borax (1–3 wt.%) as the liquid phase, in various formulations [4]. Cement pastes were prepared at a 2.5:1 g/mL powder-to-liquid ratio and cured at 37 °C for 24 h under >90% humidity. Physicochemical characterization included setting time (Vicat apparatus) and exothermic reaction (thermocouple), microstructure (SEM), chemical and phase composition (FTIR and XRD), compressive strength (universal testing machine), porosity (immersion technique), and qualitative injectability. Cytocompatibility was tested on human osteoblasts (hFOB 1.19) via the MTT assay after 72 h. Modified cements exhibited improved cohesion, reduced setting temperature (30.8–41.8 °C), and clinically acceptable setting time (9.2–13.2 min). FTIR/XRD confirmed the formation of k-struvite and PVA hydrogel, as well as successful components integration. Compressive strength reached 21.9 MPa (vs. 16.9 MPa for control), while porosity (14.9–17.8%) and degradation (7.2–8.7%) remained within therapeutic ranges. Enhanced injectability was noted in some tested groups. Cell viability remained high (above 94.5%), confirming biocompatibility. In conclusion, the incorporation of PVA hydrogel into MPC-based cement significantly enhances its physicochemical properties without compromising biological safety. The resulting composite holds strong potential for effective use in orthopedic and trauma surgery, particularly in minimally invasive procedures.

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MULTIFUNCTIONAL CALCIUM PHOSPHATES: MULTIDOPING AND SURFACE FUNCTIONALIZATION FOR BETTER BIOACTIVITY

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Mimicking bone chemistry is promising direction for designing biomaterials for regeneration and bone tissue engineering [1]. Ion-doped calcium phosphates resemble the mineral part of bone, as it mainly contains apatite and different trace elements which can affect bone growth and maturation [2]. Functional calcium phosphate are envisaged as balanced “cocktail of nutrients”, which slowly degrades while solubilizing doped ions from implant’s surface to stimulate bone regeneration [3]. Further advancement of these materials is expected to be obtained by integrating contact- based antimicrobials, non-leaching technologies designed to destroy microbial envelope [4-6]. As regeneration is strongly connected with preventing infection, contact-based antimicrobials are very good alternative for currently used high dosages of antibiotics.
Experimental: mHAp has been synthesized using homogeneous precipitation and dopants were integrated during the precipitation phase [1]. mHAp has been further functionalized using amino acids- functionalized AuNPs [4-6]. Testing was performed in human mesenchyme stem cells (MSCs), selected viruses and clinically isolated bacterial strains.
Results and Discussion: Physicochemical properties of mHAp are strongly dependent on doping and optimizing quantity and type of dopants can tailor HAp properties [1]. After functionalization, amino acid functionalized AuNPs are uniformly distributed over the surface of Hap [4-6]. Testing confirmed ability of mHAp to promote osteogenic differentiation of stem cells [1]. Comparison with non-doped and single-doped HAp revealed that osteogenic stimulation is dominantly high in case of multidoping. Functionalization with amino acid-AuNPs provided antimicrobial functionality [4-6]. Contact based antibacterial action had bactericidal effect in ten clinically isolated bacterial strains, including antibiotic resistant ones. In addition, the contact- based antimicrobial action was also able for inducing strong antivirus activity.
Conclusion: Multidoping is very effective approach for designing bioactivity of calcium phosphates. If combined with surface functionalization, which enables forming contact-based antimicrobial, the material obtains high functionality. In this form the material can be effectively used for decorating surface of implants with the role of promoting post-implantation integration and enabling faster recovery with reduced possibility for complications induced by infection.

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ENHANCEMENT OF CERAMIC AND CERAMIC-POLYHYDROXYOCTANOATE SCAFFOLDS THROUGH VANCOMYCIN FUNCTIONALIZATION

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Introduction: Bone infections remain a significant challenge in orthopedic surgery, necessitating the development of biomaterial scaffolds that possess inherent antibacterial properties to prevent implant failure [1]. Tricalcium phosphate (TCP) is a widely utilized biomaterial in bone regeneration due to its similarity to mineral phase of natural bone. Combining TCP with polyhydroxyoctanoate (PHO), a biodegradable polymer, offers the potential to enhance scaffold biological functionality.
The aim of the study was to evaluate the release kinetics of vancomycin and assess the bioactive potential of these scaffolds, proposing their suitability as infection-resistant bone substitutes. Methods TCP scaffolds were functionalized with vancomycin by immersing them in an vancomycin solution (3 $mg \cdot mL^{-1}$), which also contained Tween 20 (2 $g \cdot dL^{-1}$) to enhance vancomycin solubility. Subsequently, composite scaffolds (fTCP/VAN/PHO) were created by infiltrating vancomycin-functionalized ceramic foams (fTCP/VAN) with a solution of PHO (5 $g \cdot dL^{-1}$). Scanning electron microscopy (SEM) was employed to analyze scaffold microstructure, while vancomycin release profiles were quantitatively determined using HPLC-MS after incubation in simulated body fluid (SBF). Additionally, scaffold bioactivity was assessed via SEM imaging after 28-day immersion period in SBF. Results SEM analysis indicated the presence of a thin layer of Tween 20 on the surface of fTCP/VAN scaffolds, whereas evenly distributed surface depressions were visible in the PHO layer of composite fTCP/VAN/PHO scaffolds. Both scaffold types exhibited similar vancomycin release rates, releasing approximately equal amounts after 3 hours (fTCP/VAN: 525.25 ± 1.00 µg; fTCP/VAN/PHO: 518.97 ± 1.11 µg). After 120 hours, total vancomycin release from both scaffolds was comparable. The PHO coating did not significantly alter the drug release kinetics, likely due to vancomycin's low affinity for hydrophobic materials. Bioactivity evaluations confirmed apatite formation on scaffold surfaces, indicating that vancomycin functionalization preserved the scaffolds' bioactive potential.
Conclusions: The results demonstrate that both fTCP/VAN and fTCP/VAN/PHO scaffolds provide effective and rapid vancomycin release within 120 hours while maintaining essential bioactivity. Although the PHO coating did not extend or modulate the antibiotic release, alternative encapsulation strategies could potentially enhance prolonged drug delivery[2].
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DEVELOPMENT OF A NOVEL MICROWAVE-ASSISTED SYNTHESIS METHOD FOR ENZYMATIC POLYMERIZATION OF E-CAPROLACTONE AND RAC-LACTIDE

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A challenge for the modern pharmaceutical industry is to produce biomedical polymers ecologically and efficiently way. In recent years, microwave heating has received increased attention as an alternative heat source in green chemistry, as a safe and clean way to increase the temperature, with the added benefits of reported acceleration of specific reactions [1]. Notably, the combination of enzymatic polymerization with microwave irradiation appears particularly promising. In contrast to traditional metal-catalyzed polymerization, enzymatic polymerization is favored in the biomedical sector for its absence of metal contaminants, non-toxic characteristics and outstanding biocompatibility products [1], [2]. The enzymatic approach also allows milder reaction conditions, which can help preserve the functional integrity of sensitive monomers or co-initiators. In this research, we focused on the development of a microwave-assisted method for the enzymatic ring-opening polymerization (eROP) of ε -caprolactone (ε-CL) and rac-lactide (rac-LA) to produce PCL or copolymers of CL and LA P(CL-co-LA). A series of syntheses were conducted to study the impact of microwave irradiation time and power on the efficacy of the enzymatic polymerization of PCL and P(CL-co-LA). The conversion rate of ε-CL to PCL in the microwave-assisted eROP process using the bulk method reached c.a. 84%. When using toluene as the medium, 99% conversion rate was achieved. The conversion rate of ε-CL and rac-LA to P(CL-co-LA) in the microwave-assisted copolymerization process using toluene as medium was 47% for the conversion of ε-CL to P(CL-co-LA) and 30% for rac-LA to P(CL-co-LA), respectively. In all polymerization reactions, the synthesis time was significantly shorter compared to traditional heating methods. These findings highlight the feasibility of scaling up such processes for the production of biomedical-grade polymers. In the future, these approaches can prove to be an effective tool for the development of novel biomaterials based on aliphatic polyesters. This methodology may be particularly suitable for applications in controlled drug delivery, tissue scaffolding, or resorbable implants.

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CURDLAN-BASED WOUND DRESSINGS FOR THE MANAGEMENT OF INFECTED AND HARD-TO-HEAL WOUNDS

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Chronic wounds are characterized by high risk of microbial infections. Due to increasing antibiotic resistance of bacteria, it is recommended to limit topical drug application only to justified cases when there are no other alternative methods to control the infection [1]. However, in the case of infected wounds with poor vascularization, the topical administration of antibiotics appears to be preferable to intravenous administration [2]. The aim of this study was to develop curdlan/agarose-based biomaterials enriched with gentamicin (Mat_Gen) and zinc-doped nanohydroxyapatite (Mat_HAP_Zn) to prevent wound and surgical site infections. The biomaterials were produced in accordance with the procedure described in the Polish Patent no. 236367 (2021). Dressing materials were subjected to microstructural characterization, cytotoxicity test against human skin fibroblasts, and microbiological experiments using Staphylococcus aureus and Pseudomonas aeruginosa strains. Moreover, severely infected chronic wound in a veterinary patient was treated with the use of Mat_Gen. Both fabricated biomaterials were characterized by a highly porous microstructure, high plasma absorption capacity, and optimal water vapor transmission rate. Produced dressing materials were non-toxic to human skin fibroblasts and exhibited strong bactericidal activity against S. aureus. However, only Mat_Gen showed bactericidal effect against P. aeruginosa. Importantly, it was also proven that Mat_Gen was effective in the treatment of severely infected wound in the pygmy hedgehog who underwent enucleation surgery (the removal of the eye) due to a severe injury to the cornea. To fight the bacterial invasion, Mat_Gen was used as an implantable sponge and the wound was sutured. The complete skin healing process and scar formation was observed on the 14th day of treatment, proving effectiveness of Mat_Gen as an implantable material for the treatment of chronically infected wounds [3]. It was concluded that biomaterial enriched with gentamicin possesses great potential to be used as a dressing material or implantable sponge for the treatment of chronically infected wounds and surgical site infections. In turn, the zinc-loaded biomaterial may be used as a wound dressing to reduce and prevent microbial contamination.

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MOLECULAR INSIGHTS INTO IBUPROFEN NANOPARTICLES DECORATION OF POLYMERIC IMPLANTS

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Polymeric implants offer a versatile platform for biomedical applications due to their tunable chemical adaptability, mechanical properties, and biocompatibility. Among them, polyurethane (PU) has gained prominence for its flexibility, durability, and ability to undergo surface modifications to enhance bioactivity [1, 2]. A key challenge in polymer-based implants with drug delivery functions is achieving controlled drug release, governed largely by surface-drug interactions. This study investigates molecular-level interactions between ibuprofen nanoparticles and plasma-modified PU surfaces using Molecular Dynamics (MD) simulations. Ibuprofen, a common nonsteroidal anti-inflammatory drug (NSAID), is incorporated into polymeric implants to provide localized and sustained anti-inflammatory effects, minimizing side effects. However, the efficiency of drug loading and release kinetics depends critically on the physicochemical characteristics of the polymer surface [3, 4]. Oxygen plasma treatments were employed to functionalize PU surfaces, introducing oxygen-containing functional groups (-OH, C=O). Experimental characterization techniques (AFM, XPS, ATR) confirmed successful surface modifications, while MD simulations provided molecular-level insights into the events at the drug-polymer interface. MD simulations, conducted using the GROMACS package, revealed distinct adsorption behaviors and penetration dynamics of ibuprofen and solvent molecules on pristine and oxygen-plasma-treated PU surfaces. The presence of oxygen-containing groups enhanced ibuprofen adsorption via hydrogen bonding and dipole-dipole interactions. Additionally, simulations demonstrated that ibuprofen molecules penetrate the polymeric surface, altering the local environment and potentially influencing drug release kinetics. The diffusion of ibuprofen depended on the hydration level and functionalization degree, suggesting that surface chemistry dictates drug binding strength, penetration depth, and mobility, which are critical for controlled drug release. This study highlights the role of molecular simulations in predicting and optimizing drug-polymer interactions, paving the way for the rational design of polymeric implants with tailored drug delivery properties. Integrating computational and experimental approaches provides a comprehensive framework for advancing functionalized polymeric implants in biomedical applications.

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FUNCTIONALIZED POLYSACCHARIDES AS CROSSLINKING AGENTS FOR HYDROGEL MATERIALS: A NOVEL APPROACH TO CHITOSAN NETWORKS

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Chitosan-based hydrogels have gained considerable attention due to their biocompatibility, biodegradability and tunable physicochemical properties, making them attractive candidates for biomedical applications such as tissue engineering, drug delivery and wound healing. A critical factor influencing the performance of chitosan hydrogels is the crosslinking process, which determines their mechanical strength, stability and overall functionality. The choice of a crosslinking agent plays a pivotal role in defining both the material properties and its biocompatibility.Traditionally, aldehydes such as glutaraldehyde have been widely used as a crosslinking agent due to their efficiency in forming stable networks. However, their cytotoxicity poses a significant limitation for biomedical applications [1,2,3]. To address this challenge, we propose an alternative crosslinking strategy based on the functionalization of polysaccharides, including chitosan, dextran, furcellaran, gellan gum and xanthan gum. These polysaccharides were oxidized using sodium (meta)periodate to introduce aldehyde groups, enabling Schiff-base crosslinking with chitosan. This approach eliminates the need for cytotoxic agents while providing a tunable and sustainable method for designing advanced hydrogel materials with tailored properties. Following crosslinking, all hydrogel materials were freeze-dried to obtain highly porous three-dimensional scaffolds. The resulting hydrogel scaffolds were extensively characterized in terms of their chemical structure (FTIR spectroscopy), microstructure (SEM imaging and µCT tomography), porosity, mechanical properties, stability, swelling behavior, *in vitro* mineralization and cytocompatibility with human normal tracheal fibroblasts (Hs680.Tr). Our findings indicate that this novel crosslinking approach enables the fabrication of stable, cytocompatible hydrogel scaffolds with adjustable properties, including porosity, mechanical strength and *in vitro* stability. These characteristics enhance the potential of the scaffolds for applications in tissue engineering and regenerative medicine.

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PULMONARY-DELIVERED FORMULATIONS OF ANTIBIOTICS AND QUORUM SENSING INHIBITORS FOR THE TREATMENT OF LUNG INFECTIONS

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Drug delivery systems (DDS) play an important role in disease management and treatment. They are engineered to provide accurate tissue targeting and controlled release of active pharmaceutical ingredients (APIs) to the defined place in the body to minimise systemic exposure. Recent DDSs often consist of nanometric or micrometric-size objects in which API is encapsulated within a biocompatible shell, providing protection against degradation, loss of biological activity, and ensuring controlled API release [1]. Polyanhydrides, which degrade through surface erosion, are excellent candidates to produce such advanced DDS.

In our group, we are working on polyanhydride DDS of antibiotics and quorum sensing inhibitors for the treatment of bacterial infections in patients with chronic obstructive pulmonary disease (COPD) or cystic fibrosis (CF) exacerbations. Such DDSs have a form of microparticles made of poly(sebacic acid) derivatives loaded with antibiotics (gentamycin, tobramycin, and azithromycin) and quorum-sensing inhibitors (curcumin, linolenic acid). We found that linoleic acid used in combination with different antibiotics, particularly gentamycin, could reduce their doses up to 32 times and fight drug-resistant bacteria in the biofilm [2]. The microparticles are designed to ensure a suitable size for inhalation (aerodynamic diameter in the range of 1-5 μm), degrade in a few days and release drug cargo, which is capable of killing pathogenic bacteria and preventing biofilm formation [3]. The system is cytocompatible with lung epithelial cells, as shown by *in vitro* tests, and histocompatible with lung tissue, as shown by *ex vivo* tests in a rodent model [4].

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THE STRATEGY OF EPIGENETIC DEREPRESSION FOR ACTIVATION OF ENDOGENOUS REGENERATIVE POTENTIAL

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Introduction: Regeneration is vital to life, and multicellular organisms possess endogenous potential to regenerate. Impressive regenerative capability observed in the embryonic and neonatal stages and its decline with development and age suggests epigenetic repression of genes needed in effective regenerative response [1, 2]. Moreover, conditions decreasing regenerative abilities, like diabetes, are often associated with epigenetic aberrations [3]. This incites a question as to whether the reversal of such epigenetic alterations, permanent or transient, can revive the suppressed endogenous regenerative potential. Epigenetic drugs can be pharmacological tools that induce epigenetic repatterning, thus enhancing regenerative response.
Materials and methods: The model of the 2-mm excisional wounds in the mouse ear pinna was applied to determine the pro-regenerative effects of pharmacological treatment. The regenerative effect corresponding to the degree of ear pinna hole closure is straightforward to track. The model allows observations of regenerative responses in different cells and tissue types as the ear pinna is a complex tissue of skin, cartilage, and muscles supplied with dense networks of blood vessels and nerve fibres [4].
Results: Systemic administration of zebularine, a DNA methyltransferase inhibitor, resulted in a significant ear pinna hole closure. DNA demethylation and transcriptional activation of pluripotency and neurodevelopmental genes were determined in regenerating tissues. Histological examination demonstrated the restoration of structures resembling normal ear pinna architecture [5]. Immunofluorescence revealed extensive growth of nerves and vessels [4, 6]. Combining zebularine and retinoic acid, a potent transcriptional regulator, accelerated regeneration, resulting in almost complete wound closure [5]. Several more small-molecule epigenetic regulators, including bioflavonoids, showed promising responses in ear pinna wounds.
Conclusions: Successful induction of ear pinna hole closure based on epigenetic derepression delineated a novel pharmacological strategy. The synergistic effect of retinoic acid demonstrated that signaling molecules can augment the regenerative response after applying epigenetic derepression. The next question and step are to orchestrate the epigenetic derepression with signaling molecules capable of channeling the regenerative process to specific cells and tissues.

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LOCAL VENTRICULAR ASSIST DEVICE INFECTIONS - STATE OF THE ART

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Introduction: Despite heart transplantation remaining the gold standard for treating heart failure, the limited availability of heart donors, combined with the increasing number of recipients and patients suffering from heart failure, forces the use of mechanical circulatory support (MCS) devices [1]. Ventricular assist devices (VADs) have significantly improved survival rates and quality of life in patients with end-stage heart failure [2]. However, they are still associated with severe complications, particularly local infections at percutaneous access sites. These infections pose a critical challenge in MCS therapy and remain a significant cause of morbidity and mortality [3, 4]. Materials and Methods: Infections related to MCS occur primarily at two key sites: the cannula exit sites in pulsatile paracorporeal pumps (I generation VADs) and the driveline exit sites in fully implantable continuous-flow pumps (II and III generation VADs). The way the cannula or driveline exits the body through the skin necessitates the use of a specialized fabric covering. This material promotes tissue ingrowth, enabling the replacement of fibrin-platelet clots with granulation tissue and, at a later stage, collagen [5]. This process helps isolate the cannula exit site from the external environment and prevents infections from penetrating beneath the skin. These infections are among the most serious complications of MCS, often leading to necrosis, systemic infections, and increased mortality [6, 7]. Results: Clinical data indicate that the risk of local infections increases with prolonged MCS support duration [8, 9]. Moreover, the growing resistance of pathogens, particularly Staphylococcus epidermidis and Staphylococcus aureus, to antibiotic therapies further complicates treatment and increases healthcare costs [10]. These infections frequently necessitate rehospitalization, additional treatments, or even reoperations, contributing to the overall burden of LVAD therapy. Conclusions: Despite advances in antimicrobial therapies, an effective solution to eliminate driveline infections has not yet been found. Addressing this issue requires the development of innovative, biocompatible solutions aimed at reducing infection risks. Future research should focus on enhancing the biocompatibility of VAD's components and minimizing bacterial colonization to improve long-term outcomes in MCS patients.

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EVALUATION OF THE MECHANICAL PROPERTIES OF BIOMIMETIC BONE MODELS

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Modern biomedical engineering advances technologies that replicate biological structures, including bone tissue. Biomimetics focuses on developing models that mimic natural bone properties, with applications in medical education, surgical training, preoperative planning, and biomaterial testing. This study evaluates the mechanical properties of biomimetic bone models produced using 3D printing with Digital Light Processing (DLP) technology. The research involved compressive strength, three-point bending, and bone screw pullout tests to assess mechanical resistance, alongside macroscopic and microscopic analyses to evaluate structural accuracy. The results showed that model properties depend on internal structure and porosity. Higher-density models exhibited greater strength but lower flexibility, increasing brittleness under load. Trabecular-like structures absorbed energy efficiently but had lower overall strength. Bone screw pullout tests revealed that denser models provided better implant stability, while porous models were prone to screw loosening. DLP-printed models accurately replicated anatomical details, though some showed microcracks and uneven material distribution, affecting performance. Findings confirm that 3D printing with DLP technology effectively produces biomimetic bone models with properties similar to natural bone. Adjusting printing parameters optimizes mechanical characteristics based on application needs. Biomimetic bone models have significant potential in medical education, surgical training, and preoperative planning. They enhance learning by enabling realistic simulations without the need for live subjects. Additionally, they provide a controlled environment for biomechanical research and implant testing. In conclusion, 3D-printed bone models successfully replicate natural bone properties, making them valuable for future research and applications in biomedical engineering and medicine.

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BIOCOMPATIBLE, NANOCOMPOSITE BIOMATERIAL WITH ANTIBACTERIAL ACTIVITY AND OPTIMAL BIODEGRADABILITY IN THE TREATMENT OF SMALL BONE DEFECTS

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Composite biomaterials consisting of ceramic and polymer phases became the leading type of materials in bone tissue regenerative medicine [1]. Additionally, the biomaterial should be characterized by optimal microstructural properties and biodegradability. Nevertheless, postoperative infections and prolonged inflammation pose a serious threat that complicates the regeneration of bone defects [2]. The aim of the research was to produce a nanocomposite granulate with antibacterial properties without cytotoxicity towards eukaryotic cells. The biomaterial consisted of nanohydroxyapatite and a polymer matrix of agarose and chitosan. Immobilization of thymol (by physical adsorption) in the granules was intended to provide antimicrobial properties. The cytotoxicity of the material was tested according to ISO 10993-5:2009 standard and in direct contact with granulate after Live/Dead staining. Moreover, parameters such as porosity, specific surface area (SSA), biodegradability and bioresorbability were determined. The antibacterial activity of the biomaterial with thymol was assessed in direct contact according to OECD standard no. 202, JT03360420. In addition, the effect of the material on biofilm formation was specified. The results of the study showed that the developed biomaterials were non-toxic to mouse pre-osteoblasts (MC3T3-E1) and supported their adhesion to the surface. The granules were also characterized by high porosity and relatively high SSA. Moreover, the materials degraded faster in solution simulating the environment created by osteoclasts in the process of bone resorption. The biomaterial was also bioresorbed with the participation of cells such as human osteoblasts (hFOB 1.19), mouse preosteoblasts (MC3T3-E1), and mouse macrophages (RAW 264.7) [3]. Direct contact microbiological tests demonstrated high antibacterial activity of thymol-loaded granules against *E. coli, P. aeruginosa* and *S. aureus* bacteria. Additionally, based on the biofilm formation assay, significantly more red fluorescent (dead) bacterial cells were observed on the surface of the biomaterials with thymol compared to the control. The results of the study suggest that the produced biomaterials have high application potential. However, further studies, including in vivo, are necessary to confirm the safety and effectiveness of the granules in bone tissue regeneration.

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PHOTOACTIVE BIOCOMPATIBLE MATERIALS FOR ANTIBACTERIAL SURFACE COATINGS

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Introduction: The increasing prevalence of multidrug-resistant (MDR) bacterial infections in hospital environments necessitates innovative antimicrobial strategies. Medical implants and hospital surfaces act as reservoirs for bacterial contamination, increasing the risk of healthcare-associated infections. Photodynamic inactivation represents a promising strategy by utilizing photosensitizers (PS) activated by light to generate reactive oxygen species (ROS), leading to bacterial inactivation. The aim of this study is to develop biocompatible, photodynamically active surface coatings capable of providing long-term antibacterial protection for medical devices and hospital surfaces [1-3].
Materials and Methods: A series of porphyrin-based photosensitizers were synthesized and characterized for their chemical and antimicrobial properties. The PS derivatives were functionalized with different substituents to optimize their ROS generation, photostability, and bacterial selectivity. The PS were incorporated into various materials, including semiconductors and polymers. Antimicrobial efficacy was assessed against Gram-positive (S. aureus) and Gram-negative (E. coli) bacteria, with both planktonic and biofilm forms. The extent of bacterial inactivation was quantified via colony-forming unit (CFU) assays, live/dead fluorescence microscopy, and scanning electron microscopy (SEM).
Results: Optimized porphyrin-based materials exhibited superior antimicrobial efficacy, achieving up to 7-logs reduction in bacterial viability under low light doses. The incorporation of synthetized porphyrins into TiO_2 nanoparticles resulted in enhanced photocatalytic activity through the enhanced ROS generation. The coatings maintained their antimicrobial effectiveness over repeated activation cycles, confirming their long-term stability. Furthermore, biocompatibility tests performed on mammalian cells confirmed the non-toxic nature of the developed materials.
Conclusions: This study presents a robust and clinically relevant approach to preventing MDR bacterial infections using photodynamically active surface coatings. The developed materials provide a versatile platform for antimicrobial applications in implantable medical devices, surgical instruments, and high-risk hospital surfaces. These coatings offer long-term, light-activated bacterial protection without promoting antibiotic resistance, making them a valuable addition to infection control strategies.

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THE PH-RESPONSIVE BONE IMPLANT BASED ON A ZEOLITE-CHITOSAN-BISPHOSPHONATE COMPLEX FOR POTENTIAL BIOMEDICAL APPLICATIONS IN OSTEOPOROTIC FRACTURE REPAIR – IN VITRO STUDY

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Osteoporosis is a bone disease characterized by a decrease in bone density and mass, making bones more fragile and susceptible to fractures. Bisphosphonates are a class of drugs primarily used to treat osteoporosis that prevent the loss of bone density [1]. The aim of this study was to develop a smart, pH-responsive zeolite-chitosan-bisphosphonate complex-based bone implant for osteoporotic fracture repair. Zeolite was used as a carrier for bisphosphonate (risedronate sodium), which was incorporated into the zeolite structure using chitosan molecule as a pH 4-soluble linker. The production method of the pH-responsive zeolite-chitosan-bisphosphonate complex is described in Polish patent application no. P.449563. Wheraes bone implant containing the zeolite-chitosan-bisphosphonate complex was produced based on Polish patent application no. P.449565. Surface topography of the fabricated bone implant was visualized using a stereoscopic microscope and a scanning electron microscope. Stability and pH-responsive behaviour of zeolite-chitosan-bisphosphonate complex in bone implant were determined using PBS at pH 7.4 and citrate buffer at pH 4.0, respectively. The biological properties of the fabricated bone implant, including cytotoxicity (MTT assay, fluorescent staining), hemocompatibility, cell proliferation (fluorescent staining of the cytoskeleton), and osteogenic differentiation (ELISA, immunofluorescent staining of osteogenic markers), were evaluated under in vitro conditions. The obtained results showed that the developed novel, pH-responsive bone implant has a macroporous microstructure with high surface roughness. It was proven that the bonding between zeolite and risedronate sodium in the complex is pH-responsive, as it remains stable at physiological pH 7.4, while chitosan dissolves at pH 4, releasing the drug into the environment. Moreover, the developed bone implant is highly biocompatible, hemocompatible, and osteoconductive. Based on obtained results it may be concluded that developed bone implant is a promising candidate for use as a smart bone implant for osteoporotic fracture treatment that would release the bisphosphonate in a controlled way only in the case of excessive bone resorption process as a result of microenvironment acidification. The implant can reduce osteoclast activity and thus promote bone formation process.

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BIFUNCTIONAL SMART CURDLAN-BASED BIOMATERIAL CONTAINING A PH-SENSITIVE ZEOLITE/CHITOSAN/BISPHOSPHONATE COMPLEX AS A POTENTIAL BONE IMPLANT FOR THE OSTEOPOROTIC FRACTURES TREATMENT

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Osteoporosis is the most common systemic metabolic bone disease in the course of which the reduction in bone mass results from the excessive activity of osteoclasts, therefore bone resorption processes predominate over its formation [1]. With the aging of our societies, the number of patients suffering from osteoporosis is likely to increase. Unfortunately, existing therapeutic strategies are often burdened with a number of troublesome side effects. In the case of osteoporotic fractures, ideally, implant should inhibit osteoclasts activity, and thus bone repsorption process. [2]. The presented bone implant consists of a pH-sensitive zeolite-chitosan-bisphosphonate complex (CaMg-X-chitosan-risedronate sodium), zeolite X functionalized with chitosan (CaMg-X-chitosan), hydroxyapatite granules, and curdlan. The production method of the complex: patent application no. P.449563. The production method of the smart biomaterial: Polish patent application no P.449566. Surface topography of the biomaterial was visualized using a stereoscopic microscope and a scanning electron microscope. Stability and pH-responsive behaviour of the complex in bone implant were determined using PBS at pH 7.4 and citrate buffer at pH 4.0, respectively. The biocompatibility in vitro was evaluated using normal human fetal osteoblast cell line (hFOB 1.19, ATCC-LGC Standards, UK). Biological safety of the implant was tested according to ISO 10993-5. Osteoblast viability on the biomaterial surface was confirmed by LIVE/DEAD staining. CLSM observation after fluorescent staining of the cytoskeleton with AlexaFluor®635 phalloidin and cell nuclei with DAPI was used to qualitatively assess cell proliferation, while osteogenic differentiation was evaluated under in vitro conditions by ELISA and immunofluorescent staining of osteogenic markers. Produced implant seems to be a promising candidate for osteoporotic fracture treatment. It is nontoxic and it supports cell proliferation. Moreover, it has high surface roughness that favors osteoblast adhesion. Live/Dead staining demonstrated that osteoblasts grown on the surface of the implant were well-spread, revealed normal morphology and were viable. Its ability to release an anti-osteoporotic drug in response to acidified microenvironment seems to be crucial in effective inhibition of excessive osteoclast activity.
Acknowledgements: This research was funded by the National Science Centre in Poland within OPUS 22 grant no. UMO-2021/43/B/NZ7/00447.

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DUAL ROLE OF ZINC IN OSTEOBLASTS CHARACTERIZED BY ENHANCED MINERALIZATION AND ANTIBACTERIAL ACTIVITY

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Zinc ions (Zn^{2+}) are essential for osteoblast function and bone tissue regeneration, as they stimulate differentiation and enhance alkaline phosphatase activity (ALP) [1]. However, zinc can induce mitochondrial dysfunction and oxidative stress at higher concentrations, leading to impaired osteogenesis [2]. Alpha-lipoic acid (α-LA) and its derivative lipoamide (LAM) are potent mitochondrial antioxidants that support osteoblast viability by improving redox balance and cellular energy metabolism [3]. Understanding the dual role of zinc in osteoblast metabolism is key for optimizing surface modifications of titanium-based implants. The model for the study was a culture of human hFOB 1.19 osteoblasts and primary osteoblastic cells (POB) obtained from a patient. Cells were cultured under control conditions and in medium to which zinc chloride ($ZnCl_2$), LAM, and α-LA were added at 100–200 μmol/L. Subsequently, cell survival was examined, along with the activities of enzymes involved in citrate metabolism, alkaline phosphatase, and lactate dehydrogenase (LDH). Adding $ZnCl_2$ to cell cultures at a concentration of 200 μmol/L resulted in a significant decrease in mitochondrial enzyme activities, leading to cell death. Reducing the Zn concentration to 150 μmol/L caused a reduction in the total cell number by about 50%. However, citrate levels were markedly increased, contributing to enhanced intracellular mineralization, as evidenced by Alizarin Red staining. Moreover, the activity of citrate lyase was assessed in osteoblastic cells for the first time. The transport of citrate appeared to be unaffected under our experimental conditions, as citrate lyase activity remained unchanged. These results indicate that α-LA protects osteoblasts from the cytotoxic effects of zinc by enhancing mitochondrial activity. On the other hand, zinc promotes osteoblast differentiation by modulating citrate metabolism.

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POSTERS

POSTER 1
MAGNESIUM-BASED ZEOLITE FILLERS WITH CIPROFLOXACIN: A PROMISING ANTIBACTERIAL FILLER FOR DENTAL COMPOSITES

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A magnesium-based zeolite filler was synthesized and modified with ciprofloxacin (CF) to enhance resin-based dental composites. CF is highly effective against oral bacteria, including the highly cariogenic Streptococcus mutans [1], while magnesium ions can act as both an antimicrobial and anti-inflammatory agent [2]. Our previous studies have highlighted the potential of such porous fillers in dental composites as an active crosslinking filler [3] or remineralizing fillers capable of releasing calcium ions [4-6]. The study aimed to develop a composite with antibacterial properties while maintaining essential physicochemical characteristics for dental applications. The zeolite filler was prepared via ion exchange, replacing sodium with magnesium, followed by CF adsorption and thoroughly characterized. The fillers were then mixed with a methacrylic resin matrix and polymerized to form the composites. The composites' physicochemical properties were evaluated, including degree of conversion (DC) using FTIR spectroscopy, depth of cure (DOC) following ISO 4049, compressive strength (CS) and flexural strength (FS) with the use of universal testing machine, water sorption (SP), solubility (SL) through mass changes after incubation in water, and magnesium release using atomic absorption spectroscopy. Also antibacterial properties were tested against S. aureus and E. coli. Results showed that the CF-loaded composite had a DC above 70%, slightly higher than the control (magnesium composite). DOC exceeded 1.5 mm, meeting ISO 4049 standards. CS of both composites was above 200 MPa, while FS exceeded 55 MPa, ensuring adequate mechanical performance. The composites showed high SP, exceeding 50 μg·mm-3, but SL remained within safe thresholds, i.e. below 7.5 μg·mm-3. Both composites released magnesium ions over 28 days in artificial saliva and demineralizing solution, supporting potential remineralization and antibacterial effects. Antibacterial tests showed the reduced viability of E. coli, while CF-loaded composite exhibited also the bactericidal activity against S. aureus. In conclusion, CF-loaded magnesium zeolite enhanced antibacterial properties while maintaining acceptable mechanical performance. These results indicate that CF-loaded magnesium zeolite fillers could be promising for antibacterial dental restorations.

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POSTER 2
PLATELET-DERIVED GROWTH FACTOR AND ITS PEPTIDE DERIVATIVE FOR REGENERATIVE APPLICATIONS

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Chronic wounds, e.g. diabetic ulcers, constitute a huge challenge for modern medicine. Available methods are not fully effective in their treatment which creates a high demand for new solutions including bioactive molecules, wound dressings, biomaterials, stem cells and 3D-bioprinting products. Nowadays, a lot of attention is paid to cell therapies in regenerative medicine. However, the results of clinical trials utilizing cell therapies for wound stimulation are not fully satisfactory. Therefore, new methods for increasing their pro-regenerative activities are needed. One of the methods is cell pre-conditioning with bioactive molecules like growth factors or peptides. Platelet-derived growth factor (PDGF-BB) was the first growth factor participating in wound healing to be identified and purified. It is one of the strongest stimulators of the process. PDGF-BB is secreted from the first hours after injury till the wound closure. It acts as mitogen for keratinocytes, fibroblasts and endothelial cells. PDGF2 is a peptide derivative of PDGF-BB. It shows a favorable safety profile, pro-regenerative properties and stimulates wound healing in vivo. PDGF2 could be utilized in regenerative medicine as a component of the hydrogel wound dressing. In this work the effect of PDGF-BB and PDGF2 on the activity of human primary skin cells was analyzed. Cell proliferation was checked with EdU and XTT methods and the effect on collagen synthesis, chemotaxis and migration was evaluated. The results indicate that both PDGF-BB and PDGF2 may be used for pre-conditioning of skin cells (keratinocytes or fibroblasts), therefore the pre-stimulated cells potentially could be used for preparation of 3D-bioprinted hydrogel wound dressing.
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POSTER 3
CAN PEPTIDE HYDROGELS BE UTILIZED FOR CULTURING CELLS PARTICIPATING IN SKELETAL MUSCLE RECONSTRUCTION?

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Skeletal muscles play a vital role in motor function but can suffer damage due to trauma, excessive physical exertion, or pathological conditions. Effective regeneration is essential for proper recovery. However, the number of resident stem cells in skeletal muscle is limited and declines with age or disease, which can impair tissue regeneration and lead to severe complications. [1, 2]. One promising approach to enhancing muscle repair involves the use of biomaterials, which can support skeletal regeneration and functional restoration [3]. In this study, we introduce eight self-assembling peptide hybrid hydrogels designed to support the viability of myoblasts and HUVECs. These peptide scaffolds are based on the RADA16-I hydrogel and incorporate bioactive peptide motifs through a metalloproteinase-cleavable sequence. We characterized the structural, chemical, and physicochemical properties of these hydrogels using various analytical techniques, including CD, AFM, TEM, and cryoSEM. Additionally, we examined their behavior in selected physiological fluids. In vitro experiments were conducted to assess their effects on human myoblast and HUVEC proliferation, apoptosis, and differentiation.

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POSTER 4
MODIFICATION OF TITANIUM ALLOY SURFACE VIA PLASMA ELECTROLYTIC OXIDATION

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The implantology field is dynamically developing, which requires researchers to search for new solutions. Titanium alloys are highly valued in the medical industry for their good biocompatibility, strong osseointegration, and non-toxic nature [1, 2, 3]. The reported success rate of cases managed with custom 3D-printed titanium implants is 87% [4]. While the surface treatment of conventionally made implants is widely researched, this study focuses on analyzing the surface of 3D printed titanium alloy. The samples underwent the PEO, and were subjected to SEM, EDX, wettability XPS, cross-section, Raman and biological trials analysis. Results suggest, that while the conditions of the PEO are slightly different for conventionally made samples and 3D printed ones, they present with similar surfaces, which makes the 3D printed alloy a promising material for implants use.

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POSTER 5
IN-VITRO EVALUATION OF THE TENSILE AND FATIGUE BEHAVIOR OF AZ31 MAGNESIUM ALLOY TREATED WITH HYBRID FLASH-PEO/SOL-GEL COATING SYSTEMS FOR BIOMEDICAL APPLICATIONS

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Magnesium alloys exhibit excellent mechanical properties and biocompatibility for applications in osteosynthesis and bone regeneration. However, their high degradation rate prevents their wider use in this field. The application of coatings on the surface of the alloys can allow control of their degradation rate to match the bone regeneration rate, avoiding the failure of osteosynthesis treatments due to premature loss of mechanical integrity of the implant. In this research, single-layer and hybrid coatings were generated on the surface of AZ31 magnesium alloy substrates by combining coatings obtained by plasma electrolytic oxidation (flash-PEO) and sol-gel techniques. The protection offered by the coatings, as well as their ability to preserve the mechanical integrity of the metallic substrate, were evaluated in-vitro by immersing the samples in circulating Hanks' solution, maintaining constant temperature and pH of the solution at 37°C and 7.4, respectively. Over a month, after each week of immersion, the degree of degradation and the tensile and fatigue resistance of each coating condition were studied. It was observed that the application of these coatings, especially hybrid PEO/sol-gel coatings, delays the onset and extent of degradation in the metallic substrates, maintaining their strength and mechanical integrity for a longer time. Thus, the application of these coating treatments would enable control of the degradation rate of biodegradable magnesium alloy implants, allowing more widespread use of these materials in bone repair applications.

POSTER 6
DUAL-CROSSLINKED CHITOSAN HYDROGELS AS ADVANCED BIO-INKS IN 3D PRINTING

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Hydrogel materials are widely used in tissue engineering due to their high water content, biodegradability and ability to mimic the extracellular matrix [1]. Additive manufacturing enables innovative implant creation using biomaterials as bio-inks, allowing 3D printing of specialized scaffolds for tissue engineering [2]. However, the limited availability of materials with suitable printability restricts the broader applications of this technology. In this study, chitosan hydrogel materials were developed, crosslinked with oxidized dextran and enriched with high-calcium bioactive A2 glass obtained via the sol-gel method. The composition of A2 glass included 40 mol% SiO_2, 54 mol% CaO and 6 mol% P_2O_5. The aim was to optimize the composition of these hydrogels by changing the concentrations of biopolymer, crosslinker and bioactive glass. Additionally, the selected hydrogels were characterized based on key rheological parameters, while the stability of printed structures was evaluated in simulated physiological conditions (incubation in SBF solution). The results showed that the developed hydrogel materials exhibit significant potential for extrusion-based 3D printing. The hydrogels successfully enabled the printing of well-reproduced structures, demonstrating high stability in a simulated physiological environment. Nonetheless, to fully assess their potential in tissue engineering, including cell encapsulation to obtain bio-inks, further in-depth studies are necessary.

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POSTER 7
MODIFICATION OF TI13NB13ZR ALLOY SURFACE BY PLASMA ELECTROLYTIC OXIDATION AND SILVER NANOPARTICLE DEPOSITION

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The dynamically developing field of implantology is continuously seeking innovative solutions aimed at improving the quality of life and health of patients. One of the pressing issues is the elimination of post-surgical bacterial infections at the implant site [1]. One of the ways to reduce the chances of postoperative complications is by preparing the implant surface and coating it with a bacteriostatic and/or bactericidal layer. Plasma electrolytic oxidation (PEO, MAO) is a well-known technique for producing porous oxide coatings that bond well with bone (osseointegrate) on titanium and its alloys [2]. Additionally, the porous oxide structure is capable of adsorbing individual particles, particle aggregates, or crystals onto its surface, offering an interesting alternative to traditionally coated implant surfaces. One of the promising research directions is the incorporation and deposition of silver nanoparticles, which exhibit bactericidal properties [3]. In the presented study, the surface of the Ti13Nb13Zr alloy was ground, sandblasted (grain size 80 μm, Al_2O_3), etched in a 10% (w/w) oxalic acid solution, degreased, and electrochemically oxidized in the PEO process using phosphoric acid (V) solution at 250V and a current density of 100 mA/cm². Silver nanoparticles were gravitationally deposited onto the samples in the form of a suspension (0.125, 0.250, and 0.500 g/l) in an aqueous solution. The surface was examined using scanning electron microscopy (SEM), a goniometer, and energy-dispersive X-ray spectroscopy (EDX). Biocompatibility tests were conducted using human dermal fibroblasts (HDF), and bacteriostatic and bactericidal properties were evaluated by examining colony growth. The research has found, that while AgNPs may inhibit bacterial growth in the initial phase, the long term effects may not be sustainable. There were no adverse effects on biocompatibility of samples treated with AgNPs compared to untreated ones.

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POSTER 8
SURFACE MODIFICATION OF BIODEGRADABLE 3D IRON-BASED SCAFFOLDS FOR ORTHOPEDIC APPLICATIONS

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Orthopedic implants made from titanium or stainless steel are widely used due to their high mechanical strength and stability within the body. However, their durability, advantageous in many applications, can become problematic for temporary implants, such as those used in pediatric cases or fracture treatments. After the bone regeneration process is complete, these implants remain in the patient's body, potentially causing health complications. Often, an additional surgical procedure is required to remove the implant. Therefore, biodegradable materials should be considered for temporary implants. Iron is a material with significant potential in this context, combining favorable mechanical properties with a controllable rate of biodegradation. [1,2] Implants made of iron gradually dissolve within the body, with degradation rates adjustable to match the bone regeneration process. To accelerate degradation and enhance regeneration, doping with other metals or surface modifications can be applied. [3] This paper presents the results of studies on the synthesis and characterization of porous 3D iron scaffolds and the deposition of hydroxyapatite coatings on their surfaces using cathodic deposition. The influence of process conditions on the structure and physicochemical properties of the hydroxyapatite (HAp) coatings was analyzed. Material characterization included morphological analysis (SEM), chemical composition analysis (EDS), phase analysis (XRD), and infrared spectroscopy (FTIR). Scaffold degradation tests were also conducted in simulated body fluid (SBF), comparing systems with and without hydroxyapatite coatings. The obtained results provide a better understanding of the influence of the HAp coating on the degradation properties of iron scaffolds, which may significantly impact the further development of biodegradable orthopedic implants. Additionally, the fabricated scaffolds were tested in vitro to evaluate cytotoxicity.

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POSTER 9
EVALUATING MATERIAL QUALITY IN ORTHODONTICS: IMPACT OF KOMBUCHA ON ORTHODONTIC BRACKETS

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A growing number of patients are deciding to undergo orthodontic treatment, motivated not only by esthetic aspects. Fixed braces, made mainly of stainless steel [1], remain the leading method for correcting complex smile defects. Most market-available brackets are produced using Metal Injection Molding (MIM), which offers good dimensional accuracy and excellent mechanical properties [2]. The oral cavity is an aggressive environment for metals due to a lot of floating factors. Fermented food, despite its health benefits [3], negatively affects metal components in the oral cavity. Orthodontic materials should ensure minimal bacterial and food adhesion alongside appropriate mechanical properties. This study aimed to evaluate the quality of commercially available orthodontic brackets compared to MIM-manufactured samples with simple shapes. The focus was on the surface quality of the samples. SEM observations and confocal microscopy were used. The impact of long-term contact of orthodontic brackets with kombucha was also examined. Materials included MIM technology samples and commercial brackets placed in kombucha at 37°C for 14 days. Some samples were also attached to extracted human teeth. pH measurements and acetic acid content in kombucha were assessed before and after sample removal. Microscopic observations revealed subpar surface quality of commercial orthodontic brackets, with numerous pores and irregularities, increasing significantly after kombucha exposure. This indicates MIM allows for favorable physicochemical properties [4], but not sufficient for small and complex shapes like orthodontic brackets. The presence of pits poses risks for patients due to metal ion release [4], especially Ni and Cr ions, known for causing allergies [5]. Continuous research on dental materials under various conditions is essential to improve surface quality in dynamic environments.

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POSTER 10
ALDEHYDE-FUNCTIONALIZED HYALURONIC ACID AS AN INNOVATIVE CROSSLINKING AGENT FOR CHITOSAN-BASED HYDROGELS

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Hyaluronic acid is widely used in biomaterial engineering, particularly in regenerative medicine and drug delivery systems due to its biocompatibility, water-binding ability and interaction with cells. Its aldehyde-functionalized derivatives can effectively act as crosslinking agents of other polysaccharides which is crucial for formation of hydrogels [1], among which, chitosan-based hydrogels have particular significance. Chitosan is a natural biopolymer with antibacterial and biodegradable properties that is capable of forming stable gel structures, making it an attractive material for biomedical applications [2]. The study focused on chitosan-based hydrogel materials crosslinked with aldehyde-functionalized hyaluronic acid. The aim of the research was to optimize the functionalization process of hyaluronic acid to obtain injectable chitosan-based hydrogels and to conduct their comprehensive analysis, including physicochemical and rheological characterization. The research involved analyses of new materials using scanning electron microscopy (SEM/EDX), Fourier transform infrared spectroscopy (FTIR) and rheological property measurements. The obtained results indicate that aldehyde-functionalized hyaluronic acid can act as an effective crosslinking agent for chitosan-based hydrogels, significantly influencing their structure and mechanical properties. These findings open up new perspectives for further research on such materials, which could have broad applications in biomedical engineering, including drug delivery systems, tissue engineering and even 3D printing. However, a more in-depth analysis is required to fully understand the crosslinking mechanisms and optimize hydrogel parameters for potential clinical use.

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POSTER 11
CYTOTOXIC EFFECT OF DIFFERENT BIODEGRADABLE ZN-MG SURGICAL WIRES ON IN VITRO HBMSC AND HUMAN SAOS CELLS

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The treatment of bone fractures remains a significant challenge in modern medicine due to the invasive nature of traditional bone fixation methods. Conventional metal implants can cause adverse biological reactions, which hinder the bone healing process. As a result, several bone implants and their fixation devises, such as surgical wires, are often subject to revision surgeries after prolonged implantation time. This increases the risk of overall side-effects and extends recovery time for a patient. One promising approach is the development of biodegradable surgical wires that eliminate the need for their removal. We have recently developed and examined new formulations of surgical wires made of extruded zinc-magnesium alloys. The latter were either drawn once at room temperature, or seven times at 250ºC, followed by twisting some of the studied wires at 220ºC. Four different, 0.1mm diameter wires, designated A-D, were incubated in standard cell culture media composed of 89% MEM Alpha, 10% FBS Q and 1% ZellShield antibiotics. After initial 72h incubation time, the culture medium was exchanged to a fresh one, using 1 ml culture medium per 1 cm^2 of wire surface and the extracts were collected after following 24h incubation time. The extracts at different concentrations were used for the treatment of normal human bone marrow stromal cells (hBMSCs) and/or human osteosarcoma SaOS-2 cell line. The latter often serves as a model of human osteoblastic cells. Cells were exposed to the extracts for 24h, followed by cell viability assessments. We report increased viability of hBMSCs exposed to the diluted extracts vs. untreated, control hBMSCs, except for 100% extracts from wires B-D. The extracts from type A wires (i.e. cold-drawn, not twisted) had not affected hBMSC nor human SaOS viability vs. untreated control cells. At 50% dilution, the extracts from type C wires (i.e. hot-drawn, not twisted) and type D wires (i.e. hot-drawn and twisted) significantly increased hBMSCs viability, but they decreased human SaOS viability. Overall, this study demonstrates the new strategies to obtain degradable surgical wires that display relatively low cytotoxicity to the studied cell types . Notably, most of studied extracts increased viability of hBMSC, but at the same time they decreased viability of hSaOS-2 cells, which warrants further studies. We believe the obtained wires may prove useful in future biomedical applications, especially in treating bone fractures.

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POSTER 12
ASTAXANTHIN-INFUSED PVA-BASED HYDROGEL MASKS: FORMULATION AND CYTOTOXICITY TESTING ON HACAT HUMAN KERATINOCYTES

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Introduction: The development of hydrogel-based materials has led to the creation of multifunctional face masks that not only provide skin care but also reinforce the skin's lipid barrier [1]. These materials are capable of retaining high water content, delivering sustained hydration to the skin, thanks to their three-dimensional polymer networks [2]. Poly(vinyl alcohol) (PVA) is widely used in hydrogel formulations due to its biocompatibility, mechanical strength, and water retention capacity. The incorporation of active compounds, like astaxanthin, further enhances the functionality of these masks.
Materials and Methods: Hydrogel masks were synthesized using UV light to form the desired structure, with PVA as the base and astaxanthin as an active compound. Fourier-transform infrared spectroscopy (FTIR) was used to confirm composition purity. Sorption capacity and pH changes were assessed through incubation tests in phosphate-buffered saline (PBS), simulating the body's environment. Scanning electron microscopy (SEM) analyzed the surface morphology, while indirect cytotoxicity tests ensured biocompatibility following ISO 10993:5 standards.
Results: The PVA-based hydrogel masks exhibited significant sorption capacity, confirming their potential for skincare and medical use. FTIR analysis showed high purity, while incubation studies in PBS revealed excellent biocompatibility, with no signs of degradation. Cytotoxicity tests further validated the material's safety. SEM confirmed a well-structured hydrogel network, and the inclusion of astaxanthin improved the stability and functionality of the masks.
Conclusions: Hydrogel masks made from PVA and enriched with active ingredients like astaxanthin show promise as effective carriers for therapeutic agents in skin treatments. They ensure hydration and promote skin regeneration, with significant potential for improving dermatological solutions and quality of life for individuals with skin conditions.

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POSTER 13
ALGINATE-ENHANCED MAGNESIUM PHOSPHATE BONE CEMENT: TUNING THE SETTING BEHAVIOR AND INJECTABILITY FOR POTENTIAL 3D PRINTING

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Injectability and self-setting behavior are essential features of modern bone cements, particularly for minimally invasive surgical applications. While calcium phosphate- and poly(methyl methacrylate)- cements are well-established [1], magnesium phosphate cements (MPC) have recently drawn attention due to their rapid resorption, high initial mechanical strength, and short setting times [2]. In this study, sodium alginate (SA) was introduced into MPC formulations to improve injectability, cohesion, and handling, while simultaneously adjusting setting characteristics. Importantly, the composite system was developed with a view toward future adaptation for extrusion-based 3D printing, emphasizing material properties relevant for biofabrication of patient-specific bone implants [3]. MPCs were prepared by magnesium oxide (Fisher Chemical, USA) with potassium dihydrogen phosphate (Chempur, PL) in a 4:1 molar ratio. Sodium alginate (Chemat, PL) served as the liquid phase, enabling delayed ionic cross-linking and gelation - several formulations were tested [4]. Cement pastes were molded and cured at 37 °C and >90% humidity for 24 h. The following parameters were evaluated: setting time (Vicat), reaction temperature (thermocouple), microstructure (SEM), phase and chemical composition (XRD&FTIR), compressive strength, in vitro degradation, cytocompatibility (MTT assay), and flow properties relevant to extrusion-based 3D printing. Results demonstrated that alginate-modified MPC retained self-setting capability with reduced exothermicity and setting times below 15 min. SA addition enhanced paste cohesion and significantly improved injectability, though a slight reduction in compressive strength was observed. FTIR confirmed alginate cross-linking, while SEM and XRD revealed the formation of characteristic k-struvite crystals. The materials degraded gradually (~3% mass/month) and remained stable during PBS incubation. Slight cytotoxicity was noted, likely due to ionic imbalance caused by surface mineralization. Future work will focus on adapting the selected formulations for experimental validation in extrusion-based 3D printing of customized bone scaffolds.

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POSTER 14
THE EFFECT OF OXYGEN AND NITROGEN PLASMA TREATMEANT ON TI AND TI-6AL-4V PLASMA ELECTROLYTIC OXIDATION SURFACES

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Electrochemical processes on titanium and its alloys play a crucial role in the biomaterials industry. The methods, such as a plasma electrolytic oxidation are commonly used to form a porous surface which provides a better interaction at the bone-implant interface [1]. There are a few techniques to increase the association between the endoskeleton and implant, one of them is plasma cleaning. It provides the opportunity to increase the hydrophilicity and cleanse the oxide layer. Wettability exhibits high correlation with the chemical structure of the surface, which means it can be modified by plasma [2]. The usage of oxygen plasma allows the implementation of polar -OH and -COOH groups, which significantly enhances the surface energy, what makes the surface far more hydrophilic. The treatment with nitrogen plasma introduces -NH2 groups, which also amplifies the wettability [2]. In that study the porous and bioactive surfaces on Ti and Ti-6Al-4V alloys created in the plasma electrolytic oxidation process (PEO), were treated by O2 and N2 plasma in order to remove carbon contaminants and enhance the hydrophilicity. The coatings were prepared in divergent current conditions to aim the differences in the porous layers on each alloy. Comprehensive analyses of the surface properties, bioactivity, wettability and morphology were conducted to assess their functional performance. Each analysis was duplicated after 14 days to examine the process of coatings ageing. The O2/N2 plasma cleaning seems to detached carbon contaminants, which made the surfaces extra hydrophilic. That modification also made the surfaces more bioactive. Wettability has slightly diminished with time. Nonetheless, the process of ageing has decelerated. The SEM study and the EDX examination have proved that the porous surface has been formed and the electrolyte components have been implemented into the layer. It means the coatings are high with calcium and phosphorus.

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POSTER 15
DUAL BEAM LASER SINTERING OF PLLA AND PLLA/HAP - THE INFLUENCE OF PROCESS PARAMETERS ON BIOLOGICAL PROPERTIES OF THE SCAFFOLDS

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One of the important aspects of regenerative medicine and tissue engineering is the selection of an appropriate processing technique for implants and scaffolds manufacturing. For polymers susceptible to thermooxidative degradation, such as polylactide, it is important to avoid degradation of the material during polymer processing. Polymer degradation, i.e. changes in the chemical structure of the material, may cause cytotoxicity of the formed part. One of the dynamically developing technique of polymer processing is Powder Bed Fusion-Laser Beam/Polymer. In order to eliminate the need to heat the polymer powder and to minimize thermal degradation, a laser sintering method was developed using two laser beams, Dual Beam Laser Sintering (DBLS) [1, 2]. The aim of the studies was to determine the influence of DBLS processing parameters on poly(L-lactide) and composite poly(L-lactide)/hydroxyapatite (PLLA/HAP) materials thermal and biological properties. The PLLA microspheres and PLLA/HAP composite microspheres obtained by the emulsion method with solvent evaporation were applied [3, 4]. PLLA and PLLA/HAP materials were formed at various DBLS process parameters. The effect of selected process parameters on the thermal properties of sintered samples was determined using the differential scanning calorimetry. Cytotoxicity tests were performed using the MTT assay on two cell lines: L929 and hFOB 1.19. For all samples tested, the metabolic activity of hFOB cells was over 70%, while L929 cells exhibited an activity higher than 100% compared to the control. The effects of selected materials on the proliferation of L929 fibroblasts and hFOB 1.19 osteoblasts were evaluated using the CyQuant assay. The scaffold's colonization was assessed using confocal microscopy. Fibroblasts and osteoblasts proliferated similarly to the control cell cultures, with the highest rate observed after 7 days of incubation with the materials. hFOB 1.19 cells had higher proliferation rates after incubations with PLLA and PLLA/HAP parts at specific BDLS process parameters. The results of biological studies confirm that the implementation of DBLS method results with cytocompatible PLLA and PLLA/HAP scaffolds manufactured in a wide range of processing parameters.

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POSTER 16
NOVEL POLYESTER URETHANES-BASED MATERIAL – THERMAL AND VISCOELASTIC PROPERTIES

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Tissue engineering is a rapidly growing field of biomedicine that seeks to develop innovative strategies to regenerate damaged tissues and organs using biomaterials. [1-3] Particularly in soft tissue regeneration, polymeric materials are becoming increasingly important as they offer an attractive alternative to traditional biomaterials due to their mechanical properties, biodegradability and biocompatibility. A properly selected material should provide adequate mechanical support, promote cell adhesion, proliferation and differentiation, and provide bioactive factors that accelerate regenerative processes.[4] Among polymeric materials for soft tissue engineering, elastomeric materials are the most suitable, with the advantage that their mechanical properties can be controlled over a wide range.[5-6] Elastomeric materials used in soft tissue engineering can include aliphatic glycerol polyesters such as poly(glycerol sebacate), poly(glycerol citrate), poly(glycerol itaconate) and poly(glycerol adipate) (PGA). PGA is mainly used in drug delivery processes [7-8], but due to its ability to be formed into an elastomeric material, due to the presence of free hydroxyl groups, there is growing interest in this material for use in tissue engineering. Recent advances in research on PGA-based materials are summarised in the cited review article. [9] The research carried out focused on the development of a new elastomeric material based on poly(glycerol adipate). The poly(glycerol adipate) was pre-crosslinked using different concentrations of a chemical crosslinking agent from the diisocyanate group. This was followed by thermal cross-linking. The completeness of the cross-linking reaction was monitored by Fourier transform infrared spectroscopy FT-IR. The study also aimed to determine the thermal and linear viscoelastic properties. The thermal properties were evaluated by Differential Scanning Calorimetry and Thermogravimetric Analysis. The mechanical and viscoelastic properties were characterised by Dynamic Mechanical Analysis. The results obtained indicate that the glass transition temperature of the cross-linked elastomeric materials is below 37^{o}C, the application temperature of the material. The material will be in the rubbery state and will have stable modulus values at the temperature of use. Based on storage modulus values can be concluded that the elastomer material can be applied in soft tissue regeneration.

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POSTER 17
CHARACTERIZATION AND BIOLOGICAL EVALUATION OF MXENES-BASED COATING FORMED ON TITANIUM ALLOYS

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Electrochemical modification of titanium implants is still growing and expanding topic in the field of biomedical engineering [1]. A good example for that is research presenting developing hybrid oxide-polymer layer with drug loaded onto the layer [2]. MXenes are a new generation of 2D nanoparticles consisting of layers of carbides, nitrides or hybrid carbides-nitrides of transition metals. Their microbiological properties were tested [3], however their properties on PEO coating were not examined. Three titanium alloys: Ti-grade 4, Ti-15Mo and Ti-6Al-4V were anodized in suspension contain 0.1 Ca(H2PO2)2 solution at 300V and 100 mA/cm2. Then, the samples were coated using the spray-coating method. The samples morphology: SEM analysis, wettability, surface roughness, cell viability (osteosarcoma cell line MG-63) and bacteria S. aureus ATCC 25923 adhesion were examined. The applied methods are presented in detail [1,2]. After anodization, the porous layer was formed. The presence of MXenes particles was not detected on the whole surface of the titanium alloy, however places with the polymer are visible. Average surface roughness of modified titanium samples presented as follows: Ti-grade 4 Ra = 0.27 μm ± 0.01 μm, for Ti-6Al-4V Ra = 0.21 μm ± 0.04 μm and for Ti-15Mo Ra = 0.24 μm ± 0.04 μm. The contact angle for samples in wettability test were 73.11º ± 7.1º for modified Ti-grade 4, for Ti-6Al-4V: 92.20º ± 2.61º and for Ti-15Mo: 86.10º ± 0.84º. Viabillity of osteoblast MG-63 cell for the samples after 7 days of incubation was 61.68% ± 6.34% for Ti-6Al-4V samples, 65.68% ± 2.52% for Ti-15Mo samples and 60.85% ± 0.53% for Ti-grade 4 compared to control where percentage of reduced Alamar blue was 75.42% ± 4.72%. In microbiological assessment, there were spots on the surface of the samples where bacterial growth were noted. Morphology of the cells was regular, without signs of damage, however the singular colonies were isolated, limited to isolated spots. The coatings with MXenes of type Ti2C2Tx are not cytotoxic for the cells. Lower numbers of reduced Alamar blue dye can be associated with limited space that cells had to grow compared to reference sample, in which cells were grown at the base of the plate which has more space. Microbiological analysis showed that MXenes showed antibacterial properties after spraying on the samples' surface.

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POSTER 18
FROM 3D PRINTING TO CLINICAL PRACTICE EVALUATING THE EFFECTIVENESS OF CANINE JAW MODELS IN VETERINARY TRAINING

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The growing use of 3D printing technology in veterinary education represents a promising innovation in surgical training, particularly in the fields of veterinary dentistry and jaw surgery. The aim of this study was to evaluate the design, application, and educational impact of a 3D printed biomimetic model of the tusk jaw, developed to realistically simulate anatomical and biomechanical conditions. The model was made using the DLP method of incremental manufacturing based on detailed anatomical data, and its structure was prepared from a mixture based on metaacrylates, ensuring visibility in radiological examinations [1-4]. The model was used in a hands-on surgical workshop with 27 participants. Participants simulated clinical procedures such as bone fracture stabilization and hydroxyapatite bone filler composite implantation. After the workshop, participants completed a structured questionnaire assessing the model's realism, usability and educational value. The results showed a high level of participant satisfaction and confirmed the effectiveness of the model in developing manual skills, anatomical orientation and confidence in clinical decision-making. The reliability of the study was assessed as good, with a likelihood factor exceeding 0.861 [5]. Overall, the developed model is a valuable complement to conventional teaching tools and could become the new standard in veterinary surgical training in the future. Thanks to the precise mapping of structures and the right selection of materials, the model significantly supports the development of manual skills and anatomical orientation of training participants. The results of the study confirm its high educational value and indicate the great potential for integrating 3D printing technology into veterinary curricula, which could help to set a new standard in surgical training and improve clinical outcomes.

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POSTER 19
CORROSION RESISTANCE OF ELECTROCHEMICAL-MODIFIED NITI ALLOY

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Nitinol (NiTi) is a shape memory alloy widely used in biomedical applications. It exhibits favorable mechanical properties and biocompatibility. However, its corrosion resistance remains a critical concern, as the naturally formed titanium oxide layer is insufficient to provide long-term protection in physiological environments. Corrosion-related degradation can lead to the release of nickel ions (Ni^{2+}) into surrounding tissues, posing a potential risk of cytotoxicity, allergic reactions, and adverse immune responses. Therefore, enhancing the corrosion resistance of nitinol is crucial for its safe and long-term use in medical implants. Plasma Electrochemical Oxidation (PEO) has emerged as a promising surface modification technique to improve the corrosion resistance and biocompatibility of nitinol implants [1-2]. In this study, PEO treatment was performed using a phosphoric acid-based electrolyte to develop a protective oxide layer on the nitinol surface. The resulting layer was characterized using multiple physicochemical techniques, including contact angle measurements, roughness analysis, Scanning Electron Microscopy (SEM) with Energy-Dispersive X-ray Spectroscopy (EDX), 3D surface mapping, Raman spectroscopy, and X ray Photoelectron Spectroscopy (XPS). The modified surface exhibited increased hydrophilicity and porosity, with SEM and 3D mapping confirming the presence of a well-developed porous morphology. Additionally, EDX, XPS, and Raman spectroscopy analyses verified the incorporation of phosphorus into the oxide layer, which may be beneficial for osseointegration by promoting bone cell attachment and growth [3]. These findings highlight the potential of PEO as an effective method for producing high-quality oxide layers on nitinol, enhancing its surface properties and improving its suitability for biomedical applications. By modifying the implant surface to be more hydrophilic and porous, while incorporating bioactive elements, PEO treatment represents a promising approach for improving the long-term performance of nitinol-based implants.

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POSTER 20
3D PRINTING IN MEDICAL ASPECTS

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This paper focuses on modern 3D printing technologies for the fabrication of models for medical applications, with particular emphasis on biocompatible materials such as metal powders and polymers. It discusses both the advantages and limitations of the technological process and presents the results of our experimental research on 3D printing using titanium-based and polymer materials.
Additionally, the paper includes a current review of standards related to 3D printing in medicine, particularly in the context of implant production. Our findings demonstrate the feasibility of controlling the manufacturing process to produce medical models—implants—with designed porosity and potential for tissue integration.
The study highlights key technological challenges associated with designing implant models that meet specific quality criteria, as well as the limitations inherent in their production. Through an analysis of process parameters, we identify the potential to fabricate models with targeted porosity, geometry, and feature dimensions.

POSTER 21
DEVELOPMENT OF A NEW BIOMATERIAL PROTOTYPE FOR ORTHODONTIC USE

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In recent years, significant progress has been made in the development and application of biopolymeric materials for biomedical use. Due to their unique characteristics, such as biocompatibility, biodegradability, non-toxicity, and multifunctionality, these materials have emerged as promising candidates for various medical applications. This project aims to develop and optimize an innovative hydrogel formulation based on gellan gum and carrageenan, enriched with encapsulated thyme essential oil. The proposed formulation is intended as a substitute for traditional orthodontic wax. Once applied to orthodontic brackets, the hydrogel will solidify, forming a protective layer. The encapsulation of thyme essential oil will facilitate its controlled release, providing therapeutic benefits. Biomaterials used in dentistry must withstand the challenges posed by the aggressive oral environment while meeting strict biocompatibility and safety requirements. In this study, a cell viability assay using mouse fibroblasts was conducted to assess cytotoxicity, and the antimicrobial activity of the formulation was evaluated. Additionally, the durability of the final material was tested under conditions simulating the human oral cavity.

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POSTER 22
OPTIMIZATION OF OLIGOESTRADIOLS SYNTHESIS VIA RING-OPENING POLYMERIZATION FOR APPLICATION IN IMPLANTABLE HYDROGEL SYSTEMS FOR 5-FLUOROURACIL DELIVERY

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5-Fluorouracil (5-FU) is a synthetic analogue of uracil and belongs to the group of cytostatic agents known as antimetabolites. It is commonly used in systemic chemotherapy for colorectal cancer, as well as in the treatment of breast, pancreatic, gastric, esophageal, skin, and head and neck cancers. Despite its clinical effectiveness, 5-FU therapy is often associated with severe side effects, particularly affecting the gastrointestinal and cardiovascular systems, which can pose significant health risks. In Poland, 5-FU is currently available in the form of injectable and infusible solutions, as well as topical preparations such as creams and skin solutions. Biodegradable hydrogels represent an advanced class of drug delivery systems (DDS) that enable precise biodistribution of active pharmaceutical compounds to targeted sites of action, while allowing modulation of release kinetics to align with specific therapeutic needs. These systems support targeted therapy and controlled release of cytostatic agents in response to defined physical or biological stimuli, thereby reducing adverse effects commonly associated with systemic drug administration. As delivery platforms, hydrogel-based DDS can localize therapeutic agents at the site of interest and ensure their sustained release near target cells, thus facilitating molecular-level therapeutic effects while significantly minimizing systemic toxicity. This project focuses on the development of novel biodegradable hydrogel-based therapeutic systems for localized and controlled delivery of 5-FU. The project aimed to synthesize oligoestradiols via ring-opening polymerization using an amino acid as a co-initiator, and to evaluate their potential for application in implanted hydrogel systems for the delivery of 5-fluorouracil [1], [2]. The obtained materials were structurally characterized by nuclear magnetic resonance spectroscopy and exhibited promising properties for further development as drug carriers, offering the potential for site-specific and sustained 5-FU release with reduced systemic toxicity [3].

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POSTER 23
EFFECT OF OXIDE COATINGS OBTAINED BY ALD METHOD ON PHYSICOCHEMICAL AND ANTIBACTERIAL PROPERTIES OF BIOMATERIALS

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In recent years, there has been a significant increase in diseases of the osteoarticular, cardiovascular or stomatognathic systems. Continuous attempts to treat inflammation caused by the formation and development of bacterial biofilm on biomaterials becomes a significant medical problem. Until now, the use of conventional antibiotics and antiseptics has been an ineffective way to create a so-called barrier between the environment and the substrate. In such a case, removal of the implant, surface modification and reimplantation may remain the only option [1]. Therefore, the purpose of this study is to develop a method for surface modification of smart nitinol materials used for implants and the most commonly used titanium alloys using the low-temperature ALD- Atomic Layer Deposition method [2,3]. The surface modification involves the application of oxide coatings, the purpose of which is to improve the physicochemical properties while predicting antibacterial properties [4]. In this study, a comparison of the physicochemical and mechanical properties of the resulting modifications of titanium alloys and the resulting coatings was performed utilizing potentiodynamic tests, surface wettability tests, scratch tests, abrasion tests of the coatings, optical profilometry and microscopic observations (SEM). Based on the results obtained, the physicochemical properties of the alloy with oxide coatings varied depending on the number of cycles used, with a fixed constant process temperature. The knowledge obtained on this basis is of practical importance for the application of this type of surface modification for various types of miniaturized implants finding applications in the blood system, among others.

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POSTER 24
BIOACTIVE HYDROGEL DRESSING MATERIAL FOR SUPPORTING THE HEALING PROCESS OF CHRONIC SUPERFICIAL WOUNDS

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Wounds have become one of the main global problems that can lead to human death. A chronic wound is one that does not heal easily in a predictable and expected time and inflammatory phase is still active. The first line of battle against wounds are dressing materials, which should be easy to produce and support the wound healing process [1, 2]. The aim of this study was to create and determine properties of bioactive dressing material for skin wounds that supports the healing process. The hydrogel was synthesized by reversible addition-fragmentation chain transfer polymerization of oligo(ethylene glycol) methyl ether methacrylate (OEGMA) and 2-(dimethyl amino)ethyl methacrylate (DMAEMA) monomers. Cytotoxicity of the biomaterial was assessed by MTT assay using human skin fibroblasts (BJ cell line, ATCC) in accordance with the ISO 10993-5 (2009) standard. The cell viability and adhesion to the surface of the hydrogel dressing was assessed by confocal laser scanning microscopy (CLSM). Cell proliferation assessment was conducted using a two-compartment model by applying cell culture inserts. Cell number was determined using Cell counting kit-8. Collagen synthesis by BJ cells was assessed using Sirius Red Collagen Detection Kit. MTT cytotoxicity test showed that cell viability was approx. 99% after 24-h incubation with the extract. The CLSM images revealed numerous viable cells growing next to the biomaterial, indicating its non-cytotoxic nature. However, there were no adhered cells detected on the surface of sample, indicating that biomaterial hindered cell adhesion. It is desirable feature since it allows for painless removal of the dressing after complete healing. Quantitative assessments of BJ cell proliferation showed that the number of cells increased over time; Both cell proliferation potential and collagen synthesis in the presence of the sample were comparable to the control cells. Tested gel is non-cytotoxic towards cells and does not negatively affect cell proliferation and collagen synthesis. Biomaterial do not support cell adhesion to its surface, what is desirable characteristic of dressing materials. All obtained results are important due to the possible clinical use of the tested gel, however, further studies are necessary to prove its biomedical potential.

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POSTER 25
LOADING EUGENOL IN POLYMETHYLMETHACRYLATE DISCS USING DENSE CARBON DIOXIDE

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PolyMethylMethAcrylate (PMMA) dental discs are used in computer aided manufacturing process of milling removeable dental protheses. Such provisional or permanent protheses are often provided to patients after placing dental implants when the risk of inflammation is high. Eugenol is used as an antimicrobial agent in medical applications. It is loaded into polymeric matrices among others, also by the technique of carbon dioxide (CO2) impregnation [1, 2], where CO2 is used as a solvent for eugenol and at the same time will transport it inside the matrix of the polymer by diffusion. At the end of the process the CO2 is released, moving completely out of the polymer and leaving the solute inside it. Carbon dioxide is reported to solubilize well in the PMMA, depending on its temperature and pressure [3], but up to now, no data have been reported on loading substances into PMMA. The aim of this work is to study the possibility of eugenol loading into the PMMA dental discs via the high pressure CO2 technique.

The solubility of CO2 in PMMA was measured in a magnetic suspension balance (MSB–RUBOTHERM). Thermogravimetric analysis (STA 449 Jupiter, NETZSCH GB) were used to measure the eugenol loading of PMMA.

The solubilities of CO2 in PMMA disc were measured at temperatures of 301, 308 and 323 K and at pressures of 7, 8, 10, 16, 20 and 30 MPa, and the CO2 was released over 2 hours. In all conditions where CO2 density was higher than its critical density, the PMMA was deformed, but kept its form for lower densities. The eugenol loading of PMMA was experimented at 313, 323 and 338K at constant CO2 density of 0.375 g/cm3. The highest eugenol load of 20 % wa reached at 338K.

Eugenol loading of PMMA dental discs is possible through high pressure CO2 technique without any visual change in the form and shade, reaching the maximum value of 20 wt% at 338 K and the density of CO2 of 375 g/cm3.

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POSTER 26
CUSTOMIZED MANUFACTURING OF TPMS-BASED SCAFFOLDS FOR BONE IMPLANTS

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Magnesium and its alloys, are considered to be valuable candidates for temporary replacement of bone defects purposes, as they are bioresorbable and offer anti-bacterial and anti-inflammatory properties and combined with mechanical properties more similar to the ones of the real bones, in contrary to commonly utilized biomaterials. Manufacturing of hereby discussed open-porous or composite scaffolds involves designing a digital model, 3D printing a polymer or ceramic pattern, and then making an exact replica of a complex structure using the investment casting or infiltrating the preform by the means of squeeze casting. The innovative technique of pouring a reactive liquid magnesium alloy into a complex ceramic mold restricts ignition, and the obtained elements have a good surface and reproducibility. On the other hand, pressure infiltration ensures low residual porosity and high-quality interface. Produced TPMS-based cellular or composite structures can be customized and subjected to topological optimization in order to match a desired range of mechanical properties and, simultaneously, promote tissue ingrowth during osteo-regeneration. Comparative analysis of experimental measurements obtained from compression tests together with the outcomes of FEM numerical simulations is a key approach to create a database of solutions tailored for specific biomechanical applications mimicking the behavior of natural bones and allowing cells attachment, differentiation and proliferation processes. In spite of the magnesium's rapid bioresorption in physiological conditions, some mitigation measures can be undertaken such as the usage of protective coatings to control the degradation rate of the implants, ensuring a predictable lifespan. Plasma Electrolytic Oxidation (PEO) will be discussed and evaluated for this aim to inhibit a too rapid corrosion of magnesium components.

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POSTER 27
HYBRID SURFACE MODIFICATION OF HIGHLY POROUS ADDITIVELY MANUFACTURED IMPLANTS

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Highly porous implants manufactured using additive methods provide favorable conditions for osseointegration but pose challenges in terms of modification techniques. Developing modification methods suitable for their specific characteristics is essential to ensure high biocompatibility and safe application. The applied modifications should positively influence surface properties in the context of both short- and long-term biological responses to the implant. The study was conducted on samples reflecting the characteristics of actual intervertebral implants with a porosity of >50%. The porous structure was based on a diamond lattice with pore sizes of 600 µm. The samples were made of Ti6Al4V using selective laser melting (SLM, 3D EOS M100). The samples underwent plasma electrolytic oxidation (PEO) in a 0.5M $Ca(H_2PO_2)_2$ solution under process parameters of U = 250 V, I = 0.9 A, pulsed current, k_w = 20%, and were subsequently dip-coated with chitosan. The PEO modification aimed to create a surface layer with properties beneficial for the long-term biological response to the implant. The biodegradable polymer coating was intended to provide optimal surface and biological properties during the initial phase of implant interaction with the body. The applied PEO process parameters enabled the formation of a uniform surface layer across the entire implant, including the central part of the scaffold. The implant surface exhibited a hierarchical structure (SEM, Tescan Vega), with surface micropore depths ranging from 0.5 to 2 µm (3D Optical Profilometry, Surface Metrology Microscope Leica DCM8), which creates favorable conditions for osseointegration [1]. The produced polymer coating exhibited a heterogeneous structure due to the complex surface topography of the sample and underwent gradual degradation in simulated tissue environments. The applied modifications ensured favorable surface wettability (optical goniometer, Möller-Wedel Optical), which is crucial during the initial phase of implant integration with the body [2]. The PEO layer significantly reduced the release of metal ions into the simulated tissue environment, while the additional polymer layer completely prevented the release of V from the implant (inductively coupled plasma atomic emission spectroscopy, ICP-AES JY 2000). Biological studies demonstrated a positive impact of the applied modifications on the metabolic activity and proliferation of osteoblasts, confirming the absence of cytotoxicity in the hybrid modification using PEO and a polymer coating.

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POSTER 28
OPTIMIZATION OF DLP PRINTING PARAMETERS USING A MODIFIED RESIN FOR DENTAL APPLICATIONS

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The technology of 3D printing has enabled the manufacturing of complex structures, with comparatively short times and less material consumption when compared to typical manufacturing technologies. In recent years, 3D printing technology has gained popularity in more fields. This technology has also found widespread use in medicine and dentistry, as they allow the production of special medical items, a specially tailored to the needs of the patient. The study focuses on 3D printing technology using the DLP method, which is highly valued due to the precision and quality of the prints produced. It makes it possible to create accurate and durable models of dental products such as dental crowns, bridges or entire dentures. However, in order to create a good quality product, it is necessary to develop optimal 3D printing parameters that ensure the precision of the print and improve the strength and biocompatibility of the mechanical properties, respectively [1, 2]. In the study, the optimal settings of the 3D printer, such as resolution, printing speed, intensity and exposure time, were selected to produce prints with better strength properties and biocompatibility. During the optimization process, the Photocentric Crystal Clear resin was used, which was subjected to chemical and physical modifications to improve its performance properties, such as the exposure time and chemical composition modification. Next, experiments were conducted to determine the optimal 3D printing parameters, during which the settings of the Phrozen Sonic Mini 8K printer, such as printing speed and resolution, were changed. In the next stage, laboratory tests including mechanical and physicochemical tests were conducted on the 3D printed models, allowing them to be evaluated for suitability in dentistry. Based on the results obtained, the most optimal 3D printing parameters were determined, allowing them to obtain products of high precision and quality.

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POSTER 29
HYALURONIC ACID AND CHONDROITIN SULPHATE-BASED HYDROGEL MASKS: INNOVATIVE CARRIERS FOR SKIN HYDRATION AND REGENERATION

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Introduction Hydrogel masks enriched with hyaluronic acid and chondroitin sulphate offer a promising strategy for transdermal delivery of active ingredients. Hyaluronic acid, a key component of the extracellular matrix [1,2], is known for its exceptional water-binding capacity, ensuring deep hydration [3]. Chondroitin sulphate, naturally present in cartilage, lungs, muscles, and skin, supports tissue structure and function [2]. A combination of the above two compounds enhances skin hydration, boosts collagen and elastin production, improves elasticity, protects against pollution and UV radiation, and has anti-wrinkle properties [3]. Hydrogel masks were synthesized under UV light using hyaluronic acid and chondroitin sulphate as the base. Fourier transform infrared spectroscopy (FTIR) verified composition purity, while incubation in Simulated Body Fluid assessed its sorption capacity and pH changes, and scanning electron microscopy (SEM) examined surface morphology. The cytotoxicity of new materials was evaluated against the positive control on L-929 mouse fibroblast cells according to ISO 10993:5.
The developed formulation enables the creation of hydrogel masks using UV irradiation. It was found that the chemical composition significantly influences the material's physicochemical properties. The masks demonstrated sorptive capabilities essential for medical applications. FTIR confirmed a pure composition with appropriate functional groups, while SEM analysis validated the hydrogel structure. The new materials proved to be biocompatible, non-toxic, and stable in SBF fluid. Thus, hyaluronic acid and chondroitin sulphate-based hydrogel masks can serve as effective carriers for therapeutic skin applications as they enhance hydration and promote skin regeneration. Given the growing focus on skincare, their potential for dermatological use is vast.

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POSTER 30
ENHANCING THE CORROSION RESISTANCE AND BIOCOMPATIBILITY OF MAGNESIUM ALLOYS VIA PLASMA ELECTROLYTIC OXIDATION WITH CALCIUM PHOSPHATE COATINGS

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Mg alloys are characterized by their very good mechanical properties [1], are widely considered to be biocompatible and can promote bone fracture healing [2–4]. The most interesting property of Mg alloys is their ability to biodegrade in the body fluids, which translates into no need to perform a surgery to remove the implant. Mg alloys, despite their potential, still have a number of issues, such as poor corrosion resistance and too rapid degradation, which occurs before full bone fusion [5]. Plasma electrolytic oxidation is a commonly used technique for surface modification of Mg alloys, characterized by providing good corrosion protection. In this study, Ca-P coatings were produced on WE43 alloy to enhance its corrosion resistance and biocompatibility.

Coatings were produced with an AC+DC high-voltage power supply using two baths. First, the PEO process was carried out in a phosphate bath, which consisted of 12 g/L sodium hexametaphosphate and 0.05 M potassium hydroxide. The coating-forming process was carried out until a voltage of 350V was reached. The second bath was based on the first electrolyte with the addition of 1.038 g/L calcium acetate. The samples were oxidized under these conditions for 10 min. The following oxidation parameters were used: a duty ratio (DR) of 50% and different current ratios (R) of 2 and 1.6. The formed coatings were characterized by an electrochemical impendence spectroscopy (EIS) and a potentiodynamic polarization tests, moreover, a hydrogen evolution study was performed. Additionally, the effect of the formed coatings on the biological properties was investigated.

The results of the corrosion tests showed that the applied coating contributed to a noticeable improvement in the corrosion resistance of the magnesium alloy. In addition, biological evaluation of the fabricated coatings showed that the proposed surface modifications significantly reduced the cytotoxic effects observed in direct contact with the material, while maintaining the cell proliferation-promoting effects of the material eluents.

The corrosion resistance of the Ca-P coatings was noticeably better compared to bare magnesium alloy. Optimization of the surface modification conditions using PEO allowed the development of a Ca-P coating with a stable degradation progression, characterized by good biocompatibility, which is an important issue related to the development of temporary orthopedic implants.

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POSTER 31
TITANIUM ALLOY ENHANCED WITH STRONTIUM ZEOLITE AND BISPHOSPHONATE LOADING FOR ENHANCED OSTEOPOROSIS TREATMENT

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Each year, numerous implant surgeries are performed due to bone injuries and diseases like osteoporosis. Titanium alloys are widely used for their biocompatibility and mechanical properties similar to bone [1]. However, surface modifications are being developed to accelerate hydroxyapatite growth and improve recovery [2]. Zeolites, known for their biomedical applications, have been studied as implant coatings, enhancing osseointegration and biocompatibility while reducing cytotoxic ion release [3]. Some studies have also demonstrated their antibacterial properties [4,5]. To further improve zeolite coatings, researchers explore ion-exchange capabilities, particularly with strontium ions, which promote bone formation and inhibit resorption [6]. Additionally, controlled drug release from implants can aid osseointegration. Bisphosphonates, such as risedronate, strongly interact with divalent ions like strontium, making zeolite coatings effective carriers [7]. Previous research confirmed the controlled release of risedronate from zeolite carriers, avoiding initial high-dose bursts that could cause inflammation and delay healing. This study developed zeolite coatings containing strontium ions on titanium alloys and assessed their potential as drug carriers for osteoporosis treatment. The coatings varied in silicon-to-aluminum ratio, influencing zeolite type. In the first stage, Ti6Al4V discs were cleaned, treated with hydrogen peroxide, and coated using a hydrothermal method. Ion exchange was performed in a strontium chloride solution, followed by drug sorption in a risedronate solution. SEM analysis confirmed complete zeolite coverage with structural differences based on composition. Both sodalite and zeolite A structures were observed. Drug sorption studies showed no visible precipitation, except for slight structural changes in one sample. XRD and FTIR confirmed the crystalline nature and chemical composition of the layers. Drug sorption was effective in selected materials, with gradual increases over time. Drug release studies indicated sustained release over 119 days without an initial burst, demonstrating the coatings' potential for controlled osteoporosis treatment. Acknowledgements: This research was supported by the National Science Centre, Poland (grant no. 2020/39/B/ST5/00320).

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POSTER 32
OPTIMIZATION OF DLP PRINTING PARAMETERS USING A MODIFIED RESIN FOR DENTAL APPLICATIONS

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The technology of 3D printing has enabled the manufacturing of complex structures, with comparatively short times and less material consumption when compared to typical manufacturing technologies. In recent years, 3D printing technology has gained popularity in more fields. This technology has also found widespread use in medicine and dentistry, as they allow the production of special medical items, a specially tailored to the needs of the patient. The study focuses on 3D printing technology using the DLP method, which is highly valued due to the precision and quality of the prints produced. It makes it possible to create accurate and durable models of dental products such as dental crowns, bridges or entire dentures. However, in order to create a good quality product, it is necessary to develop optimal 3D printing parameters that ensure the precision of the print and improve the strength and biocompatibility of the mechanical properties, respectively [1, 2]. In the study, the optimal settings of the 3D printer, such as resolution, printing speed, intensity and exposure time, were selected to produce prints with better strength properties and biocompatibility. During the optimization process, the Photocentric Crystal Clear resin was used, which was subjected to chemical and physical modifications to improve its performance properties, such as the exposure time and chemical composition modification. Next, experiments were conducted to determine the optimal 3D printing parameters, during which the settings of the Phrozen Sonic Mini 8K printer, such as printing speed and resolution, were changed. In the next stage, laboratory tests including mechanical and physicochemical tests were conducted on the 3D printed models, allowing them to be evaluated for suitability in dentistry. Based on the results obtained, the most optimal 3D printing parameters were determined, allowing them to obtain products of high precision and quality.

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POSTER 33
A NEW CONCEPT OF A URINARY BLADDER WALL SUBSTITUTE MADE OF A MULTILAYER SCAFFOLD ENRICHED WITH A PROANGIOGENIC PEPTIDE

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Tissue engineering offers promising possibilities, including the creation of a complete urinary bladder from stem cells and biomaterials. Current research focuses on combining biomaterials with cells to develop urinary tract wall substitutes. However, clinical translation faces major challenges, such as urine permeability through scaffolds, adhesion formation at implantation sites, and the difficulty of replicating the bladder's complex structure and function in vivo [1-2]. Our goal is to develop a universal regenerative bladder scaffold that supports cell migration, proliferation, angiogenesis, and biodegradation [3]. This engineered bladder will incorporate essential mechanical properties such as elasticity, urine impermeability, and a multilayered structure and biological features, including vascularization, urothelial cell integration, and resistance to Gram-negative bacteria. It will be the first hydrogel model to feature a rapid, cell-safe phase transition. The scaffold will consist of chitosan and agarose, reinforced with collagen proteins or peptides. Proangiogenic and urothelial cell-supporting peptides will be embedded into a chitosan-based bioink, enhancing regenerative potential and providing antimicrobial protection. This is one of the most important stages for biological properties, which will proceed successively through the chemical synthesis of peptides on a solid support, then fibrillating peptides will be characterized using fluorometric tests with Thioflavin T and transmission electron microscopy. After determining the bioactivity of these compounds, they will be used to create a construct with chitosan. For this purpose, we will use a bifunctional linker based on the active ester NHS of maleimidoglycine, the production of which has been patented by us. Functioning as a temporary extracellular matrix (ECM), our multilayer scaffold will be able to support cell growth and differentiation until native tissue regenerates [4]. This approach has the potential to revolutionize bladder disease treatment and research, enabling the creation of personalized, functional bladder models for drug testing and individualized therapy [5].

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POSTER 34
FROM ALKAPTONURIA TO BONE REGENERATION: PYOMELANIN AS A GAME-CHANGER IN BIOMATERIAL-BASED OSTEOREGENERATION

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One of the leading trends in research on biomaterials for targeted regeneration of bone tissue is the modification of their surface or components with biologically active substances supporting the osteoconduction and osteointegration processes [1]. Pyomelanin (PyoM) isolated from *P. aeruginosa* is a black negatively charged extracellular polymer chemically similar to alkaptomelanin (ALKM) produced by humans. The formation and accumulation of ALKM deposits in patients with alkaptonuria leads to pathological ossification of the joints. Here, we present the use of PyoM as a bioactive inducer of controlled bone regeneration [2,3], a potential game-changer in the field that could revolutionize bone tissue regeneration. As part of our research work, we have optimized the production of PyoM by *P. aeruginosa* on the proprietary PMM Medium II (P.438865), achieving high production yields, reducing impurities and maintaining the bioactivity of this bacterial polymer. In addition, we developed a method for the isolation of the primary, water-soluble form of PyoM and characterized it physicochemically. We have shown a wide range of biosafety of PyoM on cell lines (human monocytes, osteoblasts, chondrocytes) and *G. mellonella in vivo* model. We have also demonstrated the immunomodulatory activity of PyoM by activating the NF-kB pathway and promoting phagocytosis of bacteria that are a risk factor in post-implantation infections. PyoM supported the process of *in vitro* bone tissue regeneration and stimulated the osteoconduction by increasing the biosynthesis of osteocalcin, IL-6, IL-10, alkaline phosphatase and TNF-α after 35 days of culture. In cooperation, poly(glycerol adipate)-based composites [4] with hydroxyapatite modified with PyoM (*in situ* and conjugated by APTES) were developed (P.451245 and P.450310), as well as physicochemical (TGA, DSC) and biological (biocompatibility, immunomodulation, osteoconduction) characterization were performed. *In vivo*, studies showed the lack of a systemic inflammatory reaction and irritating effects on the tested biocomposites and confirmed their biocompatibility.

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POSTER 35
PLANNING INNOVATIVE BIOMATERIALS TO BOOST THE RECOVERY OF OSTEOCHONDRAL DEFECTS

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Introduction: Osteochondral defects pose significant challenges in regenerative medicine, often leading to osteoarthritis (OA) and necessitating joint replacement [1]. Current therapies primarily manage symptoms rather than promoting true tissue regeneration. In our project we aim to develop a novel poly(glycerol adipate, PGA)-based biomaterial[2], containing multidoped hydroxyapatite (HA) particles [3] and bioactive peptides [4] with tailored activities designed to address these limitations through innovative mechanobiology-driven strategies. Objectives: The project focuses on creating a functional biomaterial for the regeneration of the bone-cartilage interphase. Key innovations include a layered elastomeric composite, the integration of bioactive peptides, and a novel approach to stem cell mobilization using Plerixafor . Methods: The proposed material features a two-layer structure: a hydrogel layer functionalized with lubricating peptides to mimic natural cartilage lubrication and an elastomeric layer incorporating multi-doped hydroxyapatite (multi-HAp) for enhanced osteointegration. The biomaterial will employ both chemical and photo-crosslinking techniques to ensure optimal mechanical properties and durability. Plerixafor will be used to mobilize endogenous mesenchymal stem cells (MSCs) to facilitate in situ tissue regeneration. Conclusion: The project represents a significant advancement in biomaterials for osteochondral repair, combining innovative design, mechanobiology, and stem cell technology. By addressing current limitations in osteochondral defect treatment, our project aims to improve patient outcomes and reduce the burden of osteoarthritis globally. Our findings will pave the way for future applications in regenerative medicine.

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POSTER 36
K-CARRAGEENAN-ENHANCED MAGNESIUM PHOSPHATE CEMENT FOR BONE REPAIR: A FUNCTIONAL CERAMIC-HYDROGEL SYSTEM WITH DUAL-SETTING BEHAVIOR

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Treating complex bone defects requires biomaterials that combine biocompatibility, injectability, and mechanical integrity. Although bone possesses regenerative potential, large-scale damage often exceeds its natural capacity. Traditional cements, such as PMMA and calcium phosphates, pose clinical limitations, including excessive heat release and unsatisfactory setting profiles [1,2]. To solve these issues, in this study, a dual-setting magnesium phosphate cement (MPC) reinforced with ionically cross-linked κ-carrageenan (κC) hydrogel was developed, aimed at enhancing performance for orthopedic applications. The cement matrix was formulated by combining calcined magnesia (Fisher Chemical, USA) with potassium dihydrogen phosphate (Chempur, PL) (4:1 molar ratio). Aqueous κC (0.5-1.5%) solutions (Chemat, PL) were applied as liquid phases alongside sorbitol (1:1 ratio; Merck KGaA, DE) as a plasticizer [3]. The composite was evaluated for setting time (Vicat apparatus), exothermic reaction (thermocouple), mechanical strength (universal testing machine), and physicochemical properties: microstructure (SEM), chemical and phase composition (FTIR and XRD). Further, injectability, cohesion in aqueous environment, and in vitro degradation in PBS (30 days) were evaluated. Finally, cytotoxicity was assessed using hFOB 1.19 osteoblasts via MTT assay. The incorporation of κC hydrogel improved handling and cohesion while modulating setting kinetics. The final setting time increased to ~15 min, and exothermic peak temperatures were reduced by ~9°C. SEM revealed a hydrogel-based matrix embedding MPC-crystals, while XRD indicated a phase transition from k-struvite to bobierrite. The cement maintained compressive strength (~25 MPa) and Young modulus (~1.5–3.0 GPa). Mass loss during degradation in PBS was ~6–8%/month, and cell viability exceeded 80%, confirming cytocompatibility. Overall, the κC-reinforced MPC offers improved handling, reduced thermal release, and better cohesion, without compromising strength or biocompatibility, positioning it as a promising candidate for minimally invasive bone regeneration strategies. Acknowledgement: This work was supported by the Gdańsk University of Technology under the PLUTONIUM program (DEC-3/2022/IDUB/III.4.3/Pu) and by the Polish Ministry of Education and Science through the project "Support for students in enhancing their competencies and skills" (FERS.01.05-IP.08-004/23, European Funds for Social Development 2021-2027).

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POSTER 37
NOVEL MULTIFUNCTIONAL COMPOSITES FOR POTENTIAL PERIODONTITIS TREATMENT

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Periodontitis is one of the most common health issues in companion animals, particularly dogs, leading to chronic inflammation, infection, and progressive bone loss [1, 2]. Despite its high prevalence, effective long-term treatment options remain limited, creating a significant unmet need in veterinary medicine. Addressing this gap is crucial not only for improving the well-being of affected animals but also holds promise for advancing periodontal therapies in humans, as both share similar pathophysiological mechanisms [2, 3]. We have recently developed and analyzed collagen/chitosan-based composites (CTS/COLL) that employ a selected polyphenol (i.e. +/- tannic acid, TA) to serve as composites' cross-linker and potent anti-inflammatory agent as well. We examined the physicochemical properties of such composites, including their stability and the release of polyphenol upon long-term composites exposure to physiological fluids. This was followed by assessment of the biological responses of RAW 264.7 mouse macrophages and human periodontal ligament stem cells (hPDLSCs). RAW 264.7 were examined for viability and M1/M2 polarization. Human PDLSC were examined for viability. Cells were either exposed to composites extracts or cultured directly on the composites. Our results show that the composites remain stable during long-term incubation in culture media consisting of 89% αMEM, 10% FBS and 1% Z/S. The maximum release of polyphenol can be detected by day 3 culture. The composites extracts at ≤50% concentration are not cytotoxic in both studied cell types. Moreover, at this concentration, the extracts improve hPDLSC viability vs. untreated cell control or composites without TA (CTS/COLL). Furthermore, RAW 264.7 macrophages exposed to composites extracts polarize toward the anti-inflammatory M2 phenotype and the latter is enhanced when RAW 264.7 cells are seeded directly onto the composites. Overall, the developed composites release substantial amounts of TA for the first 3 incubation days in culture media, which may contribute to the potential therapeutic effects on the studied cells. These data are thus promising for further development of such composites for potential treatment of periodontitis in animals and humans.

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POSTER 38
CHITOSAN-ZEOLITE SCAFFOLD: A POTENTIAL BIOMATERIAL FOR CONTROLLED OSTEOPOROSIS DRUG RELEASE

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Chitosan is a widely studied natural biopolymer, derived from the deacetylation of chitin [1]. Its popularity stems from its biodegradability, biocompatibility, bioactivity, and nontoxicity, making it suitable for biomedical applications such as drug carriers, wound dressings, and implants [2]. Chitosan promotes soft and hard tissue healing and can be processed into various structures, including scaffolds. Porous chitosan scaffolds are produced via controlled freezing and lyophilization and are particularly promising for bone tissue engineering. They support hydroxyapatite formation and osteoblast attachment. Various fillers have been explored to enhance these scaffolds. However, calcium phosphates, especially hydroxyapatite, remain the most common due to their role as a primary bone component [3]. Beyond structural support, scaffolds should also facilitate drug release, particularly for osteoporosis treatment using bisphosphonates [4]. Controlled, low-dose drug release is crucial to avoid toxicity. Since bisphosphonates have a strong affinity for calcium ions, materials containing divalent ions serve as potential carriers. Chitosan-hydroxyapatite composites can effectively retain bisphosphonates, but their release is often inefficient, with drugs reabsorbing onto the scaffold surface instead of targeting the bone. Zeolites offer a promising alternative to hydroxyapatite as scaffold fillers. These materials are extensively used in biotechnology and medicine for drug delivery [5]. Studies on chitosan-zeolite scaffolds suggest they can biomineralize hydroxyapatite. Given these findings, chitosan-zeolite scaffolds have significant potential for osteoporosis drug delivery. In the first step, a chitosan solution was prepared, and materials such as hydroxyapatite or zeolite were added in appropriate ratios. The mixture was then frozen and lyophilized. After preparing the scaffolds, drug sorption was tested using a risedronate solution. Zeolite was evenly distributed throughout the scaffold, improving drug sorption and release. The scaffolds with zeolite retained twice as much drug as those with hydroxyapatite. The drug release was slower and more controlled in the zeolite scaffolds, which is beneficial for osteoporosis treatment and tissue engineering applications. Acknowledgements: This research was supported by the National Science Centre, Poland (grant no. 2020/39/B/ST5/00320).

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POSTER 39
ADVANCING IN VITRO TESTING FOR DENTAL IMPLANTS: CURRENT STATE-OF-ART, FUTURE CHALLENGES, AND PRELIMINARY INSIGHTS INTO THE CONCEPT OF A NOVEL MODEL

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Dental implants are considered the most reliable option for replacing missing teeth, often lasting for many years with success rates above 90%. Nonetheless, clinical complications, including peri-implantitis, weak osseointegration, and soft tissue sealing failure – can undermine their clinical lifespan. These outcomes are strongly influenced by a combination of implant geometry, surface characteristics, anatomical site of placement, and patient-specific bone conditions [1,2]. Despite significant advancements in materials and surface technologies, reliably predicting implant behavior under clinically relevant conditions remains a major challenge in preclinical research. This study provides a comprehensive review of up-to-date in vitro models, with a particular emphasis on strategies that replicate the complexity of the oral environment. A literature analysis was conducted using PubMed, ScienceDirect, and Google Scholar. Key limitations of existing models were identified, and emerging challenges, along with future directions are discussed. Finally, we outline the preliminary efforts of our research group in developing a novel in vitro platform. Our analysis reveals that the majority of existing models are static, two-dimensional, and overly simplified, often assessing bone and soft tissue responses in isolation without accounting for the integrated architecture of the oral cavity or the mechanical forces involved in the mastication process. Although advanced multicellular systems have been proposed, they are rarely adapted for implant-related studies. Furthermore, microbial factors – key contributors to peri-implantitis, are frequently omitted, further hindering the clinical relevance of these models. In response, we have initiated work on a novel in vitro model concept designed to more accurately replicate the oral tissue architecture. Current efforts are focused on exploring optimal material combinations and designing strategies for engineering a direct soft–hard tissue interface. In the next phase, we intend to establish a co-culture system incorporating osteogenic, fibroblastic, and epithelial cells under physiologically relevant, dynamic conditions. This conceptual framework aims to support the future development of predictive tools for the preclinical screening of dental implants and biofunctional coatings.

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POSTER 40
CONTROLLED RELEASE OF AMINOMETHYLENEBISPHOSPHONATES FROM A CALCIUM ZEOLITE CARRIER: IMPACT OF COMPOUND STRUCTURE ON SORPTION AND RELEASE PROFILES

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Introduction: Aminomethylenebisphosphonates (BPs) are used in treating bone disorders due to their affinity for hydroxyapatite. However, their poor bioavailability and gastrointestinal side effects limit efficacy. Zeolite-based carriers improve BP release profiles and reduce systemic toxicity. This study investigates the sorption and release behaviors of BPs from a calcium-exchanged zeolite carrier, focusing on the influence of compound structure.
Materials and Methods: Twelve BPs and risedronate (RSD) were adsorbed onto calcium-exchanged zeolite X (CaX) via ion exchange. Sorption efficiency was assessed using UV–VIS spectroscopy, scanning electron microscopy (SEM), energy-dispersive spectroscopy (EDS), and elemental analysis. Release experiments in simulated body fluid (SBF) at pH 7.4 were conducted over 198 h. Density functional theory (DFT) calculations provided insight into adsorption mechanisms. In vitro cytotoxicity studies on human fibroblasts BJ and osteosarcoma 143b cells were performed using the Neutral Red Uptake assay. Statistical analyses included one-way and two-way ANOVA with Dunnett's multiple comparisons test.
Results: BPs with benziothiazole, iodine, and methyl groups (BP5, BP6, BP12) exhibited high sorption (>50%), while bromine- and chlorine-containing BPs had lower affinities. BP5, BP6, and RSD followed a sustained release pattern, while BP12 showed an initial burst release. DFT calculations revealed electrostatic interactions and hydrogen bonding between BP molecules and Ca 2 + 2+ ions in the zeolite. Cytotoxicity assays indicated that the zeolite carrier reduced BP toxicity toward fibroblasts while preserving activity against osteosarcoma cells. RSD-loaded zeolite exhibited enhanced selectivity, making it a promising candidate for bone-targeted therapies.
Conclusions: The calcium-exchanged zeolite carrier enabled controlled BP release, suggesting potential applications in osteoporosis and osteosarcoma treatment. Sustained release profiles of RSD and BP5 support their use in long-term drug delivery, while BP12 may require formulation adjustments. Future studies should optimize carrier modifications to enhance BP retention and bioactivity.

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