CONFERENCE
ONLINE

UK-Poland-Ukraine Bioinspired Materials Conference 29-30/11/2022

FINAL PROGRAMME AND BOOK OF ABSTRACTS

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Special Issue

"Sustainable Materials and Technologies"

Dear Colleagues,

Nature is a practically inexhaustible source of inspiration for the design of sustainable materials. In this Special Issue, we will focus on materials that promote sustainability. Contributions can be on recycling, life cycle analysis, or materials from renewable sources. Due to the wide scope of bio-(inspired) materials, contributions relating to energy materials, tissue engineering, and biomimetics are also welcome.

Dr. Marloes Peeters
Prof. Dr. Elżbieta Pamuła
Dr. Timothy E.L. Douglas
Dr. Patrycja Domalik-Pyzik
Guest Editors

ENGINEERING OF BIOMATERIALS
INŻYNIERIA BIOMATERIAŁÓW

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Engineering of Biomaterials is a well-established, peer-reviewed journal with a 25 years-long tradition, published by the Polish Society for Biomaterials. We are proudly operating in a Gold Open Access mode, which means that all articles published with Engineering of Biomaterials are available for free on our website and there is no APC for authors.

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Bioinspired and biomimetic materials are one of the most promising in biomedical applications. We have already learned that the closer we get to the perfect design, composition, and functionality of human tissues and organs, the better chances we have in successful reconstruction or regeneration of the damaged or diseased ones. Also, many different organisms are practically limitless source of novel materials inspiration. In the end, is there a better teacher than the nature itself?

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FINAL PROGRAMME

ALL TIMINGS ARE UK TIME (+1 HOUR in Poland, +2 HOURS in Ukraine)

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KEYNOTE SPEAKERS

TIMOTHY E.L. DOUGLAS

Lancaster University, United Kingdom

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Keynote lecture:

The value of Polish and Ukrainian languages in university collaboration

Timothy E.L. Douglas works at Lancaster University in the United Kingdom on the development of composite biomaterials to support regeneration of tissues, in particular bone, biomaterial coatings and the use of substances from the food industry in biomaterial development.

He has published over 100 A1 publications relating to biomaterials for bone contact with an extensive network of international collaborators, including many in Poland. He is passionate about international collaboration and has organized several international conferences on biomaterials-related topics at Lancaster University.

He a firm believer in the benefits of language learning and combining interests in science and other countries and languages. He uses several languages regularly in his work, including Polish, and has achieved a conversation level in several others, including Ukrainian.

International collaboration and mobility are encouraged, but there is very little discussion about the role of languages in communicating with others and, more importantly, in building relationships with speakers of other languages. In order to start this discussion, with colleagues from Department of Languages and Cultures (DeLC) at Lancaster University, he has organised conferences on Languages in Science.

KATARZYNA GURZAWSKA-COMIS

University of Liverpool, United Kingdom

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Keynote lecture:

GreenBone – advanced approaches in bone regeneration with immune-instructive biomaterials

Kasia Gurzawska-Comis has recently been appointed as Senior Clinical Lecturer in Oral Surgery at the University of Liverpool. She graduated from Medical University of Lodz as a dentist and from Technical University of Lodz, Mechanical Engineering.

Due to her interest in the interdisciplinary research between Medicine/Dentistry and Engineering she started to develop her scientific experience in biomaterials for medical application. She moved to Denmark to take Research Assistant position in the FP6 EU project, NanoCMM, which led to her PhD at the University of Copenhagen in nanotechnology. She also obtained second PhD in Poland in mechanical testing of biomaterials. Afterwards she continued as a post-doc in Sweden at the University of Gotheborg and later on as Marie Curie-Sklodowska Postdoctoral Fellow at the Charité Medical University in Berlin, Germany where she worked on applications of nanotechnology in dental implantology and bone regeneration. Her recent scientific findings conducted with University of Bergen, Norway showed great potential for bone regeneration and stem cell therapy. Her future research goals focus on developing an alternative materials for autogenous bone grafts in compromised patients. As a clinician she obtained her speciality training in Oral Surgery at Birmingham Dental Hospital as an NIHR Academic Clinical Lecturer and her main interest is the multidisciplinary approach to patient care.

She has also been involved in teaching dental students, development of programs for biomaterials bachelor and master course at the University of Birmingham, and, teaching Oral Surgery at the University of Liverpool.

In addition to University teaching she organised a number of hands-on-training, workshops, seminars and summer courses with international professional organisations such as IADR (International Association of Dental Research), EAO (European Association of Osseointegration), Osteology Foundation.

She is a member of Liverpool Head and Neck Research Centre (LHNC), led by Professor Richard Shaw.

JOHN HARDY

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Keynote lecture:

Stimuli-responsive materials for drug delivery, tissue engineering and regenerative medicine

John Hardy was awarded his MSci and PhD in Chemistry in 2002 and 2007 from the University of Bristol and University of York, respectively. From 2006 to 2015 he undertook postdoctoral research in Chemical Engineering at the University of Strasbourg in France, in Bioengineering at the University of Bayreuth in Germany, in Biomedical Engineering at the University of Texas at Austin, the University of Florida in the USA, and in Pharmacy at Queen's University Belfast in Northern Ireland. He is currently a 50th Anniversary Senior Lecturer in the Department of Chemistry and Materials Science Institute at Lancaster University.

JOHN HARDY

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Stimuli-responsive materials for drug delivery, tissue engineering and regenerative medicine

Introduction

Stimuli-responsive materials (SRMs) have significant potential for the development of controlled drug delivery systems or integration within instructive biomaterials. Our interest is in the design, synthesis, and characterization of a range of materials capable of responding to one or more stimuli [1-6], particularly when sensors are integrated in such devices [7].

Methods

An interdisciplinary approach combining chemistry (polymer synthesis) and materials science and engineering was employed to prepare and characterize SRMs via electrochemistry, microscopy and spectroscopy. SRMs loaded with drugs or biologics were exposed to stimuli, and the release of the drugs or biologics was quantified spectroscopically; or SRMs were used as tissue scaffolds and analysed via a variety of techniques.

Results

Electricity, light and magnetism are capable of triggering the delivery of drugs or biologics of various molecular weights from these SRMs *in-vitro*; examples of degradable SRMs are non-inflammatory *in vivo*.

Conclusion/Implications

SRMs can deliver a variety of clinically relevant drugs or biologics of various molecular weights in a controlled, triggered or sustained fashion over extended periods, and can potentially be used to control the chronopharmacology of the drugs or biologics in line with the chronobiology of the condition needing treatment; likewise SRMs can be used as instructive biomaterials for tissue engineering.

Acknowledgements

For financial support we thank United Kingdom Research and Innovation (UKRI, specifically BBSRC, EPSRC and MRC), the UK Royal Society, and the British Council Newton-Mosharafa Fund.

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LIUDMYLA NOSACH

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Keynote lecture:

Novel functional materials based on nanosilica for medical application

2016 – Academic rank: Senior researcher,
Speciality Physics and Chemistry of Surface,
Chuiko Institute of Surface Chemistry NAS of Ukraine, Kyiv, Ukraine
2008 – PhD in Chemical Sciences,
Speciality Physics and Chemistry of Surface,
Chuiko Institute of Surface Chemistry NAS of Ukraine, Kyiv, Ukraine
2001 – Specialist in Biology and Chemistry,
National Pedagogical Drahomanov University, Kyiv, Ukraine

Specialist in the field of surface chemistry with extensive research experience in processes of adsorption, chemical, polymerization and geometric modification of nanosilica with nonvolatile low- and macromolecular organic substances (including biologically-active ones) and inorganic salts under conditions of a regulated gas dispersion medium and liquid medium (impregnation), as well as creation of new functionalized materials based on nanosilica. Author of 138 scientific publications, including 50 articles and 4 patents.

LIUDMYLA NOSACH

Department of Amorphous and Structurally Ordered Oxides, Chuiko Institute of Surface Chemistry,
National Academy of Sciences of Ukraine, 17 General Naumov St., Kyiv 03164, Ukraine

Novel functional materials based on nanosilica for medical application

Amorphous highly disperse nonporous nanoscale silica (nanosilica) is the initial material for producing medical preparations with sorption-detoxification action under the commercial names Silics, Atoxil, Polysorb MP. The unique set of nanosilica properties - chemical purity, thermal and microbiological stability, physiological harmlessness, significant sorption capacity for proteins and microorganisms, a wide adsorption spectrum and high adsorption speed - determine its wide use in pharmacy and medicine. Nanosilica-based preparations show high efficiency in their use in the combined treatment of purulent-inflammatory, infectious, oncological, and other diseases. To a large extent, this is since nanosilica favorably differs from other sorbents by high sorption capacity towards proteins ~ 500-700 mg/g and microorganisms ~ 10^8-10^{10} microbial bodies/g, regardless of their species. As for the protein-sorbing properties, nanosilica surpasses the majority of modern sorbents for enteral using.

Creation of new medicinal form and functional materials based on nanosilica with specified characteristics in terms of spectrum of action opens up new broad possibilities for its using in medicine. Sorbents based on nanosilica are produced in Ukraine in the powder form. As a result of many years research in the CISC NAS of Ukraine a medicine has been developed and produced in the form of the aqueous dispersions of nanosilica [1]. Their therapeutic effect is linked to extraction of toxic substances from the body by the adsorption in the gastrointestinal tract. The main direction of research within last years was to create new complex multipurpose medicines based on nanosilica. To achieve this goal, it's important to be able to purposefully form structures consisting of layers of biologically active compounds and polymers on the surface of nanosilica particles and, at the same time, almost completely save the initial dispersity of nanosilica. Environmentally friendly and technologically advanced methods of modification of nanosilica with nonvolatile low- and macromolecular organic substances as well as inorganic salts under conditions of a regulated gas dispersion medium were developed [2, 3]. These methods allow to obtain promising nanomaterials with specified characteristics that can be used as powders for the treatment of open purulent wounds, trophic ulcers and burns, as functional fillers of polymer systems for biomedical applications, as drug delivery systems, etc. [4, 5].

References:

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4. UA Patent №117179 2018,
5. UA Patent №97613, 2015,

SERGEY PILETSKY

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Keynote lecture:

MIP nanoparticles in diagnostics and in vivo applications

A leading expert on Molecular Imprinting and Biosensors Sergey Piletsky is a Professor of Bioanalytical Chemistry and Research Director for School of Chemistry. Sergey has graduated from Kiev University in 1985 with a M.Sc. in Bioorganic Chemistry. In 1991 he received Ph.D. from Institute of Bioorganic Chemistry. Since 1992 he worked with world leading experts in biosensors such as Prof. Karube in Tokyo University, Prof. Wolfbeis in Regensburg University and Prof. Turner in Cranfield University. In 2002 Sergey became Professor of Polymer Chemistry and Head of Cranfield Biotechnology Centre. In 2013 Sergey has moved his group to the University of Leicester where he is working as a Research Director and Head of Leicester Biotechnology Group. For his scientific achievements, Sergey received number of awards such as JSPS, DFG and Leverhulme Fellowships, the award of the President of Ukraine, Royal Society Wolfson Research Merit Award, and DSc from Cranfield University. Sergey has published 400 papers and patent applications (H-index-83).

The focus of Sergey's work has been on molecularly imprinted polymers, driven by a practical need to find stable and generic alternatives to antibodies and natural receptors, as well as reducing the use of animals in antibody production. His research interests also include (i) Computational design and molecular modelling; (ii) Development of sensors and assays for clinical and environmental diagnostics; (iii) Nanoparticles for diagnostics and therapeutic applications.

This work has been supported by 11 EU projects, grants from MRC and EPSRC (JREI), grants from HPA, FSA and Home Office, Department of Health, Wellcome Trust, (UK), NOAA (USA), and numerous grants from industry.

AGATA PRZEKORA-KUŚMIERZ

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Keynote lecture:

How to correctly assess biocompatibility of bone implants using cellular models in vitro?

Agata Przekora-Kuśmierz, is a full professor (scientific post) and the head of the Independent Unit of Tissue Engineering and Regenerative Medicine of Medical University of Lublin (Poland). She obtained her master's degree (2009) as Biotechnologist from Maria Curie-Sklodowska University in Lublin (Poland) and PhD (2014) as well as habilitation degree (2018) in Pharmaceutical Sciences from Medical University of Lublin. In June 2022 the Polish President awarded her the title of professor in Pharmaceutical Sciences.

An expert in the field of engineering of biomaterials and tissue engineering. Specialist within the use of *in vitro* cellular models in preclinical studies, including preliminary evaluation of biocompatibility of novel biomaterials. Since 2018 an expert of European Commission for evaluation of scientific projects within Horizon 2020, Horizon Europe, and Maria Sklodowska-Curie Action. An author/co-author of 8 Polish patents and 90 scientific articles (total IF = 361.251) in the field of tissue engineering, materials science, and drug discovery. Main or Principal Investigator in 12 research projects related to engineering of biomaterials and tissue engineering.

AGATA PRZEKORA-KUŚMIERZ

Independent Unit of Tissue Engineering and Regenerative Medicine, Medical University of Lublin, Chodzki 1 Street, Poland

How to correctly assess biocompatibility of bone implants using cellular models *in vitro*?

Bone implants for regenerative medicine applications should be non-toxic and biocompatible. Biocompatibility has a very broad meaning, including non-toxicity of the materials, their ability to support cell adhesion, proliferation and differentiation as well as their non-immunogenic properties. Therefore, evaluation of major cell-biomaterial interactions is a key factor, determining biocompatibility and clinical usefulness of new biomaterials. Despite the possibility of the use of *in vitro* cellular models for this purpose, the researchers still preferentially choose *in vivo* animal tests even at preliminary stage, which is against the principles of the '3Rs', aiming to Replace, Reduce and Refine the use of animals wherever possible.

Within the lecture, I will present the basic tests for *in vitro* biocompatibility testing of bone implants, highlighting common mistakes made by scientists. I will provide protocols, hints and tips for cytotoxicity, proliferation, cell adhesion, and osteogenic differentiation assays. Importantly, each assay will be presented along with the examples of bone implants that were developed and/or tested by our research team [1-7].

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JENNY ROBERTS

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Keynote lecture:

Additive manufacturing as an enabler of environment solutions to address food security

Jenny has research interests in engineering design, with specific focus on human and environmental factors. Current research aligns with the UN Sustainability Goal of zero hunger with the development of artificial bumblebee nest boxes to address pollinator decline and promote food security. The use of Additive Manufacturing (AM) for redistributed manufacture is of particular interest alongside utilising bio-inspired design to mimic the design successes of the natural world.

Jenny has spent 14 years in engineering industry across a variety of sectors including engineering design consultancy, designing playground equipment and latterly designing and realising asset monitoring resilience systems. She achieved Chartered Engineer status in 2018 and is a member, councillor and trustee of the Institution of Engineering Designers (IED).

Jenny is the Equality Diversity and Inclusion (EDI) chair for the School of Engineering and for the Institution of Engineering Designers' EDI committee. In addition, she is an active supporter of STEM outreach and regularly encourages children to explore engineering beyond the traditional roles and stereotypes presented.

SYLVIA TEDESCO

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Keynote lecture:

Evaluation of anaerobic paper digestate as waster substitute in concrete

I have a BEng and an MSc in Industrial and Management Engineering from the Polytechnic of Bari, Italy. I then received my Italian qualification to CEng in 2010. In my Ph.D. sponsored by IRCSET (Ireland), I optimised mechanical pretreatment techniques for increased generation of Biogas for renewable and sustainable energy production, title awarded by Dublin City University in 2013. I was a postdoc and a part-time lecturer in the same university for two years, working on seaweed bioenergy and biorefining. I then joined MMU's Department of Engineering and now teach on UG courses in Sustainable Product Design and Design Engineering, and Sustainable Energy Systems/Engineering Sustainability at PG level.

I am passionate about the importance of the bioeconomy and that humanity lives in a more sustainable and environmentally cognizant manner. I am playing an active role in achieving these goals through my teaching and, in particular, through my scientific research which is focused on using biomass and waste organic materials to produce the energy, fuels, and chemicals for which we are currently over-reliant on non-renewable resources. In collaboration with a number of international partners from industry and academia, I'm currently expanding my work to circular economy applications for co-production of green platform chemicals and bioenergy from biomass.

I am part of the Low Carbon Fuels and Transportation (LCFT) cross-disciplinary research group at Manchester Metropolitan University and my research has also featured significant involvement with SMEs, having collaborated with companies in Ireland and the UK. I have secured grants from a number of bodies in the UK and Ireland (e.g. Science Foundation Ireland, BBSRC, Innovate UK, SUPERGEN Bioenergy Hub) and am currently preparing for a further round of grant proposal submissions to further advance the art in biomass conversion and valorisation. I am open to collaboration with interested parties that share my enthusiasm for the bioeconomy, particularly in international proposals.

SYLVIA TEDESCO

George Hurst[a], Ash Ahmed[b], Steven Taylor[c], Silvia Tedesco[a,d]

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Evaluation of anaerobic paper digestate as waster substitute in concrete

The use of recycled wastepaper for paper production has several environmental advantages over virgin paper, such as reduced greenhouse gas emissions, lower water consumption and reduced deforestation [1]. Recycled paper pulp accounts for over half of global paper production with more 250 million tons produced in 2018 [2]. The recycling process requires washing and pulping to remove contaminants such as inks, glue and other organic compounds such as food. However, the contamination removal process also removes short paper fibers that is commonly mixed with the contaminants in various waste streams such as paper sludge. The composition of the wastepaper varies significantly depending on the starting wastepaper but accounts for the 1-4 wt.% of the feedstock [3]. Monte et al. [4] estimated in 2005 that over 7 million tons of waste fibers was produced, with over 500,000 tons produced in the UK alone.

This study demonstrates that biological conversion via anaerobic digestion of paper sludge enables a cumulative production of 163 ml CH_4 gVS^{-1}, where the methane content in the biogas is 62%, therefore adequate for use in co-generation units. Subsequently, the post-digestion residue (digestate) exhibits promising potential to become an effective water substitute for the construction industry, guaranteeing structural standards (C32/40) are met after a 3-month period of curing age with a 25%-50% grade of water replacement and the use of plasticiser to improve the concrete's workability.

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MAŁGORZATA WŁODARCZYK-BIEGUN

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Keynote lecture:

Melt Electrowriting of hierarchical biomimetic scaffolds for tissue models

Małgorzata Włodarczyk-Biegun is an Assistant Professor at the Silesian University of Technology, in Gliwice, Poland, and a Principal Investigator at The University of Groningen, The Netherlands. Her research is focused on applying 3D (bio)printing technique to generate complex hierarchical scaffolds of polymeric materials for advanced tissue regeneration. She is also interested in the rational design and development of novel polymer-based bioinks with tunable properties allowing to induce a specific cellular response, to produce systems with bio-instructive properties.

She has earned her Master degree in Poland, in Psychology, and in Biomedical Engineering. For her PhD, she decided to continue in the field of Biomedical Engineering. She obtained the title in January 2016, at Wageningen University and Research Center in the Netherlands, working on recombinant proteins for biomedical applications. In the years 2016-2020, she was employed at INM-Leibniz Institute for New Materials, in Germany as a postdoctoral researcher. There, she took on the challenge to set up from scratch and supervise the Bioprinting Lab. In 2017, she was awarded a UNESCO-L'Oréal for Women in Science Prize in recognition of her research qualities and ability to combine excellence in Science with being a mother. Currently, she is working in the Polymer Science group at the University of Groningen, where she has received 3 prestigious grants from NWO (Netherlands Organization for Scientific Research). She has also been awarded NAWA Polish returns grant (2019) intended to set-up her own research group in Poland, and the Polish NCN Opus grant to further support her research. Combining all sources of funding, she is now leading a young Research Group, located partially in the Netherlands and partially in Poland, to pursue international collaborative work.

MIKHAJLO ZUBKO

Manchester Metropolitan University, United Kingdom

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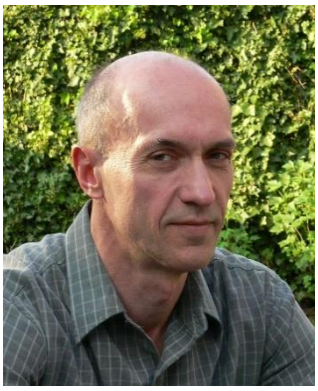
Keynote lecture:

Towards new drugs from natural resources: thoughts & reflections of a new player



My first permanent job (as a research technician at the Institute of Molecular Biology and Genetics in Kyiv) was two years before my graduation from Biology Faculty of Kyiv State University (Ukraine). Job responsibilities within this post included predominantly preparation of experiments for testing effects of nucleic acids (modified with alkylating agents) on healing tumours in animals and plants. The next research posts (since three years after graduation) were at the Institute of Cell Biology and Genetic Engineering (Kyiv). Years of work at this research institution were devoted mainly to generation of novel plants combining genetic material from remote (and thus sexually incompatible) plants (usually at inter-generic level) – in order to explore potentials of cellular engineering for expanding genetic variation. This research was continued later at the Institute of Applied Genetics, Free University, Berlin, and Institute of Plant Genetics, Gatersleben (Germany).

Since 1995 my Research Associate posts were supported during six years by BBSRC and MAAF at the School of Biological Sciences (University of Manchester), within projects on genetic modification of plastid genomes and other aspects of cytoplasmic genetics. After completing these projects, I was involved (for the next five years) in yeast genetic research with the emphasis on telomere biology (Manchester University and Newcastle University).

After getting the current post of Senior Lecturer at Manchester Metropolitan University, my research interests were generally split into three topics: 1) the roles of cytoplasmic (in particular mitochondrial) genes in generating genetic variation and adaptation to stress factors (using plant and yeast model systems); 2) genetic control of telomere maintenance in budding yeast; 3) looking for new antimicrobials from natural resources. I am open for collaborations within these areas of research.

ORAL PRESENTATIONS

EWELINA CICHOŃ

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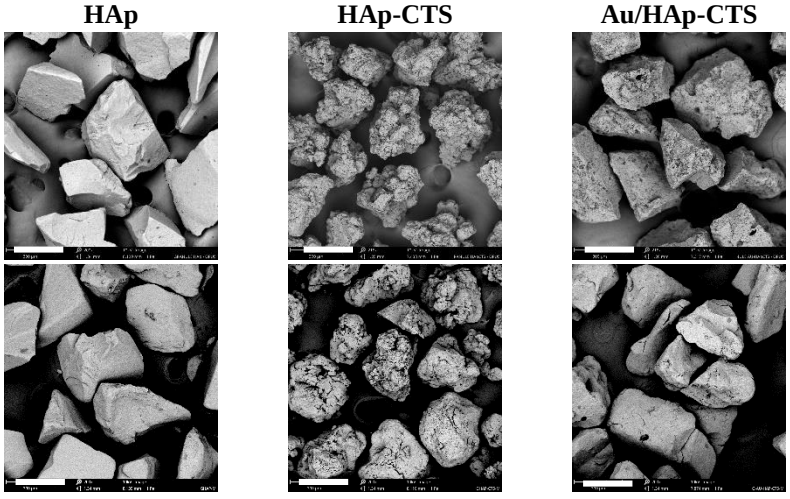
Tailoring the physicochemical properties of inorganic and hybrid calcium phosphate-based granules by etching treatment

Biomicroconcretes are defined as bone cements containing aggregates in the form of microspheres or granules [1]. A common problem with this type of materials is insufficient adhesion of the granules to the cement matrix, resulting in a deterioration of its mechanical properties. One possible solution is to use granules in the form of inorganic-organic hybrids (ex. hydroxyapatite-chitosan) [2]. These granules adhere more effectively by interacting with oppositely charged polymer from a calcium phosphate-based cementitious matrix [3]. In this study, we propose a different approach – the increase of adhesion by granules' surface modification.

As starting materials, we used different types of granules: hydroxyapatite (HAp), hydroxyapatite-chitosan (HAp-CTS) and hydroxyapatite-chitosan modified with gold nanoparticles (Au/HAp-CTS). To modify the materials' surfaces the etching with a 5% aqueous solution of citric acid has been applied. After 5 minutes of etching, the granules were centrifuged and washed several times with distilled water to remove residual acid. The granules were characterized by XRD, BET and SEM.

The granules were composed of hydroxyapatite as the only crystalline phase. Diffractograms of the hybrid materials revealed additionally the amorphous halo originating from chitosan. The specific surface area of etched HAp granules was higher (~ 26 m^2/g) if compared with their non-modified analogue (~22 m^2/g). In the case of hybrid granules, etching caused a decrease in this parameter - from ~93 to ~75 m^2/g for HAp-CTS and from ~82 to ~67 m^2/g for Au/HAp-CTS. The change of granules' microstructure before and after etching is shown in Figure 1 (magn. 200x, scale 300 μm).



Studies have confirmed the effect of etching with citric acid on both the microstructure and specific surface area of the granules. We hypothesize, that the proposed surface treatment will also affect the adhesion of granules to the cement matrix in biomicroconcrete-type materials. Nevertheless, additional studies need to be carried out to verify this assumption.

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Comparison of *in vitro* leukocyte responses to biomaterials modified with an extract containing antimicrobial peptides from porcine neutrophils

The aim of this study is to evaluate the antimicrobial activity of neutrophils isolated from porcine blood stimulated with two commercial types of bioceramics: Hydroxyapatite (HA, HA BIOCER) and Hydroxyapatite + Tricalcium β-phosphate (60% HA + 40% β-TCP, HT BIOCER) in vitro.

Neutrophils were isolated from the blood of pigs collected during their slaughter, from which an antimicrobial peptide extract and a suspension of neutrophils (N) were prepared. The resulting preparations were incubated in a 24-well plate containing HA and HA + β - TCP in PBS buffer. The free radical activity of neutrophils was determined by nitric oxide production using the Griess reaction and superoxide anion radical production using the Confer reaction.

The nitrite concentration in the medium was higher in the HA + β-TCP + N sample than in the sample containing HA + N alone, while the presence of the extract did not significantly affect the test result. Also, superoxide anion radical production was higher after stimulation with HA+ β-TCP than with pure HA. This indicates that the stimulator of neutrophil activity is tricalcium β-phosphate (β-TCP).

The experiment carried out shows a change in the antimicrobial activity of neutrophils after their contact with the biomaterial. With similar research, it will be possible to obtain ceramic biomaterials not only for tissue restoration purposes but also for antimicrobial purposes.

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MARGAUX FRIGOLI

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Thermal pyocyanin sensor based on molecularly imprinted polymers for the indirect detection of *Pseudomonas aeruginosa*

Pseudomonas aeruginosa is a ubiquitous multi-drug resistant bacterium, capable of causing serious illnesses and infections. This research focuses on the development of a thermal sensor for the indirect detection of *P. aeruginosa* infection using Molecularly Imprinted Polymers (MIPs). This was achieved by developing MIPs for the detection of pyocyanin, the main toxin secreted by *P. aeruginosa*. To this end, phenazine was used as dummy template, evaluating several polymeric compositions to achieve a selective MIP for pyocyanin recognition. The sensitivity of the synthesized MIPs was investigated by UV-Vis analysis, with the best composition having a maximum rebinding capacity of 30 μmol g^{-1} and imprinting factor (IF) of 1.59. Subsequently, the MIP particles were immobilized onto planar aluminum chips by means of an adhesive layer to perform thermal resistance measurements at clinically relevant concentrations of pyocyanin (1.4-9.8 μM), achieving a limit of detection (LoD) of 0.347 ± 0.027 μM. The selectivity of the sensor was also scrutinized, subjecting the receptor to potential interferents. Furthermore, the sensor`s performance was evaluated in King's A medium, highlighting the potential of the sensor for indirect detection of *P. aeruginosa* in complex fluids. The research culminates in the demonstration of the MIP-based sensor's applicability for clinical diagnosis. To this aim, the potential of the sensor to detect pyocyanin in saliva was illustrated, achieving a limit of detection of 0.569 ± 0.063 μM, and demonstrating that this technology is suitable to detect the presence of the toxin also at the very first stage of its production.

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Reduction of resazurin by metallic magnesium in cell culture medium

Resazurin reduction assay is a convenient and widely used tool to evaluate viability of cells *in-vitro*. Metabolically active cells readily uptake the blue colored resazurin and reduce it to bright-pink and highly fluorescent resorufin. We however observed that resazurin could be reduced in the presence of Ti_3C_2 MXene in the absence of any viable cells (1). Moreover, recent paper suggested that resazurin could be also reduced during corrosion of iron due to redox reactions (2). Magnesium (Mg) and its alloys can quickly degrade in water which makes Mg promising in design of e.g. biodegradable implants. Therefore, we investigated if resazurin could be reduced during corrosion of Mg.

Mg cubes were kept in complete cell culture medium for 10 hr in 24-well plates in CO_2 incubator at 37ºC to obtain wells with Mg-conditioned medium. The cubes were then transferred to wells with fresh medium; resazurin was added to 15 µg/ml final concentration and the plate was further incubated for 10 hr. Optical density (absorbance) was measured at 570 and 595 nm using Multiskan FC plate reader (Thermo Fisher Scientific). Results were quantified using the Method for Measuring Cytotoxicity or Proliferation Using AlamarBlue by Spectrophotometry (Bio-Rad Laboratories).

We observed that resazurin was substantially reduced in wells with Mg cubes but not in Mg-conditioned or control medium. The level of resazurin reduction did not correlate with the changes of the pH of the medium. We concluded that the resazurin reduction occurred during the process of corrosion of Mg in water environment. We suggest that the results of resazurin reduction assays should be interpreted with care taking into account a possibility of unspecific (autocatalytic) reduction independently on metabolically active cells.

Acknowledgements: This work was supported by the statutory subsidy of the Faculty of Chemistry of the Silesian University of Technology, Poland, under research project no. BKM: 04/010/BKM22/1043 and ERASMUS-JMO-2022-CHAIR project 101085451 CircuMed.

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Sustainable copolymers of poly(butylene 2,5-furanoate) for future medical sector

Plastic waste is indisputably a global challenge. Inefficient management of plastic waste, continuous economic growth as well as the COVID-19 pandemic has made the importance of using secondary raw materials seriously increase as the world cannot cope with the growing problem of waste, including medical sector. The consequence is the search for biodegradable materials that will be useful for the circular economy thus improving hospitals sustainability. There are not only disposable medical devices that generate medical waste but also varying levels of packaging, starting from semi-rigid trays to thin, flexible foils. We can presume that the problem of medical waste will become even more serious. Polyesters are currently one of the most important groups of materials as they exhibit a number of desirable features. These are compounds that can be obtained from biomass and according to literature data, poly(ethylene furanoate)(PEF), in contrast to poly(ethylene terephthalate)(PET), has a 60% greater modulus and exhibits better barrier properties and, most importantly, is biodegradable. Therefore, to extend the family of 2,5-furanoate copolyesters, new copolymers based on poly(butylene 2,5-furanoate) and dimer dilinoleic diol (DLA-OH) were synthesized via melt polycondensation using titanium dioxide/silicon dioxide catalyst (C-94). The poly(butylene 2,5-furanoate)(PBF) and poly(butylene 2,5-furanoate-co-dilinoleic 2,5-furanoate) (PBF-DLF) copolymers of variable hard (PBF) and soft (DLF) segments weight ratio, as 90-10, 70-30, and 50-50 were obtained. Chemical structure of new materials was characterized by nuclear magnetic resonance spectroscopy (NMR, ^{13}C, ^{1}H), total reflection infrared spectroscopy with Fourier transform (FT-IR), and gel permeation chromatography/size exclusion chromatography (GPC-SEC). Thermal properties of copolymers were analyzed with differential scanning calorimetry (DSC). The melt flow index (MFI) was determined and mechanical properties were tested by quasi-static tensile tests. ^{1}H NMR and ATR-FTIR measurements confirmed the expected structure of copolyesters. The DSC results showed that copolyesters exhibit T_g, $T_{m,}$ and $T_{c,}$ which are typical for semicrystalline materials. It was noticed that melting temperature is higher than for aliphatic copolyesters based on succinic sequences. Interestingly, all copolymers exhibit cold crystallization temperatures possibly due to the built-in furan cyclic structure. As the soft segments content increases, the flexibility and elongation also increase. The results confirm that PBF-DLF copolymers obtained from biomass substrates are suitable and promising materials for medical packaging due to their properties.

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Functional hydrogels for real time detection of infectious diseases

Our research focuses on the development of bio-functional and bio-programmable materials. One of our research goals is the development of rapid, real time, low-cost, biodegradable devices for an equipment free detection of target infectious organisms. These engineered materials contain cell-free protein synthesis reactions (Whitfield *et al* 2020) or a Strand Displacement Amplification (SDA) reaction in hydrogels (unpublished) that can be triggered by the target ligand. One important requirement for passive surveillance or diagnostic materials, however, is the need to liberate nucleic acids from the sample without user intervention. To this end we have immobilised active enzymes within hydrogels that can passively extract nucleic acids from the target organism. These passive biosensors represent a significant step-change from conventional diagnostics methods and could easily be used for performing diagnostics and surveillance in a sustainable, environmentally friendly way.

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KONRAD KWIECIEŃ

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Hydrophobic gentamycin-loaded microparticles from poly(sebacic anhydride) as a drug delivery system against pulmonary infections

Introduction

Limited drug delivery to the lower respiratory tract by regular administration (i.e., oral or intravenous) leads to the requirement of high doses that may cause side effects and development of antibiotic resistance. One of the possible solutions to this problem is the use of quickly biodegrading microparticles (MPs) as inhaled antibiotic delivery systems. Poly(sebacic acid) (PSA) and its copolymer with oligo(3-allyoxy-1,2-propyl succinate) (OSAGE) or poly(ethylene glycol) (PEG) are considered materials for such purposes due to the fast degradation rate. They have, however, a very low affinity to hydrophilic drugs (e.g., gentamycin) resulting in hardly any drug loading. For this reason, we produced lipophilic complex of Gent (GentAOT) with bis-2-ethylhexyl sulfosuccinate (AOT) by ion-pairing and encapsulated it within polymeric MPs to obtain a powder formulation dedicated to dry powder inhalers (DPIs).

Materials and methods

GentAOT was obtained, as described by Kwiecień *et al*. [1]. MP were manufactured using oil-in-water (O/W) emulsification from PSA and its copolymers with OSAGE (PSA:OSAGE (w:w) = 80:20 and 60:40) or with PEG (Mw = 250 or 600, PSA:PEG (w:w) = 90:10). The MP were characterized by scanning electron microscopy (SEM), and fluorometric assay for drug loading. Cytocompatibility was analyzed *in vitro* with human lung epithelial cells (BEAS-2B) using a metabolic activity test (AlamarBlue) and fluorescent staining (live/dead), and the antibacterial efficiency by Kirby-Bauer test against *Staphylococcus aureus*.

Results and conclusions

The MP were round and their surface was smooth. Mean diameters varied between 1-3 μm what is a proper size for inhalation. Drug loading was satisfactory of around 1% of MPs mass. The MPs showed no cytotoxic effect at low concentrations (10 to 100 μg/ml depending on the material). Antibacterial properties of GentAOT and GentAOT-loaded MPs against *S. aureus* showed similar antibacterial properties of GentAOT to commercial gentamycin, and the GentAOT-loaded MPs also inhibited the growth of bacteria, unlike MPs with commercially available gentamycin. Thus, GentAOT-loaded MPs seem to be a promising inhalable drug delivery system to the lungs.

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Materials for Bioelectronic Applications

A naturally occurring polymer has been chemically crosslinked in order to produce a robust hydrogel scaffold which is stable in water over several weeks. The polymer is based on a naturally occurring glycosaminoglycan, providing an inherently biocompatible starting material for the scaffold and provides predetermined routes of biodegradation. By crosslinking the polymer chains, the physical properties of the polymer were manipulated to provide a scaffold with an appropriate softness to match that of a specific target tissue and to prevent rapid degradation.[1] The mechanical properties of the spinal cord are targeted to provide a means of gauging an appropriate softness for the scaffold. Specifically, the elastic modulus provides a way of quantifying the mechanical properties. Values found in literature suggest the tissues in the spinal cord have an elastic modulus between approximately 5 and 90 kPa.[2, 3] An elastic modulus of 89 kPa has been used as a target for surrogate spinal cord materials.[4] Here, an elastic modulus value which falls within the range of 5-90 kPa would be considered appropriate for the spinal cord. The scaffold presented has an elastic modulus of 20 kPa when tested via an indentation test at an applied force of 30 mN. The scaffold is being developed as part of an organic electrochemical transistor which would be capable of mimicking the neural signals which take place within the spinal cord. Such a device would provide information about cellular communication if used *in vivo*, such as how, in the human nervous system, a chemical signal is sent through a series of neurons in response to stimuli. The device will have an active layer which will contain the conductive polymer poly(3,4-ethylenedioxythiophene), PEDOT, and a doping agent. Since PEDOT itself does not display appropriate mechanical properties nor is it biodegradable it requires doped with a material which has these properties. Fortunately, the scaffold presents as a natural dopant to PEDOT.[5] Early films containing a doped active layer have been characterised using cyclic voltammetry showing that the scaffold displays capacitance as required for future applications.

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Development of coatings rich in primary amines for biomedical applications

Biomaterial surface modification constitutes an important approach to improve the integration of the material in the surrounding tissues. Different techniques are focused on improving cell support as well as avoiding efficiently the development of infections, such as by modifying the biomaterial surface with amine groups (-NH_2). These -NH_2 groups may promote cell adhesion and proliferation and be used to link antimicrobial compounds[1,2]. In this project, whey protein fibrillar coatings and plasma coatings are two techniques used.

Whey protein isolate (WPI) can form fibrils under specific conditions. Due to the high surface/volume ratio fibril adsorption is enhanced to materials' surfaces. Fibrils withstood autoclave sterilisation and improved cell behaviour especially after the addition of phloroglucinol into the fibrillar network.

Plasma surface modification is a quick method to change homogeneously the surface properties in a one-step process. Different plasma treatment methods are commonly used with ammonia gas or by polymerisation of precursors such as allylamine which presents a high number of -NH_2 groups. However, a high degree of functionalities retention may be difficult to achieve due to multiple reactions occurring during the deposition. Two different conditions of plasma power and pressure were compared and the number of -NH_2 was quantified to 4.4% for 5.5 W at 20 Pa, and only 1.7% for 30 W at 2 Pa for allylamine plasma polymer coatings. Therefore, the use of a combination of high pressure/low power during the plasma deposition process can result in better retention of chemical functionalities.

In this talk, the cell test results of WPI fibrils containing phloroglucinol will be presented. Regarding plasma coatings, the quantification of -NH_2 by using chemical derivatisation will be presented.

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How to Implement Machine Learning in Life Sciences?

We think that artificial intelligence is limited to robots that are meant to mimic humans, to detect what kind of emails I should receive in my inbox, spam, phishing, clever emails from my boss, or simply to help my Tesla drive itself on the road. However, we have overlooked the fact that this new technology can also impact and help in life science. In this talk, we will explore different applications where machine learning has been successfully implemented in different life science fields, what are the advantages, limitations, and how you can start exploring and using machine learning in your research.

SERHII PANCHENKO

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Features of stress-strain state investigation of "bone – fixator-plate" system when taking into account the mechanical properties orthotropy of cortical bone tissue

Introduction. Osteosynthesis is one of the most efficient methods of bone fractures treatment [1]. Development of modern computer technology and specialized software gives a possibility to perform preliminary estimation of osteosynthesis efficiency. In most papers related to the study of a stress-strain state of "bone-fixator" systems, bone tissue is considered as a homogeneous, isotropic, elastic medium [2]. However, in reality it is heterogeneous and has an anisotropy of mechanical characteristics [3]. This fact indicates that in a case of using a simplified isotropic model of bone tissue, when performing calculations, there is a possibility of obtaining inaccurate results.

The aim of study. To estimate an influence of mechanical properties orthotropy of cortical bone tissue on a stress-strain state of "bone-fixator" system.

Methods. Osteosynthesis of low fracture of fibula is selected. Two simplified numerical models are constructed to solve the problem. These models are different only in properties of cortical bone tissue.

Results. Analysis of a stress state in models elements indicated that normal stresses reached the highest values, and tangential stresses are relatively small. Stress state patterns are qualitatively similar for both computational models. The maximum stresses are the result of their concentration.

Conclusion. Consideration of elastic parameters orthotropy of a bone tissue led to significant quantitative changes in the indicators of a stress state. It is established that the minimum safety margins for both osteosynthesis models turned out to be considered by the maximum tensile stresses acting in the vertical direction. Calculations results indicate a possibility of using an isotropic model of cortical tissue in order to identify the most efficient fixation plate designs.

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PIOTR PAŃTAK

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The effect of liquid phase on properties of calcium phosphate based cements containing hybrid hydroxyapatite/chitosan granules

Introduction: Although various bone substitutes are commercially available on the market; the problem of effective reconstructive treatment remains challenging. An important group of biomaterials are calcium phosphate cements (CPCs), characterized by excellent bioactivity and similarity in their chemical composition to the inorganic part of human bone [1]. Special type of bone cements are biomicroconcretes combining aggregates in the form of granules with cementitious matrix, which provides materials with unique physicochemical and biological properties [2]. Both bone cements and biomicroconcretes consist of a solid and a liquid phase which, when mixed, form a plastic, self-setting paste. Typically, the liquid phase of cement-type materials contains aqueous solution of inorganic salts, i.e., Na_2HPO_4. However, recently a lot of research is being carried out to modify the liquid phase to improved biological, applicational, as well as physicochemical properties of materials.
Aim: The aim of the study was to investigate the effect of the liquid phase composition on the properties of α-TCP-based bone cements and biomicroconcretes. Solid phase of biomaterials composed of hybrid hydroxyapatite/chitosan-based granules and α-TCP powder as a setting component. Various mixtures of Na_2HPO_4 and citrus pectin gel were used as liquid phases. Setting times, phase composition, compressive strength, microstructure, *in vitro* chemical stability, injectability and cohesion of the obtained materials were investigated.
Results and discussion: Studies have shown that the obtained biomaterials were characterized by unique properties due to different liquid phase compositions. The liquid phase, which consisted only of a citrus gel inhibited setting process of cementitious materials. Application of mixture of Na_2HPO_4 and citrus pectin gel allow to obtain materials with setting times in the range required for cementitious bone substitutes were obtained. It was due to the presence of setting accelerator - Na_2HPO_4. The compressive strength of the studied materials was from 6 up to 15 MPa and was similar to that of human cancellous bone. Cement pastes with a content of at least 50% citrus pectin in the liquid phase were highly injectable since the presence of polymer caused their plasticization.
Outlook: It has been demonstrated that due to the presence of the polymer in liquid phase and optimization of citrus pectin to Na_2HPO_4 ratio, we can obtain prosperous self-setting and injectable α-TCP-based cements and biomicroconcretes for bone defects filling.

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3D bioprinted vessels for endothelial tissue engineering

Introduction Biofabrication of hydrogel scaffolds is essential in tissue engineering (TE) allowing the manufacturing of custom-designed implants [1]. One of the most popular fabrication techniques is 3D bioprinting which can be used to produce constructs based on patients'needs and requirements [1].Printing of low viscosity and slow polymerizing solutions with good spatial resolution can be achieved by freeform reversible embedding of suspended hydrogels (FRESH) bioprinting of cell-laden natural hydrogels. In this study, gellan gum(GG) and laponite (Lp) were blended as ink mixtures for the FRESH bioprinting. GG is a natural biocompatible polysaccharide, it promotes cell adhesion and possesses angiogenic properties [2]. The addition of Lp to GG hydrogels improves the printability, increases the pore size of the cross-linked network favoring the formation of vascular network and promoting endothelial cell migration in the printed structures [3]. For FRESH bioprinting, the use of a supportive gelatin bath enhanced the construct stability as well as the shape fidelity. Furthermore, the support bath enables printing of low viscous materials such as GG used in this study, as it shows high cytocompatibility and supports vascularization.The biofabricated vessel-like structures containing L929 fibroblasts have been evaluated for their mechanical stability, swelling properties and in vitro biocompatibility. **Materials and Methods** Two blends were prepared: (i) 1% w/v GG/0.5% w/v Lp (0.5%Lp-GG) and (ii) 1% w/v GG/1% w/v Lp (1%Lp-GG). The laponite suspensions were prepared by stirring for 12h at RT. Then, GG powder was added and allowed to blend with Lp for 3h under stirring. Subsequently, the Lp/GG inks were combined with L929 at a ratio of $3x10^6$ cells/ml of ink, and were bioprinted in an Inkredible+ bioprinter (CellInk) at 37°C using a CAD model for the biofabrication of hollow tubular structures. The gelatin support bath was prepared by dissolving 2g gelatin in 40 mL ddH_2O at a maximum temperature of 45°C. The gelatin slurry was formed after cooling for 4h at RT. The produced tubular structures were crosslinked with a 2.5% w/v KCl solution by stabilizing the negatively charged groups of GG, resulting in reinforcement of their mechanical strength. Gelatin supporting bath was removed after melting in 37°C. Optimal printing parameters were selected based on preliminary trials to achieve best shape fidelity. The swelling properties of the bioinks have been determined and their Young modulus has been evaluated as an indicator of their elasticity. For their biocompatibility evaluation, the constructs were stained with the live/dead reagents and visualized under a confocal laser fluorescence microscope. **Results and Discussion** The average height of the tubular constructs was 1 cm with an inner diameter of 3 mm and a wall thickness of approximately 1 mm similarly to medium arteries structure [4]. Both Lp-GG compositions of biofabricated tubes, the 0.5%Lp-GG and the 1%Lp-GG indicated high cell viability of 84 and 88% on day 3, and Young modulus values of 10 and 12 MPa, respectively, matching the characteristics of the native femoral and internal mammary arteries[5]. Increasing the Lp concentration led to a non-significant decrease of swelling ratio from 94 to 91%. **Conclusions** Gellan gum was combined with laponite to produce multifunctional inks. Cell-laden Lp-GG bioinks were used to create hollow tubes mimicking the features of blood vessels. Both bioinks maintained high shape fidelity compared to the respective CAD designs, high viability levels, eminent elasticity and high swelling properties indicating promising constructs for TE applications. Ongoing investigation includes their endothelial regeneration capacity in vitro and in vivo. The FRESH printing technology enables to pre-vascularize 3D bioprinted constructs, which is essential towards the development of complex bioengineered implants **Acknowledgements** This research was funded by the Hellenic Foundation for Research and Innovation (H.F.R.I.) project number HFRI-FM17-1999.

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3D printing of polymer-ceramic bone implants with micrometre-scale pores

Osteoarthritis, osteoporosis, and bone damage (e.g. after tumour resection) are some of the most disruptive diseases to afflict human mobility. The way to restore mobility is to use a variety of artificial metal or ceramic implants or natural bone fragments from another donor. The better option would be to use biodegradable materials, which can use the organism's natural regeneration forces to heal damaged tissue. 3D printing techniques can deliver such materials tailored to each patient.

This work presents a fast and easy method of producing polymer or polymer-ceramic filament for obtaining 3D-printed scaffolds with micrometre-scale porous structures on scaffold surfaces. We used polycaprolactone (PCL) as the scaffold's primary polymer, β-tricalcium phosphate (β-TCP) as the model filler, and polyethene glycol (PEG) as a pore-making agent. PCL was dissolved in dichloromethane and mixed with β-TCP and PEG. Solutions of polymers and ceramic were poured on the flat glass bed and dried at 40ºC. The obtained variants of polymer-ceramic foils were melted at 120 ºC in a stainless-steel container, pressed through a nozzle, and cooled into filaments with 2.85 mm diameter. Filaments were used to 3D print simple scaffolds in ZMorph VX commercial 3D printer. Produced scaffolds were washed in distilled water to remove PEG, and obtained micro-porous structures on the surfaces of the scaffolds were evaluated by scanning electron microscopy (SEM). The composition of the scaffolds was determined in Fourier-transform infrared spectroscopy (FTIR), and *in vitro* culture with an MG63 human cell line allowed the determination of cytotoxic properties.

The presented method gave flexible and resilient filaments containing PCL, β-TCP, and PEG, useful in commercial 3D printers for printing 3D objects. SEM images of printed scaffolds revealed microporous structures with visible ceramic particles on the scaffold's surfaces. Furthermore, printed materials have good printing precision and show no cytotoxicity properties. These results open a path for fast and cheap production of micrometre-wide porous 3D-printed implants.

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Characteristics of spongy polymeric bigels containing whey protein isolate, sodium alginate and ethyl cellulose

Bigels are materials developed by blending two phases gelled with suitable polymers: hydrogel based on hydrophilic polymers and oleogel – oil gelled with an organogelator. They are noticed due to their advantages of combining two gels, including improved physicochemical properties and the possibility of adding hydrophilic and lipophilic active substances. Modification of bigels by freeze-drying may lead to further enhancement of their characteristics.

The main goal of this research was to obtain and characterise spongy bigel-based materials. The hydrogel comprised sodium alginate, whey protein isolate (WPI) and glycerol, whereas the oleogel contained sunflower oil, ethyl cellulose and emulsifier Span 80. Both phases were blended at different hydrogel/oleogel ratios using a homogenizator, freezed and freeze-dried. The three-dimensional structure of obtained materials was analysed on a scanning electron microscope (SEM). The characterisation of physicochemical properties included mechanical properties, moisture content, swelling properties, porosity and density.

The properties of developed matrices depended on the content of polymers and the ratio of mixing oleogel and hydrogel. Optimisation of preparation parameters, such as the composition of hydrogel and oleogel, as well as their mixing ratio, are crucial in obtaining materials with desired properties. Prepared materials can be the basis for obtaining a new class of functional materials for dermatological and cosmetic purposes.

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In vitro evaluation of the biodegradability of chitosan–genipin hydrogels

Biomaterials intended for *in vivo* applications should ideally be biodegradable to prevent their retention in the body, while avoiding the need for surgical removal. This study investigates the *in vitro* lysozyme degradation of chitosan–genipin hydrogels using fluorescence formed during the crosslinking reaction between chitosan and genipin, resulting from highly conjugated heterocyclic structures. Fluorescence degradation studies showed that the supernatant of degraded hydrogels significantly fluoresced, suggesting that although the hydrogel structure was broken down, chitosan–genipin crosslinks prevail. Further studies employing FTIR showed that this is not entirely the case, and that one of the bifunctional crosslinks between chitosan and genipin is broken. Results suggest that lysozyme degrades the secondary amide linkage, whilst the tertiary aromatic amine linkage remains unbroken. Seeking to evaluate feasibility and likely mechanism of removal of degraded hydrogels *in vivo*, degraded particle size was measured. Results show existence of particles as small as 1.7 nm, which is below the threshold for renal filtration. At the same time clusters of larger particles with a mean diameter of 218.4 μm ± 17.8 were detected and shown to likely form *via* agglomeration, rather than incomplete degradation. Collectively, our findings show that lysozyme partially degrades chemical crosslinks in chitosan–genipin hydrogels, and that these hydrogels have potential to be eliminated from the body *via* urinary excretion.

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AuNPs/CNOs/SWCNTs/chitosan-nanocomposite modified electrochemical sensor for the label-free detection of carcinoembryonic antigen

In this work, a nanocomposite of gold nanoparticles (AuNPs), carbon nano-onions (CNOs), single-walled carbon nanotubes (SWCNTs) and chitosan (CS) (AuNPs/CNOs/SWCNTs/CS) was prepared for the development of highly sensitive electrochemical immunosensor for the detection of carcinoembryonic antigen (CEA), clinical tumor marker. Firstly, layer-by-layer fabrication of the CEA-immunosensors was studied using cyclic voltammetry (CV) and square wave voltammetry (SWV). By combining the advantages of large surface area and electronic properties of AuNPs, CNOs, SWCNTs, and film forming properties of CS, AuNPs/CNOs/SWCNTs/CS-nanocomposite-modified glassy carbon electrode showed a 200% increase in effective surface area and electronic conductivity. The calibration plot gave a negative linear relationship between log[concentration] of CEA and electrical current with a correlation coefficient of 0.9875. The CEA-immunosensor demonstrated a wide linear detection range of 100 fg mL^{-1} to 400 ng mL^{-1} with a low detection limit of 100 fg mL^{-1}. In addition to high sensitivity, reproducibility and large stability, CEA-immunosensor provided an excellent selectivity and resistant-to-interference in the presence of other antigens in serum and hence a potential to be used with real samples.

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Dual cross-linked injectable hydrogel materials based on chitosan

Injectable hydrogel materials are attractive class of biomaterials with remarkable properties as drug-controlled release system due to their high water content, controlled degradation, rheological properties and biocompatibility. When obtaining injectable hydrogels, it is extremely important to ensure the surgical handiness by selection of appropriate cross-linking agent. It can be performed by functionalized dextran containing a reactive aldehyde groups which will be able to react with amino groups, present in chitosan, by Schiff base cross-linking. Moreover, the presence of metal ions such as calcium or boron can also influence the cross-linking of chitosan via electrostatic interactions. These elements are present in bioactive glasses (BGs), which means that BGs probably can have the potential to cross-link chitosan matrix.

In this study injectable hydrogel materials based on chitosan, cross-linked with a functionalized dextran and different BGs were obtained. BGs such as high-calcium A2 bioglass (40 mol% SiO_2, 54 mol% CaO, 6 mol% P_2O_5), A2B40 borate bioglass (54 mol% CaO, 6 mol% P_2O_5, 40% B_2O_3) and 45S5 bioglass (45 mol% SiO_2, 24.5 mol% CaO, 24.5 mol% Na_2O, 6 mol% P_2O_5) have a dual function - chitosan cross-linking agents and functional ingredients.

The aim of this study was to obtain injectable hydrogel materials based on chitosan and evaluate the effect of different BGs on the cross-linking process and physicochemical, biological and rheological properties of hydrogels. All materials were incubated in SBF solution in order to assess their degradation, while the ICP-OES analysis was held to evaluate the ion migration from/into the solution. After the materials were freeze-dried their microstructure, porosity and mineralization was assessed by SEM/EDX microscopy and ATR-FTIR spectroscopy. Mineralization process in wet state was evaluated using μCT imaging. Additionally, a rheological and self-healing properties were investigated. The preliminary *in-vitro* studies of the biological response were carried out on Hs680.Tr fibroblasts.

The conducted research allowed to conclude that presence of BGs affects the cross-linking process and modulates the properties of hydrogel materials. Each of the BGs affects the process of mineralization, self-healing ability and viscoelastic properties of materials in a different way. Additionally, the presence of each of BGs improved the biological properties of the hydrogels compared to the base material. The obtained hydrogels have promising multifunctional properties and great potential for use as injectable materials for tissue engineering.

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Bioinspired functionalization of chitin for environmental and biomedical applications

Chitin -the second most abundant polysaccharides on earth after cellulose - has drawn tremendous research attention for various environmental and biomedical applications due to their abundance availability, sustainability, biodegradability, and biocompatibility. Nonetheless despite those merits, its direct applications are often limited mainly due to the insolubility in most solvents. Chemical modification is an interesting solution involving primary amine group of chitin/chitosan to improve the solubility as well as to impart novel functionalities of the molecules for targeted applications. Herein, several materials following Oomycota (fungus)[1,2], tunicate (marine animals)[3], and cell membrane mimetic[4] strategies were developed for their application in large-scale additive manufacturing, tissue adhesive and guided bone regeneration applications, respectively.

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β tricalcium phosphate and polyhydroxyalkanoate blends composites as bone substitutes

The application of bioactive β tricalcium phosphate (βTCP) with degradable polymers not only leads to improved mechanical properties but also provides additional multifunctionality of ceramic-polymer scaffolds [1]. Polyhydroxyalkanoates (PHAs) are biocompatible and biodegradable polyesters with various physicochemical properties depending on their chemical structure. Various PHAs can be combined to form polymeric blends with some superior properties, different from those of their components. Thus, in our study, we used poly(3-hydroxybutyrate) (P(3HB)) and medium chain length PHA (mclPHA) blends as coatings on βTCP scaffolds.
The initial βTCP powder was obtained *via* wet chemical synthesis. The βTCP-based scaffolds were prepared using polyurethane sponge replica method. PHAs were synthesized by bacterial fermentation. Blends containing P(3HB) and mclPHA were obtained by mixing appropriate amounts of polymers solutions in chloroform. Next, ceramic scaffolds were treated with citric acid solution, infiltrated with blends, dried and subjected to further studies. The influence of the coating type on the physicochemical properties of scaffolds was investigated using various techniques such as XRD, ATR-FTIR, DSC/TG, SEM, AFM, wettability measurements and UHPLC-MS.
XRD, ATR-FTIR, DSC/TG analysis and SEM observations confirmed the presence of βTCP and PHA blends in the composites. The polymeric layers did not significantly influence the pore size or the open porosity of the scaffolds. Composites had a higher compressive strength than sole βTCP scaffolds. Moreover, the integrity of the composite samples after mechanical tests has been preserved. The wettability studies revealed that the polymeric coating significantly changed the character of the ceramic surface from hydrophilic to hydrophobic and influenced its roughness, as evidenced by AFM. After incubation in simulated body fluid, the formation of apatitic layer on the composite surfaces' was observed, which indicates the bioactive potential of developed materials. Moreover, after 1, 3 and 6 months of incubation in water, low quantities of hydroxyacids, and also their oligomers, were detected by UHPLC-MS analysis. According to the literature, hydroxyacids – the degradation products of PHAs were found to effectively reduce osteoporosis in both *in vitro* and *in vivo* studies [2], which broadens the range of applications of the obtained composites.
Blends with various amounts of brittle P(3HB) and viscous mclPHA can serve as coatings on βTCP scaffolds, modulating the physicochemical properties of the composites. Additional functionalities such as improved bioactivity and biodegradability can also be achieved. However, further *in vitro* cytocompatibility and *in vivo* studies are necessary.

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Development of highly selective aptamer-molecularly imprinted polymer hybrids (AptaMIPs)

Molecular recognition is a vital feature of analytical science that usually comes from bioreceptors, such as enzymes or antibodies. These bioreceptors are designed to interact with specific analytes, with a high degree of selectivity amongst a matrix of other chemical or biological components. Aptamers, short stranded DNA, offer excellent recognition properties, but performance and environmental stability is low, with environmental degradation a particular problem, use as an appropriate bioreceptor can be compromised. Molecularly imprinted polymers (MIPs) are artificial recognition materials that could be alternatives and combat these derogatory issues. They are produced by the polymerisation of functional monomers complexed around a template molecule. Removal of the template molecule leaves template-specific high-affinity cavities within the nanomaterial matrix. MIPs offer robustness and ability to work in extreme environmental conditions, but can lack the same recognition specificity of biological elements. By functionalizing the chemical structure of an aptamer making them polymerizable, we incorporate them for use as the recognition "macro-monomer" of MIPs, creating novel hybrid systems (Figure 1). This allows for the MIP to act as a protecting polymer scaffold, preventing "macro-monomer" degradation, while also locking the "macro-monomers" into their optimal conformation. Using multiple synthetic approaches, we developed aptaMIP (aptamer-MIP hybrids) nanoparticles, for protein and antibiotic targets. The developed hybrid systems have shown to offer superior (up to 100-fold) binding affinity over their conventional MIP and "macro-monomer" counterparts. The introduction of the specific recognition "macro-monomers" into the MIP scaffold offers potential to improve the molecular imprinting class of polymers significantly, generating a new class of recognition elements for biosensors and potential therapeutic applications.

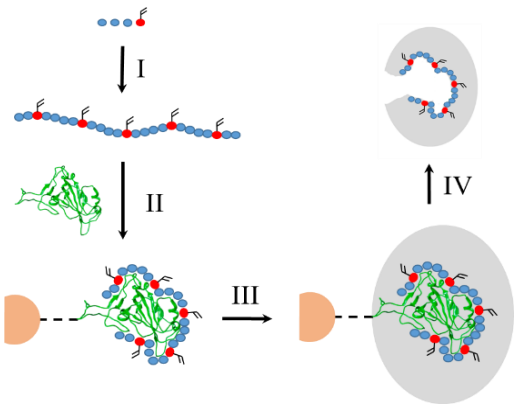

Figure 1. *Schematic representation of the solid-phase synthesis of aptaMIP NPs. Red circles indicate the modified polymerizable base, blue circles indicate normal bases, orange semi-circle indicate solid support and the green ribbon represents the spike protein subunit template molecule.* ***I:*** *Synthesis of aptamer sequence to include polymerizable moieties.* ***II:*** *Complexation of aptamer with subunit target moiety attached to an inert solid phase.* ***III:*** *Addition of polymer scaffold components, polymerisation, and formation of polymer scaffold;* ***IV:*** *Thermal (60 °C) release of the aptamer incorporated nanoparticle.*

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The effect of blood-derived products on macrophages obtained from sheep during implantation of Si-DLC coated implant

Biomaterials used in orthopedics should be characterized by high biocompatibility. One of the ways to increase biocompatibility is to cover it with Diamond-like Carbon (DLC) layer. DLC layers in addition to high biocompatibility are characterized by a smooth surface, low friction coefficient, chemical inertness, and wear resistance. They can also be modified by different atoms. It has been shown that adding silicon (Si) imparts antibacterial properties. In our study, an innovative implant with a Si-DLC layer was used in a sheep model. Macrophages are immune cells that play important role in inflammatory response after implant insertion. They can be classified by their functionality into two classes. M1-like pro-inflammatory macrophages are responsible for proinflammatory cytokines release and reactive oxygen/nitrogen species production. M2-like macrophages stimulate angiogenesis, debris clearance, and fibroblast growth and release anti-inflammatory cytokines. They can accelerate the healing process after implantation. For this reason, we analyzed the influence of blood-derived products on macrophage polarization to M2-like functionality phenotype. For stimulation of monocyte-derived macrophages, we used three types of blood-derived products which are platelet-rich plasma containing a few or no leukocytes (PURE-PRP), platelet-rich plasma containing more leukocytes (L-PRP) and platelet-poor plasma (PPP). We determined functional markers for each group based on superoxide and nitric oxide generation and arginase-1 activity. Our results suggest that is no difference between macrophage activity in sheep with and without Si-DLC layer-coated implant, but we proved that PPP and PURE-PRP in vitro stimulation have no impact on the generation of superoxide and NO but increased arginase-1 activity. L-PRP stimulation was characterized by a significant rise in both ROS generation and arginase-1 activity. Our study indicated the potential of blood-derived products for the modulation of the inflammatory response of macrophages during implantation.

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Core-shell fibers for drug delivery produced in electrospinning process

Electrospun nanofibers indicate proper characteristics to be efficient and targeted drug administration in tissue engineering applications. A novel technology is the triaxial electrospinning technique which combines three component nanofibres formation. A core and two surrounding layers form the three layers of the fibers produced using this approach. Triaxial electrospinning is a reasonable alternative to uniaxial and coaxial techniques for alleviating major limitations such insufficient sustained and controlled drug release, low drug solubility, difficulties loading multi pharmaceuticals, biodegradation, and inadequate biocompatibility [1].

The primary goal of the research is to optimize the triaxial electrospinning process to get homogenous/ free of beads fibers and desired drug release profile.

A merger of biodegradable synthetic and natural polymers, including polycaprolactone (core layer), gelatin (intermediate layer), and poly(lactic-co-glycolide) (shell layer) were used to fabricate the fibers. Synthetic polymers enhance mechanical properties of the system, while natural polymers mimic natural chemistry of the extracellular matrix. Rhodamin B was inserted to selected layers as a model of the drug.

Preliminary research will be discussed, including the optimization of triaxial fiber production. Microscopic images showed that numerous experiments led to the development of homogenous free-bead fibers. Moreover, it was observed that fibers are covered by an outer layer in accordance with expectations. Transmission electron microscopy images proved that under the shell layer, there is a middle that surrounds the core layer. We were able to select parameters of the process which ensure core-shell fiber structure. To examine the release characteristics from triaxial and coaxial fibers, preliminary in-vitro tests using rhodamin B were conducted. As compared to coaxial fibers, the results showed that triaxial fibers greatly reduced initial burst release.

According to our study, triaxial fibers indicate promisingproperties to be employed as cutting-edge drug delivery systems in biomedical applications.

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Chemical modification of chitosan to produce novel derivatives for nose – to – brain drug delivery

Nasal drug delivery is attracting increased interest as it is a promising avenue for drug delivery to the brain. The nature of certain drug molecule means that they cannot pass the Blood Brain Barrier (BBB) effectively however, the olfactory pathway allows for drug delivery directly to brain by bypassing the BBB (1). For nasal drug delivery to be effective over the conventional formulations, mucoadhesive polymers Such as: chitosan needs to play a key role in the formulation to increase the retention time within the nasal mucosa. Chitosan is a cationic biopolymer with wide ranging pharmaceutical applications. Its unique chemical nature and presence of amino and hydroxyl groups give rise to beneficial physiochemical characteristics. The main problem with chitosan is that it dissolves well at acidic pH and becomes poorly soluble in neutral conditions typically found in the nasal mucosa. To overcome this limitation, modifications of chitosan have been reported which increase the solubility and mucoadhesiveness of chitosan.

Previously, Methacrylic anhydride has been used to modify chitosan via N-alkylation reaction to produce methacrylated derivatives that improve its solubility and mucoadhesive properties (2). In this work, crotonated chitosan derivatives synthesised from crotonic anhydride have been reported. ^{1}H NMR and FTIR have been used characterise these derivatives coupled with turbidity measurements to evaluate the effect of pH on the solubility of chitosan and its derivatives. Solubility studies found that crotonated derivatives remain soluble over a wide range of pHs compared to chitosan and methacrylated derivatives. Tensile test with texture analyser and fluorescence flow through studies were conducted with sheep nasal mucosa to study the mucoadhesive properties of the new derivatives in comparison with unmodified chitosan. Modified chitosan derivatives have improved retention on the sheep nasal mucosa compared to the parent polysaccharide in both tests.

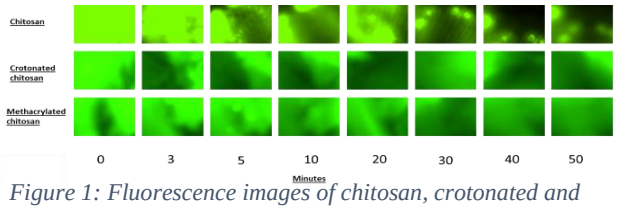

Figure 1: Fluorescence images of chitosan, crotonated and methacrylated chitosan formulations with sodium fluorescence at different time intervals during nasal retention studies.

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MICHAŁ WOJASIŃSKI

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Lecithin-modified amorphous hydroxyapatite-alendronate nanoparticles with enhanced cellular uptake

Bisphosphonate remains the leading group of drugs for osteoporosis treatment. The most popular among them – alendronate – exhibits about 0.7 % bioavailability when administered orally. Moreover, orally administered bisphosphonates induce severe side effects in therapy, including oesophagus cancer. We propose lecithin-modified hydroxyapatite nanoparticles as a drug delivery system for alendronate. The system allows for overcoming of mentioned limitations in bisphosphonate therapies.

Nanoparticles encapsulating the alendronate were precipitated in a continuous reactor by mixing aqueous solutions of calcium nitrate/lecithin and di-ammonium hydrogen phosphate/sodium alendronate in three concentrations (5 mM, 10 mM, and 15 mM). Scanning electron microscopy images indicate a significant change in size for particles encapsulating alendronate (from about 20 to about 55 nm). In suspension, all investigated particles maintained similar size regardless of the encapsulation of active substance: 40 to 60 nm in dynamic light scattering and 110-200 nm in nanoparticle tracking analysis. Fourier transform infrared spectroscopy indicated the presence of lecithin in each hydroxyapatite-lecithin-alendronate composition with specific peaks, while alendronate peaks appeared in the range from 600 to 1000 cm^{-1} typical for hydroxyapatite. Those results correspond with results from X-ray diffraction – adding alendronate into the drug delivery system results in amorphous nanoparticles. Thermogravimetric analysis show encapsulation of about 30 % of alendronate by mass. The present system releases about 30 mg of alendronate from 1 g of formulation over 30 days in a slightly acidic pH (5.0) corresponding to endosome pH. Cytotoxicity studies (L929, MG63, and Caco-2 cell lines) of all tested formulations indicate no significant drop in cell viability *in vitro* for particle concentration from 1 to 500 μg/ml. Cellular uptake studies (in MG63 and Caco-2) show that lecithin-modified hydroxyapatite particles were internalised more efficiently by cells *in vitro* than hydroxyapatite particles not modified with lecithin.

The present encapsulation of alendronate in hydroxyapatite-lecithin nanoparticles results in an amorphous drug delivery system, allowing the prolonged release of the active substance over at least 30 days and increasing the particle's cellular uptake *in vitro*.

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Facile preparation of starch-based biodegradable materials with ionic conductivity and strain-responsiveness

Natural biopolymers, from sustainable biomass resources, are biodegradable and biocompatible and thus have huge potential for developing biomedical or transient systems. However, the processing of biopolymers is challenging (e.g. poor solubility in common organic solvents and high viscosity) due to the dense hydrogen bonds existing in them. We have recently found that metal chloride salt solutions of certain concentrations can effectively destruct the granules of high-amylose maize starch (HAMS) biopolymer and allow for the easy preparation of starch-based hydrogels.

Here, we report an entirely starch-based hydrogel for flexible electronics including strain-sensitive batteries and self-powered wearable sensors. This biodegradable hydrogel is only based on natural HAMS, CaCl2, and glycerol, and the preparation method is green and facile (namely stirring at 70°C for 1 h). This hydrogel is highly stretchable, flexible, reprocessable, and self-healable. Based on this hydrogel, we developed a galvanic cell-type Zn-Cu battery (composed of one starch-based hydrogel additionally incorporated with zinc powder and the other with $CuCl_2$ and copper powder), which has a voltage of 0.81 V and its output current positively correlated with compression deformation. Based on this Zn-Cu battery, a self-powered (SP) wearable sensor was further constructed, which has high sensitivity (1.5371 kPa−1) even under weak compression stress. This SP sensor can be used to detect human activities involving small strain such as wrist pulse and throat vibration with strong, clear and stable signals. Considering the easy processability, cost-effectiveness, high strain-sensitivity, robustness, and greenness of the starch-based hydrogel and electronics, their application prospect is foreseen.

POSTER PRESENTATIONS

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Poster 1: Advanced modified polymer and carbon materials for medical application

This study investigates and compares the physicochemical properties of acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), and polycarbonate (PC) composites for their potential to replace conventionally manufactured medical rescue boards by subjecting them to test having been prepared under the same condition. Basalt, glass, cellulose and carbon fiber were shortened and used as reinforcement. The polymer composites were assisted with compatibilizer polyols to improve adhesion. Chemical integrity was confirmed using Fourier transform infrared spectroscopy (FTIR) analysis for both material matrix and reinforcement. Imaging such as Confocal microscopy was carried on them. These composites were used by the injection moulder to produce template samoles for mechanical testing. Charpy tests were performed according to ASTM D6110-18 [1]. Other tensile properties were analyzed using dog bone specimens printed through injection mold according to ASTM D638-14 [2] to verify the effect of these reinforcements on the mechanical properties of the composites under study. High-resolution images of the reinforcements were also obtained by exposing both the fiber and shortened reinforcements to confocal microscope. The surface morphologies of the shortened the reinforcements were examined by scanning electron microscopy (SEM). Results with respect to the material density and fibre volume fraction showed that cellulose composite could absorb more energy to break more than other composites as indicated by Charpy test.

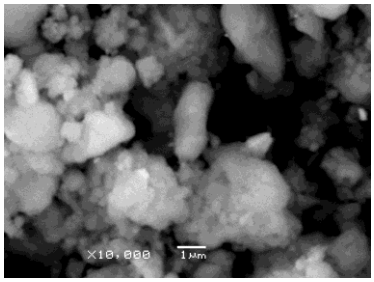

Fig 1. SEM image of PBF

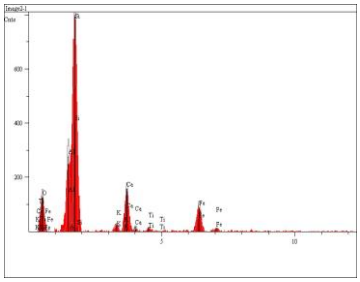

Fig 2. SEM elemental analysis of PBF

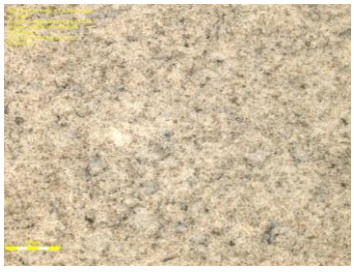

Fig 3. Confocal microscopy of PBF

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Poster 2: Preparation and characterization of albumin nanospheres as carriers of cytostatic drugs

Albumin is considered to be one of the most important proteins in the human body. It consists of almost 60% of all proteins contained in the plasma and is well soluble in water. In the human body, albumin fulfils many physiological functions, including e.g. the regulation of osmotic pressure, maintaining the proper pH of the blood as well as the nutritional functions. An extremely important property of this protein is its ability to bind and transport ligands, both exogenous and endogenous. Due to its transport functions, this protein is very often used as a carrier in controlled drug release systems [1 - 3].

The main purpose of the presented work was to develop a synthesis methodology of albumin carriers using the salt-induced precipitation process. The possibility of the use of different types and concentrations of the salting-out agent as well as the albumin solvent with different pH was verified in the course of the studies. Moreover, the syntheses were carried out with the use of various mixing methods, i.e. via the syringe system and with the use of a burette. Based on the physicochemical and biological analyses of obtained carriers, the most beneficial synthesis conditions were selected. It has been proved that the particles obtained have a nanometric size and a spherical shape. Moreover, the tested albumin carriers did not show cytotoxic activity against normal human dermal fibroblasts.

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Poster 3: Electrophoretic deposition of chitosan coatings with ceramics and metallic nanoparticles on titanium alloy for biomedical applications

Bacterial infections are one of the main causes of implant loosening [1]. Among others, metallic nanoparticles with such proven properties are used to provide antibacterial properties. In addition, research is being conducted to provide biological shielding only in the event of an infection, thus preserving the long-term antibacterial properties of the implant.

The proposed in research solution involves producing a pH-sensitive coating based on chitosan with the addition of nanohydroxyapatite and with the addition of zinc nanoparticles to provide antibacterial properties by electrophoretic deposition.

The coatings were deposited by electrophoretic method with variable electrolyte chemical composition (content of hydroxyapatite nanopowder and zinc nanoparticles). The substrate material was titanium alloy Ti13Zr13Nb. The microstructure of the modification was studied using scanning microscopy. The chemical compositions were determined with the X-ray energy dispersive spectrometer (EDS). The wettability studies were evaluated via an optical tensiometer using a falling water drop method. The inhibition of bacteria growth was evaluated by measuring the turbidity of cultured bacteria broth incubated with tested specimens according to the McFarland standards.

Microstructural and chemical composition studies have proven that it is possible to produce a coating of the proposed composition in a single electrophoretic deposition process on titanium alloy. Studies of the contact angle proved the hydrophilic character of all tested modifications. Tests of antibacterial properties indicate inhibition of bacterial growth in the presence of coatings with zinc nanoparticles.

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Acknowledgements: This research was supported in part by the Polish National Science Centre, grant no. 2019/03/X/ST5/00243

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Poster 4: Physicochemistry of hyaluronic-acid based nanocapsules with oil cores for biomedical applications

Nowadays, the topic related to drug delivery systems is one of the most developing research areas in biomedical science. The task of such structures is to release active substances at a specified rate and into a specified place in the body, protect the drug from degradation and minimize side effects, while increasing the effectiveness of therapy. In addition, they can solve problems associated with the administration of promising therapeutic compounds with poor solubility in aqueous solutions and, consequently, poor permeability through biological membranes.[1]

The subject of the presented research are polymeric nanocapsules built of a liquid-oil core and a polysaccharide shell that are dispersed in water. The core of the capsules provides a microenvironment for encapsulation of hydrophobic active substances, while stabilization is provided by alkyl hydrophobic chains grafted to the macromolecules, which anchor to the oil droplets during the encapsulation process. The structures were made by the emulsification method combining an aqueous phase, which is hyaluronic acid modified with 12-carbon alkyl chains (HyC12) dissolved in 0.15 M NaCl aqueous solution, and an oil phase.[2] Oils with different physicochemical properties, as well as their mixtures, were used as the oil phase.

Nanocapsules were tested for their ability to effectively encapsulate mixtures of oils with different physicochemical properties. The obtained structures were characterized for their physicochemical properties using the phenomenon of dynamic light scattering. The effect of interfacial tension between the aqueous and oil phases on the size and stability of the capsules was also investigated. The results obtained confirm that the size and stability of the capsules depend on the properties of the oil phase.

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Acknowledgements: This study was supported by the Polish Ministry of Science and Higher Education within the "Doktorat Wdrożeniowy I" Programme, Project title: Multifunctional polymeric nanocapsules as carriers of lipophilic active substances with synergistic effect, agreement no. DWD/5/0402/2021.

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Poster 5: Filtering membrane compliant with the FFP3 standard used to protect the upper respiratory tract against viral and bacterial infections with particular emphasis on SARS-CoV-2

Bacteria, viruses or polluted air pose a real threat to the health of every human being. The development of various diseases in the world, as well as the pandemic caused by the rapid spread of the SARS-CoV-2 virus, have increased awareness of particles and pathogens in our environment that are harmful and dangerous to mankind. Protection of the upper respiratory tract should be a priority nowadays, so more and more devices and equipment for personal protection are being created, which is slowly becoming an inseparable part of everyday lives. These types of devices have specific safety classes and are equipped with appropriate filters made of special materials that are key to reducing the level of biological hazard to which not only healthcare workers are exposed, but also every citizen. The creation of a mask with the FFP3 standard, used to protect the upper respiratory tract against viral and bacterial infections, with particular emphasis on SARS-CoV-2, based on patent No. 235673 [1], will let stop approx. 99% of harmful particles. The filtering membrane made of cellulose fibers produced by using the modern, both environmentally friendly and at economic NMMO technology is a good solution considering the widespread inflation in the world according to Trading Economics. Preliminary studies of the surface morphology have shown that not only the qualitative composition and the appropriate thickness of less than 1 den and the density of the fiber arrangement has a very large impact on the filtration coefficient Patent No. 235673 will allow the use of betulin, which has bacteriostatic, antiviral and anti-inflammatory properties. It is an organic compound that can be isolated from birch bark by extraction with organic solvents such as simple alcohols or acetone. An addition may be silver and copper nanoparticles, which will increase the efficiency of filtration through their antibacterial, antifungal and antiviral properties [2].

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Poster 6: Small-diameter prostheses modified with bioactive coating for improved endothelial cell adhesion

The aim of the project was to develop a technology to produce small-diameter polyurethane prostheses. The prostheses were manufactured using the polymer solution blow technique. In the next step, the prostheses were chemically modified to improve the biological properties of the material (1) (2). The surface modification was performed in two steps: (1) introducing a spacer molecule and (2) peptide with the REDV sequence. The surfaces were analyzed in terms of physicochemical properties and biological activity. In particular, the adhesion of endothelial cells and the adhesion of platelets were analyzed. The results showed a positive effect of the modification on the adhesion and growth of endothelial cells.

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Poster 7: The effect of various hydrogel additives on the selected properties of magnesium potassium phosphate bone cement

One of interesting group of bioinspired materials are bone cements, which play an important role in medicine, especially in minimally invasive surgery. Nowadays, there are two basic groups of cements: ceramic (mainly based on calcium phosphate) and polymer (based on PMMA - poly(methyl methacrylate) [1]. An alternative, to currently used ceramic cements may be magnesium phosphate (MPC), which is characterized by effective bioresorption, high (initial) mechanical properties and a relatively short setting time. However, there is still a problem with the high temperature of its bonding reaction and leachability of the paste [2]. The answer to these MPC disadvantages may be receiving novel composite cement - composed of both ceramic and polymer components [3]. Hence, in this work we decided to obtain cement based on MPC matrix enriched with cross-linked hydrogels. Three types of hydrogels were evaluated: 1) sodium alginate (AS, 0.25-1.0%) cross-linked by calcium carbonate and glucono-δ-lactone in mass ratios 30:60, 45:90 and 60:120, 2) guar gum (GG, 0.1-1.0%) cross-linked by borax (B, 0.1-0.5% per cement powder content) and 3) a mixture of sodium alginate and guar gum in a 50/50 ratio (0.25-1.0%) crosslinked by $CaCO_3$:GDL and B. MPC powder was consisted of burned magnesium oxide (MgO) and potassium dihydrogen phosphate (KH_2PO_4) in molar ratio of 3:1 and as cement liquid, water solutions of above mentioned polymers were applied. The following properties were evaluated: setting time (Vicat apparatus), bonding temperature (thermocouple), microstructure (SEM microscopy), microhardness (Vickers tester), degradation rate (mass loss during incubation in phosphate buffered saline) and injectability (assessed qualitatively). The result of the conducted research was the selection of the optimal manufacturing parameters of composite cements and the assessment of effects of various hydrogel incorporation into ceramic matrix. In the further research, developed cements will be evaluated in more details, in particular in the biological aspects - to receive novel bone substitute for the effective regeneration of bone tissue defects.

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Acknowledgements

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Poster 8: Effect of different matrix modifiers on the selected properties of biocomposites enriched with polyphenolic compounds

Among the expectations of clinicians regarding biomaterials for tissue engineering are their antibacterial, antioxidant and anti-inflammatory properties. Therefore, new composite materials are constantly being developed and modified with bioactive additives. A promising active substance suitable for the enrichment of bone tissue engineering biocomposites is a mixture of polyphenols (PPh) obtained from sage (*Salvia Officinalis* L.).

The study aimed to verify wheather the addition of PPh affects the surface wettability and mechanical properties of biocomposites containing melt-derived (MDBG) and sol-gel-derived (SGDBG) bioglasses. Films made of poly(ε-caprolactone)-based composites (PCLBC) with 30 wt.% MDBG or SGDBG fillers enriched with 4.5 wt.% PPh were prepared using the solvent-casting method. Both the surface in contact with solvent vapors during drying of the film (AS) and dishes-contacting (GS) surfaces of the material were analyzed separately regarding wettability and mechanical properties.

Wettability testing revealed the dependance of polyphenolic compounds binding capacity on the glass particle type. MDBG-modified composites binded PPh weaker resulting in unbound polyphenolic compounds exposed on the surface consequently influencing the wettability and surface energy of the materials. Composites modified with SGDBG bind PPh compounds more strongly presumably due to numerous -OH groups, highly developed surface and high porosity. Young's modulus, tensile strength, and elongation at the maximum force were not affected by the addition of PPh regardless of the glass type used. Nevertheless, biomaterials modified with MDBG obtained lower values of Young's modulus and tensile strength probably due to the lower porosity than SGDBG, and thus weaker bioglass-polymer interactions.

The type of bioglass used as a modifying phase in polymer-bioactive glass composite affects the ability to bind PPh which further results in changes in the wettability and surface energy. However, the mere incorporation of PPh does not change the mechanical properties of these biocomposites.

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Poster 9: Bone-mimicking organic-inorganic spheres

Biomimetic *in vitro* models of bone, such as those made of collagen and calcium phosphates (CaPs) enable understanding of bone formation and the critical steps of extracellular matrix production and subsequent mineralization, in particular [1]. Here, we developed a multilayered sphere composed of collagen and CaP. Collagen spheres (⌀ ~500 µm) were obtained by dropwise addition of type-I collagen (1.5% w/v in 0.5 M acetic acid) into 0.1 N NaOH solution, crosslinked in 0.5% glutaraldehyde, and rinsed with deionized water. The spheres were placed in a mineralization solution containing $CaCl_2.2H_2O$, NaH_2PO_4 and $NaHCO_3$, at Ca/(P + C) ratio of 1.67 and pH ~2.5 [2]. Under hermetically-sealed conditions and mild shaking, CaP coating was performed at 37 °C in the presence of ammonia solution, allowing for a gradual elevation of pH. Next, the spheres were dip-coated with a low viscosity collagen solution. CaP and collagen coating steps were repeated several times to obtain multilayered collagen-CaP spheres **(Fig 1)**.

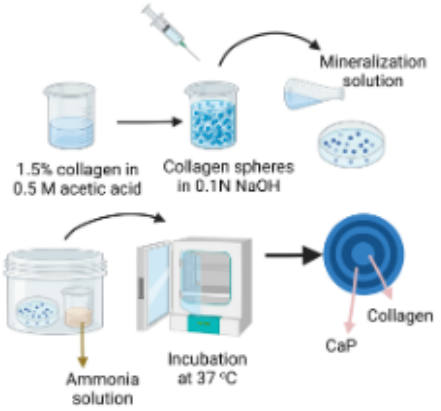

Figure 1. Illustration of experimental design

Fourier transform infrared spectroscopy (FTIR) and Raman spectroscopy revealed the mineral phase as octacalcium phosphate (OCP) [3], and the characteristic platelet-like morphology was confirmed by scanning electron microscopy (SEM) **(Fig. 2)**. The organic-inorganic phases within the multilayered structure appeared intermixed and stable. The mineralization medium can be adjusted to achieve a tailored CaP composition, for example to release different ions during the degradation process. Additionally, the CaP phase may be modified (e.g., to form carbonated apatite rather than OCP) by adjusting the pH of the mineralization medium. Furthermore, as a bone graft substitute material, the multilayered spherical geometry circumvents the need to introduce intrinsic porosity to allow the infiltration of osteoprogenitor cells.

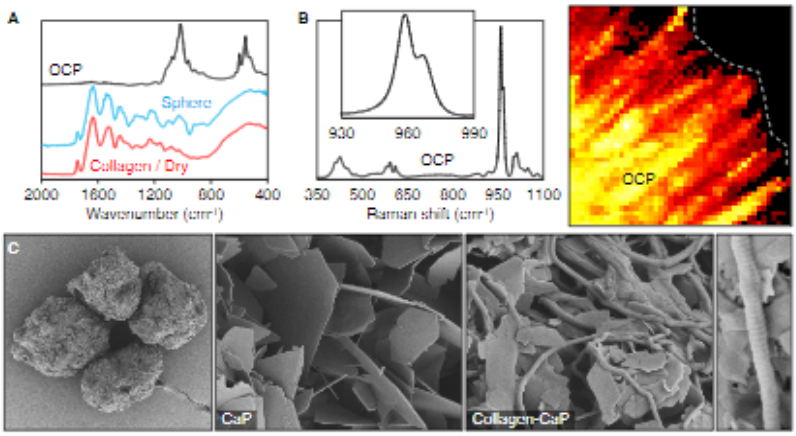

Figure 2. a) FTIR. b) Raman spectroscopy. c) SEM

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Acknowledgements: The Hjalmar Svensson Foundation, Kungliga Vetenskaps-och Vitterhets-Samhället i Göteborg, and Stiftelsen Lars Hiertas Minne.

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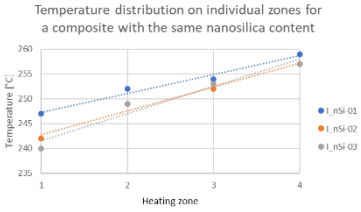
Poster 10: Technological aspects of scaling the process to the implementation procedure

Research on new materials is most often related to their design in terms of composition and verification of their properties. The impact of manufacturing technology on the material is also assessed. This part becomes vital when the work has to be implemented. Purely experimental work is carried out entirely differently from research whose outcome must be commercially viable.

The general theme of the research carried out was the production of thermoplastic polymeric materials with microbiological properties. The application of such materials is primarily in the medical sector, where it is desirable to reduce the formation of harmful pathogenic biofilms. The work succeeded in proving the anti-microbial properties, but this was insufficient for the implementation process. Additional tests have been carried out to optimize production temperatures to ensure that manufacturing costs are as low as possible regarding process energy requirements. Most important in this aspect is the reduction of the temperatures of the plasticization process and the simultaneous acceleration of the extrusion process [1]. As these are opposing assumptions, the research aims to find the golden mean. To this end, high-temperature extrusion and compression molding were carried out at different variations of pressure, temperature, and time parameters. The resulting materials were assessed visually and by infrared spectral analysis to determine the degree of degradation if any, and the extremes of performance concerning the energy expenditure of the process [2].



T [°C]	Degree of degradation during pressing [%]				
	10s	20s	30s	40s	50s
220	-	0.7	5.2	7.7	-
230	-	1	6	9.2	-
240	0.6	1.4	8.9	10.8	-
250	0.7	2	9.5	11.9	-
260	1.8	3.5	11.8	15.6	-
270	4.1	4.9	16.9	32	-
280	7.9	3.9	26	29.7	-
290	15.1	24.5	40.9	-	-
300	30.6	-	-	-	-

Fig. 1. Optimisation of parameters for high temperature extrusion and pressing of doped polycarbonate

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Poster 11: New multifunctional polymer-based carriers for temozolomide and vancomycin delivery for local treatment of brain glioma

Glioblastoma multiforme (GBM) is one of the most malignant neoplasms of the central nervous system. According to the World Health Organization (WHO), glioblastoma is classified as grade IV in brain tumors. The first-line treatment of glioblastoma is based on the surgical resection with minimal margin. Radiotherapy and chemotherapy are used as complementary therapies to remove any remaining cancer cells. Temozolomide (TMZ) is the current first-line chemotherapeutic for the treatment of GBM. This compound increases the median survival, however, its short half-life under physiological conditions strongly limits/hinders the effectiveness of TMZ therapy. The repeated administration of high doses is required, which exposes the patient to serious side effects.[1], [2]

The main aim of the presented research was the fabrication and characterization of the multifunctional hydrogel system addressed to the local therapy of brain glioma and containing TMZ and vancomycin (a broad-spectrum antibiotic). Both compounds were loaded into polymeric nanoparticles, which were next attached to a chemically cross-linked biopolymer-based hydrogel matrix consisting of collagen, chitosan, and modified hyaluronic acid.[3], [4] The system designed in this way will allow direct delivery of the active substance to the glioblastoma environment, will reduce systemic toxicity, and will also provide protection against infections, which are often the reason for reoperation.

The obtained materials were characterized for physicochemical properties, with particular emphasis on TMZ stability and encapsulation efficiency. The swelling ability and the microstructure of the resulted polymeric films were also evaluated. The characterization was made employing various techniques including UV-VIS spectroscopy, dynamic light scattering (DLS), nanoparticle tracking analysis (NTA), and scanning electron microscopy (SEM).

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Poster 12: Wearable sensor for the non-invasive detection of D-glucose with electroactive molecularly imprinted polymers (eMIPs)

Continuous monitoring of glucose levels is crucial to managing diabetes, especially in pregnant and geriatric patients. The conventional method is to measure glucose levels with a finger prick test, which is invasive and can be uncomfortable. In this work, electroactive molecularly imprinted polymers (eMIPs) based wearable devices was proposed for the continuous monitoring of glucose. This sensor offers an alternative means to existing methods with superior chemical stability, specificity, economic, and easy fabrication. eMIPs selective for glucose was fabricated using Pyrrole as monomer. eMIPs have been characterized by UV-visible, Dynamic Light Scattering (DLS), electrophoretic and Transmission Electron Microscopy (TEM). Further, Cyclic Voltammetry was employed for detection of glucose using screen printed electrode drop casted with eMIPs and showed linear response within the concentration range of 1 µM to 10 mM. Moreover, eMIPs have not shown binding with structurally similar interferents such as fructose, galactose indicating towards the selectivity. Additionally, no observed changes in the current/potential in CV to non-imprinted MIPs (NIPs) with glucose further proved the specificity. In the next steps, these MIPs will be embedded with electroactive fibres such as PEDOT:PSS and MXenes to tune the sensitivity and stability of the prepared sensor and will be used in wearable sensor technology.
Acknowledgement: I would like to thank Northern Accelerator grant for funding the presented work. I would also like to thank Dr Marloes Peeters (PI) and Dr Shayan Seyedin (Co-PI) for active engagement and suggestion for eMIPs synthesis as well as characterization.

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Poster 13: Development of a novel bioink for interface tissue engineering

Introduction: A bioink is a formulation of biomaterials, cells and biochemical cues and development of an ideal bioink is the crucial step in 3D bioprinting [1],[2]. Rheology serves as an effective tool in this process, enabling a correlation between bioink, printability aspects, and the ultimate mechanical response of the printed scaffolds. This knowledge can further be employed to adjust the scaffolds properties towards specific applications. The present work focuses on the design and development of a novel bioink formulation comprising of sodium alginate (Al), carboxy-methyl cellulose (CMC) and methacrylated gelatin (GelMA), followed by printing of the scaffolds using optimized bioinks with gradually changing stiffness. CMC serve as a thickening agent, Al improves the viscosity and shear-thinning property of the formulation, and photocrosslinked GelMA support the cell attachment and growth. The printed constructs are intended to be used in the interface tissue engineering such as musculoskeletal interfaces. **Methodology:** The inks composed of 4% (w/v) Al, 10% (w/v)CMC and different concentrations of GelMA (4%, 8% and 12%) (w/v) were prepared in PBS. CMC was added to Al solution, mixed and autoclaved at 121^0C for 20 mins followed by GelMA dissolution at 40^0C. A photoiniator (Lithium phenyl trimethylbenzoyl phosphinate) 0.25% (w/v) was added. The formulation was dually crosslinked using 0.1M $CaCl_2$ for 5 mins and UV curing for 1 min at 5 mW/cm^2. The rheological experiments were performed in a TA rotational rheometer (US). Experiments such as, amplitude sweep, frequency sweep, thixotropic test, frequency sweep under UV-curing and temperature ramp tests were performed. The GeSiM bioprinter was used for printing at optimized parameters.
Results: The bioinks were successfully printed as a 2-layered constructs with infill distance of 1.5 mm and dimension of 10x10 mm. All three formulations showed a viscoelastic solid behavior in the whole frequency range probed, and shear viscosity thinning, resulting in good printability and shape fidelity (as indicated in Fig 1. A, B and C). Bioink composed of 4%Al-10%CMC-12%GelMA (see Fig 1. C) revealed best printability and stability owing to high GelMA content which results in highest modulus and complex viscosity (see Fig 1. D and E). These properties contributed to the highest shape fidelity and thinnest fiber deposition (highest resolution) of the 4%Al-10%CMC-12%GelMA, when compared with other formulations (4%Al-10%CMC-4%GelMA shown in Fig 1. A and 4%Al-10%CMC-8%GelMA shown in Fig 1. B), which revealed thicker and irregular fiber, respectively.

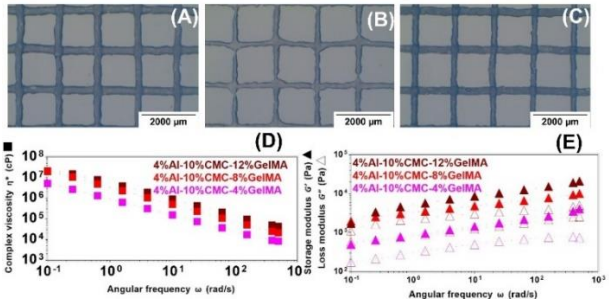

Fig 1. Printability test of the proposed inks formulations. (A), 4%A-10%CMC-4%GelMA, (B) 4%A-10%CMC-8%GelMA, (C) 4%A-10%CMC-12%GelMA. (D,E) Frequency sweep of 4%A-10%CMC at different concentrations of GelMA.

Conclusions: We have shown that the proposed Al/CMC/GelMA inks are well-printable. Yet, the ink with highest GelMA content characterized by high modulus and complex viscosity depicted best printability and stability. Characterization of rheological properties of the tested materials gave a strong indication of the shape fidelity, stability and printability, and is a powerful tool in the development of optimal printable materials.

Funding: National Science Centre (2020/37/B/ST5/00743), NAWA Polish Returns 2019 (PPN/PPO/2019/1/00004/U/0001).

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Poster 14: Molecular insights into the self-assembly of hydrophobically modified chondroitin sulfate in aqueous media

Drug delivery systems (DDSs) based on polymer nanoparticles have many benefits. Natural polysaccharides such as chondroitin sulfate (CS) are being intensively researched to develop nano-scale DDS systems.[1] In this study, the behavior of amphiphilic CSs in aqueous media and the drug accumulation inside the formed micelle-like structures were studied using experimental methods and molecular dynamics simulations.n this study, the amphiphilic derivatives of CS were synthesized and their behavior in the water phase was investigated. In particular, the focus was on the hydration of the polysaccharide backbone, the influence of the degree of substitution with hydrophobic groups on the aggregation capacity of the amphiphilic CS.[2]

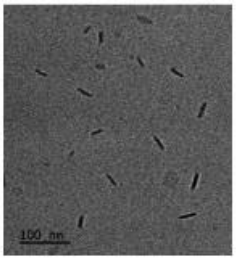

Figure 1. Cryo-TEM micrographs of structures formed in aqueous dispersions of chondroitin sulfate substituted with octadecylamine.

The morphology of the nanostructures and their molecular organization were investigated using electron microscopy imaging and computer simulations. Then, several experimental methods and molecular dynamics simulations were used to determine the suitability of the obtained polymer structures as drug carriers. Curcumin was used as a model drug. Our work provides important information on the development of drug delivery systems based on amphiphilic polysaccharides.

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Poster 15: Optimisation and tailoring of ECM complexity in a multi compartmental biomaterial based 3D model of pancreatic cancer

Introduction: With a 5-year survival rate of only 11%, Pancreatic Ductal Adenocarcinoma (PDAC) is the 7th leading cause of cancer related deaths worldwide. This is partly attributed to PDAC's tumour microenvironment (TME) and its resistance to treatment. The TME consists of various structural, cellular and protein components. Advanced studies of the disease and its' treatment resistance mechanisms, require the development of biomimetic, *in vitro* tumour models. We have developed poly urethane (PU) based 3D pancreatic cancer model using (i) pancreatic cancer cells (monocellular model) and (ii) pancreatic cancer cells, stellate cells and endothelial cells (multicellular model).We have shown long term physiological maintenance, feasibility of extracellular matrix (ECM) mimicry, mimicry of PDAC fibrosis/desmoplasia, and we have mapped the effect of hypoxia[1-3]
The current work focusses on further development of our scaffold assisted multicellular model via optimisation of the ECM composition for the different cell compartments, i.e., cancer vs stromal.
Methods: PU scaffolds were prepared as per previously published protocols[1-4]. Absorption based surface modification of the scaffolds enabled coating with ECM proteins (laminin, collagen I and/or fibronectin) followed by incorporation of different cell types (cancer, stellate, endothelial) within the equivalent stromal (external) and cancer (internal) compartments. The effect of ECM coatings and their combinations for both model compartments were systematically assessed (> 4 weeks). Imaging of cellular proliferation/spatial organisation and ECM secretion was carried out to compare the cell spatial behaviour for different ECM compositions.
Results & Conclusion: Our study shows that cancer cells and stromal cells show preference to different ECM proteins for optimal growth. Furthermore, the spatial organisation of highly viable cells and/or their functionality might be different for different ECM coatins of the scaffold. Overall, our work highlights the importance of ccompartmentalisation, i.e., developing zonal/spatial cellular and matrix structures in 3D for the accurate mimicry of the tumour tissue architecture.
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Poster 16: Curcumin-based nanoassemblies modified with gossypol for magnetic hyperthermia

Multimodal targeting of cancer cells can be perceived as a promising approach to overcome the limitations typical for conventional treatment of cancer, i.e., insufficient efficacy, high toxicity associated with short- and long-term adverse reactions, and resistance to chemotherapeutics.

In this study, we have developed curcumin-based magnetic nanoassemblies modified with gossypol-grafted chitosan (CS-GP) for multimodal cancer treatment, including chemotherapy and magnetic fluid hyperthermia. Curcumin is known for its antitumor effects, whereas gossypol can induce the production of radical oxygen species (ROS) in cancer cells. ROS are highly reactive molecules damaging every component of the cell, leading to its apoptosis. Magnetic nanoparticles were found useful as a source of heat in magnetic hyperthermia. Three CS-GPs were prepared using a free-radical method. They differed in the degree of GP substitution in CS backbone (0.1, 0.3, and 0.8 wt.%). Iron oxide-based nanoparticles were prepared by a thermal decomposition of iron oleate in the presence of oleic acid. The curcumin-based nanoassemblies were precipitated by pouring tetrahydrofuran dispersions containing magnetic nanoparticles and curcumin in an aqueous CS-GP solution of various concentrations. The effect of the degree of GP substitution and CS-GP concentration and pH was investigated on morphology and stability of nanoassemblies and their ability to produce heat under alternating magnetic field. The significant effect of polymer concentration and pH during the nanoassembly precipitation was observed only in the case of polymer with the lowest content of GP (0.1 wt.% per mol of CS). With decreasing pH, the size of nanoassemblies increased. In contrast, increasing concentration of polymer resulted in a decrease of the nanoassembly diameter. Moreover, the nanoassemblies precipitated at low pH were characterized by good colloidal stability expressed in small hydrodynamic diameter, low polydispersity, and high ζ-potential. The highest heating efficacy was observed for the most colloidally stable nanoparticles; however, the smaller nanoparticles (D_n = 48 nm) showed significantly higher magnetothermal properties than the bigger ones (D_n = 67 nm).

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Poster 17: Polymeric transdermal systems and their applications in medicine

The subject of my work is hydrogel materials defined as at least two-component systems consisting of polymer chains forming a three-dimensional spatial network filled with water. The method of synthesis of hydrogels is photopolymerisation. This is a short term, waste-free process so it is environmentally friendly and proceeds with simultaneous sterilisation of the material in a UV field. Hydrogels represent the most modern group of dressing materials. Their unique features give them an advantage over traditional wound dressing systems [1]. An extremely desirable feature from the point of view of absorbing potential wound exudate is the ability to absorb aqueous solutions in a reversible manner [2]. In addition, hydrogel dressings, allow gas exchange, which is essential in the wound healing process.
The hydrogel matrix can be modified with a number of therapeutic substances that give such a dressing its therapeutic properties. The materials presented in my work are enriched with Aloe vera. Aloe vera juice has soothing and pain-relieving properties for patients with burn wounds and diabetic foot wounds [3]. Hydrogels enable controlled delivery of the drug. By selecting the composition and synthesis conditions, it is possible to obtain a dressing with the desired therapeutic release profile. In summary, hydrogel systems for transdermal drug delivery gain an advantage over traditional dressings in the treatment of many skin conditions due to the possibility of extensive modification of the polymer matrix.

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Poster 18: β-cyclodextrin-pioglitazone inclusion complex coupled with superparamagnetic iron oxide nanoparticles as prospectiveanti-cancer system

Introduction Superparamagnetic iron oxide nanoparticles (SPIONs), possess various unique features, thus are broadly applicable in medicine. Easy synthesis, high biocompatibility, possibility of surface modification and superparamagnetic properties, make SPIONs a valuable component of advanced drug delivery systems [1]. Recently, SPIONs are widely studied in the context of the circulating tumor cells (CTCs) capture and neutralization [1] [2] as well as being a systems for magnetic drug delivery. Pioglitazone (PIO) is a ligandof peroxisome proliferator activated receptor (PPAR-γ) and was shown to possess the antitumor effectin several types of cancer. By activation of PPAR-γ, PIO may inhibit cancer cell growth and also so called epithelial-mesenchymal transition (EMT) - process during which cancer cells gain the invasive character and metastatic potential [3]. The aim of our study was to prepare colloidally stable SPIONs, coated with cationic chitosan derivative (CCh/SPION), further functionalized with obtained β-cyclodextrin-pioglitazone complex, resulting in system which will be able to kill or capture cancer cells, especially those with metastatic potential.

Results Chitosan was modified using GTMAC according to the procedure described before [4]. CCh/SPION nanoparticles were synthesized by co-precipitation of Fe^{2+} and Fe^{3+} salts with ammonia in the presence of CCh and further purified using magnetic filtration. Obtained nanoparticles had an average hydrodynamic diameter of 120 nm, according to the DLS measurements, and were colloidally stable (average zeta potential about 47 mV). β-cyclodextrin was modified with p-toluenesulfonyl chloride to introduce reactive tosyl groups to BCD's structure [7]. BCD-ToS was then characterized using ATR-FTIR and ^{1}H NMR, to confirm such a modification and to asses tosylation degree (84 %). The inclusion complex of BCD-ToS with PIO was synthesized based on modified literature reports [5] [6]. Stoichiometry and complexation efficacy of formed complex was also determined. BCD-ToS was further attached to CCh/SPION and PIO was complexed under previously established conditions. The obtained system was characterized using DLS and ATR-FTIR, magnetic properties of nanoparticles were also established.

Conclusion SPIONs stabilized with cationic derivative of chitosan, were functionalized with the inclusion complexof modified β-cyclodextrin with pioglitazone, which was previously prepared and characterized. Tosyl-β-cyclodextrin was bounded to the surface of CCh/SPIONs, and the interaction between SPION-boundedβ-cyclodextrin and PIO was studied. The obtained nanoparticles were characterized physiochemically. Preliminary biological studies will be performed on colon cancer cell lines derived from primary tumor (HT29 cancer cell line) as well as metastatic site (SW620 cancer cell line), to asses cytotoxicity of formulation as well as CCh/SPION-BCD(PIO) potential as magnetic drug delivery system.

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Poster 19: Voltammetric and potentiometric sensors for selective electrochemical quantification of Copper(II) ions

Detection of Copper is vital due to the health risks posed by excessive Cu^{2+} in environment (sources such as drinking water and food items) in spite of its biological importance. The present work is focused on the development of ferrocene based electrochemical sensors for the detection of copper ions using electrochemical techniques such as Voltammetry and Potentiometry. Voltammetric sensor demonstrated a selective response towards Cu^{2+} in the concentration range of 0-26 µM with detection limit 0.09 µM. For utilization of proposed sensor for real application modified carbon paste electrode (CPE) was prepared and it exhibited a selective response for Cu^{2+} in the concentration range of 1.0×10^{-6} -1.0×10^{-1} M and detection limit 7.9×10^{-7}M. UV-Vis, Fluorescence and DFT studies confirmed the favorable complexation between ferrocene derived receptor and Cu^{2+} and it was also validated by ^{1}H-NMR and mass spectrometry. The proposed sensor was successfully utilized for quantification of Cu^{2+} content in real water and milk samples.

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Poster 20: Bioinspired hybrid systems for the alendronate delivery and the osteoporosis treatment

Osteoporosis is one of the most progressive, systemic, and metabolic diseases affecting bone tissue[1]. Microarchitectural deterioration and reduced bone mass could be prevented or treated with bisphosphonates, from which nitrogen-containing alendronate (ALN) is the leading drug. However, the use of ALN has its own limitations - high dosage of the drug is needed due to low bioavailability (0.9-1.8%) and limited oral absorption which can cause side effects mainly from gastrointestinal track[2,3]. **Therefore superior systems should be designed, that could improve bioavailability, limit the side effects from the ALN oral delivery, and enhance overall therapeutic potential.** Hence the aim of this work was to prepare multifunctional hybrid system composed of inorganic, bioactive ALN carrier-mesoporous silica particles functionalized with amino groups and decorated with hydroxyapatite (MSP-NH_2-Hap-ALN), combined with hydrogel matrix (collagen:modified chondroitin sulfate:chitosan) being crosslinked with genipin. In obtained samples, clear tendency between MSP-NH_2-HAp-ALN concentration and wettability, swellability was established. Higher particles content decreased both parameters and **improved mechanical properties** compared to pure hydrogel sample. Prolonged release of ALN (up to even 20 days) and limited burst effect from the first day was observed in comparison to MSP-NH_2-HAp-ALN. Additionally, by extrusion through the 27G needle, **injectability** of prepared systems was established which could eliminate the side effects associated with oral use. Hybrid systems were also **bioactive** which was proven by formation of new apatite-like structures in simulated body fluid conditions. Biological evaluation *in vitro* revealed that developed materials not only **supported the proliferation of MG-63 cells** but also their differentiation. Moreover, they hindered the proliferation of model osteoclast cell lines demonstrated their **therapeutic potential** as the materials for the treatment of osteoporosis bones. Importantly, the **antibacterial activity** of the resulted hybrids against *Staphylococcus aureus* (Gram-positive) and *Escherichia coli* (Gram-negative) in *in vitro* experiment was also established.

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Poster 21: Modification of TiO_2 scaffold surfaces with whey protein isolate and incubation in simulated body fluid

Introduction

Surface modification of scaffolds may enhance bone tissue healing. One method could be to use whey protein isolate (WPI), a by-product from the dairy industry, which consists mainly of the protein β-lactoglobulin (β-LG). After heating for several hours in an acidic environment, β-LG degrades to low molecular weight peptides that self-organize to form amyloid nanofibrils, which showed the ability to increase mesenchymal stem cell proliferation and osteogenic differentiation [1].

The purpose of this work was to develop a method to modify TiO_2 scaffolds with WPI nanofibrils and incubate them in simulated body fluid (SBF), characterize their properties and analyze their performance in contact with model osteoblast-like cells.

Materials and methods

TiO_2 scaffolds were manufactured using the polymer sponge replication method and sintered at 1500°C according to a previously developed method [2]. Scaffolds were placed in a syringe, which contained 3 ml of 2.5% wt. WPI solution. Scaffolds were incubated at 37°C for 1 hour for the purpose of surface modification. The scaffolds were then triple rinsed in 2 ml of water at pH 2 and dried in air and then incubated in SBF for 2 weeks. The cytocompatibility of TiO_2 scaffolds was evaluated in contact with human osteoblast-like MG-63 cells. Cell viability was analyzed using the resazurin reduction assay and live/dead and hematoxylin/eosin staining. In addition, cells were visualized with scanning electron microscopy (SEM).

Results and conclusions

The results show that TiO_2 scaffolds (T) and TiO_2 scaffolds modified with WPI and incubated in SBF (T/WPI/SBF) are not cytotoxic for the cells. This modification improves bone cell growth and viability, so the material appears promising for the treatment of bone tissue defects. However, more experiments are necessary, such as investigation of osteogenic differentiation, mineralized nodule formation, alkaline phosphatase activity, collagen expression, etc. prior to in vivo studies and further clinical trials.

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Poster 22: Controlled formation of highly porous polymer-calcium phosphate granules with defined structure

Autologous iliac crest bone transplants are still considered the gold standard in patients afflicted by bone resection, despite the risk of complications. Living human cells can reconstruct the lost tissue when they can proliferate in an environment enabling 3D growth. Ideal scaffolds should provide good transport of oxygen and nutrients, a large surface-to-volume ratio, conditions for cell adhesion, and mechanical integrity similar to the original tissue. Examples of materials used for synthetic scaffold manufacturing are polymers (e.g., polylactide, polycaprolactone), metals (titanium), ceramics (e.g., hydroxyapatite, alumina) and composites combining mechanical strength of polymers with osteoconductive properties of bioceramics. The granulated form is appreciated in dentistry, where removed tooth cavities can be conveniently filled with granulated biomaterial. One can control the pore size in the scaffold by manipulating the particle size, which is essential for the early stages of regeneration, like cell infiltration and angiogenesis. This work presents the manufacturing of highly porous, polymer-calcium phosphate granulates. Our goal was to prepare a synthetic biomaterial suitable for cell attachment and proliferation in bone defects or resections. The solvent-induced phase separation (SIPS) process has been successfully adapted for obtaining composite polylactic acid – β-tricalcium phosphate porous particles in the 0.2 – 1.8 mm diameter range, with porosity between 69 and 89 %. Two types of biomedical PLA were used – Biomer L9000 and Resomer LR706S. DoE approach was used to determine standardised effects of process parameters – polymer, β-TCP and emulsifier concentrations, temperature, and mixing speed. The method is also suitable for other polymers like polylactide-polyglycolide or polycaprolactone. Granulates were thermally fused into 12 mm diameter porous discs. The scaffolds, composed of PLA and PLA/β-TCP composite granulates, have been proven non-cytotoxic to L929 cells *in vitro*. The osteogenic potential of prepared scaffolds has been measured with alkaline phosphatase activity in human mesenchymal stem cells cultured on them *in vitro* for 3 weeks. Cells have also been visualised with confocal microscopy and alizarin red staining to show calcium deposits produced by cells. Those studies revealed that Resomer granulates had been overgrown with elastin fibres, and calcium staining can be visible after 3 weeks. Prepared granulates could potentially build the synthetic bone regeneration scaffold upon thermal assembly. They can be fused into shapes with desired porosity, mimicking the structure of natural bone tissue. Further *in vivo* tests are the next step in testing the usefulness of our developed alternative to auto-, allo- or xenografts as applied to regenerate damaged bone tissue.

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Poster 23: Implantable biopolymeric hydrogel-based materials delivering temozolomide for treating glioblastoma

Glioblastoma multiforme (GBL) poses the most commonly diagnosed central nervous system tumour. GBL is also the most malignant glial neoplasm, characterized by high invasiveness, a tendency to spread throughout the brain parenchyma, and a lethal nature. The clinical treatment uses a regimen of surgery and subsequent radiation, and chemotherapy. [1] The most extensively used chemotherapeutic is temozolomide (TMZ). Due to its hydrolytic instability and frequent chemoresistance, the effectiveness of complementary therapy with TMZ is limited by the serious systemic and dose-related side effects.[2] Therefore, the primary goal of the studies was the determination of the implantable material characteristics, fabrication, and performing a preliminary analysis of biopolymeric material serving as a system for the local delivery of TMZ. The proposed approach could increase drug concentration at the desired site simultaneously reducing adverse systemic complications [3].
The main constituent of the proposed preparation is a lyophilized form of a hydrogel, cross-linked with a genipin matrix composed of three biopolymers such as collagen, lysine-modified hyaluronic acid (HAmod), and chitosan. Gelled using tripolyphosphate chitosan particles loaded with TMZ or antibiotic, viz vancomycin (VANC) were introduced into the polymeric sol, which upon the formation of covalent bonds generated biomaterial. Due to the application of the lyophilization process, the swelling ratio of the obtained systems was reduced significantly in comparison with the hydrogel-based formulations, thus the values of this parameter were closer to the commercially available materials (TachoSil®/ Floseal®/ Clinisponge®). The presence of the drug in the complete preparation was confirmed spectroscopically, in the UV-Vis range, however, TMZ entrapped into the bare chitosan particles and placed into the matrix demonstrated the burst release. Therefore, two different versions of the provided material were tested in order to change the TMZ release profile. The first concerns the additional functionalization of chitosan particles with HAmod, whereas the latter is related to attaching the TMZ molecules to the chitosan using EDC/NHS chemistry, which demands the transformation of TMZ into its derivative, TMZ-COOH. Scanning electron microscopy microphotographs showed that both types of carriers are embedded into the porous matrix. The intended functionalization was validated by an increase in particle size from chitosan particles of about 100 nm to those modified with an additional HAmod shell of over 350 nm, as well as by changes in their potential zeta values. Nuclear magnetic resonance and Fourier transform infrared spectroscopies identified the product of TMZ conversion as a temozolomide acid (TMZ-COOH) and provided its further attachment to the polymeric chitosan chains. Our research implies that the presented herein lyophilized hydrogel-based preparation could pose a reasonable starting point for the development of a unique local delivery system of TMZ. Owing to its tuneable physicochemical characteristics, the “mass effect” in the brain will be avoided. It is expected that the proposed two modifications will ensure a more favourable, controlled release profile of TMZ.

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Poster 24: Release of 10*H*-2,7-diazaphenothiazine from albumin nanoparticles in different pH conditions

Drug resistance is the major reason for cancer therapy failure. There are many attempts to circumvent the drug resistance of cancer cells, such as the synthesis of new compounds and nanoparticle encapsulation [1]. Our research is a proposal for the two methods mentioned before of avoiding drug resistance and a proposal for the 2,7-DAPT formulation at the same time.

10*H*-2,7-diazaphenothiazine (2,7-DAPT) is a newly synthesized azaphenotiazine derivative with potential anticancer activity [2]. 2,7-DAPT spectrum is characterized by two absorption peaks: at 265 nm and at 315 nm. Bovine serum albumin (BSA) nanoparticles with 2,7-DAPT were obtained by desolvation method with crosslink 51% of the theoretical amount of BSA amino groups by glutaraldehyde. The release studies of the nanoparticles were conducted using sample and separate method in phosphate buffer at different pH conditions: pH 7.4 and pH 5.6. The samples were collected, filtrated and the drug content was measured by the UV-vis spectrophotometer (JASCO V-760, Hachioji, Tokyo, Japan). Parameters of the absorption spectra for released samples as well as free 2,7-DAPT were recorded in the range between 230 and 400 nm and the absorption maximum is found to be at λ_{max} 265 nm. In quantitative studies the absorbance values at λ_{max} 265 nm was used. Release at pH 5.6 proceeded more rapidly and higher amounts of drug have been labeled in the medium, in comparison to the physiological conditions (pH 7.4). However, after 24 hours, there was more drug labeled in the medium at pH 7.4 (54.77%) than at pH 5.6 (45.83%). Samples release profiles seem to be described by the zero order model for both of the study groups (R^2 = 0.918 at pH 7.4 and R^2 = 0.671 at pH 5.6).

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Poster 25: Impact of the degradation of the electrospun fibers on optical and biological properties of the substrate for corneal regeneration

Problems associated with impaired vision involve corneal damage in a number of cases. Injuries, bacterial and viral infections and hereditary diseases affect more than ten million people worldwide [1]. The ease of transplantation of the cornea tissue and its immunologically privileged nature have led to the widespread practice of transplanting allogeneic corneal tissue to replace scarred or damaged corneas [2]. The short-term success rate of this procedure is high, turning the cornea the most commonly transplanted organ. Unfortunately, for many patients this procedure is not possible due to inflammation of the eye [3]. Once the cornea is rejected, acceptance of another graft often fails. Thus, material solutions (implants, substrates, scaffolds) that fulfill the short-term function of the cornea are sought. Of particular interest here are the solutions proposed in the literature, which are based on transparent polymer substrates. An important factor in the case of these materials is the relation between the substrate's transparency and the rate of degradation. The controlled rate of degradation allows the mechanical integrity of the scaffold to be preserved during the remodeling process and to be completely absorbed once the process is complete. In the case of cornea regeneration, most of the works are focused mainly on the biocompatibility of the scaffold, however, the issue of degradation of such material in vitro and the impact of this process on the optical and biological properties of the substrate needs further research.

In the present study, we focused on obtaining and studying the degradation rate of a fibrous substrate produced by coaxial electrospinning. The core-shell fibers with different geometries (random/parallel arrangement of fibers), consisting of polycaprolactone (PCL) in the core part and polyvinylpyrrolidone (PVP), were degraded in vitro (37°C/simulated tear fluid/2months). Core-shell PCL/PVP fibers exhibited unimodal size distribution with an average core size in the range of 50–350 nm (NOVA NANOSEM, FEI). The transmittance of the initial substrates in the visible range (380-780 nm) is dependent on the fiber orientation and is ~75% for parallel fibers and ~80% for randomly arranged fibers (UV-Vis, Jasco V-630). After 30 days of in vitro degradation, the polymeric PVP shell dissolves. This process contributed to reduce of the fiber diameter by about 40% (after 1 month) and by about 55% (after 2 months). At the same time, the degradation effect is more prominent on materials with a random distribution of the fibers. The decrease in the diameter of the fibers, as well as the increase in the wetting angle are caused by the destruction of the fiber shell (dissolution of PVP). The two-month degradation process reduced the translucency by 5% for parallel fibers and 2% for random fibers, respectively. The PVP residue on the fibers was visible after the degradation process by changes in the FTIR spectrum of the substrate (Bruker Tensor 27 FTIR). Bioassays showed better cytocompatibility against macrophages (RAW 264.7) than keratinocytes (HaCaT), which may be due to the PVP residue on the fibers. Due to the rapid increase in scaffold porosity associated with the destruction of the fiber's shell layer, the substrate shows the potential to induce cell migration under more dynamic cell culture conditions.

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Poster 26: Electrochemical deposited calcium-phosphate coatings on titanium alloy for biomedical application

Titanium alloys are commonly used implant materials, due to their good corrosion resistance, biocompatibility and mechanical properties. However, solutions are sought that could minimize post-surgery complications such as mechanical loosening of the implant or infections around the implant [1-2]. Furthermore, in the case of bone implants, also an important aspect is to improve the overgrowth of the implant with bone tissue. Modification of the surface of implants can significantly improve or give these properties. Such solutions include deposition of calcium-phosphate-based coating on the titanium alloy surface (i.e., hydroxyapatite or tricalcium phosphate coating) [3]. One of the promising techniques is electrochemical deposition, which may be an alternative to plasma spraying. The main advantage is that electrochemical method allows the deposition of coatings on irregular and porous surface. In addition, it is possible to carry out processes in selected ranges of parameters and electrolytes at low process costs [4]. The aim of this work is analyse of the influence the parameters to physico-chemical properties of electrochemical deposition obtained calcium-phosphate coatings. A Ti6Al7Nb titanium alloy was used as a substrate and calcium-phosphate-based coatings was obtained by pulsed galvanostatic electrochemical deposition in electrolyte containing 0.0042 M $Ca(NO_3)_2 \cdot 4H_2O$ and 0.0025 M $(NH_4)_2HPO_4$. The scanning electron microscopy (SEM), EDS technique, Raman spectroscopy and XRD tests are used to characterize the coated samples. This study shows that by electrochemical deposition process, by different process parameters, it is possible to obtain various calcium-phosphate coatings, whereby the substrate at deposition 10 mA/cm2 10 min presented the most homogeneous hydroxyapatite coating.

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Poster 27: Morphometric assessment the effect of mesenchymal stem cells on neuropil of cerebral hemispheres in rats with scopolamine-induced Alzheimer's type dementia

Introduction. The stem cell therapy is of particular interest, which seems to be a promising, effective, and safe therapeutic strategy for neurodegenerative diseases, including Alzheimer's type dementia (DAT) [1]. **Aim of study:** to assess morphometrically effect of mesenchymal stem cells on neuropil of cerebral hemispheres in rats with scopolamine-induced Alzheimer's type dementia. **Materials and methods.** 48 male WAG rats weighing 180–230 g were divided into 5 groups. Animals of control group (n=16) received injections of 0.9% sodium chloride solution intraperitoneally for 14 and 28 days. Animals with DAT (gr.Scop-14 (n=8), Scop-28(n=8)) were injected intraperitoneally with scopolamine buthylbromide at a dose of 1 mg/kg per rat for 14 days and 28 days [2]. Half of rats (gr.Scop-14-MSC (n=8), Scop-28-MSC (n=8)) were received intravenously mesenchymal stem cells (MSC) at a dose 500000 cells per one rat the day after last Scopite injections. Rats were removed from the experiment 14 days after the last day of all injections. Histological brain slides were stained with the Congo red (for amyloid determination), bromphenol blue (BPB) (to study oxidative modification and amount of neuropil proteins) and according to Einarson method (to evaluate the RNA content in the cytoplasm of neuropil) and examined on an Axiostar plus binocular microscope with a ProgRes C10Plus digital camera (Zeiss, Germany). **Results.** In the main groups, the the appearance of congophilia in the areas of neuropil homogenization was detected. The MSC did not have the resorptive effect on amyloid areas in neuropil. In gr. Scop-14-MSC, Scop-28-MSC the optical density (RNA count) of neuropil increased compared to gr. Scop-14, Scop-28. The R/B ratio and optical density in the RGB (red, green, blue) parts of the spectrum (using BPB) showed the level of oxidative modification and amount of neuropil proteins in the cerebral hemispheres. In gr. Scop-14-MSC, Scop-28-MSC there were a dense formation with stable optical density values at different R/B ratios (amyloid) and areas where the optical density of neuropil proteins decreased with increasing R/B ratio (as in control group). It can be interpreted as the presence of new proteins in the nerve processes. **Conclusion.** The morphological evidence of stimulation of neuropil regeneration by using mesenchymal stem cells in cerebral hemisheres was detected in rats with sopolamine-induced Alzheimer's type dementia using simple morphometric methods. **References:** 1. Kocaoglu M, et al. Brain Disord Ther. 2014;3:4. 2. Deiko RD, et al. Actual Problems of Modern Medicine.2017;17(3):13–25.

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Poster 28: Production of bacterial cellulose using waste materials as substrate for agricultural application as mulch film

Mulches have been traditionally used in agriculture since early 1900s as an agricultural practice to improve crop production because they help to reduce evapotranspiration, prevent weed infestation, and enhance seedling growth [1]. The commonly used mulches are composed of polyethylene plastic which has increased crop production but subsequently caused plastic pollution [2]. To mitigate this issue, biodegradable mulch films provide an environment-friendly option. Bacterial cellulose is a promising material owing to its properties such as mechanical strength, water retention and biodegradability. It can be produced by the bacterium *Gluconoacetobacter xylinus*, using standard HS (Hestrin Schramm) medium [3]. However, for commercial production of bacterial cellulose-based films the process needs further improvement to be cost-effective. This study aims to utilize different waste materials including both household and industrial waste for the production of bacterial cellulose.

Various waste materials including tea and coffee waste, fruit and vegetable peels, and waste from the food and brewery industries were tested and characterized for bacterial cellulose (BC) production. HS medium produced the best films with an average weight of 47.3g/L and 0.6 cm thickness. Apple peel hydrolysate produced very thin and fragile BC films that weighed 10.13g/L on average and had a thickness of 0.15cm. Among the waste material the best BC films were produced using seaweed extract followed by potato peel hydrolysate, which had an average weight and thickness of 40.06 g/L and 0.3 cm, and 20.53g/L and 0.25cm, respectively. FTIR and SEM analysis of the bacterial cellulose was also done for characterization. The sugar, protein and phenolic contents of the waste materials were estimated. The results suggest that seaweed extract and potato peel hydrolysate have the potential to be used for BC production.

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Poster 29: Curcumin delivery systems for the treatment of diabetic foot ulcers

Introduction

Chronic wounds represent a global health problem due to the fact that they cause many consequences for patients and represent a major cost to healthcare systems. A common chronic wound is diabetic foot ulcer – a very severe complication of diabetes mellitus, often requiring foot amputation. Treatment of these wounds includes hydrogel, hydrocolloid, alginate, foam and textile dressings [1]. Curcumin (CU), a diarylheptanoid, belonging to the group of curcuminoids, has been reported to have antimicrobial and antioxidant properties and may be beneficial in the treatment of diabetic foot ulcers [2]. In our studies we intend to develop a hydrogel dressing providing controlled release of CU. In the first stage we plan to encapsulate CU into degradable poly(sebacic anhydride) (PSA) microparticles, characterize their size, microstructure and encapsulation efficiency. In the following studies we will suspend them in polysaccharide matrix to produce dressing prototypes for the treatment of diabetic foot ulcers.

Materials and Methods

The carriers were manufactured from PSA [3] by a solvent evaporation method with oil-in-water (o/w) emulsification. CU (CU:PSA ratio of 1:20; 1:10 and 1:5) was dissolved in 2% w/v PSA solution in dichloromethane (DCM) and homogenized using an ultrasound probe for 90 s (amplitude 40%). 20 ml of chilled 8% w/v poly(vinyl alcohol) (PVA) solutions in ultra-high quality water (UHQ water) were placed on the magnetic stirrer at 1000 rpm. Then 3 ml of the PSA/CU/DCM solution was poured to the PVA solution and left on the magnetic stirrer for 5 h. After this time, the emulsions were centrifuged using 15000 rpm for 10 min. The supernatants were collected for encapsulation efficiency studies, and the centrifuged microparticles were freeze-dried. Unloaded MPs were fabricated as a reference. Encapsulation efficiency of CU was determined using the fluorimetry. For this purpose, solutions of curcumin in DMSO were prepared to create a calibration curve. Microstructure and surface properties of the carriers were analysed by optical microscopy.

Results and Conclusions

Manufactured MPs were round, regular shape and homogeneous. Their size was around 0.5 – 10 μm Microparticles with curcumin were yellow in color. The encapsulation efficiency for the 1:20; 1:10 and 1:5 CU:PSA ratio was 88.6 ± 1.0%; 75.2 ± 1,1% and 56,9 ± 3,7% respectively. Although the process was less efficient at the higher CU ratio, the final drug loading was satisfactory. In conclusion, PSA microparticles loaded with CU are promising delivery systems for diabetic foot ulcers treatment. Future work will focus on manufacturing a hydrogel dressing containing CU carriers.

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Acknowledgements

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Poster 30: Circular economy approaches for 3D printing of environmental sensors

Plastic waste remains a critical problem, with predictions that by 2050 there will be more plastic in the ocean than fish. Therefore, we need to consider circular economy approaches to develop novel functional materials from plastic waste. The aim of this study is to critically assess the performance of 3D printed sensors that are made of recycled elements rather than polylactic acid or metal. An overview of different measurement designs for thermal sensors to determine antibiotic concentrations is given in Figure 1. These designs enabled rapid (15 min) and low-cost detection of a variety of beta lactam antibiotics with patented thermal technology, which has been coined the Heat-Transfer Method.

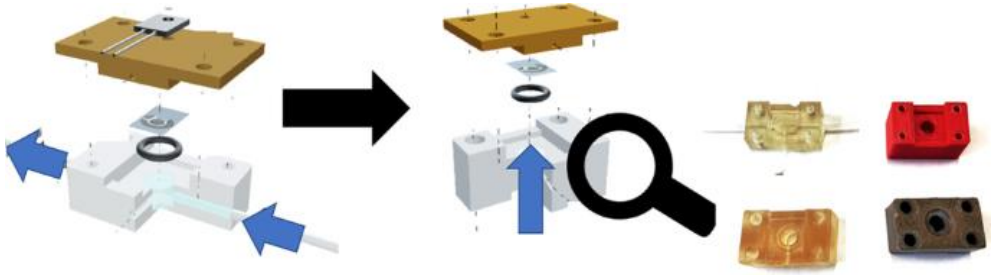

Figure 1. An overview of previous 3D printed measurement cells used by Figueiredo et al.[1]

In this work, we show that there is no significant difference in the performance in terms of thermal and mechanical properties of measurement cells made from recycled plastic. In the future, we aim to use extrusion to integrate polymer particles to make environmental sensors that can be mass produced. These polymers will be produced by molecular imprinting technology and can be used for a variety of compounds ranging from ions, to small organic molecules, to larger macromolecules such as bacteria or cells.

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Poster 31: Thermochromic phase change materials for potential bioinspired applications

Phase change materials (PCMs) show the potential to play a significant role in energy saving. They are characterized by the high enthalpy of melting and, at the same time, the ability to store and then release thermal energy during the phase change. Moreover, fatty acid and fatty alcohol, used in the course of this work, show low toxicity, biodegradability, and high abundance. The second featureof the proposed materials is thermochromism. Thermochromic systemspresent different colors with changes in temperature, showing various functions such as sensing, indicating, and monitoringenergy statesor temperature. The incorporation of a thermochromic system into the PCMs will make it possible to observe the color changes of PCMs during the phase transition. Such materials may successfully find various applications, including bioinspired ones, for example, bird feathersandplant leaves [1,2].

This work aimed to study thermochromic phase change materials for bioinspired applications. A fatty acid, fatty alcohol, and leuco dyewere used as thermochromic system components. To characterize the obtained materials thermogravimetry (TG), differentialscanning calorimetry (DSC), Fourier-transform infrared spectroscopy (FTIR), and polarized light microscopy (PLM) have been used. The results of this research showed that the tested materials have great potential as thermochromic phase change materials forbioinspired applications.

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Poster 32: Properties of laser-encapsulated titanium oxide nanotubes decorated with nanosilver and covered with a chitosan/Eudragit E 100 coating

Postoperative bacterial infections remain a significant problem. To reduce this phenomenon, the surfaces of materials intended for load-bearing implants are subjected to numerous modifications [1]. The subject of this study was the modification of titanium by electrochemical oxidation in a fluoride-containing diethylene glycol-based electrolyte to produce a nanotube oxide layer. The surface was then sputtered with a silver layer and treated with a laser, resulting in the formation of encapsulated nanotubes with silver nanoparticles (AgNPs) of about 30 nm in diameter formed on their top. The final stage of modification was the deposition of a smart pH-sensitive chitosan/Eudragit E 100 coating to ensure the controlled release of antibacterial substances. The as-produced titanium samples were further characterized using SEM, EDS, AFM, Raman, and XPS techniques. Wettability, corrosion properties, adhesion of the coating to the substrate, the release of AgNPs into solutions simulating body fluids of different pH, and antibacterial properties were also examined. The resulting coatings showed hydrophilic properties and satisfactory corrosion resistance. AgNPs release studies showed an increase in the concentration of silver released (with reduced burst release) as ions or metallic particles into simulated body fluid solution at acidic pH for samples modified with the biopolymer coating after three days of exposure. The proposed three-step modification was effective against both Gram-positive and Gram-negative bacteria.

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Poster 33: New approaches to the synthesis of conjugated polymers

Conjugated polymers have been used successfully since their discovery as organic electronic materials in electrochromic devices, photovoltaic cells, chemical sensors, organic field-effect transistors (OFETs), and organic light-emitting diodes (OLEDs). They are also actively investigated for their potential biological/biomedical applications such as components of biosensors or biomaterials for drug/gene delivery, and tissue engineering. For biomedical applications, derivatives of polyaniline, polypyrrole, polythiophene and poly(3,4-ethylenedioxythiophene) have been studied [1, 2, 3]. Two commonly used methods to synthesize conjugated polymers are solution phase chemical polymerisations (employing catalysts of various forms) and electrochemical redox polymerizations (using electrodes as a "green" method of polymerisation). The former produces polymers, often in powder form; the second produces polymers typically as thin films conforming to the architecture of the electrode used for polymerisation, in both cases dependent on the specific functionality of the polymers. Although the solution phase synthetic methods allow for mass production of conjugated polymers, the syntheses tend to be more complex (often multi-step), whereas, electrochemical polymerization is simple (single step) and useful for depositing coatings on substrates (e.g., devices, electrodes for neuromodulation, etc.). Increasing interest in sustainable chemistry motivates investigations aiming to develop new polymerization methods in recent years. Two examples of these new methods are sonochemistry and mechanochemistry which have been employed to facilitate polymerization reactions to take place under mild conditions, with short reaction times and high yields [4, 5, 6]. In this project we have investigated the synthesis of derivatives of pyrrole and 3,4-ethylenedioxythiophene displaying various functionalities, and their sonochemical/mechanochemical polymerization. The conjugated polymers (with polypyrrole (PPY) and poly(3,4-ethylenedioxythiophene) (PEDOT) backbones) have been characterised by various methods and are being investigated for biomedical applications.

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Poster 34: Direct detection of glyphosphate in water with fluorescent molecularly imprinted polymer particle

Analysis of environmental contaminants such as pesticides is increasing in importance due to frequent detection of residues in water reserves and food stuff, as well as lowering of maximum residue levels (MRLs). Molecularly imprinted polymers (MIPs) have been developed for preconcentration of these analytes prior to analysis by chromatographic techniques [1]. MIPs are prepared by polymerization of monomers in a matrix containing the analyte, followed by extraction of the analyte to obtain binding sites that are complementary to the analyte of interest. Recently, our group developed MIPs containing fluorescent reporter molecules that can be used for direct detection and quantification of 2,4-D in contaminated water. Core/shell MIP particles were employed, consisting of sub-micron silica nanoparticles coated with a MIP shell containing a fluorescent reporter whose signal was enhanced upon binding with 2,4-D in water. A limit of detection of 20 nM was attained [2]. We present here a comparable system, composed of fluorescent core-shell MIPs for the direct analysis of pesticides in environmental samples.

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Poster 35: Analysis of materials dedicated for sealing in everyday dental practice

Over recent years, methods of prevention of tooth decay are shifting towards minimal intervention dentistry and even prevention rather than treatment [1]. One of noninvasive methods of managing early caries lesions or preventing from attack of cariogenic bacteria is covering pit and fissures of the tooth's crown [2]. Different materials can be dedicated for that purpose. Most popular in everyday dental practice are flowable composite materials or dental sealants. They are relatively easy in usage for operators and declared by manufacturers to be effective means in prevention. That statement was evaluated in many studies [3]. As an introduction to further modification of chemical composition of materials to make them more resistant to bacterial attack, a comparison of nine popular commercially available materials was done. We considered their chemical composition declared by manufacturers, verified by FT-IR spectroscopy analysis, as well as contact angle analysis and fluoride release over time in water and solutions of different pH. Evaluation of the materials confirmed content of methacrylate derivatives as a matrix and different additives. Differences in both contact angle and amount of fluoride release to the environment of various materials were observed.

Fig.1. Juxtaposition of composite materials dedicated for sealing.

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Poster 36: Gradient polymer-ceramic composites based on poly(glycerol sebacate) and hydroxyapatite

Poly(glycerol sebacate) (PGS) is an emerging polyester indicated for various application in the field of regenerative medicine, including bone and cartilage tissue engineering [1]. Gradient polymer-ceramic composites based on elastomeric PGS and hydroxyapatite (HAp) could potentially act as a bone-cartilage interface. In this study bulk PGS-HAp composites were manufactured and subsequently characterized by means of micro-computed tomography (μCT). Both PGS prepolymer (pPGS) and hydroxyapatite (HAp) were synthesized according to the previously reported procedures [2]. The PGS prepolymer was synthesized using solventless thermal polycondensation and HAp was obtained using wet precipitation technique. The polymer-ceramic composites containing 2.5 and 5 wt.% of HAp were formed by homogenization in elevated temperature (60°C) and subsequent thermal cross-linking in reduced pressure for 60 and 120h in the dedicated silicon multi-well plates.

The composites were tested using μCT in order to investigate the HAp distribution in the polymer matrix. A significant variability of the reconstructed X-ray absorption coefficient along samples' height was demonstrated. Larger grains of HAp (most of which exceeded 0.2 mm in size) sedimented on the bottom of the samples forming a layer of 1.0-1.5 mm in height. Above this layer, the HAp is fairly evenly distributed without visible grains. However, the average absorption coefficient varies with height, demonstrating greater values closer to the bottom and generally greater compared to reference sample without the addition of ceramic filler. Therefore, the composites structure is considered gradient and gives an indication of diverse material properties along the samples' height, as desired for the bone-cartilage interface.

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Poster 37: The use of foam replication method to obtain zirconia scaffolds for bone tissue regeneration

Depending on the size of a bone defect, natural bone tissue can reveal the capability of self-healing. Defects that are considered of critical size need to be filled with a bone substitute or graft to be healed [1]. Porous scaffolds due to high relative surface area are able to support osteoblast migration and growth to higher extent than nonporous bone-substituting biomaterials [1], [2]. Zirconia ceramics (ZrO_2) is characterized by high biocompatibility with bone tissue and good mechanical properties, although its cellular and tissue affinity can be improved [2]. One of the methods that may improve the bioactivity of ZrO_2 is to cover it with a layer of calcium phosphate (CaP) [3]. The aim of this work was to obtain porous zirconia scaffolds with the use of the foam replication method and to coat them with a calcium phosphate layer doped with drug-loaded polymer nanoparticles (NPs). We obtained porous zirconia scaffolds using foam replication method. Briefly, polyurethane foams were immersed in a ceramic slurry, dried at 37°C and sintered at 1450°C. With the use of the co-precipitation method, we deposited CaP layers on received scaffolds and observed their microstructure using optical and scanning electron microscopy (SEM); porosity and mechanical properties were tested as well. SEM pictures confirmed that with the use of co-precipitation it is possible to coat scaffolds with CaP layer and to entrap NPs between CaP crystals without negative influence on CaP crystallization process. This study confirmed that it is feasible to manufacture the ZrO_2 scaffolds with an open porous microstructure and improved bioactivity.

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Poster 38: Modern polymer materials based on an ultra-light and universal rescue board for use in water and medical rescue

Modern medical devices, such as a spinal board, results in the effectiveness of ALS and BLS. Currently the problematic issue is its universality and too much weight oscillating around 7 kg. Frequent contact with the human body and diagnostic tests in the hospital affect the use of antimicrobial materials, that don't have metal elements in their structure and don't absorb any fluids. Most often orthopedic boards are made of high-density polyethylene (HDPE) and polyvinyl chloride (PVC). The first one is a flexible thermoplastic material, lighter than water and its density is 0.96 g/cm^3 approximately. The second material is characterized by high mechanical strength and chemical resistance [1]. These features make both materials appropriate for the production of orthopedic boards and also for the universal, ultra-light rescue board.

The spine board is a primitive evacuation equipment for people with and injured spinal cord [2]. It has metal elements that prevent the patient from performing initial tests, such as MRI or CT. The title rescue board is available in three variants and all have a 0.5 mm thick shell made of HDPE and a place for attaching safety belts made of solid and clear polycarbonate. They differ only in the filling of the equipment. Polycarbonate is a plastic material with very high stiffness and mechanical resistance, which will provide stable protection of the patient on the spinal board. The first filling is made of expanded polystyrene, which is a low-weight material, perfectly absorbing impacts, obtained in the polymerization of styrene. This material belongs to polyolefins, i.e. polymers consisting only of carbon and hydrogen, the weight of the first option was 3.190 kg. The second one is foamed polyurethane, which is characterized by good chemical resistance and doesn't change properties over time. The weight of the board with such filling was 2.444 kg. The third variant of the equipment has a "honeycomb" structure with a 20% capacity, which will significantly reduce the weight of the board. A characteristic feature of the universal, ultra-light rescue board is the profiled bottom with distinctive fins based on the utility model no.: 67456 [3]. This will increase the bouyancy of the equipment and should make the rescue board more used by lifeguards.

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Poster 39: Cell attachment and biocompatibility studies on meltelectrowritten polycaprolactone fibers: towards fabricating gradient scaffold for interfacial tissue regeneration

Introduction Interfacial tissues are structurally and compositionally heterogeneous consisting of architectural gradients, extracellular matrix constituents, cell phenotypes, and biochemical factors. Mimicking the structural complexity through scaffold designs for in-vitro tissue regeneration is challenging. Conventional tissue engineering techniques using biomaterial scaffolds with cells have limited abilities to fabricate the gradient structure with typical biomechanical properties. Therefore, we introduce melt electrowriting (MEW), as a high-resolution additive manufacturing method that holds great promise for reconstructing such native gradients.

Methods MEW was used to fabricate polycaprolactone (PCL) crimped, grid and rectangular design scaffolds. Tensile tests were performed to investigate the mechanical properties. Biocompatibility tests were done by culturing mouse fibroblasts (NIH3T3) on MEW scaffolds: live/dead assay, Alamar Blue assay. Immunofluorescence staining was performed by DAPI, phalloidin and vinculin staining to evaluate the complex focal adhesions.

Results MEW scaffolds were obtained with high precision in similar fiber diameter of collagen fibrils (10 µm – 20 µm). Mechanical studies exhibited similar values of young's modulus with different scaffold design due to the identical fiber-to-fiber distances. Additionally, crimped design scaffolds exhibited toe region, typically seen in native tendons with a lower young's modulus value compared to whole elastic region in the crimped design itself. Cell viability was above 86% for all the scaffolds at every time point. The cells revealed increased expression of phalloidin and vinculin, with increase in the culture time.

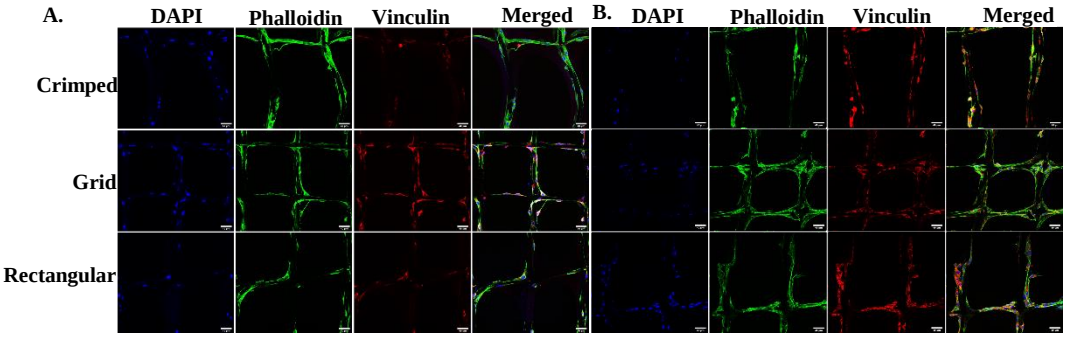

Figure:1 Nuclei (red) , Actin expression (green) vinculin expression of NIH3T3 cells on MEW PCL scaffolds after 24 hours (A) and 3 days (B) of culture (scale bar -40µm).

Conclusion

MEW PCL scaffolds showed good biocompatibility irrespective of the design. Plasma treatment and Poly-D-lysine coating on MEW scaffolds aided in uniform cell attachment. Mechanical testing of crimped, grid and rectangular scaffolds showed young's modulus values that are close to human tendons. Further cell studies will be performed using primary cells on individual MEW PCL scaffolds to scrutinize the zonal-specific differentiation conditions to fabricate a bone- cartilage- tendon gradient.

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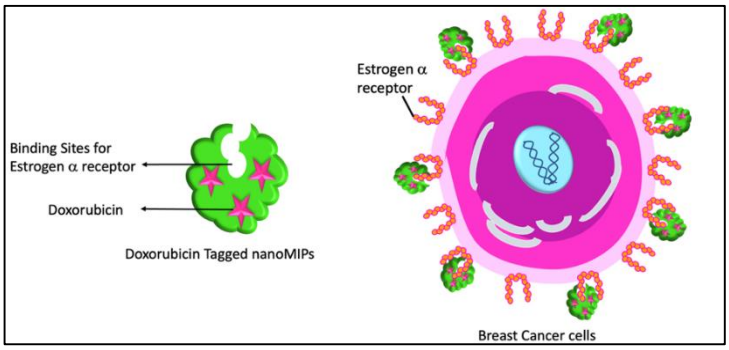
Poster 40: Engineered double-imprinted nanoparticles for targeted drug delivery to breast cancer

Nowadays, nanoparticles are crosslinked with certain antibodies, aptamers or peptide to achieve the targeted drug delivery to cancer cells.[1,2,3] However, these ligands are expensive and have severe side effects including immune intolerances.[1,4] In this work, we have synthesized double imprinted polymeric nanoparticles (nanoMIPs) for the delivery of Doxorubicin (DOX) drug to target Estrogen positive breast cancer cells. These nanoMIPs were synthesized using a novel solid phase synthesis using an epitope (short peptide sequence) of Estrogen Alpha sequence.[5,6] NanoMIPs were further characterized with UV-visible Spectroscopy, Dynamic Light Scattering (DLS), Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). Binding affinity of nanoMIPs have been adjudged by Surface Plasmon Resonance (SPR) Spectroscopy and highest binding affinity (K_D) out of all batches was found for fluorescein tagged DOX loaded nanoMIPs that was 19.2 nM and 10.06 nM for epitope and whole Estrogen alpha protein, respectively. In addition to that, *in vitro* cell binding assay and cytotoxic assays showed that these nanoMIPs more specifically target the Estrogen positive breast cancer cell line (MCF-7) than negative cancer cell line (MDAMB-231). These results encourage that nanoMIPs can be used in nanomedicine for Breast cancer cells, and as this technology is highly tuneable so can be used for range of other anticancer drugs and different cancer types.



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Poster 41: Development and characterization of chitosan-based coatings with nanosilver particles on the screw line of a model dental implant

In the case of dental implants, it is estimated that due to bacterial infection and the occurrence of peri-implantitis phenomenon, which is inflammation of the tissues surrounding the implant, about 10% of implants must be replaced within 5-10 years after implantation [1].

In this study, chitosan-based coatings with silver nanoparticles were deposited on the screw line of a model dental implant made of titanium alloy Ti13Zr13Nb.

The coatings were deposited by electrophoretic method using chitosan with 3 different molecular weights (low, medium and high). The coatings were deposited with the addition of silver nanoparticles with an average grain size of 30nm and with the addition of Polysorbate20 to ensure proper dispersion of the nanoparticles in suspension.

Microstructure studies were performed using scanning electron microscopy (SEM). The chemical composition was determined with the X-ray energy dispersive spectrometer (EDS). In addition, 3D reconstruction of the studied surfaces was performed using SEM and the value of surface roughness (Sa parameter) was determined. Evaluation of coating degradation included studies of weight change after incubation in SBF solutions of different pH (7.4 5.0 and 3.0) for a period of 7 days.

Studies using scanning microscopy showed that the highest amount of silver nanoparticles was deposited in high-molecular-weight chitosan-based coatings. The highest surface roughness value Sa (7,14 μm) was also obtained for these coatings. All of the modifications tested in an environment of pH 7.4 increased in weight due to swelling. However, the degradation rate studies showed that the lowest degradation rate was characterized by high-molecular-weight chitosan coatings on implants that resided in an environment with a pH of 5.0.

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Poster 42: The use of mass spectrometry with laser ionization assisted matrix desorption with time-of-flight detector to analyze tissue biopsies of patients with head and neck squamous cell carcinoma. A pilot study

The most common craniofacial cancer is squamous cell carcinoma. According to the KRN data, a continuous increase in the number of cases is observed, mortality is also increasing due to diagnostic difficulties. 5-year survival rates among patients with lip, oropharyngeal cancer ranged from 43.3% to 49.1% [1]. Early detection of dysplastic foci and neoplasms in situ is crucial for effective treatment. Currently, the most effective and the only correct way to differentiate pathological processes is histopathological examination. Collecting the material during a biopsy and its proper assessment is not easy, because it is possible to obtain an unrepresentative piece of tissue, which results in a misdiagnosis. It should also be taken into account that the analysis of the biopsy material is time-consuming, which in turn delays the diagnosis process. The idea of the following research was to find a simple, fast and at the same time specific method that uses small pieces of tissue. It meets all these features mass spectrometry with laser ionization assisted matrix with time-of-flight detektor [2,3].

The aim of this critical review is develop a panel of candidate biomarkers, which may collectively improve the sensitivity and specificity for detecting HNSCC. As a consequence of the routine clinical application of this tech-nique in the future, may lead to earlier diagnosis which may have a sig-nificantly positive impact on the quality of life of affected patients and to improve survival rate.

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Poster 43: Coated fabrics modified with bio admixture

Polymers are present in almost every area of human life, replacing traditional materials. Coated fabrics are one of branches of the synthetic material industry. Their application is very wide and reaches as far as the human imagination can reach. They are used in construction, automotive, agriculture and even in modern medicine. Over the years, we have learned how to design polymers to best fulfill their tasks. Today it is difficult to imagine life without such materials.

Coated fabrics are an interesting material from the cognitive and application point of view. Such materials are made of base – fabric, and a polymer coating applied to it. It is possible to modify such a coating with various additives that gives special properties: biostatic, antistatic, flame retardant or anti-aging.From the human point of view, protection against microorganisms is important for example in the case of flexitanks for water or tents in field hospitals. Silver-based additives are often used to gives antibacterial properties to coated fabrics [1]. However, silver ions show cytotoxic properties. It is natural to search for new solutions in the modification of the material in order to replace silver. Betulin may be the ideal solution. A natural compound found, among others, in the white part of birch bark with antibacterial, antiviral and anti-inflammatory properties. Betulin-modified polymers show antibacterial activity against *Escherichia coli* DSM 1576 and *Staphylococcus aureus* DSM 346 at the R<1 level even in the concentration below 0,1% [2, 3] which indicates the correctness of the direction of modification of coated fabrics with this natural raw material. This hybrid combination of natural betulin with artificial coated fabric can be used in the aera of saving health and life on the battlefield, for example in the form of flexible stretchers or the aforementioned mobile hospitals.

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Poster 44: Determination of nanomechanical properties of bacterial nanocellulose produced by *Gluconacetobacter xylinus E25*

Bacterial cellulose (BNC), thanks to its unique properties, can be used in many areas of life [1]. Significant number of applications relate to the medical industry, including BNC as a biomaterial for artificial heart valves [2]. BNC can be produced by many strains of bacteria. The most efficient strain is *Gluconacetobacter xylinus E25*, with which the BNC membrane was synthesized and then subjected to convection drying at temperatures of 20°C and 105°C and at freeze drying. The dried membranes were then soaked in distilled water for a period of 2 hours. The physically modified material was subjected to X-ray diffraction and nanoindentation test, and then the Williamson-Hall analysis was performed to determine the residual stresses and the size of the crystallites. The analysis of the nanoindentation test showed an increase in the hardness and Young's Modulus of the modified BNC. The highest, over 5-fold increase in hardness, was observed for BNC dried at 25°C and Young's Modulus increased from 1.5 GPa for native BNC up to 3.99 GPa for 20°C dried BNC. Williamson-Hall's analysis showed that dried BNC has a crystallite size between 14.25 and 25.67 nm and compressive residuals stresses ranging from 0.39 to 2.00 MPa. The obtained results of the influence of drying conditions and temperatures on the nanomechanical properties may help to understand the essence of the influence of the structure on the mechanical, physicochemical and biological properties of bacterial nanocellulose.

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Poster 45: PCM composite materials as a support in thermal energy management equipment for body temperature stabilization

Phase change materials (PCM) are the group of materials that are widely used for thermal energy management in a variety of disciplines and applications. One of the disciplines which note a significant increase in PCM development is medicine [1]. As the PCM materials can store or release thermal energy during phase transitions they can be used in drug delivery systems, cancer therapy, thermotherapy or pharmaceuticals and organs transportation [2].

Poly(ethylene glycol) (PEG), paraffins, polyurethanes (PUR), silicone and different nanoadditives composites were investigated as a potential material for body temperature stabilization, both in cooling and heating of the human body. The thermal properties of obtained composites were analyzed using differential scanning calorimetry (DSC) and thermogravimetry (TG). Additionally, materials samples were examined with scanning electron microscopy (SEM).

DSC results shows that incorporated nanoadditives led to increase of the latent heat of phase transition of obtained composites and raise the transition temperature so the heat can be released earlier. Moreover, the SEM results show that PCM composites with nanoadditives tend to create microcapsules which is beneficial due to the long heat release requirement for this type of materials.

The obtained results demonstrated that PEG-paraffin-PUR-silicone PCM composites are promising for further investigation as support in thermal energy management equipment for body temperature stabilization.

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Poster 46: Porous bone scaffolds obtained by solvent casting - particulate leaching method

More than four million surgeries performed annually are related to the surgical treatment of bone defects, placing bone tissue as the second most commonly transplanted tissue worldwide. Autologous and allogeneic bone grafts remain the traditional treatment approaches, but their significant limitations contribute the need to develop a bioactive tissue scaffold [1] that will act as a temporary bridge to the damaged tissue, promoting its full regeneration. Tissue scaffolds based on biodegradable polyesters, with a particular focus on the poly(α-hydroxy acid) group, are currently being widely investigated for use in bone tissue engineering. This is due to their easy processability, the possibility of managing their properties such as pore morphology, degree of porosity, geometry, mechanical properties or degradation rate, adapting them to the requirements of a given application [2]. Over the years, a number of methods for producing 3D scaffolds have been developed, including solvent-based techniques (Solvent Casting Particulate Leaching, Thermally Induced Phase Separation, Electrospinning), Gas foaming, Injection molding or 3D printing. Solutions based on solvent methods make it possible to obtain highly porous scaffolds with a variety of pore morphologies, but require the use of potentially harmful organic solvents. For this reason, it is paramount to ensure an effective procedure for their removal in the ongoing manufacturing process [3]. The aim of this study was to produce tissue scaffolds using the Solvent Casting Particulate Leaching method and to determine the effect of the blowing agents and organic solvents on selected functional properties.

The results obtained during the implementation of the study indicate that the applied parameters of the tissue scaffold fabrication process made it possible to obtain the porous structures characteristic for the Solvent Casting Particulate Leaching technique. Morphology analysis showed a strong correlation between the type of organic solvent applied and the microstructure observed in the images. The obtained values of the degree of porosity for all the produced samples, determined using computed microtomography, are in the range of 60-90%, required for tissue scaffolds used in the field of bone tissue engineering [1]. Analysis of FT-IR spectra revealed the presence of characteristic peaks derived from the studied pol(L-lactide). No peaks corresponding to the blowing agents used in the production process were registered on the absorption spectra, which confirms that the procedure used to leach the porogen particles proved effective and enabled their nearly complete removal from the polymer matrix. However, the FT-IR spectra recorded the presence of low intensity peaks derived from the organic solvents used, but these values are traces in relation to the reference sample. The negligible amounts of residual solvent residues are also confirmed by the gas chromatography coupled with mass spectrometry. The study indicated that the residual solvent concentrations remaining in the samples are significantly lower than the acceptable values for pharmaceutical applications [4].

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Poster 47: Phase change materials based on sugar alcohol stabilized with starch

Materials synthesized in nature have many applications. One such material is starch. It is the most important polysaccharide in plants; it can be stored, e.g., in fruits, seeds, and roots. It is a material used in the food, pharmaceutical, cosmetic, and textile industries. One of the application may be phase-change materials with shape stabilization. These materials that are designed to store energy when there is excess of it and to give it back when there is a demand for it. In the literature, attempts have been made to use starch for shape stabilization of phase change materials (PCM) [1]. The second example of a biomaterial with many applications are sugar alcohols. They are used as sweeteners, fillers, stabilizers in the food industry, but also in the pharmaceutical industry, e.g. for the treatment of the oliguria phase in acute renal failure, and for reduction of intracranial pressure. In recent years, these materials have also attracted considerable interest as potential phase-change materials [2].

The main goal of the current research was to obtain a phase change material with shape stabilization. For this purpose, a polysaccharide-based PCMs were prepared with starch in various percentages. In order to characterize the materials obtained, differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), Fourier-transform infrared spectroscopy (FTIR) and phase-contrast microscopy were used.

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Poster 48: Polyurethanes modified with calcium phosphate ceramics for use in bone cements

A significant increase in the demand for biomedical elastomers has been noticeable for several years. It results from the constantly growing number of people suffering from osteoporosis, the aging of the population and the increasing number of osteoporotic fractures. Currently, the most commonly used material in bone cements is poly (methyl methacrylate) (PMMA). However, this material has many disadvantages, including: exothermic cement bonding process in situ, which often leads to tissue necrosis, hypersensitivity to some cement components, release of toxic monomer, polymerization shrinkage, fractures of adjacent vertebrae due to too high hardness and material stiffness [1–4]. In order to eliminate the disadvantages of acrylate cements, attempts were made to replace PMMA with other compounds, however, due to poor surgical convenience, these materials are still rarely used in clinical practice [1,2]. For these reasons, there is a need to try to develop a new material that would overcome the disadvantages of currently used bone cements. Polyurethanes (PUR) are among the most commonly used elastomers for medical purposes. The aim of the work was to introduce nano hydroxyapatite (nHAp) and self-synthesized micro hydroxyapatite (μHAp) into the polyurethane matrix for use in bone cements. Both types of hydroxyapatites were introduced into PUR in various weight concentrations and then they were subjected to physicochemical and biological tests. Analysis of the surface morphology using scanning electron microscopy (SEM) with energy dispersion spectroscopy (EDS) and our previous literature reports showed that HAp tends to agglomerate [5,6]. The present study confirms that μHAp exhibits less agglomerating capacity compared to nHAp in polyurethane. The introduction of fillers into the polyurethane matrix causes an increase in Young's modulus in the tensile test and an increase in hardness. These properties increase with increasing filler concentration, however, a greater increase was observed for composites containing μHAp. Surface free energy (SFE) analysis showed that composites containing μHAp have a higher SFE, around 40 mJ/m^2, which means that they are a good material for orthopedics because they promote cell adhesion. The tests also showed that all the composites produced are not cytotoxic.

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Poster 49: Biocompatible granules made of nanohydroxyapatite and natural polymers as a bone biomaterial for regenerative medicine applications

Hydroxyapatite (HA) based granules sintered at high temperatures (> 1000°C) are the most popular on the market due to their high biocompatibility. This type of stable ceramics, unfortunately, are also characterized by a low specific surface area (SSA), which negatively affects their bioactivity and bioresorption. Lowering the sintering temperature leads to the production of granules with high microporosity and SSA, however their huge disadvantage is cytotoxicity to cells [1-3]. The aim of the research was to produce nanocomposite granules made of nanohydroxyapatite and two polysaccharides: agarose and chitosan. The developed material, apart from biocompatibility, was supposed to show high porosity and SSA. The viability of mouse preosteoblasts and human osteoblasts was determined in accordance with the ISO 10993-5: 2009 standard using the MTT assay. In addition, cells were imaged in direct contact with the biomaterial by LIVE/DEAD fluorescent staining and CLSM observation. In order to investigate the porosity of the granules, the Mercury Intrusion Porosimetry (MIP) technique was used, while the nitrogen adsorption technique with Brunaurer-Emmett-Teller theory was applied to measure the SSA. The ability of the granules to uptake liquid was determined by measuring the weight increase with time after placing the material into PBS and human plasma. The bioactivity of the material after incubation in simulated body fluid (SBF) was analyzed according to the ISO 23317: 2014 procedure. The Young's modulus was measured by the Oliver-Pharr method in accordance with the ISO 14577: 2016 standard. The test results showed that the nanocomposite granules had no toxic effect on the tested cell lines. Properly flattened cells growing at high density on the surface of the material indicated the osteconductive properties of the granules. Moreover, tested biomaterial, after 14 days of incubation in SBF was able to induce the formation of apatite on its surface (Ca/P atomic ratio = 1.82). In turn, studies of the liquid absorption capacity showed the ability of the granules to retain a large volume of fluid in a very short time. In addition, the biomaterial had relatively high specific surface area (approx. 29 m^2/g) and a structure rich in pores (51%). The value of Young's modulus for the examined granules was 8.13 ± 2.62 GPa which is close to the value for the cortical bone (12-18 GPa) [4]. The results of the conducted research prove that hydroxyapatite-polymer granules can be a promising implantable material for small bone defects due to their biocompatibility and favorable microstructural parameters.

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Poster 50: Fabrication and characterization of nanohydroxyapatite/silk fibroin/chitosan agglomerated scaffolds for bone tissue engineering

For many years, materials engineering has been trying to support medicine in the treatment of organ defects and tissue reconstruction. Scaffolds play a key role to provide temporary mechanical integrity at the defect site until the damaged tissue is repaired or regenerated, and normal biomechanical function is restored. Many methods are used to prepare 3D scaffolds, such as electrospinning, bioprinting, lyophilization, etching, or foaming. Materials with bone replacement potential are still required. The serious problem is to get the proper mechanical strength, biodegradability, and biocompatibility simultaneously. The material architecture concept was based on the fabrication of 3D porous constructs based on a pre-designed composite from nanohydroxyapatite (nHA), silk fibroin (SF), and chitosan (CTS), and then bringing this system to intentional agglomeration in molds in the presence of a solvent. Partial dissolution of the granulate surface led to the formation of permanent connections between the beads, which formed an ordered structure with irregular pores, and the materials thus produced were subjected to further testing to assess their suitability for tissue engineering applications. Biodegradable polymers were used to produce the structures: silk fibroin, chitosan, and osteoconductive calcium phosphate ceramic nanohydroxyapatite. The materials produced have a unique structure, with an evenly distributed mineral substance throughout the volume of the sample. Increased surface area ensures good adhesion to bone tissue. The cross-section indicates the internal porosity and roughness of the material.

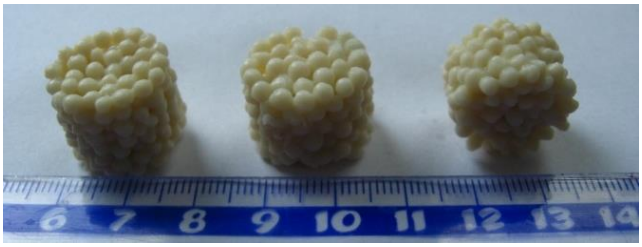

Fig. 1. Nanohydroxyapatite/silk fibroin/chitosan agglomerated scaffolds.

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Poster 51: Composite materials for bone tissue regeneration – synthesis and characteristics

Regenerative medicine is an interdisciplinary field combining concepts from, among others, materials engineering, molecular biology, or even nanotechnology. It is one of the most dynamically developing fields of medicine which main purpose is to stimulate the natural repair processes of the human body. One of the important aspects of this field is bone tissue regeneration aiming at restoring the bone structure as well as the function of lost tissues. Various treatment methods are currently used depending on the degree of bone loss at the implantation site. Bone tissue regeneration processes may also be supported by the application of composite materials. One of the most effective solutions is the combination of a polymer material (providing load transfer) with hydroxyapatite ceramics (responsible for the bioactivity of the composite) [1, 2].

The main purpose of the research was to obtain composite materials dedicated to bone tissue regeneration. The basis of the developed material are polymer components such as polyvinylpyrrolidone, poly(vinyl alcohol), and collagen. In turn, hydroxyapatite synthesized via the wet precipitation method was used as the ceramic phase. Obtained composites were next subjected to the detailed physicochemical characteristics. Based on the performed studies, it was demonstrated that the composites showed great application potential in bone regenerative medicine. Moreover, the synthesis methodology applied makes it possible to obtain composites of various shapes and sizes, due to which these materials may be selected individually according to the patient's needs, which constitutes their additional advantage.

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Poster 52: Electrospun chitosan (Ch)/polylactic acid (PLA) composite nanofibrous scaffolds for biomedical application

Introduction. Electrospinning is the technique used to produce biomaterials with appropriate structural, mechanical, and biological properties[1]. It points to combining biocompatible polymers such as PLA and chitosan to make effective, biocompatible scaffolds for different applications. PLA nanofibers are similar to the extracellular matrix (ECM) and possess a large specific surface area and high porosity with small pore size and appropriate mechanical properties[2]. Chitosan (biodegradable natural polysaccharide found naturally in marine) is an abundant and renewable resource with robust antibacterial mode[3]. The addition of polyethylene glycol (PEG) to the blended solution of Ch and PLA is used to control wettability and increase PCL's biocompatibility. Therefore, it is very important that such materials have controlled antibacterial properties[4].
The **goal** is a new strategy of composite materials fabrication with improved antibacterial properties for regenerative medicine.
Materials and methods. As-spun Ch/PLA and Ch/PLA-PEG membranes were treated with 1M sodium hydroxide (NaOH) to decrease their extreme degradation in aqueous solutions and preserve their nanofibrous structure. Membranes' antibacterial activity was assessed against *Staphylococcus aureus* and *Escherichia coli*. The samples were incubated with bacterial suspension in a 10^5 CFU/ml concentration for 2, 4, 6, and 24 h. Then, 20 µL aliquots were incubated on agar plates at 37°C for 24 h. The colonies were counted in CFU/mL. The untreated bacterial suspension was used as a control. The antibacterial effectiveness was assessed, calculating the antibacterial reduction rate (R) using the following equation (1):

$$R = (C-T) / C \times 100 \quad (1);$$

where C and T are the amounts of surviving bacteria (CFU/mL) in the controls and tested samples, respectively.
Results. The bacteriological survey indicates that Ch/PLA-PEG samples possess more vital antibacterial ability against both species after 4 h and 6 h incubation. However, at these time points of assay *E. coli* was more sensitive to the antibacterial effect of Ch/PLA-PEG membranes. Compared to Ch/PLA membranes, specimens with PEG showed more effective bacteria growth inhibition after 2 h of co-cultivation with *S. aureus* ($p<0.05$). There was no significant difference between samples after 24 h experiment.
Conclusion. Ch/PLA-PEG membranes revealed better time-depending antibacterial properties than the PEG-free sample. The addition of PEG as a co-solvent affects the samples' antibacterial properties on gram-negative and gram-positive bacteria in different ways.
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Poster 53: The main differences between biomaterials produced using lyophilization and air drying techniques

Based on the wound type, dressing selection must be conducted to ensure the most effective wound-healing process [1]. The recent developments in regenerative medicine allow the management of different wound types by using appropriate wound dressing materials [2]. The main aim of the research was the production of biomaterials using two different methods: lyophilization and room-temperature drying techniques. The production of biomaterials was carried out using two marine derived polysaccharides, chitosan and agarose. After synthesis, both biomaterials were comprehensively assessed in terms of their biological and physicochemical properties. It is worth noting that the production methods of both biomaterials differed in the last stage of the materials drying technique. The lyophilization method allowed to obtain a foam-like material, whereas in the case of room temperature drying, the production method resulted in a thin film synthesis. The selected production techniques determined the newly fabricated biomaterials' potential application in regenerative medicine. The main difference between both produced materials was their biological properties. Freeze drying of the sample resulted in a foam-like material that was biocompatible but did not promote cell adhesion and growth on its surface. In contrast, drying the sample at room temperature produced a thin film that supported cells attachment and proliferation. Other noted differences were mainly related to the nature of the obtained biomaterials. The foam biomaterial was characterized by a highly porous, biocompatible structure with excellent absorption properties and possessed high potential to be used as highly absorbent external wound dressing [3]. The thin film possessed a highly biocompatible and elastic structure, indicating its potential use as an artificial skin substitute [4,5]. Significant differences between both tested materials indicated that the selection of an appropriate production method results in obtaining unique features of the biomaterial.

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Poster 54: Bioinspired bone cement based on magnesium phosphate enriched with poly(HEMA) hydrogel

A variety of synthetic bone substitutes are currently used in medicine, however bone healing is still a considerable challenge in today`s clinical routine. A particularly interesting group of bioinspired materials are ceramic bone cements, which may be injected in a minimally invasive surgery. Currently, mainly calcium phosphates and calcium sulfates are applied in a bone defect therapy, but intensive research work has begun on the use of magnesium phosphate (MPC) as well [1]. This MPC cement is characterized by fast bonding, high initial mechanical strength, effective degradation and demonstrate greater osteogenic potential. However still, like every biomaterial, MPC has its drawbacks, such as: high temperature setting reaction and leachability of the paste [2,3]. Therefore, the novel bone cement formula was proposed - based on combination of MPC matrix with 2-hydroxyethyl methacrylate (HEMA) hydrogel. Tri-magnesium phosphate and di-ammonium hydrogen phosphate in 4:1 mass ratio was used as cement powder and cement liquids were water solutions of HEMA (15, 20 and 25%) cross-linked by TEMED/APS. The powder-to-liquid ratio was 2.5 g/mL and hydrogelling reaction started before mixing of cement components (premix times – 2:30 and 4:00 min). The following properties of composite cements were evaluated: microstructure, setting time, compression strength, cytocompatibility and degradation behavior.

The addition of the HEMA hydrogel component significantly influenced the main characteristic of the MPC cement - shortening its setting time, improving its mechanical properties, but also worsening the cellular response. Based on all obtained results, we decided that the longer premix time (4:00 min) and the medium HEMA concentration (20%) show the most favorable effect on the cement properties. Moreover, the proposed and applied modification of MPC cement allow to obtain a novel cement type, i.e. dual-setting cement.

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Poster 55: Assessment of the influence of using different concentrations of alginate and gelatin on the printability, viability and proliferation of cells contained in the hydrogel printouts

One of the most important aspects of 3D bioprinted structures designed for tissue reconstruction is to obtain printouts containing cells with high viability, proliferation and formation of cell networks to imitate the native tissue [1]. Currently, sodium alginate-based hydrogels are one of the most commonly used materials to produce bioinks. Their common use in the 3D bioprinting is a result of the ability to modify their rheological properties, and also the biocompatibility with a wide range of cell types [1][2]. Due to the biological inertness of alginate, to improve the adhesion and proliferation of cells placed in printouts, it is generally used in combination with various natural or synthetic polymers. One of the most commonly used combination is the addition of gelatin, which contains in the structure the bioactive collagen sequences [2]-[4]. Many research works indicate that the use of a hydrogel bioinks composition based on sodium alginate with the addition of gelatin provides an environment promoting high viability of eukaryotic cells immediately after the 3D bioprinting process [2], however, during the incubation of the printouts for particular periods of time, the viability of the cells may gradually decrease [5]. This phenomenon can be a result of the applied high concentration of bioink components leading to an overly high mechanical stiffness of the hydrogel matrix and a reduction in the diffusion rate of nutrients, which significantly reduces the proliferation, migration and proliferation of cells contained in the printouts [5][6].
The aim of this study was the optimization of sodium alginate and gelatin-based hydrogel bioink compositions in terms of selecting the appropriate concentrations of hydrogel components to create the most optimal environment for promoting the viability and proliferation of NIH/3T3 fibroblast cells contained in the printouts. The analysis included six compositions of hydrogel bioinks containing 1%, 1.5%, 1.75% and 2% (w/v) sodium alginate (Alg) and 3%, 6% and 9% (w/v) gelatin (Gel). During the study, an evaluation of the rheological properties of polymer solutions, printability of the prepared hydrogel bioinks and an analysis of changes in the viability of cells contained in the hydrogel printouts immediately after the 3D bioprinting process and after individual periods of structures incubation under conditions reflecting the organism's environment was carried out. Changes of weight of printed structures during the different degradation periods were also evaluated. Printing of tubular structures was possible only with the use of bioinks based on 1.75% Alg 9% Gel, 2% Alg 6% Gel and 2% Alg 9% Gel. The results of the assessment of polymer solutions rheological properties indicate that the use of higher concentrations of individual hydrogel components leads to obtain bioinks with higher viscosity. Immediately after the 3D bioprinting process, cell viability exceeding 85% was observed for all hydrogel bioinks compositions. Fibroblast cells contained in the hydrogel printouts were characterized by spheroidal morphology for all of analyzed incubation perioids and bioinks compositions. After a 7-day incubation process, the highest cell viability, exceeding 90%, was recorded for printouts containing 1.75% Alg 9% Gel. This phenomenon may be the result of the lower viscosity of the polymer solution and highest rate of sample degradation, which was confirmed by the analysis of changes in the weight of samples during incubation of the printouts.

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Poster 56: Microstructural characterization of the metal cations doped bioactive silicon oxycarbide materials

Silicon oxycarbides, the so-called black glasses, possess structure of amorphous silica with carbon ions substituting a number of oxygen ions [1]. This leads to the local densification of bonds and, as a consequence, to the strengthening of network. Their properties could be altered by the appropriate selection of organosilicon compounds as substrates in the synthesis and the introduction of additional metal ions.

The sol-gel synthesis of ladder-like polysilsesquioxanes was carried out using methyltriethoxysilane (MTES) and dimethyldiethoxysilane (DMDES) as substrates. Cerium(III) and zinc(II) cations were introduced by the addition of appropriate amount of metal nitrate(V) to the reaction mixture. The product in the form of a sol was then subjected to a two-stage thermal processing including drying at 80°C and pyrolysis at 800°C in an inert gas atmosphere. The obtained material was subjected to a detailed microstructural characterization using Scanning Electron Microscopy.

Microstructure of the black glasses changes remarkably depending of the type of introduced metal cation which affects the bioactivity of the material.

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Poster 57: Curdlan-agarose matrix as a base for creating biomaterials supporting wound healing

Polymer-based biomaterials thanks to their broad potential uses have become an integral part of regenerative medicine due to their low cost, ease of processing, and controlled chemical and mechanical properties [1]. Moreover, the advantage of using natural polymers is their greater environmental friendliness, biocompatibility, biodegradability, non-toxicity, versatility and often their intrinsic biological activity. Such polymers are relatively easily subjected to a variety of chemical and physical treatments specific for promoting tissue regeneration [2]. In the last decade, there has been significant progress in using natural polymers to accelerate wound healing, due to their heal-promoting properties and similarity to ECM, which significantly accelerates therapy [3]. The presented research was aimed at developing wound dressings based on a natural polymer matrix (curdlan and agarose) for use in wound care. [4]. The matrix was subjected to extensive tests to assess physicochemical, microstructural, and biological parameters in the context of its potential use in regenerative medicine. The conducted tests showed that the polymer matrix is biocompatible for skin cells, while not conducive to their adhesion on its surface. Physiochemical and microstructural analyses showed that the matrix exhibited high macroporosity, superabsorbent properties, and water vapor transmission rate at the level recommended for optimal skin healing. Interestingly, it degraded in a simulated infected wound environment. These studies proved that this matrix can be an excellent carrier for bioactive agents that stimulate healing (e.g. vitamin C) for the management of chronic wounds [5]. Bactericidal compounds such as antibiotics (e.g. gentamicin) can also be incorporated into the polymer base for the treatment of infected wounds and prevention of surgical site infections [6]. Results so far have proven that this polymer matrix is an excellent biomaterial for use in the supply of various types of wounds, especially exudate types.

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Poster 58: Nanocarbon-modified polysulfone membranes with an increased hydrophilicity as a step toward anti-fouling materials.

A polymeric filter used in haemodialysis process separates and removes metabolic waste products from patients' blood. Due to biofouling, it loses its efficacy and may be a source of bacterial infection in acute patients. Currently efforts are directed at limiting protein adhesion to the polymeric surface. One way to address this issue is to obtain nanocomposite membrane with new anti-fouling properties.
The goal of this study was to assess how 2%wt. carbon additives such as carbon nanotubes (CNT), carbon nanofibers (CNF) and carbon microfibers (CMF) affect polymer membrane properties by comparing ultrafiltration efficacy with unmodified PSU membrane. Nanocomposite membranes were obtained by phase inversion method (NIPS). The system selected for membrane preparation was polysulfone-dimethylformamide-water (PSU-DMF-W). The obtained nanostructured membranes were characterized morphologically by scanning electron microscopy (SEM, Nova NanoSEM). Physicochemical properties of membrane surface were characterised by wettability and surface free energy (SFE, Kruss 25). The porosity of membranes was determined gravimetrically, using water as a wetting agent. Total volume porosity was determined by considering the volume of water (Vwater) in the membrane relative to the geometric volume of the membrane (Vmembrane). Mechanical properties of nanocomposite membranes were compared based on the performed tensile test (universal testing machine Zwick 1435). The suitability of nanocomposite membranes for the processes of water permeation and retention of bovine serum albumin (BSA) were tested under static conditions. The amount of BSA retained on the membrane was determined by UV-Vis spectroscopy using the Exton reagent protein assay method (Shimadzu 1900i).
The microstructure of the PSU polymer membrane is asymmetric sponge-like and the addition of carbon changes the morphology of the pores to finger-like. The skin layer of the membrane is the smallest in the PSU/CNF membrane and it's the one where the asymmetric pores have the largest size (50-100 um). These sizes affect the porosity of the material (about 62%) and its physicochemical properties. The permeability of membranes with carbon nano-additives remained the same for 72h, in contrast to the PSU membrane, where the permeability efficiency decreased by 30% during this time.

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Poster 59: A spectrofluorimetric sensor for Fosfosmycin Trometamol based on molecularly imprinted polymers on carbon dots for fluorescent sensing of in Urine

A novel fluorescent probe based on molecularly imprinted polymers (MIPs) coupled with carbon dots (CDs) was prepared and used for specific recognition and sensitive determination of Fosfomycin Trometamol. Citric acid and dipotassium hydrogen phosphate (K_2HPO_4) were dissolved in 10 mL deionized water under vigorous stirring. Then, the mixture was sonicated for 2 minutes and then heated in an ordinary household microwave oven. CDs were modified with 3-aminopropyltriethoxysilane (APTES). The MIPs were fabricated on the silica-coated CDs via a typical sol–gel polymerization. Under optimized conditions the linearity is observed between 0.02 and 14 μmol L^{-1}. Finally, the proposed method was successfully applied to the detection of fosfomycin trometamol in human urine.

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Poster 60: Study of the influence of ginger, garlic and ascorbic acid on the growth of microorganisms in drinking water

Treated water intended for consumption during storage is exposed to the development of microorganisms, including those hazardous to human health, e.g. E. Coli bacteria, streptococci, Leptospira spirochetes, Shigella or Salmonella. In devices that are used by the Polish army, water is preserved with the use of agents based on silver or with compounds that release free chlorine into the water. Silver or chlorine based remedies have a negative impact on human health and degrade the quality (smell and taste) of the water to which they are used. Research [1] shows the negative impact of silver compounds on human health, which results in the ECHA's Biocidal Products Committee (BPC) ban for use products containing silver and having direct contact with food and beverages on the market in the EU. The consumption of water containing free chlorine is safe, provided that the concentration of chlorine does not exceed some levels. The content of free chlorine at the level of 0.3 mg/dm^3 results in an unpleasant smell of water, which may cause discomfort to the person consuming such water. Chlorine generally has a negative impact on the natural environment, used packaging must be disposed of in specialized companies, and improper use may lead to loss of health. The increased use of chlorine-based agents during the COVID-19 pandemic has highlighted the disadvantages and problems of such solutions [2]. The Armed Forces of the Republic of Poland also use sodium metabisulphite as a preservative for filtration membranes in water treatment systems, the substance is included in the list of permitted food additives with a concentration limit. It is desirable that the metabisulphite be completely discarded before using the water treatment systems, which requires a long flushing process of the entire system.

Studies on ginger [3], garlic [4] or ascorbic acid [5] show their bactericidal effects. The biocidal potential of those substances can be used in the process of drinking water conservation as well as devices intended for filtration. The use of natural ingredients would have a positive effect on the health of users of water treatment and storage systems, and would also be less harmful to the environment. The study used: powdered ginger root at a concentration of 3 g/dm^3, granules of dried and powdered garlic at a concentration of 0.6 g/dm^3 and ascorbic acid (pure for analysis) obtained from D-glucose in the Reichstein synthesis process at a concentration of 1 g/dm^3, which have been dissolved in microbiologically clean water from the water supply. The concentrations were selected based on the maximum allowable daily doses for consumption of individual substances. The test includes four tanks, one with pure water without additives, which is the reference sample, and in the following tanks: ginger, garlic and ascorbic acid. All powders were previously sterilized with a UV-C xenon lamp with a wavelength at the peak of 253 nm and a power of 72 W in order to neutralize any natural microflora. The conducted research shows the biocidal potential of the tested ingredients, which can be used to ensure bacteriostaticity of drinking water for long-term storage. The results can be the basis for further work on obtaining a mixture of tested agents with the optimal composition, and then for the development of effervescent tablets to be dissolved in water, which will ensure appropriate ergonomics and ease of use.

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Poster 61: Functionalization of polyethylene surface with silver nanoparticles prepared by a sonochemical method

Polyethylene (PE) is a commonly used polymer in medicine applications, especially for medical implants manufacturing. A significant problem associated with the use of polymeric biomaterials is implant-related infections caused by bacterial adhesion to their surface. An alternative to the classical antibiotics therapy is functionalization of polymeric materials surface with antibacterial nanoparticles. [1]. In this study, silver nanoparticles (AgNPs) were prepared using sonochemical method and then embedded on polyethylene film surface. During the functionalization of polyethylene surface, different parameters were tested. The obtained AgNPs were characterized using Nanoparticle Tracking Analysis (NTA) and transmission electron microscopy (TEM). The embedment of the AgNPs on polyethylene film surface was confirmed by XRF technique. XRD method was used to determine the size of crystallites before and after modification of PE surface with silver nanoparticles. Microbiological studies of the obtained AgNPs-HDPE composite materials were performed.

The results showed that optimized parameters of the sonochemical synthesis resulted in nanoparticles with diameters below 50 nm. The experiment confirmed that the most efficient deposition of AgNPs on PE surface was obtained for the amplitude of 50%, regardless of the irradiation time. After incubation of bacterial suspensions of *Staphylococcus aureus* and *Pseudomonas aeruginosa* strains with samples of pure PE, modified with silver nanoparticles, and in the control sample, growth of microorganisms seeded on solid media was observed.

The study showed that the silver nanoparticles can be performed and embedded into the surface of the polymer using the sonochemical method. The AgNPs deposited on the surface of polyethylene did not show antibacterial activity, probably due to their low concentration on PE surface or deep embedded in the polymer structure, preventing the formation of reactive oxygen species and/or the release of silver ions. The presented results are preliminary, however, they outline further research paths.

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